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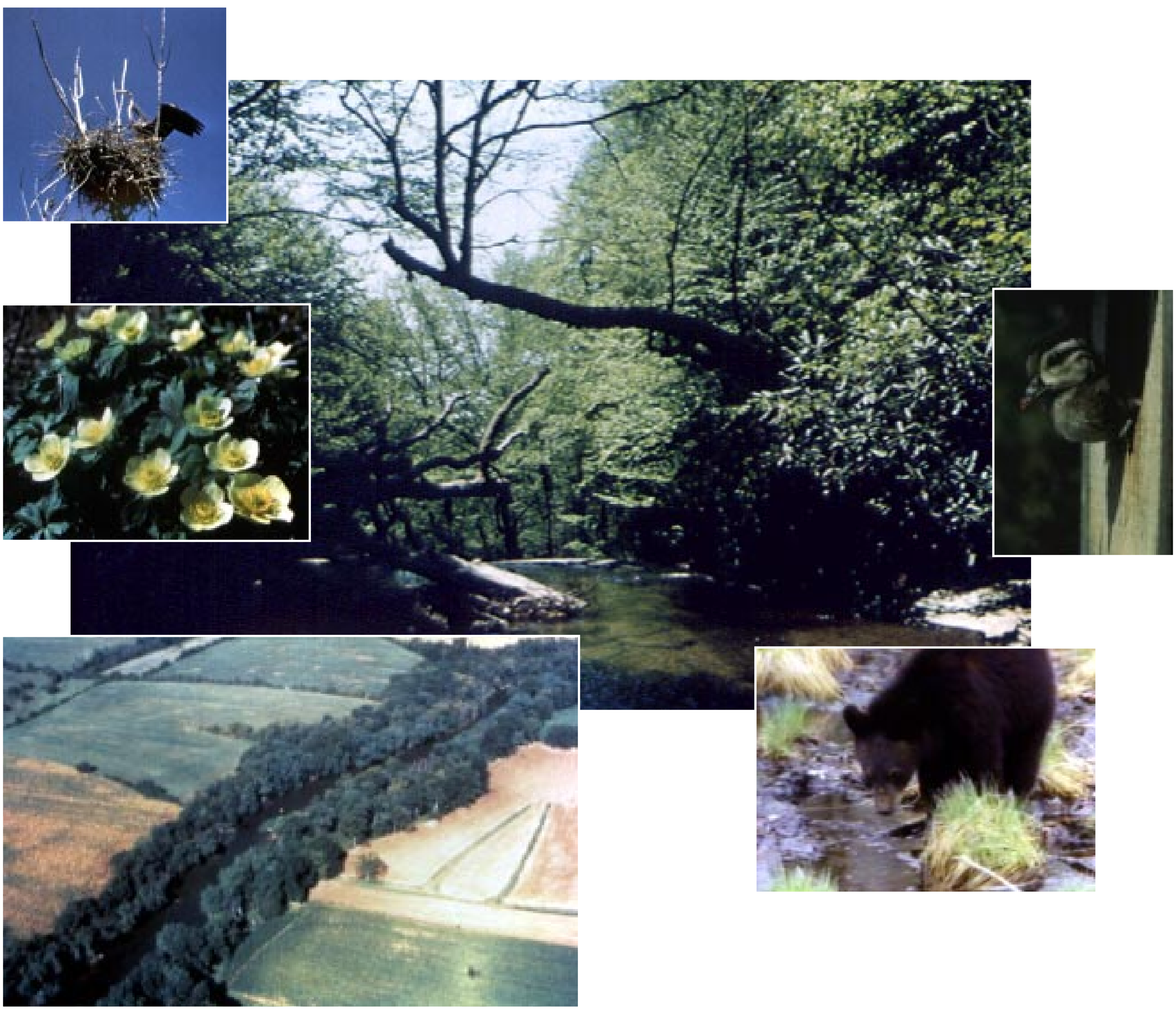
Chesapeake Bay Riparian Handbook:

A Guide for Establishing and Maintaining Riparian Forest Buffers



CHESAPEAKE BAY
PROGRAM

NORTHEASTERN AREA
State and Private Forestry

Chesapeake Bay Riparian Handbook: A Guide for Establishing and Maintaining Riparian Forest Buffers

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May 1997
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HYDROLOGIC UNIT MAP
OF THE
CHESAPEAKE BAY WATERSHED
DEL., D.C., MD., N.Y., PA., VA. AND W.V.

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Introduction

Introduction

The Purpose of This Handbook

Riparian forest buffers have been identified as a valuable nutrient reduction tool when used in conjunction with other conservation practices. For this reason, the Chesapeake Bay Program has targeted riparian forests as a key habitat for restoration. The purpose of this handbook is to provide professional land managers and planners with the latest information on the **functions, design, establishment, and management** of riparian forest buffers. This handbook is intended for use by:

- agencies and private concerns that provide technical assistance in the field,
- local governments who want to use the handbook as a technical basis for decision-making,
- policy makers,
- public/consulting or service/private foresters, and
- professional land managers, both industrial and public.

The handbook is specifically written to serve those states in the Chesapeake Bay Watershed – Delaware, Maryland, New York, Pennsylvania, Virginia, and West Virginia. However, states that are adjacent to the Bay states, with similar physiography, can also use the publication for guidance. The handbook uses the three-zone riparian buffer concept developed by Welsch as a guideline for buffer establishment.

This publication is done in three-ring binder format so that additional materials can be added as they become available. Local publications and regulations can be added to personalize the handbook.

Historical Background

When colonists first arrived on the shores of the Chesapeake Bay, more than 95 percent of the landscape was forested. This vast forest was an important regulator of the Bay's environment – a "living filter" which protected the land, filtered pollutants and sediment from rainfall, regulated stream and air temperatures, controlled runoff, and provided living resource habitat.

Lumber quickly became one of the first exports from the colonies; the first ship returning to England carried a cargo of oak and cedar. Soon, the colonies became an important supplier of ship masts and hardwood lumber. Land was quickly cleared for farming, settlements, and fuel.

The last 300 years have brought dramatic changes to the Bay's forests. The rate of land clearing increased rapidly through the 1800s as demand for wood, primarily as fuel for industry, grew. By the early 1900s, only about 30 to 40 percent of the watershed was still covered by forest. After the early part of the century however, forests gradually reclaimed some land, particularly as previously harvested areas regrew and farmland was allowed to return to forest. By the late 1970s, forestland made up 60 percent of the Chesapeake Bay Watershed. Since then, the amount has declined, largely because of development

Almost 15 million people live in the Bay's watershed. Urban growth results in the loss of almost 100 acres of forest daily, making the management and protection of the remaining forestland base critical to the overall health and resiliency of the Bay ecosystem. As a result, today's forests are not evenly distributed in the watershed. Much of the remaining contiguous forestland is far inland, covering the mountains of Pennsylvania, Maryland, and Virginia. By contrast, most of the forests have vanished in agricultural areas and rapidly developing urban centers nearest the Bay. Deforestation in some of these counties approaches 80 percent.

For the Chesapeake Bay, that change has major ramifications. Acre for acre, forests contribute less sediment and nutrient runoff pollution than any other land use. Riparian forests have an ability to filter water that is often comparable to wetlands. The loss of forests is therefore correlated with declining water quality in both the Bay and the rivers and streams that supply it with fresh-water. In recent years, studies have suggested that streamside forests can serve as highly effective filters that control both surface runoff and, in many landscapes, groundwater flow in streams. In addition, they provide shade, temperature control, and food required by many aquatic species.

Streamside forests, as a result, are being viewed as a way to partially mitigate the loss of forest over much of the remaining landscape. This recognition has come after many streamside forests were cleared for other uses. The Chesapeake Basin has more than 112,000 miles of rivers, streams, and shorelines, but it has been estimated that as much as 60 percent of the streamside forests have been removed or severely impaired. Although comprising only 5-10 percent of the land in the watershed, riparian areas have an extremely important role in maintaining the health of the Bay in its entirety.

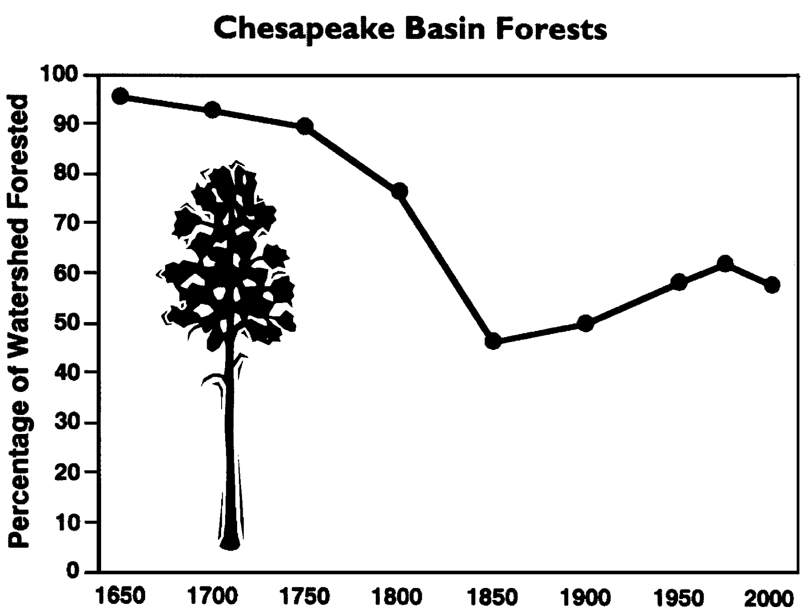


Figure 1 - 1. Percentage of Chesapeake Bay Watershed forested from the years 1650 to 2000. (Source: USDA Forest Service, Chesapeake Bay Program)

Defining the Chesapeake Bay's Riparian Resources

Riparian areas are landscapes with high economic and ecological values. In their natural forested state, they provide crucial fish and wildlife habitat and help control stream stability, flow, and water quality. In addition, riparian areas are used for recreation and/or timber production. Shorelines are highly valued building sites. Many acres of riparian areas have been converted to other land uses, especially fertile flood plain soils that have been converted to crops. Cultivated agriculture, pasture, grass filter strips, lawns, or residential, commercial, and industrial development and infrastructure are common land uses. Recognizing these multiple values and uses is essential in developing effective management and restoration strategies.

Understanding any concept requires knowledge of the terminology used to describe it. The definitions of a riparian area sometimes vary depending on the perspectives of managers and scientists. The word ***"riparian"*** is derived from the Latin word for bank or shore and simply refers to land adjacent to a body of water. Plant ecologists define riparian areas based on soil moisture conditions and unique plant communities associated with wet and mesic soils. Others may define riparian areas in terms of soil characteristics, hydrology, or landscape features. Law or policy often defines a riparian area in terms of its uses. Consequently, riparian areas do not stop at an arbitrary, uniform distance away from a stream or watercourse; they vary in width, shape, and character.

Ecosystem perspectives of riparian areas incorporate concepts of geomorphology, terrestrial plant succession, and aquatic ecology. Here, riparian areas are defined as three-dimensional zones of influence between terrestrial and aquatic ecosystems. The boundaries of the riparian area extend out from the streambed or tidal shoreline and upward into the canopy of streamside vegetation. Likewise, the functioning riparian zone may be considered to extend into the soil to the water table, and thus incorporate underlying hydrogeologic conditions.

With the exception of tidal marshes and emergent wetlands, nearly all riparian ecosystems of the Chesapeake Bay Watershed in their natural state were dominated by forest plant communities. Relative to other land types, forested riparian areas are characterized by a combination of high species diversity, high species density, and high bio-productivity. Natural and human-caused factors have greatly altered riparian character and condition over time. Landscape differences, such as physiographic region, also result in variation in form and function of riparian systems.

The Riparian Area

The USDA Forest Service defines a ***riparian area*** as:

> *"the aquatic ecosystem and the portions of the adjacent terrestrial ecosystem that directly affect or are affected by the aquatic environment. This includes streams, rivers, lakes, and bays and their adjacent side channels, flood plain, and wetlands. In specific cases, the riparian area may also include a portion of the hillslope that directly serves as streamside habitats for wildlife."*

Lowrance, Leonard, and Sheridan define the ***riparian ecosystem*** as:

> *"a complex assemblage of plants and other organisms in an environment adjacent to water. Without definitive boundaries, it may include streambanks, flood plain, and wetlands, . . . forming a transitional zone between upland and aquatic habitat. Mainly linear in shape and extent, they are characterized by laterally flowing water that rises and falls at least once within a growing season."*

The Coastal Zone Management Handbook defines ***riparian areas*** as:

> *"vegetated ecosystems along a waterbody through which energy, materials, and water pass. Riparian areas characteristically have a high water table and are subject to periodic flooding and influence from the adjacent waterbody. These systems encompass wetlands, uplands, or some combination of these two land forms. They will not in all cases have all the characteristics necessary for them to be classified as wetlands."*

American Fisheries Society defines ***riparian areas*** as:

> *"the lands adjacent to streams, rivers, or other bodies of water where vegetation is strongly influenced by the presence of water."*

These and other definitions identify aspects of a riparian area held in common. They:

- are adjacent to a body of water,
- are linear in nature.
- lack clearly defined or linear boundaries,
- provide a transition between aquatic and upland environments, and

In the Chesapeake Bay Watershed, forests are the natural vegetation which comprises the riparian area of most streamsides and shorelines.

Filter Strips and Buffers

When adjoining land uses are significantly different, or where potential for conflict is serious, it is common practice to create a buffer between them. Thus we have ***"buffers"*** between highways and houses, industrial and residential areas, and around recreation sites and airports. Generally, as the density or magnitude of the activity or the potential for impact increases, the width of the buffer necessary to contain the negative effects increases proportionally. In terms of a riparian area, the differences between developed or disturbed lands and the stream or aquatic environment are significant. The more intensely disturbed or developed, the more the difference. Likewise, the size or importance of the buffer increases as the potential impact created by increased yields of nutrients, chemicals, and sediment from adjacent land use increases. Riparian buffers have been described as "one of the most effective tools for coping with non-point source pollution."

"Filter strips" are vegetated sections of land designed to accept runoff for pollutant removal. Grass filter strips have commonly been used to help control pollutants in run-off. They are not designed for high velocity flows, but rather low volume dispersed flows and groundwater. Filter strips differ from ***"natural buffers"*** in that strips are not "natural;" they are designed and managed specifically for the purpose of pollutant removal. ***"Enhanced natural buffers"*** are natural buffers whose removal capacity has been improved through land grading, water spreaders, planting of additional vegetation, increased width, or other measures.

Riparian buffer strips should be designed to fulfill one or more of the following basic roles:

- protect fish and wildlife by supplying food, cover, and thermal protection.
- help prevent upland sources of pollution from reaching surface waters by trapping, filtering and converting sediments, nutrients, and chemicals.
- maintain the hydrologic, hydraulic, and ecological integrity of the stream channel and associated soil and vegetation (i.e. maintaining streambank stability and channel capacity).

Riparian (Streamside) Forests

Naturally forested riparian areas have also been called "streamside forests," "river woods," and "wet woods" to name a few. When thinking of these areas as part of a landscape, people also routinely define them by their desired use or perceived value to people rather than by their ecological significance. Natural riparian forests are often enhanced or protected to serve the role of a buffer.

The Riparian Forest Buffer

Buffers or filter strips may utilize a variety of vegetation types. Forested riparian buffers (or streamside forests) are riparian buffers with a functional forest ecosystem. Forest buffers are recognized as the most beneficial of any type of buffer because of the multiple environmental benefits they provide. The use of forested zones near streams has long been recognized as an important strategy for improving water quality while simultaneously protecting or restoring the stream ecosystem. Forested riparian buffers should be clearly distinguished from vegetative or grassed filter strips commonly recommended as a best management practice (BMP) because of their ability to accomplish both water quality and ecological roles.

The Executive Council of the Chesapeake Bay Program has defined a ***Riparian Forest Buffer*** as:

> *"an area of trees, usually accompanied by shrubs and other vegetation, that is adjacent to a body of water and which is managed to maintain the integrity of stream channels and shorelines, to reduce the impact of upland sources of pollution by trapping, filtering and converting sediments, nutrients, and other chemicals, and to supply food, cover, and thermal protection to fish and other wildlife."*

Riparian forest buffers may vary in size, shape, mix of vegetation, and management objectives; however, they maintain trees over the long term as the dominant part of their plant communities.

Describing Riparian Forest Buffers in Different Landscapes

To increase general understanding, it is sometimes useful to characterize riparian forest buffers by their use in each of the unique land use settings in which the practice is applied.

There are four land uses on which riparian forest buffers can be described:

- Forested Landscape
- Agricultural Landscape
- Suburban/Developing Landscape
- Urban Landscape

FORESTED LANDSCAPE

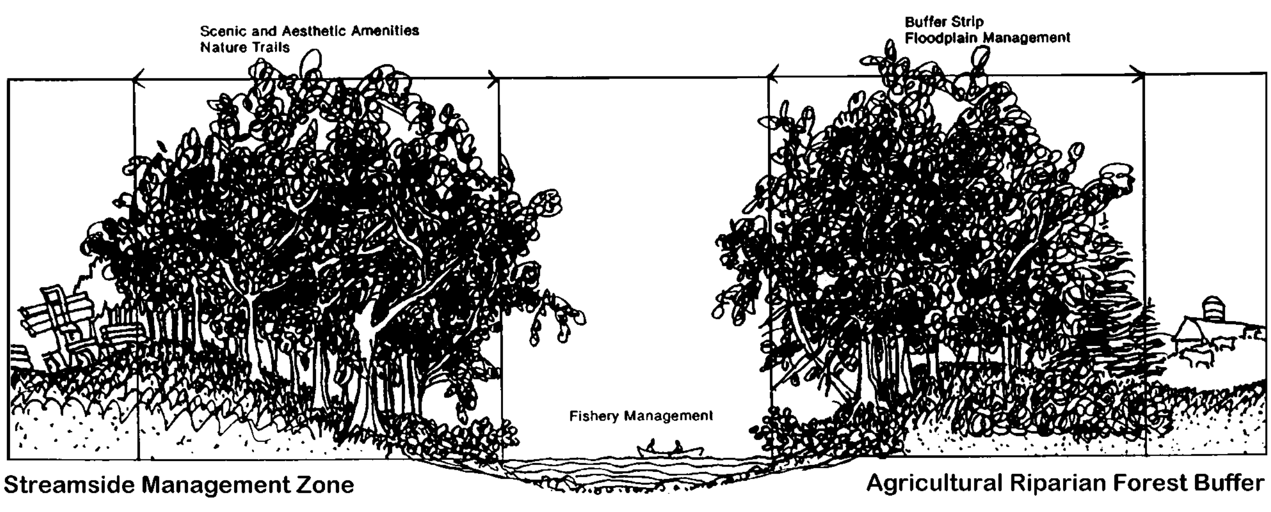
Streamside Management Zone (SMZ) - an area of forest, varying in width, where timber management practices that might affect water quality or aquatic resources are modified.

This is the riparian portion of forested lands. Where the landscape is managed for wood products, the riparian forest buffer is referred to as a "streamside management zone (SMZ)" or "streamside management area." In a forest landscape, management objectives for the forested areas closest to the water are oriented away from timber production and toward water quality protection and habitat concerns. Forest composition in the SMZ commonly represents a more natural diversity, rather than favoring only commercial species. SMZ widths are usually fixed, but may vary from 25 feet to more than 300 feet, primarily controlled by slope or biological considerations.

AGRICULTURAL LANDSCAPE

Agricultural Riparian Forest Buffer (RFB) - an area of trees and other vegetation separating cropland or pasture from a stream, another body of water, or a groundwater recharge area. RFBs are designed and managed to provide shade, restore stream habitat, and to trap and remove nutrients, sediments, pesticides, and other chemicals from surface runoff and subsurface/groundwater flows. These areas are retained, enhanced, or planted.

Forests that have remained a part of agricultural areas may be managed as woodlots, recreational open space, or wildlife habitat. Many are limited to fragmented patches confined to wet soils or steep slopes and hilltops too difficult to cultivate. Riparian forests have usually been cleared on farms managed for livestock. These areas represent the classic definition of riparian forest buffer as a water quality and habitat enhancement BMP. Because of potentially high levels of sediments, nutrients, and other chemicals leaving the crop fields or pastures in surface or groundwater, RFBs are designed to serve as a



zone to buffer water quality impacts of this land use from a stream, river, or bay. In addition,

streams have often been highly altered in these areas, and the forest buffer supports the restoration of aquatic habitat. Remaining riparian forests are often very narrow bands (10 to 25 feet) of intermittent trees along the bank of a river or stream. Groundwater may be drained by tile systems.

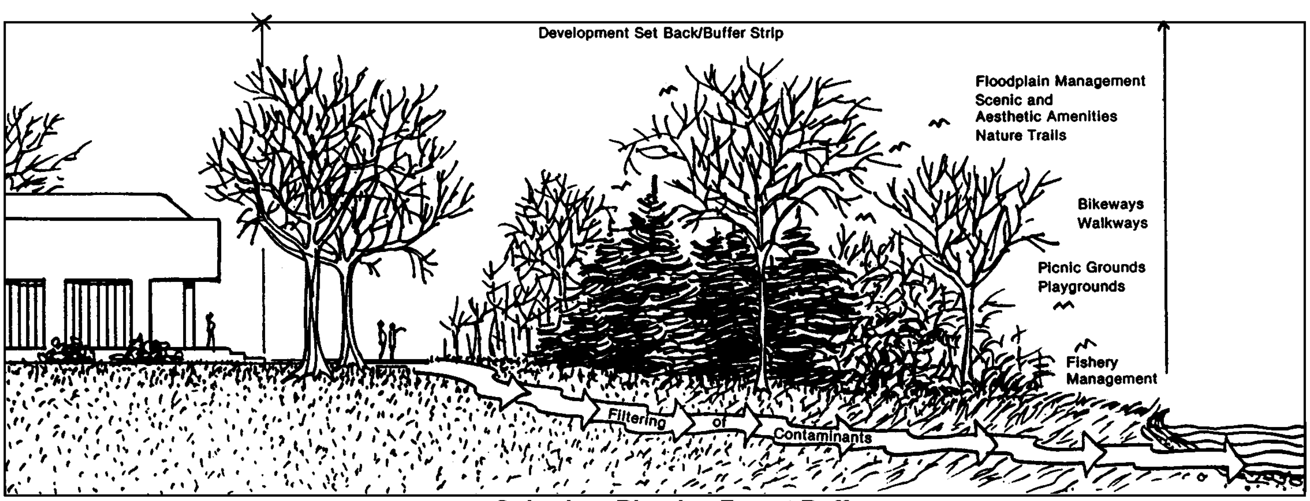
Agricultural applications of forest buffers sometimes require the conversion of active cropland, but most often are a combination of pasture, grass filter strip, and/or cultivated field. Establishing riparian forest buffers may involve the task of conversion of grass or crop fields to forest where no forest has existed for 50 to 250 years. In other cases, the RFB may be just an expansion of a narrow existing forest strip.

SUBURBAN/DEVELOPING LANDSCAPE

Suburban Riparian Forest Buffer - corridors of forest bordered by parks, ballfields, roadways, lawns, and residential/commercial structures. They are also landscapes that are retained and managed to provide the natural functions and values of sediment filtering, enhanced infiltration, nutrient uptake and processing, temperature moderation, noise control, screening, aesthetics, and wildlife habitat.

When describing forests, whether riparian or in general, the suburban or developing landscape is one of change. The challenge is retaining existing riparian forests and planning for sustaining them over the long term. As forests are cleared for development and runoff, temperature, edge effect, exotic plants, and pests all increase. The focus is to retain functional riparian forest corridors. The potential benefits of retaining these riparian forests are equally high for future water quality and aquatic and human resources. Increased nutrients from road runoff and lawn fertilizers are effectively treated by the riparian forest buffer if stormwater designs allow adequate watershed infiltration. RFBs can be integrated with stormwater management strategies (See Section XI). Riparian forests in these areas also contribute to higher property values.

In developing areas, many communities already have subdivision or zoning rules that impose mandatory building setbacks from lot lines. Some communities require a specific setback from the shoreline (such as mean high tide) or streambank. Maintaining buffers that provide environmental benefits generally means preserving or establishing a zone of woody vegetation where disturbance and building are limited. To accomplish this, lot line setbacks may need to be reduced or a subdivision may need to alter lot sizes. Riparian buffers and stream corridors can be effectively established during zoning or in the planning of a subdivision. Riparian for-



Suburban Riparian Forest Buffer

ests should be considered a high priority for retention and restoration in a community's open space plan. However, if too much recreation occurs without proper management, then both erosion reduction values and wildlife benefits may be lost.

One key principle of modern land use planning promotes concentrating intense development in areas where supporting infrastructure already exists. This principle focuses on “infill” development and redevelopment. In many communities, these intensely developed areas may include streambanks and shorelines or larger bodies of water. These shorelines may already have high land values and tax burdens, creating a desire to maximize the economic return on such properties. This can preclude giving such land over to environmental uses, such as a buffer, unless a financial incentive, like a tax reduction, is provided.

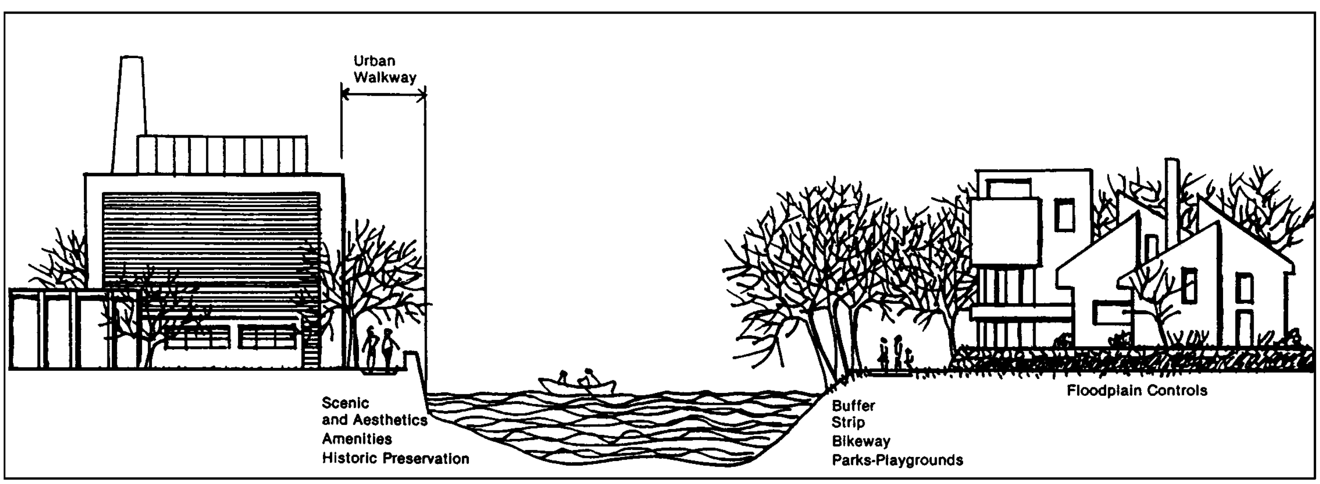
URBAN LANDSCAPE

Urban Riparian Forest Buffer - corridors or strips of forest, often narrow or highly irregular in extent or linear distance, which are protected, managed, and/or enhanced for aesthetic, habitat, recreational, climatic, or water quality benefits within a highly impervious setting.

Riparian forest buffers have also found a place in stormwater management in conjunction with wet ponds, wetland detention, and stream erosion control. Combined with stormwater planning, forests provide a net reduction in stormwater and a significant cost savings in future stormwater facility repair and replacement.

Forests in the urbanized landscape are highly fragmented and often dysfunctional ecosystems. Of all the various types of urban forests, including trees in parks, along streets, and on private lots, forests bordering streams and rivers are probably the most valuable forests from a water quality and habitat perspective. The fragments of riparian forest that have been protected from development often represent the largest contiguous forests within urban areas. Refuges for songbirds, amphibians, and other wildlife, they can be unique areas for appreciating nature. From a human perspective, they provide much needed recreational areas for urban residents through the accommodation of streamside trails.

Interest and activity in reforestation and tree planting have greatly increased over the past decade. Most projects involve augmenting or connecting fragmented riparian forest buffers. The ability of riparian forest buffers in urban areas to significantly improve surface water quality is limited because of the volume and velocity of stormwater runoff. However, merging aesthetic and habitat improvement objectives with open space, vacant lot, and parkland management has yielded many excellent examples of riparian forest restoration and natural buffer creation.



Urban Riparian Forest Buffer

The Three-Zone Concept:

A Tool to Guide Forest Buffer Planning

A three-zone system has been developed to help plan riparian forest buffers. This three-zone concept is intended to be flexible in order to achieve both water quality and landowner objectives.

Zone 1

This is the near stream portion of the buffer, stretching upland from the edge of the stream. Its primary purpose is to stabilize the streambank and provide habitat for aquatic organisms. The roots of trees in Zone 1 hold together the soil to resist the erosive force of flowing water. This also keeps sediment, and any nutrients bound to it, out of the stream.

Roots and fallen logs slow stream flow. This not only provides additional protection against erosion, but also creates pools that form unique "microenvironments." Pools support species of macroinvertebrates different from those in riffles only a few feet away. As a result, the presence of trees is directly related to greater biodiversity in the stream ecosystem.

Roots and submerged tree limbs also provide important habitats for macroinvertebrates, supporting even greater densities of the insects than can be found on the rocky stream bottom. This fallen debris also traps leaves, twigs, fruit seeds, and other material in the stream, allowing it to decay and be used by stream-dwelling organisms.

The leafy canopy of the trees provides shade that helps to control water temperature. Maximum summer temperatures in a deforested stream may be 10-20 degrees warmer than in a forested stream. That is significant as temperature changes of only 4-10 degrees usually alter the life-history characteristics of macroinvertebrates that form an important part of the food web.

In addition, shaded streams support algae communities dominated by diatoms — a type of algae favored by many species — throughout the year, while areas getting more direct sunlight are dominated by filamentous algae. This change, at the very bottom of the food web, is critically important. While crayfish and a few insect species will consume filamentous algae, most macroinvertebrate species cannot because they have evolved as specialists for scraping diatoms from the bottom.

While Zone 1 will improve habitat along all streams, its greatest impact will be along smaller streams where the canopy completely covers the water surface, providing maximum control over light and temperature conditions. Trees in Zone 1 will aid in filtering surface runoff and, in some landscapes, can help remove nutrients carried in the groundwater.

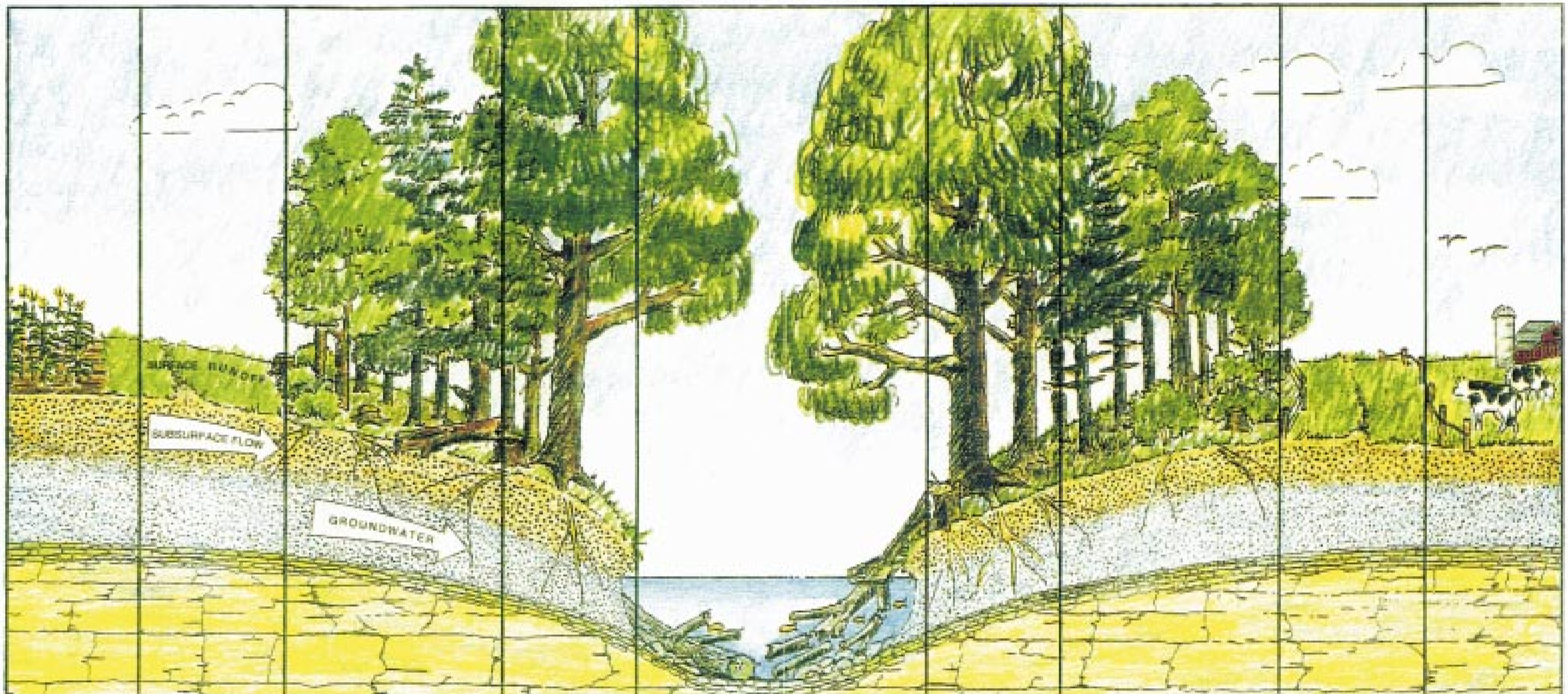
Zone 2

Located immediately upslope from Zone 1, the primary function of Zone 2 is to remove, transform, or store nutrients, sediments and other pollutants flowing over the surface and through the groundwater. Widths of Zone 2 can vary.

In areas where shallow groundwater flows through the root zones of trees, large amounts of nitrate can be removed before the water enters a stream. This results primarily from plant uptake and denitrification in the soils. Nitrate removal in these areas can be high — on the order of 90 percent. In areas where the groundwater flows deeper, much of this benefit will be lost as most of the water bypasses the root zone and enters the stream directly through the sediment.

Regardless of whether shallow groundwater flows through the root zones, all Zone 2 forest buffers will remove surface-borne pollutants. Debris from the trees slows and traps sediments in the runoff, giving the nutrients they carry time to infiltrate into the ground where they may be stored or removed through natural processes.

THE STREAMSIDE FOREST BUFFER



	20'	60'	15'		15'	60'	20'	
CROPLAND	ZONE 3 RUNOFF CONTROL	ZONE 2 MANAGED FOREST	ZONE 1 UNDISTURBED FOREST	STREAMBOTTOM	ZONE 1 UNDISTURBED FOREST	ZONE 2 MANAGED FOREST	ZONE 3 RUNOFF CONTROL	PASTURE
Sediment, fertilizer and pesticides are carefully managed.	Concentrated flows are converted to dispersed flows by water bars or spreaders, facilitating ground contact and infiltration.	Filtration, deposition, plant uptake, anaerobic denitrification and other natural processes remove sediment and nutrients from runoff and subsurface flows.	Maturing trees provide detritus to the stream and help maintain lower water temperature vital to fish habitat.	Debris dams hold detritus for processing by aquatic fauna and provide cover and cooling shade for fish and other stream dwellers.	Tree removal is generally not permitted in this zone.	Periodic harvesting is necessary in Zone 2 to remove nutrients sequestered in tree stems and branches and to maintain nutrient uptake through vigorous tree growth.	Controlled grazing or haying can be permitted in Zone 3 under certain conditions.	Watering facilities and livestock are kept out of the Riparian Zone insofar as practicable.

Studies have found that Zone 2 can remove 50-80 percent of the sediment in runoff from upland fields.

Whether they are pulled from shallow groundwater or infiltrate into the soils from surface runoff, nutrients are removed in Zone 2 through a variety of mechanisms. The most obvious process is plant uptake, as all plants must absorb nutrients to grow. In addition, forests provide large amounts of decaying organic material necessary to fuel the microbial processes in Zone 2 soils that remove nutrients. There are three main ways those processes work:

- Microbes in the soil can take up nutrients and store them until they die, at which time the nutrients are released in a mineralized form that is less biologically available to other organisms and more readily stored in the soil. If managed to foster accumulation of this material, Zone 2 may support significant long-term nutrient storage.
- Denitrification takes place under the proper conditions when certain denitrifying bacteria convert nitrate to nitrogen gases. Denitrification is carried out by anaerobic microbes, organisms which survive in water or soils — usually wetlands — without oxygen. The large amount of decaying organic material on the ground in forested buffers depletes oxygen in the soils, and there is usually enough moisture in riparian areas to support the microbes needed for denitrification. Even drier forest soils commonly have small pockets which support these bacteria. Denitrification rates will vary depending on site conditions.
- Microbes use organic compounds as food and, through various reactions, change them so they are degraded to simpler compounds or synthesized into microbial biomass. Riparian forests appear to support a variety of microbial degradation mechanisms, though the management strategies that would promote them are not understood at this point.

Zone 3

Located immediately upslope of Zone 2, Zone 3 contains grass filter strips or other control measures which help slow runoff, filter sediment and its associated chemicals, and allow water to infiltrate into the ground. Grass filter strips help to protect the wooded areas and set the stage so the forest buffer can perform at its maximum potential. Effective sediment trapping in Zone 2 requires that runoff entering that portion of the buffer be in the form of sheet flow. Zone 3, therefore, acts to spread out the flow and prevent runoff from adjacent land uses from eroding channels into the buffer.

Several studies show that grass filter strips are highly effective at reducing sediment runoff, with removal rates of 50 percent or more. Also, the filter strips are highly effective at removing sediment-bound nutrients such as phosphorus, but less effective at removing dissolved nutrients. Over time, the removal efficiency decreases as grass is smothered by deposited sediment. Generally, the narrower the filter strip, the shorter its effective life. As a result, grass filter strips require periodic maintenance which includes the removal of sediment, reestablishment of vegetation, and removal of channels. In urban areas, infiltration trenches and stormwater control measures may be common in Zone 3.

Additional Definitions

Aquiclude

Impermeable layer, such as a clay bed, that confines an aquifer.

Anadromous species

Organisms that spend part of their life cycle in freshwater and part in saltwater and ascend rivers and streams to breed.

Bankfull depth

The mean water depth that occurs during a bankfull stream flow event.

Bankfull width

The mean water width that occurs during a bankfull stream flow event.

Baseflow

Portions of stream discharge derived from natural sources, such as groundwater and large lakes and swamps situated outside the area of net rainfall that created local surface runoff; the sustained discharge that does not result from direct runoff or from stream regulations, water diversion, or other human activities.

Benthos

Organisms that inhabit the bottom substrate of lakes, ponds, and streams. These organisms are divided into two groups: macrobenthos and microbenthos. The adjective is benthic.

Best management practices

Methods, measures or practices to prevent or reduce water pollution, including but not limited to, structural and nonstructural controls, operation and maintenance procedures, other requirements and scheduling and distribution of activities.

Bioengineering

An applied science that combines structural, biological, and ecological concepts to construct living structures for erosion, sediment, and flood control.

Buffer

An area maintained in permanent vegetation and managed to reduce the impacts of adjacent land use.

Channel stability

The sensitivity of a channel area to disruptions in its physical structure. Under undisturbed conditions, natural channels demonstrate wide variability in withstanding physical disruptions without experiencing changes in their ability to pass streamflow, process sediment, or provide habitat. Stable channels are capable of withstanding an appreciable amount of disruption with little effect on function.

Channelization

The practice of straightening a waterway to remove meanders and increase flow. Sometimes concrete is used to line the sides and bottom of the channel.

Community

An aggregation of living organisms having mutual relationships among themselves and to their environment.

Dendritic

Branched pattern; similar to that of a tree.

Ecosystem

The system formed by the interaction of a community of organisms with their environment.

Ecosystem management

The careful and skillful use of ecological, economic, social, and managerial principles in managing ecosystems to produce, restore, or sustain ecosystem integrity and desired uses, products, and services over the long-term.

Environment

All the biotic and abiotic factors of a site.

Ephemeral stream

A stream or portion of a stream that flows only in direct response to precipitation. It receives little or no water from springs and no long-continued supply from melting snow or other sources. Its channel is at all times above the water table. The term may be arbitrarily restricted to streams which do not flow continuously during periods of one month.

Erosion

The removal of rock debris and soil by wind, moving water, or gravity.

Exotic invasive species

An organism that is out of its naturally occurring range and environment, and occupying the habitat of native species.

Filter strip

A linear strip of land maintained to slow the velocity of runoff and filter sediment.

Flood plain

That portion of a stream valley adjacent to the channel that is built by sediments of the stream and covered with water when the stream overflows its banks at flood stage. Also, the nearly level land situated on either side of a channel that is subject to overflow flooding.

Forest

A descriptive classification of land type predominated by trees and woody vegetation and characterized by high structural diversity, greater than 25 percent canopy shading, and by the significant accumulation of organic duff on the soil surface.

Forest buffer conservation

Retaining and managing existing riparian forests so that they continue to provide the benefits of a forest buffer.

Forest buffer restoration

The re-establishment of a sustainable community of native trees, shrubs, and other vegetation capable of providing multiple buffer functions adjacent to a body of water where forest cover was converted to other uses.

Forest buffer width

A fixed or variable distance measured from the edge of the streambank or shoreline within which the vegetation and land is retained and managed for the purpose of sustaining specific or multiple buffer functions.

Fluvial

Geomorphic processes associated with running water; of, or pertaining to rivers.

Geomorphology

The geologic study of the evolution and configuration of land forms.

Habitat

A place where the physical and biological elements of ecosystems provide a suitable environment and the food, cover, and space resources needed for plant and animal livelihood.

Headwaters

The uppermost reaches of a stream or river.

Hydrologic function

The capacity of a stream to move or to store water, bedload material, and suspended sediment. Stream gradient, the resultant stream power and size of material are critical factors.

Hydrology

The study of the properties, distribution, and effects of water on the earth's surface, soil, and atmosphere.

Infiltration

Movement of surface water into the soil.

Intermittent stream

A defined channel in which surface water is absent during a portion of the year.

Large woody debris

A term used to describe logs, tree boles, rootwads, and limbs that are in, on, or near a stream channel.

Level spreader

A device used to spread out stormwater runoff uniformly over the ground surface as sheet flow. The purpose of level spreaders is to prevent concentrated, erosive flows from occurring and to enhance infiltration.

Limnology

Study of aquatic ecology.

Meander

A circuitous winding or bend in the river.

Native species

A naturally occurring organism that is within its range and normal environment.

Nonpoint source pollution

Pollution that originates from many diffuse sources, such as runoff from roads, fields, or other surfaces.

Nutrient cycling

The path of an element through the ecosystem, including its assimilation by organisms and its release in a reusable inorganic form.

Perennial streams

A defined channel containing surface water throughout an average rainfall year.

Physiographic province

An area of land, less extensive than a region, having a characteristic plant and animal population, landforms, climate, and other processes.

Point source

Originating from a discrete identifiable source or conveyance.

Pool

Deeper areas of a stream with slow-moving water, often used by larger fish for cover.

Riffle

Shallow section of a stream or river with rapid current and a surface broken by gravel, rubble, or boulders.

Riparian

Pertaining to anything connected with or immediately adjacent to the banks of a stream or other body of water.

Riparian area

The area of land adjacent to streams, rivers, and other bodies of water that serves as a transition between aquatic and terrestrial environments and directly affects or is affected by that body of water.

Riparian forest buffer

An area of trees, usually accompanied by shrubs and other vegetation, adjacent to a body of water and managed to maintain the integrity of stream channels and shorelines to 1) reduce the impact of upland sources of pollution by trapping, filtering, and converting sediments, nutrients, and other chemicals, and 2) supply food, cover, and thermal protection to fish and other wildlife.

Riprap

Stones of varying size used to dissipate energy or stabilize a soil surface.

Scour

Local removal of material from a streambed by flowing water.

Sediment

Fragmented material that originated from weathering rocks and decomposing organic material that is transported by, suspended in, and eventually deposited in the streambed.

Shannon Diversity Index

A system of analysis that relates the number of kinds of benthos to the total number of organisms and, in some cases, that number of individuals of each kind. The index is an indicator of water quality: low diversity often indicates water of low quality.

Sheetflow

A flow process associated with water movement on sloping ground surfaces that is not channelized or concentrated.

Stream

A perennial or intermittent watercourse having a defined channel (excluding man-made ditches) which contains flow from surface and groundwater sources during at least 50 percent of an average rainfall year.

Stream corridor conservation

An approach to management that encourages the protection of a stream and a continuous vegetated buffer zone from a stream's headwaters to its mouth and integrates riparian buffers with other needed stream protection and restoration actions.

Stream order

A numerical system (ranking from headwaters to river terminus) used to designate the relative position of a stream or stream segment in a drainage basin.

Streamside management zone (SMZ)

A forested area along a stream or other body of water, varying in width, where timber management practices that might affect water quality or aquatic resources are modified.

Streambank

The portion of the channel cross-section that restricts lateral movement of water at normal water levels.

Swale

A natural depression or wide shallow ditch used to temporarily store, route, or filter runoff.

Unconstrained channel stream

Not confined to an entrenched or well defined channel.

Vegetated filter strip

An area maintained in permanent vegetation, such as grass, shrubs, or trees and designed to capture and filter runoff and sediment from surrounding land uses.

Watershed

1) An area of land that drains into a particular river or body of water; usually divided by topography.
2) The total area of land above a given point on a waterway that contributes surface runoff water to the flow at that point; a drainage basin or a major subdivision of a drainage basin.

Watershed-based planning

An approach to resource, land use, and development planning that utilizes natural watersheds instead of geopolitical boundaries in order to sustain natural stream functions while accommodating a reasonable level of land development.

Wetland

An area of land that has a predominance of hydric soils and is inundated or saturated with water at a frequency and duration sufficient to support a prevalence of vegetation typically adapted to saturated soil conditions. Usually found in depressions, adjacent to bodies of water, or along flood plains or coastal waters.

Zoning

The practice of dividing land into regions or parcels pertaining to its use or activities within it.

References

American Fisheries Society. 1985. Stream obstruction removal guidelines. AFS, Grosvenor Lane, Bethesda, MD.

Belt, G.H., J. O'Laughlin, and T. Merrill. 1992. Design of forest riparian buffer strips for the protection of water quality: Analysis of Scientific Literature. University of Idaho, Report No. 8, Moscow, ID.

Cooksey, R.A. and A.H. Todd. 1996. Conserving the forests of the Chesapeake: the status, trends, and importance of forests for the Bay's sustainable future. NA-TP-03-96. USDA Forest Service, Northeastern Area, State and Private Forestry, Radnor, PA.

Hunter, Jr., M. 1990. Wildlife, forests, and forestry: principles for managing for biological diversity. Prentice-Hall, Inc.

Karr, J.R. and I.J. Schlosser. 1978. Water resources and the land-water interface. Science 201:229-234.

Lowrance, R., R. Leonard, and J. Sheridan. 1985. Managing riparian ecosystems to control nonpoint pollution. J. Soil and Water Conservation, 40(1):87-91.

USDA Forest Service. 1988. Management of riparian resources within forested landscapes. Riparian Management Guide, Williamette National Forest, Pacific Northwest Region, Portland, OR.

Welsch, D.J. 1991. Riparian forest buffers: function and design for protection and enhancement of water resources. NA-PR-07-91. USDA Forest Service, Northeastern Area, State and Private Forestry, Forest Resources Management, Radnor, PA.

Section II

Physiographic and Hydro-Physiographic Provinces

Physiographic and Hydro-Physiographic Provinces

Introduction

This section contains the biophysical descriptions of the physiographic provinces as depicted from the USDA Forest Service national eco-mapping project. The basis for the section is the document "Ecological Subregions of the United States: Section Descriptions." The section introduces the physiographic provinces by discussing similarities and differences in their geologic (see Table 2-1), climatic, vegetative, faunal, and resource attributes. Table 2-2 shows how these physiographic provinces are oriented in relation to the Chesapeake Bay.

The section further defines these regions in terms of hydrology and the potential function of riparian forest buffers.

Table 2 - 1
Table of Ages
(modified from several recent sources)

Period	Duration*	Began**	Ended**
Quaternary	2.5	2.5	
Tertiary	63.5	66	2.5
Cretaceous	69	135	66
Jurassic	50	185	135
Triassic	40	225	185
Permian	45	270	225
Pennsylvanian	45	315	270
Mississippian	30	345	315
Devonian	60	405	345
Silurian	25	430	405
Ordovician	70	500	430
Cambrian	100	600	500
Ante-Cambrian	400	1,000	600
First evidences of life known		3,200	

*Millions of years **Millions of years ago

Source: Cardwell, D.H. Geologic History of West Virginia.

Table 2-2
Summary of the Biophysical Descriptions of the Physiographic Provinces

Physiographic Provinces	*Land Surface Form Geomorphology Elevation*	*Lithology and Stratigraphy*	*Soil Taxa*	*Climate*	*Surface Water Characteristics*	*Vegetation*	*Land Use and Disturbance*
Northern Glaciated Allegheny Plateau	Dissected plateau, glacial features, mast wasting, fluvial erosion, transport & deposition, karst solution; 650 to 1,970 feet	Pleistocene till and stratified drift; Devonian sandstone, siltstone, and shale	Fragiaquepts, Fragiochrepts, Dystrochrepts; utic, aquic; mesic	Prcp: 30-50 in. Temp: 46-50° F G.s.: 100-160 d	Perennial streams, small lakes; high gradient, bedrock controlled; some marsh/swamps; dendritic pattern	Northern hardwoods and Appalachian oak forests; hardwood/pine	Agricultural and forestry; insect & disease, droughts
Northern Ridge and Valley	Parallel, folded, faulted valleys & ridges; mast wasting , karst solution, fluvial erosion, transport & deposition; trellis & some dendritic; 300 to 4,000 feet	Residuum, colluvium & alluvium; Ordovician & Silurian in PA section; shale, siltstone, chert, limestone, coal	Utisols, Alfisols, Inceptisols; Ochrepts & Udults; mesic; utic	Prcp: 30-45 in. Temp: 39-57º F G.s.: 120-180 d	Streams regulated by seasons; trellis pattern, dendritic in Blue Ridge; wetlands scarce	Appalachian oak, oak-hickory-pine; some northern hardwoods	Farming, grazing, timber, recreation; insects
Northern Appalachian Piedmont	Dissected peneplain, broad structural basin, hilly & rolling; dendritic drainage; fluvial erosion, transport & deposition; sea level-1,000 ft.	Residuum, colluvium & alluvium; shale, sandstone, conglomerates, basalt, diabase sills, mixed metamorphics	Udults, Udalfs, Ochrepts; Dystrochrepts & Fluvaquents on flood plains; mesic; udic	Prcp: 39-47 in. Temp: 40-55 º F G.s.: 160-250 d	Dendritic drainage; natural lakes rare; few bogs, swamps; salt marshes close to Bay area; tidal effects	Appalachian oaks, sugar maple-mixed hardwoods, hemlock-mixed hardwoods; red maple in wet bottoms	Farming, urban, industrial, forestry; insects
Southern Appalachian Piedmont	Dissected & irregular plains; differential erosion, mass-wasting, fluvial erosion, transport & deposition; 330-1,300 feet	Metamorphic complexes, volcanics, marine deposits	Udults, mixtures of moist soils; thermic	Prcp: 45-55 in. Temp: 58-60º F G.s.: 205-235 d	Numerous lakes, marshes & swamps; streams sluggish; perennial streams and rivers; low flow rates	Oak-hickory, oak-hickory-pine; loblolly pine	Agriculture, development; droughts, rare hurricanes, insects
Middle Atlantic Coastal Plain	Sloping, flat plains; weakly dissected alluvial fan; fluvial deposition sea level - 80 feet	Marine deposits	Udults, hydraquents in tidal marshes; mesic; utic	Prcp: 46 in. Temp: 55-57 º F G.s. 185-220 d	Streams & rivers sluggish; marshes, swamps, lakes; small-medium perennial streams; high water tables; poorly defined drainage	Gum, cypress swamps; oak-hickory-pine	Agriculture, development; rare hurricanes

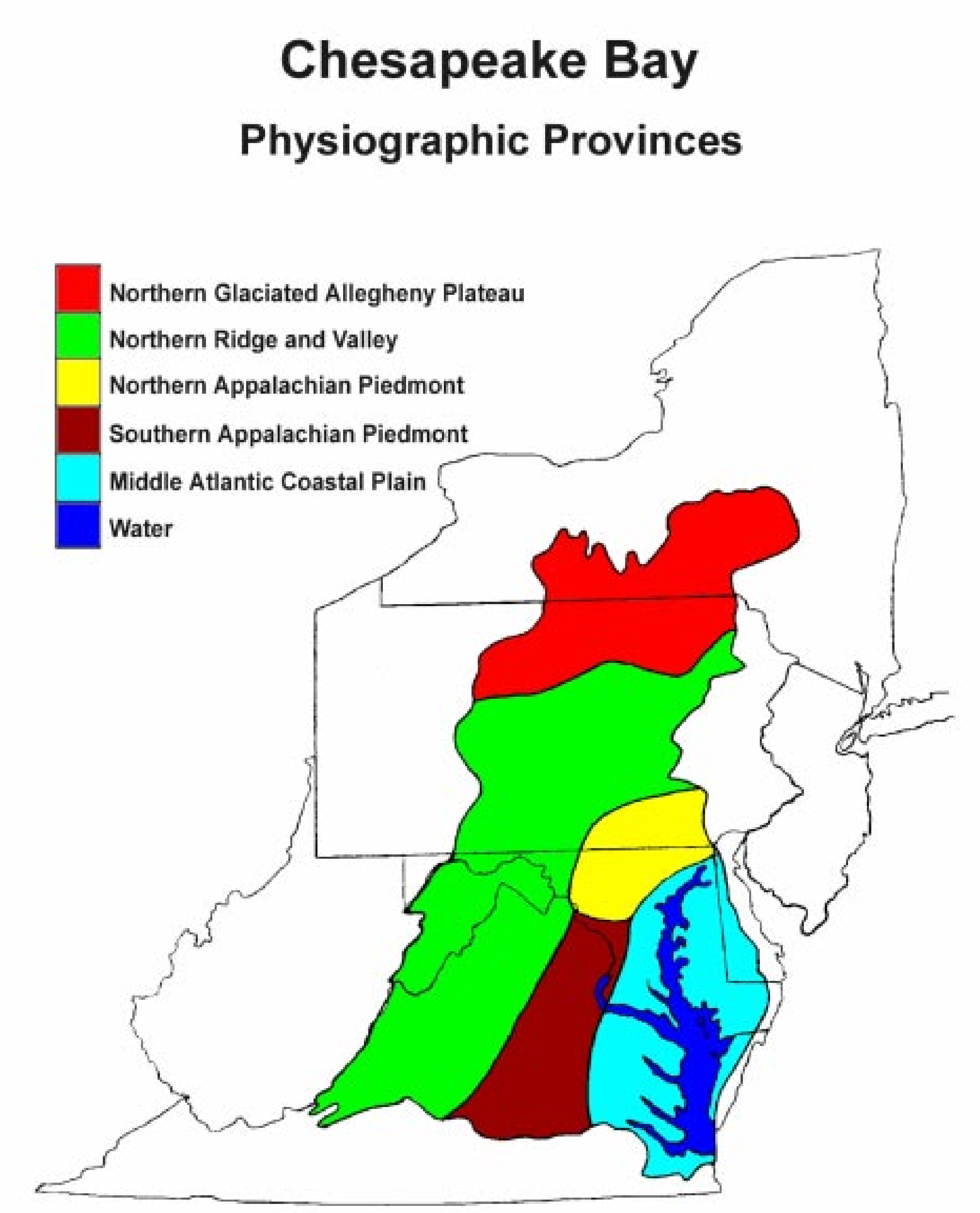


Figure 2 - 1. Chesapeake Bay Physiographic Provinces. (Source: USDA Forest Service, 1997)

Northern Glaciated Allegheny Plateau

- **Land-Surface Form and Geomorphology -** Most of this area consists of a dissected plateau of moderate relief, but rolling hills occur in many places. Its northern boundary is the Erie and Ontario Lake Plain, and its southern is the Ridge and Valley Province. Lakes, poorly-drained depressions, morainic hills, drumlins, kettles, eskers, outwash plains, scour, and other glacial features are typical of the area, which was entirely covered by glaciers during parts of the Pleistocene. Mass-wasting, karst solution, fluvial erosion, and transport and deposition are the primary operating geomorphic processes. Elevations range from 650 to 1,970 feet.

- **Lithology and Stratigraphy -** Most of the area is covered by a thin, stony Pleistocene till and stratified drift. On top of the plateau, beneath the drift, bedrock is mostly Devonian sandstone, siltstone, and shale. Silurian conglomerate holds up a prominent escarpment in the southeast corner of the province. In the central region, bedrock had been broadly folded into a series of gentle, sub-parallel, east-west trending anticlines and synclines.

- **Soil Taxa -** Soils are mainly Fragiaquepts, Fragiochrepts, and Dystrochrepts with utic and aquic moisture regimes, and mesic temperatures dominate. Soils are derived from glacial materials left by the Wisconsin Glacier when it retreated about 12,000 to 15,000 years ago. Alluvial and organic materials are of recent origin and are still being deposited.

- **Climate -** Winters are moderately long and severe, but more than 120 days have temperatures above 50° F. Snow usually stays on the ground all winter; snowfall averages from 60 to 80 inches. The growing season is considered short, lasting 100 to 160 days, and the frost-free season lasts from 100 to 140 days. Average annual rainfall is moderate, ranging from 30 to 50 inches.

- **Surface Water Characteristics -** Perennial streams and small lakes provide an abundance of water. The area is characterized by deeply incised high gradient and bedrock-controlled streams in the uplands, and low and moderate gradient, mature streams in the valleys. Swamps and marshes occupy poorly-drained uplands and valleys. The drainage pattern is dendritic. Numerous waterfalls and rapids exist where streams cross beds of resistant rock. Runoff values are lowest in the center of the Allegheny Plateau and increase both east and west. Highest runoff occurs in the spring; lowest runoff occurs in the summer and fall. Major rivers include the Susquehanna, Chenango, and Chemung.

- **Vegetation -** This province lies between the boreal forest and the broadleaf deciduous forest zones, so it is transitional. Part of it consists of mixed stands of a few coniferous species, mainly pine, and a few deciduous species such as yellow birch, sugar maple, and American beech. The rest of the area is a macromosiac of pure deciduous forests in favorable habitats with good soils and pure coniferous forests in less favorable habitats with poor soils. Mixed stands may have several species of conifer and eastern hemlock. Eastern white cedar is found in the southeast part of the province. Küchler vegetation types include northern hardwoods and Appalachian oak forests. Regionally defined important vegetation types include Appalachian oak-hickory forests, Appalachian oak-pine forests, beech-maple mesic forests, and hemlock-northern hardwood forests.

- **Fauna -** White-tailed deer is the most common large mammal. Smaller mammals include beaver, red and gray fox, raccoon, skunk, gray squirrel, coyotes, mink, and muskrat. The most common game birds are wild turkey, ruffed grouse, woodcock, and other waterfowl. Other birds include raptors, cavity nesters, and songbirds. Historically this area was habitat for peregrine falcon. No federally listed threatened or endangered species are unique to the area.

- **Disturbance Regimes -** Fire was historically important to maintain the oak-dominated communities in the central part of the plateau and the western and southern slopes of the region. Insect and disease disturbances that dominate the area include chestnut blight, beech bark disease, sugar maple borer, and ongoing ash dieback. Occasional droughts have occurred in the central part of the region.

- **Land Use -** Most of the area is agricultural land; second and third growth forests occupy the ridgetops and steeper slopes. The main form of recreation is hunting, although camping, fishing, and hiking are also popular.

Northern Ridge And Valley

- **Land-Surface Form and Geomorphology -** This province is characterized by a series of parallel, southwest to northeast trending, narrow valleys and mountain ranges created by differential erosion of tightly folded, intensely faulted bedrock. The eastern boundary is the Great Valley low land; the western boundary is the steep, high ridge Allegheny Front. Drainage is structurally controlled, dominantly trellis with some dendritic patterns. Mass-wasting, karst solution, and fluvial erosion, transport, and deposition are the dominant geomorphic processes. A notable but minor landform are lands that have been strip-mined. Elevations range from 300 to 4,000 feet.

  One of the major features of the Ridge and Valley is the Great Valley and Blue Ridge Mountains. The Great Valley is part of the Ridge and Valley, whereas, the Blue Ridge itself is a physiographic province. But it is so similar to the Ridge and Valley that it has been lumped in with it. Major differences in the two provinces will be noted throughout this section. The northern part of the Blue Ridge (north of Roanoke Gap in Virginia) is characterized by a single, broad ridge that extends into southern Pennsylvania. Drainage is structurally controlled; it is dominantly trellis in the north and dendritic in the south. Landforms on about 80 percent of the area are low mountains, with elevations ranging from 1,000 to 3,000 feet.

- **Lithology and Stratigraphy -** Unconsolidated materials overlie most bedrock; residuum on flats and gently sloping uplands, colluvium on slopes, and alluvium in valley bottoms. Shale, siltstone, sandstone, chert, and carbonates form the bedrock. Ordovician and Silurian rock dominate the northern Pennsylvanian extension of the province. Some Devonian, Mississippian, and Pennsylvanian rock (including coal) are exposed in the larger synclines, and Cambrian limestone is exposed in a few anticlines.

- **Soil Taxa -** Soils are mostly Utisols, Alfisols, and Inceptisols, with mesic temperature regimes and mostly utic moisture regimes. They are derived from heavily weathered shale, siltstone, sandstone residuum and colluvium, cherty limestone, and limestone residuum. The Blue Ridge soils are dominated by Ochrepts and Udults. Soils are generally moderately-deep and medium-textured. Boulders and bedrock outcrops are common.

- **Climate -** The climate is temperate, with distinct summer and winter seasons, and all areas are subject to frost. Mean annual temperature is approximately 39 to 57° F. The average length of the frost-free period is about 100 days in the northern mountains. Mean annual precipitation is generally 30 to 45 inches in the valleys and up to 80 inches on the highest peaks. Precipitation is fairly well distributed throughout the year. Snowfall is more than 24 inches in Pennsylvania, increasing southward along the mountains to about 30 inches in the Great Smoky Mountains. In the transition to the Allegheny Plateau, rainfall may range as high as 60 inches. Approximately 20 percent of the precipitation falls as snow. At elevations above 3,500 feet, 30 percent falls as snow. The growing season ranges from 120 to 180 days, extending to 220 days on the

Blue Ridge. Southeast and south-facing slopes are notably warmer and drier than the northwest and north-facing slopes, because they face the sun and are on the lee side of the ridges. One result is that forest fires are more frequent on the south-facing slopes.

- **Surface Water Characteristics -** Streams are most active in the spring. Many smaller streams dry up in the summer and are not recharged until October and November. Stream patterns are trellis-shaped, reflecting the regular folding of the geomorphology. Streams are generally more alkaline and productive than in the Allegheny Mountains. Wetlands are scarce. In the Blue Ridge Mountains, there is a high density of small- to medium-sized streams and associated rivers. Some streams in mountainous areas in zones of high rainfall are characterized by high flow rates and velocities. A dendritic drainage pattern has developed on deeply dissected surfaces, with some control from the underlying bedrock. Isolated areas in some locations are wet all year as a result of seeps. Major rivers include the Susquehanna, Juniata, Shenandoah, and Potomac.

- **Vegetation -** Because much of the area lies in the rainshadow of the Allegheny Mountains, vegetation reflects drier conditions. Küchler types are mapped as Appalachian oak forests, oak-hickory-pine forests, and some northern hardwoods. Red and white oaks occur on more productive, mesic sites. Eastern white pine can occur with white oak on lower portions of slopes. On the driest sites, oaks are mixed with pitch, table mountain, or Virginia pine. Other regionally important species include hickories, yellow-poplar, maples, and associated upland hardwoods.

- **Fauna -** White-tailed deer are dominant and have an impact on understory flora. The black bear is the sole representative of large carnivores. Smaller mammals include squirrels, fox, weasels, and bats. The endangered Indiana bat and Virginia big-eared bat are associated with karst areas. Bird species are diverse and include both residents and neotropicals. Game birds include ruffed grouse and wild turkey. The Blue Ridge supports the largest diversity of salamanders in North America. Most endemic species occur in the central and southern sections of the Blue Ridge where topographic relief is greater and ridges isolated.

- **Disturbance Regimes -** Fire was used extensively by Native Americans. Major historical disturbance includes grazing from about 1780 onward and logging from 1880 to 1920. Gypsy moth is affecting Virginia, Pennsylvania, Maryland, and West Virginia.

- **Land Use -** Farming, grazing, and hay production are common on river flood plains and on limestone areas in the northern part of the province. Timber production is important in forested areas. The area also receives some recreation pressure for fishing, hiking, hunting, and camping. Canoeing and climbing occur in certain areas.

Northern Appalachian Piedmont

- **Land-Surface Form and Geomorphology -** This province includes topography of a diverse nature. The northern limits that stretch to southern Maine have been glaciated, and west of the Ridge and Valley Province is the Appalachian Plateau. The section discussed here is the Piedmont Plateau and coastal plain, where altitudes range from sea level to about 1,000 feet. Most of the area is a maturely dissected peneplain sloping gently toward the Atlantic coast. It is hilly to rolling terrain, with a few high ridges. The area is crossed southwest to northeast by a broad structural basin forming a lowland plain. An extension of the plain forms northern New Jersey, Long Island, and Connecticut. Drainage is dendritic; fluvial erosion, transport and deposition, and mass-wasting are the primary geomorphic processes operating.

- **Lithology and Stratigraphy -** Bedrock is overlain by residuum on the ridges and hill tops, colluvium on the slopes, and alluvial materials in the valleys. The youngest bedrock in the area occupies the structural basin: Triassic and Jurassic conglomerates; sandstones and shales; basalt flows and diabase sills; and mixed metamorphics of marble, slate, quartzite, schist, and gneiss of the Protozoic to Paleozoic age.

- **Soil Taxa -** Soils include Udults, Udalfs, and Ochrepts. These were derived by Triassic sandstone, shale, and conglomerate. The sedimentary rocks contain numerous dikes and sills of diabase and basalt. Other local areas are underlaid by limestone. The dominant moisture regime is udic. The temperature regime is mesic. Soils are dominantly well-drained and range from moderately-deep to deep. Dominant soils on the flood plains are Dystrochrepts and Fluvaquents.

- **Climate -** The continental climate regime here ensures a strong annual temperature cycle, with cold winters and warm summers. Precipitation averages between 39 to 47 inches. It falls mainly in the spring and early summer. Snowfall ranges from 27 to 40 inches. Temperature ranges from 40 to 55° F. The growing season lasts for 160 to 250 days.

- **Surface Water Characteristics -** The area is characterized by a mature, dendritic drainage network. Natural lakes are rare to nonexistent, except in the northeastern extremity, which was covered by glaciation. Small impoundments are common along upper reaches of streams. A few bogs, swamps, and salt marshes occur in areas adjacent to the Atlantic Ocean and the Chesapeake Bay. The lower extremities of some of the major streams are affected by tides. There is ample water for farm, urban, and industrial uses, however, urban development is affecting water yields. Good groundwater recharge areas are being impacted by encroaching development. Susquehanna is a major river.

- **Vegetation -** The province is dominated by a temperate deciduous forest. Prior to European settlement in the early 17^{th} century, the native vegetation consisted mainly of oak and hickory. Currently, Appalachian oak forests (Küchler) and sugar maple-mixed hardwoods, hemlock-mixed hardwoods, and oak-chestnut (Braun) dominate. Red maple is dominant on the wet bottomlands.

- **Fauna -** Relatively fertile soils result in very diverse habitats. Large areas of the original forested wildlife habitat have been altered or eliminated as a result of intensive agricultural and residential development. Examples of openland wildlife include birds, rabbits, red fox, and woodchuck. Among the mammals and birds that prefer forestlands are ruffed grouse, woodcock, various thrushes, squirrels, white-tailed deer, gray fox, and raccoon. Ducks, herons, geese, shore birds, mink, and muskrats are found in ponds, marshes, and swamps. No federally listed threatened or endangered species are unique to this area.

- **Disturbance Regimes** - Historically, fire was a significant natural disturbance. Gypsy moth and chestnut blight have had effects on vegetation.

- **Land Use** - Farms, woodlands, and industrial and urban development are the current land uses.

Southern Appalachian Piedmont

- **Land-Surface Form and Geomorphology -** This province comprises the Piedmont where 50 to 80 percent of the area slopes gently. The area consists of an intensely metamorphosed, moderately dissected plain. It consists of thick saprolite, continental sediments, and accreted terraces**.** Differential erosion has produced some isolated mountains (monadnocks) that rise above the general land surface. Landforms on about 70 percent of the area are irregular plains. Landforms on the remaining area are about equally divided among plains with high hills, open low hills, and tablelands of moderate relief. A major feature of the outer boundary is the Fall Line, which indicates the prevalence of falls and rapids in the area (Fenneman).

Mass-wasting, fluvial erosion, and transport and deposition are the dominant operating geomorphic processes. Elevation ranges from 330 to 1,300 feet.

- **Lithology and Stratigraphy** - Rock units formed during the Precambrian, Paleozoic, and Mesozoic Eras. Precambrian strata consist of metamorphic complexes with compositions of schist and phylite and mafic paragneiss. Paleozoic strata consist of about equal amounts of Cambrian eugosynclinal and volcanic rocks. Mesozoic strata consist of Triassic marine deposits of sandstone, siltstone, and shale.

- **Soil Taxa -** Udults are the predominant soils. Paleudults and Hapludults are on gently sloping uplands. Steeper slopes are dominated by Hapludults, Rhodudults, Dystrochrepts, and Hapludalfs. Dystrochrepts, Udifluvents, and Fluvaquests are on alluvium. Soils have a thermic temperature regime, and kaolinitic, mixed, or oxidic mineralogy. Soils are generally deep, with a clayey or loamy subsoil. In many areas, soils are severely eroded as a result of past agricultural practices.

- **Climate** - The climate is usually uniform throughout the region. Mild winters and hot, humid summers are the rule. Average annual temperature ranges from 58 to 64º F. Precipitation, which ranges from 45 to 55 inches, is evenly distributed throughout the year. Precipitation exceeds evapotranspiration, but summer droughts occur. Growing season lasts from 205 to 235 days.

- **Surface Water Characteristics** - There is a moderate density of small- to medium-size perennial streams and associated rivers; most have low to moderate rates of flow and moderate velocity. Marshes, lakes, and swamps are numerous. A dendritic drainage pattern has developed on moderately dissected surfaces, with some influence from the underlying bedrock. All streams are relatively swift in crossing the denuded edge of the older, steeper peneplain. Some have pronounced rapids and falls, also called the “Fall Line.” Major rivers in the area include the Potomac, Rappahannock, Appomattox, and James.

- **Vegetation** - The climax vegetation of the area consists of broad-leaved deciduous and needle-leaf evergreen trees. At least 50 percent of the stands are made up of loblolly, shortleaf, and other southern pines. Common associates include oak, hickory, sweetgum, black gum, and red maple. Küchler mapped vegetation as oak-hickory-pine forests and oak-hickory forests. The oak-hickory forest type consist of white, post, and southern red oaks and pignut and mockernut hickories. The loblolly-shortleaf combination is common on disturbed areas.

- **Fauna** - White-tailed deer, black bear, bobcat, gray fox, cottontail rabbit, and squirrels are among the common mammals found in this area. Wild turkey, bobwhite quail, and mourning dove are the common game bird species. Numerous songbirds and herpetofauna are also found.

- **Disturbance Regimes** - Fire has been the principle historic disturbance. Agriculture and development are the current major disturbances. Climatic disturbances include occasional summer drought, winter ice storms, and infrequent tornadoes and hurricanes. Insect-related disturbances are caused by the Southern pine beetle.

- **Land Use** - Natural vegetation has been cleared for agriculture in most of the area.

Middle Atlantic Coastal Plain

- **Land-Surface Form and Geomorphology -** The province comprises the flat and irregular Atlantic Coastal Plain down to the sea. Well over 50 percent of the area is gently sloping, flat plains. Much of the other landforms are irregular plains. Elevation ranges from 0 to 80 feet. The predominant land form is a flat, weakly dissected alluvial plain formed by deposition of continental sediments onto a submerged, shallow continental shelf. Later, it was exposed by sea level subsidence**.** Along the coast, fluvial deposition and shore zone processes are active in developing and maintaining beaches, swamps, and mud flats. One prominent feature is the Fall Line, which is the inner edge of the province.

- **Lithology and Stratigraphy -** Rocks in this province were formed during the Cenozoic Era. Strata consist of Quarternary marine deposits (shales and sands). Small areas of Tertiary marine deposits (silts and clays) are exposed along some large rivers.

- **Soil Taxa -** Soils consist of Udults. Hapludults are common in areas with and without loess. Quartzipsamments are on the high ridges. Hydraquents are in the tidal marshes of the Chesapeake Bay. These soils are deep and have inadequate to excessive moisture contents. Their temperature regime is mesic and moisture regime utic. These soils are deep, adequately drained, and have adequate moisture supply for use by vegetation during the growing season.

- **Climate -** The climate regime has a small to moderate annual temperature range; average annual temperature is 55 to 57° F. Rainfall is usually abundant and evenly distributed throughout the year; precipitation averages 46 inches. The growing season lasts 185 to 220 days.

- **Surface Water Characteristics -** The area has a moderate density of small- to medium-sized perennial streams. There is also a low density of associated rivers, most with a moderate volume of water, flowing at very low velocity. Water table is high in many areas, resulting in poor natural drainage and abundance of wetlands. A poorly defined drainage pattern has developed on this relatively young plain. There are numerous palustrine systems having seasonally high water levels, especially in pocosin areas. Major rivers in this area include the James, Patuxent, and Potomac.

- **Vegetation -** Along the Atlantic coast, the extensive marshes and interior swamps are dominated by gum and cypress. Most upland areas are covered by subclimax pine forests. Küchler classified most vegetation as oak-hickory-pine forests and southern flood plain forests. The predominant vegetation form is needle-leafed evergreen forests and deciduous broad-leafed forests. The main forest cover type is loblolly pine-hardwood. Hardwood species are sweetgum, water oak, white ash, yellow-poplar, red maple, and swamp hickory. On bottomland areas along major rivers, species include green ash, sugarberry, water oak, American sycamore, sweetgum, and American elm.

- **Fauna -** Fauna include white-tailed deer and numerous other mammals. Wild turkey, bobwhite quail, and mourning dove are the common game birds. Both saltwater and freshwater birds, such as herons, egrets, ducks, geese, and cormorants, are present. There are numerous herpetofauna, songbirds, and amphibians.

- **Disturbance Regimes -** Present disturbances include development and agriculture. Climatic disturbances include infrequent hurricanes.

- **Land Use -** Natural vegetation has been cleared for agriculture on about 65 percent of the area. Other areas are in rapid development.

Hydro-Physiographic Response

The following map, diagrams, and tables provide an interpretation of hydrology and potential level of water quality function expected for riparian forest buffers when used in these provinces.

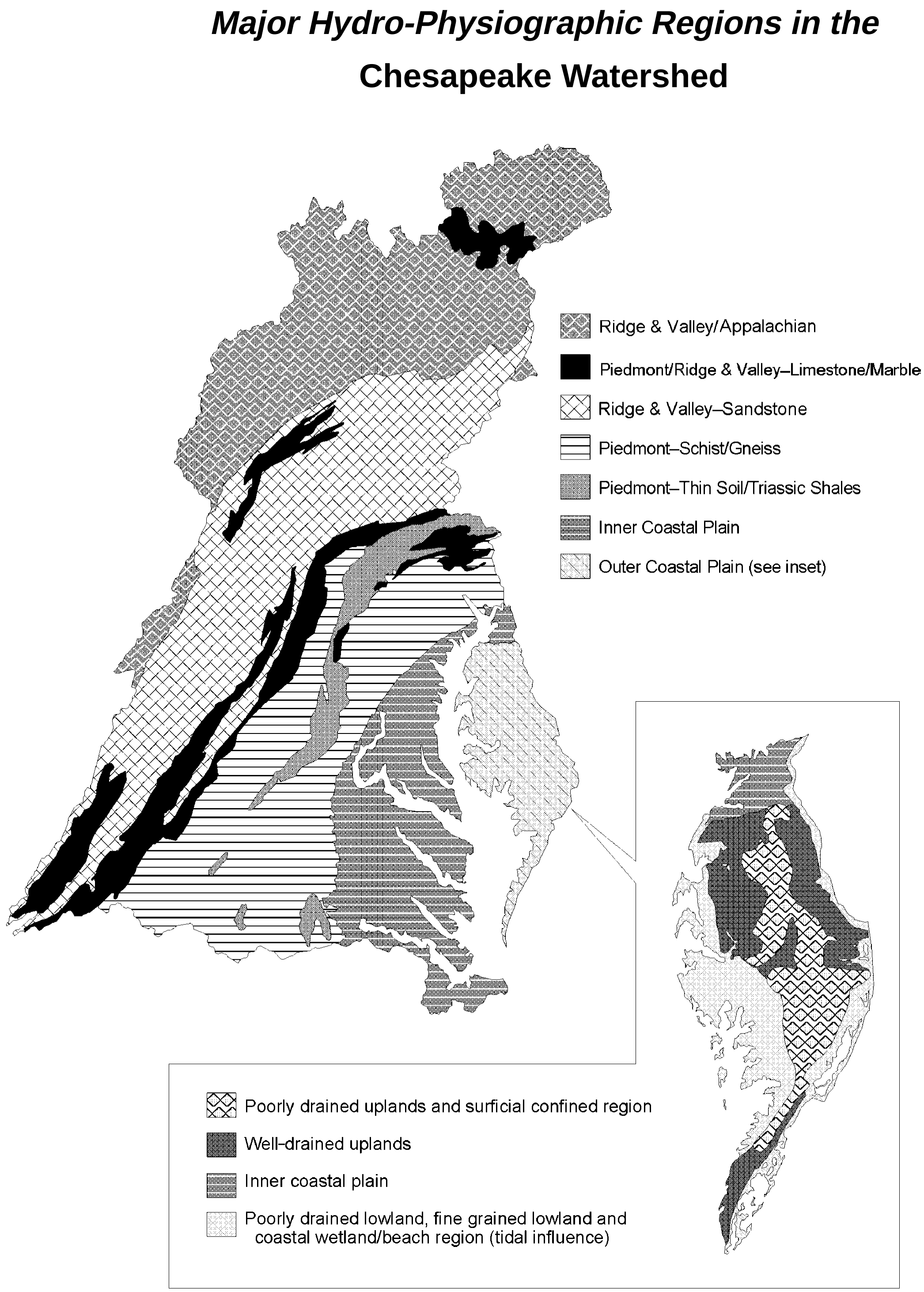
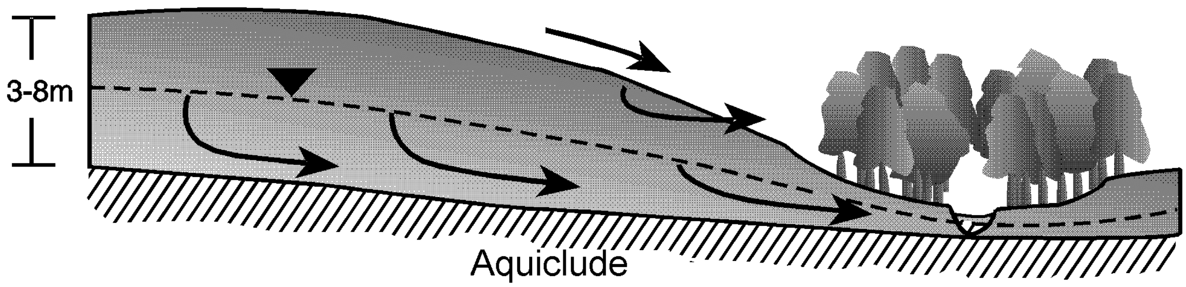


Figure 2 - 2. Major Hydro-Physiographic Regions in the Chesapeake Watershed. (Source: Alliance for the Chesapeake Bay, 1996)

Inner Coastal Plain

INNER COASTAL PLAIN FLOW SYSTEM



Water Quality Function	Expected Level	Critical Constraints	Restoration/ Enhancement
Removal of nitrate from groundwater	High, most water moves in or near root zone.	Bypass due to artificial subsurface drains. Organics in Zone 2.	Important on all streams. Rapid restoration of denitrification function. Ground cover in Zone 3.
Removal of sediment and sediment-borne pollutants	High/Medium	Convert concentrated flow to sheet flow.	Restore in all areas. Enhance existing forest with Zone 3 spreaders.
Removal of dissolved phosphorus	Medium/Low	Control of dissolved P in surface runoff and groundwater is limited.	Restore in areas with major P load in surface runoff. Enhance existing forest with Zone 3.

Riparian Forest Buffers:
% Reduction of Nutrients and Sediment*

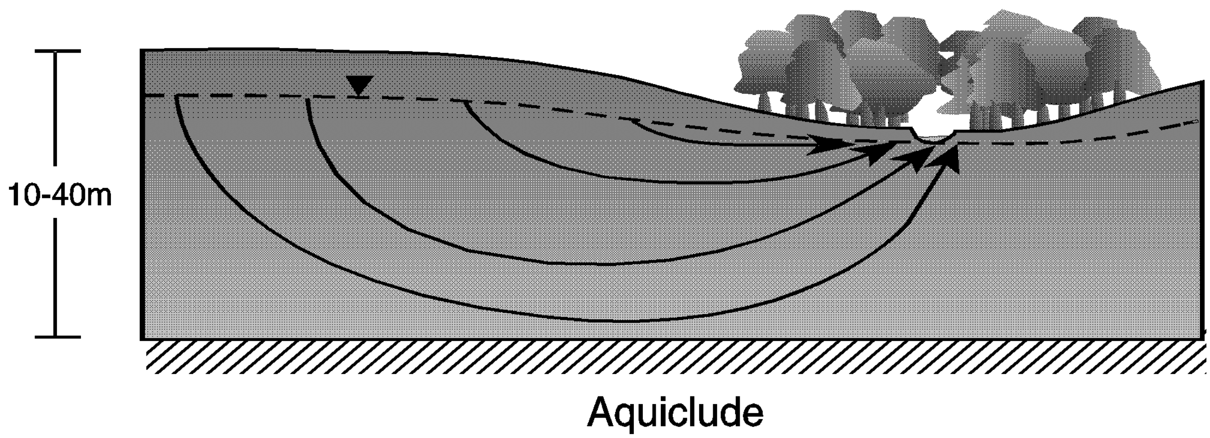
Level	Sediment	Nitrogen	Phosphorus
High	85-95	68-92	70-81
Medium	65-85	45-68	50-70
Low	40-65	15-45	24-50

* General approximations for 100-foot forest buffer system. Actual levels will vary by land use and site conditions. Based on loadings from agricultural lands, performance in field studies rated as high removed total N in the range of 23-66 pounds/acre/year and total P in the range of 1-3 pounds/acre/year from adjacent fields. Expected level of function is based on mature forest in Zones 1 and 2.

Of all the physiographic regions, the inner coastal plain probably represents the maximum potential for nonpoint source control in riparian forest buffer systems. Most excess rainfall enters streams through subsurface runoff or shallow groundwater and therefore moves in or near the forest buffer root zone where nutrient removal is very high. Forest buffers will be very effective in controlling most particulate surface runoff as well, though dissolved phosphorus removal takes place at a lower rate. Because this region is often flat, many agricultural areas have drainage systems. For forest buffers to be effective, those systems must be modified to encourage flow through the buffer.

Outer Coastal Plain

OUTER COASTAL PLAIN FLOW SYSTEM
Well-Drained Upland

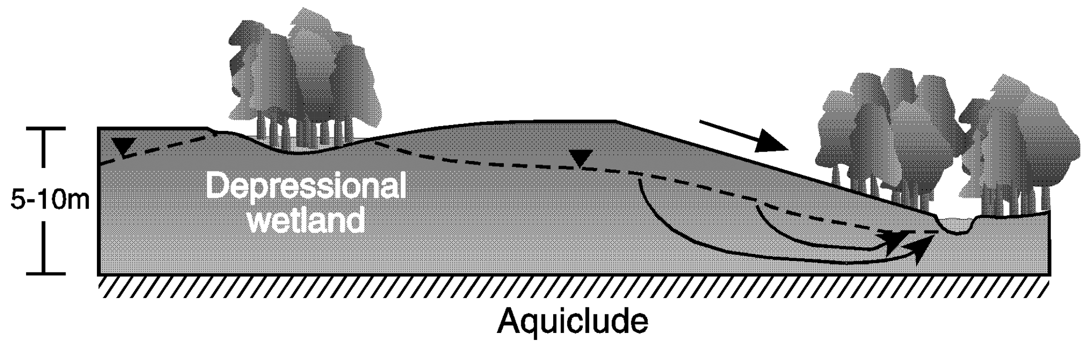


Water Quality Function	Expected Level	Critical Constraints	Restoration/ Enhancement
Removal of nitrate from groundwater	Low, primarily removal from shorter flow paths.	Bypass flow due to deeper aquifers. Long flow paths surface in stream channels.	Concentration on headwater areas. Zone 1 important for nitrate removal.
Removal of sediment and sediment-borne pollutants	High/Medium	Concentrated flow must be converted to sheet flow.	On larger streams, focus on filtering eroded sediment. Enhance functions of Zones 2 & 3.
Removal of dissolved phosphorus	Medium/Low	Dissolved P control is limited. Focus on P load in surface runoff.	Increase vegetation uptake and accretion. Enhance existing forest and grass strips.

Well drained upland: Aside from lands immediately adjacent to streams, excess rainfall sinks farther into the ground and therefore enters the streams through their bottoms, never coming into contact with the root zone. As a result, there is little nitrate removal from groundwater. In this area, Zone 1 vegetation is particularly important because trees immediately adjacent to small streams offer the most potential for root systems to intercept the deeper groundwater before entering small streams. Management actions in this area might include the selection of trees that would have roots most likely to make that connection. If the roots can reach the groundwater, nitrate removal could be about as effective as buffer systems in other landscapes. Regardless of the groundwater situation, buffer systems in this area would still provide sediment control capacity similar to the Inner Coastal Plain. Because of the lower water tables, well-drained uplands may have more capacity to store dissolved chemicals in groundwater.

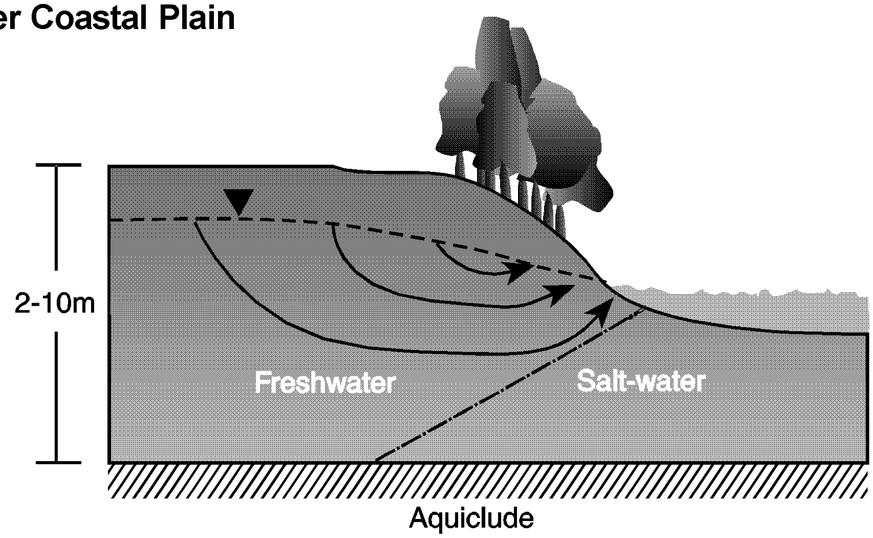
Poorly drained upland/surficial confined: Groundwater is slightly higher here than in the well-drained upland, but lower than the inner coastal plain. As a result, the effectiveness of nitrate removal from the groundwater is between those two extremes.

OUTER COASTAL PLAIN FLOW SYSTEM
Poorly Drained Upland/Surficial Confined



Water Quality Function	Expected Level	Critical Constraints	Restoration/ Enhancement
Removal of nitrate from groundwater	Medium/High	Lower loadings. Lower rates of removal in head water areas.	Restore first in headwaters, then larger streams. Rapid restoration of denitrification function.
Removal of sediment and sediment-borne pollutants	High/Medium	Less surface runoff, but similiar efficiencies as in other CP systems.	Enhance vegetation in broad existing areas. Restore in headwaters.
Removal of dissolved phosphorus	Medium/Low	Dissolved P control is limited. Focus on P load in surface runoff.	Increase vegetation uptake and accretion. Enhance existing forest and grass strips.

TIDAL FLOW SYSTEM
Outer Coastal Plain



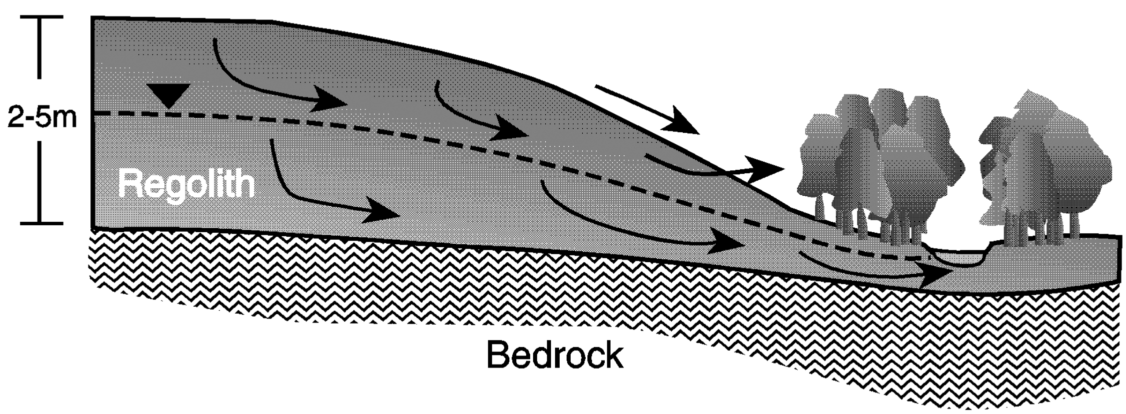
Water Quality Function	Expected Level	Critical Constraints	Restoration/ Enhancement
Removal of nitrate from groundwater	Low/Medium	Depth to water-tables. Bank erosion due to unstable soils.	Limit practice to areas without marsh wetlands down slope. Enhance vegetation uptake.
Removal of sediment and sediment-borne pollutants	High/Medium	Convert concentrated flow to sheet flow. Bank stability limits usefulness in some areas.	Restore/enhance in all areas. Limit to wider Zone 3 in some areas. Enhance Zone 3.
Removal of dissolved phosphorus	Medium/Low	Dissolved P control is limited. Focus on P load in surface runoff.	Increase vegetation uptake and accretion. Enhance existing forest and grass strips.

Surface runoff control would still be effective, but removal of dissolved chemicals would probably be less than in the well-drained upland because the higher groundwater level limits storage. Agriculture in this region is commonly associated with artificial drainage, which requires integration into the buffer system.

Tidal area: Tidally-influenced areas are unique because groundwater discharges are affected by tidal movements. Also, unlike most of the Bay watershed, marshes are the natural shore vegetation in many of these areas. At sites where marshes are not the natural shoreline, forest buffers can help stabilize the banks. Shorelines and cliffs are unique areas where special management may be needed. In most areas, the water table will be completely under the root zone, minimizing its impact. Restoration efforts should focus on areas with shallow water tables and wetland soils. Sediment control would be similar to the inner coastal plain.

Piedmont

PIEDMONT FLOW SYSTEM
Thin Soils/Triassic Shales



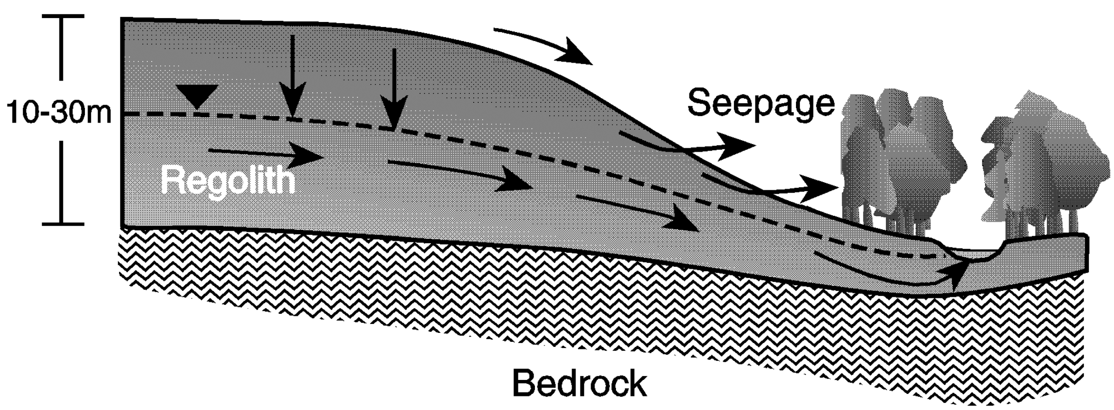
Water Quality Function	Expected Level	Critical Constraints	Restoration/ Enhancement
Removal of nitrate from groundwater	High	Lower loadings than ICP. Valley shapes control local flow paths.	Select deeply rooted vegetation, restore small and large streams, seepage areas.
Removal of sediment and sediment-borne pollutants	High/Medium	Slope of non-floodplain areas. Volumes of surface runoff.	Restore in areas. Function dependent on Zone 3 in first few years. Enhance Zone 3.
Removal of dissolved phosphorus	Medium/Low	Control of dissolved P in surface runoff.	Restore in areas with large surface runoff P loads. Increase infiltration.

The Piedmont contains rich soils that can be quite deep. The effectiveness of a riparian forest buffer's ability to remove nitrate from the groundwater hinges on the depth of those soils and the underlying bedrock. In areas with thin or finely textured soils and short flow paths to streams through shallow groundwater or surface seepage — characteristics common in the Virginia Piedmont — nitrate removal would be high, as in the inner coastal plain.

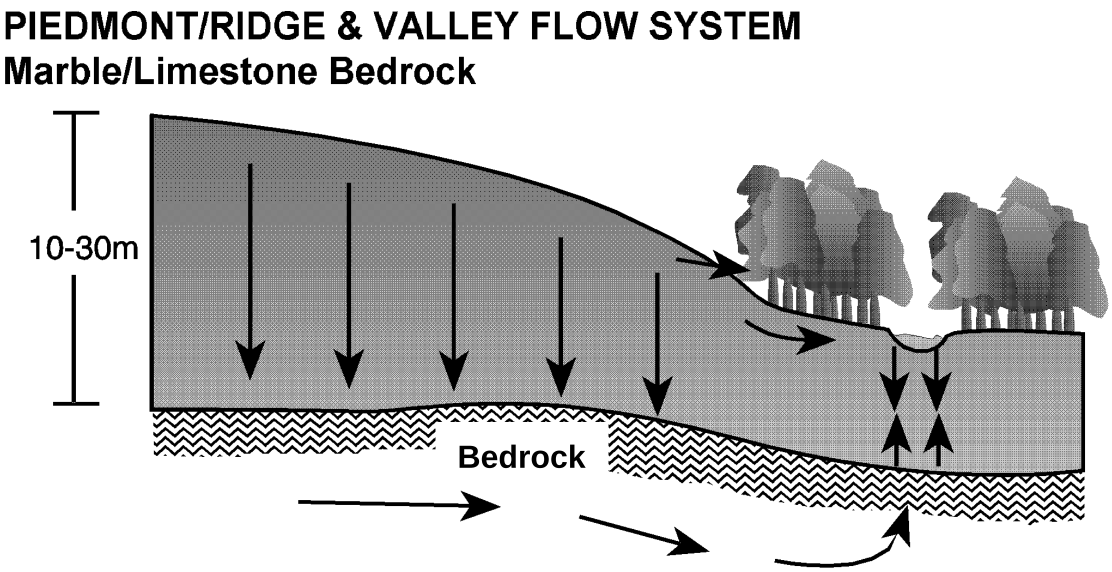
Piedmont areas with deeper soils are likely to have longer flow paths which allow water to sink deeper into the ground before entering the stream, in some cases bypassing the forest buffer. These areas are characterized by two different types of bedrock--gneiss/schist and marble. Areas with primarily schist bedrock would achieve moderate nitrate removal, as groundwater would be forced to move laterally toward small streams. Some groundwater would either seep up toward the surface before reaching the stream or would pass through the root zone of the buffer, while some flowing more deeply would bypass the buffer. In areas with deep soils underlaid by marble, nitrate removal would be minimal, as much of the groundwater would move through the porous marble layer and into regional aquifers. Riparian forests are most valuable here in flood plains and valley bottoms.

Sediment control in areas characterized by thin soils and flatter terrain would be similar to that of the inner coastal plain, with the removal of sediment and particulate nutrients being fairly high, while control of dissolved phosphorus would be fairly low. In hillier areas of the Piedmont, sediment control will depend on how effectively Zone 3 is managed to spread out the runoff and prevent it from cutting channels into the forest, allowing water to pass rapidly through the buffer. Steeper slopes in riparian areas may limit both the sediment filtering capacity and the retention time of water, possibly requiring expansion of Zone 3 and/or Zone 2.

PIEDMONT FLOW SYSTEM
Schist/Gneiss Bedrock



Water Quality Function	Expected Level	Critical Constraints	Restoration/ Enhancement
Removal of nitrate from groundwater	Medium	More flow into regional aquifers, bypassing riparian zone.	Select deeply rooted vegetation. Restore in seepage areas.
Removal of sediment and sediment-borne pollutants	High/Medium	Slope of non-floodplain areas. Sediment loads in stream flow from valley sides.	Restore in areas with erosion impacting streams. Enhance existing forests with Zone 3.
Removal of dissolved phosphorus	Medium/Low	Control of dissolved P in surface runoff.	Restore in areas with large surface runoff P loads. Increase infiltration.



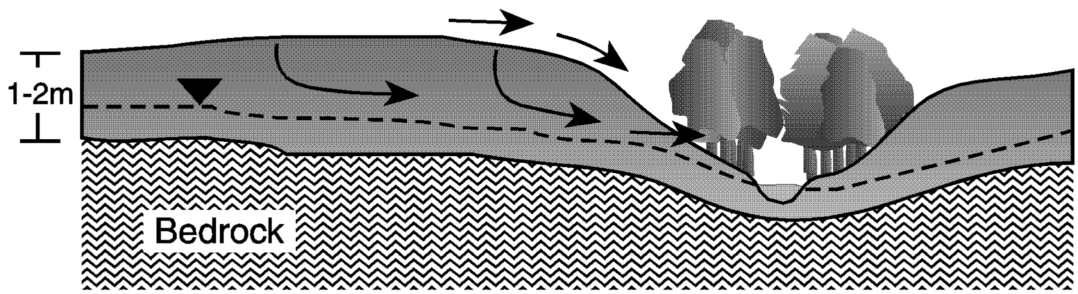
Water Quality Function	Expected Level	Critical Constraints	Restoration/ Enhancement
Removal of nitrate from groundwater	Low	Most flow into regional aquifers and into large rivers.	Denitrification focus. Select deeply rooted vegetation. Restore in seepage areas.
Removal of sediment and sediment-borne pollutants	High/Medium	Slope of non-floodplain areas. Sediment loads in stream flow from valley sides.	Restore in all areas with erosion impacting streams. Enhance existing forests with Zone 3.
Removal of dissolved phosphorus	Medium/Low	Control of dissolved P in surface runoff.	Restore in areas with large surface runoff P loads. Increase infiltration and fine sediment filter.

Ridge & Valley/Appalachian

The Ridge and Valley province is characterized by folds in topography. Ridges of harder, more resistant rock lie parallel to softer rock worn down over time to form the lowlands. Streams are intimately connected to this topography, flowing on belts of soft rock which rarely cross mountain ridges. Where they do, they cross at right angles, forming a distinctive "trellised" drainage pattern. Springs and seepage areas are common, and the water table is often close to the surface in near-stream areas.

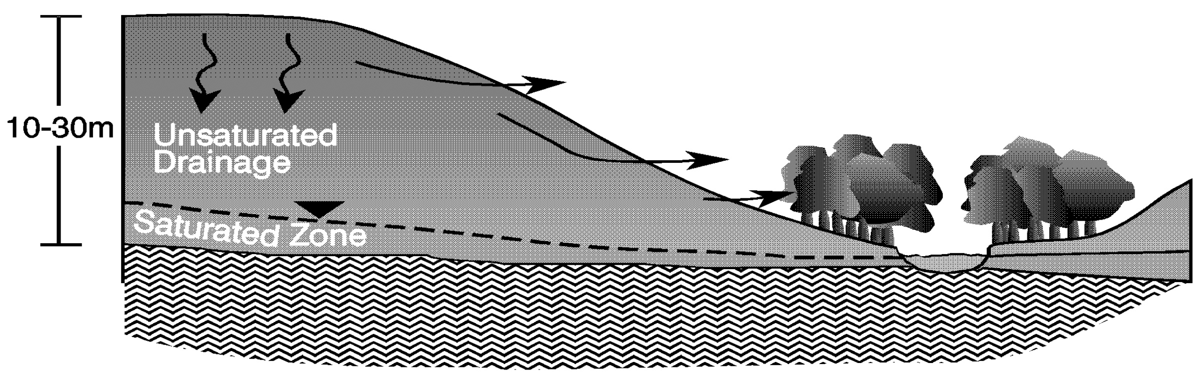
This area is characterized by larger streams that drain the main valleys, with smaller, and often steeper, streams draining the ridges. Forested riparian buffers have proven highly effective in controlling water temperature and sediment delivery to streams in forest and agricultural settings in the Ridge and Valley, but knowledge of the removal of nutrients from groundwater is less certain. This is primarily because of differences in geology. Water flow in Ridge and Valley areas with limestone bedrock is complicated and quite variable over time. There is often little potential for removing nitrate from groundwater as water will flow through cavernous openings in the rock to deep aquifers. From there, groundwater will eventually flow into the bottom of larger streams or rivers, bypassing riparian buffer zones altogether. Ridge and Valley areas with sandstone/shale bedrock have greater potential for groundwater nitrate removal as the hard bedrock keeps water moving laterally in the shallow soils toward the streams. Seepage and near-stream areas provide opportunities for substantial nitrate removal, while valley flood plains where groundwater discharge occurs will likely be areas for forest buffers to influence water quality. Surface runoff control would face the same issues as in hilly portions of the Piedmont.

RIDGE & VALLEY FLOW SYSTEM
Sandstone/Shale Bedrock



Water Quality Function	Expected Level	Critical Constraints	Restoration/ Enhancement
Removal of nitrate from groundwater	Medium/High	Presence of seeps and floodplains. Valley configurations.	Select for vegetation uptake, especially early in growing season. Deeply rooted.
Removal of sediment and sediment-borne pollutants	High/Medium	Sediment loads in stream flow from valley walls. Slopes of non-floodplains.	Restore in all areas with stream erosion. Enhance Zone 3 to control sediment.
Removal of dissolved phosphorus	Medium/Low	Control of dissolved P in surface runoff.	Restore in areas with large surface runoff P loads. Increase infiltration.

RIDGE & VALLEY/APPALACHIAN FLOW SYSTEM
Low Order Streams



Water Quality Function	Expected Level	Critical Constraints	Restoration/ Enhancement
Removal of nitrate from groundwater	Medium/High	Residence time of water. Presence of seeps and floodplains.	Select deeply rooted vegetation for uptake. Zone 1 is important for removal.
Removal of sediment and sediment-borne pollutants	High/Medium	Sediment loads in stream flow from valley walls. Slopes of non-floodplains.	Restore in all areas with stream erosion. Enhance Zone 3 to control sediment.
Removal of dissolved phosphorus	Medium/Low	Control of dissolved P in surface runoff.	Restore in areas with large surface runoff P loads. Increase infiltration.

References

Bailey, R.G. 1980. Descriptions of the ecoregions of the United States. Miscellaneous U.S. Department of Agriculture Publication 1391. Washington, DC. 77p.

Braun, L.E. 1950. Deciduous forests of eastern North America. The Free Press. Macmillan Publishing Co., Inc., NY. 596p.

Fenneman, N.M. 1938. Physiography of the eastern United States. McGraw-Hill Book Company, Inc., NY and London. 714p.

Küchler, A.W. 1964. Potential natural vegetation of the conterminous United States. Special Publication 36. New York, NY: American Geographical Society. 116p.

USDA Forest Service. 1994. Ecological subregions of the United States: section descriptions. WO-WSA-5. Washington DC: U.S. Department of Agriculture, Forest Service.

USDA Soil Conservation Service. 1981. Land resource regions and major land resource areas of the United States. Agric. Handbook. No. 296. Washington, DC: U.S. Department of Agriculture, Soil Conservation Service. 156p.

Section III

Functions/Values of Riparian Forest Buffers

Functions/Values of Riparian Forest Buffers

Introduction

This section describes the functions and values of riparian areas and riparian forest buffers as they relate to:

- Water Quality and Hydrology
- Wildlife and Fish
- Aesthetics and Outdoor Recreation

Water Quality and Hydrologic Functions/Values of Riparian Forest Buffer Systems

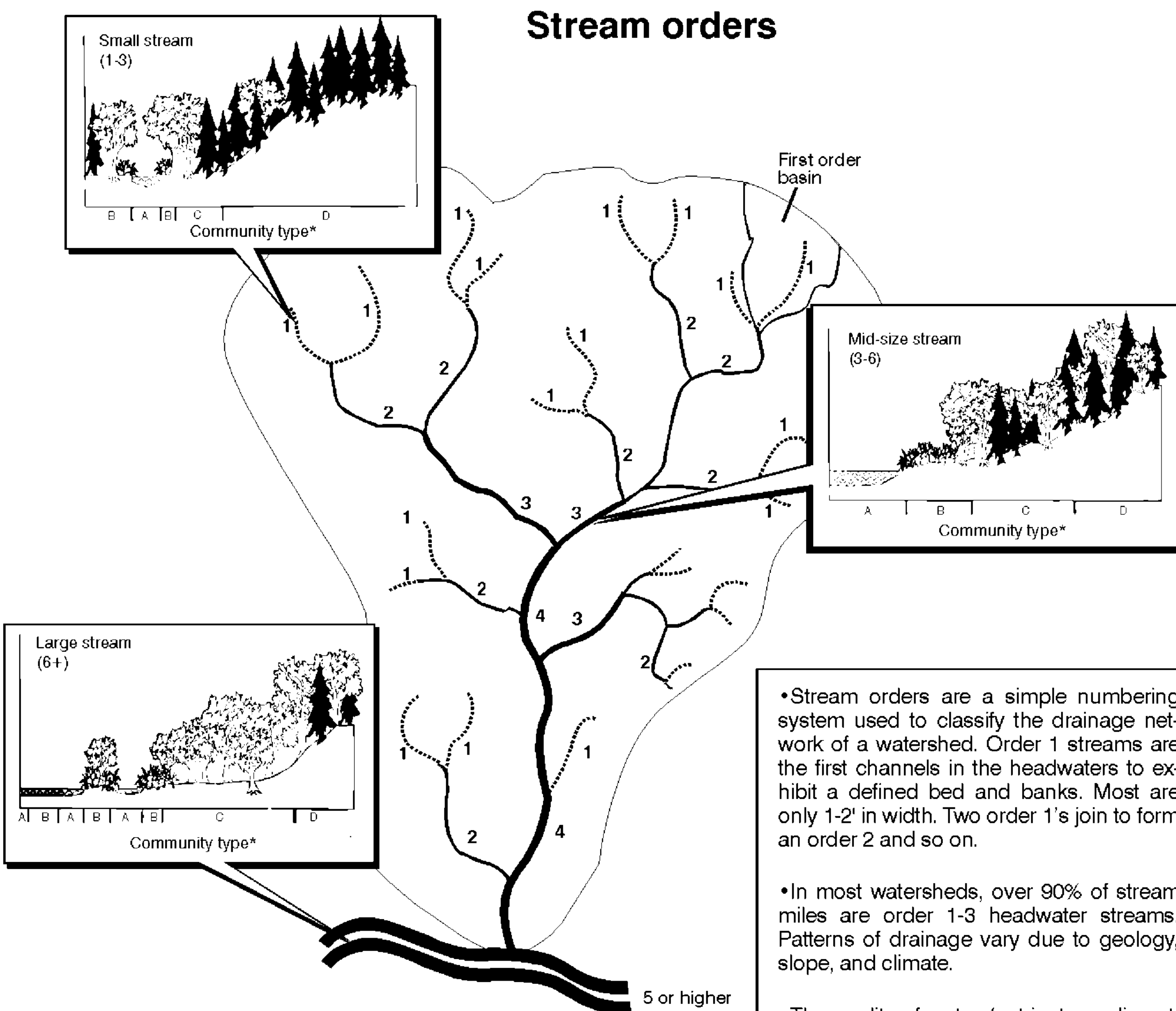
First and second order streams comprise nearly three-quarters of the total stream length in the United States (see Figure 3-1). Riparian ecosystems along these small streams are influenced by processes occurring on both land and water. Small streams can be completely covered by the canopies of streamside vegetation. Riparian vegetation has well-known beneficial effects on the bank stability, biological diversity, and water temperatures of streams. Riparian forests of mature trees (30 to 75 years old) are known to effectively reduce nonpoint pollution from agricultural fields.

Compared to other water quality improvement measures, Riparian Forest Buffer Systems (RFBS) can lead to longer-term changes in the structure and function of human-dominated landscapes. To produce long-term improvements in water quality, RFBS must be designed with an understanding of the following:

- processes which remove or sequester pollutants entering the riparian buffer system
- effects of riparian management practices on pollutant retention
- effects of riparian forest buffers on aquatic ecosystems
- effects and potential benefits of planned harvesting of trees on riparian buffer systems
- effects of underlying soil and geologic materials on chemical, hydrological, and biological processes

It is important to note that the current understanding of the functions of the RFBS is based on studies that have been done in areas where riparian forests currently exist because of a combination of hydrology, soils, cultural practices, and economics. Most of the current knowledge of the water quality functions of the three zones of the RFBS specification is derived from studies in existing riparian forests and on experimental and real-world grass buffer systems.

Stream orders



•Stream orders are a simple numbering system used to classify the drainage network of a watershed. Order 1 streams are the first channels in the headwaters to exhibit a defined bed and banks. Most are only 1-2' in width. Two order 1's join to form an order 2 and so on.

•In most watersheds, over 90% of stream miles are order 1-3 headwater streams. Patterns of drainage vary due to geology, slope, and climate.

•The quality of water (nutrients, sediment, and temperature) is affected most by the condition of headwater streams (order 1-4). Riparian forest buffers may exert their greatest influence here as the majority of water flows through the shaded riparian zone.

•Riparian forests may provide the greatest opportunities to enhance fish habitat on mid-order streams (3-6) and shorelines where there is sufficient large woody debris, stream structure and flow to support fish and other aquatic life.

•Larger streams and rivers (order 6+) are often characterized by well-defined floodplains or adjacent wetlands. Wider buffers may be needed here to allow meandering, as well as improve channel stability, water quality, and wildlife corridors.

***Key**

A–Active channel or water body
B–Stream banks and adjacent area flooded on an annual basis
C–Riparian zone of influence-zone of vegetation directly affecting or affected by the stream or water body
D–Uplands

(Note that A, B and C make up the complete riparian zone. In some cases, portions of D may be included in a riparian buffer.)

Figure 3 - 1. Stream orders as illustrated in the Alliance for the Chesapeake Bay White Paper, 1996.

How Riparian Forest Buffers Control the Stream Environment

Although reduction of nonpoint source (NPS) pollution is a widely recognized function of riparian forest buffer systems, they also contribute significantly to other aspects of water quality and physical habitat. Habitat alterations, especially channel straightening and removal of riparian vegetation, continue to impair the ecological health of streams more often and for longer time periods than toxic chemicals. Studies in Pennsylvania consider loss of riparian forests in eastern North America to be one of the major causes of aquatic ecosystem degradation.

Zone 1, the permanent woody vegetation at the stream edge, enhances ecosystem stability and helps control the physical, chemical, and trophic status of the stream. Healthy riparian vegetation in Zone 1 also contributes to bank stability and minimizes instream sediment loading because of bank erosion. Zone 1 also has substantial ability to control NPS pollution through denitrification, sedimentation, or direct root uptake of pollutants.

Riparian forest vegetation controls light quantity and quality, moderates temperature, stabilizes channel geometry, provides tree roots and woody debris for habitat, and provides litter for detritivores. To maintain the biological integrity of the aquatic ecosystem, an ideal managed buffer system should have patterns of vegetation, litterfall, and light penetration similar to those in a natural, undisturbed riparian forest. However, for many locations, representative sites of truly natural, undisturbed riparian ecosystems do not exist. In fact, after a long history of human disturbance in many areas, the concept can be difficult to define. Studies suggest that within a homogeneous region, relatively pristine areas may be identified as benchmarks for the evaluation of other sites.

1. Temperature and Light

The daily and seasonal patterns of water temperature are critical habitat features that directly and indirectly affect the ability of a given stream to maintain viable populations of most aquatic species, both plant and animal. Considerable indirect evidence suggests that the absence of riparian forests along many streams and rivers in the Chesapeake drainage, particularly in agricultural areas, may have a profound effect on the current geographic distribution of many species of macroinvertebrates and fish. Studies reviewed the effects of temperature alterations on the growth, development, and survival of stream macroinvertebrates found in the Pennsylvania Piedmont. These studies showed that temperature changes of 2-6° C usually alter key life-history characteristics of most of the study species.

In the absence of shading by a forest canopy, direct sunlight can warm stream temperatures significantly, especially during summer periods of low flow. For example, maximum summer temperatures have been reported to increase 6°-15° C following removal of the riparian forest canopy. Streams flowing through forests will warm very rapidly as they enter deforested areas, but excess heat dissipates quickly when streams reenter the forest. Studies demonstrated this alternate warming (by 4-5° C) and cooling as a stream passed through clearcut and uncut strips in the Hubbard Brook Experimental Forest, New Hampshire. In Pennsylvania (Ridge and Valley Province), average daily stream temperatures that increased 11.7° C through a clearcut area were substantially moderated after flow through 500 meters of forest below the clearcut. The temperature reduction was attributed primarily to inflows of cooler groundwater. The impact of deforestation on stream temperature varies seasonally. In the Pennsylvania Piedmont, studies found that from April through October average daily temperatures in a second-order meadow stream reach were higher than in a comparable wooded reach, but that the reverse was true from November through March.

Riparian forest buffers have been shown to prevent the disruption of natural temperature patterns as well as to mitigate the increases in temperature following deforestation. Studies found that buffer strips of 10 meters wide were as effective as a complete forest canopy in reducing solar radiation reaching small streams in the Pacific Northwest. The exact width of Zone 1 needed for temperature control will vary from site-to-site depending on a variety of factors (see Sections V and VI). A previous study pointed out that: 1) streams oriented in a north-south direction are less easily shaded than streams flowing east or west, and 2) a buffer on the north side of a stream may have little or no effect. Also, in larger streams and rivers, the width of the channel prevents a complete canopy cover, so the effect of canopy shading may be reduced. In eastern North America, openings in the canopy immediately above streams occur when the channel width exceeds about 20 meters in width (i.e., about stream order 4 or 5). Stream orientation relative to solar angle may also affect the extent of shading for larger streams. Although shading on larger rivers may have little or no influence on water temperature, shaded stream banks provide habitat microsites for fish and other aquatic organisms.

The ability of a given width of streamside forest to maintain or restore the natural temperature characteristics of a stream segment depends on how it affects the factors that control the daily and seasonal thermal regime of the stream. Such factors (other than shading) include: flow, channel geometry, solar radiation, evaporative heat loss, conductive surface heat exchange, and, in some cases, conductive heat exchange with the streambed.

2. Habitat Diversity and Channel Morphology

The biological diversity of streams depends on the diversity of habitats available. Woody debris is one of the major factors in habitat diversity. Woody debris can benefit a stream by:

- stabilizing the stream environment by reducing the severity of the erosive influence of stream flow,
- increasing the diversity and amount of habitat for aquatic organisms,
- providing a source of slowly decomposable nutrients, and
- forming debris dams, it enhances the availability of nutrients for aquatic organisms from more rapidly decaying material.

Quantities of large woody debris (LWD) recommended for healthy streams in the George Washington National Forest in Virginia range from 34 pieces of LWD per km for warm water fisheries to 136 pieces/km for cold water fisheries. Although the quantity of woody debris in streams without forested riparian areas would be expected to be very low, there are few quantitative studies. Studies in Pennsylvania found that the volume of woody debris under forested canopies in a Mid-Atlantic Piedmont stream was 20 times greater than the volume in a comparable meadow reach. Following removal of a riparian forest, large woody debris present in the stream declines through gradual decomposition, flushing during storms, and lack of inputs. Smaller debris from second-growth stands promotes less stability of the aquatic habitat and tends to have a shorter residence time in the stream.

Loss of streamside forest can lead to loss of habitat through stream widening where no permanent vegetation replaces forest, or through stream narrowing where forest is replaced by permanent sod. In the absence of other perennial vegetation, bank erosion and channel straightening can occur as unimpeded streamflow scours the streambed and banks. The accelerated streamflow velocity allowed by straight channels promotes channel incision as erosion from the stream bottom exceeds sediment entering the stream. This process can eventually lead to the development of wide, shallow streams that support fewer species.

Studies point out that stability of debris accumulation is important for aquatic habitat. Because of the greater resistance to displacement by hydraulic forces, large woody debris is of greater benefit to stream stability. Longer material is relatively more important for the stability of wider streams.

In contrast, narrowing of stream channels has also been reported following the replacement of streamside forest with permanent grassland or grass sod. Studies found that the narrowing of deforested stream channels was evident for streams up to drainage areas five square miles, or about a third or fourth order stream. Other studies quantified the narrowing phenomenon more explicitly in a Pennsylvania Piedmont basin, showing that:

- first and second order wooded reaches averaged about 2 times wider than their meadow counterparts of the same order.
- third and fourth order forested reaches were about 1.7 times wider than in deforested areas.

The channel narrows in the absence of a streamside forest because grassy vegetation, which is normally shaded out, develops a sod that gradually encroaches on the channel banks. For benthic macroinvertebrates, microbes, and algae, which live in and on the stream bed, the loss in stream width translates into a proportional loss of habitat. The effects of channel narrowing on fish habitat are more complex and involve the influence of woody debris on the pool and riffle structure.

Links between large woody debris in streams, the abundance of fish habitat, and the populations, growth, and diversity of fishes have been documented. Even when the selection method of tree harvesting has been done along streams, the removal of old growth has caused a decline in aquatic habitat quality because of diminished inputs of large woody debris. The surfaces of submerged logs and roots provide habitat that often support macroinvertebrate densities far higher than on the stream bottom itself.

Woody debris, like boulders and bedrock protrusions, tends to form pools in streams by directly damming flow, by the scouring effects of plunge pools downstream of fallen logs, or by forming backwater eddies where logs divert flow laterally. In undisturbed forests, large woody debris accounts for the majority of pool formation. As expected, removal of woody debris by deforestation typically results in loss of pool habitat. Although pools are spatially contiguous with riffles, there is little or no overlap in the species composition of the dominant macroinvertebrates occurring in the two habitats. The loss of pools, therefore, translates directly into lower populations and diversity for this group. For fish, pools improve habitat by providing space, cover, and a diversity of microenvironments. Greater depth and slower velocity in pools afford protection to fish during storms, droughts, and other stressful conditions.

Debris dams of large woody material block the transport of both sediment and smaller litter materials. The impoundment and delayed transport of organic material downstream enhances its utilization by aquatic organisms. By slowing transport rates, dams on small order streams serve as buffers against the sudden deposition of sediment downstream. The capacity of a stream to retain debris, therefore, is an important characteristic influencing the aquatic habitat.

Although it is often thought that large woody debris is less important on large rivers and open water habitats, it has been shown that woody debris derived from riparian forests along tidal shorelines of the Bay provides an important refuge habitat for numerous species of fish and crustaceans. Shallow water habitats, with plentiful large woody debris, support greater abundance of many species of fish and crustaceans than do areas with no woody debris bordered by narrow strips of marsh. Studies hypothesize that the importance of large woody debris along Bay shorelines has been increased because of loss of habitat in submerged aquatic vegetation and oysterbeds.

3. Food Webs and Species Diversity

The two primary sources of food energy input to streams are litterfall (leaves, twigs, fruit seeds, and other organic debris) from streamside vegetation and algal production within the stream. Total annual food energy inputs (litter plus algal production) are similar under shaded and open canopies, but the presence or absence of a tree canopy has a major influence on the balance between litter input and primary production of algae in the stream.

Studies noted that "streams flowing through older, stratified forests receive the greatest variation in quality of food for detritus-processing organisms." In the Piedmont, streams flowing through forested landscapes do not contribute food energy to downstream channels that have been deforested (even contiguous reaches) because the large pieces of litter do not move very far. This means that a streamside forest is needed along the entire length of a stream in order to assure a proper balance of food inputs appropriate to the food chain of native species. Macroinvertebrate populations are affected by changes in litter inputs. The activity of benthic organisms may increase following streamside plant removal. Woody material decomposes more quickly following riparian forest removal, thereby further reducing the stream's nutrient retention.

The quantity and quality of algal production in a stream are greatly affected by the quantity and quality of light striking its surface. For example, studies showed that the algal community of a stream heavily shaded by an old growth forest was dominated by diatoms all year, while a nearby stream in a deforested area contained mainly filamentous green algae in the spring and diatoms at other times. Other studies have also shown that deforested sites tend to be dominated by filamentous algae while diatoms prevail under dense canopy cover. In the eastern Piedmont, filamentous algae such as *Cladophora* can be dominant in deforested streams due primarily to a combination of high nutrients, high light levels, and warm temperatures. Although some macroinvertebrates such as crayfish and waterboatmen insects readily consume this type of algae, most herbivorous species of stream macroinvertebrates have evolved mouth parts specialized for scraping diatoms from the surface of benthic substrates and cannot eat filamentous algae.

The influence of differences in the quality of algal production on the aquatic ecosystem is complex. Algal grazing species generally benefit from an increase in algal growth. Because the growth efficiency of insects is often higher on algae than on detritus, the opening of the canopy may increase the production of macroinvertebrates in these reaches. For example, studies found both higher biomass and densities for most grazer species in deforested sites relative to forested sites. The pattern is not clear, however, because other studies found higher biomass but lower densities of grazers in deforested versus forested sites. Researchers observed in California streams that the benthic community in logged watersheds became dominated by a few algal feeding species. The diversity of the macroinvertebrate community was significantly lower than in unlogged watersheds, except where the stream was protected by a riparian buffer of 30 meters or more. For buffer strips less than 30 meters in width, the Shannon diversity was significantly correlated with buffer width.

How Riparian Forest Buffers Facilitate Removal of Nonpoint Source Pollutants

Riparian forests remove, sequester, or transform nutrients, sediments, and other pollutants. The pollutant removal function of a Riparian Forest Buffer System depends on two key factors:

- The capability of a particular area to intercept surface and/or groundwater-borne pollutants, and
- The activity of specific pollutant removal processes.

Focusing on these two factors as regulators of buffer zone effectiveness is useful for evaluating the importance of a particular site as a buffer.

1. Nitrate Removal

Most studies with high levels of nitrate removal were in areas with high water tables that caused shallow groundwater to flow through or near the root zone. The mechanisms for removal of nitrate in these study areas are thought to be a combination of denitrification and plant uptake. Denitrification is the biochemical reduction of nitrate or nitrite to gaseous nitrogen, either as molecular nitrogen or as an oxide of nitrogen. Linkages between plant uptake and denitrification in surface soils have been proposed as a means for maintaining high denitrification rates in riparian ecosystems. In contrast, riparian systems without substantial contact between the biologically active soil layers and groundwater, or with very rapid groundwater movement, appear to allow passage of nitrate with only minor reductions in concentration and load. A study reported both high nitrate concentrations and high nitrate removal rates beneath a riparian forest where very high nitrate flux and rapid groundwater movement through sandy aquifer material limited nitrate removal efficiency. Another study showed that groundwater flow beneath the biologically active zone of a narrow riparian buffer along a tidal bay in Maryland resulted in little removal of nitrate. It is also known that groundwater discharging through sediments of tidal creeks may have up to 20 times the nitrate concentrations found in the main stem of the creeks. A study indicated that groundwater nitrate might bypass narrow areas of riparian forest wetland and discharge into stream channels relatively unaltered when the forest is underlain by an oxygenated aquifer. This pattern of groundwater flow was supported by modeling of a small Coastal Plain watershed in Maryland. Isotopic analysis of groundwater and surface water in this watershed suggested that denitrification was not affecting the nitrate concentrations of discharging groundwater. In these cases where nitrate enriched water surfaces in the stream channel, a wide RFBS would have little effect on nitrate. Deeply rooted vegetation near the stream might have some effect.

Studies in New Zealand have shown that the majority of nitrate removal in a pasture watershed took place in organic riparian soils which received large amounts of nitrate laden groundwater. The location of the high organic soils at the base of hollows caused a high proportion of groundwater (37-81%) to flow through the organic soils although they occupied only 12 percent of the riparian area. A related study in New Zealand found very high nitrate removal in the organic riparian soils, but streamflow was still enriched with nitrate. The authors speculated that water movement through mineral soils was responsible for most of the nitrate transport to streams. Riparian systems with intermingling organic and mineral soils point out the need to understand where groundwater is moving and what types of soils it will contact, especially in seepage areas.

2. Plant Uptake of Nutrients

Maintenance of active nutrient uptake by vegetation in Zone 2 should increase the potential for short-term (non-woody biomass) or long-term (woody biomass) sequestering of nutrients. Although plant water uptake is chiefly a passive transpiration process, plant nutrient uptake is mostly an active process, dependent upon plant metabolic activity.

Nutrient uptake by flood-intolerant plants is strongly influenced by the aeration status of the soil. As low oxygen supply decreases root metabolism, the uptake of most nutrients decreases. Flood-tolerant species, such as those found in many riparian forests, may tolerate low-oxygen conditions by means of adaptive metabolic responses. They may also avoid root anoxia by morphological adaptations that facilitate the availability of oxygen. Under flooded conditions, roots may become thicker and increase in porosity, allowing an internal downward diffusion of oxygen. The growth of adventitious roots may also allow water and nutrient uptake from near-surface areas that are more aerated. Vegetation selection for restored or managed RFBS must consider the ability of different species to take up and store nutrients under specific conditions of the site. A study points out that flooding can enhance the nutrient uptake and growth of some species. Bottomland hardwood seedlings grow faster under saturated conditions than under drained but well-watered conditions. More rapid increases in total dry weight and nitrogen and phosphorus uptake were found in water tupelo (*Nyssa aquatica* L.) as well as several other species under saturated conditions. Shoot weights of a majority of wetland and intermediate plant species were either unaffected or increased under flooded conditions.

Compared to the "natural" riparian forests studied in most existing research, managed riparian forests have the potential for increased accumulation of nitrogen and phosphorus in biomass through both increased biomass production and increased foliar nutrient contents. Trees can respond to nitrogen subsidy by both increased growth rates and luxury nitrogen uptake. The growth rate of forests is commonly nitrogen limited. A study suggested that high efficiency of nitrogen use by forests is an adaptation to the nitrogen-deficient environments that they frequently inhabit. Often the potential nitrogen uptake rate is much higher than observed rates.

Conditions do exist where nitrogen is no longer the limiting nutrient for forest growth. Long-term inputs of nitrogen, such as may occur from atmospheric deposition in the northeastern United States, could result in nitrogen levels exceeding the total combined plant and microbial nutritional demands. Under these conditions, phosphorus might become the limiting factor for tree growth. Unlike upland forests, phosphorus may often be the most limiting nutrient in wetland ecosystems. A study found the growth of baldcypress (*Taxodium distichum* (L). Rich.) in a southern Illinois swamp to correspond well with phosphorus inputs from flooding. Foliar phosphorus content of loblolly pine on wet Coastal Plain sites in South Carolina has been observed to correlate well with growth. An analysis of nutrient ratios in decaying litter from tupelo gum trees in a North Carolina swamp forest suggested that phosphorus levels may limit decomposition rates. If phosphorus is the limiting nutrient for tree growth, it should make vegetation an effective phosphorus sink.

While several studies have found plant uptake to be an important nutrient removal mechanism in riparian forest buffers, several factors may reduce the importance of plants as nutrient sinks. Pollutants in groundwater flowing into the riparian buffer will only be accessible to plants if the water table is high in the soil profile or if mass movement of water because of transpiration demands moves water and solutes into the root zone. Coastal Plain riparian forests have been shown to control localized downslope water transport by creating moisture gradients which move water in unsaturated flow from both the adjacent stream and the upland field. Nutrients in surface runoff and in water percolating rapidly through soil macropores as "gravitational water" may not be available to plants. Large rainfall events that often transport a high percentage of pollutants in the Chesapeake Bay Watershed (CBW) often produce concentrated surface flow and macropore-dominated percolation.

Plant sequestering of nutrients is also limited by seasonal factors. In the temperate deciduous ecosystems that dominate riparian forest buffers in the CBW, plant uptake will decline or stop during the winter season. A high percentage of surface and groundwater flow occurs in the CBW during winter. There is also concern that nutrients trapped in plant tissues can be released back into the soil solution following litterfall and decomposition. However, nutrients released from decomposing plant litter may be subject to microbial, physical or chemical attenuation mechanisms in the root zone of forest soils. Storage of nutrients in woody tissue is a relatively long-term attenuation, but still does not result in removal of pollutants from the ecosystem unless biomass is removed. A final concern about plant uptake as a nutrient removal mechanism arises from the possibility that the ability of trees in a buffer zone to sequester nutrients in woody biomass becomes less as trees mature. The average tree age in most riparian forest buffers in the CBW is less than 100 years and should thus be accumulating nutrients in woody biomass. Although net vegetation accumulation of nutrients may reach zero, net ecosystem accumulation may continue as nutrients are stored in soil organic matter.

3. Microbial Processes

In addition to plant uptake, there are microbial processes that attenuate pollutants in RFBS. These processes include immobilization of nutrients, denitrification of nitrate and degradation of organic pollutants. Microbes take up or "immobilize" dissolved nutrients just as plants do. These immobilized nutrients can be re-released or "mineralized" following death and decomposition of microbial cells, just as nutrients sequestered by plants can be released following litterfall. In ecosystems that are accumulating soil organic matter, there will be a net storage of immobilized nutrients. Riparian forest buffers, if managed to foster soil organic matter accumulation, may thus support significant long-term rates of nutrient storage by immobilization.

Denitrification refers to the anaerobic microbial conversion of nitrate to nitrogen gases. Denitrification is controlled by the availability of oxygen (O_2), nitrate, and carbon (C). Although essentially an anaerobic process, denitrification can occur in well-drained soils because of the presence of anaerobic microsites, often associated with decomposing organic matter fragments which deplete available oxygen. It is likely that soil moisture gradients in riparian ecosystems cause a change in controlling factors within most three-zone RFBS. In parts of the RFBS with better internal drainage and generally lower soil moisture conditions, denitrification may be generally limited by the interacting factors of carbon availability and aeration status. Although many wetlands are often assumed to have high levels of denitrification because of high carbon soils and anaerobic conditions, denitrification in many wetlands will be nitrogen limited. In the more poorly drained or wetland portions of an RFBS, denitrification is more likely to be limited by nitrate availability.

Wetland soils develop high levels of organic matter because of their slope position and hydrologic condition. Frequently inundated soils will have lower rates of litter decomposition because the flow of carbon from litter to microbial populations is reduced under anaerobic conditions. The interactive nature of oxygen, nitrate, and carbon control of denitrification means that more denitrification generally occurs in intermittently flooded sites than in permanently flooded conditions.

Denitrification has been identified as the key nitrate removal mechanism in several riparian forest buffer studies. Estimates in the range of 30 to 40 kilograms of nitrogen per hectare per year have been reported for natural riparian forests in the United States. In several studies of denitrification in riparian ecosystems, denitrification has been concentrated in surface soil and rates are generally much lower below the top 12 to 15 centimeters of soil. A study reported very high denitrification in the top 30 centimeters of an organic riparian zone soil in New Zealand. Denitrification rates (measured on anaerobic soil slurries) were over 11 kilograms of nitrogen per hectare per day at this site.

While the factors regulating denitrification in surface soils and aquifers are relatively well understood, the amounts of direct denitrification of groundwater-borne nitrate are much less well established. Subsurface microbial activity is usually limited by carbon availability. In settings where the total and dissolved carbon contents of aquifers are low, they are poor quality substrates for microbial growth, and anaerobic conditions necessary for denitrification to proceed are not generated.

Microbial attenuation of organic compounds arises from their ability to degrade these compounds as food sources or through non-energy yielding "cometabolism" reactions. There are many different microbial degradation mechanisms including aerobic, anaerobic, chemoautotrophic and heterotrophic pathways. The wide range of environments and high diversity of microbial metabolism in RFBS should support many of these mechanisms. Further research into specific management strategies to foster a wide range of degradation strategies is needed.

In many cases, riparian area retention of groundwater-borne pollutants may depend on a complex interaction of hydrology, plant, soil, and microbial factors. The potential importance of these interactions is hypothesized based on studies where significant rates of nitrate removal from groundwater were measured, but the potential for denitrification in the subsurface was low. Studies suggested that surface soil denitrification of groundwater derived nitrate is an important route of nitrogen removal in riparian forests. This route depends on plant uptake of nitrate from groundwater, decomposition and nitrogen release from plant litter, and nitrification and denitrification of this nitrogen in surface soil. In riparian forests where this route of nitrogen removal is important, the nitrate removal function may depend on complex interactions among hydrology, plant dynamics, and soil microbial processes. These interactions vary within and between riparian forests and should be strongly influenced by soil drainage class, vegetation and soil type, climate, and groundwater quality. Although soil denitrification should be sustainable indefinitely under proper conditions with a supply of nitrate and available C, a study found that long-term groundwater nitrate loading led to symptoms of nitrogen saturation in the surface soils of a riparian forest buffer.

4. Removal of Surface-Borne Pollutants

Sediment trapping in riparian forest buffers is facilitated by physical interception of surface runoff that causes flow to slow and sediment particles to be deposited. Effective sediment trapping requires that runoff be primarily sheet flow. Channelized flow is not conducive to sediment deposition and can actually cause erosion of the RFBS. Two studies on long-term sediment deposition in riparian forests indicated that it is substantial. Results of both studies indicate that two main actions occur:

- The forest edge fosters large amounts of coarse sediment deposition within a few meters of the field/forest boundary, and
- Finer sediments are deposited further into the forest and near the stream.

Two other studies found much higher depths of sediment deposition at the forest edge than near the stream. A second peak of sediment depth was often found near the stream, possibly from upstream sediment sources deposited in overbank flows. The surface runoff which passes through the forest edge environment is much reduced in sediment load because of coarse sediment deposition, but the fine sediment fraction is enriched relative to total sediment load. These fine sediments carry higher concentrations of labile nutrients and adsorbed pollutants which are carried further into the riparian forest and are deposited broadly across the RFBS.

Movement of nutrients through the RFBS in surface runoff will be controlled by a combination of the following:

- sediment deposition and erosion processes,
- infiltration of runoff,
- dilution by incoming rainfall/throughfall, and
- adsorption/desorption reactions with forest floor soil and litter.

Studies that separate the effects of these various processes are not available. A study found large reductions in concentrations of sediment, ammonium-nitrogen, and ortho-phosphorus in surface runoff which passed through about 50 meters of a mature riparian forest in the Maryland Coastal Plain. Although the concentrations of these pollutants were reduced by a factor of three or four in most cases, the flow-length was about twice that recommended in the RFBS specification. Another study found that dissolved ortho-phosphorus loads in surface runoff were not reduced markedly in a Zone 2-like area of the riparian forest. The studies of surface runoff through riparian forests agreed on the importance of eliminating channelized flow through the riparian forest and recommended spreading flow before it reached the forest buffer. In-field practices are also critical in preventing channelized flow from reaching the field edge.

Integrated Water Quality Functions of Riparian Forest Buffer Systems

The need to simultaneously control at least three major transport mechanisms of waterborne pollutants creates potential difficulties for RFBS. It is likely that control of pollutants transported in the sediment-adsorbed phase of surface runoff, the dissolved phase of surface runoff, and groundwater (dissolved phase only) may be optimal on different sorts of RFBS with differing soils, vegetation, and management.

For surface-borne pollutants, increasing infiltration in the RFBS will be an effective measure for both dissolved and adsorbed pollutant control. Conversely, the sandy well-drained soils which have highest infiltration will likely have lowest denitrification rates and may have rapid groundwater movement rates leading to high rates of nitrate transport through the riparian forest buffer.

For nitrate removal via denitrification, a riparian ecosystem where high nitrate water moves into high organic matter soils or subsoils is the best way to promote denitrification and the best way to permanently remove nitrate from the soil-water-plant system. This is illustrated both by the New Zealand riparian studies of organic riparian soils and by the findings that denitrification is highly stratified in mineral soils with most denitrification occurring in the high organic carbon surface soils. Organic-rich wetland soils can often respond to increased nitrate loads with increased denitrification. The same conditions which are likely to promote denitrification are also likely to decrease the amount of retention of surface-borne pollutants. Wetland soils which are frequently inundated will have little or no infiltration capacity or available water storage capacity.

Loading Rates and Nonpoint Source Pollution Control

As a nonpoint pollution control practice, Riparian Forest Buffer Systems represent a long-term investment which can change landscape structure. As a long-term management option, it is quite likely that RFBS will be exposed to a wide range of pollutant loadings because of both interannual variation and changes in management practices in source areas. Information on how mature RFBS respond to changing pollutant loads is essential to understanding long-term sustainability of RFBS. Some research on Coastal Plain RFBS indicates that higher rates of nitrate removal would be possible under higher loadings of nitrate. Published studies indicate that this is most likely to be true in areas where denitrification is the primary means of nitrate removal. Given the range in nutrient uptake observed both among different plant species and within the same plant species, it is likely that vegetation uptake will increase with increasing loads, if there is significant hydrologic interaction with vegetation.

Increasing loads of phosphorus are likely to be less effectively controlled than increasing loads of nitrogen, because of the lack of biological processes to remove or sequester phosphorus in the RFBS. If increasing phosphorus loads are to be controlled, it will require effective management of Zone 2 for infiltration and both Zones 2 and 3 for sediment removal. If dissolved or particulated phosphorus can be retained in the root zone, it will be available for both biological and chemical removal processes. If RFBS have some absolute removal potential for phosphorus, reducing input loads should increase the efficiency of removal.

Management to control increasing loads of sediment and sediment-borne chemicals will require specific management for sediment retention. Most of the mass of sediment will be deposited in Zone 3 or in the upper portions of Zone 2 and most of the sediment-borne nutrients will be deposited downslope in Zone 2. Increased sediment loadings will require increased management to eliminate concentrated flows, remove accumulated sediment, especially in berms, and restore the herbaceous vegetation. Increased sediment and sediment-borne chemical loads should lead to higher amounts of chemical deposition in surface litter. The ability of RFBS to retain dissolved phosphorus, especially under high loadings, may be limited.

Loading rate/buffer width relationships are only poorly defined, especially for dissolved pollutants. In published studies with water clearly in contact with surface litter or the biologically active root zone, buffers of about 100 feet have been effective for at least sediment and nitrate removal. One of the difficulties in describing these relationships is that increasing pollutant loads may also be accompanied by increasing water volumes in either surface runoff, groundwater, or both. In the presence of increased water movement, denitrification for nitrate removal should be enhanced and sedimentation and infiltration may be decreased. Increased surface runoff and loading of sediment and sediment-borne chemicals can be accommodated by management to increase roughness and control channelized flow.

Stream Order and Size Effects

Regardless of the size of stream or the hydrologic setting, water moving across the surface or through the root zone of a RFBS should show reduction in either nitrate (groundwater) or sediment and sediment-borne chemical loads reaching the stream. As streams increase in size, the integrated effects of adjacent riparian ecosystems should decrease relative to the overall water quality of the stream. On lower order streams there is greatest potential for interactions between water and riparian areas. For NPS pollution control, the change in impact of RFBS as stream order increases can be estimated based on hydrologic contributions from upstream and from the riparian ecosystem.

For first-order streams, the potential impact of the RFBS on chemical load or flow-weighted concentration is directly proportional to the proportion of the excess precipitation from the contributing area which moves through or near the root zone or surface of the RFBS. For all streams above first order, the contributing area is only one source of pollutants, with upstream reaches providing the other source.

For second-order and above, the NPS pollution control function of a given RFBS is based on both the proportion of water from the contributing area which moves through the riparian system and the relative sizes of the two potential pollutant loads - upstream sources or adjacent land uses. Clearly, the larger the stream, the less impact a RFBS along a particular stream reach can have on reduction in overall load within that reach. If there are no RFBS upstream from a particular stream reach, the water entering the stream reach is likely to be already contaminated.

On a watershed basis, the higher the proportion of total streamflow originating from relatively short flow-paths to small streams, the larger the potential impact of RFBS. In comparing the potential effectiveness of RFBS among watersheds, drainage density (length of channel per unit area of watershed) should provide a useful starting point. Higher drainage density implies greater potential importance for RFBS in NPS pollution control.

Control of the stream environment is most effective when native vegetation forms a complete canopy over the stream. This is obviously only possible on relatively small streams. The effect of the RFBS on the stream environment is not simply proportional to the amount of the channel that is shaded. As previously noted, besides direct shading of the stream channel, cooling of groundwater, recharging streams, and provision of bank habitat will occur even on larger streams. Providing for bank habitat, large woody debris and leaf detritus remain important functions, regardless of stream size.

Stormwater Management

Retaining forests as open space and using riparian forest buffer corridors can be effective practices to integrate with stormwater planning in urbanizing areas. Forests can capture, absorb, and store amounts of rainfall 40 times greater than disturbed soils, like agricultural fields or construction sites, and 15 times more than grass turf or pasture. Capitalizing on this ability to reduce the amount of water available for stormwater runoff is a function that makes forests valuable as an "open space tool" for stormwater reduction. Fairfax County, VA, recently estimated that forests were providing almost $57 million in stormwater reduction benefits annually to local taxpayers.

A buffer network acts as the right-of-way for a stream and functions as an integral part of the stream ecosystem. Buffers can be an important component of the stormwater treatment system of a development site. They cannot, however, treat all the stormwater runoff generated within a watershed. In heavily urbanized watersheds, only 10 percent or so of water contributing to stormflow may end up passing through a buffer area. When buffers can be designed to accept flow directly from impervious areas – such as cuts in roadside curbs – a narrow stone layer, a grass filter strip, or some other method, can be used to spread water. The buffer can better function as a direct filtering system. Roadside swales or small collection areas just outside the forest buffer may also provide a means to slowly release and spread stormflow for treatment by the buffer. Locating larger ponds and wetland detention areas in or adjacent to buffers will always be a balancing act. However, these practices can be designed to work well in tandem.

Flood Reduction and Control

Streams and their valleys in the Chesapeake Bay Watershed were formed in a hydrologic balance with their forested watersheds. The capacity of downstream channels was also influenced by forested flood plains. Forested flood plains temporarily store flood waters, and woody vegetation helps reduce and capture sediment loads.

Human activities have changed the hydrologic balance between channels and their watersheds. Some examples of changes are:

- Forested lands have been cleared, resulting in increased storm runoff.
- Drainage efficiency has been increased through channelization, gully formation, or the removal of large woody debris, resulting in rapid surface runoff.
- The construction of dikes and levees has increased downstream peaks.
- Flooding is increased by deposition and stream aggradation.
- Channels are cleaned and cleared of snags, resulting in increased flood velocities.
- Eventually channels are downcut, and the force of bankfull flows is increased.

The influence of past human use will still affect the hydrology of watersheds that have become reforested, and the function of reestablished riparian forests will sometimes be limited by existing watershed and channel conditions.

Flood Plain Function

The Federal Flood Plain Assessment Report calls for restoring the natural function of flood plains. The natural flood control functions of flood plain forests include the following:

- Retarding flood flow velocities is the primary beneficial function of flood plain forests. The U.S. Geological Survey developed a procedure for determining the rate at which increasing the number of woody stems increases flood plain roughness, thereby reducing flood velocity. The role of woody stems in reducing velocity and increasing sediment deposition during floods has been well documented. By comparison, grass covered flood plains, when submerged, do not retard flow.

- Maintaining downstream flood control capacities. Colonization of riparian areas with woody vegetation can dramatically decrease the rate of sedimentation in a downstream reservoir. This can help maintain the flood storage capacity of small reservoirs.
- Streamside forests contribute to channel stability and roughness. They contribute large woody debris that prevents downcutting, traps bedload sediments, and dissipates stream energy in plunge pools.

The natural resources manager should assess the site-specific opportunities to restore flood plain functions with riparian forest buffers. The following are areas that should receive special attention and consideration:

- In headwaters - By restoring forests along smaller streams, more storm flow can be dispersed and retained higher in the watershed, thus reducing flood heights and damage along downstream rivers
- Along downcut channels - Where channels are contained within steep banks, and the stream reaches the former flood plain less frequently, the opportunity to restore flood plain function will be reduced.
- Channels with levees - Where stream access to the flood plain is blocked by levees, the flood plain function is lost. However, establishing trees on the levee will help protect the levee and provide other benefits. Studies by the Agricultural Research Service indicate that rock-faced revetments with woody vegetation suffered less damage during floods. Similar results were observed following the 1993 Mississippi River floods where tree-covered levees withstood overtopping better than grass-covered levees.
  - Watershed – Consideration must be given to the following upstream conditions that increase the frequency of flooding:
    1) Land development
    2) Addition of levees
    3) Clearing and snagging operations
    4) Clearing streamside trees

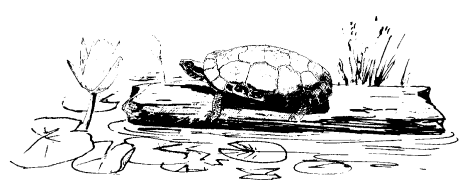
    Downstream considerations that reduce the stream's access to the flood plain include:
    1) Potential for dredging and channel clearing
    2) Presence of active headcuts
- Channel type - Many types of stream channels do not have active flood plains. Channels with the National Wetland Classification of "lower perennial" are more likely to have flood plains.
- Period of inundation - Areas that are inundated for extended periods will limit the selection of suitable woody vegetation.

Opportunities for Management

Restoring a streamside forest with the attendant understory and ground cover will make a significant difference in flood plain function. Periodic harvesting will keep those functions at an optimum by:

1) Opening the canopy to increase the number of woody stems that retard velocity.
2) Harvesting to control tree size which is important where there are levees.

Wildlife and Fish Habitat Functions/Values of Riparian Forest Buffer Systems



Riparian areas are used by wildlife more that any other type of habitat. Many resource managers are aware of the water quality values of riparian areas, but many are not aware of the direct effects these areas have on wildlife, both aquatic and terrestrial.

Riparian areas provide valuable habitat in many forms for different types of wildlife. Establishing, managing, and protecting these areas can increase biodiversity. Aquatic biodiversity, in many cases, is dependent on the quality of the riparian areas. Equally important is the value of these areas for terrestrial wildlife. They provide valuable wildlife corridors, many of which have been lost over the years, for agriculture expansion and housing development.

The primary determinants of stream flora and fauna are water abundance and quality and the ecological character of the riparian area, as well as the watershed as a whole. The riparian system provides a reflection of the surrounding terrestrial ecosystems. Removal or degradation of riparian areas can have a domino effect with negative results in both aquatic and terrestrial ecosystems that are linked to it.

Riparian Area Importance to Wildlife

The major reasons why riparian areas are so important to wildlife are:

- Wildlife habitat is composed of cover, food, and "**water.**"
- The greater availability of water to plants, frequently in combination with deeper soils, increases plant production and provides a

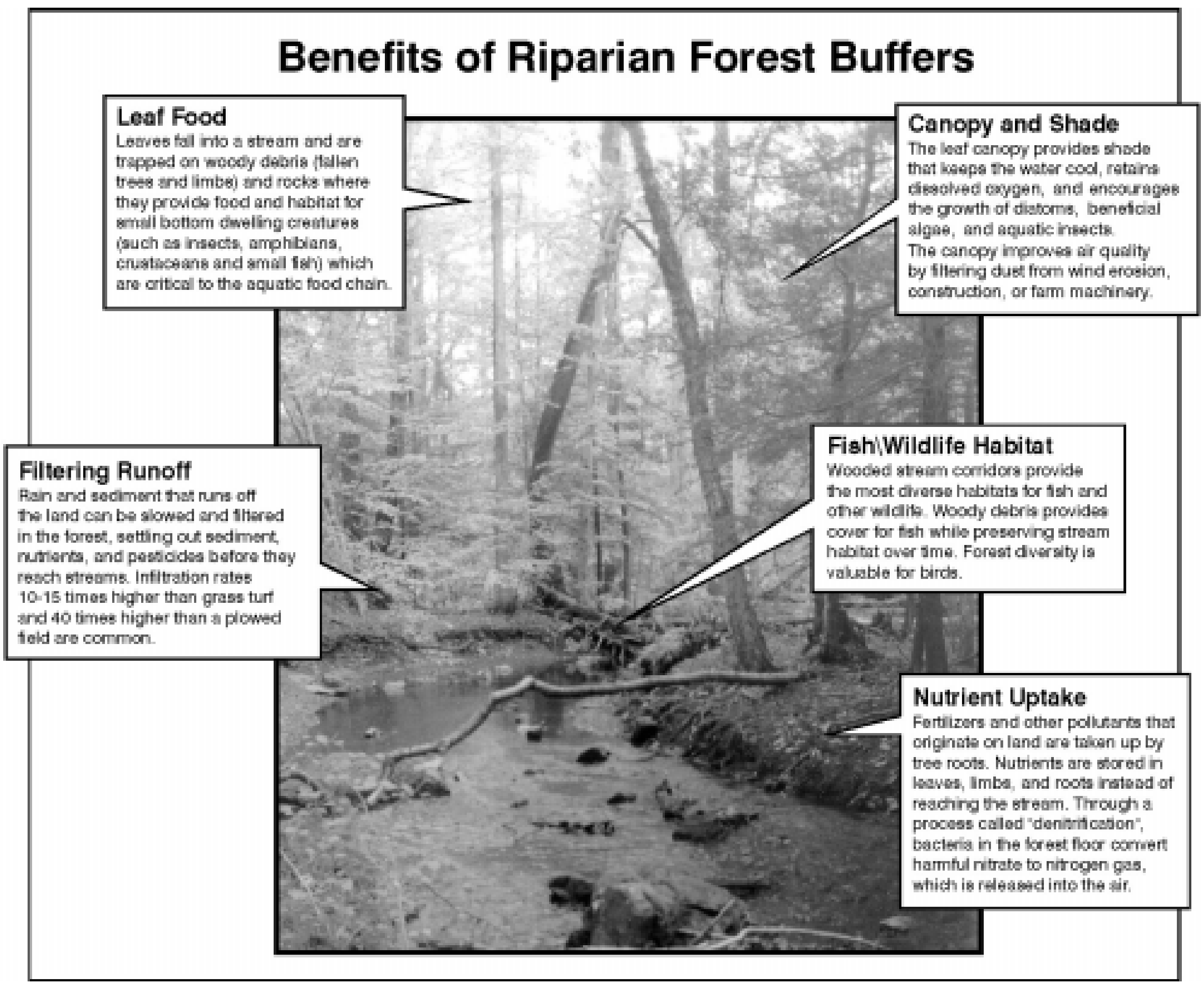


Figure 3 - 2. Benefits of Riparian Forest Buffers. (Source: Alliance for the Chesapeake Bay, January 1996)

suitable site for plants that could not occur in areas with inadequate water. This increases plant diversity.

- The shape of many riparian areas, particularly their linear meandering nature along streams, provides a great deal of productive edge.Riparian areas frequently produce more edge within a small area.
- Along streams, there are many layers of vegetation exposed in stair step structure. The stair step of vegetation of contrasting form (deciduous vs. coniferous, shrubs vs. trees) provides diverse nesting and feeding opportunities for wildlife.
- Riparian areas along intermittent and permanent streams and rivers provide travel routes for wildlife. These may serve as forested connectors between wooded habitats. Wildlife may use such habitat for cover to travel through otherwise unforested agricultural or urban areas.

Principles of the Riparian Ecosystem

Definition of Terms

To better understand the important wildlife values that riparian areas provide, concepts of the ecosystem and the food web are addressed first. An ecosystem is the area in which one lives. Derived from "Eco," which is the Greek word meaning "Home," ecology is the study of the "Home." So, an ecosystem is the "system" or "make up" of one's "home." This home could be as small as under a rock in a stream or as large as the entire Chesapeake Bay Watershed. When thinking about the importance of riparian areas to wildlife, the type and species of wildlife being managed must be considered along with relative ecosystem size. Smaller systems are connected to a larger ecosystem, providing the base support for the larger system.

An ecosystem includes populations, communities, habitats, and environments, and it specifically refers to the dynamic interaction of all parts of the environment, focusing particularly on the exchange of materials between the living and nonliving parts.

A **population** is a group of interacting individuals, usually of the same species, in a definable space. A **community**, in the biologic sense, consists of the population of plants, animals, and microorganisms living together in a given place.

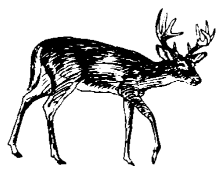
The terms **environment** and **habitat** refer to a definable place where an organism lives, including both the physical and biologic features of the place. The word environment comes from the French verb "environner," to surround, and means surrounding or something that surrounds. It includes all the conditions, circumstances, and influences surrounding and affecting an organism or group of organisms.

A **habitat** is the natural abode or locality of an animal, plant, or person. It is derived from the Latin, "habitare" - to "dwell." It also includes all features of the environment in a given locality.

The term **abiotic** means "without life or nonliving." Many substances such as water, oxygen, sodium chloride, nitrogen, and carbon dioxide are abiotic when they are physically outside living organisms. However, once they are within living organisms they become part of the biotic world. An important property of an ecosystem that determines its productivity is the form and composition in which bioactive elements and compounds occur. For example, an ecosystem may have an abundance of vital nutrients, such as nitrates and phosphates. If they are present in relatively insoluble particulate form, as when they are linked to ferric ions, they are not readily available to plants. When they are in the soluble form of potassium or calcium nitrate and phosphate, they are more readily available. One of the most important qualities of an ecosystem is the rate of release of nutrients from solids; this regulates the rate of function of the entire system.

Photosynthesis is the basic production force in the ecosystem, and it is dependent upon green plants, sunlight, water, carbon dioxide, and certain inorganic ions.

The transfer of energy from plants through a series of other organisms constitutes a food chain. The term **trophic (feeding) level** refers to the parts of a food chain or nutritive series in which a group of organisms secures food in the same general way. Thus, all animals that obtain their energy directly from eating grass such as grasshoppers, meadow mice, and deer are part of the same trophic level.



The particular assemblage of trophic levels within an ecosystem is known as the trophic structure. Typically, ecosystems have three to six trophic levels through which energy and organic materials pass. In more *vernacular* terms, food chains usually have three to six links, or groups of organisms, which derive their nutrition similarly.

It may even be more appropriate to call such trophic structures food webs rather than food chains. The interlocking nature of these relationships is typical of other ecosystems. This interlocking or interaction is extremely important to the overall function and value of riparian buffers.

Structure

It is very important for riparian areas to have structure. Depending on the diversity of the area, the structure can be very simple and not support a wide range of values for wildlife, or it can be complex and supply a wide range of values for many different species of wildlife.

Horizontal and vertical diversity are two components of habitat structure. Horizontal diversity or “patchiness” refers to the complexity of the arrangement of plant communities and other habitats (see Figure 3-3). Different forest types have different wildlife communities. Vertical diversity refers to the extent to which plants are layered in a stand (see Figure 3-4 on the next page). The degree of layering is determined by the arrangement of plant growth forms, by distribution of trees of varying heights and crown characteristics, and by trees of the same species but different ages.

It is important to think of structure and dynamics when managing a riparian area. **Structure** refers to the spatial organization of communities and what part of the area populations utilize. **Dynamics** refers to the interactional processes, energetic relationships, and patterns of change

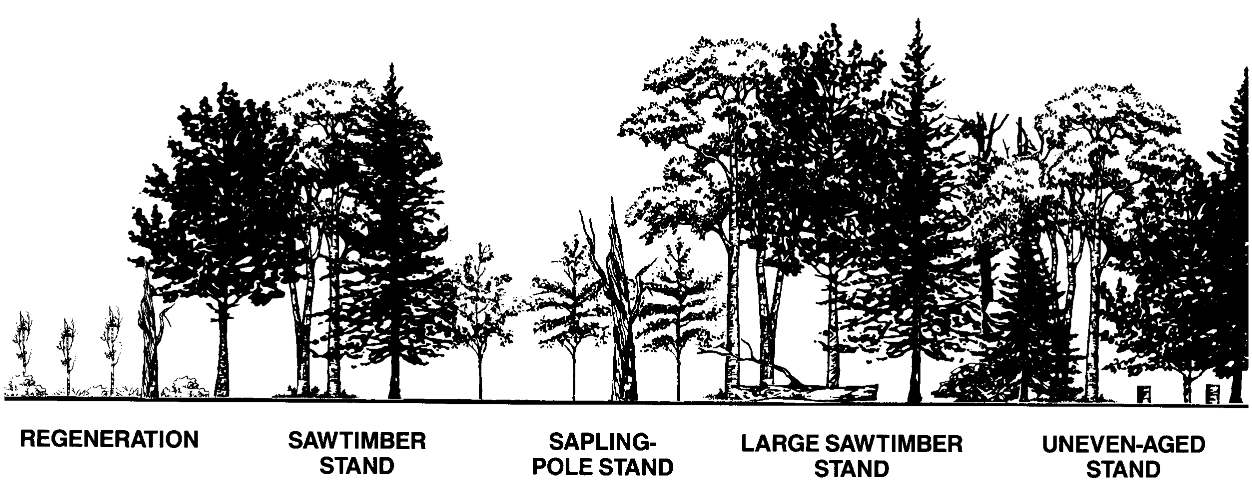
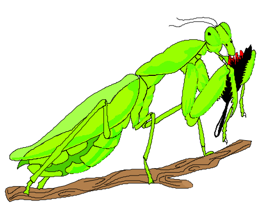


Figure 3 - 3. Horizontal diversity depends on the type of area and size-class management used on a property. (Source: DeGraaf, 1992)

Figure 3 - 4. Vertical diversity depends on the number of vegetative layers present in a stand. (Source: DeGraaf, 1992)

within communities. The riparian forest buffer may be thought of as a layered system, with each layer possessing characteristic populations and a typical organization.

One can obtain a partial glimpse of the dynamic complexity of the forest floor by carefully examining the leaf litter of this biotic community and by turning over a rotten log, or parting the grass and herbaceous cover of the edges. The soil-air interface is a particularly rich and active area for living organisms. There is a variety of insects, isopods, spiders, and myriapods (millipedes and centipedes), but those that are easily seen represent only a small portion of the total community.



They are interacting with a great number of smaller forms—springtails, mites, and nematodes. They are also part of the food chain of vertebrates, such as salamanders, reptiles, shrews, mice, and ground dwelling birds, that patrol the area..

Reptiles and Amphibians that use riparian forested areas as their preferred habitat:

- ***eastern ribbon snake***
- ***eastern worm snake***
- ***green frog***
- ***Jefferson salamander***
- ***mountain dusky salamander***
- ***northern two-lined salamander***

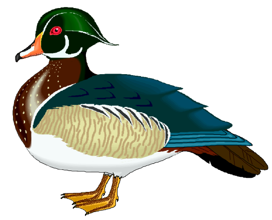
In moving upward from the floor of the riparian forest, the biotic community thins out to a certain extent. Animals become more widely spaced in three dimensions, and they become more mobile. The plant community is dominated by herbs and shrubs and the animal community by insects, birds, and mammals.

Mammals that use riparian forested areas as their preferred habitat:

- ***beaver***
- ***big brown bat***
- ***black bear***
- ***eastern Pipistrelle***
- ***Keen's Myotis***
- ***little brown Myotis***
- ***long-tailed weasel***
- ***mink***
- ***northern short-tailed shrew***
- ***raccoon***
- ***river otter***
- ***silver-haired bat***
- ***Virginia opossum***

Mammals, including deer, rabbits, mice, shrews, raccoons, and opossum, actively forage through the lower layer of the community. Many animal species, including annelids, some molluscs, myriapods, and soil dwelling arthropods, do not enter this realm and are seldom if ever found above the surface of the ground. There are exceptions, of course, such as certain snails (molluscs) which climb trees.

The intermediate, codominant, and dominant canopy layers of the riparian forest, dominated by the foliage of trees and vines, also have their characteristic animal communities. This is the realm of insects and birds. Relatively few mammals penetrate these upper levels. Squirrels, bats, and occasionally opossums and raccoons may be seen in this level, however.



Birds that use riparian forested areas as their preferred habitat:

- ***alder flycatcher***
- ***American goldfinch***
- ***bald eagle***
- ***barred owl***
- ***red-bellied woodpecker***
- ***belted kingfisher***
- ***cerulean warbler***
- ***common yellowthroat***
- ***eastern screech-owl***
- ***eastern wood-peewee***
- ***gray catbird***
- ***Louisiana waterthrush***
- ***northern rough-winged swallow***
- ***northern waterthrush***
- ***prothonotary warbler***
- ***red herons***
- ***red-shouldered hawk***
- ***song sparrow***
- ***tufted titmouse***
- ***veery***
- ***wood duck***
- ***yellow-breasted chat***
- ***yellow warbler***

Stratification is evident in bird populations that are obviously capable of ranging throughout the riparian forest from the floor to the canopy. Birds have definite preferences and tendencies to frequent certain layers. Morley showed a definite stratification of bird life: in the upper canopy, tree creepers (Certhia sp.); and robins and wrens on the ground and the herbaceous zone. These patterns of vertical distribution reflect the feeding habitats of the birds and are an indication of the distribution of seeds and insects.

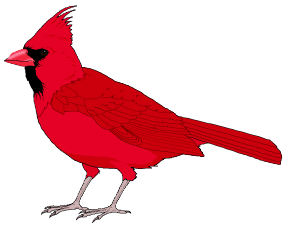
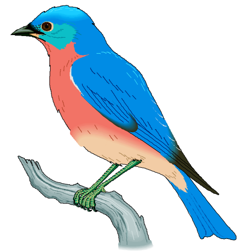


Table 3-1 describes some plants used by common songbirds for food, cover, and nesting. Morse has shown that the stratum distribution of many birds within the forest is further limited to specific sites. He found, for example, that the brown creeper (Certhia familiaris) and white breasted nuthatch (Sitta carolinensis) forage mainly on the lower part of tree trunks, whereas the downy woodpecker (Dryobates pubescens) and the Carolina chickadee (Parus carolinensis) forage on twig tips high in the canopy.



As described, these riparian forests provide a home, or habitat, for many kinds of wildlife-game animals, songbirds, and many forms of tiny insects and animal life. Hundreds of kinds of plants make their home under this forest canopy and could not exist without it. The important elements of a wildlife habitat are food, cover, and water. The combination and balance of these factors determines the kinds of wildlife to be found in any riparian forest area. Table 3-2 lists some wildlife food plants for specific wildlife species and seasons available.

Table 3 - 1.

Native Plants Used by Common Songbirds for Food, Cover, and Nesting

PLANT	BIRD												
	Bluebird Thrush	Bunting	Cardinal Grosbeak	Catbird Thrasher	Finch Siskin	Jay	Mockingbird	Oriole Tanager	Robin	Sparrow Junco	Titmouse Nuthatch	Towhee	Waxwing
Ash			✓	✓	✓			✓					✓
Bayberry	✓		✓	✓			✓			✓	✓		
Bittersweet	✓	✓	✓	✓			✓		✓				✓
Blackberry	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
Blueberry	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
Cedar	✓		✓	✓	✓		✓		✓	✓			✓
Cherry	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Crabapple	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
Dogwood	✓		✓	✓	✓		✓	✓	✓	✓		✓	✓
Elderberry	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Grape	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
Hawthorn	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓
Hickory			✓			✓							
Holly	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
Honeysuckle	✓	✓	✓	✓	✓		✓		✓	✓			✓
Maple					✓			✓	✓	✓			
Millet		✓	✓		✓	✓				✓	✓	✓	
Mulberry	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Oak			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Pine	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓
Plum			✓	✓		✓	✓	✓	✓			✓	

PLANT	BIRD												
	Bluebird Thrush	Bunting	Cardinal Grosbeak	Catbird Thrasher	Finch Siskin	Jay	Mockingbird	Oriole Tanager	Robin	Sparrow Junco	Titmouse Nuthatch	Towhee	Waxwing
Pokeberry	✓		✓	✓			✓	✓	✓	✓			✓
Pyracanthia	✓	✓	✓	✓	✓	✓	✓		✓	✓			✓
Rose	✓		✓	✓	✓		✓		✓	✓			✓
Sassafras	✓			✓			✓		✓			✓	
Serviceberry	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Spicebush	✓		✓	✓					✓	✓			
Spruce			✓		✓	✓	✓		✓	✓	✓		✓
Sumac	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
Sunflower		✓	✓		✓	✓				✓	✓	✓	
Viburnum	✓	✓	✓	✓	✓	✓	✓		✓	✓			✓
Virginia Creeper	✓	✓		✓	✓	✓	✓	✓	✓		✓		

Table 3 - 2
Wildlife Food Plants

Plant Species	Wildlife Species Using Plants for Food	No. of Species Using Plants	Seasons Available[a]
Ash	cardinal, purple finch, evening grosbeak, pine grosbeak, cedar waxwing, yellow-bellied sapsucker, wood duck, bobwhite quail, black bear, beaver, porcupine, white-tailed deer	20	W
Blackberry	brown thrasher, chipmunk, gray catbird, rabbit, ring-necked pheasant, robin, white-tailed deer	56	S, F
Cherry	black bear, cedar waxwing, raccoon, red squirrel, rose-breasted grosbeak, ruffed grouse, white-footed mouse	56	S, F
Grape	black bear, cardinal, fox sparrow, gray fox, mockingbird, ruffed grouse, wild turkey	53	S, F, W
Ragweed	dark-eyed junco, goldfinch, horned lark, mourning dove, red-winged blackbird, sparrows	49	F, W
Dogwood	bluebird, cardinal, cedar waxwing, rabbit, ruffed grouse, wild turkey, wood duck	47	S, F, W
Oak	black bear, blue jay, raccoon, ruffed grouse, white-tailed deer, wild turkey, wood duck	43	Sp, F, W
Sedge	horned lark, ruffed grouse, sparrows, wild turkey	43	Sp, S
Serviceberry	beaver, bluebird, cardinal, cedar waxwing, gray catbird, red squirrel, scarlet tanager, white-tailed deer	39	Sp, S
Blueberry	black bear, gray catbird, rabbit, rufous-sided towhee, skunk, white-footed mouse, white-tailed deer	37	S, F
Elderberry	bluebird, brown thrasher, cardinal, indigo bunting, rabbit, rose-breasted grosbeak	36	S
Pine	beaver, black-capped chickadee, brown creeper	33	W
Panic grass	dark-eyed junco, sparrows, red-winged blackbird, wild turkey	32	F
Beech	black bear, blue jay, chipmunk, porcupine, ruffed grouse, squirrels, tufted titmouse, white-tailed deer, wild turkey	31	Sp, W
Poison Ivy	black-capped chickadee, gray catbird, downy woodpecker, flicker, hairy woodpecker, hermit thrush, wild turkey	28	F, W

Table 3 - 2 (cont.)
Wildlife Food Plants

Plant Species	Wildlife Species Using Plants for Food	No. of Species Using Plants	Seasons Available[a]
Sumac	bluebird, cardinal, black-capped chickadee, hermit thrush, rabbit, robin	28	F, W
Maple	beaver, chipmunk, porcupine, rose-breasted grosbeak, squirrels, white-tailed deer	27	S, F
Pokeweed	bluebird, cedar waxwing, gray catbird, gray fox, mourning dove, raccoon, red fox	25	F
Greenbriar	gray catbird, hermit thrush, mockingbird, raccoon, ruffed grouse	23	F, W
Birch	black-capped chickadee, beaver, porcupine, rabbit, ruffed grouse	22	Sp, S
Virginia creeper	bluebird, great-crested flycatcher, pileated woodpecker, red-eyed vireo	22	F, W
Hickory	chipmunk, red-bellied woodpecker, rose-breasted grosbeak, squirrels, wood duck	19	Sp, S, F, W
Aspen	beaver, porcupine, ruffed grouse, white-tailed deer	17	Sp, S, F, W
Hawthorn	fox sparrow, gray fox, raccoon, ruffed grouse	15	S, F
Hemlock	black-capped chickadee, porcupine, red squirrel, ruffed grouse, white-footed mouse	13	F, W
Walnut	red-bellied woodpecker, beaver, fox squirrel, gray squirrel, red squirrel	7	F, W
Yellow-poplar	redwing blackbird, cardinal, chickadee, purple finch, goldfinch, hummingbird, yellow-bellied sapsucker, beaver, red squirrel, fox squirrel, gray squirrel, white-tailed deer	14	Sp, S F, W
Alder	beaver, goldfinch, ruffed grouse	11	Sp, S, F, W

Source: Adapted from Martin, A. C. et al. 1951.
[a] Sp = spring, S = summer, F = fall, W = winter.

Although the species that live in stream corridors differ from one part of the region to another, all wildlife has similar basic needs: food, water, and shelter – collectively called habitat. In Maryland, different wildlife lives near a fast-flowing, cool stream in the western part of the state than a slow-flowing, warm stream on the Eastern Shore, or near an urban stream in central Maryland.

Travel Corridors

Riparian forests are transition zones between wet lowlands and drier upland habitats. They often include a greater variety of plant types and habitats than neighboring uplands areas. They tend to be linear, creating a series of travel corridors and natural edges from the water to the uplands. In areas of intensive farming, where agricultural operations remove most crop residues, riparian vegetation provides cover for reproduction, escape, nesting, and protection from the weather. Where farmlands are bare for most of the year, riparian areas provide abundant food and water year-round.

Riparian forests also provide corridors for wildlife to move from one area to another. This is especially important in winter, where cover is nearby and travel is easier because of reduced snow depth. Young birds and mammals use riparian areas during dispersal from their birth place. Migrating birds often use these areas and wetlands for resting. The wildlife trees (snags and den trees) found in these areas are used extensively for nest sites and perches. Riparian areas also serve as links between different types of habitat, providing dispersal and travel routes for species that would not otherwise cross large openings or cuts. It is extremely important that these riparian buffer corridors are linked to other areas of cover.

There were two studies conducted in the Chesapeake Bay Watershed that examined the use of forest corridors by songbirds. One study examined use of riparian buffers of different widths by breeding birds. Those authors recommended a minimum buffer width of 100 meters to attract breeding neotropical migratory birds, because many of those species were not present in narrower buffers. Yet, past research has indicated that, even if a species of songbird is present, reproduction success of that species may be lower in narrow strips compared to larger habitat patches. Thus, only wide riparian buffers may provide high-quality breeding habitat for many songbird species.

Another study conducted by the Smithsonian Institution indicated that forest corridors, including riparian buffers, may be very important for songbirds during migration. In that study, more species of migratory songbirds were found in large (greater than 500 hectares) rather than in small (less than 100 hectares) forest tracts. This was the case whether or not the tracts were connected to other forests by corridors. However, small tracts that were connected to other forests by an intervening corridor supported significantly more species than did isolated small tracts. Here, the presence of a corridor apparently increased the use of small forest tracts by migrating birds, possibly by serving as a connection to other habitat patches.

The few studies conducted on wildlife use of corridors have suggested that corridors may be beneficial for movement of individuals during some periods, but may not provide high-quality breeding habitats.

For example, riparian buffers that join with large forest tracts may not be needed to provide high-quality breeding habitat for songbirds. These areas still may provide breeding habitat for some reptiles, amphibians, or invertebrates and be useful connecting habitat for migrating songbirds. In most cases, vegetation within riparian buffers should be planted or managed to maintain both a high structural diversity and a high plant species diversity using native plant species.

Fish Habitat

The Riparian Forest as a Food Source

Macroinvertebrates, including aquatic insects, are important sources of food for fish. The presence or absence of riparian trees may be the single most important factor altered by humans that affects the structure and functions of stream macoinvertebrates. Several changes occur in a watershed as a result of removing the riparian forest buffers. Watercourses become much narrower, resulting in less benthic area. Once trees are removed, grasses take over, sod forms, and the stream narrows rapidly. Tree removal results in loss of tree root systems, an important component of fish habitat.

Aquatic macroinvertebrates can be herbivores, detrivores (scavengers), carnivores (predators), or parasites. Aquatic insects can be classified by the specialized way in which they obtain food as follows:

1. shredders – chew, mince, or gouge coarse particulate detritus or live macrophytes (example - some caddisflies)
2. scrapers – scrape diatoms and other food from rocks (example - mayflies, stoneflies)
3. collectors – gather fine particulate detritus loosely associated with the sediment or from the surface film (example - some caddisflies)
4. piercers – pierce and suck the contents of green plants or of animals (example - true bugs, waterstriders)
5. predators – attack live prey and ingest whole or parts of animals (example - dragonfly, damselfly, hellgrammite)
6. parasites – live in or on aquatic animals, not necessarily killing them
7. filter feeders – filter particles suspended in the water column (example - blackflies, caddisflies that spin silk nets)
8. grazers – remove attached periphyton and material closely associated with mineral or organic substrates (example - mayflies, stoneflies)

As aquatic insects go through different stages in their life cycles, they become different types of feeders.

Quality and quantity of food deteriorates when riparian trees are removed. Loss of the forest canopy allows high light levels to reach the watercourses. This promotes the growth of filamentous green algae, which few, if any, aquatic species eat. Shade promotes diatoms, a good food source for all macroinvertebrates, especially caddisflies and mayflies. Seeds, twigs, and leaves are also a good source of dissolved organic chemicals. The chemicals support beneficial bacteria, which in turn support protozoans and higher forms of animal life. Some macroinvertebrates eat leaves directly. It is not uncommon for small Pennsylvania streams flowing through forested land to contain more than 1,000 grams of leaf material per square meter in November. In a healthy stream, most of the food is consumed by the following April. Leaves generally travel less than 220 feet from where they enter small streams and are eaten by mayflies and caddisflies.

Most species of insects seem to prefer and flourish best on a particular tree species. If preferred trees are removed and replaced with less desirable species, some species of insects will vanish from a watershed. Sycamore is a good species for most insects, as are sweet birch, river birch, and red maple. For example, certain stonefly species grow best by eating chestnut oak leaves. Some stoneflies need to eat the flowers of riparian trees in order to survive. Removal of the riparian forest eliminates tree flowers (food) that stoneflies must have to complete their life cycle. Some species of caddisflies need hollowed out twigs with which to build a home, while others actually eat the wood for food (like termites do).

How Sediments Adversely Affect Fish Habitat

Sediment by weight is the largest single pollutant of water resources in the United States. Sediment entering watercourses is caused by rainsplash erosion and sheetwash erosion. Sediment reduces the productivity of aquatic plant, invertebrate, and vertebrate communities. It can threaten the survival of fish by covering essential spawning grounds, covering eggs, and preventing emergence of recently hatched fry. Sedimentation is one of the major causes of decline in the quality of fisheries throughout the United States. Turbidity in excess of 100 ppm can inhibit fish growth and reproduction. Studies have shown that 2mm of silt deposition caused 100 percent mortality in white perch eggs, and 0.5 to 1 mm of sediment caused 50 percent mortality in adults.

The Use of Riparian Forest Buffers to Moderate Stream Water Temperatures

Water temperature is very important in assessing water quality. As water temperature increases, the capacity of water to hold oxygen decreases. At elevated water temperatures, there is a risk of oxygen depletion as a result of the decomposition of organic matter.

Temperature also affects the release of nutrients attached to sediment particles. As water temperature increases, the solubility of the nutrients increases. Slight increases in water temperature can produce substantial increases in the amount of phosphorus released into the water.

The removal of trees and other streamside vegetation will cause detrimental effects. During hot summer months, a stream that is not shaded will not be able to hold oxygen required for aquatic life. Lack of oxygen, coupled with the release of more nutrients into the water is disastrous. An increase in sunlight and nutrients will cause large algal blooms, further decreasing water quality and aquatic habitat.

Temperature increases can cause a shift in the aquatic community from more desirable species to less desirable species that are more tolerant to elevated water temperatures. This is an important concern in the coldwater fish habitat of the Chesapeake Bay Watershed. Water temperature must be controlled if the region is to promote outdoor recreation that includes an emphasis on fishing. In addition, if streamside vegetation is removed from headwater areas, optimum breeding areas for important game fish may be destroyed. An increase in temperature in these areas will cause fish to stop reproduction activities.

Studies show that maintenance of forest buffers along streams is an excellent way to moderate stream temperatures. One study compared stream temperatures of two streams; one flowing through cropland and the other flowing through a forest (see Figure 3-5). The cropland stream, which had no forest buffer, had a maximum temperature that was 5 to 13 degrees Celsius warmer than the stream flowing through a forest. Not only did the buffer keep the water temperature cooler during the summer months, but it kept the stream warmer during the coldest months of winter. Studies in southeastern Pennsylvania have shown that during the summer months, streams passing through open fields are 10 degrees Fahrenheit warmer than streams passing through forest shade. The streams in the open fields are usually too warm to support trout all year.

Studies show that temperature minimums during summer months are greater for streams with no forest buffer. If the temperature is elevated for prolonged periods of time, there will be an adverse impact to the energy budget of the aquatic ecosystem. If nearstream vegetation is left to shade the stream, only minor changes in stream temperature will result. If forested buffers are maintained adjacent to streams, significant decreases in water temperature will result. Grass buffers cannot provide this benefit.

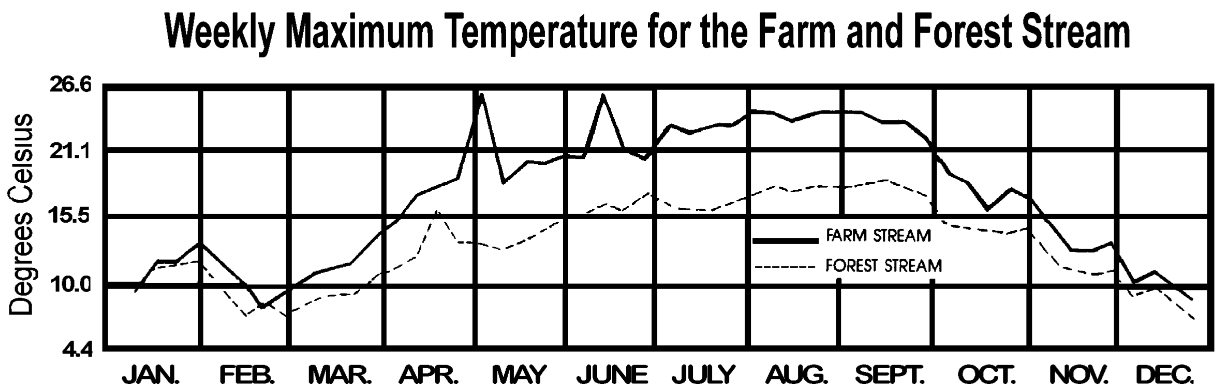


Figure 3 - 5. Riparian forests are very important for shading streams and keeping water temperatures lower. As water temperature increases, the stream has less ability to hold oxygen. Oxygen is needed for plants and animals to survive. A cropland stream with no forest buffer is 5 to 13 degrees Celsius (generally 10 degrees Fahrenheit) warmer than a forest stream. (Source: G.F. Greene, 1950. Land Use and Trout Streams, Journal of Soil and Water Conservation.)

Research statistics have shown that angular canopy density (a parameter used to measure shading) is strongly correlated with temperature control. The width of the buffer is also related to the effectiveness of the buffer to regulate stream temperatures. The research recommends that canopy density be kept at least at 80 percent coverage. It concludes that the maximum shading ability is reached within a width of 80 feet, with 90 percent of the maximum reached within 55 feet.

Buffer effectiveness in controlling temperature increases as stream size decreases. Usually, the smaller streams have the greatest temperature problems; therefore, if temperatures are controlled in the upper reaches of the watershed, temperature problems in larger downstream channels will be controlled as well.

Table 3-3 shows the range of some habitat requirements for typical fish.

Large Woody Debris as Fish Habitat Enhancement

One of the most important functions of the riparian forest buffer is the addition of large woody debris (LWD) to a stream. LWD is the natural accumulation of trees, branches and root wads, at least 10 centimeters (4 inches) in diameter, upon which a large number of aquatic organisms depend. LWD becomes lodged, forming pools that are needed by trout for sur-

Table 3 - 3
Habitat Requirements of Major Families of Fish

Family	Oxygen	Temperature	pH	Turbidity Tolerance
Carp	>0.5 ppm	70-90° F	7.5-9.0	High
Catfish	>4.0 ppm	70-90° F	7.5-9.0	High
Sunfish (including Bass)	>5.0 ppm	73-80° F	7.5-8.5	Low-moderate
Trout	>5.0 ppm	50-60° F	6.0-8.0	Low

vival. LWD in the form of overhanging logs, debris jams, and root wads provides complex cover for fish that is used for hiding from predators or to stalk prey. LWD provides food and shelter to micro- and macro-organisms that are eaten by fish. Lack of LWD results in lower fish numbers, lower average size, and lower biomass for both warmwater and coldwater fish species. Most LWD debris originates within 60 feet of a stream, so it is imperative that the riparian forest is established if fish habitat is be to maintained. Ideally, streams supporting fish should have 75 to 200 pieces of large woody debris per stream mile.

Different types of vegetation play certain roles in maintaining a healthy aquatic habitat. Both the size and type of vegetation within the riparian area are important in creating a productive and stable environment. Table 3-4 gives benefits of vegetation to aquatic ecology.

Management Considerations

How wide should a riparian buffer be to provide these benefits? It depends on the conditions of the site, but most experts agree that 50 to 100 feet of natural riparian buffer is adequate to protect water quality and improve stream conditions for fish and other aquatic organisms. A corridor of this width also will provide suitable habitat for many wildlife species such as wood ducks, herons, kingfishers, beaver, muskrat, songbirds, pheasants, quail, fox, deer, raccoons, turtles, snakes, salamanders, and frogs.

Careful management of stream corridors can make naturally good habitat even better. Before designing riparian buffers to enhance their value for wildlife populations, land managers should consider the following key issues:

1. Which wildlife species are of the greatest conservation priority in the region?
2. How important would the corridor be as habitat for those priority species within the region?

Table 3 - 4

Benefits of Vegetation on Aquatic Ecology

VEGETATION	BENEFITS
Trees and shrubs overhanging the stream.	• Shade lowers the water temperature, which improves the conditions for fish. • Source of large and fine plant debris. • Source of terrestrial insects that fish eat.
Leaves, branches, and other debris in the stream.	• Helps create pools and cover. • Provides food source and stable base for many stream aquatic organisms.
Roots in the stream bank.	• Increases bank stability. • Creates overhanging bank cover.
Stems and low-growing vegetation next to the watercourse.	• Restarts movement of sediment, water, and debris floating in flood waters.

3. Can the buffer be enhanced enough to meet the minimum area requirements of target wildlife species?

Planting certain types of trees and shrubs can enhance some areas. For example, pheasants find wild grapes and dogwood highly desirable, and quail find certain types of lespedeza desirable. The Maryland Department of Natural Resources - Forest Service sells "conservation packets" of plant materials through the state nursery. These packets can be very useful in riparian buffer enhancement. A variety of tree species provides a wide array of wildlife food, dens, roosts, and nesting sites. A combination of tree sizes provides tall, medium, and short tree heights, with each height serving as specific habitat for different species of wildlife.

There are many factors to consider when choosing plant materials for each Zone of the riparian buffer, depending on the landowner's objective and what Zone is being planted. Table 3-5 is a partial list of trees, shrubs, and grasses that could be planted within the riparian area. It shows how each benefits wildlife. It is important to select vegetation that may be periodically subjected to flooding. Although this list is not all inclusive, it lists several plant species that could be used within the riparian area.

Table 3 - 5

Plant Species That Grow Well in the Riparian Area and Their Value to Wildlife

Common Name	Vegetation Type	Wildlife Value
River birch	tree	good; cavity nesting
Black willow	tree	high; nesting
American beech	tree	high
Eastern cottonwood	tree	low
Green ash	tree	low
Silver maple	tree	moderate
Red maple	tree	high; seeds/browse
Sweetgum	tree	low
Sycamore	tree	high; cavity nesters
American hornbeam	tree	low
Bitternut hickory	tree	moderate; food
Flowering dogwood	tree	high; food (birds)
Persimmon	tree	extremely high; mammals
Boxelder	tree	low
Baldcypress	tree	low
Black locust	tree	low
Pawpaw	tree	high; fox & opossum

Common Name	Vegetation Type	Wildlife Value
American holly	tree	high; food, cover, nests
Black walnut	tree	high
Eastern redcedar	tree	high; food
Yellow-poplar	tree	low
Sweetbay	tree	very low
Blackgum or sourgum	tree	moderate; seeds
Hophornbeam	tree	moderate
Swamp tupelo	tree	high
Red bay	tree	good, food (quail/ bluebirds)
Loblolly pine	tree	moderate
White oak	tree	high; food (on well drained sites)
Overcup oak	tree	high
Swamp chestnut oak	tree	high
Water oak	tree	high
Cherrybark oak	tree	high
Willow oak	tree	high; mast
Eastern hemlock	tree	high; nesting
Southern wax myrtle	shrub	moderate
Common spicebush	shrub	high; songbirds
Winterberry	shrub	high; cover & fruit- (birds). Holds berries in winter.
Pussy willow	shrub	moderate; cover- (birds) & nectar- (butterflies)
Sweet pepperbush	shrub	high
Red-osier dogwood	shrub	high
Silky dogwood	shrub	high; mammals & songbirds
Witch-hazel	shrub	moderate
Hackberry	tree	high

Common Name	Vegetation Type	Wildlife Value
Buttonbush	shrub	moderate; (duck/shore birds) & nectar (hummingbirds)
Gray dogwood	shrub	moderate
Hawthorn	shrub	moderate
American elderberry	shrub	high; food
Arrowwood viburnum	shrub	high
Switch grass	grass	high; cover
Reeds canary grass	grass	high; cover, drought-tolerant
Little or big blue stem	grass	high; cover
Eastern gamagrass	grass	high; cover
Weeping love grass	grass	high; cover
Indian grass	grass	high; cover
Coastal panic grass	grass	high; cover

NOTE: (For use with the three-zone riparian forest buffer system)

1. Zone 1 has the greatest potential for annual inundation of water and the least moisture stress.
2. Zone 2 has the potential for the greatest moisture stress during the summer, because it could be a steep area subject to rapid drying.
3. Zone 3 has the greatest variability, because some plant species have naturally adapted to these areas, and the width could vary greatly.

Grasses integrated as part of riparian forest buffer systems are often used in Zone 3. There are many grass species that provide excellent habitat for birds and other wildlife. Specifically, many of the warm season grasses (Table 3-6 on the next page) provide this valuable habitat in the form of brood rearing cover, nesting habitat, and superior winter cover. These warm season grasses grow upright with some bare ground in between, which provides overhead cover for protection, quality nest sites, and free movement. It also provides more opportunities for food searching in between the clumps by ground feeding wildlife such as quail. It has been documented in Iowa that switch grass plantings dramatically increase nesting success of both game and song birds. Pheasants built 20 percent more nests in switch grass than in orchard grass and alfalfa combination. These warm season grasses also stand upright under snow, offering more winter cover. It is also important to note that the management of many of these warm season grasses requires prescribed burning every one to three years. Prescribed burns stimulate insect life, which is valuable food for chicks, and intense seed set.

Spring is the best time to burn, as the warm season grasses first reach an inch of new growth–usually about April 1. This date can vary from mid-March in a warm spring to mid-April in a cool spring, and it varies in the Piedmont or Coastal Plain.

Table 3 - 6

Minimum Planting Rates for Warm Season Grasses in Zone 3 of the Riparian Forest Buffer

Grass Species	Planting rate (lb/acre)
Switch grass	5*
Big Bluestem	7
Indian grass	7
Coastal Panic grass	8
Weeping Love grass	3**

*lb is in PLS, which means pounds of pure live seed, not bulk. This is especially important on fluffy seeds and those with low germination.
**Often seed is mixed with other grasses or 5 pounds Korean or Kobe *Lespedeza.*

May and June are the preferred planting months for warm season grasses. In Coastal Plain areas, late April is suitable, and some people have good planting results into the first few days of July in the Piedmont. Minimum planting rates are given in Table 3-6.

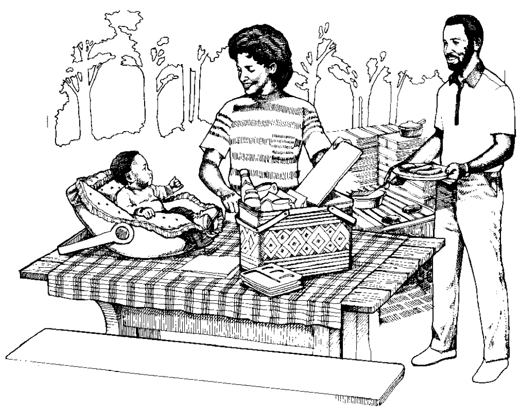
When planning and maintaining a riparian forest buffer in a suburban area, the following must be taken into consideration:

1. Corridors in the suburban landscape frequently are surrounded by commercial, residential, and industrial developments. These habitats harbor species that are predators to forest dwellers, such as cowbirds, raccoons, and domestic cats.
2. Corridors may already be planted to non-native species, such as Norway maple, that can cause the slow deterioration of the vegetation structure and diversity of the forest ecosystem.
3. The wildlife population in the corridor may depend on large forest patches for survival during some portion of its life cycle.
4. The wildlife population densities are naturally low such that they must receive immigrants in order to survive in isolated patches.
5. The wildlife population cannot move from forest patch to patch without an interconnecting forest corridor.

In summary, riparian areas vary considerably in size and vegetation makeup depending on characteristics such as gradient, aspect, topography, soil type of stream bottom, water quality, elevation, and plant community. Riparian areas are used by wildlife more than any other type of habitat; they are one of the most productive wildlife habitats in many areas of the Chesapeake Bay Watershed.

Aesthetics and Outdoor Recreation Functions/Values of Riparian Forest Buffer Systems

Riparian forests enhance the natural beauty of streams within the Chesapeake Bay Watershed by increasing their aesthetic value. A variety of trees and other green vegetation on the landscape provides an enjoyable scenic view and stimulates appreciation of the natural environment.

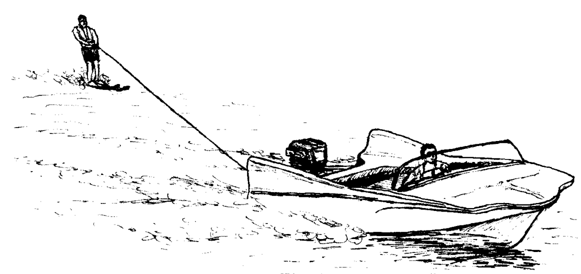


Riparian forests, which include streamside management zones, furnish a variety of recreational values. An important function of riparian forests is their use as urban area greenway systems with linear parks. Greenways, resulting from establishing riparian forest buffers, will be particularly advantageous to residents of Chesapeake Bay urban areas experiencing a shortage of green space. Riparian forest buffers offer urban residents an alternative to cement and concrete and a solace for rest and relaxation. Increased greenspace improves the overall quality of life in both rural and urban areas. It offers people a beautiful natural setting in which to recreate, socialize, and enjoy all forest resources.

The Pennsylvania Citizen's Advisory Council found that the Pennsylvania state forest system is experiencing a dramatic increase in recreational use. With demand for recreation resources on the rise, riparian forest buffers not only contribute to natural resource conservation and clean water, but they also enhance existing state, county, and municipal park and forest systems within the Chesapeake Bay Watershed. Riparian forest buffer establishment serves as additional greenspaces offering alternative places for recreational opportunities in the Chesapeake Bay Watershed. Both watershed residents and visitors will benefit from an increase in greenspace.

Recreational activities can be a revenue-generating mechanism for the landowner. Fees, especially for hunting privileges, are often charged on a per acre basis and are considered routine compensation for landowners in the Chesapeake Bay Watershed. For example, in Virginia, nearly two-thirds of its citizens over the age of sixteen participated in wildlife-related recreation spending $1.1 billion annually.

There are two forms of recreational settings that occur in riparian areas – developed and dispersed. Natural resource managers who establish riparian forest buffers must consider the landowner objectives for recreation when developing and implementing a resource plan.



Some developed recreation areas are designed specifically to attract visitors to riparian areas. Developed recreation areas place more emphasis and reliance on specially improved constructed facilities to enhance visitor comfort, convenience, and safety. These facilities are usually concentrated in areas that have easy access. Developed campgrounds may provide restrooms and showers, paved roads and drive-ups, designated camp sites, tent pads, grills, and picnic tables. These areas have a tendency to attract more people in a concentrated area. Developed campgrounds have designated campsites in close proximity to each other. Many campgrounds are designed with vegetation left between sites providing natural buffer areas, yet there is little privacy. Developed lakes and rivers feature boat ramps, launches, and fishing piers. Other examples of developed areas are ski resorts and golf courses. Occasionally, highly developed recreational areas feature visitor centers and contract with concessionaires to sell food and souvenir items. Developed recreation facilities are provided by public and private entities. Because of the dependence on constructed facilities, there are increased impacts to the surrounding area.

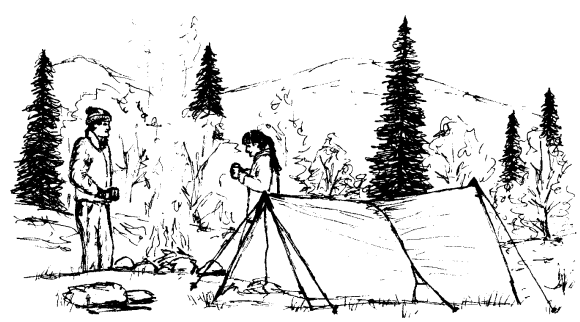
Other riparian areas are more suited to, or may be restricted to, dispersed recreation. In contrast to developed recreation, dispersed recreational activities occur over wide areas in a variety of natural settings, such as entire national, state, and private parks and forests. Dispersed recreational activities are more reliant on the use of natural resources. Facility development is limited to the extent necessary for visitor safety, resource protection, general information, and interpretation. As a result, dispersed recreation is less disturbing to the surrounding environment and more conducive to experiences of solitude and “getting away from it all.” Access to and within dispersed recreational areas may be more difficult than for developed recreation areas. In some dispersed recreation areas, the roads may be low standard, requiring a four-wheel drive vehicle. Trails will be non-existent, or primitive, with little to no maintenance. Signing is minimal or non-existent. Dispersed recreation areas may be located farther from urban areas and require more travel to get to them.

Riparian forest buffers and streamside management zones are suitable for a wide variety of recreational activities. Landowner objectives determine the type of recreation and level of development. It is important to keep in mind that these areas are in close proximity to streams and may have fragile vegetation growing that is not resilient to higher impacts. When deciding upon the type of recreational use, consider the particular environment of the area and plan accordingly. Recreationists should learn and practice leave-no-trace, low-impact outdoor recreation principles in order to help protect riparian areas. Depending on size, location, and natural features, riparian forest buffers provide a beautiful natural setting for a wide range of outdoor recreational activities.

Types of Recreation That Occur in Riparian Forests

Camping and Picnicking

Camping is one of the most popular forms of outdoor recreation, whether in a developed or dispersed setting. Campers must be aware of their impact, especially on streams, and take steps to avoid disturbing them. Human waste and garbage negatively impact water quality. Developed campgrounds are usually intended for car-camping and generally require more space and permanent structures, such as restroom facilities, tent pads, grills, and picnic tables. The addition of these conveniences will cause greater disturbance and impact. In riparian areas, developed campgrounds should be located on higher, stable ground.



Backpacking is a more rugged and primitive form of camping, allowing the recreationist to venture into remote forested areas. Backpackers carry all of their equipment into the forest with them in specially designed backpacks. They must be self-sufficient without relying on constructed facilities. Backpacking is generally less disturbing to forested areas, as long as campers practice leave-no-trace outdoor principles.

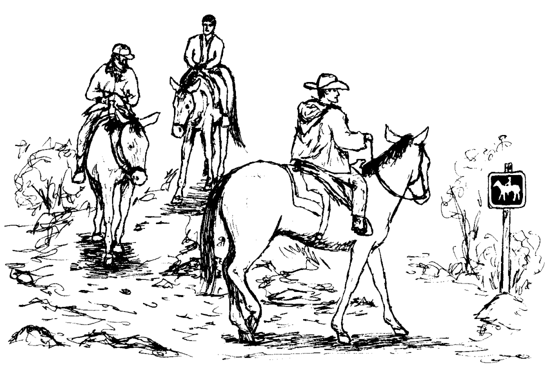
Riparian forests also provide a peaceful location in which to enjoy a picnic with friends and family. Picnicking can be as simple as bringing a picnic basket and a blanket or using designated picnic areas that provide tables, restrooms, and garbage facilities.

Cycling, Motorbiking, and ATVs

Cycling is another form of outdoor recreation and exercise that can be enjoyed within riparian settings, on lightly used roads, or on appropriately designed trails. Cycling not only provides a convenient form of travel for exploring beautiful areas, it also increases the heart rate and tones the lower body. Touring bikes are suitable for paved road cycling, while mountain and motorbiking are suitable for more rugged terrain. Driving ATVs is an increasingly popular recreational activity. Mountain biking, motorbiking, and ATV driving are higher-impact recreational activities that contribute to soil loss and erosion. It is important to find suitable locations designated for these uses in order to avoid excessive disturbance and damage to soils, vegetation, and streams.

Horseback Riding

Horses have become favored recreational animals. Many people enjoy horseback riding on trails through forests and parks. Riparian forests provide an ideal location for a pleasurable horseback riding experience, either solo or with family and friends.



Hunting and Fishing

Because of their close proximity to streams and a variety of habitat, riparian forests are ideal locations for hunting, trapping, and fishing. Hunting and fishing are age-old activities, once undertaken for survival. Today, many people enjoy hunting and fishing as recreational activities.

They allow particicpants to express an inner natural instinct and to commune with nature on nature's terms. Some of the wildlife species found in riparian forests include: deer, elk, black bear, wild turkey, grouse, quail, rabbit, squirrel, raccoon, and waterfowl including ducks and geese. Many people enjoy fishing, whether they release the catch or use fish for food. Riparian forests provide a beautiful and peaceful access for fishing in streams, ponds, lakes, bays, or along ocean beaches.

Relaxing

Relaxing is restorative and pleasurable, providing a respite from hectic schedules and the everyday pressures of life in an increasingly fast-paced world. A riparian forested area is a wonderful location for rest and relaxation. Individuals who choose riparian areas as a place to relax, enjoy peace, quiet, and nature will be recharged and ready to take on the world again. The resulting peace of mind can have far-reaching effects on the whole being. Relaxing in nature is constructive as well. Reflection in and communing with nature can be inspirational, enlightening, and enhancing to the creative processes. Many successful authors have written popular books about the positive benefits and effects of their outdoor experiences. Relaxing can be particularly important to urban communities where a riparian forest can provide recreation and aesthetic values close to home.

Walking/Hiking/Running/Roller and In-Line Skating

Riparian areas provide a natural setting for exercising and enjoying the pleasures of aerobic activities. More people are walking, hiking, and running to improve their overall health and well-being and to reduce stress. Participation in aerobic activities within a refreshing riparian area enhances the emotional and physical benefits. The benefits provide incentive for walkers, hikers, and runners to engage in regular exercise programs. Roller blading is becoming a more popular outdoor recreational activity and a good way to exercise. Skating, an alternative form of aerobic exercise, enables recreationists to cover more miles than simply walking or running. Riparian areas are a valuable resource in suburban and urban areas where the chances for outdoor recreation are sometimes limited.

Water Recreation (Motor Boating, Sailing, Canoeing, Rafting, Kayaking, and Swimming)

More than half of all outdoor recreational activities are water-related. This type of recreation ranges from aesthetic appreciation of water, to observation of waterfowl and aquatic life, to activities occurring in the water. Canoeing, rafting, kayaking, and tubing are increasingly popular recreational activities, as well as snorkeling and scuba diving. Rafting tends to be largely a commercial venture with outfitters guiding large groups; kayaking is both commercial and private. Although some outfitters do guide canoe trips, canoeing is a more solitary activity motivated by the desire for solitude and a wilderness experience.

Canoeing, rafting, and kayaking require put-in and take-out areas. These areas can be wooden docks, concrete boat ramps, built-up gravel and sand beds (mini-docks), or a simple grassy area where use is funneled. These recreationists usually camp in primitive, designated campsites along the shore. Some put-in and take-out areas have shelters, fire rings, and/or picnic tables to use, depending on the land ownership. Land along rivers, lakes, and bay shores often has a combination of owners. Canoeists, rafters, and kayakers need to know who owns the land they desire to use, so they can make appropriate arrangements with the landowner(s). Riparian forests provide access to water-based recreation and a beautiful backdrop for engaging in the activities.

Wildlife Viewing, Birdwatching, Nature Appreciation, Environmental Study, Wildlife and Nature Photography, Collecting for Arts and Crafts

Riparian forests are a natural laboratory for nature appreciation and environmental studies. Many people enjoy studying and collecting shells and rocks dispersed along river banks and lake and bay shores. Wildlife, birds, and waterfowl are interesting to observe in their natural settings.

Many people enjoy photographing wildlife as a hobby or for their professional livelihood. The outdoors also stimulates creative expression in writing, drawing, painting, arts, and crafts. Riparian forests are a good place to find natural materials used in many art and craft projects. Seeds, nuts, shells, leaves, cones, needles, fibers, plants, woods, and flowers are used to make wreaths, terrariums, birdhouses, and other crafts. These are made for personal enjoyment, gifts, and displays, or for arts and crafts businesses.

Winter Recreation (Snowmobiling, Cross-Country Skiing, Ice Skating, and Snow Shoeing)

Many recreationists enjoy the exhilaration of winter sport activities. Cross-country skiing, ice skating, and snow shoeing are relatively low-impact activities that provide opportunities for solitude and exercise. Snowmobiling is a higher-impact, adventuresome, and social-orientated activity. Riparian forests provide another resource for the enjoyment of winter recreation.

The above mentioned outdoor recreational activities can be pursued and enjoyed within riparian forest buffers or streamside management zones. Riparian forest buffers protect and enhance streams and increase the opportunities for recreational pursuits in the Chesapeake Bay Watershed.

References

Allan, J.D. and A.S. Flecker. 1993. Biodiversity conservation in running waters. BioScience 43:32-43.

Capel, S. 1992. Warm season grasses for Virginia and North Carolina - benefits for livestock and wildlife. Virginia Division of Game and Inland Fisheries.

Chesapeake Bay Program. 1994. Riparian forest buffers: restoring and managing a vital Chesapeake resource. Conference proceedings –Riparian Forest Buffers, Chesapeake Bay Program Office; October 5-6, 1994; Ellicott City, MD.

Citizens Advisory Council to the Department of Natural Resources. 1992. These woods are ours. A Report on Pennsylvania’s State Forest System. Harrisburg, PA.

DeGraaf, R.M., M. Yamasaki, W.B. Leak, and J.W. Lanier. 1992. New England wildlife: management of forested habitats. Gen. Tech. Report NE-144. USDA Forest Service, Northeastern Forest Experiment Station.

Dissmeyer, G. and B. Foster. 1986. Some positive economics of protecting water quality for fish. Presentation at SAF National Convention in Birmingham, AL.

Gregory, S.V., F.J. Swanson, W.A. McKee, and K.W. Cummins. 1991. An ecosystem perspective of riparian zones. BioScience 41:540-551.

Groffman, P.M. 1994. Denitrification in freshwater wetlands. p. 15-35, In Current Topics in Wetland Biogeochemistry. Wetland Biogeochemistry Institute, Louisiana St. Univ., Baton Rouge, LA.

Hammitt, W.E. and D.N. Cole. 1987. Wildland recreation. New York, NY: John Wiley & Sons.

Jacobs, T.C. and J.W. Gilliam. 1985. Riparian losses of nitrate from agricultural drainage waters. J. Environ. Qual. 14:472-478.

Jayne, P. and R. Tjaden. 1992. Field border management. University of Maryland Cooperative Extension Service. Fact Sheet #600.

Jordan, T.E., D.L. Correll, and D.E. Weller. 1993. Nutrient interception by a riparian forest receiving inputs from adjacent cropland. J. Environ. Qual. 22:467-473.

Karr, J.R. and I.J. Schlosser. 1978. Water resources and the land-water interface. Science 01:229-234.

Kraus, R. 1994. Leisure in a changing America. New York, NY: Macmillan College Publishing Company.

Kroll, J.C. 1994. A practical guide to producing and harvesting white-tailed deer. 3rd ed. Institute for White-tailed Deer Management and Research. Stephen F. Austin State University, Nachogdoches, TX.

Lowrance, R., L.S. Altier, J.D. Newbold, R.R. Schnabel, P.M. Groffman, J.M. Denver, D.L. Correll, J.W. Gilliam, J.L. Robinson, R.B. Brinsfield, K.W. Staver, W. Lucas, and A.H. Todd. 1995. Water quality functions of riparian forest buffer systems in the Chesapeake Bay watershed. EPA 903-R-95-004. CBP/TRS 134/95. Annapolis, MD. 67pp.

Lowrance, R.R., R.L. Todd, J. Fail, Jr., O. Hendrickson, Jr., R. Leonard, and L. Asmussen. 1984. Riparian forests as nutrient filters in agricultural watersheds. BioScience 34:374-377.

Lusk, A. no date. Getting around in rural America: trails. In: Proceedings of a National Policy Symposium. Enhancing Rural Economies Through Amenity Resources. Penn State University.

Maclean, J.R., J.A. Peterson, and W.D. Martin. 1985. Recreation and leisure: the changing scene. 4th ed. New York, NY: Macmillan Publishing Company.

Martin, A.C., H.S. Zim, and A.L. Nelson. 1951. American wildlife and plants: a guide to wildlife food habits. Dover Publications, NY.

Missouri Conservation Commission. 1985. Trees along streams.

Morse, D.H. Ecological aspects of some mixed species foraging flocks of birds. Ecology Monogram, 40(1):119-168 (1970).

Newbold, J.D., D.C. Erman, and K.B. Roby. 1980. Effects of logging on macroinvertebrates in streams with and without buffer strips. Can. J. of Fish. and Aquatic Sci. 37:1076-1085.

Pais, R. 1994. Wildlife corridors in the suburban environment. Conference Proceedings - Riparian Forest Buffers, Chesapeake Bay Program; October 5-6, 1994; Ellicott City, MD.

Peterjohn, W.T. and D.L. Correll. 1984. Nutrient dynamics in an agricultural watershed: Observations on the role of a riparian forest. Ecology 65:1466-1475.

Petit, L. 1994. Planning forest buffers with wildlife in mind. Conference Proceedings - Riparian Forest Buffers, Chesapeake Bay Program; October 5-6, 1994; Ellicott City, MD.

Phillips, P.J., J.M. Denver, R.J. Shedlock, P.A. Hamilton. 1993. Effect of forested wetlands on nitrate concentrations in ground water and surface water on the Delmarva Peninsula. Wetlands 13:75-83.

Rader, T. 1975. Fish and forests. Pennsylvania Forest Resources - No. 26. December.

Schueler, T. 1995. The architecture of urban stream buffers. Watershed Protection Techniques. Center For Watershed Protection. Vol. 1, No. 4, Summer.

Smith, S. and R. Tjaden. 1993. Songbirds: life history and management. University of Maryland Cooperative Extension Service. Fact Sheet # 613.

Southwick, C.H. 1976. Ecology and the quality of our environments. D. Van Nostrand Company, NY.

Stoddard, C.H. 1978. Essentials of forestry practice. John Wiley and Sons, NY.

Sweeney, B. 1994. Ecology of forested streams in the Chesapeake Bay watershed. Conference Proceedings - Riparian Forest Buffers, Chesapeake Bay Program Office; October 5-6, 1994. Ellicott City, MD.

Sweeney, B. 1993. Effects of stream side vegetation on macroinvertebrate communities of White Clay Creek in eastern North America. Proceedings of the Academy of Natural Sciences of Philadelphia, 144: 291-340.

Sweeney, B.W. 1992. Streamside forests and the physical, chemical, and trophic characteristics of Piedmont streams in Eastern North America. Water Sci. Tech. 26:2653-2673.

Tjaden, R. 1991-92. Eastern cottontail rabbits; bobwhite quail; ring-necked pheasants; ruffed grouse; eastern wild turkeys. University of

Maryland Cooperative Extension. Fact Sheets # 601-604 & 606.

Tjaden, R. 1991-92. Introduction to wildlife habitat. University of Maryland Cooperative Extension. Fact Sheet # 597.

Trial, L. 1992. Life within the water. Conservation Commission of the State of Missouri.

University of Maine Cooperative Extension Service. 1988. A forester's guide to managing wildlife habitats in Maine. University of Maine at Orono.

USDA-Soil Conservation Service and Missouri Department of Conservation. 1985. Stream corridor management. December.

Wade, R. 1992. Planting crops for wildlife. University of Maryland Cooperative Extension. Fact Sheet #598.

Wilson, E.O. 1988. Biodiversity. National Academy Press, Washington, DC.

Section IV

Soils

Soils

Introduction

The purpose of this chapter is to provide an understanding of soils, enabling natural resource professionals to develop suitable and effective forest riparian buffers. This chapter discusses some basic definitions used in soil science and describes the factors of soil formation. The Mattapex soil series, found in Baltimore County, Maryland, serves as a reference to readers throughout the chapter. The Soil Classification system is introduced, and several soil properties essential to forestry are discussed. The chapter explains soil surveys, so they will be more useful to foresters and planners. Next, the chapter examines the importance of hydrologic soil groups and

Land Capability Classes and their importance to forest riparian buffers. Finally, the chapter discusses how soil relates to establishing a riparian forest buffer.

Definitions

Soil

The collection of natural bodies on the earth's surface, in places modified or even made by man of earthy materials, containing living matter and supporting or capable of supporting plants out-of-doors.

Solum

The upper and most weathered part of the soil profile; the A and B horizons.

Ped

A unit of soil structure such as an aggregate, crumb, prism, block, or granule, formed by natural processes.

Hydric Soil

A hydric soil is a soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part.

Organic Soil

A soil that contains at least 20 percent organic matter (by weight) if the clay content is low and at least 30 percent if the clay content is as high as 60 percent. These soils are classified as Histosols.

Mineral Soil

A soil consisting predominantly of, and having its properties determined predominantly by, mineral matter. It usually contains less than 20 percent organic matter, but may contain an organic surface layer up to 30 cm (12 inches) thick.

Factors of Soil Formation

There are 5 factors that determine the development of a soil—parent material, climate, vegetation, topography, and time.

1. Parent material

loess - wind-blown, silty material derived from glacial outwash plains. These materials originally had a high content of weatherable minerals and high base saturation.

glacial till - material deposited by action of glaciers and usually unstratified materials or sediments ranging in particle size from boulders to clay. It is comprised of materials over which the glacier passed, and may be identified by the presence of materials not common to the local area.

Residuum - unconsolidated and partially weathered mineral materials accumulated by the disintegration of rocks in place. The nature of the rocks varies by locality and may include igneous, sedimentary, and metamorphic types.

Colluvium - deposits located at the footslopes of hills or mountains. It is the result of erosion and/or gravity and has little or no sorting.

Alluvium - material transported and deposited by flowing water, either streams or local wash. It may or may not be related to present streams or drainageways. It includes material on bottoms, terraces, gentle footslopes, and some depressions. Stratification may be present in recent deposits.

Unconsolidated Coastal Plain Sediments - materials deposited in both marine and nonmarine environments, but they have not undergone compaction to the extent that they would be classified as rock. The sediments are usually stratified and may include materials from boulders to clay size. The Coastal Plain of the Chesapeake Bay Watershed includes gravels, sands, silts, and clays.

Eolian Sands - sandy material which has accumulated into dune-type topography by wind action.

2. Climate

Soil Temperature Regime

frigid - The mean annual temperature of the soil is lower than 47 degrees F, and the difference between mean summer and mean winter soil temperature is more than 9 degrees F at 50 cm.

mesic - The mean annual soil temperature is greater than 47 degrees F, but lower than 59 degrees F, and the difference between mean summer and mean winter soil temperature is more than 9 degrees F at 50 cm.

thermic - The mean annual temperature of the soil is over 59 degrees F, but lower than 72 degrees F, and the difference between mean summer and mean winter soil temperature is more than 9 degrees F at 50 cm.

Soil Moisture Regime

aquic - The aquic moisture regime implies a reducing regime that is free of dissolved oxygen because the soil is saturated by ground water or by water of the capillary fringe.

aridic - The aridic moisture regime occurs in soils that are dry in all parts more than half the time (cumulative), usually occurring in arid areas.

udic - The udic moisture regime implies that in most years the soil is not dry in any part for as long as 90 days (cumulative).

ustic - This regime is intermediate between the aridic and udic regime. The concept is one of limited moisture, but the moisture is present at a time when conditions are suitable for plant growth.

3. Vegetation/organisms

Vegetation on the surface of soil protects it from erosion and desiccation. This vegetation also moderates soil temperature. Subterranean roots promote soil aeration. As vegetation dies, it adds organic matter both to the forest floor and to the subsurface soil.

Earthworms perform an important function by mixing and cementing soil into small aggregates, resulting in crumbly structure that affects air and water permeability.

Microorganisms in the soil decompose organic matter, decompose and synthesize nitrogenous compounds, and transform mineral compounds. These microorganisms include algae, yeasts, molds, actinomycetes, bacteria, and protozoans.

4. Topography

Within specific geographic regions, many soil properties are related to topography or relief. They include: depth of the solum, thickness and organic matter content of the A horizon, relative wetness of the profile, color of the profile, degree of horizon differentiation, soil reaction, temperature, and degree of pan development.

Classes of Soil Slope Gradient

Soil slope is normally measured and expressed in terms of percentage – the difference in elevation in feet for each 100 feet horizontal. The following slope classes have been established:

A - nearly level, level – 0 to 3 percent

B - gently sloping, very gently sloping – 3 to 8 percent

C - sloping, strongly sloping – 8 to 15 percent

D - moderately steep – 15 to 25 percent

E - steep – 25 to 35 percent

F - very steep – 35 to 55 percent

G - extremely steep – 55 to 80 percent

Position of Site

Land form on which the soil is located:

flood plain - The flood plain refers to the lowest level or levels associated with a stream valley and is sometimes referred to as bottom land, stream bottom, or first bottom. Sediments may be stratified. Soils found in a flood plain normally have little profile development and are subject to periodic inundation unless protected by man.

terrace - This refers to a surface level or a level positioned higher than the active flood plain. It may be associated with either present or past streams. Terraces may or may not flood or show evidence of stratification.

upland - Upland refers to geomorphic land forms, not otherwise designated, on which soils are forming in residuum, glacial till, marine sediments, loess, or mixtures of these parent materials.

footslope - This refers to the position at the base of a slope on which colluvium has accumulated. Such colluvial parent materials are believed to have been transported by gravity and/or local alluvial action. There is generally little or no sorting.

depression - This term refers to a basin which has no visible external or surface drainage. Ponding of water may occur during and following periods of heavy rainfall. A depression is not the result of some man-made structure.

drainageway - A natural or artificial depression on the landscape that provides external surface drainage to a microwatershed within the landscape. It may be found anywhere on the landscape.

5. Time

There are some soil properties that can be used to indicate the relative age of a soil. Older soils, such as Oxisols, have thick B horizons, and younger soils, such as Entisols, have no B horizon. Most soils turn redder with age, with an exception for those soils that develop in red parent material. Older soils generally have more developed structure. Older soils have clay movement into lower horizons, which is denoted by a Bt horizon.

Following is an example soil series description for a soil that occurs in the Chesapeake Bay Watershed. This description is taken from the Soil Survey of Baltimore County, Maryland, written by W. U. Reybold and E. D. Matthews and published in 1976. This description will serve as a reference to the reader as the various soil properties are discussed.

Mattapex Series

The Mattapex series consists of deep, moderately well drained, nearly level to gently sloping soils on uplands of the Coastal Plain. These soils formed in old deposits of silty material underlain by older, coarser textured sediment. The native vegetation is mixed hardwoods that tolerate wetness.

In a representative profile the surface layer is dark grayish-brown silt loam about 9 inches thick. The subsoil, about 27 inches thick, is yellowish-brown and dark yellowish-brown silty clay loam and silt loam that is mottled in the lower part. The underlying material is yellowish-brown mottled silt loam.

Mattapex soils are fairly easy to work, but at times in spring they are not dry and warm soon enough for early planting. Artificial drainage is needed for some crops, especially in the more nearly level areas. These soils are strongly acid to very strongly acid and have a high available moisture capacity. Permeability is moderately slow. Seasonal wetness and impeded drainage impose moderate to severe limitations on Mattapex soils for many non-farm uses. Erosion is a moderate hazard in sloping areas.

Representative profile of Mattapex silt loam, 2 to 5 percent slopes, in a cultivated area on Holly Neck Road, one mile east of Back River Neck Road:

Ap--0 to 9 inches, dark grayish-brown (10YR 4/2) silt loam; moderate, medium, granular structure; friable, slightly sticky; many roots; strongly acid; clear, smooth boundary.

B21t--9 to 17 inches, yellowish-brown (10YR 5/4) light silty clay loam; weak, fine, subangular blocky structure; friable, slightly sticky and slightly plastic; common roots; distinct clay films; very strongly acid; gradual, wavy boundary.

B22t--17 to 26 inches, yellowish-brown (10YR 5/6) heavy silt loam; common, medium, distinct mottles of light brownish gray (10YR 6/2) and few, fine, faint mottles of strong brown (7.5YR 5/8); weak, medium, subangular blocky structure; friable to firm, slightly sticky; few roots; distinct but discontinuous clay films; very strongly acid; gradual wavy boundary.

B3--26 to 36 inches, dark yellowish-brown (10YR 4/4) silt loam; common, coarse, distinct mottles of pale brown (10YR 6/3) and light brownish gray (10YR 6/2); weak, medium, subangular blocky structure; friable to firm, slightly sticky; faint clay films in upper part; very strongly acid; gradual, wavy boundary.

C--36 to 72 inches, yellowish-brown (10YR 5/8) silt loam; many, coarse, prominent mottles of gray or light gray (10 YR 6/1); massive; firm; distinctly gritty with fine sand; very strongly acid.

Hue throughout the profile is either 10 YR or 2.5Y.

In the A horizon, the value ranges from 3 to 5 and the chroma from 1 to 4. The lower value is in undisturbed A1 horizons less than 6 inches thick, and the highest chroma is in undisturbed A2 horizons.

In the B horizon, the value ranges from 4 to 6 and the chroma from 4 to 8. Mottles that have chroma of 2 or less occur in the lower part of the Bt horizon and in the B3 horizon. The Bt horizon is silt loam or silty clay loam that is 18 to 30 percent clay.

The C horizon is similar to the B3 horizon except that it lacks structure. In some profiles a IIC horizon of highly contrasting coarser texture replaces the C horizon. Fine smooth pebbles are in the IIC horizon in places.

The solum ranges from about 30 to 40 inches in thickness.

Mattapex soils resemble Delanco and Woodstown soils in color and drainage but are more silty in the solum. They are deeper to bedrock than Delanco soils and are less sandy throughout the profile than Woodstown soils. Mattapex soils formed in the same kind of silty material as the Matapeake, Beltsville, Barclay, Leonardtown, and Othello soils.

Mattapex silt loam, 0 to 2 percent slopes (MIA). The profile of this soil is similar to the one described as representative of the series, but the lower part of the subsoil generally is mottled with lighter gray colors. Impeded drainage is the principal limitation to use and management. Where drainage is improved, it is well suited to cultivated crops and improved pasture. The choice of plants is more restricted in undrained areas. Capability unit IIw-1; woodland subclass 3o.

Mattapex silt loam, 2 to 5 percent slopes (MIB). This soil has the profile described as representative of the series. Included in mapping are a few moderately to severely eroded areas, and a few areas of soils that have slopes of more than 5 percent. The soil has good surface drainage and does not need drainage improvement for many crops. The hazard of erosion is moderate in tilled areas. Capability unit IIe-16; woodland subclass 3o.

Mattapex-Urban land complex, 0 to 5 percent slopes (MmB). This complex consists of soils of the Mattapex series that have been graded, cut, filled, or otherwise disturbed for nonfarm uses. Included in mapping are some areas where the subsoil is less silty but more sandy than is typical of Mattapex soils.

In about 35 percent of the area of this complex, the soils are relatively undisturbed. In about 40 percent of the complex, the soils have been covered by as much as 18 inches of fill material, or they have had as much as two-thirds of the original profile removed by cutting or grading. The remaining 25 percent of the complex is urban land, where the soils have been covered by fill material to a depth of more than 18 inches, or most of the profile or all of it has been cut or graded away. The fill material is variable, but it generally is from adjacent areas of the same kinds of soils. Roads, streets, sidewalks, and buildings make up a large part of the complex.

Except where fill materials are deep, seasonal wetness limits the suitability of this complex for building sites, septic tanks, and other nonfarm uses. The soil materials, and most fill materials, are fairly suitable for lawn grasses, ornamental shrubs, and other vegetation. In deeply filled or cut areas, suitability of the soil materials must be determined locally at each site. Capability unit and woodland subclass are not assigned.

Soil Classification

In the example of Mattapex soil series, the taxonomic name of the soil is:

Fine-silty, mixed, mesic Aquic Hapludults

Another example, taken from Section II, Physiographic Provinces, is:

Sandy-skeletal, mixed, mesic Typic Dystrochrepts

Categories of soil classification from broadest to most specific are as follows:

1. **Order** - 10 in the U.S. Order indicates the presence or absence of diagnostic horizons (epipedon). The order name is carried on through the whole system. The order of the Mattapex soil is Ultisols. The order from the Section II example is Inceptisols.

2. **Suborder** - These are broken down by differences in wetness in a soil, soil moisture regime, parent material, and vegetational effects. The suborder of the Mattapex series is Udults. The suborder of the Section II example is Ochrepts.

3. **Great Group** - This category denotes degree of expression of horizons. If it is used here, it has not been used in the preceding categories. Soil temperature and moisture regime may be at this level. The great group of the Mattapex soil is Hapludults. The Great Group of the Section II example is Dystrochrepts.

4. **Subgroup** - The subgroup of the Mattapex soil is Aquic Hapludults. The Subgroup of the Section II example is Typic Dystrochrepts. There are three types of subgroups:

<u>typic</u> - typical-within center of range of properties for the soil

<u>intergrade</u> - intergrades to another great group, suborder, or order

<u>extragrade</u> - soils that are not typical. They have a property that differs from the typical.

5. **Family** - This category is related to agriculture and plant growth. It has four parts:

    1) particle size
    2) texture group
    3) soil temperature
    4) soil reaction, in some cases

    Using the Mattapex series, fine-silty is the particle size, and mixed indicates mineralogy. In the Dystrochepts example, sandy-skeletal is the particle size. Mixed is the mineralogy, and mesic indicates the soil temperature.

6. Soil Series - A series is a group of soils that have similar horizons. Characteristics such as horizon arrangement, kind, and thickness distinguish one series from another. Additional soil characteristics such as soil structure, color, texture, and reaction also help to differentiate between series. A series is named for the community near where it was first described, and can be thought of as the common name of the soil.

Soil Characteristics

In order to fully utilize a soil survey, a comprehensive understanding of several soil characteristics is important. It is imperative to analyze the soils in the area prior to developing forest riparian buffers. The characteristics discussed in the next section must be considered before any management activities are planned. Most of them will be evaluated from the soil survey.

Soil Profile

The soil profile is a cross-sectional view of all the soil horizons, the natural organic layers at the soil surface, and the parent material beneath the soil that influences the formation and behavior of the soil.

Soil Horizons

A soil horizon is defined as a layer of soil, approximately parallel to the soil surface. The soil-forming process determines its characteristics. Master horizons are designated by the capital letters O, A, B, C, E and R.

O - organic horizons of mineral soils are: (1) formed or forming in the upper part of mineral soils above the mineral part; and (2) dominated by fresh or partly decomposed organic material.

A - mineral horizons that formed at the surface and (1) are characterized by an accumulation of humidified organic matter intimately mixed with the mineral fraction and not dominated by properties characteristic of E or B horizons (defined below), or (2) have properties resulting from cultivation, pasturing, or similar kinds of disturbance.

E - mineral horizons in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these, leaving a concentration of sand and silt particles of quartz or other resistant minerals.

B - horizons formed below an A or E horizon and dominated by obliteration of all or much of the original rock structure and by:

(1) illuvial concentration of silicate clay, iron, aluminum, humus, carbonates, gypsum, or silica;

(2) evidence of removal of carbonates;

(3) residual concentrations of sesquioxides;

(4) coatings of sesquioxides that result in a different color from horizons above or below;

(5) alteration that forms silicate clay or liberates oxides or both and that forms granular, blocky, or prismatic structure; or

(6) any combination of these.

C - horizons, excluding hard bedrock, that are little affected by soil-forming properties, and lack properties of the above horizons.

R - hard bedrock.

Horizons may be followed by subhorizon symbols, designated by a lower case subscript. Symbols that the natural resource manager should recognize when planning a riparian forest buffer include:

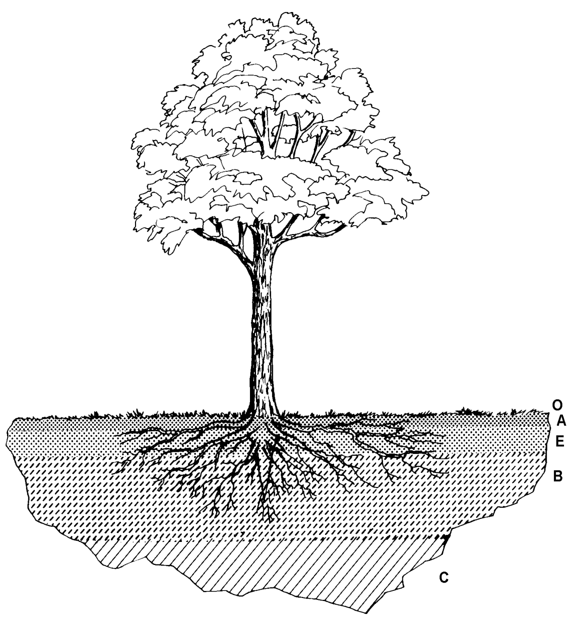
g - strong gleying. This symbol is used to indicate either that iron has been reduced and removed during soil formation or that saturation with stagnant water has preserved a reduced state. This may indicate a hydric soil and/or a wetland.

p - plowing or other disturbance. This symbol is used to indicate disturbance of the surface layer by cultivation, pasturing or similar uses. The Ap horizon is very common in the Chesapeake Bay Watershed.

t - accumulation of silicate clay. This symbol is used to indicate an accumulation of silicate clay that either has formed in the horizon or has been moved into it by illuviation.

x - fragipan character. This symbol is used to indicate firmness, brittleness, or high bulk density. Few or no tree roots are able to penetrate this horizon.

Generally, forest soils have O, A, E, B, and C horizons.



Comparison of Grassland and Forest Soils

The base status is greater and pH is higher in grass soils, due to less leaching. Organic matter is greater in forest soil near the surface, but it reaches a greater depth in grasslands because of a greater abundance of fibrous roots. Evapotranspiration is lower in the forest. Clay content is greater in forest soils because of greater leaching. The A horizon is thicker in grasslands.

Grassland	Forest
A	O
AB	A
B	E
C	B
	C

Soil Depth

In humid regions, such as the Chesapeake Bay, soil depth is classified as follows:

Very shallow	0 - 10 inches
Shallow	10 - 20 inches
Moderately deep or moderately shallow	20 - 40 inches
Deep	40 - 60 inches
Very deep	60+ inches

The denitrification process generally occurs in the first 5 inches of the soil. Refer to the glossary of the particular soil survey that is being used to determine exact depth classes. Not every soil survey will contain a glossary.

Depth to Bedrock

The depth to bedrock is expressed in inches. If bedrock is present within a depth of 60 inches from the surface, it will be a factor on the soil survey. The hardness of bedrock is classified as follows:

- **Soft bedrock** is so soft or fractured that excavations can be made usually with trenching machines, backhoes, or small rippers.
- **Hard bedrock** is so hard and massive that blasting and special equipment is needed to excavate.

The depth to bedrock generally indicates the depth of soil material favorable for root growth. Even though this layer will tend to inhibit root growth, roots may penetrate soft or fractured bedrock. If bedrock is hard or massive, rooting will be restricted almost completely. Soils that are shallow to bedrock have a low or very low available water capacity, high windthrow hazard, and moderate seedling mortality.

Soil Color

- Soil color is written in Munsell notation, in order of hue, value, and chroma.
- Hue is the dominant rainbow color; it is related to the dominant wavelength of light. Hue may be R for red, YR for yellow-red (orange) or Y for yellow.
- Value refers to the relative lightness of color and is a function of the total amount of light. Value ranges from 0 (black) to 10 (white).
- Chroma is the relative purity or strength of the spectral color and increases with decreasing grayness. It ranges from 0 for neutral grays to 20, which is never seen in soils.

The color of the Ap horizon in the Mattapex soil is **10YR 4/2**. 10YR is the hue, 4 is the value, 2 is the chroma.

Soil Texture (figure 4-1)

In the preceding example, Mattapex has a silt loam texture. Soil texture refers to the proportions of clay, silt, and sand below 2 millimeters in diameter contained in mineral soil. A silt loam contains 50 percent or more silt and 12 to 27 percent clay (or) 50 to 80 percent silt and less than12 percent clay.

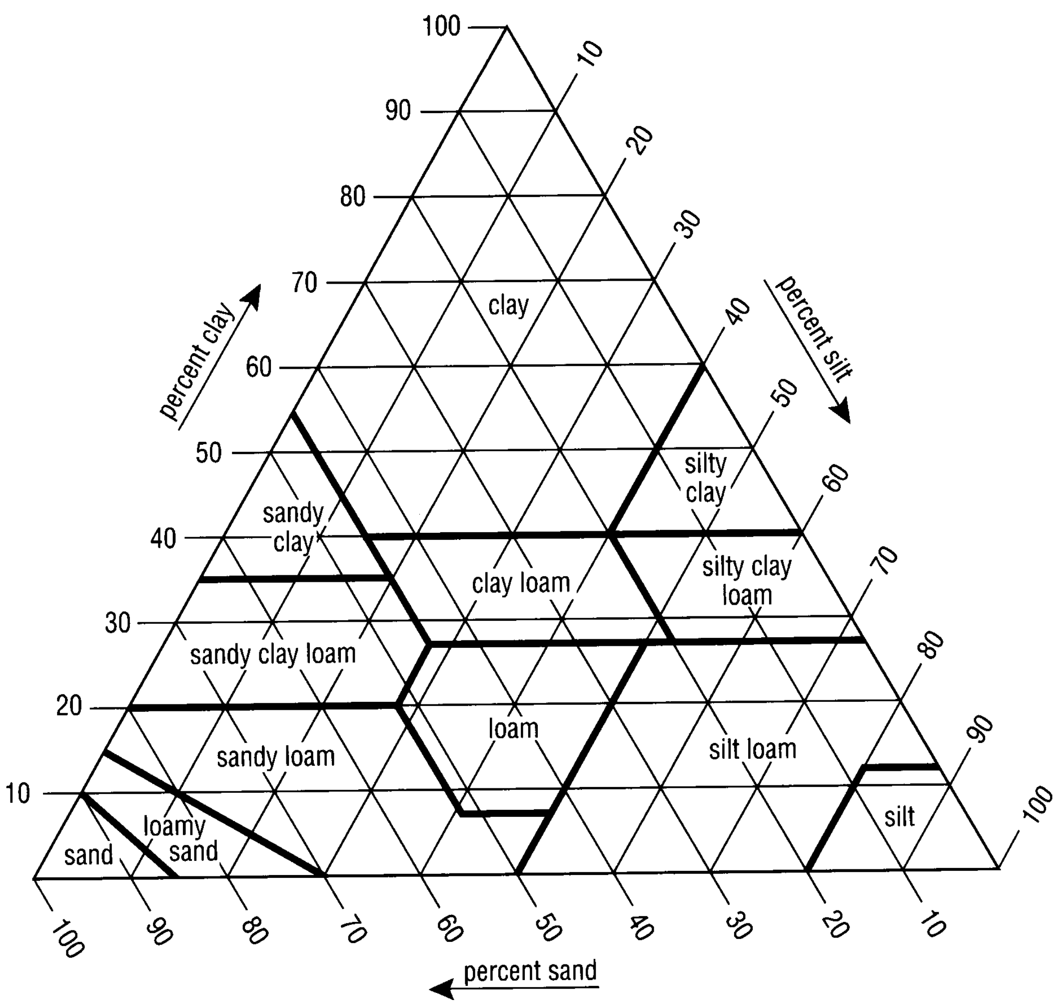


Figure 4-1. Texture Triangle. Soil Survey Manual, 1993.

In organic soils, muck, peat, mucky peat, and peaty muck are used in place of the textural class names of mineral soils.

Coarse Fragments

Soils that have rocks or stones larger than very coarse sand use adjectives in the texture to describe the size and shape of the coarse fragments. Coarse fragments reduce the water holding capacity of the soil. They influence infiltration, runoff, and tree root growth. They provide little or no soil fertility.

Thin, flat fragments:

- channery
- flaggy
- stony
- slaty
- shaly

Rounded fragments:

- gravelly
- cobbly
- stony or bouldery
- cherty

Soil Structure

Soil structure is the combination or arrangement of primary soil particles into secondary particles, units, or peds. These secondary units may be, but usually are not, arranged in a profile in such a manner as to give a distinctive characteristic pattern. The units are characterized and classified on the basis of size, shape, and degree of distinctness into classes, types, and grades, respectively.

Soil structure classes group soil structural units or peds on the basis of size. Sizes range from very fine to very coarse.

Soil structure grades classify soil structure on the basis of inter- and intra-aggregate adhesion, cohesion, or stability within the profile. Four grades of structure, designated from 0 to 3, are recognized.

0: structureless-no observable aggregation

1: weakly durable peds

2: moderately durable peds

3: strong, durable peds

Soil structure types is a classification of soil structure based on the shape of the aggregates or peds and their arrangement in the profile. There are four types:

<u>*Spheroidal*</u> (granular and crumb subtypes). All rounded peds or aggregates are placed in this category. These rounded complexes usually lie loosely and are readily shaken apart. Usually the aggregates are called granules and the pattern granular, however, when the granules are especially porous, the term crumb is applied. This type of structure is characteristic of a furrow slice and is subject to wide and rapid changes. It is especially prominent in grassland soils and is the only type that is commonly influenced by practical methods of soil management. The Ap horizon of the Mattapex soil has granular structure.

<u>*Plate-like*</u> (platy). In this structural type the peds are arranged in relatively thin horizontal plates, leaflets, or lenses. Platy structure is most noticeable in the surface layers of virgin soils, but may characterize the subsoil horizons as well. Although most structural features are a product of soil-forming forces, the platy type is often inherited from the parent materials, especially those laid down by water or ice.

<u>*Prism-like*</u> (columnar or prismatic subtypes). These subtypes are characterized by vertically oriented aggregates or pillars that vary in length with different soils. They occur in some poorly drained soils of humid areas. When the tops of prisms are rounded, the term columnar is used. When the tops of the prisms are still plane, level and clean cut, the structural pattern is designated prismatic.

<u>*Block-like*</u> (blocky and subangular blocky subtypes). In this case the original aggregates have been reduced to blocks, irregularly six-faced, with their three dimensions more or less equal. When the edges of the cubes are sharp and the rectangular faces distinct, the subtype is designated blocky. When sub-

rounding has occurred, the aggregates are referred to as subangular blocky. These types usually are confined to the subsoil, and their stage of development and other characteristics have much to do with soil drainage, aeration, and root penetration. The B22t horizon of the Mattapex soil has subangular blocky structure.

Moist Consistence

Consistence is the feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are:

loose - noncoherent when dry or moist; does not hold together in a mass.

friable - when moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together in a lump (Ap horizon of Mattapex soil).

firm - when moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

plastic - when wet, readily deformed by moderate pressure, but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

sticky - when wet, adheres to other material and tends to stretch somewhat and pull apart rather than to pull free from other material.

Redoximorphic Features

In most soil surveys, these features are referred to as mottles. The term mottles and low chroma colors have been replaced in Soil Taxonomy by redoximorphic features. These features are formed by the processes of reduction, translocation, and oxidation of iron and manganese oxides. The following kinds of redoximorphic features have been identified for use in modern profile descriptions.

redox concentrations - bodies of an apparent accumulation of iron and manganese oxides. These take the form of firm nodules, reddish mottles, or pore linings.

redox depletions - bodies of low chroma having values of 4 or more where iron-manganese along ped faces hasbeen stripped out.

reduced matrices - soil matrices that have a low chroma color in situ because of the presence of iron, but whose color changes in hue or chroma when exposed to air.

Examples of soil with description of redoximorphic features:

- Very few thin, faint, yellowish-red (5YR 5/8) pore linings along 1 mm diameter root channels.
- Medium, dark brown (7.5 YR 3/2 and 4/4) Fe nodules with sharp boundaries; many fine, few coarse, distinct strong brown (7.5 YR 5/6) Fe depletions along ped surfaces and some root channels.

In the Mattapex example, the B22t horizon has common, medium, distinct mottles of light brownish gray (10YR 6/2) and a few, fine, faint mottles of strong brown (7.5YR 5/8).

Soil Reaction, pH

The strength of soil acidity or alkalinity is expressed in pH – the logarithm of the reciprocal of the H-ion concentration. A pH of 7 is neutral; soils range in pH from 3.5 to 9.5. The terms used in soil descriptions to describe the base status of the soil correspond to the following:

Extremely acid	below 4.5
Very strongly acid	4.5-5.0
Strongly acid	5.1-5.5
Medium acid	5.6-6.0
Slightly acid	6.1-6.5
Neutral	6.6-7.3
Mildly alkaline	7.4-7.8
Moderately alkaline	7.9-8.4
Strongly alkaline	8.5-9.0
Very strongly alkaline	9.1 & higher

Mattapex soils are strongly acid to very strongly acid.

Cation Exchange Capacity

Cation exchange capacity (CEC) is the capacity of a soil to retain nutrient cations in a form that can be used by trees. It is the sum total of the exchangeable cations that a soil can absorb. Finer-textured soils tend to have a higher CEC than sandy soils. Also, the amount of organic matter and the amount and kind of clay influence the CEC. As pH rises, the CEC is larger.

Shrink-Swell Potential

The shrink-swell potential is defined as the potential for a soil to change volume as it loses or gains moisture. Shrink-swell potential is classified as:

- Low
- Medium
- High
- Very high

The shrink-swell potential is determined by the amount and kinds of clays present in the soil and the magnitude of soil moisture change. On sites with high or very high shrink-swell potential, the use of heavy logging equipment may be restricted, and seedling mortality may result, due primarily to frost heaving.

Bulk Density

Bulk density is the weight of the soil solids per unit volume of the total soil. It is the weight per unit volume of oven-dried soil expressed in grams per cubic centimeter. Bulk density a measure of the total pore space in a soil. Soils that are loose and porous have low values and those soils that are compacted have high values. Sandy soils generally will have higher values than silty and clayey soils. Undisturbed forest soils will have lower bulk densities in the surface than the same soils in a cultivated field. Bulk densities of forest soils range from 0.2 grams per cubic centimeter in some organic soils to 1.9 grams per cubic centimeter in coarse soils, with 1 to 1.3 an average range. The bulk density of rock is 2.65 grams per cubic centimeter.

Soils with high bulk densities can limit rooting and plant growth. Shallow rooting depths in forests can increase the chance of windthrow. Compacted soil horizons are those that are naturally dense, such as fragipans, firm glacial till, and duripans. Bulk densities of 1.75 grams per cubic centimeter for sands and 1.55 for clays can restrict root penetration and water storage.

Bulk density is influenced by texture, content of organic matter, soil structure, and type of clays present. Bulk density is an indicator of porosity, the degree of aeration, and the infiltration rate of the soil.

Mycorrhiza

Practically all tree roots form close mycorrhizal associations with fungi, either around root cells or in root cells themselves. Mycorrhizae enhance the tree’s ability to obtain water and nutrients by increasing the surface area of the tree’s roots.

Forest nurseries now infect tree seedlings with specific mycorrhizal fungi. Commonly, *Pisolithus tinctorius (Pt)* is used for inoculation of bare-root tree seedlings. Tree species inoculated successfully include Eastern white pine, Virginia pine, shortleaf pine, and red and white oak.

Soil Characteristics Relating to Hydrology

Permeability

Soil permeability is that quality of the soil that enables it to transmit water or air. It is measured in terms of rate of flow of water through a unit cross section of saturated soil in one hour, under specified temperature and hydraulic conditions.

Classes of soil permeability vary by state. The following sets of relative classes are taken from the USDA Soil Survey Manual.

Possible Rates in Inches per Hour

Slow	
very slow	less than 0.05
slow	0.05 to 0.20
Moderate	
moderately slow	0.20 to 0.80
moderate	0.80 to 2.50
moderately rapid	2.50 to 5.00
Rapid	
rapid	5.00 to 10.00
very rapid	over 10.00

Mattapex soils have moderately slow permeability.

Runoff

Runoff, sometimes called surface runoff or external soil drainage, refers to the relative rate that water is removed by flow over the surface of the soil. This includes water falling as rain as well as water flowing onto the soil from other soils. Six classes are recognized on the basis of the relative flow of water from the soil surface as determined by the characteristics of the soil profile, soil slope, climate, and vegetative cover.

ponded - None of the water added to the soil as precipitation, or by flow from surrounding higher land, escapes as runoff. Ponding occurs in depressions.

very slow - Surface water flows away so very slowly that free water lies on the surface for long periods or enters immediately into the soil. Soils with very slow surface runoff are commonly level or nearly level.

slow - Surface water flows away so slowly that free water covers the soil for significant periods or enters the soil rapidly, and a large part of the water passes through the profile or evaporates into the air. Soils with a slow rate of surface runoff are either nearly level or very gently sloping, with little or no erosion hazard.

medium - Surface water flows away at such a rate that a moderate proportion of the water enters the soil profile, and free water lies on the surface for only short periods. With medium runoff, the loss of water over the surface does not reduce seriously the supply available for tree growth. The erosion hazard may be slight to moderate if soils of this class are cultivated.

rapid - A large proportion of precipitation moves rapidly over the surface of the soil, and a small part moves through the soil profile. Surface water runs off nearly as fast as it is added. Soils with rapid runoff are usually moderately steep to steep and have low infiltration capacities. The erosion hazard is commonly moderate to high.

very rapid - A very large part of the water moves rapidly over the surface of the soil and a very small part goes through the profile. Surface water runs off as fast as it is added. Soils with very rapid rates of runoff are usually steep or very steep and have low infiltration capacities. The erosion hazard is commonly high or very high.

Available Water Capacity

Available water capacity is defined as the amount of water that can be stored by the soil for plant use. Available water is the moisture content of the soil between wilting point and field capacity. Wilting point is reached when all soil moisture held by soil particles is held so tightly that it cannot be taken up by plants. At wilting point, most plants will wilt steadily and never recover. Field capacity is the point at which the soil is so saturated that water begins to move by force of gravity. It is commonly expressed as inches of water per inch of soil, expressed as:

Very low .... 0 to 2.4 inches

Low............................. 2.4 to 3.2 inches

Moderate..................... 3.2 to 5.2 inches

High .... more than 5.2 inches

In soil surveys, the available water capacity will be described in the section called “General Soil

Map Units" and/or under the soil series descriptions.

Natural Soil Drainage (figure 4-2)

Natural drainage refers to the frequency and duration of periods of saturation or partial saturation during soil formation. Natural drainage conditions are usually reflected in soil morphology. Seven classes of soil drainage are used in soil descriptions and definitions to describe the natural drainage under which the soil occurs. Examples of Chesapeake Bay Watershed soil series of each drainage class are shown in parentheses.

very poorly drained - water is removed from the soil so slowly that the water table remains at or on the surface most of the time. Soils of this drainage class usually occupy level or depressed sites and are frequently ponded. Very poorly drained soils in forests commonly have dark-gray or black surface layers and are light gray, with or without mottles, in deeper parts of the profile. (Dunning, Pocomoke, Purdy)

poorly drained - water is removed so slowly that the soil remains wet for a large part of the time. The water table is commonly at or near the surface during a considerable part of the year. Poorly drained conditions are due to a high water table, to a slowly permeable layer within the profile, to seepage, or to some combination of these conditions. In forests, poorly drained soils may be light gray from the surface downward, with or without mottles. (Baile, Elkton, Fallingston, Hatboro, Leonardtown, Melvin, Othello, Trussel, Watchung)

somewhat poorly drained - Water is removed from the soil slowly enough to keep it wet for significant periods, but not all the time. Somewhat poorly drained soils commonly have a slowly permeable layer within the profile, a high water table, and additions through seepage or rainfall. Under forest conditions, these soils are uniformly grayish, brownish, or yellowish in the upper A horizon and commonly have mottles below 6 to 16 inches in the lower A and in the B and C horizons. (Barclay, Kelly, Lenoir, Orrville, Toms, Tygart)

moderately well drained - Water is removed from the soil somewhat slowly so that the profile is wet for a small, but significant, part of the time. Moderately well drained soils commonly have a slowly permeable layer within or immediately beneath the solum, a relatively high water table, or additions of water through seepage. Among forest sites, moderately well drained soils have uniform colors in the A and upper B horizons, with mottling in the lower B and in the C horizons. (Aldino, Beltsville, Buchanan, Captina, Clarksburg, Codorus, Delanco, Ernest, Glenville, Iuka, Lindside, Lobdell, Mattapex, Monongahela, Simoda, Woodstown)

well-drained - A well-drained soil has "good" drainage. Water is removed from the soil readily but not rapidly. Well-drained soils are commonly intermediate in texture, although soils of other textural classes may also be well drained. On forests, well-drained soils are free of mottles (except for fossil gley), and horizons may be brownish, yellowish, grayish, or reddish. They may be mottled deep in the C horizon or below depths of several feet. Well-drained soils commonly retain optimum amounts of moisture for tree growth after rains. (Allegheny, Baltimore, Belmont, Berks, Blackthorn, Calvin, Caneyville, Cateache, Chagrin, Chester, Chillum, Christiana, Chrome, Comus, Conestoga, Dekalb, Edgemont, Edom, Elliber, Elioak, Elsinboro, Fort Mott, Gauley, Glenelg, Hagerstown, Hazleton, Hollinger, Joppa, Laidig, Legore, Lehew, Mandy, Massanetta, Matapeake, Montalto, Neshaminy, Opequon, Relay, Sassafras, Shouns, Sunnyside, Tioga, Weikert)

somewhat excessively drained - Water is removed from the soil rapidly. Some of the soils are stony and shallow. Many of them have little horizon differentiation and are sandy and very porous. Among forests, somewhat excessively drained soils are brown, yellow, gray, or red. (Brandywine, Galestown, Joppa, Manor, Mt. Airy, Potomac) *excessively drained* - Water is removed from the soil very rapidly. Excessively drained soils are commonly shallow, and may be steep, very porous, or both. In forests, these soils are commonly brownish, yellowish, grayish, or reddish in color and free of mottles throughout the profile. (Rushtown)

Flooding

The frequency of flooding is classified as follows:

none - Flooding is not probable.

rare - Flooding is unlikely, but possible under unusual weather conditions.

occasional - Flooding is expected to occur on average less frequently than once in two years (5 to 50 times in 100 years).

frequent - Flooding is expected to occur on average more frequently than once in two years (more than 50 times in 100 years).

Duration is expressed as:

very brief - The soil is flooded less than two days.

brief - The soil is flooded from two to seven days.

long - The soil is flooded from seven days to one month.

very long - The soil is flooded longer than one month.

Information Necessary to Establish Riparian Forest Buffers

To determine the width of riparian forest buffers an evaluation of the soil survey, hydrologic soil groups, and the land capability class are essential. The final sections of this chapter will help the land manager get the best use from the soil survey, and describe hydrologic soil groups, land capability classification, and soil properties as they apply to riparian forest buffers.

The Soil Survey

Forest planning begins with the soil survey. Soil surveys have been evolving for decades, so the information presented in each one will vary depending on the knowledge that was available at the time the survey was written. This chapter cannot cover all the various taxonomic and

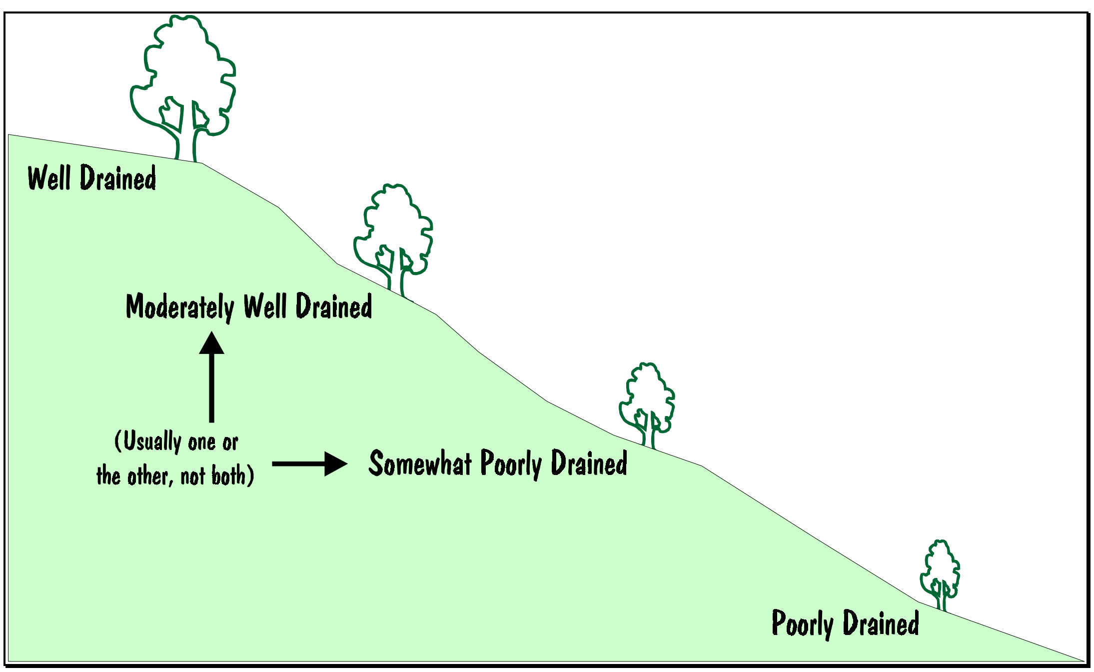


Figure 4 - 1. The position of the soil on a slope determines its drainage class.

ecological changes that have occurred in surveys over the years, but examples will be used to discuss and interpret information that foresters will most commonly use in a soil survey. Some of this information is presented quite well in some of the Chesapeake Bay Watershed's surveys, while it is completely absent from others.

Most soil surveys have a table called "Factors affecting woodland management," or "Woodland management and Productivity," or a similar title (see Table 4-1). There are several things a manager needs to know to make the best use of such a table.

Ordination System

The NRCS uses a national system of labeling individual soils to determine the potential productivity and the principal soil properties in relation to any hazards or limitations of that soil. This is called the ordination system. It has three levels: Class, designated by a number; Subclass, designated by a letter; and Group, designated by a number. The three-part symbol is called a woodland suitability group. The class and subclass symbols are called ordination symbols.

Table 4 - 1

(A portion of Table 3. *Factors Affecting Woodland Management.* Excerpted from the Baltimore County Soil Survey)

Soil Series	**Woodland Subclass**	**Management Concerns**						**Site Index Mixed Oaks**	**Preferred Species**	
		Erosion Hazard	Equipment Limitation	Seedling Mortality	Windthrow Hazard	Conifer Competition	Hardwoods Competition		In existing Stands	For planting
Mattapex	**3o**	slight	slight	slight	slight	moderate to severe	slight to moderate	70-80	red oak, yellow-poplar, sweetgum	loblolly pine, white pine, sweetgum

Class - This is the first element in ordination, and it is a number that denotes potential productivity in terms of cubic meters of wood per hectare.

1-1 cubic meter per hectare per year (14.3 cubic feet per acre)

2-2 cubic meters per hectare per year (28.6 cubic feet per acre)

10-10 cubic meters per hectare per year (143 cubic feet per acre)

In modern surveys, class and potential productivity are rated as follows:

1 – low potential productivity

2 and 3 – moderate

4 and 5 – moderately high

6 to 8 – high

9 to 11 – very high

12 or more – extremely high

> *Note: This is opposite of older surveys. Using our example of Baltimore County, class 1 is very high productivity and class 6 are soils of such low productivity that they are of little or no economic value for trees. Be very careful in reading each soil survey woodland section so that the tables are correctly interpreted. The Baltimore County system is more common than the correct modern system.*

Subclass - This is the second element in ordination and is indicated by a capital letter.

R - relief or slope steepness. Soils with restrictions or limitations for forest land use or management because of steepness or slope.

X - stoniness or rockiness. Soils having restrictions or limitations for forestry because of stones or rocks.

W - excessive wetness. Soils in which excessive water, either seasonally or year-round, causes significant limitations for forest land use or management. These soils have restricted drainage, high water tables, or overflow hazards that adversely affect either stand development or management.

T - toxic substances. Soils that have within the rooting zone excessive alkalinity, acidity, sodium salts, or other toxic substances that limit or impede development of desirable tree species.

D - restricted rooting depth. Soils with restrictions or limitations for forestry because of shallowness, hard rock, hardpan or any layer that restricts root growth.

C - clayey soils. Soils having limitations for forestry because of the kind or amount of clay in the upper portion of the soil profile.

S - sandy soils. Dry sandy soils with little or no textural B horizons or having moderate to severe restrictions for forestry. These soils impose equipment limitations, have low moisture holding capacity, and are normally low in available plant nutrients.

F - fragmental or skeletal soils. Soils with limitations for forestry because the profile reveals large amounts of coarse fragments that are more than 2mm and less than 10 inches.

A - soils with no significant limitations for forestry.

> *Note: In many soil surveys, this letter will be small in the tables. In the Baltimore County example, the woodland subclass for Mattapex silt loam, 2 to 5 percent slope is 3o. Three indicates the soil has medium productivity (site index of 65 to 75) and o indicates it has no limitations. Notice that o is no longer in use.*

Soil descriptions may not be useful if the resource manager does not know what soil survey they are from and what the numbers actually mean.

Group - Unlike Class and Subclass, there is no national meaning attached to the group number. The group number is used to present soil mapping units that respond similarly. A woodland suitablity group is composed of soils with similar productivity potential and capability and similar management needs.

Erosion Hazard

Erosion hazard is the probability that damage may occur as a result of site preparation and following cutting operations where the soil is exposed along roads, skid trails, fire lanes, and log landings. Forests abused by fire and overgrazing are also subject to erosion. Erosion hazard has the following classes:

Slight - no particular preventive measures are needed under ordinary conditions.

Moderate - erosion control measures are needed in certain silvicultural activities.

Severe - special precautions are needed to control erosion in most silvicultural activities.

Windthrow Hazard

Windthrow hazard is the likelihood of trees being uprooted (tipped over) by the wind as a result of insufficient depth of the soil to give adequate root anchorage. Some modern surveys do not include windthrow hazard. Windthrow hazard is classified as follows:

Table 4 - 2

Guidelines: Equipment Limitation Ratings on Soils for Forest Use

CRITERIA	SLIGHT	MODERATE	SEVERE
Slope	0-15%	15-35%*	> 35%
Stoniness (% surface cover by volume)	< 15	15-50	> 50
Rock outcrop (%)	< 10	10-25	> 25
Wetness (depth to water table is < 15") duration	< 2 months	2-6 months	> 6 months
Surface texture	sands 10-20 inches; all textures other than those listed	sands 20 inches; clay, silty clay, sandy clay, less than 10 inches over clayey materials	-----------------------
* clayey soils - clay, sandy clay, and silty clay, and soils subject to slippage will rate severe.			

Slight - normally there are no trees blown down by the wind. Trees may break, but they will not be uprooted by strong winds.

Moderate - an occasional tree may blow down during periods of soil wetness with moderate or strong winds.

Severe - many trees may be expected to blow down during periods of soil wetness with moderate or strong winds.

Restricted rooting depth is the principal reason for windthrow hazard. This restriction may be caused by a high water table, fragipan, bedrock, or any other restricting layer. If effective rooting depth is greater than 30 inches, windthrow hazard is slight. If rooting depth is 20 to 30 inches, the hazard is moderate; and if rooting depth is less than 20 inches, then the hazard is severe. Examine the potential planting site for soil and rooting depth.

Equipment Limitations

Equipment limitations are limits on the use of equipment, year round or seasonally, as a result of soil characteristics (see Table 4-2). The ratings are as follows:

Slight - equipment use normally is not restricted in kind or time of year because of soil factors. For soil wetness, equipment use can be restricted for a period not to exceed one month.

Moderate - equipment use is moderately restricted because of one or more soil factors. Equipment use might be limited by slope, stones, soil wetness, soil instability, extremes in soil texture (clayeyness or sandiness), or combinations of two or more factors. For soil wetness, equipment use is restricted one to three months.

Severe - equipment use is severely restricted either as to kind of equipment that can be used or season of use. For soil wetness, equipment use is restricted more than three months.

Seedling Mortality

Seedling mortality can be caused by several soil factors:

1. The main cause is too much or too little water – soil wetness or soil droughtiness. Too much water is caused by high water tables or flooding during a significant part of the growing season. Soils that are very poorly drained or are frequently flooded have severe seedling mortality. Poorly drained soils have a moderate hazard.

2. Soil droughtiness is caused by several factors: lack of rainfall at appropriate time, low available water capacity, shallow rooting depth, high evaporation, or a combination of these factors. Seedlings can survive on soils with low available water capacity if rains come at the right frequency and duration. If rainfall is less than optimum, the amount of water that enters the soils and is held within the root zone becomes the limiting factor that determines seedling survival.

3. Surface texture must be coarse enough so that water enters readily, but not so coarse as to have a low available water capacity. Seedling mortality is greatest on soils with sandy and clayey surface textures.

4. The amount of water held in the soil for plant use is determined by the available water capacity of the soil and the effective rooting depth. The amount of water held within a 20-inch effective rooting depth is used as an indicator of droughtiness.

5. Seedling mortality may also be affected by the high temperatures and evaporation associated with steep south-facing slopes.

Plant Competition

Plant competition is the likelihood of the invasion or growth of undesirable species when openings are made in the canopy during intermediate cuttings or final harvest. The ratings are as follows:

<u>slight</u> - Competition of unwanted plants is not likely to prevent the development of natural regeneration or suppress the more desirable species. Planted seedlings have good prospects for development without undue competition.

<u>moderate</u> - Competition may delay natural desirable trees or planted trees and may hamper stand development , but it will not prevent the eventual development of fully stocked stands.

<u>severe</u> **-** Competition can be expected to prevent natural or planted regeneration unless precautionary measures are taken. The natural resources manager may want to consider herbicides or tree shelters as described in Section VII.

Hydrologic Soil Groups

This refers to soils grouped according to their runoff-producing characteristics. The main consideration is the inherent capacity of soil devoid of vegetation to permit infiltration. Groups are described using saturated hydraulic conductivity. Saturated hydraulic conductivity is the factor relating soil water flow rate (flux density) to the hydraulic gradient and is a measure of the ease of water movement in soil. The slope and kind of plant cover are not considered, but they are separate factors in predicting runoff. Soils are assigned to four groups:

A - Soils having a high infiltration rate when thoroughly wet and having a low runoff potential. They are mainly deep, well drained, and sandy or gravelly. Saturated hydraulic conductivity is *very high* or in the upper half of high, and internal free water occurrence is *very deep*.

B - Saturated hydraulic conductivity is in the lower half of *high* or in the upper half of *moderately high*, and free water occurrence is *deep* or *very deep*.

C - Saturated hydraulic conductivity is in the lower half of *moderately high* or in the upper half of *moderately low*, and internal free water occurrence is deeper than *shallow*.

D - Soils having a very slow infiltration rate and thus a high runoff potential. They have a claypan or clay layer at or near the surface, have a permanent high water table, or are shallow over nearly impervious bedrock or other material. Saturated hydraulic conductivity is below the upper half of *moderately* *low*, and/or internal free water occurrence is *shallow* or *very shallow* and *transitory* through *permanent.*

A soil is assigned to two hydrologic groups if part of the acreage is artificially drained and part is undrained.

Zone 2 width of the riparian forest buffer is increased to occupy soils in hydrologic group D and those soils in hydrologic group C that are subject to frequent flooding.

Land Capability Classification

This system categorizes land on the basis of its capability and limitations. Soil surveys will include capability class and subclass either in the soil series description or in the soil map unit descriptions. This information is very useful in determining the width of the riparian forest buffer needed. The USDA Natural Resources Conservation Service uses eight land capability classes. Keep in mind that this system was developed primarily for agricultural use, but it is also used for engineering purposes. A brief description of the characteristics and best use of soils in each class follows. This information is summarized in Figure 4-3.

Class I. Soils in this land class have few limitations as to what uses are suitable for them. Uses can range from intensive cropping to forestry and wildlife reserves. The soils are deep, well-drained, and the topography is level. These soils have natural fertility or are able to respond well to soil amendments. The water-holding capacity of these soils is high. No extraordinary measures are needed to manage crops in Class I. Riparian forest buffers in this class would be narrower relative to other classes.

Class II. Soils in this land class have some limitations that result in a narrower choice of plants or requires the use of some conservation practices. Some of the limiting factors of Class II soils are 1) gentle slopes, 2) moderate erosion hazards, 3) inadequate soil depth, 4) less than ideal soil structure and tilth, 5) slight to moderate alkaline or saline conditions, or 6) somewhat restricted drainage.

Class III. Soils in Class III have severe limitations that reduce the choice of plants or require special conservation practices. Limitations in the use of soils in Class III result from factors such as 1) moderately steep slopes, 2) high erosion hazards, 3) very slow water permeability, 4) shallow depth and restricted root zone, 5) low water-holding capacity, 6) low fertility, 7) moderate alkalinity or salinity, and 8) unstable soil structure.

Class IV. Soils in this class can be used for cultivation, but there are very severe limitations that greatly reduce the choice of crops that can be grown. Limiting factors on these soils may be one or more of the following: 1) steep slopes, 2) severe erosion susceptibility, 3) severe past erosion, 4) shallow soils, 5) low water-holding capacity, 6) poor drainage, 7) severe alkalinity or salinity.

Class V. Soils in this class are generally not cultivated, but are often used for pasture. Erosion is generally not the concern, but several other limitations include 1) frequent flooding, 2) short growing season, 3) stones or rocks, and 4) ponded areas that cannot be drained.

Class VI. Soils in this class have extreme limitations that restrict their use to grazing, forestry, range, or wildlife. They have the same limitations as soils in Class V, only more rigid.

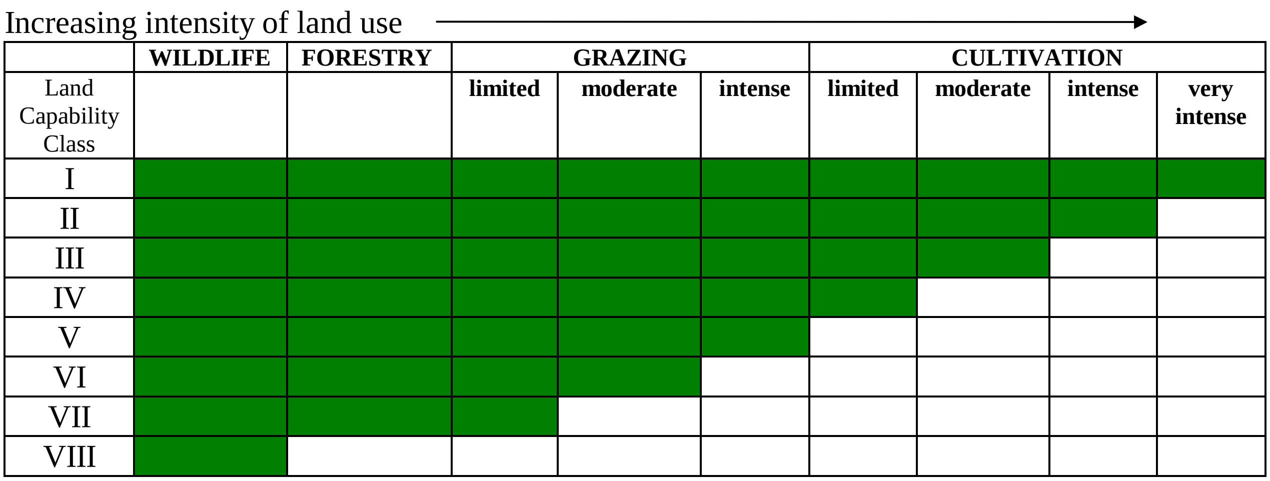
Class VII. Soils in this class have very severe limitations that restrict their use to grazing, forestry, or wildlife. Pasture improvement for soils in this class is impractical.

Class VIII. Soils in this class are not capable of producing commercial agricultural crops. Their use is restricted to recreation, wildlife, water supply, or aesthetic purposes. Examples of soils in this class would be sandy beaches, river wash, or rock outcrops.

Subclasses. Each of the land capability classes are further divided by limitations designated by a small letter. The four limitations recognized in these subclasses are risks of erosion **(e),** wetness, drainage, or flooding **(w),** root-zone limitations **(s),** and climatic limitations **(c).**

Capability classes are used to help determine the total width of the buffer. Referring to the specifications published by the USDA Forest Service and the Natural Resources Conservation Service, the width of Zones 1 and 2 should be 100 feet in soils of capability classes IIIe or IIIs. These classes indicate problems with erosion, hardpans, or shallow soils that require a wide riparian forest buffer.

In the Bay watershed, about 48 percent of the land is in classes V through VIII, about 11 percent is in Class IV, and about 40 percent is in Classes I through III.



Source: Adapted from Brady, 1984

Figure 4 - 2. The shaded blocks show uses for which classes are suitable. There are increasing limitations on the prudent use of land as one moves from Class I to Class VIII. Also there is decreasing adaptability and freedom of choice of uses moving from Class I to Class VIII.

Soil as It Relates to Establishing a Riparian Forest Buffer

The first step in the successful establishment of a riparian forest buffer is to look around at what is already growing in the vicinity. Trees growing nearby will reveal the parent material of the area and indicate what trees grow naturally on that site. Pines generally compete better in soil derived from sandstone, while hardwoods have the advantage on soils derived from limestone. Following are examples of tree species that grow in the watershed on soils derived from various materials:

- limestone - walnut, beech, ash, elm, red-cedar, red oak, shagbark hickory
- sandstone and chert - black oak, white oak, mockernut hickory, black gum, flowering dogwood

Parent material has a direct effect on soil texture, which is one of the most important characteristics affecting site quality. It influences the chemical properties of the soil, soil moisture, and root development. Clay in the soil has the largest surface area from which nutrients may be released to the roots. The fertility of a soil is directly related to the amount of clay and silt in the soil. Very sandy soils are not fertile, and only conifers may be able to grow in them. It may be a waste of time to plant hardwoods in sandy soil.

Texture also is related to the amount of soil moisture retained. Sandy soils are droughty, so drought-tolerant species should be planted in them. Clay loams have good soil moisture characteristics, and heavy clay soils lack proper aeration.

Structure also affects how well trees will grow when planted in riparian areas. Soils that contain silt and clay and have granular or crumb structure will grow the best trees. They permit good percolation of both water and air, and reduce erosion. The presence of many earthworms in the soil indicates that organic matter is being moved from the surface into other layers of the soil, and that large soil aggregates are being reduced in size. A soil with a healthy population of earthworms should produce a healthy riparian forest.

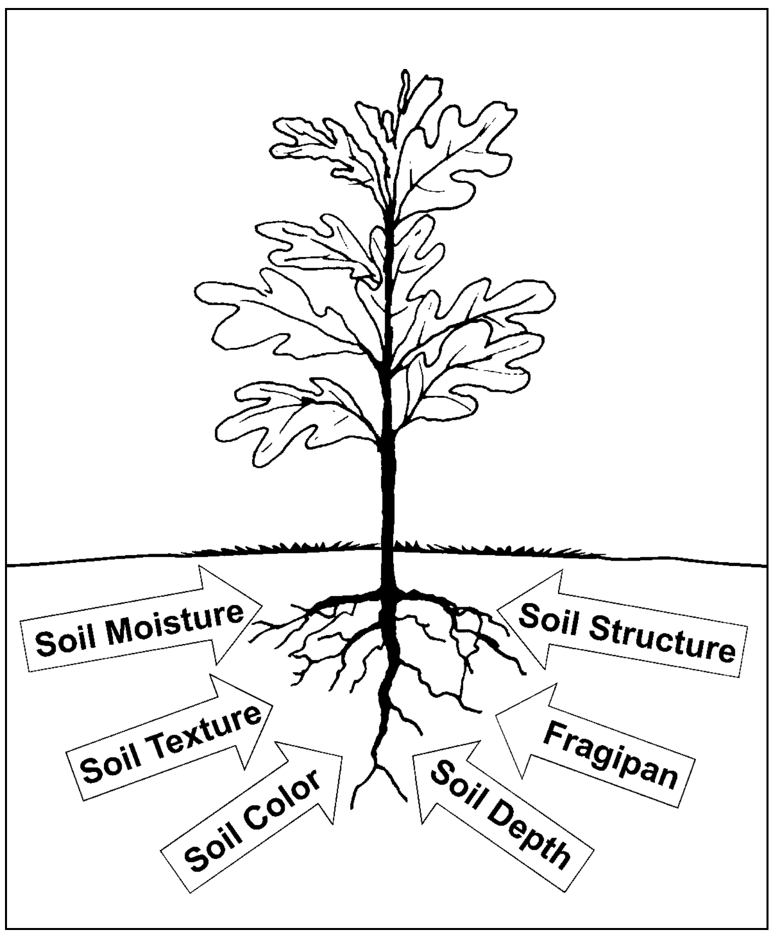
The third important consideration for successful riparian tree planting is the topographic position of the site, its slope and its aspect. Topographic position affects soil depth, profile development, and the texture and structure of the surface soil and subsoil. This, in turn, influences the composition, development and productivity of the forest.

Riparian areas are generally at the low position on a slope. At this position, trees will generally be sheltered from high winds and have access to more soil moisture. These are areas of soil deposition, and are subject to cold-air drainage. Areas that have moderate slope are usually more productive than flat, level areas.

The aspect of the site should be evaluated before planting. South-facing slopes are hotter and drier. North slopes receive less sunlight and are cooler and moister than southern slopes. In the watershed, northeast facing slopes are the most productive for forests, and south-west facing slopes are the least productive.

There have been numerous studies conducted that attempt to relate soil properties to forest site. These studies show that the effective depth of the soil, the surface soil depth, is the most important property affecting forest productivity. This is the depth of the portion of the soil occupied by tree roots or capable of being occupied by tree roots that take up nutrients and water from this space. The effective depth can be affected by a fragipan (Bx horizon), shallow soil (lithic) where the bedrock is close to the surface, or by a high water table during much of or part of the year.

Before deciding to plant trees, and before deciding what species to plant, the land manager should go to the site with a shovel and dig up a small area. A soil survey for the area should be taken to the site, and the soil type that has been



mapped for the area should be determined. If any of the following conditions occur, then the situation must be reevaluated.

- The soil has a hardpan or fragipan, denoted by Bx soil horizon.
- The soil is very gray, or has gleying, near the surface.
- The hole that is dug fills up with water immediately.
- The soil is described as lithic, which means that bedrock will be found at less than 50 cm (20 inches) from the surface.
- The soil is described as having mottles or redoximorphic features, such as redox depletions, redox concentration, or reduced matrix, close to the surface.

If any of the above conditions apply, be sure to plant tree species that do not have deep tap roots, such as black walnut, and can withstand wet conditions.

References

Armson, K.A. 1979. Forest soils: properties and processes. Univ. of Toronto Press, Toronto, Canada. 390 pp.

Brady, N.C. 1984. The nature and properties of soils. 9th ed. Macmillan, NY. 750 pp.

Bunker, A.F. and H.G. Todd. 1987. Forest soils handbook for Ohio. ODNR Division of Forestry, Columbus, OH.

Karathanasis, A.D., R.I. Barnhisel, and W.W. Frye. 1987. Handbook for collegiate soils contest: southeastern region. Univ. of Kentucky. Lexington, KY.

Soil Survey Staff, USDA. 1993. Soil survey manual. Ag. Handbook No. 18. USDA Soil Conservation Service. Washington, DC.

Soil Survey Staff, USDA. 1987. Keys to soil taxonomy. SMSS Tech. Monograph #6. Cornell Univ. Ithaca, NY.

Soil Survey Staff, USDA. 1994. Keys to soil taxonomy. 6th ed. Pocahontas Press, Inc. Blacksburg, VA.

USDA Soil Conservation Service. 1980. National forestry manual. Title 190. Washington, DC.

USDA Soil Conservation Service. 1983. National soils handbook. Title 430. Washington, DC.

Section V

Design of Buffer Systems for Nonpoint Source Pollution Reduction

Design of Buffer Systems for Nonpoint Source Pollution Reduction

Introduction

To determine where a riparian forest buffer system (RFBS) will be most effective for removal of nonpoint source (NPS) pollutants, it is necessary to relate upland pollutant loading to the potential buffering of a riparian corridor. Where upland pollutant loading is high, a partially functioning RFBS often provides more benefits than a completely functioning RFBS where upland pollutant loading is already low. Therefore, the entire watershed must be evaluated in terms of its pollutant sources as a first step in the process of RFBS design.

Agricultural land uses are recognized as a major source of NPS pollutants in the Chesapeake Bay Watershed. Areas generating high NPS loading, such as cultivated fields or intensely maintained turf, require more buffering than areas of lesser loading, such as hay fields. If favorable conditions for NPS pollutant removal exist downgradient from areas of high loading, these areas are prime locations for riparian forest buffers.

First order streams and their tributary seeps and springs have the greatest interface with upland source areas, so they are likely to be the most effective locations for potential riparian forest buffers. First and second order streams represent most of the total stream length within a watershed. NPS pollutant loading into higher order streams is largely from the low order tributaries where RFBs are more effective. For these reasons, it is important that the low order streams be closely examined for potential RFBs.

The potential for removal of NPS pollutant loading in surface runoff and shallow groundwater can be quite site dependent. The pathways by which NPS pollutants are transported into a RFB as well as the potential for their interception by a RFB are affected by the topography, geology, and hydrology of a riparian site. In certain riparian sites, groundwater hydrology may not lend itself to interception of a high proportion of dissolved nutrients, such as nitrates. In more steeply sloped sites, channelized flows of sediments and adsorbed pollutants often bypass the filtering effect of a RFBS. In any site, proper design of a RFBS is necessary to ensure that the pollutant removal benefits meet the potential inherent to the riparian site.

This section presents the factors involved in evaluating the extent and location of upland loading of NPS pollutants, as determined by land uses and physiographic factors. Pollutant transport pathways and the potential for their removal by riparian sites are also evaluated according to inherent physiographic factors. By relating upland loading to potential removal by riparian sites in accordance with appropriate design considerations, it is possible to optimize the design of the RFBSs for the watershed.

Suspended Sediments and Sediment Bound Pollutants

Loading from Upland Sources

To determine upland loading of suspended sediments and adsorbed pollutants such as phosphates, upland land uses must be evaluated. Aerial photographs, U.S.G.S. Quad maps, Soil Survey maps, and Conservation Plans provide information on field slope, slope length, soil erodibility, land cover, and management practices.

These factors are variables used in the Universal Soil Loss Equation (USLE) to quantitatively project the unit losses of suspended sediments at the field scale.

By relating unit sediment losses to field area, a Geographical Information System (GIS) and/or computer programs such as Agricultural Non-Point-Source Pollution Model (AGNPS) can graphically display sediment losses throughout the watershed with a high degree of spatial precision. Note that sediment loading into a RFB is a product of upland slope area and the sediment losses calculated by the USLE. Riparian sites downgradient from areas of the highest loading would then be evaluated for their potential to remove runoff pollutants.

Where these computing resources are not available, a qualitative approach is adequate for the purpose of RFB design. Using the criteria presented in Table 5-1, the cumulative effect of these factors can be estimated to project sediment losses at the field scale. Manual mapping of high loss areas such as cultivated fields will highlight problem areas. Sediment loading from various upland areas into the riparian area can then be visually evaluated to determine where buffers are most needed. To aid in evaluating annual sediment losses per acre of field, data sources and technical assistance are available from the local Conservation District.

Interception of Sediments by Riparian Forest Buffers

RFBs can be quite effective in filtering sediments when the sediment loading is not excessive. Cropped or grass vegetated filter strips (VFS) have also been shown to trap sediment effectively at a width of roughly 25 feet if located on slopes less than 16 percent. As the slope increases above 4 or 5 percent, the capability of the filter strip decreases. At high sediment loading rates, VFSs are quickly saturated with sediments and become ineffective, unless regularly maintained. Furthermore, VFSs are easily bypassed by concentrated flows. Field studies of existing riparian forest buffers confirm that they also do not intercept concentrated flows. Phosphorus removal by a VFS is usually about half that of sediments, since it is adsorbed to the finer fractions which pass more easily through the VFS.

Where sediment loading occurs in concentrated flow, the filtering effect of the forest and grass vegetation is likely to be bypassed. Some method to eliminate channelized flow must be provided to ensure sheet flow conditions. Unless level spreaders or biofiltration swales are provided, RFBSs will not be effective for sediment removal, even at the lower range of loading conditions. While a divergent hillslope (the nose of a ridge) disperses runoff, a convergent hillslope such as a draw usually collects upland runoff into

Table 5 - 1
Relative Loading from Upland Sources According to Upland Conditions

SITE CONDITION	LOW LOADING	MEDIUM LOADING	HIGH LOADING
Upland Loading	<1,000 lbs. sediment/acre	1,000-10,000 lbs. sediment/acre	>10,000 lbs. sediment/acre
Upland Slope Length	<150 feet	150 to 300 feet	>300 feet
Upland Slope	1-5 percent	5-15 percent	>15 percent
Upland Soil Erodibility	K < 0.22	K= 0.22 to 0.36	K> 0.36
Upland Cover	Forest or hayfields	Pastures	Cultivated crops
Upland Practice	No-till or no earth disturbance.	Till-plant, strip and contour cropping.	Conventional plowing, not along contour.

a channelized flow. Where such loading is intercepted by a small area of riparian forest, as in the case of a concave hillslope, the buffering potential is likely to be relatively low. Topography and surface flow hydrology will thus control the potential for a RFBS to filter runoff sediments. Figure 5-1 displays the landforms typically found in the Piedmont of the Chesapeake Bay Watershed.

At present, simple methods to quantify the extent of channelized overland flow do not exist. As an initial estimate, channelized flows from cultivated fields are likely to begin when the slope length is over 250 feet, the upland slope is over 10 percent, and a concave landform exists. High resolution stereo aerial photographs and on-site field investigation will show where channelized flow occurs. Soil stability in the riparian area also plays an important role in projecting filtering potential, since easily erodable soils form channels easily.

Table 5-2 displays a list of site conditions to help determine the potential of a riparian site to effectively filter suspended sediments. Upland slope, slope length, flow regime, and convergence are factors that determine the likelihood of concentrated flow pathways. Riparian slope, flow regime, and erodibility determine the sediment filtering potential of a riparian forest buffer.

Where sediment loading values into a RFB are very high, where concentrated flows exist, or where the riparian site conditions are not favorable, an engineered biofiltration swale is one tool that can be used to disperse concentrated flow. Such structures can be effective at high loading rates, however it is necessary to remove accumulated sediments on an annual basis. The advantage of biofiltration swales is that the accumulated sediments are easily accessible.

Design Considerations

Where analysis of the riparian zone and upland conditions indicate that overland sheet flow is present, a RFB can effectively filter sediments. At acceptable upland loading rates (generally where sediment losses are less than 5,000 pounds per acre), the outermost zone of the RFB (Zone 3) should be planted in grasses or alfalfa that can be mowed or harvested on a regular basis to allow for periodic removal of accumulated sediments. Where loading rates are low enough not to require routine sediment removal (generally below 1,000 pounds per acre), herbaceous forbs and shrubs can be included in Zone 3.

Table 5 - 2
Relative Potential for Sediment Filtering of Surface Runoff According to Riparian Conditions

SITE CONDITION	HIGH POTENTIAL	MEDIUM POTENTIAL	LOW POTENTIAL
Upland Slope Length	<150 feet	150 to 300 feet	>300 feet
Upland Slope	1-5 percent	5-15 percent	>15 percent
Upland Flow Regime	No rills	Small rills	Rills and gullys
Upland Convergence	Divergent hillslope	Linear hillslope	Convergent hillslope
Riparian Slope	0-5 percent	5-15 percent	>15 percent
Riparian Flow Regime	No channels	Small rills	Rills and gullys
Riparian Soil Erodibility	K < 0.22	K= 0.22 to 0.36	K> 0.36

For effective deposition of sediments, Zone 3 should be at least 25 feet wide and located on slopes less than 5 percent. As the projected loading increases, the width of the sediment deposition area in Zone 3 should increase proportionately. At any given sediment loading, where the riparian slope is greater than 5 percent, the width should also increase 5 feet for each percent increase in slope in the riparian deposition zone. Where possible, Zone 3 should extend up into the side draws where sheet flow is more likely to occur, as shown in Figure 5-1.

Upland slope is only one of many factors incorporated into the USLE, in which sediment losses are by no means directly proportional to upland slope. Therefore, there is no simple relationship between sediment loading and upland slope. As a consequence, upland slope should not be the sole design criterion for buffer width. The other factors shown in Table 5-1 also need to be addressed, as they generally exert more influence on potential sediment loading than slope.

For control of sediments where channelized flow begins, a level spreader can redirect runoff into sheet flow. However, great care must be used to ensure that the level spreader is precisely level. Furthermore, it must be situated in locations where runoff does not form channels immediately downgradient from the spreader in the riparian area. Inherent to their design, level spreaders also cause sediments to settle immediately upstream, requiring continual maintenance

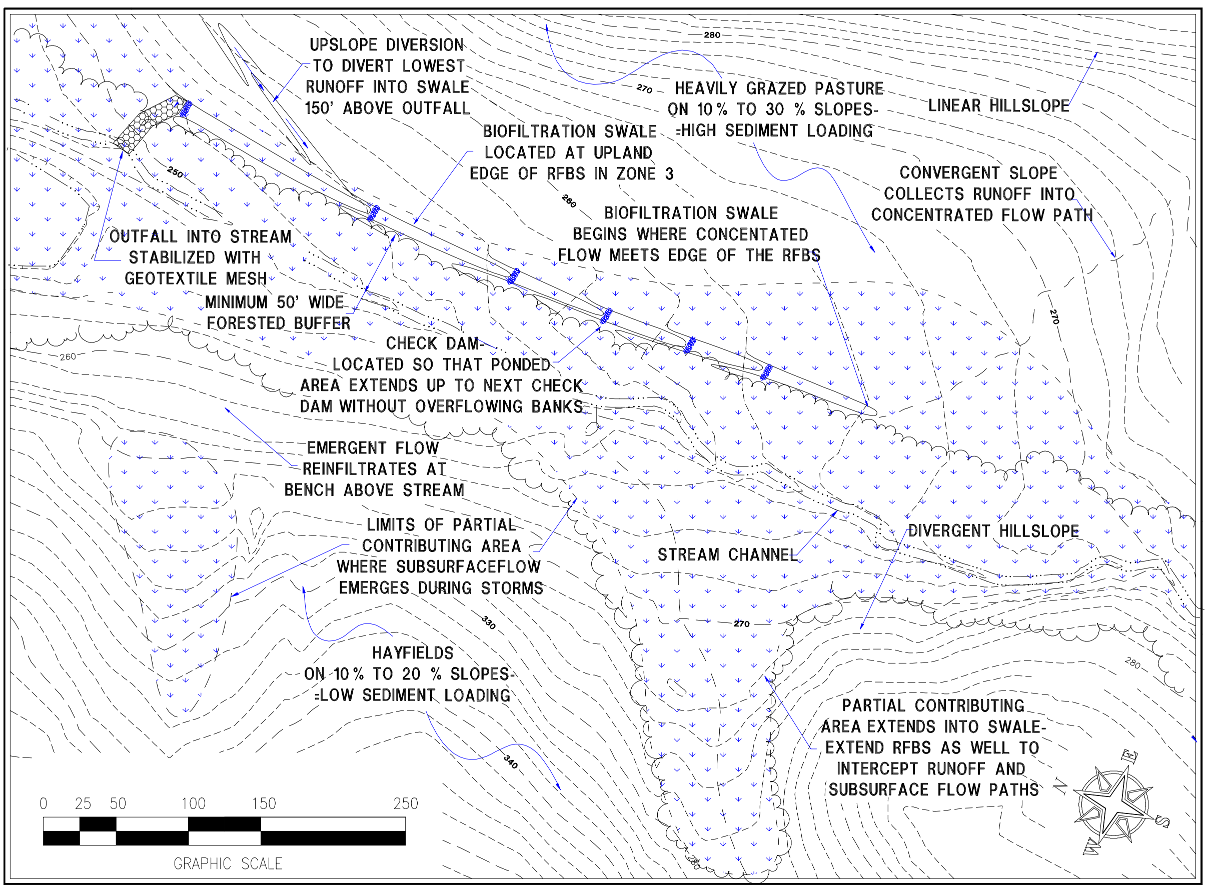


Figure 5 - 1. Plan view of Piedmont hillslope hydrology shows typical landforms and locations where partial contributing areas and channelized flows are likely. Biofiltration swale is included to show typical layout. Source: William Lucas

to operate effectively. For these reasons, level spreaders should be not be used where high sediment loading or channelized flows have occurred.

One alternative for use where substantial channelized flow exists is the biofiltration swale. Biofiltration swales are used in urban and developed areas as part of a riparian buffer system. Designed to settle sediments from concentrated flows, biofiltration swales are essentially diversions that convey runoff at very shallow flow depths. These engineered swales intercept the channelized flows from the upslope areas and direct them parallel to the riparian corridor. They are typically 15 to 25 feet wide and 1 to 2 feet deep, so they can be located within Zone 3 of the riparian forest buffer. Biofiltration swales have been shown to reduce sediment transport by up to 80 percent.

As displayed in Figure 5-2, biofiltration swales are designed so that the flow depth is very shallow, less than two-thirds the height of the grass (typically 6 inches), resulting in a flow velocity of less than 2 feet per second. To properly design a biofiltration swale, the hydrological program TR-55 should be used to calculate anticipated runoff for the 2-year design flows. One hundred year flood flows are also projected for swale design to ensure that the banks are not overtopped. Based upon the design flows, Manning's equation for channel flow is then used to design the swale to convey the required flows.

Typically, a trapezoidal section is used for swale design. As the swale collects sediment, the cross-section will evolve into a parabolic shape. A bioswale with a bottom width of 10 to 15 feet and side slopes no steeper than 3:1 (to permit mowing) can generally handle runoff from an area of up to 10 acres or so. As the contributory area increases, the swale cross-section increases to ensure that the flow remains within the vegetation. Since the flow depth is designed to be in the range of 4 to 8 inches, a value of 0.12 is generally appropriate for Manning's n. The swale slope follows the natural slope of the corridor, typically varying from <1 percent to >4 percent.

Where the calculations indicate that peak flow velocities will exceed 2 feet/second, check dams should be installed. Check dams of coarse riprap at regular intervals form ponds during peri-

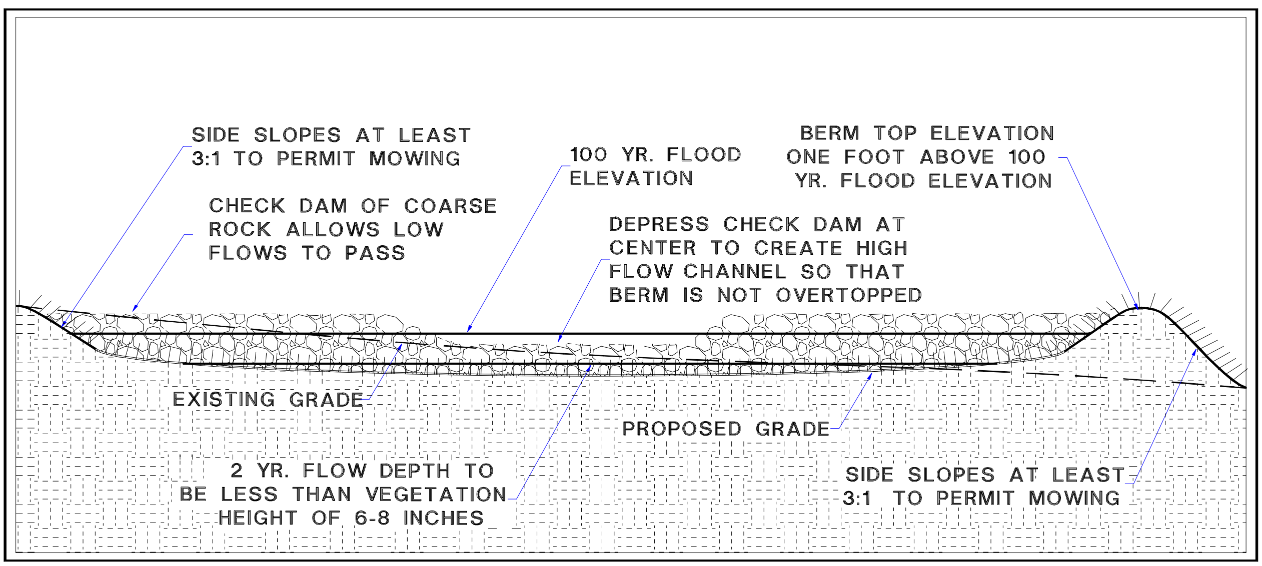


Figure 5 - 2. Typical biofiltration swale cross section (not to scale), showing design elements to be considered. Source: William Lucas

ods of high flow to stabilize the swales and slow down the flow velocity. Where peak velocities over 5 feet/second are projected, check dams should be installed in intervals so that the ponded water extends up to the base of the upstream check dam. In this manner, the energy of the highly erosive flows is controlled by the rip-rap.

Since the anticipated flows can be quite high, the discharge channel through the RFBS to the receiving stream should be stabilized with geotextiles or riprap. In large fields where sediment loading occurs up to the discharge point, an upstream diversion should be installed to redirect runoff from the lowest part of the field into the bioswale some 150 feet or so upstream of the discharge point. This diversion can also be designed as a biofiltration swale for additional sediment filtering. In this manner, all of the runoff will be filtered.

Figure 5-1 displays the schematic location of a biofiltration swale used to intercept upslope channelized flow. Note the diversion used to redirect the runoff from the lowest part of the pasture. Technical assistance to help in designing biofiltration swales and level spreaders is available from the local Conservation District.

Nitrates & Dissolved Pesticides

Loading from Upland Sources

Tributary sources of nitrate in groundwater leached from agricultural sources are a primary cause of eutrophication in the Chesapeake Bay. While conservation is very effective in reducing sediment runoff (by over 90 percent), this practice seems to increase nitrate leaching due to increased infiltration, and it also relies on extensive use of herbicides. Under such circumstances, the potential for removal of nitrates (and herbicides) by riparian buffers has generated much interest in the use of RFBSs as a tributary strategy for the Chesapeake Bay Program. RFBSs can reduce instream concentrations of herbicides by isolating streams from drift during application; however, no data exist on removal of groundwater herbicides by RFBSs.

To best locate and design riparian forest buffers for removal of nitrates, it is necessary to first evaluate the extent of upland loading into the riparian zones throughout the watershed. Many studies suggest that some 20 to 40 percent of applied fertilizer nitrogen (N) is leached into the groundwater. In the Piedmont region of Pennsylvania, nitrate-N concentrations under heavily fertilized crops can exceed 35 mg/l, far above the EPA action level of 10 mg/l for drinking water supplies.

Nitrate loading can be estimated from the type and extent of crop or land use, as interpreted from aerial photographs and Conservation Plans on file. For most crops and land uses, there is fairly extensive literature on groundwater or soil profile concentrations of nitrates which is summarized here to assist in allocating loading levels according to land use. Using a GIS or manual mapping techniques, areas where nitrate loading is high can then be graphically displayed to show their relationship to potential RFBS in the riparian areas.

Shown in decreasing order of loading, Table 5-3 displays nitrate loadings from various land uses within the Chesapeake Bay Watershed. Note that loading rates vary widely in response to fertilizer application rates. Detailed information on the actual fertilizer application rates is necessary to more accurately project the loading values in a specific watershed.

Many of the cited sources measured groundwater or soil profile nitrate concentrations, from which the authors inferred the unit area loading. Values shown with an asterisk in Table 5-3 have been estimated by multiplying reported nitrate-N concentrations by average annual groundwater recharge. This is estimated by adding some 2 inches of riparian area evapo-transpiration to average stream baseflow, which varies from 10 to 16 inches in the Chesapeake Bay Watershed. For instance, at an average recharge of 15 inches (or 0.38 meters), nitrate concentrations would be multiplied by a factor of 3.8 to obtain area load-

Table 5 - 3
Reported Nitrate Loading by Land Cover

LAND COVER	SOIL WATER CONC. (mg/l)	LOADING (kg/ha/yr.)	FERTILIZER (kg/ha/yr.)	LOCATION	SOURCE CITED
Corn Fields	7.1	29	105	MD Coastal Plain	Peterjohn and Correll, 1984
	9-15	38	154	MD Piedmont	Angle et. al, 1989
	19.3	94	259	PA Ridge and Valley	Roth and Fox, 1990
	17.5-24.3	107	192	PA Ridge and Valley	Jemison and Fox, 1994
	12-56	162*	310+	PA Piedmont	Hall and Risser, 1992
Pastures	-	162	420	UK - Hapladults	Ryden et. al, 1984
	-	27.1	56	OH - Hapladults	Owens et. al, 1992
Small Grains	14.8	52*	120	Sweden	Bergstrom, 1987
Soybeans	13.7-14.4	52-55*	0	MD Piedmont	Angle, 1990
Alfalfa Fields	-	10	0	PA Ridge and Valley	Toth and Fox, 1994
Hayfields	2.2	8.1	179	OH - Hapladults	Chichester, 1977
	-	29	420	UK - Hapladults	Ryden et. al, 1984
	-	6	224	RI - Inceptisols	Gold et. al, 1990
Forests	0.04	1-2*	0	TN Ridge and Valley	Mulholland et. al, 1993

* These values are estimated by multiplying reported nitrate-N concentrations by average annual groundwater recharge.

ing rates in kg/ha/yr. To convert to lb/ac/yr, this figure is multiplied by 0.89.

Loading rates for corn vary widely, ranging from 30 to 160 kg/ha/yr., depending upon fertilizer application rates and the use of nutrient management conservation practices. For small grain crops, there is less data, but one study suggests lesser loading rates since they normally require less fertilizer. Average loading rates for crops such as barley, wheat, and oats are projected in the range of 30 to 50 kg/ha/yr.

Legumes such as soybeans and alfalfa can fix considerable quantities of nitrogen from the atmosphere, some of which is released into the groundwater when the crop residue is plowed under. In the case of soybeans, this seems to result in loading rates as high as 30 to 50 kg/ha/yr. Alfalfa is typically in a 3- to 5-year rotation, so fixed nitrogen is not released until plowing. With much of the nitrate then used by subsequent row crops, losses seem to be 10 to 20 kg/ha/yr.

When groundwater nitrate concentrations are high, alfalfa stops fixing nitrogen. Instead, alfalfa begins to utilize nitrate from groundwater and the soil profile, sometimes at remarkable rates. Alfalfa, with its deep roots, would thus seem to be an excellent candidate for Zone 3 where the slope and hydrology in the riparian area result in well drained soils with a relatively deep seasonal high water table (SHWT).

Loading from hayfields is also quite low, since the root zone remains undisturbed and applied nitrogen is returned as hay, instead of leaching out. For this reason, rather low leaching losses have been found under even heavily fertilized hay fields or golf courses, and by extension, suburban lawns. Loading rates for grasses are estimated at 5 to 10 kg/ha/yr.

In contrast to hayfields, heavily grazed fertilized pastures can have remarkably high losses of nitrates, since nitrogen is returned in a concentrated form as urea. Much of the urea is converted to nitrates, which percolates readily through the soil. In the Chesapeake Bay Watershed, loading rates for pastures are estimated to range from 20 to 120 kg/ha/yr, depending upon the extent of grazing, amount of manure spreading, and fertilization.

Water bodies such as lakes and estuaries receive atmospheric inputs averaging 10 to 15 kg/ha/yr. Forests, being nitrogen limited, have very low losses of nitrates, generally in the range of 2 to 5 kg/ha/yr. When cut, forests release substantial amounts of nitrates into the groundwater as the root systems decompose.

The above values should be used as a guide to form an estimate of the loading rates within each subwatershed in question. Where application rates of fertilizer and manure are utilized in projecting loading, the estimates would be more refined. Using a map of the subwatershed, the area of each land cover type within a subwatershed is assigned the projected loading rates for each land cover type. (In allocating land cover types, it is important to keep in mind that while rotation schedules may change, cultivated fields and pastures will remain in similar uses due to underlying soil factors.)

The average nitrate loading rate for an individual subwatershed is then the weighted average of the field areas multiplied by the particular loading rate involved. Using a hypothetical 100 acre subwatershed as an example, if 50 acres are in pasture at a rate of 20 pounds per acre and 50 acres are in corn at 70 pounds per acre , the average loading rate would be:

[(50 x20) +(50 x 70)]/100, or 45 pounds per acre

By initially screening the estimated loadings at the subwatershed level in this manner, those subwatersheds with high loading can be identified for more detailed evaluation, where isolated "hot spots" should become apparent. In the simple example above, loading would be higher in areas downslope from the corn, and less below the pasture. Riparian corridors in heavily loaded subwatersheds and/or downgradient from such locations would then be evaluated for their potential to intercept and transform nitrates from the upland source areas according to the methods described below.

Design Considerations

Riparian forests can remove much of the nitrate in groundwater when it passes through the riparian area under confined conditions. The highest removal rates occur in conditions where virtually all of the nitrate-laden groundwater is confined within the root zone by an aquiclude. Where groundwater inputs are not confined to the root zone, riparian forests have been found to offer considerably less nitrate reduction. These results imply that groundwater entering streams must pass close to or through the root zone for nitrate removal to occur. Therefore, the hydrological relationship between the riparian zone and upland contributing areas determines the potential for removal of nitrates by the riparian buffer.

Two components of regional hydrology affect the potential for groundwater interception by the riparian buffer: the relative depth of groundwater pathways through the riparian buffer, and site characteristics of the riparian area. As shown in Figure 5-3, groundwater movement from the upland source areas varies from shallow pathways flowing parallel to the slope, to deeper recharge pathways descending vertically before proceeding downgradient and flowing upward into streams from the bottom.

Note that groundwater infiltrating from upland areas farthest from the stream follows the deepest pathways, while groundwater infiltrating from uplands closer to the stream follows a shallower profile. Therefore, loading from sources closer to the stream will follow a shallower pathway more likely to be intercepted by a riparian forest buffer. When the aquifer is deep, groundwater pathways will remain partitioned in the riparian area, even though mixing occurs in the discharge zone under the streambed.

The nature of groundwater pathways depends upon the physiographic province and its underlying geology, soils and local topography. These criteria affecting the potential for removal by differing physiographic regimes are discussed more fully in Sections II and III.

Table 5-4 summarizes the relationships among regional hydrogeology, local topography, and soils as they affect the relative depth of flow in the riparian buffer. Sites with factors that tend to favor shallow pathways will have a greater potential for riparian interaction than sites where groundwater flow paths are deeper.

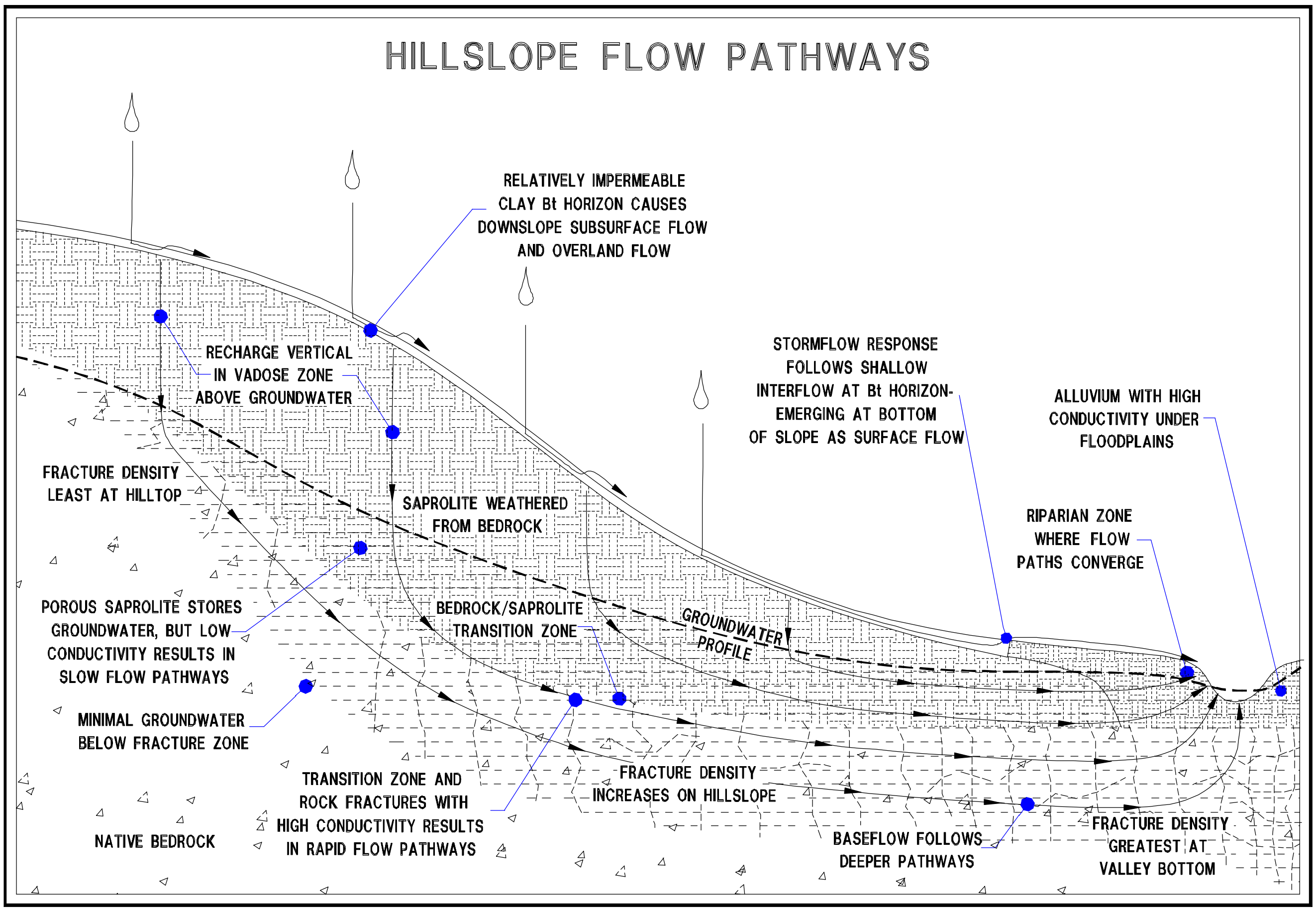


Figure 5 - 3. Schematic diagram of a Piedmont hillslope, showing how rainfall is partitioned between overland flow, shallow interflow, and deep recharge. Source: William Lucas

Table 5 - 4
Relative Groundwater Depth According To Physiographic Factors

Groundwater Flow	Shallow	Medium	Deep	Deepest
Geological Region	Inner Coastal Plain (w/ Aquiclude)	Shallow Saprolite Crystalline, Shales	Sandstones, Deep Saprolite Crystalline	Limestones, Outer Coastal Plain
Base Flow Proportion	<0.30 mgd/mi^2	0.30 to 0.40 mgd/mi^2	0.40 to 0.50 mgd/mi^2	>0.50 mgd/mi^2
Drainage Density	>1.25 $mi./mi^2$	1.0 to 1.25 $mi./mi^2$	0.75 to 1.0 $mi./mi^2$	<0.75 $mi./mi^2$
Upland Hillslope	Convergent, Concave (valley)	Convergent to Linear	Linear to Divergent	Divergent, Convex (ridge)
Upland Bt Horizon	>40 percent clay	25-40 percent clay	10-25 percent clay	<10 percent clay

*mgd = million gallons per day

The optimal situation for groundwater interaction with the riparian area occurs in many watersheds of the Inner Coastal Plain, in which all groundwater is well mixed and confined within shallow pathways into and through the riparian zone. It is in these locations where most studies have documented the removal of nitrate from groundwater.

In more complex hydrogeological regimes, such as the Piedmont and Ridge and Valley Provinces, the potential for groundwater interception by the riparian buffer can be highly variable. The crystalline rocks of the Piedmont have a deep regolith of weathered saprolite and alluvium, within which much of the groundwater moves. A thick regolith permits deeper flow paths to bypass the riparian root zone in many cases, emerging into the streams from under the bottom. Where geomorphology results in less regolith under streams, there would seem to be more potential for groundwater interactions in the riparian zone.

In limestone formations, groundwater flow paths have a substantial vertical component along deeper solution channels, upwelling through the saprolite under streams as base flow. As in the case of the well-drained Outer Coastal Plain, this characteristic of groundwater inflow tends to bypass the riparian buffer. In fact, in some limestone stream reaches, the stream flow actually percolates through the streambed back into the groundwater, suggesting minimal riparian interaction with groundwater.

In sedimentary materials, as found in the Ridge and Valley Province, groundwater flow paths tend to follow the fracture planes which can be quite complex. As a result, instead of being downslope, groundwater discharge locations are often far removed from upland source areas. Sandstones are generally better drained and well fractured, favoring deeper bypassing flow. Shales, mudstones, and siltstones tend to be aquicludes, so flow paths are confined along shallower pathways into the riparian area. Soils derived from these parent materials also tend to have a high clay content, which generally increases the proportion of shallow interflow and overland runoff.

Reflecting underlying geology, regional hydrological characteristics of drainage density and base flow partitioning provide additional information about the potential for groundwater interception in the riparian area. A relatively high base flow component, as found in limestone terrain, indicates that groundwater follows deeper pathways less likely to be intercepted in the riparian area. Drainage density (the linear extent of streams per square mile) in such areas is also less, since there is less runoff to establish stream channels. A high drainage density also results in less loading per linear foot of riparian buffer. Drainage density can provide a reasonable estimate of base flow partitioning where USGS data are unavailable.

Information on the geology of a site is readily available from the state geology maps. State and U.S. Geological Survey personnel are also helpful in interpreting their hydrogeological implications, including base flow/storm flow partitioning.

In many areas of the Chesapeake Bay Watershed where there is a high clay content or fragipan in the Bt horizon, some of the groundwater follows a shallow subsurface pathway. Known as interflow, this groundwater flow contributes to the formation of the "Partial Contributing Area" (PCA) when it emerges at the base of hillslopes during storm events. As displayed in Figure 5-1, PCAs occur at the base of concave, convergent hillslopes and generally extend to the streamside, although there are many instances where the groundwater reinfiltrates before contact with the riparian buffer. PCA sites occur above the headwaters and in the draws draining into streams. These sites are also excellent locations for the removal of dissolved NPS pollutants, even though they would not be considered in a streamside location. Channelized flow often begins in the PCAs along draws, where RFBSs would stabilize the soils and permit reinfiltration to occur.

In certain cases, PCAs in soils with a high clay content can occur in areas with limestone geology and high base flows. In this case, RFBSs located in the PCAs in upland draws may well be more effective than those located in the riparian area.

It is also important to examine the hydrology of the riparian area itself. Where the riparian area is very well-drained, there is much less potential for groundwater interception by the root zone. Where the riparian area is moderately well drained and subject to occasional inundation, the potential for interception is greater, as groundwater is closer to the surface. Where riparian soils are saturated, as in a wetland, much of the groundwater flows through the root zone.

Geomorphology and topography also control groundwater interactions. Groundwater will tend to bypass the riparian buffer where the valley is relatively steep, except at the immediate edge of the stream. Where the riparian buffer area is relatively flat, groundwater will be closer to the root zone farther from the edge of the stream, and the RFBS would be wide enough to be effective.

Table 5-5 lists the characteristics of the riparian area that affect the potential for interaction with groundwater.

Using the criteria displayed in the preceding tables, the potential for groundwater interactions within the riparian root zone can be estimated after examining and comparing the geology, hydrology, riparian drainage, and riparian/upland topography. The best locations for groundwater interactions would have the shallowest flows and greatest potential for riparian interception. Riparian interception potential may be the controlling factor, since a steep well drained riparian area will have minimal interactions, regardless of the thickness of the underlying flow groundwater flow paths.

Having determined the areas of greatest loading and evaluated downslope riparian site potential, it is a straight-forward process to determine the most effective locations for riparian forest buffers. Where loading is high, but interception potential is low, or where loading is low, a RFB will remove relatively little nitrate. Where the loading is highest and the interception potential is best, a RFB will have the greatest effectiveness.

Table 5 - 5
Riparian Groundwater Interception According to Physiographic Factors

Interception Potential	Highest	Medium	Low	Lowest
Riparian Slope	0-3 percent	3-8 percent	8-15 percent	>15 percent
Hydrologic Soil Group	D	C	B	A
Riparian depth to SHWT	0-2 feet	2-4 feet	4-8 feet	>8 feet
Proximity to Source	adjacent	close (<200 feet)	far (200 feet to <600 feet)	distant (> 600 feet)
Stream Order	draws, first order	second order	third order	higher orders

The width of a riparian forest buffer designed for removal of dissolved NPS pollutants is strongly influenced by its potential to intercept groundwater flow. Removal of groundwater nitrate seems to occur within a relatively short width, as narrow as 50 feet. This corresponds to Zone 2 of the USDA Forest Service specification. In a flood plain where site conditions are favorable over a large area, a narrow RFB next to the stream may intercept most of the groundwater flow.

Where riparian site conditions are less than favorable, the riparian forest buffer width should only extend to the point at which interception by the root zone is likely. A wider buffer is unlikely to remove additional nitrate. Instead, potential RFB sites should be located in the PCAs at the bottom of slopes where channelized flows originate above the riparian area. While not streamside forest buffers per se, these locations should be considered as part of the overall NPS removal strategy, particularly where the landowner objectives may be the other functions that are discussed in Section III.

This discussion has provided a framework to evaluate riparian sites for their potential to remove NPS pollutants. By mapping those sites that most effectively intercept both overland and subsurface loading, the optimal locations for a RFB will become apparent. The location and width of the RFBS would then be based upon the specific criteria presented in the tables. Specific planting design methods for a RFB are presented in Section VII.

References

Angle, J.S. 1990. Nitrate leaching losses from soybeans (*Glycine max* L. Merr.). Agriculture, Ecosystems and Environment 31:91-97.

Angle, J.S., C.M. Cross, and M.S. McIntosh. 1989. Nitrate concentrations in percolate and groundwater under conventional and no-till zea mays watersheds. Agriculture, Ecosystems and Environment 25: 279-286.

Bergstrom, L. 1987. Nitrate leaching and drainage from annual and perennial crops in tile-drained plots and lysimeters. Journal of Environmental Quality 16.1: 11-17.

Chichester, F.W. 1977. Effects of increased fertilizer rates on nitrogen content of runoff and percolate from monolith lysimeters. Journal of Environmental Quality 6:211-217.

Daniels, R.B. and J.W Gilliam. 1996. Sediment and chemical load reduction by grass and riparian filters. Soil Science Society of America Journal 60:246-251.

Dillaha, T.A., R.B. Reneau, S. Mostaghimi, and D. Lee. 1989. Vegetative filter strips for agricultural nonpoint source pollution control. Transactions of the ASAE 32:513-519.

Gaskin, J.W., J.F. Dowd, W.L Nutter, and W.T. Swank. 1989. Vertical and lateral components of soil nutrient flux in a hillslope. Journal of Environmental Quality 18: 403-410.

Gold, A.J., W.R. DeRagon, W.M. Sullivan, and J.L. Lemunyon. 1990. Nitrate-nitrogen losses to groundwater from rural and suburban land uses. Journal of Soil and Water Conservation 47:305-310.

Hall, D.W. and D.W. Risser. 1992. Effects of nutrient management on nitrogen flux through a karst aquifer, Conestoga River Headwaters, Pennsylvania in 10 years of controlling agricultural nonpoint source pollution: the RWCP experience. Proceedings of the National RWCP Symposium, September 13-17, 1992. EPA/625/R-92/006 pp 115-130.

Horner, R.R. 1988. Biofiltration systems for water quality control. Puget Sound COG.

Jemison, J.J. and R.H. Fox. 1994. Nitrate leaching from nitrogen fertilized and manured corn measured with zero-tension pan lysimeters. Journal of Environmental Quality (in press).

Kirkby, M. 1988. Hillslope runoff processes and models. In Modeling Geomorphological Systems, Anderson, M.G. ed. John Wiley and Sons, Ltd.

Mathers, A.C., B.A. Stewart, and B. Blair. 1975. Nitrate-nitrogen removal from soil profiles by alfalfa. Journal of Environmental Quality 4.3: 403-405.

McFarlane, E.R. 1995. Groundwater flow, geochemistry, and effects of agricultural practices on nitrogen transport in the Piedmont and Coastal Plain Physiographic provinces, Patuxent River Basin, Maryland. U.S. Geological Survey Open-File Report 94-507.

Mulholland, P.J. 1993. Regulation of nutrient concentrations in a temperate forest stream: roles of upland, riparian and instream processes. Limnology and Oceanography 37(7): 1512-1526

Owens, L.B, W.M. Edwards, and R.W. Van Keuren. 1992. Nitrate levels in shallow groundwater under pastures receiving ammonium nitrate or slow-release nitrogen fertilizer. Journal of Environmental Quality 21:607-613.

Parsons, J.E., R.B. Daniels, J.W. Gilliam, and T.A. Dillaha. 1994. Reduction in sediment and chemical load in agricultural field runoff by vegetated filter strips. Report to Water resources Research Institute and USDA-SCS.

Pearce, A.J., M.K. Stewart, and M.G. Sklash. 1986. Storm runoff generation in humid headwater catchments 1. Where does the water come from? Water Res. Research 22:1263-1272.

Peterjohn, W.T. and D.T Correll. 1984. Nutrient dynamics in an agricultural watershed: observations on the role of a riparian forest. Ecology 65(5): 1466-1475.

Peterjohn, W.T. and D.T. Correll. 1986. The effect of riparian forest on the volume and chemical composition of baseflow in an agricultural watershed. In Watershed Research Perspectives, D.L. Correll, ed. Smithsonian Institution Press. pp. 244-262.

Petersen, G.W., J.M. Hamlett, G.M. Baumer, D.A. Miller, R.L. Day, and J.M. Russo. 1990. Evaluation of agricultural nonpoint pollution potential in Pennsylvania using a geographic information system. Environmental Resources Research Institute, Penn State Univ. University Park, PA. 60 pp.

Pionke, H.B., D.E. Glotfelty, A.D. Lucas, and J.B. Urban. 1988. Pesticide contamination of groundwaters in the Mahantango Creek Watershed. Journal of Environmental Quality 17.1: 76-84.

Power, J.F. and J.S. Schepers. 1989. Nitrate contamination of groundwater in North America.

Agriculture, Ecosystems and Environment. 26: 165-187.

Robbins, C.W. and D.L. Carter. 1980. Nitrate - nitrogen leached below the root zone during and following alfalfa. J. Environmental Quality 9(3): 447-450.

Roth, G.W and R.H. Fox. 1990. Soil nitrate accumulations following nitrogen-fertilized corn in Pennsylvania. Journal of Environmental Quality 19:243-248.

Ryden, J.C., P.R. Ball, and E.A. Garwood. 1984. Nitrate leaching from grassland. Nature 311 (Sep. 6):50-52.

Schertz, D.L. and D.A. Miller. 1972. Nitrate-n accumulation in the soil profile under alfalfa. Agronomy Journal 64 (Sep.-Oct.): 660-664.

Schuman, G.E. and L.F. Elliott. 1978. Cropping an abandoned feedlot to prevent deep percolation of nitrate-nitrogen. Soil Science 126.4: 237-243.

Sklash, M.G, M.K. Stewart, and A.J. Pearce. 1986. Storm runoff generation in humid headwater catchments 2. A case study of hillslope and low-order stream response. Water Res. Research 22:1273-1282.

Sloto, R.A. 1994. Geology, hydrology and groundwater quality of Chester County, Pennsylvania. Chester County Water Resources Authority Water Resource Report 2. Chester County, PA. 127 pp.

Toth, J.D. and R.H. Fox. 1993. Measurements and computer simulation of nitrate leaching losses from continuous corn and alfalfa in central Pennsylvania. Abstract from ASA meetings, November 1993. Cincinnati, OH, Title Summary No. A5-131P.

Wanielista, M.P. and Y.A. Yousef. 1992. Stormwater Management. John Wiley and Sons, New York, NY. pp. 240-253.

Wanielista, M.P., Y.A. Yousef, and E.E. Shannon. 1978. Shallow water roadside ditches for stormwater purification. Report ESEI-78-11, Florida Dept. of Transportation, Tallahassee, FL.

White, K.E. and R.A. Sloto. 1990. Base flow frequency characteristics of selected Pennsylvania streams. U.S. Geological Survey Water Resources Investigations Report 90-4160.

Wiley, R.E. and G. Achmad. 1986. Simulation of groundwater flow and base flow in weathered crystalline rock, Upper Cattail Creek, Howard County, Maryland. Report of Investigations No. 45, Maryland Geological Survey, Baltimore, MD.

Section VI

Determining Buffer Width

Determining Buffer Width

Determining the Width of Riparian Buffers

There is substantial agreement in the scientific community about the value of using vegetation to buffer valuable aquatic resources from the potential impacts of adjacent human use of the land. There is also general agreement that the greatest range of buffer benefits is provided when natural vegetation, like forests, are the target vegetation. However, there is often little agreement and much continuing research and debate over how to best achieve the level of protection needed and how to best delineate and manage a buffer. Of all questions related to practical use of riparian buffers, determining the appropriate minimum width of a buffer is certainly the most frequently discussed.

One of the important factors which determines the effectiveness of a buffer is its size or effective width. Buffers that are too narrow may still place water quality or aquatic resources at risk. They may also present problems with sustainability over the long term. Although wider is nearly always better, buffers that are wider than needed may unnecessarily restrict use of a portion of the land. Therefore, the need to determine "minimum" widths has been a primary focus of resource agencies and local governments for many years. Complicating the picture further, buffer size requirements are typically established by political acceptability and compromise rather than on scientific merit. It is likely that these debates will continue.

Buffer Width Criteria

Various approaches and formulas have been devised to determine and evaluate the needed width of a riparian buffer. Establishing criteria that are scientifically based should be the goal of resource and conservation agencies. Four criteria are generally discussed for determining the adequate width of riparian buffers for protection of streams. They are the:

1. existing or potential value of the resource to be protected,
2. site, watershed, and buffer characteristics,
3. intensity of adjacent land use, and
4. specific water quality and/or habitat functions desired.

If necessary, these scientific criteria can then be modified by the management objectives or constraints of a given landowner or land management agency. In this way, scientific criteria guide width decisions, but are modified by socioeconomic variables where the risk and benefits of the decisions can be identified and discussed.

For example, when a 75-foot-wide buffer is determined appropriate, but is reduced to 25 foot by constraints imposed by land use, the risk of reduced water quality functions and potential sustainability should be identified. Likewise, when a decision is made to choose warmseason grasses over forest as the target buffer vegetation, reductions in stream stability, flood mitigation, groundwater nutrient removal, and aquatic/terrestrial habitat should be identified. In simple terms, narrower buffers may be adequate when the riparian area is in good condition, the resource values may be low, site conditions are ideal, the adjacent land use has a low potential for impact, and/or the desired buffer functions are few. Conversely, wider buffers are necessary when the buffer quality is poor and high-value water resources exist adjacent to intense land uses where a high level of multiple buffer functions is desired.

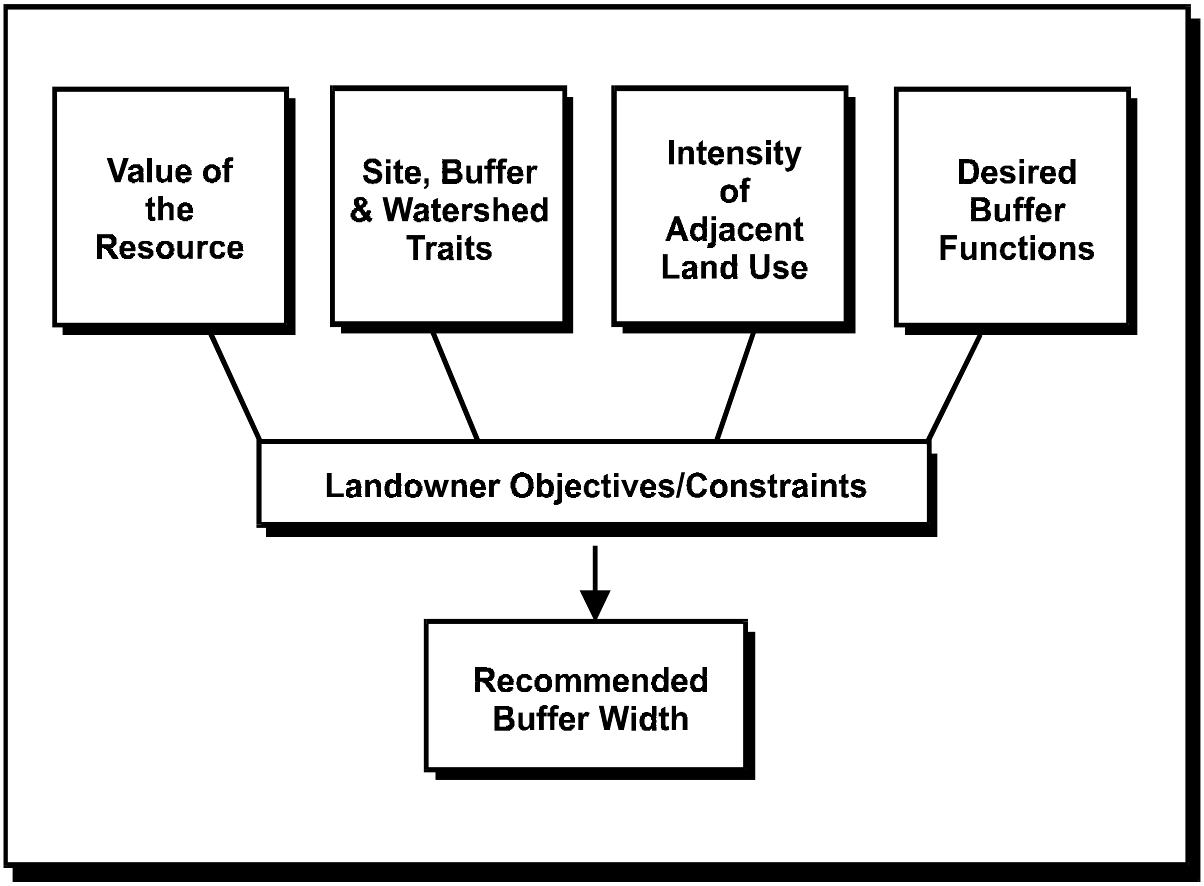


Figure 6 - 1. Criteria for determining width of riparian buffers and their relationship to landowner objectives.

Science-Based Criteria

Decisions about buffer width can be made using professional judgment in choosing among the following criteria. Four criteria (Figure 6-1) are discussed for which data may be available to support an informed decision. These criteria can form a “checklist” for buffer width determination.

Existing or Potential Resource Value

In general terms, narrower buffers are adequate when the stream, wetland, shorezone, or lake is of relatively low functional value. Although the determination of “value” can involve subjective judgment, scientific information can be applied to assist in this assessment. For example, states routinely rate the value of fish habitat based on potential natural condition or the target species being managed. The Chesapeake Bay Program has identified priorities for stream blockage removal based on value to migratory fish. Streams in watersheds providing municipal water supply or recreational use would likewise be considered of high functional value. Aquatic systems with a high disturbance regime or ones that are dominated by non-native species may be considered of lower functional value.

Conversely, degraded watershed, water quality, or habitat conditions may also be used as criteria for increasing buffer width if desire for improvement of conditions related to riparian areas has been specified. The designated uses of water or specific fish or wildlife species needs should be considered when buffers are established as a component of watershed restoration rather than protection strategies.

Site, Buffer, and Watershed Characteristics

Site factors are most important when evaluating performance in pollutant removal (Table 6-1). This is because reliable generalizations about the role of riparian buffers as nutrient and sediment filters can be based on the condition of the soil in the buffer area (including plant, animal, and microbial communities present) and the route and rate of surface and groundwater movement through the buffer. These characteristics are complex, interrelated, and not always apparent to the field observer. For example, judgments about water quality performance of a buffer in the Coastal Plain may be made on observations of surface storm runoff, not recognizing that 50-80 percent of nitrogen loads are carried by subsurface water flow. Site factors are also discussed later in desired buffer functions, but some general comments can also be made.

Site Criteria Affecting Buffer Width

- **watershed condition**
- **slope**
- **stream order**
- **soil depth and erodibility**
- **hydrology**
- **flood plains**
- **wetlands**
- **streambanks**
- **vegetation type**
- **stormwater system**

Table 6 - 1
Site Factors that Enhance or Limit Pollutant Removal Effectiveness of Buffers
(adapted from Schueler, 1995)

Factors that enhance effectiveness	Factors that reduce effectiveness
Slopes < 5 percent	Slopes greater than 5 percent
Contributing flow length <150 feet	Overland flow paths over 300 feet
Seeps, high water table—subsurface flow	Flow path to deep or regional groundwater
Permeable, but not highly sandy soils	Compacted soils
Level spreaders or flow dispersal	Concentrated storm flow
Organic matter, humus, or mulch layer	Snowmelt, ice conditions, low organic soil
Entry runoff velocity less than 1.5 feet/second	Entry runoff velocity more than 5 feet/second
Routine maintenance	Sediment buildup at entrance
Poorly-drained soils, deep roots	Shallow root systems
Forest and dense grass cover (6 inches)	Tall bunch grass; Sparse vegetative cover

Slope - Slope has the greatest influence over sediment removal and is a determinant in the rate and nature of water flow. In general terms, steep slopes increase runoff velocity and the volume of surface runoff. Buffers are often expanded to include steep slopes on small streams or buffer widths are increased on steeper slopes to provide a lower risk of impact from adjacent land use. For forestry practices in Maryland for example, a minimum 50 foot buffer width is modified for slope by adding 4 feet for each percent of side slope.

Stream Order – In order to design an effective stream buffer system, it is important to understand spatial connections between the stream and its watershed. Stream order is a useful tool to classify elements of the stream network. Headwater streams, defined as first or second order, are generally short in length, but comprise 75 percent or more of the total stream and river miles. In general terms, buffers have the greatest potential for control over water quality when adjacent to low-order streams. Lower order streams are small in size and have less contributing area per unit volume of water. Smaller buffers may be adequate to maintain the desired level of protection for first order streams.

As stream order increases, the contributing area and volume of water available to the buffer area also increases, potentially diminishing the relative capability of the buffer to filter and remove pollutants as a percent of total loading. This does not mean that the buffer's effectiveness in treating pollutants immediately upslope may be compromised, only that the magnitude of control exerted over the water in the stream diminishes. An example of this type of relationship is portrayed in Figure 6-2. Likewise, as stream order increases so does stream size, thus decreasing the ability of streamside trees to provide control of water temperature. The importance of the buffer zone in flood mitigation, on the other hand, may increase with stream order, whereas, critical fish habitat may be maximized by streamside trees in low to mid order streams.

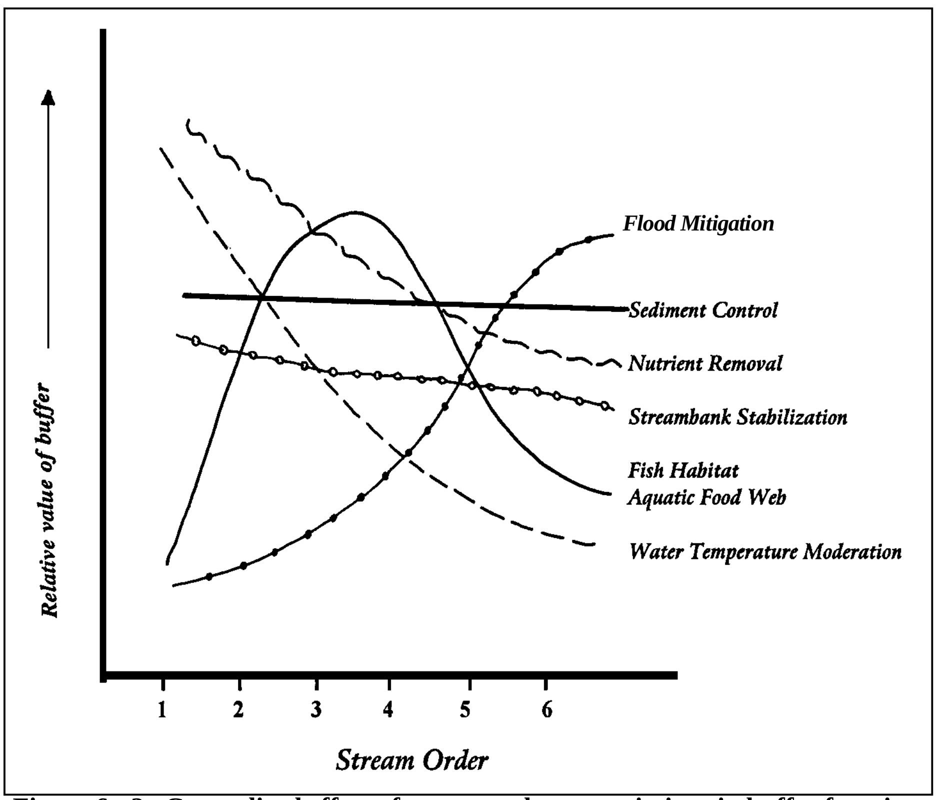


Figure 6 - 2. Generalized effect of stream order on variations in buffer function.

Target Vegetation and Condition **-** In simple terms, adequate buffers may be smaller if properly designed and maintained in good condition. Most riparian buffers use adapted or enhanced natural vegetative systems. Therefore, buffers in better condition (e.g. dense native vegetation, undisturbed soils, healthy microbial community) are likely to provide a variety of functions more effectively. Common sense shows that by looking to the natural ecosystem, the natural resource manager will find guidance in maintaining and restoring riparian functions.

Although a number of vegetation types can be used to meet these specific buffer functions and provide multiple benefits, in the Chesapeake Bay region, as in much of the eastern United States, these benefits are amplified by or require a streamside area that is forested. Forests provide the greatest range and number of potential environmental benefits, and therefore, should be promoted as the target vegetation whenever possible in a hierarchy of vegetation types. These benefits are summarized in Table 6-2.

Table 6 - 2
Benefits of Riparian Buffers That Include Woody Vegetation

Benefit	***Greatly enhanced by or requiring Forest***
Protection from streambank erosion	✓
Increased removal of nitrogen	✓
Removal of phosphorus and sediment	
Reduced downstream flooding	✓
Thermal protection	✓
Food and habitat for wildlife	✓
Food and habitat for fish and amphibians	✓
Foundation for present or future greenways	✓
Increased urban/suburban property values	✓
Provision of corridors for habitat conservation	✓
Preservation of “right-of-way” for lateral movement	
Enhanced potential for stream restoration	✓
Reduced watershed imperviousness	✓
Reduced small drainage complaints	
Protection of associated wetlands	✓

Incorporation of flood plains and wetlands - Buffer width is often expanded to incorporate sensitive landscape features such as flood plains and wetlands. Including the entire flood plain width is desirable, but often difficult. Additional areas such as stormwater ponds and buffer infiltration areas (biofiltration swales) will often be incorporated in buffer layout in urban areas.

Continuity - Achieving contiguous buffers on the landscape along a stream system may be given a higher priority than increased width in areas where aquatic and terrestrial habitat goals are important.

Soils - Along with hydrology, soil characteristics are important in determining potential for removal of nitrogen and pollutants carried by sediment such as phosphorus and some pesticides. Primary considerations are soil texture, depth to water table, and organic matter content of soils. Moderate- to well-drained soils have the greatest permeability and intercept large amounts of water that may enter the buffer as surface flow, thus promoting deposition of sediment and related pollutants. Conversely, moderate- to fine-textured soils have superior potential to create conditions favorable for extensive denitrification.

Since denitrification is carried out by anaerobic microbes, soil conditions must be wet enough to allow oxygen depletion to occur. The large amount of decaying organic material on the ground and in upper soil layers in forested buffers helps to deplete oxygen supply and "fuel" the denitrification process. Although denitrification rates and duration vary depending on site conditions, even drier forest soils commonly have pockets that support these bacteria. In more poorly drained, higher organic matter soil, denitrification may proceed at relatively high rates in the top foot of soil. At better-drained sites, denitrification depends on the cycling of plant biomass back to the surface in litter fall. Here denitrification will not be uniform, but still active in surface soil. A combination of soil properties which provides a gradation of coarse- to finer-grained materials closer to the waterbody seems ideal. Sites with a depth to water table of 3 to 15 feet will allow maximum root penetration by woody plants and sustain uptake of nutrients and chemicals in solution below the surface. The water table need only be present for a portion of the year.

Hydrologic Soil Groups are often used as criteria for determining buffer width and are commonly available in county soil survey reports (Section IV).

Intensity of Adjacent Land Use

Generally, when the density, intensity, magnitude, or potential impact of the activity increases, the width of the buffer necessary to contain the negative effects increases proportionally. The differences between developed or disturbed lands and the aquatic environment are significant; the more intensely developed or disturbed, the more significant. Likewise, the size or importance of the buffer increases as the potential yield of nutrients, chemicals, sediment, and runoff from adjacent land use increases. Table 6-3 illustrates how these loadings can vary by land use. However, it is clearly recognized that a number of desired buffer functions, such as nutrient removal, are reduced in urban areas as impervious surface increases. Impervious surfaces increase watershed runoff efficiency reducing base flow to the stream and limiting the total volume of water passing through the buffer.

Buffer widths prescribed in urbanized areas are often increased to account for the risk of future encroachments and to anticipate future changes in stream morphology due to increases in stormwater runoff. This stream "right-of-way" approach is useful in development site planning. Maintaining larger wooded corridors along streams and rivers in urban planning helps preserve open space and offset general forest loss in a watershed. It is often most economical to consider this approach at the onset of land use change.

Table 6 - 3
Nutrient Loading Delivered to Edge of Stream as Used in the Chesapeake Bay Watershed Model
(does not include manure application areas)

Land Use	Total N (lbs./acre/year)	Total P (lbs./acre/year)
Forest	3.00	0.05
Pasture	9.34	0.61
Urban	11.44	0.67
Cropland	21.13	1.84

Studies in the coastal plain of Georgia described a relationship of buffer area to contributing area treated of 1:3 in agricultural areas with high nutrient loads. This ratio may be higher where potential impacts are less. Likewise, smaller buffers may be adequate where the magnitude of impact from land use is also low, e.g. parklands, haylands, or low-density development. A buffer width that is one-third the distance from the streambank to the top of the pollutant source area is sometimes recommended. The intent is to create a buffer between field and stream which occupies approximately one-third of the source area. This is reduced to one-fifth of the drainage area for lakes and ponds.

Desired Buffer Functions

One of the most important scientific criteria for determining buffer size requirements is an evaluation of the specific functions that a buffer needs to provide under site-specific conditions. A search of the literature clearly suggests that buffer sizes necessary for adequate performance of specific buffer functions vary widely. Accordingly, some judgment and setting of priorities is nearly always necessary to attain a desired minimum buffer width for a desired set of functions. Figure 6-3 illustrates a generalized range of minimum widths based on specific objectives for the buffer. The following is an overview of some important buffer functions and discussion of their relationship to width. Scientific references for these discussions are extensive.

Sustainability - Inevitably, when discussing riparian buffer establishment, the concept that "anything is better than nothing" will be raised. This is probably an accurate assessment when it comes to maintaining the functions of stable streambanks and making some improvements in stream or shoreline habitat. However, it is important to recognize that for a riparian area to serve the water quality functions of buffering impacts from adjacent land use, a "critical mass" or sustainable width is often essential. Buffers of less than 50 feet have proven increasingly difficult to maintain as effective filters in the field, except on small, low order drainages.

Sustainability should be a key consideration of buffer layout and design, prior to making substantial investments or assumptions about expected buffer performance. Sustainability like other functions will be determined by site characteristics and adjacent land use. For example, very narrow buffer strips of 15 to 25 feet are generally inadequate for sediment or nutrient reductions, except on small, low order streams. Narrow forest strips may provide shade and bank stability, but may not sustain a forest ecosystem capable of accumulating organic matter

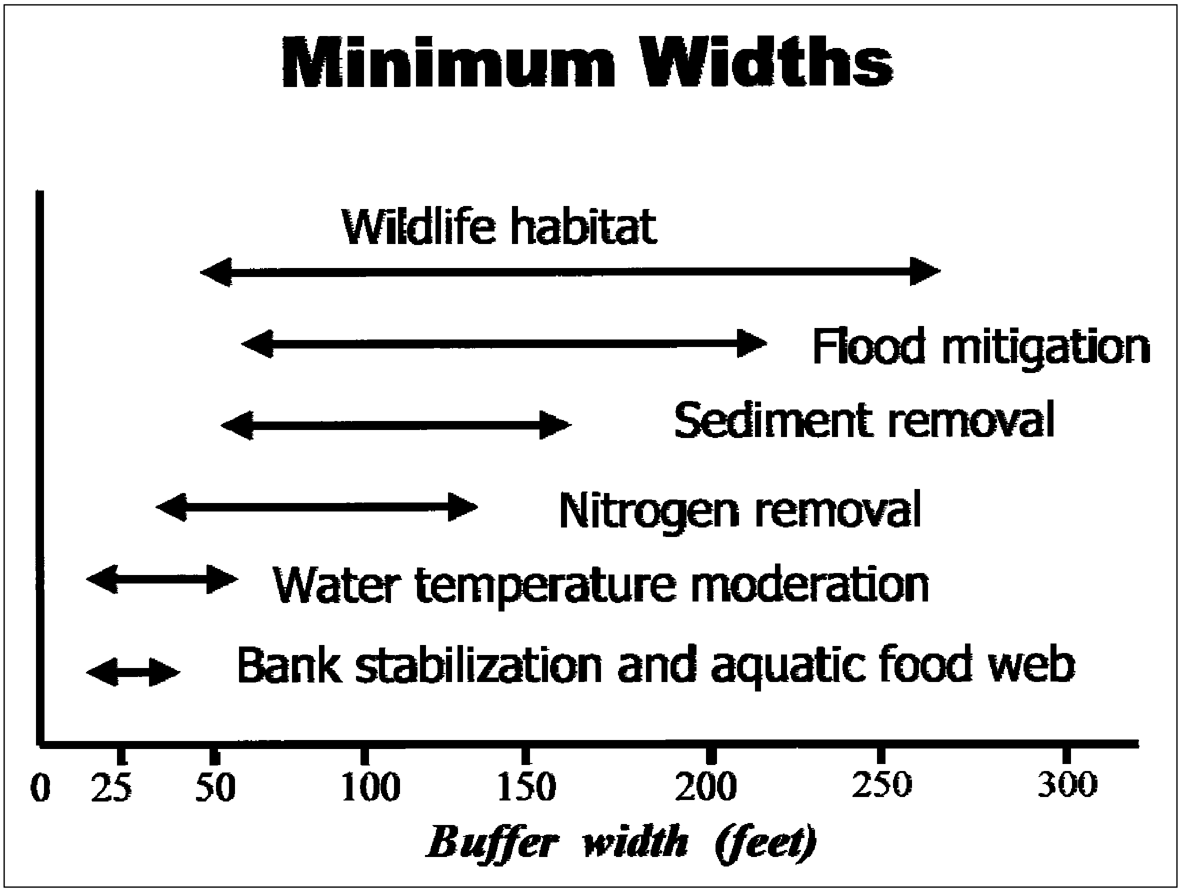


Figure 6 - 3. Range of minimum widths for meeting specific buffer objectives.

and providing the water storage necessary for desired levels of nitrogen removal. These narrow strips are also far more susceptible to damage from floods and blowdowns. Grass filterstrips may be effective initially at reducing sediment loads, but be quickly overwhelmed if sediment loads remain high.

Excess nitrogen removal - Determining the ability to provide nitrogen removal should consider: 1) the pathway by which nitrogen enters the buffer zone (e.g. surface runoff, deep or shallow groundwater, atmospheric deposition), and 2) the potential for transformation of nitrogen within the buffer strip due to site conditions. By filtering and absorbing runoff and reaching groundwater within the rooting zone, nutrients such as nitrogen (and dissolved phosphorus) are processed in plant uptake or transformed by denitrification. The denitrification process converts excess nitrogen compounds into nitrogen gas that is released into the atmosphere. Microbes use organic compounds as food, degrading them into simpler compounds or synthesizing them into microbial biomass. Riparian forests in particular, support a variety of microbial degradation mechanisms, though the specific conditions that promote them are not yet well understood.

Although the focus of many studies is often placed on surface flow, it is important to recognize interactions with water traveling as shallow or deeper groundwater. Groundwater carrying nitrogen passes through or surfaces within the riparian area where it can be acted upon by biological processes in the buffer. The natural resource manager must pay close attention to both localized and regional flow paths in determining this function.

Processes of denitrification occur under a wide range of conditions, but will be most intense in the wetter streamside area, whereas, the uptake of nitrogen by vegetation will begin at the up-slope edge of the vegetation. Woody plants enhance buffer functions through aggressive uptake of nitrogen in plant biomass, accumulation of organic matter, root-fungal interactions, and moisture retention. In this way, some reductions in overall buffer width may be possible when forests occupy a substantial portion of the buffer system. Efficiency will depend on residence time (affected by width) and nutrient load. In nearly all documented studies, most nitrogen removal occurred in the first 35 to 90 feet of forest. Nitrogen reductions of 25 to over 90 percent of total loadings have been shown in field studies. Where conditions for water storage, vegetative uptake, and denitrification are ideal, widths as small as 35 feet may provide substantial removal of the nitrogen passing through the buffer.

There are a variety of hydro-physiographic regions in the Chesapeake Bay Watershed and each one has an effect on nitrogen processing. See Section II for additional descriptions of these areas.

Reduction of sediment and phosphorus - Vegetated buffers improve water quality by trapping sediment and debris, by stabilizing streambanks, and by promoting infiltration of runoff. Vegetation forms a physical barrier to movement and mechanically traps associated sediment. Roots maintain soil structure and prevent erosion of soil. Reducing flow rates and disrupting channelized flow by providing resistance is the role of vegetation, thus allowing more time for infiltration and settling of sediment. Because nearly 90 percent of phosphorus is carried to streams attached to soil particles or organic matter, reducing sediment transport helps to reduce phosphorus loads. The ability of vegetation to colonize the sediment and rapidly use available phosphorus is a related function. Reductions in soil sediment by 40 to 70 percent from lands using riparian buffers are typical.

Prevention of channelized flow is the primary concern for sediment removal and is significantly affected by slope. Most studies show buffer widths of 50 to 100 feet for adequate removal. While small buffers remove small amounts of sediments, the relationship between buffer width and sediment removal is not linear. Beyond efficiencies of 80 percent removal, disproportionately large buffer widths are required for incrementally greater sediment removal. Except under conditions of excessive channelized flow and steep slopes, buffer widths in excess of 150 feet did not show additional returns. Maintaining vegetation cover sufficient to reduce flow is key. In agricultural areas, researchers found that of the 35 or more grass filter strips inspected after three to five years of use, less than 10 percent continued to be effective because of channelized flow and sediment build-up at the field edge of the filter strip. The combination of grass filter strips with a forested buffer are especially efficient in performing this function.

Reduction of pesticides - Generally speaking, buffer strips of 45 feet or more have proven effective in reducing some pesticide contamination of streamflow. Factors that affect pesticide transport in buffers are similar to those affecting nutrients. Most pesticides in common use are adsorbed to soil particles or carried in runoff and subsurface flow. Organic pesticides are subject to microbial breakdown processes common in organically rich riparian forest environments. For example, buffers are an effective tool prescribed for protection of water supplies from atrazine.

Moderation of water temperature - Forested riparian buffers provide shade cover, thereby helping to lower water temperatures during summer and lessen temperature decreases in winter. Lack of shade has a direct effect on water quality and aquatic life. Elevated temperatures are a catalyst for water quality problems by accelerating or increasing the impacts of nonpoint source pollution and robbing oxygen from the system. Small streams flowing through exposed reaches can increase as much as 1.5 degrees F for every 100 feet of exposure to summer sun. Maximum temperature fluctuations for daily peaks can be as much as 12 to15 degrees F higher, and ambient temperatures of 6 to 8 F degrees higher are not uncommon. The evapotranspiration process of forests also contributes to lower water temperatures. The removal of streamside trees is one of the most significant causes of degradation for streams in the United States.

The ability of a buffer to provide shade is directly proportional to height of the vegetation and bankfull width of the stream. Even 15- to 25-foot buffers can provide adequate shade for small streams. Fifty- to 75-foot forest buffers are sufficient to ensure favorable conditions for trout, and buffer widths along slopes can decrease with increasing tree height with no loss of shading. Aspect is also an important consideration. Grass filter strips along streams are generally unable to provide cover sufficient to moderate water temperature.

Preservation of stream channel integrity and bank stability - Vegetation in the riparian area exerts a strong control over the condition and stability of the stream and its banks. In the eastern United States, trees often define the physical characteristics of stream channels. Trees anchor streambank soils through dense root masses, and large roots provide physical resistance to flow energy. Woody debris anchors channel substrate and determines bar formation, stores large amounts of streambed sediment and gravel, helps control sinuosity, and provides channel structure through pool/riffle or step formation. Until recently, the value of large woody debris was misunderstood and much was removed throughout the country. It is likely that the direct effect of buffer width on this function is limited. Only vegetation within 25 feet of the stream channel will provide a powerful role in stabilization. However, increasing buffer width will continue to indirectly enhance stream stability by providing additional protection and stability during extreme flood events, allowing stability during channel migration, and as a physical barrier to human impact.

Moderation of storm flows and runoff - Stream corridors and natural forest vegetation help to reduce the downstream effects of floods by dissipating stream energy, temporarily storing flood waters, and helping to remove sediment loads through incorporation in the flood plain. On a given site, a vegetated buffer that resists channelization is effective in decreasing the rate of flow, and in turn, increasing infiltration. Forests provide as much as 40 times the water storage of a cropped field and 15 times that of grass turf. These increases in storage are largely due to the forest's ability to capture rainfall on the vast surface area of the leaves, stems, and branches; the porosity and water holding capacity of organic material stored on the forest floor and in the soil; and the greater transpiration rates common to the community of forest vegetation. Forests are being evaluated more frequently for their role in reduction of water volume for stormwater management.

Increasing width to incorporate the flood plain also increases the potential efficiency of water storage from upstream flow during storm events. Providing flood storage buffers where possible along smaller streams in a watershed may provide a valuable approach to downstream flood reduction. However, once the entire flood plain is included within the buffer area, the effect of buffer width on flood peak reductions is negligible.

Provision for aquatic habitat and food - Leaf litter is the base food source in most stream ecosystems and streamside trees are critical in establishing this aquatic food web. Small fish, some amphibians, and most aquatic insects rely primarily on leaf detritus (dead leaf material) from trees as food. Studies have shown that when streamside trees are removed, many aquatic insects decline or even disappear, and with them, native fish, birds, and other species that may depend on them. Some insects are adapted to specific tree species and are unable to reproduce or even survive when fed the leaves of grasses that are non-native or exotic species.

Large woody debris also creates cover and habitat structure for fish and other aquatic species in shallow water estuarine habitat. Here it may serve as a nursery area or refuge for fish, crabs, and other organisms. This function is noteworthy in the Chesapeake Bay since the decline of submerged aquatic vegetation. Although the portion of the buffer nearest the waterbody exerts the greatest influence over this function, increasing buffer width provides support and sustainability. This is especially true when considering the need to provide long-term woody debris recruitment, diversity of vegetation for leaf detritus, and refuge for species during high water. The presence of trees is directly related to greater biodiversity in the stream ecosystem.

Provision for terrestrial habitat corridors - Riparian areas have the potential to provide rich habitats for a wide diversity of wildlife species. Species such as turtles, pheasant, turkey, wood ducks, great blue herons, woodpeckers, raptors, tree frogs, salamanders, songbirds, and many mammals require trees for breeding, nesting, feeding, and escape habitats. Even narrow forest strips will provide essential habitats for some of these species. However, the width and character of buffers will vary to meet the needs of particular species. A mixture of grasses and forbs, especially tall species, will provide suitable habitat for some game birds. In all cases, maintaining forests as a component of the buffer system greatly enhances diversity and abundance of birds and other wildlife.

Buffers also provide transition zones between upland and aquatic environments. Although buffers alone will not provide needed migratory songbird habitat, studies have shown that even narrow 100-foot corridors increased neotropical bird abundance when they connected small patches of remaining forest. To provide corridors for movement of many larger mammals such as deer and bear, or to provide reliable breeding habitat for migratory songbirds, larger buffer widths (100 to 300 feet) are needed.

Landowner-Based Criteria

Riparian buffers can also be designed to provide additional human benefits such as recreation and aesthetic enjoyment, as well as sites for hunting, fishing, or observing nature. Buffers can provide the foundation for future greenways. In addition, buffer width may be expanded to provide an economically-viable unit for future timber harvest or to provide sufficient land base to sustain other secondary products derived from compatible activity within the buffer.

Landowner concerns most often serve to constrain the width of a buffer. These decisions may be due to economic considerations, livestock watering and pasture management, operation of adjacent farm fields, competing uses, or existing developments. As decisions are made, landowners should be aware of the potential changes in desired buffer functions that occur and the potential compromise of long-term values. This is especially important when buffers are being used within the context of overall nutrient management plans. In most cases, a buffer width can be determined which will meet landowner needs while also providing an adequate array of buffer functions.

Application

Given the practical need for simplicity, the operable question is how these multiple criteria can be incorporated in field applications. The problems related to using multiple criteria are not effectively addressed in the scientific literature. Most often, states or local agencies use an approach where multiple buffer criteria are simply stated as separate requirements and their interpretation is left to field staff. This approach has considerable merit, but results in inconsistency. There are several other methods with potential where multiple criteria are combined into a single requirement. One example is the cartographic modeling approach used in conjunction with a GIS. Here, multiple criteria are expressed in spatial terms, and mapping of buffer widths capable of meeting the criteria are displayed. For example, if temperature moderation is desired, a level of shading needed for the stream can be determined. Extension of this approach to multiple resource values and desired functions would be possible if additional criteria can be determined and expressed in spatial terms.

Another approach, maximum protection, evaluates each of several criteria and then adopts the greatest width to accommodate all desired functions. A variation on this approach commonly used is to utilize average widths in the same manner. A regional method might also be used to set a recommended buffer width. For example, buffer widths could be determined based on a set of criteria and desired function for selected stream reaches within a region. Then, by evaluating the statistical probability of occurrence for various stream types within a watershed, a regional buffer width could be selected to meet the criterion a prescribed percent of the time. Approaches of this kind are also useful in prioritizing or targeting areas for protection or restoration.

Many agencies rely predominantly on stream rating systems to establish minimum buffer sizes. Most minimum widths are determined by functional resource value alone or a specific intended use or group of uses rather than by site-specific factors. By looking at one function alone or one site criteria, application is simplified, but most of the scientific information available may be ignored.

The last and perhaps simplest approach may be to determine a minimum width that will meet a majority of the multiple desired functions with the target vegetation. This could provide a limited number of additional site criteria that would allow for modification and flexibility based on site conditions.

Fixed Minimum Versus Variable Width Buffers

There are two principal ways by which most buffer widths are defined: 1) the width may be set as a fixed distance, usually measured from the streambank on each side of the stream, or 2) the width may be variable depending on specific natural or man-made features adjacent to the waterway. Minimum width buffer strips are usually promoted primarily because they are simple to implement and administer. Because minimum widths are most often developed by compromise or by considering an average of desired functions, it is likely that minimum width buffers may provide more than adequate protection in some areas, and inadequate protection in others. Where political compromise has resulted in very narrow buffer widths, people may be given a false perception that a stream is protected when serious risk may still exist. Fixed buffer widths in common use across the country range from 25 to 300 feet or more.

Variable width approaches to buffers usually attempt to integrate buffer functions with site-specific conditions. In this way, the width of the buffer depends not only on the minimum width needed for a specific function or set of functions, but also on the sensitivity and characteristics of the stream and watershed in which it is located. Adjacent slope, soil type, presence of wetlands and flood plains, mature forests or special habitats, scenic or cultural features, recreation use, and other local aspects of significance may be considered in determining buffer width. Buffer expansion and contraction, as a characteristic of design width, are promoted, especially in urban settings. A range of adequate widths may also be provided. Although, variable width approaches are likely to be more science-based, they inevitably require more extensive site investigation and evaluation and are ultimately more difficult to monitor and administer. Often a combination of these approaches is used. For example, a minimum width is determined and specific criteria for expansion and contraction are specified.

The 3-zone buffer concept, discussed in Section I, presents another way in which desired buffer functions/values can be evaluated, resulting in a design that meets the landowner's or resource manager's needs. Specific zones are managed

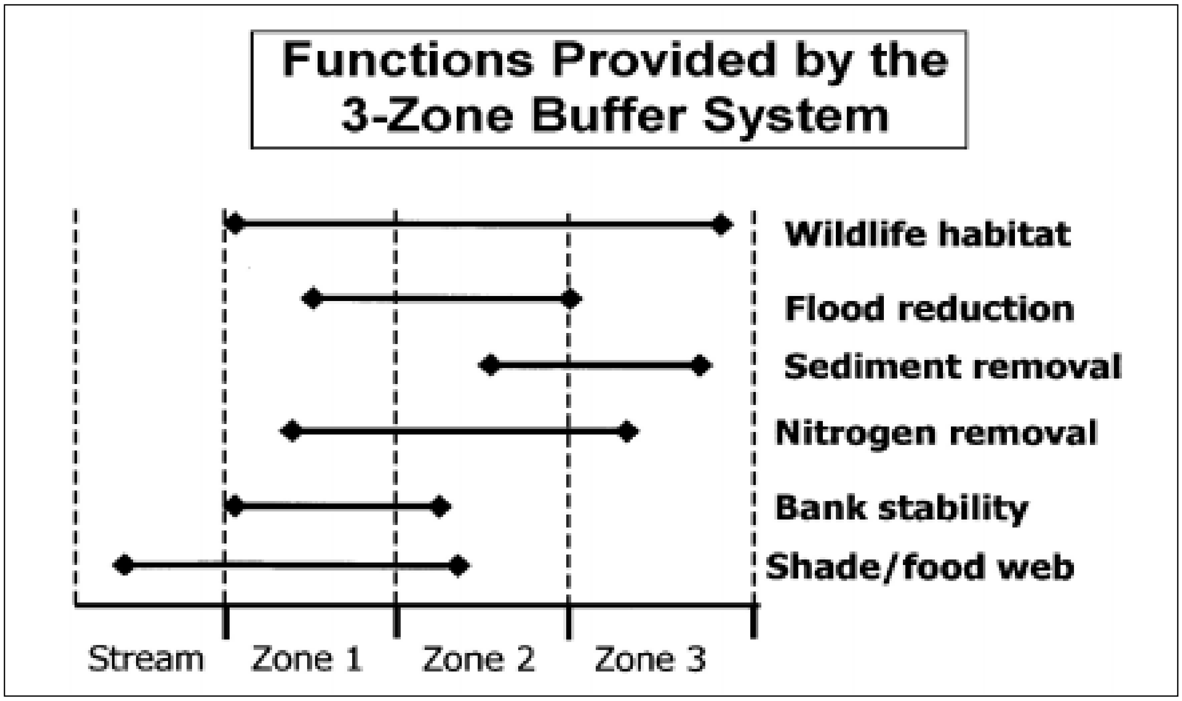


Figure 6 - 4. Each zone of the riparian forest buffer provides various functions and values to the landowner.

alone or in combination to accomplish various objectives. Figure 6-4 illustrates how some common buffer functions apply to the 3-zone concept of buffer design.

Conclusion

The scientific literature clearly supports that there is no "ideal" buffer width for all applications in all areas. A number of criteria are appropriate for consideration in determining adequate buffer widths in an ecosystem context. Evaluating a combination of these factors such as site and watershed characteristics, functional resource value, intensity of land use, and desired buffer functions all provide considerations from a scientific viewpoint. Because most buffers are established on private lands or public lands managed for a variety of uses, landowner/manager and public constraints and objectives are also considered.

The most commonly prescribed minimum buffer widths for use in water quality and habitat maintenance are approximately 75 to 100 feet. The scientific literature appears to support that buffers of less than 35 feet cannot sustain long-term protection of aquatic resources. To provide an array of functions then, buffers should be a minimum of 35 to 100 feet in width under most circumstances. Buffer widths toward the lower end of the range appear to provide some physical and biological components of the stream ecosystem, especially on small streams. Buffer widths at the upper end of the range are likely to provide protection of physical, chemical, and biological characteristics of the aquatic resource.

The establishment of riparian forest buffers in agricultural or urban/suburban areas may require significant care and investment. Likewise, protecting riparian forests as buffers also requires an investment of land in lieu of other uses. Regardless of how buffer width is determined, resource professionals should ensure that three basic elements are considered. First, the minimum width should be of significant size to perform desired functions for water quality and habitat. If buffer width is significantly reduced or constrained by landowner or other criteria, then the risk that certain desired buffer functions may not be realized over time should also be recognized. It is safe to say that an increase in buffer width reduces the risk of failure. Third, a determination of minimum width should consider sustaining stream protection and buffer functions over the long term and the potential future threats to buffer integrity that the site, stream, or watershed may experience.

Three main considerations for determining minimum width:

- ✓ **FUNCTION**
- ✓ **RISK**
- ✓ **SUSTAINABILITY**

References

Ambus, P., and R. Lowrance. 1991. Comparison of denitrification in two riparian soils. Soil Science Society American Journal, 55:994-997.

Belt, G.H., J. O'Laughlin, and T. Merrill. 1992. Design of forest riparian buffer strips for the protection of water quality: Analysis of scientific literature. University of Idaho, Report No. 8, Idaho Forest, Wildlife, and Range Policy Analysis Group.

Correll, D.L. 1996. Buffer zones and water quality protection: general principles. In Proceedings of the International Conference on Buffer Zones, N. Heycock, ed., Oxford, England, 8/28-9/2, 1996.

Correll, D.L., T.E. Jordan, and D.E. Weller. 1994. Coastal riparian forests: their role in filtering agricultural drainage. pp. 67-72, in: Altered, Artificial and Managed Wetlands, Agriculture and Forestry, J. Kussler and C. Lassonde (eds), Assoc. of State Wetlands Managers.

Dillaha, T.A., R.B. Reneau, S. Mostaghimi, and D. Lee. 1989. Vegetative filter strips for agricultural nonpoint source pollution control. Transactions of ASAE 32:513-519.

Dillaha, T.E. 1993. Development of a buffer zone evaluation model/procedure. Report to the Virginia Council on the Environment Coastal Resources Management Program by Virginia Polytechnic Institute and University, Blacksburg, VA.

Doyle, R.C., G.C. Stanton, and D.C. Wolff. 1977. Effectiveness of forest and grass buffer strips in improving the water quality of manure polluted runoff. ASAE Paper 77-2501, ASAE, St. Joseph. MO.

Fail Jr., J.L., B.L. Haines, and R.L. Todd. 1986. Riparian forest communities and their role in nutrient conservation in an agricultural watershed. American Journal of Alternative Agriculture II(3); 114-121.

Fail, J.L., Jr., M.N. Hamzah, B.L. Haines, and R.L. Todd. 1986. Above and below ground biomass, production, and element accumulation in riparian forests of an agricultural watershed. pg. 193-224, In D.L. Correll (ed.) Watershed research perspectives, Smithsonian Institute Press, Washington, DC.

Gregory, S.V., F.J. Swanson, W.A. McKee, and K.W. Cummins. 1991. An ecosystem perspective of riparian areas. Bioscience 41:540-551.

Herson-Jones, L., M. Heraty, and B. Jones. 1996. Riparian buffer strategies for urban watersheds. Metropolitan Council of Governments, Environmental Land Planning Document Series, No. 95703, Washington, DC.

Hill, A. 1996. The potential role of in-stream and hyporheic environments as buffer zones. In Proceedings of the International Conference on Buffer Zones, N. Heycock (ed.) Oxford, England, 8/28-9/2, 1996.

Lowrance, R.R., R. Leonard, and J. Sheridan. 1985. Managing riparian ecosystems to control nonpoint pollution. Journal of Soil and Water Conservation No. 40; 87-97.

Myrold, D.D., and J.M. Tiedje. 1985. Establishment of denitrification capacity in soil: effects of carbon nitrate, and moisture. Soil Biol. Biochem. 17:819-822.

Pais, Richard. 1994. Wildlife corridors in the suburban environment. Proceedings of Conference: "Riparian Forest Buffers: Restoring and Managing a Vital Chesapeake Resource." October 5-6, 1994. Ellicott City, MD, Chesapeake Bay Program.

Sweeney, B.W. 1992. Streamside forests and the physical, chemical, and trophic characteristics of piedmont streams in eastern North America. Water Science Tech. 26:2653-2673.

U.S. Environmental Protection Agency - Chesapeake Bay Program. 1995. A framework for habitat restoration. C. Bisland (ed.) Living Resources Subcommittee, Annapolis, MD.

Section VII

Site Evaluation, Planning, and Establishment

Site Evaluation, Planning, and Establishment

Riparian Site Evaluation and Planning

Site Analysis – Physical Features

To design and establish a successful riparian forest buffer, it is necessary to evaluate the riparian area with respect to factors controlling the viability of riparian plants. Soil moisture, depth to seasonal high water table, flooding potential, topography, soil reaction (pH), soil texture, and climate are the most important physical characteristics of a riparian site. Since they cannot be altered, these characteristics are the primary criteria for selecting the proper plant species.

Soil Moisture

An important factor affecting plant viability is soil moisture in the root zone. Certain plants tolerate, or even prefer, the saturated soils found in wetlands. Most riparian species prefer moist soils, such as those found on forested north-facing slopes. Many species tolerate average moisture soils found in less protected sites, and a few riparian species can tolerate the dry soils found on the most exposed sites. Table 7-1 presents the soil moisture tolerances and preferences of riparian plants, segregated by structural categories of canopy, understory, shrubs and forbs. Riparian species are listed in order of relative soil moisture preferences.

In the field, simple procedures exist to measure soil moisture. However, soil moisture fluctuates considerably over the course of a year, so it is difficult to reliably project the average growing season moisture levels from a single measurement. The soil moisture regime and a table of temperatures and precipitation are in soil surveys.

Depth to Seasonable High Water Table

The seasonal high water table (SHWT) in the riparian area can range from that of poorly drained wet soils to well-drained drier soils over a short distance from the stream bank. From the stream, the groundwater rises at a relatively uniform gradient controlled by soil texture. Coarser soils drain readily and have a flat profile. Fine textured clays retard drainage, increasing the groundwater gradient. Typically, the groundwater gradient is less than the surface profile, so depth to SHWT increases farther from the stream. In clay soils, perched water tables also occur, particularly in draws and at the bottom of hill slopes. Where such perched water tables occur, soils will be wet or moist, even though the permanent groundwater table may be considerably deeper.

Soil probes are a simple method to determine depth to SHWT by observation of wetness and/or soil mottling and gleying. Groundwater elevations in the riparian area do not fluctuate substantially over the year. Therefore, depths to SHWT found from soil probes are a reliable indicator of soil moisture. Information on the typical depth to SHWT for a soil series is also presented in the soil survey produced by the Natural Resources Conservation Service.

Topography

Aspect and slope affect solar exposure. South- and west-facing slopes are more exposed to sunlight, lowering soil moisture. North- and east-facing slopes and stream reaches are less exposed, increasing soil moisture. This effect is accentuated where the general topography is relatively steep. Local topography within the riparian area is also important. Hummocks and levees within the flood plain can isolate moisture-intolerant species from the wet conditions found at a similar SHWT below adjacent hill-slopes.

Table 7 - 1
Physical Tolerances and Preferences of Riparian Plants

\+ Preference/High Tolerance = Tolerance

PLANT NAME	SOIL MOISTURE				DEPTH TO SHWT				FLOODING			TEXTURE			REACTION(pH)				ZONE
COMMON NAME	WET	MOIST	AVG.	DRY	0-1.5'	1.5-5'	5-10'	>10'	HIGH	AVG.	LOW	SAND	LOAM	CLAY	<5.0	50-6.0	6.0.70	>7.0	
RIPARIAN CANOPY																			
Swamp white-cedar	+	+			+	+			+			+	+	+	+	+	+		5b-9a
Baldcypress	+	+			+	+	+		+				+	+		+			5a-9a
Black willow	+	+	=		+	+	+	+	+			+	+	+	+	+	+	+	3b-9a
Eastern cottonwood	+	+	+		+	+	+		+			+	+	+	+	+	+	+	3a-9a
Red maple	+	+	+		+	+	+	+	+			+	+	+	+	+	+		3b-9a
Swamp white oak	+	+	+		+	+	+		+				+	+	+	+	+		4a-8b
Blackgum	+	+	+	=	+	+	+	+		+		+	+	+	+	+	+		5a-9a
Green ash	+	+	+	=	+	+	+	+	+			+	+	+	+	+	+	+	2a-9a
Silver maple	+	+	+	=	+	+	+	+	+			+	+	+	+	+	+		3a-9a
Sycamore	=	+	+		+	+	+	+		+		+	+	+	+	+	+	+	5a-9a
River birch	=	+	+		+	+	+		+			+	+	+	+	+	+		4a-9a
Pin oak	=	+	+		+	+	+	+	+			+	+	+	+	+	+		5a-8b
Willow oak	=	+	+		+	+	+	+	+			+	+	+	+	+	+		6a-9a
Hackberry	=	+	+	=	+	+	+	+		+		+	+	+	+	+	+	+	3b-8b
Pitch pine	=	+	+	=	+	+	+	+		+		+	+	+	+	+	+		4b-7b
American beech		+	+		+	+	+	+			+	+	+	+	+	+	+		4a-9a
Sweetgum		+	+		+	+	+	+	+			+	+	+	+	+	+		5b-9a
Black walnut		+	+	=		+	+	+		+		+	+	+	+	+	+	+	4b-9a
Bitternut hickory		+	+			+	+	+		+		+	+	+	+	+	+	+	4b-8b
Persimmon		+	+	=		+	+	+		+			+	+	+	+	+		5a-9a
White ash		+	+			+	+	+		+		+	+	+	+	+	+	+	4a-9a
Yellow-poplar		+	+			+	+	+			+		+	+	+	+	+		5a-9a
White oak		+	+	=		+	+	+			+		+	+	+	+	+	+	4b-9a
Red oak		+	+			+	+	+			+	+	+	+	+	+	+		3b-9a
Basswood		+	+			+	+	+			+	+	+	+		+	+	+	3a-8a
RIPARIAN UNDERSTORY																			
Boxelder	+	+	+	=	+	+	+	+	+			+	+	+	+	+	+		2b-8a
Hazel alder	+	+	=		+	+	+	+	+			+	+	+	+	+	+		3b-9a
Sweet bay	+	+	=		+	+	+	+	+				+	+	+	+	+		5b-9a
Blackhaw	=	+	+		+	+	+	+	+			+	+	+	+	+	+		6b-9a
Possumhaw	=	+	+		+	+	+	+	+			+	+	+	+	+	+	+	5b-9a
Witch-hazel	=	+	+			+	+	+			+	+	+	+	+	+	+		4a-9a
Shad bush		+	+		+	+	+	+			+	+	+	+	+	+	+		3b-8a
Pawpaw		+	+				+	+			+	+	+	+	+	+	+	+	5b-8a
Hornbeam		+	+	=		+	+	+			+		+	+	+	+	+		3b-9a
Redbud		+	+	=			+	+		+		+	+	+		+	+	+	5b-9a
Flowering dogwood		+	+			+	+	+			+		+	+	+	+	+		5b-8b

Table 7-1 (cont.)

Physical Tolerances and Preferences of Riparian Plants

\+ Preference/High Tolerance = Tolerance

PLANT NAME	SOIL MOISTURE				DEPTH TO SHWT				FLOODING			TEXTURE			REACTION(pH)				ZONE
COMMON NAME	WET	MOIST	AVG.	DRY	0-1.5'	1.5-5'	5-10'	>10'	HIGH	AVG.	LOW	SAND	LOAM	CLAY	<5.0	50-6.0	6.0.70	>7.0	
RIPARIAN SHRUBS																			
Buttonbush	+	+			+	+	+	=	+			+	+	+	=	+	+	=	4b-9a
Pussy willow	+	+	=		+	+	+		+			=	+	=	+	=			3a-9a
Sweet pepperbush	+	+	=		+	+	+	=	+			+	+	+	+	+			4b-9a
Swamp azalea	+	+	=		+	+	=		+			+	+	+	+	=			4b-9a
Winterberry	+	+	+		+	+	+		+				+	+	+	+	=	=	4a-9a
Arrowwood	+	+	+	=	+	+	+	+	=			=	+	+	+	+			4a-9a
Highbush blueberry	+	+	+	=	+	+	+	+	+			+	+	+	+	+			4b-9a
Elderberry	+	+	+	=	+	+	+	+	+			+	+	+		=	+		3a-9a
Virginia sweetspire	=	+	=		+	+	=		+			+	+	+	=	+	+		6b-9a
Inkberry	=	+	+		+	+	+		+			+	+	+	+	+			5a-9a
Swamp leucothoe	=	+	+		+	+	=		=			=	+	+	+	+			6a-9a
Pinxterbloom azalea	=	+	+	=	+	+	+	+	+			+	+	+	+				5b-8b
Bayberry	=	+	+	=	+	+	+	+	+			+	+	+	=	+	=		4b-9a
Silky dogwood	=	+	+	=	+	+	+	+		=		+	+	+	=	+	+	=	4b-9a
Common ninebark	=	+	+	=	=	+	+	+	+			=	+	+	=	=	+	+	3a-6b
Red chokeberry	=	+	+	=	=	+	+	+	+			+	+	+	+	+	=		4b-9a
Spicebush	=	+	+	=	=	+	+	+		=		=	+	=	+	+	=		5b-9a
Gray dogwood		+	+	=	=	+	+	+		=		=	+	+	=	=	+	=	3b-7b
Rosebay rhododendron	=	+	+			+	+	+			=	=	+	=	=	+	+	=	5a-6b+
Maple-leaf viburnum		+	+	=		+	+	+			=	=	+	+	+	+			3b-9a
FORBS AND FERNS																			
Jewelweed	+	+	=		+	+	+		+			=	+	+					
Smartweed	+	+	+		+	+	+		+			=	+	+		+	+		
Royal fern	+	+	+		+	+	+			=		=	+	=					
Sensitive fern	+	+	+		+	+	+			=		=	+	=					
Joe-Pye weed		+	+	=		+	+	+	=			=	+	+					
Swamp dewberry	=	+	+		+	+	+		=			=	+	+	=	+	+		4a-7b
Thimbleberry		+	+	=		+	+	=			=	=	+	+					
Raspberry		+	+	=		+	+	=			=	=	+	+					
GRASSES																			
Switchgrass	+	+	+		+	+	+		+			+	+		+	+	+		
Eastern gamagrass	+	+	+		+	+	+			=		=	+	=		+	+		
Field bromegrass	+	+	+	=	+	+	+	=	=			=	+	+		+	+		
Fowl meadow grass	+	+	+		+	+	+			=		+	+	+		+	+		
Deertongue	=	+	+	=		+	+	+		=		+	+	+	+	+	+		
Tall fescue		+	+	+		+	+	+		=		+	+	+		+	+		
Indiangrass	=	+	+	=		+	+	+		=		=	+	+	+	+	+		
Purpletop	=	+	+	=		+	+	+		=		=	+	=		+	+		
Big Bluestem		=	+	=		=	+	+			=	+	+	+		+	+		
Little Bluestem		=	+	=		=	+	+			=	+	+	+		+	+		

The soil moisture regime in the riparian area can thus be estimated by relating SHWT and topography. Wet soils are found at a SHWT less than 1.5 feet. Moist soils will occur where the SHWT is from 1.5 feet to about 5 feet deep; deeper where solar exposure is relatively low. Average moisture occurs at a lower depth to SHWT or where the site is more exposed. Dry soils occur where the SHWT is deepest, and the site is most exposed, as would be found in a deeply incised south-facing slope. Since wet and moist soils dominate riparian sites, mapping depth to SHWT concentrates on delineating the boundary between wet and moist soils.

Topography also determines the extent and duration of flooding events. Many species are well adapted to flooding and should be planted in flood plains and at the stream margin. Less tolerant species should be located further upslope. Where topographic features are less well-defined, local experience, high water debris marks, soils maps, and informed judgment can determine the limits of flooding. A map of likely flooding, potential flooding, and unlikely flooding can then be prepared. Information on flooding tolerances of riparian species is listed in Table 7-1.

The stability of the streambanks is another important factor that affects riparian forest buffer design. Where the streambanks migrate during excessive flooding, it is important to address bank stability as part of the buffer design process. This is discussed in detail in Section VIII.

Soil Reaction (pH)

In addition to soil moisture, pH is another important soil property relating to plant selection. Plants should be selected based on the existing soil pH. For this reason, field testing of soil pH at representative locations in the riparian area is necessary to ensure proper plant selection. Usually, soil reaction does not vary widely in the riparian area. Where it does, a map of soil reaction should be generated to assist in plant selection. The pH preferences and tolerances of riparian plants are listed in Table 7-1.

Soil Texture

Soil attributes such as texture, pH, and fertility are discussed in detail in Section IV. Most riparian plants tolerate a wide variety of soil textures, although certain species do not tolerate excessively sandy or clayey soils. Along with organic matter, soil texture plays an important part in determining available water capacity (discussed in Section IV). Texture also affects the groundwater gradient, as discussed previously. Table 7-1 displays the differing preferences of riparian species to soil texture.

Climate and Hardiness Zones

Climate affects plant hardiness. Plant hardiness zones in the Chesapeake Bay Watershed range from zone 5a to zone 8b. Nearly all of the plant species listed in the Tables 7-1 and 7-2 are classified as being hardy throughout the watershed. However, caution must be exercised when specifying plants near the northern limit of their hardiness zone. Riparian areas typically lie in frost pockets that effectively reduce the regional zone value by at least one increment. Microclimate is also affected by solar exposure. Microclimate and seed source must be considered where plants are specified near the limits of their hardiness zone. (See USDA Plant Hardiness Zone Map in the Appendix.)

Generating Maps

The first step in site analysis is to generate a usable base map of the tract. U.S.G.S. quadrangles and soil survey maps can be enlarged for use. Keep in mind, however, that if the maps are enlarged, there will be significant inaccuracies because data are being used at a much larger scale than they were intended. To enlarge a 2000 scale quad to a 100 scale, enlarge it on a copier by a factor of two over four steps to bring it close to 125 scale. To calculate the final enlargement factor, a known distance between two features (measured on the original quad) is measured with a 100 scale on the last enlargement. For instance, if a known distance of 600 feet scales at 730 feet, the final enlargement factor will be 730/600, or 1.22. A similar procedure is used for the 1667 scale soils maps.

An alternative method is to digitize the features within a Computer-Aided Design (CAD) system and then scale to the final scale. An initial enlargement or two is necessary to assist digitizing accuracy. CAD systems rapidly manipulate data in the process of preparing and refining base maps, as well as formulating the planting plans and plant schedules.

The enlarged quads and soil maps are traced onto a combined base map. For field use, the base map should incorporate features and landmarks from the vegetation maps to help in locating the resource manager on the ground. After refinements from field notes, the base map is used to assist layout of the planting plan.

From field observations and soil probe measurements of the seasonable high water table, it is possible to draw up a map of the area. The procedure involves several steps: On the initial base map, note soil probe locations with depths to SHWT, wetland vegetation, incised channels, hummocks, swales, benches, and other features of interest. From this initial sketch, revise the contours on the initial base map to conform more closely to the observed conditions. Then, insert interpolated contours to portray variations in local relief. Absolute accuracy is not required; rather it is important to indicate the relative topography in relation to the stream channel, which sets the SHWT elevation. Where incised channels, benches, and hummocks occur, the SHWT will be deeper. Where flat areas occur next to streams, or farther from streams, the SHWT can rise within 1.5 feet behind drier benches or incised stream channels. The SHWT can be mapped to show where it is less than 1.5 feet and over five feet. (Depths over 10 feet are unlikely in most riparian areas.)

Table 7 - 2

Ecological and Silvicultural Characteristics of Riparian Plants

\+ Characteristic/Preference = Tolerance

PLANT NAME	REGION			WILDLIFE VALUE				SHADE INDEX				GROWTH RATE				SIZE			ROOTING
COMMON NAME	C. PLAIN	PIEDMONT	MTNS.	V. HIGH	HIGH	MED.	LOW	<2.0	2.0-5.0	50-7.9	>8.0	V. FAST	FAST	MED.	SLOW	>75'	50-75'	<50'	
RIPARIAN CANOPY																			
Swamp white-cedar	+					+		+						+	+		+		shallow
Baldcypress	+	+					+	+	=					+		+			shallow
Black willow	=	+	+		+			+				+					+		shallow
Eastern cottonwood		+	+				+	+					+			+			shallow
Red maple	+	+	+	+				+	+	=			+	+			+		v. shallow
Swamp white oak	+	+			+			+	=	=			+	+		+			shallow
Blackgum	+	+	+			+		+	=						+			+	taproot
Green ash	=	+	+				+	+				+					+		shallow
Silver maple	+	+	+	+				+	+	=		+		+		+			v. shallow
Sycamore	+	+					+	+	=	=		+					+		shallow
River birch	+	+	+	+				+	=				+				+		shallow
Pin oak	+	+			+			+	=				+	+		+			shallow
Willow oak	+	+			+			+	=				+	+		+			shallow
Hackberry	+	+	+	+				+	=	=			+	+		+			deep lateral
Pitch pine	+						+	+						+	+			+	shallow
American beech	+	+			+			=	+	+	+			+	+	+			shallow
Sweetgum	+	+					+	+	=					+			+		deep taproot
Black walnut	=	+	+				+	+	=				+			+			taproot
Bitternut hickory	+	+	=			+		+	+	=				+	+	+			deep taproot
Persimmon	+	+			+			+	=						+			+	deep taproot
White ash	=	+	+				+	+	+	+				+		+			shallow
Yellow-poplar	+	+	+				+	+	+	=			+	+		+			shallow/deep
White oak	=	+	+	+				+	=	=					+	+			deep taproot
Red oak	=	+	+		+			+	+	=				+		+			deep lateral
Basswood		+	+				+	+	+	+	=			+			+		deep lateral
RIPARIAN UNDERSTORY																>40'	40-30'	<30'	
Boxelder	=	+	+	+				+				+				+			deep lateral
Hazel alder		+	+			+		+					+					+	shallow
Sweet bay	+	+					+	=	+	=				+				+	deep lateral
Blackhaw		+	+		+			+	+	=				+				+	shallow
Possumhaw	=	+	+		+			+	+					+	+			+	shallow
Witch-hazel		+	+				+	=	+	+	+			+			+		deep lateral
Shad bush		+	+		+			=	+	+	+				+		+		shallow
Pawpaw		+		+				+	+	=					+		+		deep lateral
Hornbeam		+	+	+					=	+	+				+		+		deep lateral
Redbud		+	+				+	=	+	+			+	+			+		shallow
Flowering Dogwood		+	+			+		=	+	+	+				+		+		shallow

Table 7-2 (cont.)

Ecological and Silvicultural Characteristics for Riparian Plants

\+ Characteristic/Preference = Tolerance

PLANT NAME	REGION			WILDLIFE VALUE				SHADE INDEX				GROWTH RATE				SIZE			ROOTING
COMMON NAME	C. PLAIN	PIEDMONT	MTNS.	V. HIGH	HIGH	MED.	LOW	<2.0	2.0-5.0	50-7.9	>8.0	V. FAST	FAST	MED.	SLOW	>75'	50-75'	<50'	
RIPARIAN SHRUBS																			
Buttonbush	+	+	+				+	+	=					+			+		shallow
Pussy willow		+	+		+			+					+			+			shallow
Sweet pepperbush	+	+			+			+	+	+				+	+		+		shallow
Swamp azalea	+	+					+	+	+	=				+		+			shallow
Winterberry	+	+			+			+	+	=					+	+			shallow
Arrowwood	+	+	+		+			+	+					+		+			shallow
Highbush blueberry	+	+		+				+	+						+		+		shallow
Elderberry	+	+	+	+					=	+	+		+			+			shallow
Virginia sweetspire		+	+				+	+	+	+	=			+	+			+	shallow
Inkberry	+	=			+			+	+	=					+			+	shallow
Swamp leucothoe	+	+					+		=	+	+				+			+	shallow
Pinxterbloom azalea	+	+					+		=	+	+				+		+		shallow
Bayberry	+				+			+	=					+			+		shallow
Silky dogwood		+	+	+				+	=	=			+				+		shallow
Common ninebark	+	+				+		+	=				+					+	shallow
Red chokeberry	+					+		+	+	=					+			+	shallow
Spicebush	+	+	+	+					=	+	+				+		+		deep laterals
Gray dogwood		+	+	+				+	+	=				+			+		shallow
Rosebay rhododendron	+	+	+				+		=	+	+				+	+			shallow
Maple-leaf viburnum		+	+		+				=	+	+			+	+		+		shallow
FORBS AND FERNS																>6'	3-6'	<3'	**TYPE**
Jewelweed	+	+	+		+			+	=					+			+		annual
Smartweed	+	+			+			+					+					+	annual
Royal fern		+	+				+	+	+	=			+					+	fern
Sensitive fern		+	+				+	+	+	+	=		+					+	fern
Joe-Pye weed	+	+	+			+		+					+				+		perennial
Swamp dewberry	=	+	+		+			+	=				+					+	perennial
Thimbleberry	=	+	+		+			+	=				+				+		perennial
Raspberry	=	+	+		+			+	=				+				+		perennial
GRASSES																>6'	3-6'	<3'	
Switchgrass	=	+	+	+				+	=				+				+		warm,clump
Eastern gamagrass	+	+		+				+	=	=			+				+		warm,clump
Field bromegrass	=	+	+		+			+					+					+	w. annual
Fowl meadow grass	=	+	+		+			+					+					+	cold, sod
Deertongue	=	+	+		+			+	+	=			+					+	warm,clump
Tall fescue	=	+	+			+		+	=				+					+	cold, sod
Indiangrass	=	+	+		+			+	+				+			+			warm,sod
Purpletop	=	+	+		+			+	=				+				+		warm,clump
Big Bluestem	=	+	+		+			+						+		+			warm,clump
Little Bluestem	=	+	+		+			+						+				+	warm,clump

Using this procedure, Figure 7-1 displays how topography and SHWT are related to generate a soil moisture map for a parcel in the Pennsylvania Piedmont. In this site, the overall slopes are gentle, so exposure will be uniform during RFB establishment, and soil moisture will be closely related to depth to SHWT. Note that the SHWT is deeper than 1.5 feet where the stream channel is incised below that depth. However, where flat slopes lie behind such banks, the SHWT will rise within 1.5 feet, creating wet areas. This map of wet areas can then be related to the preferences and tolerances of riparian species (Table 7-1) to select the most appropriate species during the planning process.

For the site shown in Figure 7-1, flooding is minimal in this headwater drainage area. Soils are slightly acidic throughout the site, which is located in Hardiness Zone 6b. These physical features are combined with the moisture map to determine which of the plant species listed in Table 7-1 will do best on the site. Soil mois-

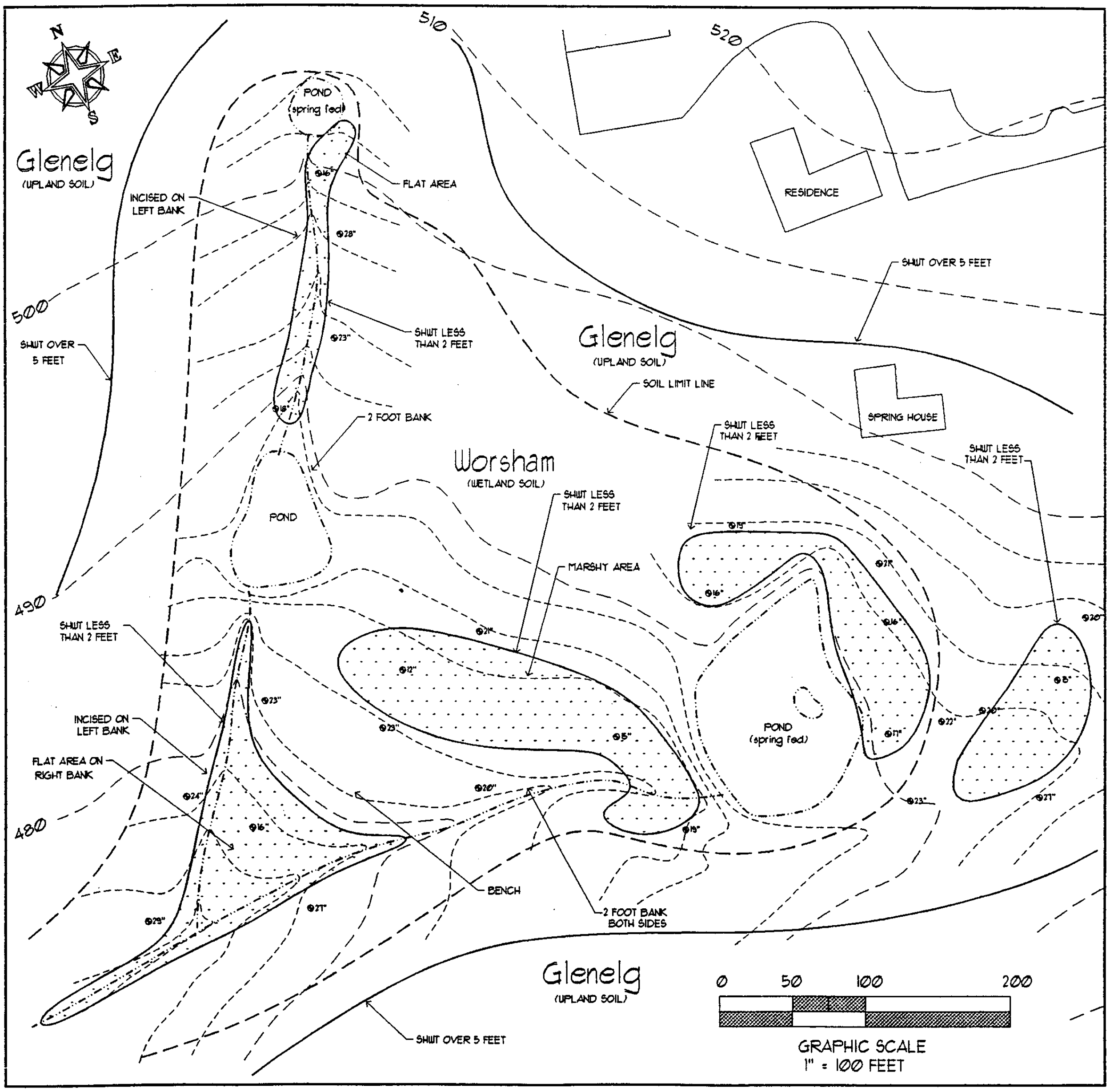


Figure 7 - 1. Soil moisture map relating topography and seasonal high water table in the Pennsylvania Piedmont. Round area with dots = SHWT less than 2 feet.

ture, texture, and reaction are described in Section IV.

Site Analysis - Vegetative Features

While physical features control plant selection, existing vegetation in a riparian area will dictate the choice of strategy for buffer establishment. Depending on whether the site is presently a pasture, an overgrown abandoned crop field, or a mid-successional forest, different approaches are needed to properly establish the desired vegetation. The structural aspect of the successional stage affects conditions such as competition for light, water, and nutrients. Depending upon the species, different plants will respond differently to these conditions. In addition to the previously mentioned ground vegetation, the seed bank in the upper soil layers will also determine the plant community likely to emerge during buffer establishment. The seed bank includes not only the seeds of plants in the immediate vicinity, but also the substantial extent of root biomass from which new vegetation can sprout. Vegetative reproduction from root suckers often dominates in the successional situations found during riparian buffer establishment.

In many cases, riparian areas are overgrown with invasive species, most of which are exotic. In order to establish desired native species successfully, these plants and their seed bank must be controlled to reduce competitive pressure during establishment and maintenance of the riparian forest buffer. Given the relatively narrow width of the typical forest buffer, this often requires eradication of invasive species in the riparian area during site preparation. Where desirable species are also present, a more selective approach is required in site preparation.

A similar procedure to physical mapping is used to prepare the vegetation base map. Soils maps are based upon aerial photography, so they show features such as treelines and ponds that may not appear on U.S.G.S. topographic quadrangles. Government offices, such as the Natural Resources Conservation Service, Farm Service Agency, U.S. Geological Survey, and USDA Forest Service offer aerial photos at 800 or 400 scale. These should be used as the source for feature mapping as they are more recent than most soil surveys. Aerial photography at the lower scale will show individual trees, fence lines, and other features useful as landmarks to help locate the resource manager in the field. With aerial photography, it is often best to trace the features directly from the base photos or blueprints, and then enlarge the tracings as described above. This prevents loss of clarity resulting from the copying process.

Riparian sites can be analyzed for physical and vegetative features in one field visit, so the base maps are often combined for field use. Using this base map to locate features, note plant species, relative size, and condition from field observations. Existing trees should be located and described individually, unless part of a mass of trees, in which case the species composition, average size, and density will be adequate. Understory, shrub, and vine composition should also be noted in a similar manner. Figure 7-2 displays the existing vegetation in the site shown in Figure 7-1.

Identify Desired Species

Many different native tree and shrub species thrive in riparian areas and provide substantial benefits to the stream ecosystem. Tables 7-1 and 7-2 list native species available that have characteristics desirable for establishment of riparian buffer functions and values. In addition to the plants listed, other native riparian trees and shrubs that are difficult to transplant and/or find should be identified for retention during the site analysis phase. These species are listed on the following page.

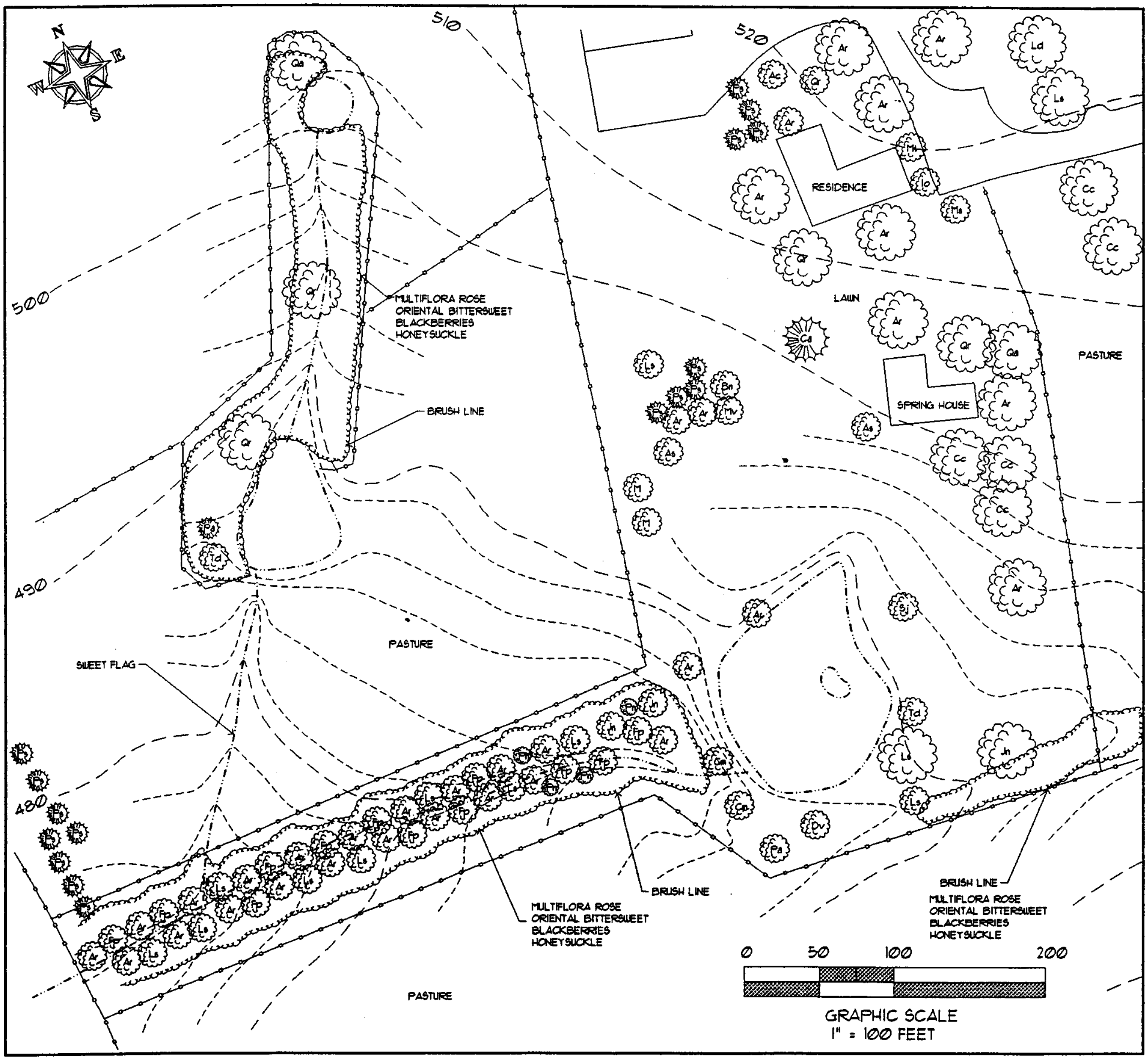


Figure 7 - 2. Existing vegetation on the map shown in Figure 7-1. Desired and undesired species can be identified here.

Native Plants That Should Be Retained		
Fringetree	*Chionanthus virginicus*	difficult to find
Fothergilla	*Fothergilla major*	difficult to find
Black Ash	*Fraxinus nigra*	difficult to find
Carolina Silverbell	*Halesia carolinia*	difficult to find
Water Tupelo	*Nyssa aquatica*	difficult to find
Snowbell	*Styrax americanus*	difficult to find
American Elm	*Ulmus americana*	subject to disease
Slippery Elm	*Ulmus rubra*	difficult to find

In addition to these species, there are also several pioneer tree species that can be found colonizing a riparian area. Since they are short-lived, shade-intolerant, upland species, these species are not included in Tables 7-1 and 7-2. However, these species can play a very important part in providing shade and structural diversity in a young riparian forest, and their presence will benefit the establishment of the riparian forest buffer. These species include the following:

Native trees should be retained during buffer establishment. It is important to carefully examine the site to locate the seedlings of these species. While certain species may be inappropriate as part of the final stand (for example, black locust where nitrate reduction is a goal), they should be retained during buffer establishment to provide shade for tolerant species and to protect the stream environment.

Pioneer Riparian Species		
Gray Birch	*Betula populifolia*	intolerant fast growing tree
Bigtooth Aspen	*Populus grandidentata*	intolerant fast growing tree
Black Cherry	*Prunus serotina*	intolerant fast growing tree, high wildlife value
Sweet Cherry	*Prunus avium*	intolerant fast growing tree, high wildlife value
Shining Sumac	*Rhus copallina*	intolerant fast growing tree
Black Locust	*Robinia pseudoacacia*	Nitrogen fixer, useful for canopy establishment
Sassafras	*Sassafras albidum*	intolerant fast growing tree

Several native shrub and vine species also thrive in the transitional disturbed conditions often found in riparian areas. Common species are listed below:

Native Shrubs and Vines in Transitional Zone		
Blackberry	*Rubus spp.*	thorny herbaceous shrub, intolerant, high wildlife value
Greenbrier	*Smilax rotundifolia*	thorny vine, tolerant
Poison ivy	*Toxicodendron radicans*	noxious vine, tolerant, high wildlife value
Wild grape	*Vitis spp.*	very aggressive vine, intolerant, high wildlife value
Spicebush	*Lindera benzoin*	aggressive shrub where deer herbivory heavy, tolerant
Fragrant Sumac	*Rhus aromatica*	aggressive shrub, intolerant, high wildlife value

While less desirable as components of a riparian forest, these native species can provide an effective ground cover during establishment of the buffer. They also provide many wildlife benefits. Therefore, they should be selectively controlled only when they will interfere with the establishment and/or vegetative management methods involved in establishing a buffer. Eventually, forest canopy species will shade out the intolerant species.

Identify Undesirable Species

Since the introduction of exotic plants for landscape and reclamation purposes over the last century, many exotic species have aggressively invaded riparian areas of the Chesapeake Bay Watershed. In many cases, these plants have completely taken over the riparian areas to the exclusion of desired native species, effectively stalling succession. Most invasive species reproduce heavily from underground stolons, as well as by seeds. The more notable of these species are listed on Page 7-12.

Since these plants are so aggressive when established, it is preferable to control them as much as possible before buffer planting. Where present in adjacent upland areas, these plants should also be controlled to reduce the propagule source into the riparian area. In pasture situations, sod-forming cold season grasses are also undesirable in the riparian area since they compete with tree seedlings and confine streams, causing narrow, incised channels.

Riparian Forest Buffer Establishment

There are generally five steps to establishing and maintaining riparian forest buffers. These steps include site preparation, tree planting, maintenance, survival inspections, and reinforcement planting. Site preparation, tree planting, maintenance, and reinforcement planting will be discussed here.

Site Preparation

Streambank Stabilization

Where the streambank is unstable due to conditions of altered hydrology and inadequate soil stability, bioengineering and mechanical techniques are necessary to stabilize the stream banks. Discussed in Section VIII, some of the bioengineering methods will overlap with the formulation of the planting plan.

Vegetative Management Methods

Target Plant Control

Forest management practices generally use herbicides for target plant control. Herbicides are very effective in controlling root biomass. By eliminating soil disturbance, direct sediment losses in herbicide treated areas are barely one percent of that associated with mechanical treatments. Most herbicides affect plant enzymes or hormones exclusively, and they are less toxic than table salt to animals. Therefore, the potential for adverse toxic effects from herbicides is minimal if label directions are carefully followed.

Mowing and cutting leave the roots in place to generate even more vigorous growth of target species from root and stump sprouting. Only repeated cutting over the growing season will eventually exhaust the remaining root systems. Shrubs and vines can be ripped out with a tractor and chain, but it is time-consuming and dangerous, and control of the remaining root tips is still necessary. Girdling is effective, but it requires at least a year for complete control. Ripping with power machinery removes roots effectively, but the ground disturbance can result in sediment losses up to 7,000 to 13,000 pounds per acre. Mechanical removal of vegetation has been shown to be more costly than chemical removal. For these reasons, mechanical methods are best used in concert with herbicides alone only in areas where herbicides are considered inappropriate.

Herbicides vary in their selectivity upon different target species. By using precise application methods such as basal bark sprays and carefully chosen application timing, it is possible to specifically control undesirable target species, leaving the desired species unaffected. This releases the desired species from competition, accelerating their growth. Methods of application, mode of action, application timing, toxicity characteristics, and species susceptibility are briefly summarized in Table 7-3.

Exotic Undesirable Species		
Common reed	*Phragmites communis*	very aggressive reed, intolerant
Oriental bittersweet	*Celastris orbiculatis*	aggressive vine, tolerant
Japanese honeysuckle	*Lonicera japonica*	aggressive vine, tolerant
Kudzu	*Pueraria lobata*	very aggressive vine, intolerant
Porcelain berry	*Polygonum spp.*	aggressive vine, tolerant
Mile-a-Minute vine	*Polygonum perfoliatum*	very aggressive vine, tolerant
Trumpet creeper	*Ampelopsis brevipendiculata*	very aggresive vine, intolerant
Japanese bamboo	*Polygonum cuspidatum*	very agressive shrub, intolerant
Privet	*Ligustrum spp.*	aggressive shrub, intolerant
Multiflora rose	*Rosa multiflora*	aggressive shrub, intolerant
Tree-of-heaven	*Ailanthus altissima*	very aggressive tree, intolerant
Norway maple	*Acer platanoides*	aggressive allelopathic tree, tolerant

Table 7 - 3

Herbicide Information

Herbicide	Trade Name	Half Life	Sol.	Ads. Coeff.	Lc50 (96hr)	Mode Of Action	Selectivity	Appl. Method	Appl. Timing	Susceptible Plants	Resistant Plants	Additional Information
Glyphosate	Roundup	60	12k	20.0	120.0	Enzymatic	Broad	Injection	May-Oct	Herb. Annuals	Woody	Poor Control of Roses, Poison Ivy, all Vines.
(Most	Accord	Nontoxic To Aquatic Spp.				Some	Spectrum	Foliar	May-Oct	Grasses	Plants	Good for all Grasses and Herbaceous Plants.
Preferred)	Rodeo	If No Surfactant & Very				Translocation		Foliar	May-Oct	Bracken Fern	Greenbrier	Acceptable for Aquatic Situations.
	Compadre	High Adsorbance						Cut Stump	All Year			Safer than Phenoxy and Benzoic.
Sulfometuron	Oust	10	300	0.5	12.0	Enzymatic	Non-Selective	Preemergent	Mar-Apr	Broadleaf	Warm Season	Except for Multiflora Rose - Use w/ Glyphosate.
Metsulfuron	Escort	Extremely Low App. Rates				Translocates	Selective	Foliar Only	Apr-Oct	Herbaceous	Grasses	Releases Warm Season Grasses.
(Preferred)		And Rapid Hydrolysis				Readily				And Grasses		
Gluphosinate	Finale	7-20		High	High	Enzymatic	Broad	Foliar	Apr-Oct	All Spp., Esp.	Woody	Less Translocation than Glyphosate,
(Preferred)		Low Toxicity & Very				Little	Spectrum		All Year	Herbaceous	Plants	so Good for Maintenance.
		High Adsorbance				Translocation						Controls Nut Sedge, Warm Season Grasses.
Fosamine	Krenite	10	1.8m	20.0	278.0	Bud Inhibitor	Very	Foliar	June-Oct	Woody W/	Herbaceous	Bud Inhibition, Except for Pruning W/O Browning.
(Preferred)		Low Toxicity & Very				No	Selective			Terminal Buds	Plants,	
		High Adsorbance				Translocation					Grasses	
Triclopyr	Garlon 3a	45	430	1.5	148.0	Hormonal	Selective	Foliar	Apr-Oct	Broadleaf	Conifers	Good on Brush, Poor on Honeysuckle.
(Preferred)	Garlon 4	Very Low Toxicity				Translocates		Stump/Basal	All Year	Woody		More Toxic - Use for Basal Bark
						Readily						or Injection Only.
Imazapyr	Arsenal	30	15k	0.3	100.0	Enzymatic	Non-	Foliar	June-Oct	Broadleaf	Annual	W/ Glyphosate , Except on Japanese Bamboo, Vines.
(Acceptable)	Chopper Rtu	Low Toxicity				Translocates	Selective	Stump/Basal	All Year	Perennials	Herbaceous	Except on Multiflora Rose , Releases Ragweed.
						Readily		Pre-Emergent	Mar-Apr	And Grasses	Legumes	Very Slow Control, Combine with Others.
Dicamba	Banvel Cst	25	4.5k	0.1	135.0	Hormonal	Very	Cut Stump	All Year	Broadleaf	Woody	Used for Ailanthus, Sumac Sprout Control
(Acceptable)	Banvel 720	Low Toxicity				Translocates	Selective	Foliar	Apr-Oct	All Spp.		and Broadleaf Weeds.
(W/ 2,4 D)						Readily						For Vines, Kudzu, Honeysuckle and Poison Ivy.
2,4 D	Generic	28	3m	0.5	168.0	Hormonal	Broad	Foliar	Apr-Oct	All Spp., Esp.	Certain	Inexpensive, Enhances Translocation
(Acceptable)		Low Toxicity				Translocates	Spectrum	Stump/Basal	All Year	Herbaceous	Woody	and Synergy with Other Herbicides.

More detailed information on application methods and suitable herbicides is presented in "A Manual of Ground Application of Forestry Herbicides" which is listed in the references at the end of this Section. Other materials from herbicide manufacturers are included in the Appendix. The pesticide specialist at the local NRCS, Cooperative Extension, or Conservation District office can also provide valuable assistance in drafting a program for a specific site. A computer-aided expert system, called ChESS, is available to assist in formulating the most appropriate mixture, and will also provide cost data.

Highly mobile herbicides (eg. Hexazinone or Picloram) or more toxic herbicides (eg. Atrazine and Fluazifop) should not be used anywhere within the riparian areas. Herbicides suitable for application in the riparian area, where herbicide drift and/or movement in groundwater could enter streams, are listed as "Most Preferred" or "Preferred" in Table 7-3. In many cases, the surfactant used to promote leaf wetting is much more toxic to aquatic organisms than the herbicide itself. As surfactant formulations improve, other relatively nontoxic herbicides will eventually be approved for wetland use. Herbicides listed as "Acceptable" in the Table are best used only for basal bark spray or cut stump treatment. Where used as foliar sprays for tough plants such as kudzu or Japanese bamboo, these herbicides should be applied with great caution because of the potential for drift and/or runoff.

Wetlands and streams should not be exposed to herbicides if it can be avoided. Even though aquatic insects and fishes seem to be unaffected by the "Most Preferred" herbicides, diatoms are likely to be affected. Notwithstanding the low toxicity of such herbicides to aquatic organisms, timing application after peak diatom activity in early spring should result in lesser effects upon stream ecosystems. The only herbicide listed for direct application to aquatic areas is Rodeo™, a glyphosate formulation used for phragmites control in many parts of the Chesapeake Bay Watershed. Rodeo™ is practically nontoxic to Daphnia.

Temporary Cover

After herbicide treatments, the standing stalks should be left to provide shade, cover, perching locations, nesting cavities, and coarse woody debris. However, where dense thickets have been controlled, it will be necessary to remove the stalks to do the plantings. Alternatively, burning the stalks is possible where permitted. Known as the "brown and burn" strategy, this should be used with caution as it will release weeds and forbs. If desired plants exist where extensive foliar applications are anticipated, they can be removed to grow offsite during site preparation, providing a source of locally adapted native material for riparian forest establishment.

When the plant cover over extensive areas is completely eradicated, it is necessary to establish a ground cover as soon as possible. Cover crops such as annual or cereal rye also provide a rapid, but temporary, ground cover. Since a good cover is essential, cool season grasses such as field bromegrass and tall fescue are often appropriate. These intolerant grasses are not invasive, do not require mowing, and will give way to other plants as they are shaded out. They are poor choices for wildlife, however. Where heavy vine growth occurs, legumes such as *Sericea lespediza* and birds-foot trefoil form a vigorous cover able to compete with the vines. Legumes compete for nutrients much less than grasses. These cover crops should be combined with native warmseason grasses to provide a diverse mixture of species appropriate to the riparian ecosystem.

Tables 7-1 and 7-2 list several native annual plants and warmseason grasses that thrive in the riparian area without aggressively competing for tree nutrients. For the wettest areas, a mixture of switchgrass (<15%), deertongue, and eastern gamagrass can be combined with smartweed seed to provide an effective cover. For moist areas, some of the gamagrass and switchgrass can be replaced with tall fescue, indiangrass, and purpletop. For drier sites at the upland margins, switchgrass and eastern gamagrass would be replaced with the bluestem grasses.

Seeding rates, mixtures, and planting methods are best determined with the assistance of the local extension agent or district conservationist.

Site Preparation Practices

Often, a riparian site will have a mixture of turfed pasture, overgrown fields, and early successional forests along the stream, requiring a combination of site preparation techniques. In all site preparation situations, a variety of physical and herbicidal methods will be effective in manipulating the plant composition to control undesired species. In many situations, site preparation procedures can require up to a year of vegetative control prior to planting.

Pasture Preparation

In an existing pasture, the absence of woody plants favors mechanical site preparation, as tree seedlings grow most vigorously in tilled soils. Turf-forming grasses such as blue grass, bermudagrass, johnsongrass, and panic grass are among the worst competitors with seedlings. The sod should be plowed and disked in early spring followed by application of Oust®, Escort™, and Arsenal™ to control turf grasses. The site should be immediately seeded with an appropriate warmseason and cover crop grass mixture to stabilize the exposed soil as soon as possible. In this case, site preparation essentially overlaps with the establishment of the riparian forest buffer. This method is appropriate on sites of relatively nonerosive soils where concentrated runoff is less likely to occur.

Where concentrated runoff and erosion occur, extensive mechanical preparation is not recommended. Instead, a combination of Roundup™ and Oust® should be applied in a four-foot diameter circle at each planting location to control sod-forming grasses. As part of site preparation in either case, other target species such as multiflora rose will have to be controlled by cutting, pulling, and/or herbicides.

Abandoned Field Preparation

Abandoned fields are covered by shrubs and vines, interspersed with tree saplings. In this situation, preparation methods focus on releasing saplings and proposed plantings from competition by established undesirable species. Other smaller seedlings encountered during site evaluation can also be released if not heavily overgrown by invasives.

Release methods vary according to the target species and extent of infestation by invasives. Where many seedlings of desirable plants occur, basal bark sprays on target species during the dormant season are very selective, and will provide effective control. Large shrubs and vines can be cut, and the stumps treated after cutting to prevent resprouting. In a sunny field, cutting will not be effective by itself, unless the sprouts are regularly cut back throughout the entire growing season after cutting. This requires considerable effort.

Different target species are more susceptible to different formulations, which are applied as direct applications to the cut stumps, basal bark, and adventitious roots. The most susceptible target species are listed for the following formulations:

Pathfinder II™	wild grape, poison ivy
Stalker™	multiflora rose, Norway maple
Compadre™	tree-of-heaven, sumac

In situations where the target species are mostly herbaceous, or where few desired species exist among an overgrown tangle of vines and shrubs, a viable approach is to cut all undesired vines, shrubs, and trees after the target species are completely leafed out, prior to hardening off in late May. At this time, root reserves are at the lowest, reducing resprouting vigor. Cut stump formulations can be applied to the cut stumps of the larger vines and trees by the cutter as each cut is made, using a spray bottle carried at the belt. To control sprouting adjacent to the stream, cut stumps should be treated by Compadre™, a glyphosate formulation.

Even where cut stump and/or basal treatment does not prevent regrowth, the root biomass will be weakened and further depleted by sending up additional shoots. Summer foliar applications of a mixture of Accord™ and Escort™ will generally control most target species. Where control is less effective with this formulation, the following foliar mixtures will provide more effective control of the sprouts. A brief listing of target species and foliar herbicide mixtures is presented in Table 7-4.

Table 7 - 4

Foliar Herbicide Mixtures and Target Species

Name of Herbicide	Target Species
Garlon™ , Escort™	oriental bittersweet, porcelain berry, poison ivy, wild grape, blackberry, and multiflora rose
Escort™	kudzu, tree-of-heaven, and sumac
Escort™ , Arsenal™	greenbrier, honeysuckle, multiflora rose, blackberries, and kudzu
Arsenal™ , Accord™	Japanese bamboo and phragmites

Following foliar application, most target species should be completely controlled, except the toughest species such as kudzu and Japanese bamboo. These species require higher application rates and repeat applications for effective control. Control of wild grape is complicated by its prodigious seed bank, which is capable of sending up shoots for an eight-year period, where light conditions permit. Since grape has a very high wildlife value, forest managers recommend retention of the “arbors” which occur when the vines completely overtop and break trees, creating an opening in the canopy. However, in a riparian forest buffer, it is usually necessary to control wild grape, since arbors would overwhelm a narrow buffer. This will depend on the landowner’s objectives.

Early-successional Site Preparation

Early-successional sites occur where tree saplings are well enough established to begin canopy closure. This stage occurs when saplings are at least 2-4 inches dbh (diameter at breast height, 4.5 feet from the ground on the uphill side of a tree) and have a crown height of 12-20 feet. Less tolerant species, such as wild grape, blackberries, and multiflora rose, will be more susceptible to cutting, requiring less herbicide control. Tolerant species such as honeysuckle and porcelain berry will still require herbicidal control. In general, site preparation strategies are similar to those involved in early successional sites, although to a lesser degree. If aggressive ferns have become established, their control will be necessary to prevent competition for nutrients during the seedling stage.

Riparian Forest Buffer Design

In many cases, the riparian forest buffer will be fairly narrow, following the three-zone concept of Welsch that is described in Section I. Width will depend on the landowner. Within this strip, locally native riparian species are preferable, since they have co-evolved with the benthic stream community. Table 7-2 lists these species by physiographic region, wildlife value, shade tolerance, mature size, growth rate, and rooting structure.

After mapping the physical constraints of a riparian site, design of the planting plan becomes a process of selecting the best plants for each particular combination of hardiness, moisture, flooding, and soil pH listed in Table 7-1. Species not suited for reasons of pH, moisture, or flooding will be excluded from certain areas of the riparian buffer. The remaining species are selected according to physiographic region, wildlife value, price, and availability. The resource manager should always look at riparian species in the vicinity to get an idea of the best locally adapted species.

Plant Species Selection

Zone 1

The design of the riparian buffer emphasizes control of the stream environment in Zone 1. Providing shade, deadfall, and leaf litter inputs to the stream, this zone exerts the greatest ecological influence over instream habitat. This zone also has the greatest potential for nitrate interception. In this zone, bank stabilization bioengineering and establishment of native riparian trees are important. A dense canopy and understory are required to provide shade and overhang the stream.

Zone 1 is most subject to inundation. Species with the greatest tolerance to these conditions are listed at the beginning of Table 7-1. Silver maple, sycamore, black willow and eastern cottonwood are best suited in these conditions in most locations throughout the Chesapeake Bay Watershed. The fast growth rate and brittle habit of these species withstand the periodic trauma of heavy floods. Instead of washing away and exposing unstabilized banks, these species shed branches, regrowing from the remaining trunk. Because of their fast growth rate, they are established relatively easily and rapidly reach canopy closure. These species facilitate the important goal of stream shading and promote establishment of the riparian forest buffer. Nitrogen-fixing plants should be avoided.

Along the stream, understory trees and shrubs tolerant of flooding and wet soils are densely interplanted among canopy species to provide additional structure and shading of the riparian area. On sunny banks, intolerant species such as boxelder, pussy willow, and buttonbush will thrive until shaded out as the buffer grows over the stream. On wide streams, south and west-oriented streambanks have more solar exposure. Solar exposure will be reduced in north-facing valleys and streambanks, so fewer species will thrive in the shadier conditions. Information on shade tolerance is in Table 7-2.

Zone 2

Zone 2, generally a canopy's width behind Zone 1, can include commercially viable canopy species such as red oak and black walnut where site conditions permit. More flood and wet soil tolerant species, such as green ash, sycamore, river birch, and pin oak, may be necessary in Zone 2. An understory of shad bush, hornbeam, blackhaw, and redbud will provide additional shade and structure to Zone 2. Shade tolerant shrub species, such as winterberry, virginia sweetspire, and maple-leaf viburnum, will grow in the deeper shade further inland and shade the forest floor to inhibit competition from intolerant edge species. Highly resistant to deer browsing, spicebush often dominates certain sites. However, it and maple-leaf viburnum are good choices where heavy deer herbivory precludes the use of other species. Nitrogen-fixing plants should be avoided.

If not established during site preparation, a forb layer of warm season grasses and annuals may be planted in all Zones. Cold season grasses should be included in open sites, along with raspberry, dewberry, and thimbleberry. These plants will effectively compete with undesired invasive plants until canopy closure is reached. Ostrich fern, cinnamon fern, and sensitive fern grow well in shadier conditions found in Zone 2. Since ferns can be invasive, it is recommended that they be planted after the canopy, understory, and shrub layers are well established, if they are desired.

Zone 3

As the transition zone between the forested buffer and adjacent land uses, Zone 3 must be carefully designed to meet management objectives. Edge effects of increased light and exposure to the adjacent seed bank in the ecotone pose particular management problems. For structural diversity, the transition across Zone 3 between open lands and the forest should be as densely planted as possible. This will reduce light penetration into Zone 2 and recolonization by intolerant exotic species.

In the riparian forest buffer, this transition between Zones 2 and 3 should be provided by the establishment of understory edge species, such as arrowwood, silky dogwood, azalea, elderberry, and gray dogwood to provide a dense shrub layer. In the herbaceous layer, warm season grasses are combined with cold season grasses for the densest herbaceous layer. Where sediment filtering is a primary objective, Zone 3 should be designed and managed to provide a dense herbaceous cover. This requires that no trees or shrubs are located where sediments will accumulate. For control of channelized flows, a diversion should be installed in this area to intercept channelized flows. Following along the side of the buffer, the diversion retards the flow, settling out the sediments. Discharge to the stream then occurs in a stabilized channel through the riparian forest buffer.

Planting Density

Succession Strategy

The preceding discussion provides the broad selection criteria to formulate a planting plan. Usually, the planting plan corresponds to the desired final plant spacing and species composition, after accounting for losses during growth. Table 7-5 lists number of trees per acre based on various methods of planting. An alternative approach is to accelerate succession by overplanting seedlings of fast growing intolerant species at a high enough density to provide canopy closure relatively rapidly. Yellow-poplar, sycamore, river birch, and silver maple are among the fastest growing trees appropriate for the riparian area. Seedlings of tolerant canopy species, such as red oak interplanted among the pioneer species, can be selectively released after canopy closure to become the eventual dominants. Canopy overplanting will also reduce deer herbivory on

Table 7 - 5
Number of Trees per Acre by Various Methods of Spacing

Spacing (feet)	Trees (number)	Spacing (feet)	Trees (number)	Spacing (feet)	Trees (number)
2x2	10,890	7x9	691	12x15	242
3x3	4,840	7x10	622	12x18	202
4x4	2,722	7x12	519	12x20	182
4x5	2,178	7x15	415	12x25	145
4x6	1,815	8x8	681	13x13	258
4x7	1,556	8x9	605	13x15	223
4x8	1,361	8x10	544	13x20	168
4x9	1,210	8x12	454	13x25	134
4x10	1,089	8x15	363	14x14	222
5x5	1,742	8x25	218	14x15	207
5x6	1,452	9x9	538	14x20	156
5x7	1,245	9x10	484	14x25	124
5x8	1,089	9x12	403	15x15	194
5x9	968	9x15	323	15x20	145
5x10	871	10x10	436	15x25	116
6x6	1,210	10x12	363	16x16	170
6x7	1,037	10x15	290	16x20	136
6x8	908	10x18	242	16x25	109
6x9	807	11x11	360	18x18	134
6x10	726	11x12	330	18x20	121
6x12	605	11x15	264	18x25	97
6x15	484	11x20	198	20x20	109
7x7	889	11x25	158	20x25	87
7x8	778	12x12	302	25x25	70

desired tolerant species. This release strategy also provides more wildlife habitat and deadfall in the riparian area.

One or two years prior to release of canopy species, tolerant understory trees and shrubs can be planted to take advantage of the semi-shaded conditions without competition from intolerant shrubs and vines. Since enough light is present for good growth after release, the understory plants will become well established as the canopy fills in. The use of succession management strategies is largely determined by the existing vegetation in the riparian area. Where many indigenous seedlings exist, the planting approach should attempt to capitalize on this by accelerating succession.

Succession management also involves the herbaceous control procedures discussed in “Vegetative Management Methods” on page 7-12. After planting the buffer, competition by adjacent herbaceous plants must be controlled during the initial years to release the plantings. The larger the plant, the less extensive these measures need to be. Where tree shelters are used, smaller plant material can be used with good results.

Plant Size

Planting stock ranges from seeds to large caliper nursery stock. Planting strategies are largely determined by the extent of available funding resources. Larger plant material, such as balled and burlapped (B&B) trees or large container stock (>2 gal.), will cost much more, although they will attain the desired goals more rapidly. The higher initial expense accelerates establishment of the riparian forest buffer. However, quality of plants should receive much greater attention during the selection process than price.

Balled & Burlap and/or Container Stock

The most expensive approach is to plant the canopy, midstory, and understory species in the final locations, using B&B and large container stock. The most common sizes of planting stock are 1½ to 2½ in caliper. Smaller, less expensive tree will be suitable for most riparian sites. Most B&B trees are too heavy to easily handle. In mature riparian forests, canopy tree stem density is roughly 150 stems per acre, indicating a tree spacing of 16 to 18 feet. B&B material will attain a higher canopy height in the shortest time.

Large material is most appropriate in riparian forests where intensive multiple uses are anticipated, as in urban development or part of an urban park system. Often using a high maintenance manicured approach, the herbaceous layer would be a combination of wood chip mulch and mowed cold season grasses. Note that the use of grasses as the ground cover in the riparian forest buffer will sequester nutrients within the grasses, retarding the growth of trees. Shade tolerant herbaceous species will eventually colonize the site as canopy closure is attained.

The typical plant cost for B&B material 1.5-inch caliper is about $35.00 and up. Five-foot-tall B&B material costs from $8.00 to $20.00, depending upon source and species. Installation costs are about $10.00 to $30.00 per plant, depending upon method, size of plant, and source. The installed cost ranges from $18.00 to $50.00 (or higher) per plant, or $2,700 to $7,500 per acre. Herbaceous controls are least with this option if regular mowing is not required. Since it is relatively expensive, this approach is inappropriate for use in most riparian sites.

Bare Root Stock

A more cost-effective approach is to use bare root material. Planting density should be higher than the final stem density desired, to allow for losses due to competition, stress, and herbivory. At a survival rate of 75 percent, roughly 200 plants are needed per acre. A spacing of 14 to 16 feet is appropriate for larger material at least several feet high and around ¾ inches in diameter. Bare root material can grow relatively rapidly after the root system is established, reaching canopy closure soon after similar size B&B material.

Bare root plantings are best in situations where visible plantings are desired after riparian forest buffer planting.

Bare root material ranges in price from $2.00 to $6.00 per plant for five-foot plants, less than half the price of B&B for the same height. Hand planting with mattocks is the least expensive method, but root spread may be compromised. Using power augers to dig the planting holes, installation costs should run from $0.40 to $0.50 per plant, indicating an installed cost from $2.40 to $6.50 per plant. At 240 stems per acre, installed costs would range from $575 to $1500 per acre. Since bare root stock is already high enough to compete with the herbaceous layer, only a few years of herbaceous control is needed during riparian forest buffer establishment.

Container Grown Seedlings

Container grown seedlings are commonly grown in paper pots that disintegrate. Both seedling and pot are planted. This increases survival rate because the plant never loses contact with its soil, and suffers less stress. They can be planted more quickly and efficiently than bare root seedlings.

Containerized seedlings can be grown 1) as tubelings in plantable pots or tubes 2) as plugs that are pulled out of the containers before planting, and 3) in blocks of pressed peat or pulp that serves as both a container and a rooting medium. Plastic containers work well for producing plugs. They are reusable. Some containers are hinged and open like a book for plant removal. Container grown seedlings range in price from $2.50 to $12.00 each, depending on the size of the plant. Plugs are sold in quantities of 50 plants, ranging in price from 50¢ to 85¢ per plug.

There are advantages to container seedlings over bare root seedlings. Survival risks are lower for container seedlings than for bare root seedlings. Shipping dates are much more flexible because there is no worry about roots freezing. There is less chance of the seedlings becoming crushed because they are shipped in racks. Their roots are more developed than bare root plants, so they can tolerate drought better.

Bare Root Seedlings and Year Transplants

In situations where a longer time to attain canopy closure is acceptable, smaller 1-0 and 2-0 seedlings or 2-1 transplants are used. 1-0 and 2-0 seedlings are lifted directly from the nursery bed and shipped. They are the least expensive type of plants. 2-1 seedlings spend two years in the nursery and one year in a transplant bed. Often, this may be the only alternative to obtaining enough stock for large projects.

Red oak transplants with at least 6 lateral roots demonstrate more vigorous growth compared to those with fewer lateral roots. Top pruning is not recommended The root-pruned species stock will provide the best results. While initially more expensive, increases in growth rate and survivability of root-pruned material are less expensive in the long run. Careful examination of the stock is required to ensure that high-quality plants are delivered; even then, substandard material will have to be culled.

Since the process of establishing riparian forest buffers may involve site preparation measures for as long as a year, less expensive one-year seedlings can be root pruned and grown in a temporary bed on-site prior to setting out in the riparian zone. Alternatively, the transplants can be contract grown offsite. An advantage of contract growing is that the final transplant cost should be lower than that listed in supplier catalogs.

Depending upon the plant condition, species, and site stresses, the survival rates range from less than 30 percent to over 90 percent. At an average survival rate around 50 percent, the plant spacing should be 6-feet-by-6-feet, or 1,210 stems per acre, to provide sufficient stem density upon maturity. Assuming a 50 percent survival rate, the site will have over 600 free-to-grow seedlings per acre. Seedlings and two-year transplants are considerably less expensive, varying from $0.30 to $1.50 per plant according to source and type of plant. With experienced personnel, at least 60 to 80 plants can be planted per hour. At $10.00 per hour, this results in installation costs from $0.10 to $0.15 per plant, indicating an installed cost of $0.40 to $1.65 per plant. Given a planting density of 300 trees per acre, the installed cost ranges from $120 to $495 per acre. Herbaceous control measures are more extensive, though, requiring at least several years of control. Tree shelters accelerate growth and increase the survivability of seedlings. Where shelters are used, the density can be decreased and the results improved.

Seeds

For certain riparian species with large propagules, such as walnut and oak, seed planting is a viable alternative. While the plant material may be the least expensive, tree shelters are required to obtain acceptable survivability. Given the absence of transplant shock and the favorable conditions inside a shelter, growth rates from seed can be surprisingly fast. Walnut seedlings in shelters have grown up to 4 feet within the first growing season. For grasses and forbs, seed is the material of choice.

Sources of Plant Material

Species native to the local riparian site are most appropriate for planting in the riparian area. This is because local biotypes have better vigor and hardiness and are better able to compete. As pioneer colonizers, they assist in providing rapid canopy establishment. Local biotypes coadapted with the local benthic macroinvertebrates may provide better riparian biomass inputs to the stream.

While local biotypes may be more appropriate for a riparian site, it is likely that most planting material will have to be obtained from available nursery stock. In recognition of the merits of native material, many nurseries now stock native plants, some from local sources. Where available, this stock should be used, although much of the plant material may have to come from more distant genetic sources. Nursery stock from large or distant suppliers often comes from a biotype far removed from the site of installation. Where stock from remote sources differs substantially in hardiness, it is a less desirable option, even though its cost may be slightly more competitive. Local sources may be a little more expensive, but the better quality control and reduced shipping and handling costs can offset initial price disadvantages.

Even if they are remote, large suppliers can assist in locating and/or contract growing locally-adapted plant material, so they should be contacted. Suppliers of native plants are listed in Appendix 8. This list is by no means exhaustive; other suppliers will have suitable material as well. The NRCS office and local service forester should be contacted to ensure that potential sources are not overlooked.

Planting Plan and Schedule

After determining physical site conditions, the detailed planting plan starts by eliminating those plants that would not thrive on the site. Depending upon succession strategy and maintenance measures, sources are then evaluated as to size, price, and availability of the remaining plants. Often, certain species are unavailable or expensive, while others may be abundant in the trade, and relatively inexpensive. In this manner, the plants listed in Tables 7-1 and 7-2 will be narrowed down to appropriate species available in the proper sizes.

The planting schedule should take price variation into account, so as to ensure the greatest potential for the riparian forest buffer. Least expensive material can be widely used, while the most expensive material will be used sparingly in high visibility locations where it will be most appreciated. Where cost differential is not a factor, plants remaining on the list should be used in roughly equal proportions within each combination of physical conditions to provide the greatest diversity and resistance to plant diseases.

Table 7-6 is a blank plant list to be filled out with the costs and sizes from individual suppliers to assist in comparisons. After selecting the size of the plantings, this table will be the basis for the planting schedule.

Table 7 - 6

Plant Availability List

COMMON NAME	BOTANICAL NAME	SYM.	QTY.	PRICE AND AVAILABILITY (25-50 TO 100-1000)				
RIPARIAN CANOPY				SEED	SDLG.	B. ROOT	CONT.	B & B 1"
Swamp white-cedar	*Chamaecyparis thyoides*	Ct						
Baldcypress	*Taxodium distichum*	Td						
Black willow	*Salix nigra*	Sn						
Eastern cottonwood	*Populus deltoides*	Pd						
Red maple	*Acer rubrum*	Ar						
Swamp white oak	*Quercus bicolor*	Qb						
Blackgum	*Nyssa sylvatica*	Ns						
Green ash	*Fraxinus pennsylvanica*	Fp						
Silver maple	*Acer saccharinum*	As						
Sycamore	*Platanus occidentalis*	Po						
River birch	*Betula nigra*	Bn						
Pin oak	*Quercus palustris*	Qp						
Willow oak	*Quercus phellos*	Qw						
Hackberry	*Celtis occidentalis*	Co						
Pitch pine	*Pinus rigida*	Pr						
American beech	*Fagus grandifolia*	Fg						
Sweetgum	*Liquidambar styraciflua*	Ls						
Black walnut	*Juglans nigra*	Jn						
Bitternut hickory	*Carya cordiformis*	Cb						
Persimmon	*Diospyros virginiana*	Dv						
White ash	*Fraxinus americana*	Fa						
Yellow-poplar	*Liriodendron tulipifera*	Lt						
White oak	*Quercus alba*	Qa						
Red oak	*Quercus rubra*	Qr						
Basswood	*Tilia americana*	Ta						
RIPARIAN UNDERSTORY								
Boxelder	*Acer negundo*	An						
Hazel alder	*Alnus serrulata*	Al						
Sweet bay	*Magnolia virginiana*	Mv						
Blackhaw	*Viburnum prunifolium*	Vp						
Possumhaw	*Ilex decidua*	Id						
Witch-hazel	*Hamamellis virginiana*	Hv						
Shad bush	*Amelanchier arborea*	Ac						
Pawpaw	*Asamina triloba*	At						
Hornbeam	*Carpinus caroliniana*	Ch						
Redbud	*Cercis canadensis*	Cc						
Flowering Dogwood	*Cornus florida*	Cf						

Table 7-6 (cont.)
Plant Availability List

COMMON NAME	BOTANICAL NAME	SYM.	QTY.	PRICE AND AVAILABILITY (25-50 TO 100-1000)				
RIPARIAN SHRUBS				SEED	SDLG.	B. ROOT	CONT.	B & B 1"
Buttonbush	*Cephalanthus occidentalis*	Cu						
Pussy willow	*Salix discolor*	Sd						
Sweet pepperbush	*Clethra acuminata*	Ca						
Swamp azalea	*Rhododendron viscosum*	Rv						
Winterberry	*Ilex verticillata*	Iv						
Arrowwood	*Viburnum dentatum*	Vd						
Highbush blueberry	*Vaccinium corymbosum*	Vc						
Elderberry	*Sambucus canadensis*	Sc						
Virginia sweetspire	*Itea virginica*	Is						
Inkberry	*Ilex glabra*	Ig						
Swamp leucothoe	*Leucothoe racemosa*	Lr						
Pinxterbloom azalea	*Rhododendron nudiflorum*	Rn						
Bayberry	*Myrica pennsylvanica*	Mp						
Silky dogwood	*Cornus amomum*	Cd						
Common ninebark	*Physocarpus opulifolius*	Po						
Red chokeberry	*Aronia arbutifolia*	Aa						
Spicebush	*Lindera benzoin*	Lb						
Gray dogwood	*Cornus racemosa*	Cr						
Rosebay rhododendron	*Rhododendron maximum*	Rm						
Maple-leaf viburnum	*Viburnum acerifolium*	Va						
FORBS AND FERNS								
Jewelweed	*Impatiens capensis*							
Smartweed	*Polygonum pensylvanicum*							
Royal fern	*Osmunda regalis*							
Sensitive fern	*Onoclea sensibilis*							
Joe-Pye weed	*Eupatorium maculatum*							
Swamp dewberry	*Rubus hispidus*							
Thimbleberry	*Rubus odoratus*							
Raspberry	*Rubus occidentalis*							
GRASSES								
Switchgrass	*Panicum virgatum*							
Eastern gamagrass	*Tripsacum dactyloides*							
Field bromegrass	*Bromus arvensis*							
Fowl meadow grass	*Poa palustris*							
Deertongue	*Panicum clandestinum*							
Tall fescue	*Festuca cultivar*							
Indiangrass	*Sorghastrum nutans*							
Purpletop	*Tridens flavus*							
Big Bluestem	*Andropogon gerardi*							
Little Bluestem	*Andropogon scoparius*							

Referring to Tables 7-1 and 7-2, species appropriate for each combination of site conditions are listed for each habitat type, according to structural category. This will provide the conceptual plant mix to be used in each category of physical habitat mapped during the site analysis of physical features. Given the planting density and a conceptual plant mix, formulation of the planting plan is straightforward. Canopy plantings are delineated with graphic symbols of a diameter representing the spacing and arranged randomly throughout the riparian area. (Assuming mowing is not used for herbaceous control, an artificial grid pattern is not necessary.) Individual species are allocated to each symbol from the conceptual plant mix described earlier. Note that many riparian plant species have a wide degree of tolerance in soil moisture, pH, and shade tolerance. Therefore, these species can be used effectively in many locations throughout the riparian area. Where site conditions permit a wide choice of material, the individual species selection is not as important as the overall mix in a particular area. In essence, the planting plan should appear random; the crucial issue being that all plants are located where they will thrive.

Understory plants are similarly arranged, using symbols of a smaller diameter. Typically, there should be at least three or four understory trees for every canopy tree. This will provide structural diversity similar to mature forests. Shrub species are most intensively arranged at the margins of riparian forest buffers, where edge effects are the greatest. (Shade tolerant shrubs can be placed in the interior after herbaceous control practices are no longer required.) More tolerant species are used on the north-facing margins. To avoid clutter and provide more graphic clarity in the dense plantings of buffer, complete names can be omitted from the plan. Instead, species can be listed by initials generally representing the genus and species, with the key listed in the Plant Schedule.

Figure 7-3 on the next page displays a planting plan for the site displayed in Figures 7-1 and 7-2. In this site, the relatively small scale precludes a wide buffer, so control of the aquatic environment is the primary goal. Removal of sediments and nitrates is a lesser objective. Plants are to be bare root, and species that deer do not like, so a high survival rate is anticipated. A spacing of about 18 feet is used. Shrubs are concentrated along the external edge of Zone 3 to provide more shade and structure. Shade tolerant species are specified on the north-facing edges. Grass mixtures in Zone 3 are chosen by solar exposure and depth to SHWT. High-value trees are concentrated closer to the residence.

An important step in planning and establishment is the Plant Schedule, which lists the plant species, quantity, size, and type. The latter specifications are very important, particularly when material such as 2-year seedlings are involved, and great variability can be found in identically listed material. Planting specifications should detail the installation procedures, protection measures, and maintenance practices to be followed.

Riparian Forest Buffer Planting

Ordering Plants

During formulation of the plan, likely sources will have been identified. Likely sources should not only be contacted, but also visited to see the condition of the materials. Knowledgeable personnel should examine the size, condition, and health of the plants to be ordered. Such visits can be an invaluable educational tool, as nursery managers take pride in their material and will take the time to discuss details such as the best planting methods. Specimen material can be tagged at this time, and arrangements made for delivery. Payment and guarantee conditions are drawn up. Discounts are often available for government-sponsored projects. When ordering plants, it is important to provide as much lead time as possible to ensure the best selection. It would be prudent to place orders for trees about four to six months before the planting date.

Plant Delivery and Inspection

In most cases, plants should not be paid for until delivery and unloading. This ensures that delivered material meets the specifications stipulated, and that the plants arrive in good condition. Plants that do not meet specifications should not be accepted and sent back to the supplier with arrangements for replacement or refund. The material should be examined for the following criteria at delivery:

Size – The plants should meet the dimensions specified in the Planting Schedule.

Form – The plants should not have broken branches, misshapen crowns, poor crotch angles, or other defects in growth habit that may preclude long-term viability. This is particularly important for larger material. Seedlings available in “Conservation Grade” have poorer form, but they are much less expensive than nursery grade stock. Such seedlings are best used on very large projects where seedling cost is a critical factor.

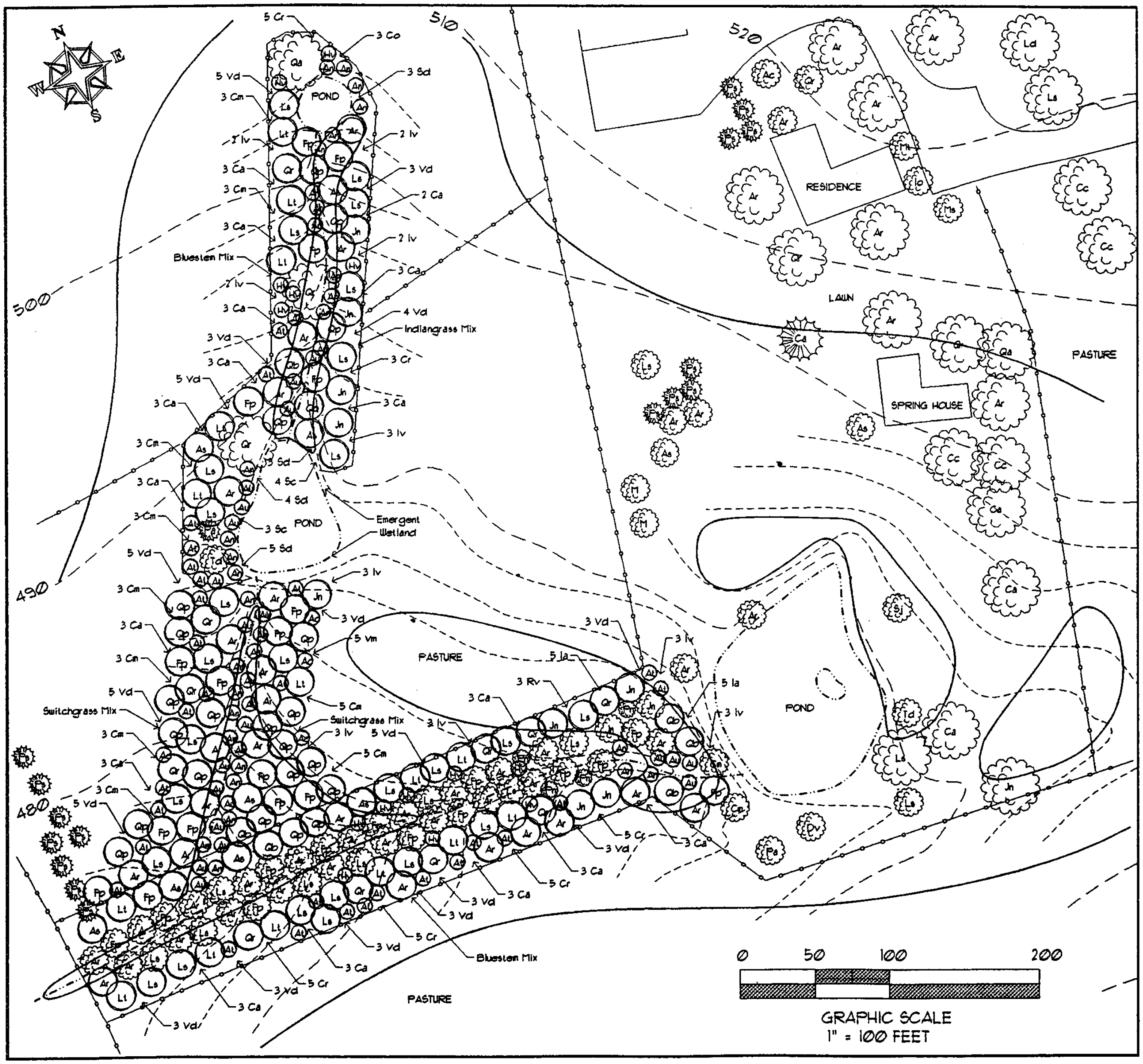


Figure 7 - 3. Planting plan for the site displayed in Figures 7-1 and 7-2.

Vigor – The plants should have well developed branches and adequate buds. Bark should be pliable and green when scratched, without shriveling or discoloring. Leaves should not be discolored or desiccated, or show spotting indicative of potential disease or nutrient stress.

Roots – B&B plants should have the specified root ball size. The root ball should be securely wrapped and competent without any signs of looseness, or the roots are likely to be damaged and/or desiccated. The ball should be moist. Container plants should be upright and firmly rooted. Inspect for circling, kinked, or "J" roots that may girdle the tree. Rootbound plants often have roots protruding above the surface or through the drain holes, a leggy appearance, and/or they are unusually large for the container. Bare root material should be wrapped in burlap and packing. The roots should be damp, fresh, and flexible.

Wounds and Diseases – The trunk should be free of abrasions, cuts, scars, knots, and/or sunscald injury. There should be no insect egg masses or fungi on the branches or trunk.

Planting Layout

Prior to planting, the site must be marked so the planting crew can put the right plant in the right place. Usually, a specific marker is used to delineate each plant at each location. This approach is necessary for high-visibility sites or inexperienced field crews. On large sites where precise detail is not essential, markers are coded for the conceptual plant mix, and an experienced planting crew selects the individual species as it proceeds. This increases productivity, since crews do not have to carry the precise planting mix every time they pick up plants.

A variety of markers can be used. Spray paint can be rapidly applied to the ground and vegetation, but this method has minimal ability to convey species selection. Prelabeled for species, flagged wires color coded to the conceptual mix can be individually placed by the resource professional. Survey flagging can be used in a similar manner if enough vegetation is present onto which the flagging can be tied.

To lay out the site, it may not be practical to conform rigidly to the spacing specified in the planting plan. Plants should not be placed where roots, stumps, hummocks, depressions, and gullies will interfere or create less than optimal conditions. Plants should not be placed next to existing plants, or they will compete with each other. Knowing the average plant spacing, relative plant location is easily paced off, starting from the streambank and proceeding upslope. For greater accuracy, the tree planter can use a thin rod cut to the desired plant spacing. Landmarks from the mapping are used to ensure that spacing errors are not compounded as the planter proceeds along the stream. In wide buffers without landmarks, a survey crew can set location points at specific intervals to provide base points, but this is expensive.

In smaller sites where the buffer is not too wide, an experienced professional should be able to lay out the plantings without even drawing up a detailed planting plan. Each plant or conceptual mix is placed as he/she proceeds through the riparian area, based upon judgment of site conditions and a knowledge of plant availability. The plantings are then counted, and the Planting Schedule is drawn up according to the actual layout. This is a more accurate method as to total number, and the total effort involved is reduced. A conceptual plan is still necessary to assist field crews in staging.

Planting Practices

Planting Seasons

Trees can be planted during the spring or fall. Deciduous trees are best planted in the early spring before bud break in April. This ensures the longest season for root growth and gives the plant a chance to establish feeder roots prior to the moisture demands of the growing season. While less than optimal, planting can extend into late May in the moist conditions found in riparian areas. Evergreens can be planted with good results before the new growth is fully extended in May. Planting later in the growing season will subject plants to moisture stress, unless proper care is taken to ensure adequate moisture in the root zone.

Evergreens can be planted early in the fall after the heat of summer is past. Most deciduous trees can be planted later in the fall after leaf drop, since their roots will continue to grow until the soil temperature falls below 45 degrees. However, the ground must have adequate moisture, or a severe winter will kill the trees. Many oaks are listed as fall hazard plants, so they should be planted only in the spring. Winter transplanting is possible if the soil around the tree to be transplanted is not frozen, and if the planting area is mulched enough to prevent freezing through the winter. Bare root material and seedlings should be planted in the winter to early spring while they are still dormant.

Planting bare root material after leaf emergence is not recommended even if adequate shade and moisture are present.

Planting Procedures

Storage During Planting

After delivery, plant material should be stored on site in a moist shaded location prior to and during planting. The root balls of B&B stock and the packing of bare root stock should be thoroughly watered and kept moist with a covering of peat moss, straw, or sawdust. Bare root stock can be stored for several weeks if "heeled in" (Figure 7-4) by laying the plants in a trench of loose soil or mulch. The tops should face toward the south at an angle of 30 to 45 degrees. Seedlings can be stored by stacking them in a circle with the roots facing inward in layers separated by packing material and kept moist at all times, or refrigerated if facilities are available. Container material is least susceptible to moisture stress and will store well if properly watered.

B&B Trees

B&B stock should never be picked up by the trunk or dropped, as this will damage the root ball. To move B&B stock during planting, the root ball should be firmly cradled. The planting hole should be twice the width of the root ball, but no deeper (see Figure 7-5 on the next page). To dig the planting holes, a tractor-mounted auger can be used to drill a 2 to 4 foot diameter hole. Soil amendments are not recommended, since few roots will grow beyond the amended soils. All sod should be discarded. The root collar should be placed at the same level as the original soil; if the hole is overdug and backfill is necessary, the tree should be placed an inch or two higher to allow for settlement. After placement of the tree, completely remove any wire baskets and twine. Remove as much burlap as possible without damaging the root ball by cutting it down to where the root ball rests on the native soil.

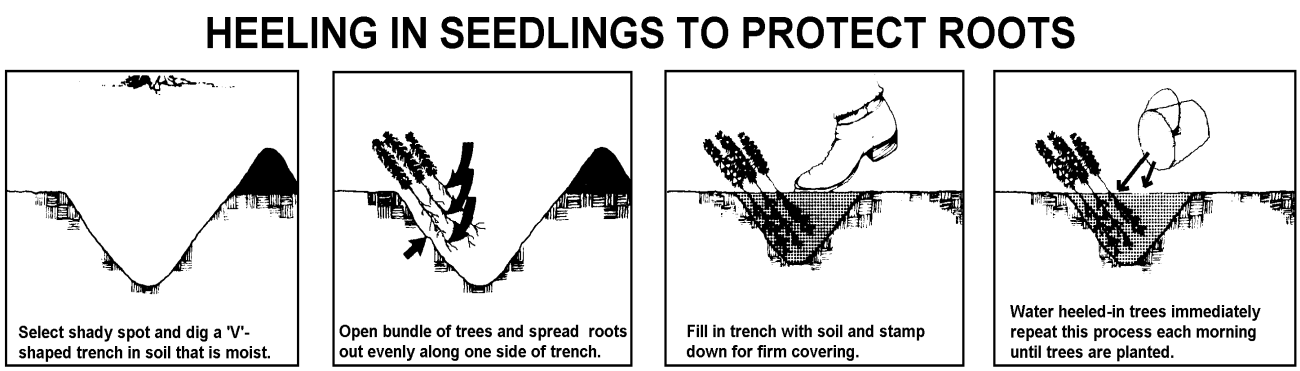
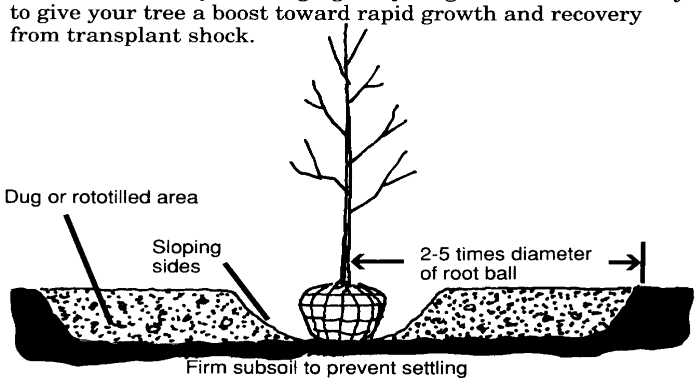


Figure 7 - 4. Heeling In Method. (Source: Tree Planting Notes, Minnesota Department of Natural Resources, Division of Forestry.)

Recommendations for planting have evolved in recent years as more is learned about the nature of roots and urban soils. Local conditions make generalizations difficult, but here are some guidelines that reflect the latest opinions of tree experts:

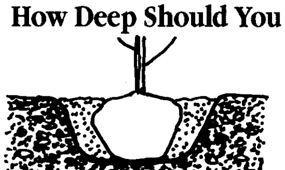
The Planting Hole

More than any other change in tree planting procedures is the new focus on the planting hole. It can be summed up by the saying, "Don't plant a $100 tree in a $10 hole!" Proper preparation will encourage root growth rather than adding to the difficulties already challenging the young tree. Here's the way to give your tree a boost toward rapid growth and recovery from transplant shock.

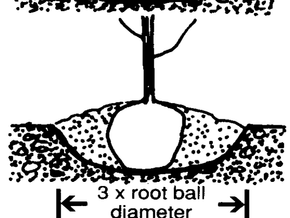


This method recognizes the fact that most roots spread through the top 12" of soil in a wide periphery around the tree. Therefore, slope the sides of the hole and dig or deeply rototill an area around the hole at least twice the diameter of the ball or container. An area up to five times the diameter is recommended if the soil is particularly compacted, the roots of other trees will not be damaged, and space and aesthetics allow.

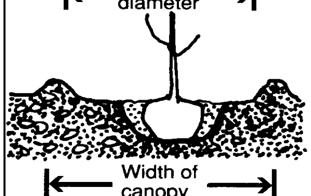
How Deep Should You Plant?



- Under normal conditions, root growth is best encouraged by planting even with the surrounding terrain.



- When wet conditions or heavy soil are problems, raising about 1/3 of the root ball above ground will aid the spread of lateral roots.



- In arid climates, a basin can be used to collect precious water.

Figure 7 - 5. Planting Burlapped or Potted Trees. Source: Tree City USA Bulletin No. 19, The National Arbor Day Foundation.

Work the backfill around the root ball, firmly tamping in place to avoid any air pockets. Fill up to original grade with the balance of the soil, tamp, and water. Fill in any spots that settle, and place excess soil in a ring around the tree to retain water. A mulch of wood chips and/or geotextile fabric should be placed in a three-to-four-foot-diameter circle around the tree to inhibit grass and herbaceous competition. Avoid placing organic mulch directly against the trunk, as this will harbor insects and rodents that may damage the tree. Broken and diseased branches should be pruned.

Container Stock

For container material, the planting hole should be twice as wide and as deep as the soil in the container. A portable or tractor-mounted auger can be used to drill the planting hole, or the hole can be hand dug. Carefully cut the container away from the plant to expose the roots. Where size, soil texture, and rooting density permits, plants can be removed from the containers by turning them upside down and pulling the containers off in an upward direction. (This is appropriate only if the soil remains firmly attached to the root system). Where the soil is very loose, the container can be cut away after placing it in the hole, and the bottom can be slid out from under the plant.

After exposing the roots, look for circling roots. The small ones can be teased apart and spread out in the planting hole. The large and extensive ones will have to be severed in several vertical cuts to prevent girdling the plant, which would set them back substantially. These plants should be rejected, as cutting roots introduces soil borne diseases. Backfill, water, and mulch as in B&B plants.

Container Grown Seedlings

Container seedlings can be planted manually or mechanically with a hand held portable auger. Roots should be white. If roots are completely brown, do not use the plant. The recommended planting density for container grown seedlings is 350 plants per acre.

Bare Root Seedlings and Year Transplants

Trees can be planted by hand or by machine. A correctly planted tree should have the following general characteristics:

1. Planted at about the same depth, or not exceeding one-half inch deeper than it was in the nursery. This is very important. Use the root collar for depth judgment.
2. Have the main roots nearly straight and spread out, not doubled, or sharply bent.
3. Have the soil firm around the roots. Leave no air pockets.
4. Have the tree in an upright position, and have it nearly even with the general ground level, not sunk in a hole or raised on a mound.

There are two methods of hand planting – slit method and side-hole method (Figures 7-7 and 7-8). Hand planting tools such as planting bars, dibble bars, mattocks, and hoe-dads are used for rapid planting of bare root stock and seedlings. Figure 7-6 shows four tree planting tools.

The slit method consists of making a slit with a planting bar or a dibble bar for smaller seedlings. It is much more rapid than the side-hole method. After placement, the bar is reinserted several inches away, rocked away from the plant to kick in the soil at the bottom of the roots, and then rocked toward the plant to compress the soil around the base of the plant. Where water is not available to settle the soil, it is important to firmly com-

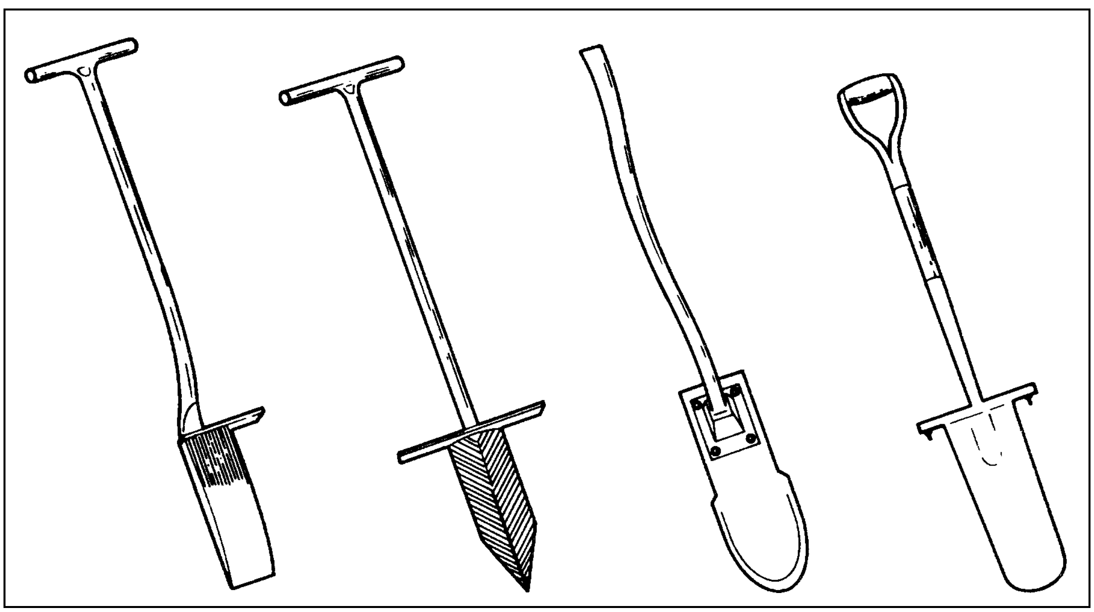


Figure 7 - 6. Four tree-planting tools (left to right): planting bar, a pointed planting bar useful in stony soils, the Rindi grub-hoe (L-shaped) for making straight-sided planting holes, and a tile spade planting shovel for digging deep holes for large planting stock. (Source: The Practice of Silviculture, Smith, 1986.)

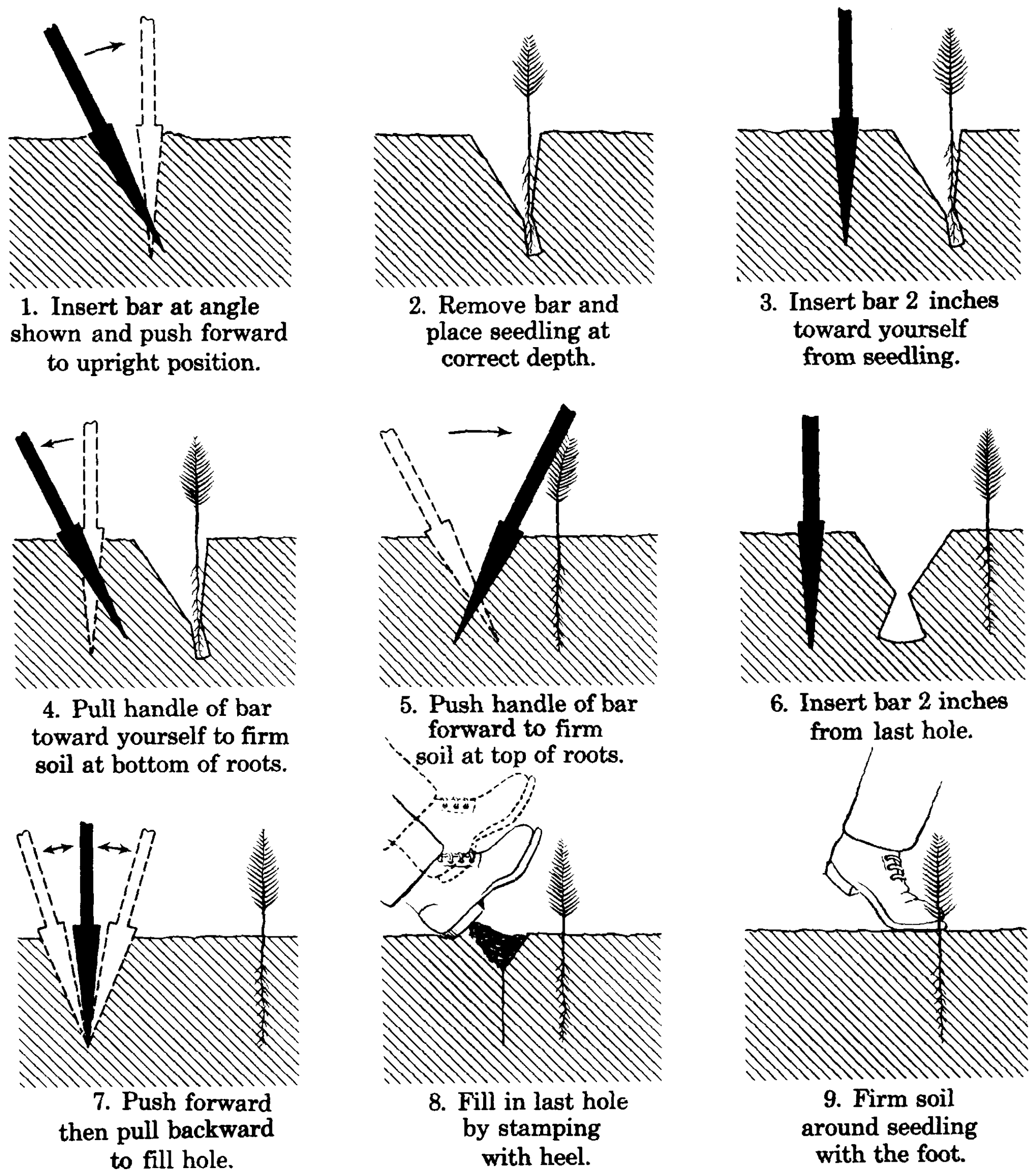


Figure 7 - 7. Slit Method. Steps in the use of the slit method of planting seedlings in sandy soil. (Sketch by U.S. Forest Service.)

press the soil around the plants (Figure 7-7).

The side-hole method consists of digging a hole deep enough with a mattock or grub hoe to hold the roots of the tree (see Figure 7-8 on the next page). Mattocks and hoe-dads are suitable for larger seedlings and most bare root stock. With larger bare root stock, the planting hole may not be large enough to permit adequate root spread with these tools, and the holes will have to be hand dug. These tools are driven into the ground and rocked to create a wedge-shaped hole, into which the plant is placed at the proper depth. It is important to hold the plant at the proper depth when backfilling and compacting

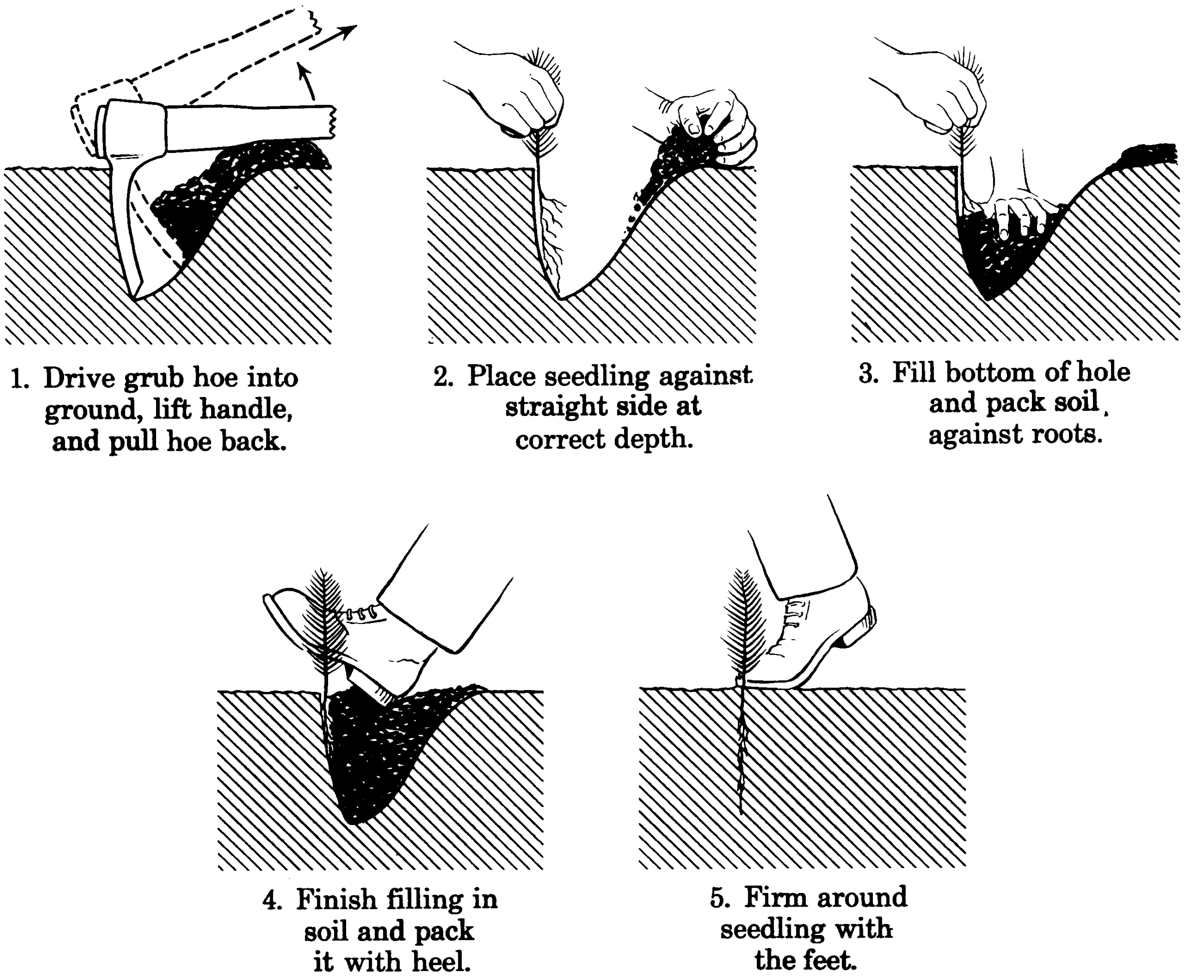


Figure 7 - 8. The Side-Hole Method of Planting. (Sketch adapted from U.S. Forest Service and The Practice of Silviculture, Smith, 1986.)

the soil, so as to prevent plant settling below the root collar. If the roots are long, the hole should be deepened, rather than bending the roots into a "J" shape.

Trees can also be machine planted. Results of good machine planting are comparable to those of good hand planting and superior to average for poorly hand-planted trees. A machine with a three-person crew can plant 10,000 seedlings per day. Planting machines are now generally available and their use is recommended wherever conditions permit.

Several makes of commercial planting machines are available for purchase. The type of machine to use depends upon the nature of the terrain and cover types to be planted. On relatively smooth open fields, one of the lighter machines pulled by a small tractor may be used. On areas with heavy, brushy cover, a machine that prepares the site and plants at the same time may be required.

Planting machines work best in light soils with light or moderate plant cover. They will also work well on heavy silt or clay soils if the moisture conditions are right, that is, if the soil is in what is considered a good condition for plowing. Soils eroded down to heavy clay are impossible to plant by machine unless they are dry. Heavy soils with some topsoil and a good

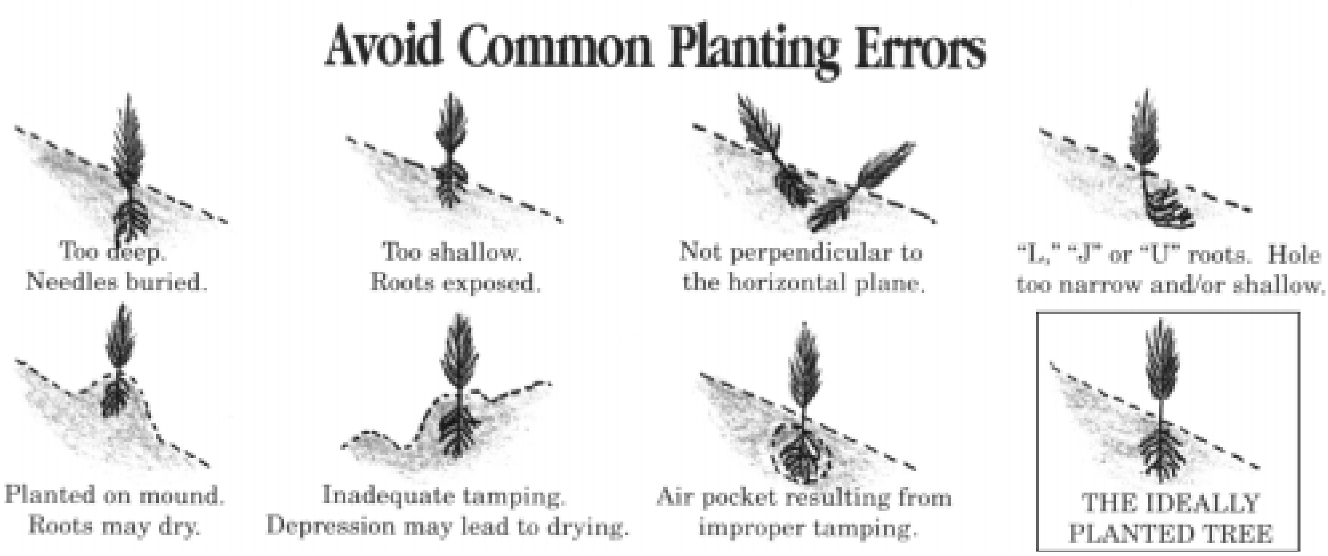


Figure 7 - 9. (Source: The Forest Steward, The National Arbor Day Foundation, March/April 1996.)

cover of broomsedge will plant well by machine unless excessively wet.

Figure 7-9 illustrates some common planting errors to avoid.

Tree Shelters

In areas where deer browsing is a substantial problem, tree shelters have been used with considerable success. With shelters 4-feet high, seedlings are protected until the root system is well-established. Even if the emerging tips are browsed, the root system will send up vigorous new shoots. Five-foot shelters should be used where deer herbivory is very heavy. Tree shelters protect against buck rub on the trunks, as well as minimizing disease entry from wound scars. Tree shelters also prevent rabbit and rodents from girdling the base of the tender trunks. Where deer browsing is light, shorter tree shelters (2 or 3 foot lengths) will provide herbivory protection at a lesser cost. Overplanting other vigorous species is another method to sustain deer browsing without excessive pressure on the desired species.

While important for herbivore control, tree shelters also provide a favorable microclimate for the seedlings. When shelters are properly installed, moisture transpired from the leaves condenses inside the tube, resulting in more humidity and a moister root zone. Carbon dioxide levels are also higher, promoting favorable growth. For these reasons, tree shelters generally increase initial growth rates by a factor of two to four times that of unsheltered seedlings. Sheltered seedlings also produce more leaves and have greater apical dominance. By protecting against wind and drought, tree shelters substantially increase seedling survivability in adverse circumstances. Red oak is particularly responsive to the beneficial effects of tree shelters. Shelters are also used for black walnut and other fruit and nut trees.

By isolating the trunk, tree shelters also ensure that herbaceous control measures are much less likely to affect the seedlings. Management of competing vegetation after planting is much easier; mowing and weedwacker strikes are prevented, and herbicides are isolated from trunk contact. As a result, herbicide labor costs can be reduced to one-fourth that required for unsheltered plantings. In the intensive management regime required for establishment of a riparian forest buffer, such savings may be considerable.

There is some concern that shelters reduce rooting and trunk strength due to wind isolation during initial growth. However, once the sapling has emerged so the crown spreads, there is enough trunk movement to build stem and root strength. The tree then allocates resources toward stem growth. For this reason, tree shelters should be left on for two to three years after emergence. After this time, the tree shelter must be physically removed.

Because of the relative absence of moisture stress, sheltered seedlings can grow later into the season, making them susceptible to die-back in cold winters. This is a temporary effect; regrowth in the following year will usually harden off properly. Where repeated die-back is a problem, the tubes can be lifted off the ground around Labor Day, drying out the seedling in time for winter. The tubes must be reinserted around Halloween, to ensure a good growing season the following year.

White tree shelters allow more light through them, and are preferred in sites where shady conditions will occur over the four to five-year span that tree shelters are used. Brown shelters are less obtrusive in more open sites. Tree shelters should be staked with rot-resistant stakes such as white oak. In southern states where termites are a problem, southern yellow pine or treated stakes are necessary. Stakes should be installed on the upwind side on open sites; on the north side in shadier sites. The base of a tree shelter must be driven at least an inch into the soil to avoid a chimney effect, which increases moisture loss. Tree shelters are then tied to the stake and a protective mesh placed over the top to prevent entry of birds. Netting should be removed once the tree grows out of the top of the shelter.

There are several different types of shelters available. The most widely used is the Supertube manufactured by the Treessentials Company. The one-piece seamless tube ensures moisture integrity, and the flared ends minimize bark rubbing where the seedling emerges. Recloseable shelters are offered by Tree Pro and Tree Sentry. These products may retain less moisture, but they permit inspection of the plants, as well as the potential for reuse. Tree Pro shelters are flared to minimize bark rubbing. Tree Sentry also offers a flared two-foot-high conical shelter with a mesh top to control browsing up to a height of four feet. TreePee makes a two-foot conical shelter, and Blue-X offers rolled tubes of recycled X-ray film. Addresses and contact information for these companies are listed in Appendix 10.

The cost of installing tree shelters varies according to the product type and size used. Using four-foot Supertubes as an example, the 1995 cost for 1,000 shelters with stakes was $2.50 per shelter, plus shipping cost of $0.21 each. Labor costs about $0.35 per shelter, suggesting an installed cost around $3.06 per shelter. Other products are similar in price. Given that the installed seedling costs are about $0.40 to $1.65, tree shelters would not be recommended for every seedling. They are most appropriate for the more expensive seedlings of species difficult to establish, such as red oak. However, reductions in maintenance costs and increased seedling vigor associated with tree shelters suggest that tree shelter plantings may be a more cost-effective approach than planting unprotected larger material.

Riparian Forest Buffer Maintenance

The most critical period during riparian forest buffer establishment is maintenance of the newly planted trees during canopy closure. Ongoing maintenance practices are necessary to ensure establishment of a thriving buffer, particularly where smaller seedling plant material has been used. Even where large plants are involved, herbivory, invasion by exotic species, and competition by herbaceous forbs and grasses will be a continuing problem. Therefore, maintenance practices are necessary to ensure the long-term effectiveness of the buffer.

In the early stages of riparian forest buffer establishment, competition for nutrients by adjacent grasses and forbs will substantially inhibit seedling growth. Release from herbaceous competition has been demonstrated as a most cost-effective method to accelerate the growth of seedlings and saplings. Therefore, the riparian forest buffer establishment strategy must incorporate control of the herbaceous layer over the near term until canopy closure shades out grasses and herbaceous competition.

In many cases, existing grasses and forbs are mowed once or twice per year to control their height. This method maintains a vigorous herbaceous layer, even though the species mixture may shift away from cold season grasses to other perennial forbs. Since nutrient uptake by the herbaceous layer is unaffected, or even increased by mowing, competition for nutrients will persist until canopy closure shades out the herbaceous layer. This substantially retards the rate of growth of the seedlings. Mowing also requires that the plants be spaced in a grid pattern, resulting in an artificial aspect to the buffer. The requirement for mowing also inhibits the establishment of understory species and shrubs until canopy closure. Mower strikes on the trunks are often unavoidable if no protective measures such as mulches or tree shelters are used.

An alternative to mowing is the use of mulches to control weed and forb growth. A well-aged hardwood mulch will not compete for nutrients, and it will retain moisture in the root zone of plantings. However, annuals and perennials easily root within such organic mulches as they decompose, increasing herbaceous competition. Geotextile fabrics reduce the rooting ability under organic mulches. However, plants in the humid east thrive in organic mulches, and their feeder roots can penetrate the underlying geotextile to obtain required nutrients and moisture. Using exposed geotextile fabric without mulch solves this problem, but then the uncovered fabric must be stapled down to prevent being entangled in mowers, blown away, or washed away during floods. Weed control fabrics are available from sources listed in the Appendix.

Herbicides can control herbaceous competition without the preceding drawbacks, particularly where tree shelters are present to isolate seedlings from control measures. Post emergent application of a mixture of Oust® and Accord™ controls grasses and broadleaf annuals and perennials. A clear zone of four feet in diameter will substantially promote the vigor of the seedlings compared to no treatment. Two to three years of control will successfully release the seedlings from grass and forb competition. Outside of the clear zone, selective control of broadleafs by Escort™ will direct succession to warmseason grasses, which have a high wildlife value and pose less competition for desired woody species. Herbicide application is less expensive and more flexible over the establishment period than repeated mowing, and it will result in more rapid establishment of the riparian forest buffer.

For control of vines and woody species, the procedures are similar to that involved for site preparation on early successional sites. Selection cutting of trees and basal sprays are needed from time to time to control undesirable species as the riparian trees grow. Adjacent upland source areas may need to be controlled by foliar spraying as conditions warrant. By using a regular maintenance regimen, the success of a new riparian forest buffer will be assured.

References

Coughlin, R.E., J.R. Denworth, J. Keene, and J.W. Rogers. 1992. Guiding growth: building better communities and protecting our countryside. PA Environmental Council, Philadelphia, PA.

Dick, R.C. 1991. Cartographic modeling of riparian buffers. In M. Heit and A. Shortreid, editors, GIS Applications in natural resources, GIS World, Inc. Ft Collins, CO.

Dillaha, T.E. 1993. Development of a buffer zone evaluation model/procedure. Report to the Virginia Council on the Environment Coastal Resources Management Program by Virginia Polytechnic Institute and University, Blacksburg, VA.

Dirr, M.A. 1983. Manual of woody landscape plants. Champaign IL. Stipes Publishing Co.

Flint, H.L. 1983. Landscape plants of Eastern North America. John Wiley & Sons, Inc.

Hightshoe, G.L. 1988. Native trees, shrubs and vines for urban and rural America. New York. Van Nostrand Reinhold.

Lorenz, D.G., W.C. Sharp, and J.D. Ruffner. 1991. Conservation plants for the northeast. USDA Soil Conservation Service. Program Aid 1154.

Miller, J.H. and R.J. Mitchell (editors). 1994. A manual on ground applications of forestry herbicides. USDA Forest Service. Mgmt. Bull. R8-MB21. Atlanta, GA.

Natural Resources Conservation Service. 1996. Riparian forest buffer technical standard #392. NRCS - Watershed Center, Seattle, WA.

Redington, C.B. 1994. Plants in wetlands. Kendall Hunt Publishing Co.

Schueler, T. 1995. Site planning for urban stream protection. Metropolitan Washington Council of Governments and Center for Watershed Protection, Publication # 95708, Environmental Land Planning Series, Washington, DC.

Welsch, D. 1991. Riparian forest buffers. NA-PR-07-91, USDA Forest Service, Northeastern Area, Radnor, PA.

U.S. Environmental Protection Agency - Chesapeake Bay Program. 1995. A framework for habitat restoration. Living Resources Subcommittee, Annapolis, MD.

Section VIII

Streamside Stabilization as a Component of Riparian Restoration

Streamside Stabilization as a Component of Riparian Restoration

Introduction

It is difficult to find an undisturbed stream in the Chesapeake Bay Watershed. For centuries, people have altered the landscape and the flow of streams and rivers for a variety of reasons: flood control, roads, power, agriculture and development, aesthetics, and even erosion control or "stabilization." Unfortunately, most manipulations of the stream and its riparian area did not take into consideration the natural dynamic processes at work in the stream channel and flood plain. Nor did they take into account the vital role of the stream environment to wildlife, fish, and the function of the downstream ecological system. The result is many unstable, degraded streams and watersheds.

Although establishing a riparian forest buffer will not always require stream stabilization, all successful stream stabilization efforts include the replanting of natural woody riparian vegetation.

Aside from direct damage to streams or streambanks, other disturbances are more subtle and occur over long periods of time, creating chronic stress on streambanks and channels. Continuous grazing by livestock slowly degrades streams and rivers. Another example of degradation is the gradual increase in impervious surface in a watershed because of development and repeated sedimentation. The view people have of most streams is a distorted one, because they often see unstable conditions altered by lifetimes of continuous impact.

Stabilization Techniques

Evaluation of a site for establishment of a riparian forest buffer often highlights the need for additional actions to stabilize the stream or protect the channel itself through stabilization or control of bank erosion. In this way, planning for stream restoration, fishery enhancement, bank stabilization, and riparian buffer planting can be integrated. Although streambank stabilization work may not always be needed to establish a riparian forest buffer, planting of native woody vegetation is always a recommended component of a stream restoration project.

Finding the "Cure"

In order to control erosion, the approach to streambank management must be compatible with the nature of the stream and the composition of its streambanks. Before restorative measures are applied to actively eroding streambanks, it is essential to understand what is causing the erosion problem. Otherwise, time and money are wasted. It is necessary to look at the streambank as part of the channel, the channel as part of the stream, and the stream in relation to its watershed (Figure 8-1). Like a doctor with his patient, diagnosing a stream's health and erosion problems usually involves some detective work. Too often, many of the actions taken by people to control stream erosion focus on treating the symptoms of a problem rather than curing its disease. Unfortunately, many of the techniques used to control erosion at a single point on a stream have actually accelerated erosion or degraded downstream conditions. Focusing on the restoration of natural vegetation and the

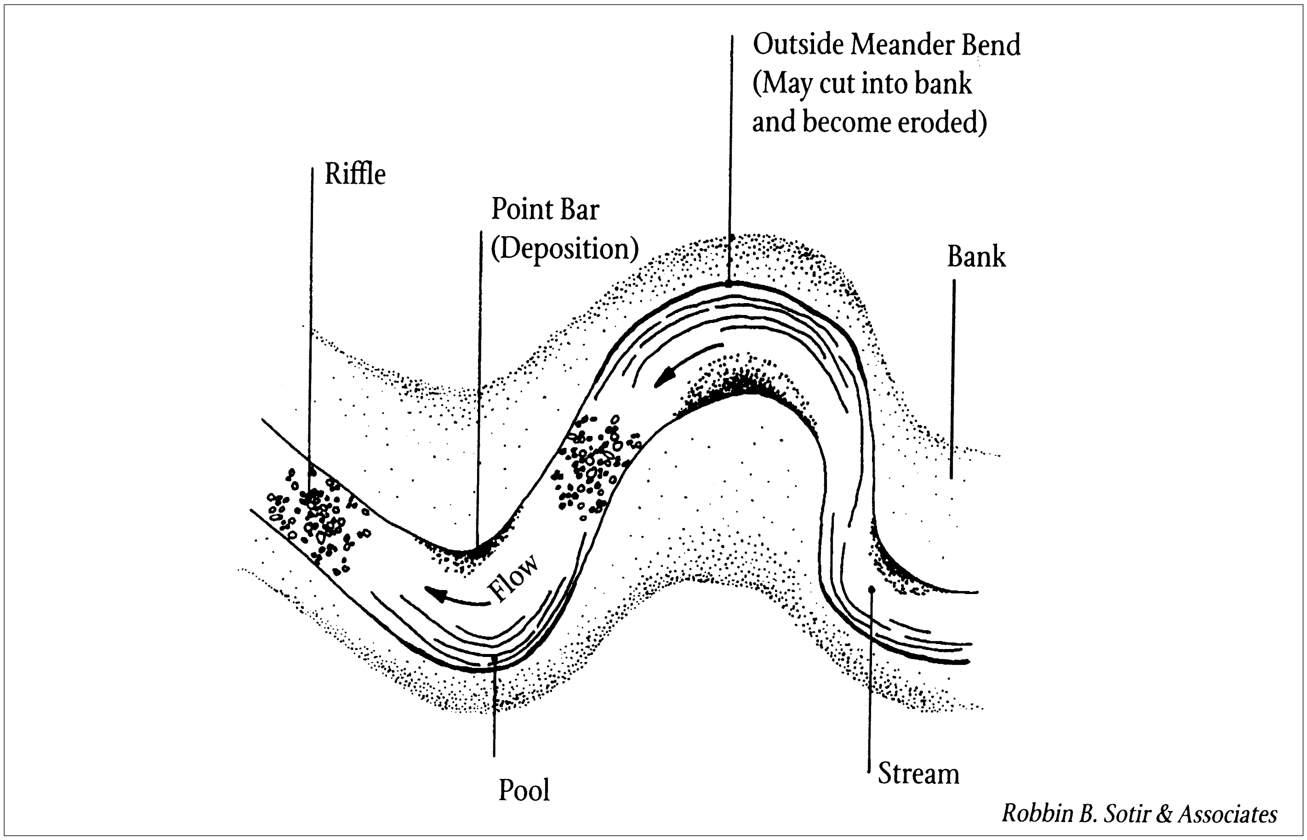


Figure 8-1. Illustration of streambank erosion and deposition.

form and function of channels may be the best approaches to maintaining the "patient's" health over the long term.

Using Non-Structural Erosion Control

Many effective means of streambank erosion control are available, but each technique will not work equally well in every situation. Many ineffective and costly techniques attempted in the past have often tried to solve long-term problems with quick solutions. For example, dumping rocks or other materials into the streamin the eroding area may do more harm than good. In some cases, streambanks will need engineering solutions to protect important structures, such as real estate or utility poles. In most cases, however, techniques that result in "hardened" channels, that is, concrete and rip-rap, should be avoided.

Helping Mother Nature heal herself by using natural processes to guide a streambank back to

Woody vegetation is the best streambank stabilizer. A goal of stabilization should always be to maintain and increase streamside trees and shrubs.

a stable condition is most likely to achieve long-term success. "Biotechnical" approaches, as they are called, have other important benefits. They are dramatically lower in cost, and they reclaim a more natural appearance and stream equilibrium. These approaches are also easily incorporated in the riparian forest buffer.

Non-structural approaches are differentiated primarily by their reliance on vegetation as a major component of the stabilization technique. Using cuttings of willow and other woody shrubs and trees that root from the stem is a highly successful and inexpensive treatment. Used as stakes, fascines, brush mats, or layered in a stream bank, woody plants are combined with placement of log cribs, boulders, stones, or other structural features.

To be successful, stream stabilization projects should be carefully planned with the help of technical experts, take a watershed approach, and incorporate solutions that protect habitat, water quality, and aesthetics.

Using a "Natural Channel Systems Approach"

Despite a wealth of knowledge and experience with low-cost, sustainable, and ecologically sound stream restoration techniques, streams continue to be channelized, diked, dammed, and hardened by rocks and concrete. The goal of stream restoration should be to design and manage channels in a natural form., Until recently, scientific principles of hydrology and geomorphology had not been widely applied to stream restoration techniques. The "Natural Channel Systems Approach" recognizes the role of hydrologic function of streams and rivers as part in the overall health of the natural ecosystem.

A healthy natural stream system should exhibit two key characteristics:

- Physically, the stream system will be dynamically stable. It will exhibit self-regulatory mechanisms that are stable over time and adjust to accommodate changes in water yields and sediment loads.
- Biologically, the stream and valley system will be self-sustaining and self-regulating. It will exhibit healthy ecological functions manifested by productive vegetative communities in the valley. The stream and valley system will have healthy aquatic and terrestrial communities supported by diverse habitat.

Based on the Rosgen stream classification system that characterizes how a channel changes over time, the natural channel systems approach aims to work with altered or eroding streams by mimicking natural form and materials. Stream restoration is carried out in such a way as to approximate a channel width, depth, sinuosity,

<u>Natural Channel Design Process</u>

CLIMATE | **GEOLOGY**

<u>Hydrology</u>

Discharge
Velocity
Roughness

<u>Sediment</u>

Character
Load

⇓

<u>Channel Character</u>

size + shape + pattern + slope
bed and bank material + vegetation

⇓

<u>Character Of Restored Channel</u>

width - depth - slope - sinuosity - pattern
roughness - flood plain - riparian vegetation

and roughness that are compatible with channel flow, sediment load, bed and bank materials, and slope. By focusing on these natural channel characteristics, restoration is more likely to be stable and maintained over time. In addition to the stability of natural channel design, this approach incorporates natural materials and vegetation in restoration. As a result, the end product is more valuable from an aesthetic, recreational, and habitat standpoint. In addition, these approaches are more cost effective than traditional engineering techniques.

The Role of Riparian Forest Buffers

With foresight to maintain riparian forests, properly manage stream corridors, and avoid land use practices that initiate erosion, unstable streams or streambank erosion can often be prevented. Woody vegetation is <u>the</u> best streambank stabilizer. Reestablishing trees and shrubs adjacent to stream channels should be one of the goals of all restoration efforts. The planting of a riparian forest buffer may even help restore a stream over the long term, provided the forest reaches maturity and is extensive enough to allow natural stream widening and migration over time. Riparian buffer planting may be enhanced by simple biotechnical approaches when streambank erosion is present. Adding willow posts or additional shrub planting in rows nearest the stream may be appropriate.

Simple Adjustments in the Riparian Forest Buffer to Enhance Stabilization:

- Add 1-2 rows of high-density shrub plantings closest to stream.
- Willow posting along streambank with shrub row.
- Integrate biotechnical bank treatments.
- Expand the width of the buffer.

Normally though, riparian forest buffers alone should not be viewed as a stream restoration technique. Trees and other vegetation cannot quickly cure the erosion problems of an unstable stream system. It is best to combine tree planting with other stabilization and erosion control practices. Many landowners, however, may be unable to undertake the time or cost involved in a major stream restoration project. In these cases, RFBs may be used to achieve habitat and water quality buffering values, prevent further degradation of the stream, and begin a natural healing process. The value of the RFB to stream stabilization will be maximized by placing priority on ensuring adequate width and continuity of buffers in the stream system.

Planning for Streambank and Channel Restoration

Rivers and streams are complex systems. Riparian forests are a part of these systems and trees are an integral part of flood plain and stream function. However, it is also the nature of streams to change their course periodically. Erosion of streambanks is often a natural part of this process. To choose the best solution for a given stream, a match must be made among the local watershed conditions, the objectives of the landowner, and the range of available techniques. Before beginning a stabilization project, the following steps should be taken:

- Determine the problems affecting the stream.
- Establish the goals of the project.
- Develop a stabilization plan with professional advice.

EROSION TYPES AND CAUSES

Type of Erosion	Causes
General Bank Scour	Increased discharge resulting from watershed changes; increased flow velocities caused by reduction in channel roughness or increased gradient; removal or loss of bank vegetation.
Toe Erosion and Upper Bank Failure	Removal of unconsolidated or loose lower bank materials, especially along outside bends. Widespread toe erosion may be associated with bed lowering.
Local Streambank and Streambed Scour	Scour of local lenses or deposits of unconsolidated material; erosion by secondary currents caused by flow obstructions and channel irregularities; loss of bank vegetation. Local bed scour may be caused by channel constrictions and flow obstructions. Some bed scour generally occurs below culverts.
Overbank Runoff	Failure to provide adequate means of directing concentrated flows from overbank areas into the channel.

Sources: Adapted from Nelson R. Nunnally; Georgia State Soil & Water Conservation Commission.

- Obtain required permits and funding.
- Organize volunteers, materials, and equipment.
- Implement the project.
- Provide follow-up maintenance and monitoring.

A number of recent handbooks and guides provide a wealth of design, installation, cost, and effectiveness information on a variety of stream stabilization and stream restoration techniques. A list of references is provided at the end of this section.

not planned adequately, can do more harm than good to the streambank.

To protect the streambank during installation, preserve as much of the existing vegetation as possible. Hand equipment will not do as much potential damage as heavy motorized equipment. As a rule, willows are the most effective species in most of these applications. Their matted roots will form a natural barrier to erosion. They are also easily propagated from cuttings. However, a number of other species show promise. Species are listed in Table 8-1.

Following are seven common soil bio-engineering techniques.

GENERAL CONDITIONS
FREQUENTLY ASSOCIATED WITH STABLE AND ERODING BANKS

Characteristic	Stable Bank	Eroding Bank
Bank Slope	1 H to 1 V (Horizontal to Vertical) or flatter; may be stepped or benched with vegetated berm at toe	Often vertical or near vertical; may have mass of sod or other failed material at toe
Bank Cover	May have variety of vegetation growing on slope, including ferns or moss	General absence of vegetation
Trees	Often has trees growing on bank or on the bed at toe	Standing live or dead trees inside the bank line, often leaning toward channel; fallen trees may obstruct flow
Bankline	Relatively uniform or smoothly curving	Irregular, sometimes with scalloped appearance
Sediment	Sediment located in bars; bars may be partially stabilized by vegetation especially along bank toe	Entire bed may be covered with sediment, bars not stabilized

Sources: Adapted from Nelson R. Nunnally; Georgia State Soil & Water Conservation Commission.

Construction Techniques and Materials

Before constructing any of the following structures, a permit may be needed from the State Environmental Protection Agency or Division. It is also important to diagnose the problem and determine what the stream is doing before any work is done to stabilize its streambank. Some stabilization techniques, if

Tree Revetments

Tree revetments (Figure 8-2) are made by anchoring trees along a lake shore or streambank. Revetments are used to control erosion on cut and fill slopes subject to scour and undermining. The vegetation will stop or prevent erosion and shallow sloughing on or at the slope face above the toe.

GENERAL GUIDANCE FOR ESTABLISHING SEVERITY OF EROSION

Degree of Erosion	Characteristics
Stable to Mild	Little or no evidence of erosion; if eroding banks are present, they are small in extent (linear extent less than average bank height) and rates are modest (less than ½ foot per year); greater erosion may be tolerated at bends if it causes no associated problems.
Moderate	Extent of problem or rate of erosion exceeds criteria for stable class, it is less than severe.
Severe	Erosion covers large area of bank (linear extent greater than three times average bank height) and is occurring at a rate in excess of one foot per year or a rate that is unacceptable for safety, environmental, or economic reasons.

Sources: Robbin B. Sotir & Associates; Georgia State Soil & Water Conservation Commission.

Where applicable

- Small to medium banks that are unstable because original trees have been cleared away. The eroding bank should be less than 12 feet high.
- Most effective on moderately eroding sites (1 to 3 feet of bank erosion annually).

Advantages

- Inexpensive and effective way to slow wave action along the eroding shore.

Disadvantages

- For severely eroding sites, tree revetments should be backed by an additional method.

Effectiveness

- Provide excellent fish and wildlife cover that is absent on eroding, bare banks.
- Will cause a new bank to form as silt and other material becomes deposited along the bank and within tree branches.
- Will enable a good seed bed to form where local lake shore species, such as willow, can sprout and grow.

Construction Guidelines

- **Timing** – During any season, but late winter and early spring are the best times.
- **Preparation** – Cut fresh cedar trees.
- **Installation**
  1. Trees are moved to the top of the eroding bank, then pulled into the stream, one at a time.
  2. Construction begins at the downstream end of the eroding streambank. The tree is anchored firmly against the eroding bank with its butt end pointed upstream.
  3. Trees can be anchored using steel T-posts, screw-in anchors, or driven earth anchors.
  4. A cable, 3/16 inches or larger, is attached to a T-post, driven into the bank, then the cable is wrapped around the tree, and secured with a common cable clamp.
  5. The next tree is then moved into place, with its top overlapping the butt of the first tree, so that no gap exists between the two.
  6. The cable used to anchor the butt of the first tree is then secured to the top of the second tree. This process is continued upstream until the entire streambank is covered with trees.
  7. A riparian forest buffer, 35 to 100 feet wide, should be established along the stream.

Table 8 - 1
Plants Suitable for Use as Unrooted Hardwood Cuttings

Species	Region	Tolerance to Flooding	Tolerance to Drought	Tolerance to Deposition	Tolerance to Shade
Acer negundo **Boxelder**	C,P,M	H	H	H	L
Baccharis halimifolia **Groundsel bush**	C, P (lower)	M	M	H	L
Cornus amomum **Silky dogwood**	P, M	L	M	L	M
Cornus stolonifera **Red osier dogwood**	P, M	L	M	H	M
Crataegus spp. **Hawthorn**	C, P, M	M	H	L	L
Ligustrum sinense **Chinese privet**	C, P, M	H	M	M	M
Populus deltoides **Eastern cottonwood**	C, P, M	M	M	H	L
Salix interior **Sandbar willow**	C, P, M	H	L	H	L
Salix nigra **Black willow**	C, P, M	H	H	H	L
Salix purpurea **Streamco willow**	C, P, M	H	M	H	L
Salix x cotteri **Bankers willow**	P, M	H	M	H	L
Sambucus canadensis **American elderberry**	P, M	H	M	M	M
Viburnum dentatum **Arrowwood viburnum**	C, P, M	M	M	M	M
Viburnum lentago **Nannyberry viburnum**	C, P, M	M	M	L	M
Robinia pseudoacacia **Black Locust**	P,M	L	H	M	L

Source: Adapted from the USDA Soil Conservation Service Engineering Field Handbook, Chapter 18.

Legend:
Tolerance to flooding, drought, deposition, and shade
H=high, M=medium, L=low
Region
C=Coastal Plain, P=Piedmont, M=Mountains

EVERGREEN REVETMENT WORKSHEET

Source: Ohio Stream Management Guide No. 12

1. Determine water depth at toe of bank slope under normal water level conditions.
   A. If more than 3 feet, then revetments may not stabilize the bank.
   B. If 3 feet or less, then revetments should work.
2. Determine streambank soil type and anchoring method by using ¾ inch steel rod (scrap rebar) to probe at least 4 feet into channel bottom and streambank.
   A. If bedrock is less than 4 feet below streambank, anchors won't hold.
   B. If bedrock is more than 4 feet below surface, and soils are rocky, use T-post or duckbill anchor.
   C. If bedrock is more thant 4 feet below the surface, and soils are sand, silt, or clay, use T-post.
3. Determine size of channel constriction the revetment will cause, and optional approaches.
   A. Difference in elevation (in feet) from top of eroded bank to toe of bank slope = ______ (3A).
   B. Tree crown diameter (in feet) needed = answer to 3A x 0.67 = ______ (3B).
   C. Tree crown radius = answer to 3B x 0.5 = ______ (3C).
   D. Measure stream width (average) in feet at revetment site = ______ feet (3D).
   E. Percent constriction caused by revetment = (3C ÷ 3D) x 100 = ______ % (3E).
   F. If answer to 3E is less than 15%, then one row of anchored trees should work. At least two rows are recommended if bank height will accommodate them.
   G. If 3E is greater than 15%, a second row is needed, but with smaller diameter tree crowns. Also, the narrower the stream width, the greater the likelihood water will overtop one row.
4. Determine total length (in feet) of trees needed.
   A. Length of bank needing coverage by the revetment (measure beyond area of exposed soils) = ______ feet (4A).
   B. Total length of trees needed, accounting for tree overlap during construction = 4A x 1.2 = ______ feet (4B).
5. Determine number of **trees** needed.
   A. Number of trees needed for one row = total length of trees needed (4B) ÷ estimated average height of trees available = ______ trees for one row (5A).
   B. Height of revetment = height of area needing protection, measured vertically from the toe of the slope up to a point 1-2 feet above where flows will spread out across the low bank into the flood plain = ______ feet (5B).
   C. Number of rows up the bank = 5B ÷ estimated average *compressed* tree crown diameter (cedar and arborvitae compress more than fir trees) = ______ (5C).
   D. The number of rows up the bank is also the number of trees in a "set", the number of trees needed for one row = the number of sets needed. 5A = ______sets (5D).

E. Estimated total number of trees needed for the revetment = 5A x 5C = ______ trees (5E).

F. *<u>If height or diameter of trees found available is different than the estimate, re-calculate number of trees, anchors, clamps and cable length needed, and adjust purchases</u>*.

6. Determine the number of **anchors** needed.

   A. For a one-row revetment, the number of anchors = 1 + number of trees in one row = ______ anchors.

   B. For a multiple-row revetment, the number of anchors = 2 x number of sets + 2 = ______ anchors.

7. Determine the number of **cable clamps** (sized for cable) needed = 2 x the number of anchors______. Bring extra clamps to replace any lost in the water. Some lost clamps can be retrieved with a large magnet.

8. Estimating the amount of **cable or wire** needed, especially for multiple row revetments, is difficult considering the difference among tree species on how much they will compact when wrapped with cable. Use the following guidelines.

   A. When using cable, ¼ inch steel aircraft cable is flexible and adequate in most circumstances. If in real doubt, double it, but washouts rarely happen because of a ¼ inch cable breaking.

   B. When the revetment will have **one row of trees**, the amount of cable/wire needed to wrap around the trees = (4 feet x the number of anchors (6A)) + 20% = ______ feet of cable or wire (8C).

   C. When the revetment design is for **multiple rows**, the amount of cable needed = (2 x revetment height (5B)) x (the number of sets + 1) + 20% = ______ feet of cable or wire (8D).

   D. *If you are using **anchors without pre-attached cable** for sinking into the soil, you must estimate the depth of your anchor installations, add 0.5 to 1.0 foot more for a loop to clamp the cable onto the anchor, multiply that sum times the number of anchors, and add that total to your results for 8C or 8D, whichever is applicable.*

Example

A revetment covering 200 feet of eroded bank needs 240 feet of trees to cover the first row (200 x 1.2 = 240). (See worksheet items 4A and 4B). If using 8 foot trees, 30 trees are needed for a one-row revetment (240 ÷ 8 = 30) or 30 sets of trees are needed for a multiple row revetment (see 5D). If the revetment needs to cover an eroded area 5 feet high, and the average tree crown diameter is 2 feet, then the revetment needs to have 3 rows [(5 ÷ 2 = 2.5)(round up to 3)(see 5C)]. Three rows x 30 sets = 90 trees needed (see 5E). Sixty-two anchors are needed (2 x 30 sets + 2 = 62) (see 6B) and 124 clamps (see 7) are needed. Each set needs 10 feet of cable for wrapping (2 x 5 feet eroded area height), so 10 feet per set x (30 sets + 1) = miminum 310 feet of cable needed (see 8D). Purchase an additional 20% for a margin of error. Cut the cable in lengths of 10 feet per set at first. If you find less cable is needed for wrapping, reduce that length, saving cable for its next use.

If using anchors without pre-attached cable, and they are to be sunk 3 feet into the streambank, add (3 feet + 0.5 to 1.0 foot for the loop) x (30 sets + 1) to the 310 feet minimum before calculating the 20% extra and cut the cable in 13.5 to 14 feet lengths at first (see 8E).

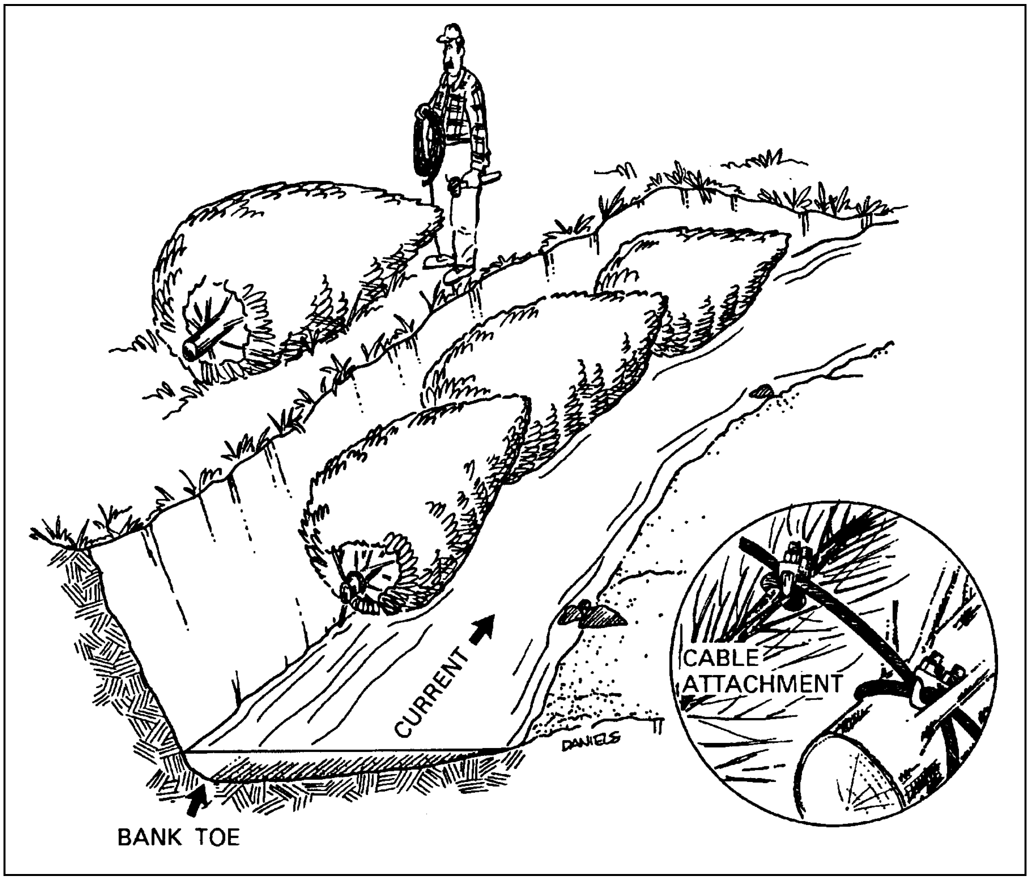


Figure 8 - 2. Tree Revetments. (Source: Missouri Department of Conservation, no date)

Live Stakes

Live stakes (Figure 8-3) are living woody plant cuttings capable of quickly rooting in the streamside environment. The cuttings need to be large and long enough to be tamped as stakes. A common rule is to use stakes no smaller than the size of a person's thumb or index finger.

Where applicable

- Stakes are used on streambanks of moderate slope (4:1 or less) in original soil, not on fill.

Advantages

- Enhances conditions for natural invasion and the establishment of other plants, resulting in a permanent, natural stabilizer.
- Use to stabilize intervening area between other techniques.
- Economical, if cuttings are available locally.
- Can be installed quickly with minimum labor.

Disadvantages

- Will not stabilize the bank until top growth has occurred.
- Will be unsuccessful unless combined with another method in areas of active erosion or on streams with high fluctuation of flow.

Effectiveness

- A very effective stabilization method once vegetation is established.
- An effective barrier to siltation from erosion of adjacent land.

- An effective method for increasing vegetative cover along a stream where existing vegetation is sparse.
- Most effective on small earth slips and slumps that are frequently wet.

Construction Guidelines

- **Timing** - Dormant season (generally November to March) at low water levels.
- **Sizes -** The cuttings are usually 1/2 to 1-1/2 inches in diameter and 2 to 3 feet long.
- **Preparation -** The cuttings must be alive, with side branches cleanly removed, and with bark intact. The basal ends should be cut at an angle for easy insertion into the soil. The top should be cut square. Materials should be installed the same day they are prepared.
- **Installation**

1. Tamp the live stake, at any point on the slope face, into the ground at right angles to the slope.
2. The stakes should be installed 2 to 3 feet apart, using triangular spacing. The density of installation will range from 2 to 4 stakes per square yard.
3. The buds should be oriented up.
4. Four-fifths of the length of the live stake should be installed into the ground with soil firmly packed around it.
5. Do not split the stakes during installation.
6. An iron bar can be used to make a pilot hole in firm soil.

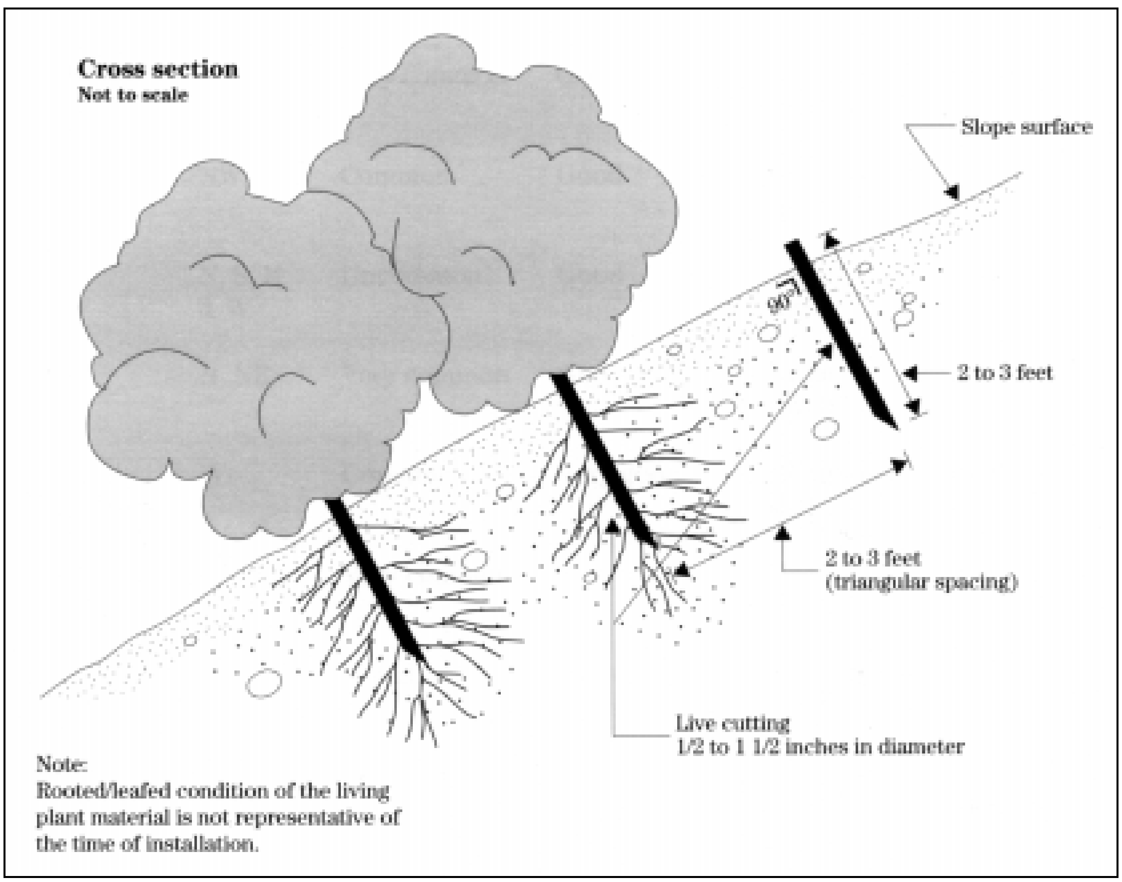


Figure 8 - 3. Live Stakes. (Source: Soil Conservation Service, 1992)

Live Fascines

Live fascines (Figure 8-4) are long bundles of branch cuttings bound together into sausage-like structures. They are secured into the streambank with live or dead stakes. They are often used in combination with other techniques and will provide stability while other vegetation takes root.

Where Applicable

- Used to protect banks from washout and seepage, particulary at the edge of a stream and where water levels fluctuate moderately.
- Used on all sizes and classifications of streams.

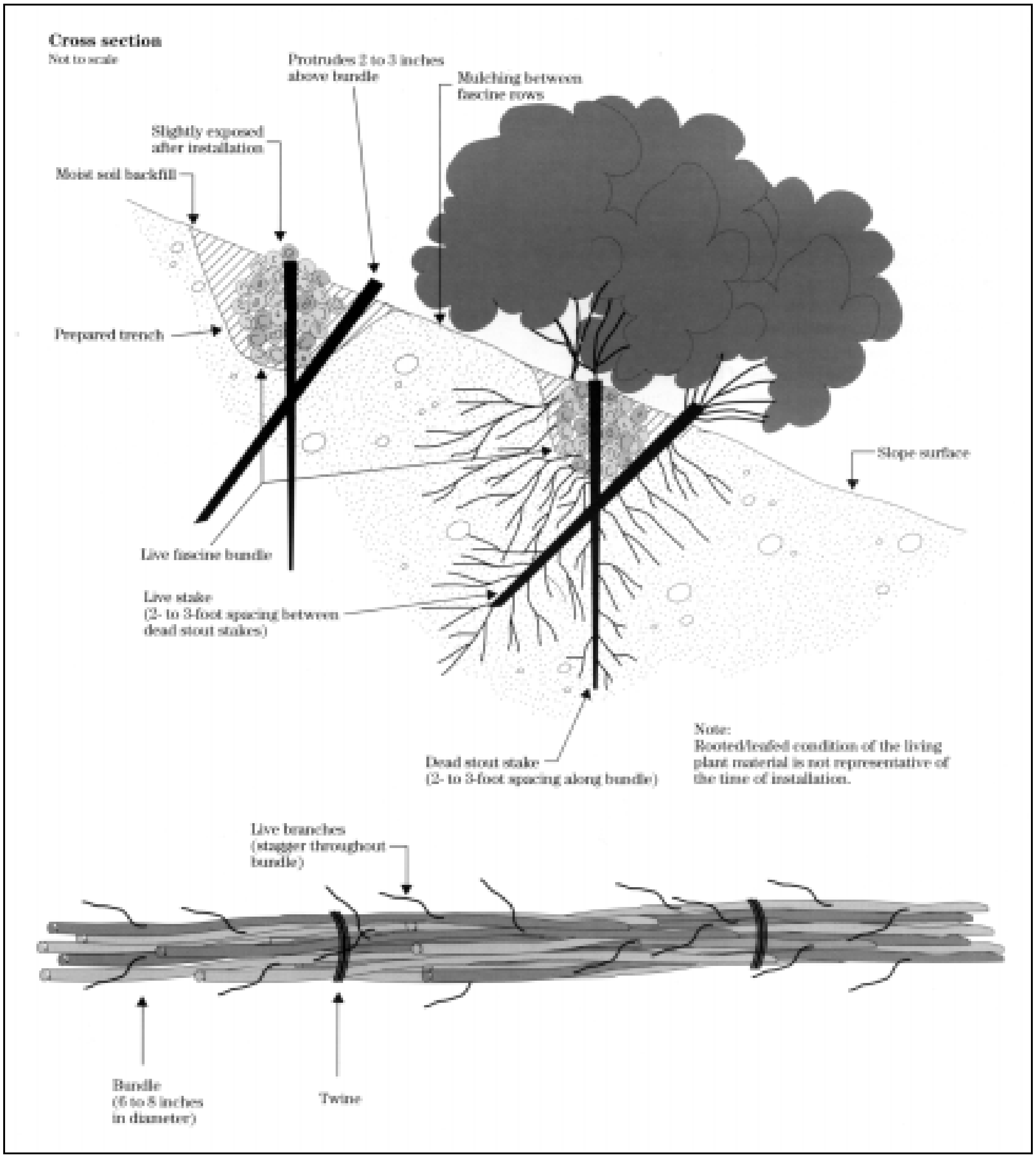


Figure 8 - 4. Live Fascines. (Source: Soil Conservation Service, 1992)

Advantages

- Will not cause much site disturbance, if installed properly.
- Are economical where materials are locally available.
- Are effective at the water's edge even before the cuttings have rooted.
- Grow into a durable, natural appearing installation.

Disadvantages

- Hand labor is required.
- Wide spreading branches cannot be used.
- Not recommended where surface drainage occurs over the face of the streambank.

Effectiveness

- Immediately reduce surface erosion or rilling.
- Are suitable for steep, rocky slopes, where digging is difficult.
- Are capable of collecting sediment.
- Enhance vegetative establishment by creating a microclimate conducive to plant growth.

Construction Guidelines

- **Timing** - Construction must occur in the dormant season.
- **Sizes** - Fascines can be 15 to 20 feet long. The bundles are 6 to 8 inches in diameter when prepared. The branches contained in the bundle should be at least 4 feet long and have a maximum trunk diameter of 1 inch. The wire for bundling should be 1/10-inch in diameter or larger.
- **Preparation** - Cuttings must be from a species that roots easily and has long, straight branches. Young willows or shrub dogwoods are ideal. The cuttings are placed in bundles with the butt ends in the same direction and wired together every 12 to 18 inches. Live stakes should be 2 to 3 feet long and should be placed through and below the fascine.
- **Installation**
  1. Beginning at the base of the bank at mean low water level, tamp stakes in a row across the slope.
  2. A shallow trench as deep as the diameter of the fascine is dug above the stakes.
  3. Place the bundles in the trench.
  4. Tamp more stakes through the bundles.
  5. Live stakes should be spaced approximately 12 inches apart. Extra stakes should be used at joints. Leave the tips of the stakes 6 inches above the soil.
  6. Cover the bundles with soil from above and tamp firmly.
  7. Walk on top of the bundles to eliminate any air.
  8. To minimize drying of the soil, trenching should not precede placement of the bundles by more than one hour.
  9. Fascines should be prepared immediately before installation and must be stored in a moist, shady location.
  10. The sequence proceeds layer by layer up the slope with trenches about 3 feet apart. Twigs at the top of the bundles should protrude above the soil.

Brushlayer

The Brushlayer Method (Figure 8-5) is similar to live fascine systems because they both involve the cutting and placement of live branch cuttings on slopes. In brushlayering, the cuttings are oriented more or less perpendicular to the slope contour. Brushlayering consists of placing live branch cuttings in small benches excavated into the slope.

Where applicable

- Recommended on slopes up to 2:1 in steepness and not to exceed 15 feet in vertical height.
- Benches can range from 2 to 3 feet wide.

Advantages

- Performs several immediate functions in erosion control, earth reinforcement, and mass stability of slopes.

Disadvantages

- Cannot install in dry conditions.
- More difficult to install than other techniques.

Effectiveness

- Breaks up the slope length into a series of shorter slopes.
- Reinforces the soil as roots develop, provides slope stability, and allows vegetative cover to become established.

Construction guidelines

- **Timing** - Seedlings do not have to be dormant, but construction should be done during spring or fall.
- **Sizes** - Branch cuttings should be ½ to 2 inches in diameter and long enough to reach the back of the bench. Side branches should remain intact for installation.
- **Preparation -** See size.
- **Installation**
  1. Starting at the toe of the slope, benches should be excavated horizontally, on the contour, or angled slightly down the slope, if needed to aid drainage. The bench should be constructed 2 to 3 feet wide.
  2. The surface of the bench should be sloped so that the outside edge is higher than the inside.
  3. Live branch cuttings should be placed on the bench in a crisscross or overlapping configuration.
  4. Branch growing tips should be aligned toward the outside of the bench.
  5. Backfill is placed on top of the branches and compacted to eliminate air spaces. The brush tips should extend slightly beyond the fill to filter sedimentation.
  6. Each lower bench is backfilled with the soil obtained from excavating the bench above.

SELECTED EROSION PROTECTION MEASURES FOR STREAMBANKS

Erosion Problem	Streambank Protection Measures Ranked by Environmental Benefits
General bank scour	1. Brushlayer 2. Live fascine 3. Live staking
Toe erosion and upper bank failure	1. Live cribwall 2. Brushlayer with rock toe
Local streambank scour	1. Branchpacking 2. Live cribwall 3. Live fascine with erosion control fabric
Overbank runoff	Intercept and divert runoff and repair damage with: 1. Branchpacking 2. Live fascine 3. Live staking with erosion control fabric

Adapted from Robbin B. Sotir & Associates; Georgia State Soil & Water Conservation Commission

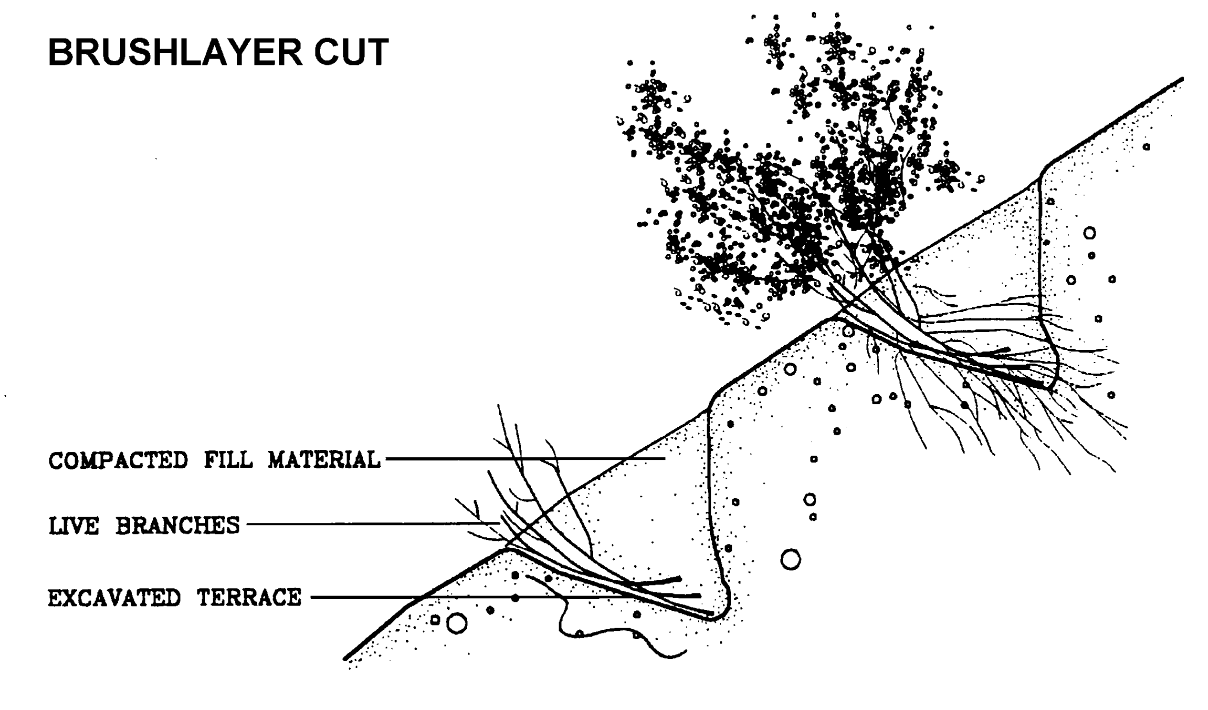


Figure 8 - 5. Brushlayer. Rooted/leafed condition of plant material is not representative at time of installation. (Source: Darby Stream Team of the Darby Creek Watershed Partnership, 1996)

7. Long straw or mulching material with seeding should be placed between rows on 3:1 flatter slopes, while slopes steeper than 3:1 should have jute mesh or similar material placed in addition to the mulch.
8. The brushlayer rows should vary from 3 to 5 feet apart, depending upon the slope angle and stability.

Branchpacking

Branchpacking (Figure 8-6) is alternating layers of live branches and soil incorporated into a washed out streambank. Branches are used above and below the water surface. The branches above the water line root to form a permanent installation while those below the water line provide initial stability.

Where Applicable

- Banks that have had washouts.
- A scoured hole or localized stump. These hollows should not exceed 12 feet in length, 5 feet in width, or 4 feet in depth.

Advantages

- Plant materials are usually available locally.
- Is an economical method.
- Reliable in fast moving water.
- Produces a permanent, natural appearing installation.

Disadvantages

- Large amounts of branches are required.
- Considerable labor is required.

Effectiveness

- Provides immediate soil reinforcement by redirecting water flow.
- One of the most effective methods for revegetating holes scoured in a streambank.
- Produces a filter barrier, reducing erosion and scouring conditions.

Construction Guidelines

- **Timing -** Install during the dormant season.

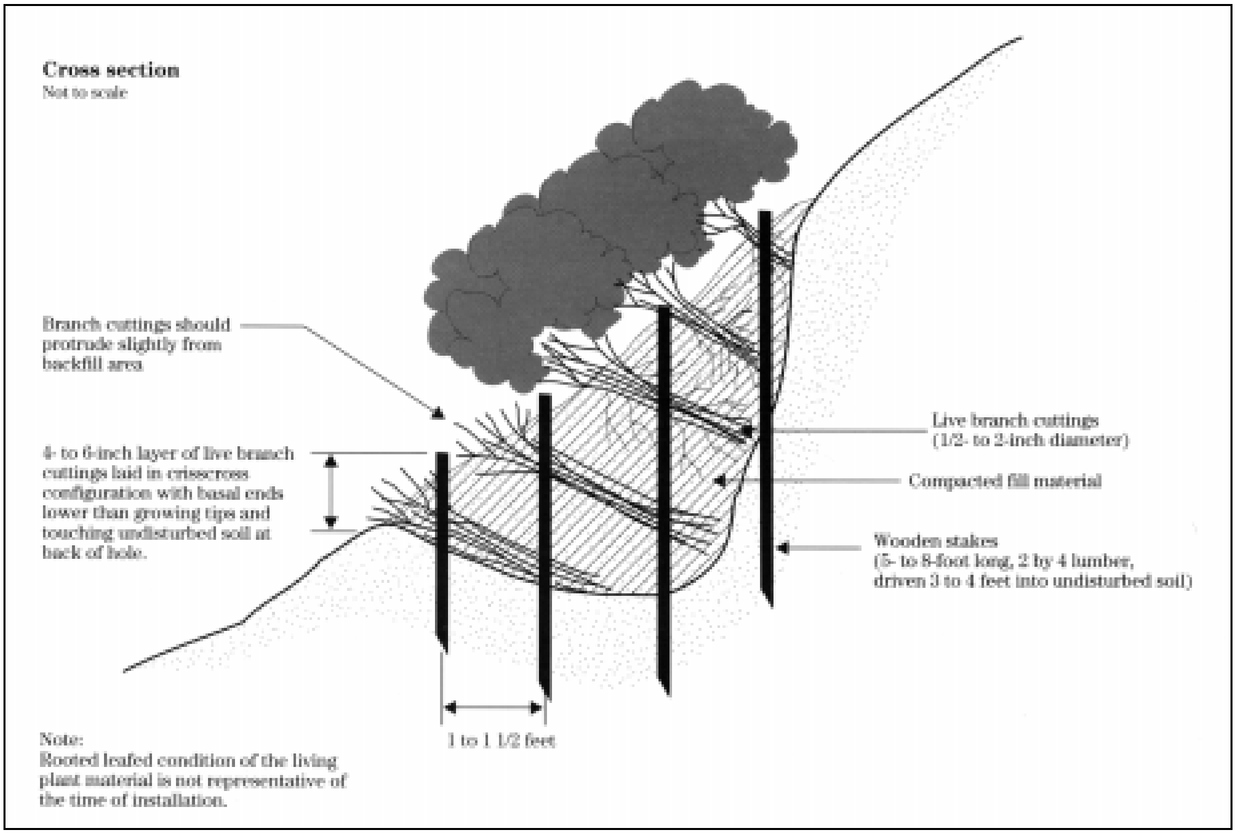


Figure 8 - 6. Branchpacking. (Source: Soil Conservation Service, 1992)

- **Sizes -** Live branch cuttings may range from ½-inch to 2 inches in diameter. They should be long enough to reach original bank soil with 12 inches left exposed on the stream side. Stakes should be 6 to 8 feet long.
- **Preparation -** Live cuttings are required. Soil and gravel are mixed and used as alternate layers between brush layers.
- **Installation**
  1. Starting below the water line, tamp stakes vertically into the soil 3 feet apart.
  2. Place a 3- to 5-inch layer of compressed branches on the bottom of the washout between the vertical stakes. Cover with an 8- to 12-inch layer of soil and gravel.
  3. The following layers of branches are installed with the basal ends angled down into the streambank, so that they are at least 12 inches lower than the tip of the branches.
  4. Each layer of branches must be followed by a layer of soil mix and compacted thoroughly, tamping by foot, in order to ensure soil contact with the branch cuttings.
  5. Succeeding layers of branches and fill are alternated until the washout is completely filled.
  6. The top layer should be filled with soil and gravel.
  7. From the stream bottom up to the average water level, large rocks (do not use rocks from the stream) capable of resisting the current may be placed over the layers to prevent scour.
  8. Tips of the branches must extend beyond the soil layers to grow. The basal ends must extend into the undisturbed soil.

Live Cribwall

The live cribwall (Figure 8-7) is a rectangular, hollow, interlocking arrangement of logs, rocks, and woody cuttings that can protect an eroding streambank or prevent the formation of a split channel. The structure is filled with suitable backfill material and layers of live branch cuttings that root inside the crib structure and extend into the slope.

Where Applicable

- Outside bends of main channels where strong currents are present.
- An eroding bank that may eventually form a split channel.
- Applicable on all character types to maintain a natural appearance.

Advantages

- Useful where space is limited and a more vertical structure is required.
- Provides immediate protection from erosion, while established vegetation provides long-term stability.
- An economical technique, when local materials and unskilled labor are used.

Disadvantages

- Construction depends on local availability of logs and rocks.
- A more complex installation than live fascines or branch packings.
- Not designed for or intended to resist large, lateral stresses.

Effectiveness

- Very effective in controlling bank erosion on fast-flowing streams.
- Not effective where the bed of the stream is actively eroding, as undercutting of the cribbing will result, even when the structure has been keyed into the streambed.

Construction Guidelines

- **Timing -** Live cribwalls should be built during low to normal flow conditions. Construction must take place in the dormant season.
- **Sizes -** Live branch cuttings should be ½ to 2 inches in diameter and long enough to reach the back of the wooden crib structure. The height of the cribbing should be 50 to 70 percent of the height of the bank. The height should be greater when this method is being applied where a vertical load, such as a road, is present.
- **Preparation -** Logs should be bark free and should range from 4 to 6 inches in diameter or dimension. The lengths will vary with the size of the crib.
- **Installation**
  1. Dig out the cribwall base 2 to 3 feet below the existing streambed.
  2. Place the first front log parallel to the bank.
  3. Place the next series of logs at right angles to the first parallel log.
  4. Overlap the end of each right angle log on top of the parallel log.
  5. Secure each log in place.
  6. Place fill in the openings and compact the soil.
  7. Place the second parallel log on top of the right angle logs.
  8. Install live cuttings on top of the parallel logs at right angles to the streambank. Place another fill layer.
  9. Continue to place layers of logs, cuttings, and fill until the desired height is reached.
  10. The top layer should be compacted fill. The top log should be a parallel unit.
  11. The upper end of the crib should be protected by a riprap delfector to prevent

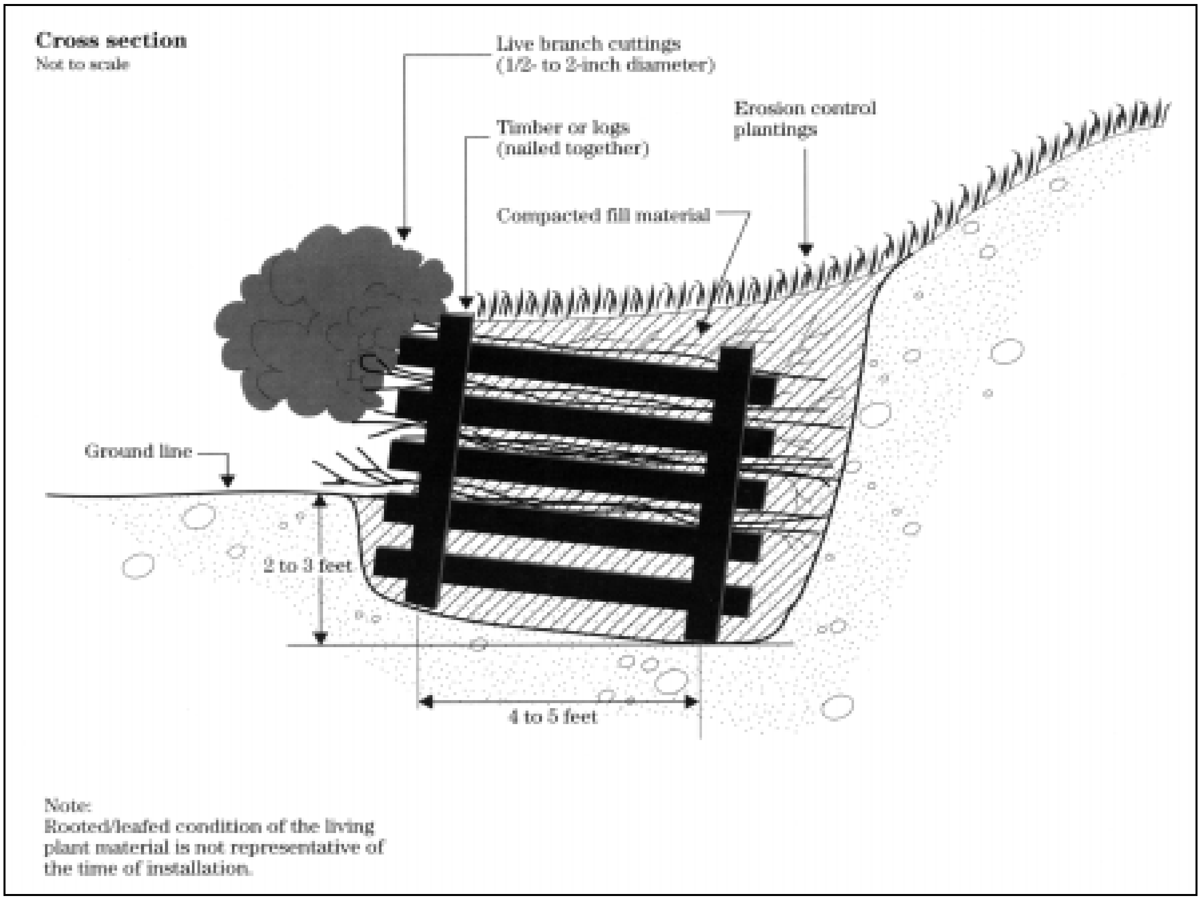


Figure 8-7. Live Cribwall. (Source: Soil Conservation Service, 1992)

undercutting. The lower end should be protected by riprap.

Lunker Structures

The "Lunker" technique combines willow posts with the placement of large wooden pallets (lunkers). Lunker structures (Figure 8-8) are oak planks, oak blocks, and reinforcing rods put together to form a crib-like structure. When they are anchored to the streambed they provide bank stabilization and an undercut shelter for fish. They are designed to survive and function well in trout streams as well as small warm water streams.

Where Applicable

- Lunkers are used on severely eroding banks and areas suffering from widespread erosion, stream channelization, and removal of riparian cover.

Advantages

- Lunker structures immediately provide instream cover, while appearing natural and helping stabilize the bank.

Disadvantages

- They are more difficult to install than other methods. Heavy equipment is required to install lunker structures. To be successful they need additional structures, such as culverts.

Effectiveness

- Most effective in combination with additional techniques on steep streambanks and on sites that are severely eroded.

Construction Guidelines

- **Timing -** Construction should be done when the ground is frozen or dry. If using willow posts for further stabilization, the construction should be during the dormant season.
- **Sizes -** Oak blocks need to be 6 to 8 inches in length and diameter. Dormant willow posts should be 10 to 12 feet long.
- **Preparation -** Oak blocks should be cut with a chain saw and drilled with a 5/8-inch auger bit. All blocks must be cut in the same length. Site evaluation and preparation is recommended. Stockpiling of materials, such as rock, planking, and logs, is necessary.

Installation - For instructions on how to install the lunker structure, see "The Use of Unit Construction for Trout Habitat Improvement Structures in the Coulee Streams of the La Crosse Area" by David M. Vetrano, La Crosse, Bureau of Fish Management, Wisconsin Department of Natural Resources, Madison, Wisconsin. There are also two videos on installation. For more information contact Donald Roseboom, Water Quality Section, Illinois State Water Survey, Box 697, Peoria, Illinois 61652.

STREAMBANK EROSION PROTECTION MEASURES' RELATIVE COST AND COMPLEXITY

Measure	Relative Cost	Relative Complexity
Live stake	Low	Simple
Live fascine	Moderate	Moderate
Brushlayer	Moderate	Moderate to Complex
Live cribwall	High	Complex
Branchpacking	Moderate	Moderate to Complex
Lunker	High	Moderate to Complex
Conventional riprap	Low to Moderate	Simple to Complex
Conventional vegetation	Low to Moderate	Simple to Moderate

Sources: Robbin B. Sotir & Associates; Georgia State Soil & Water Conservation Commission.

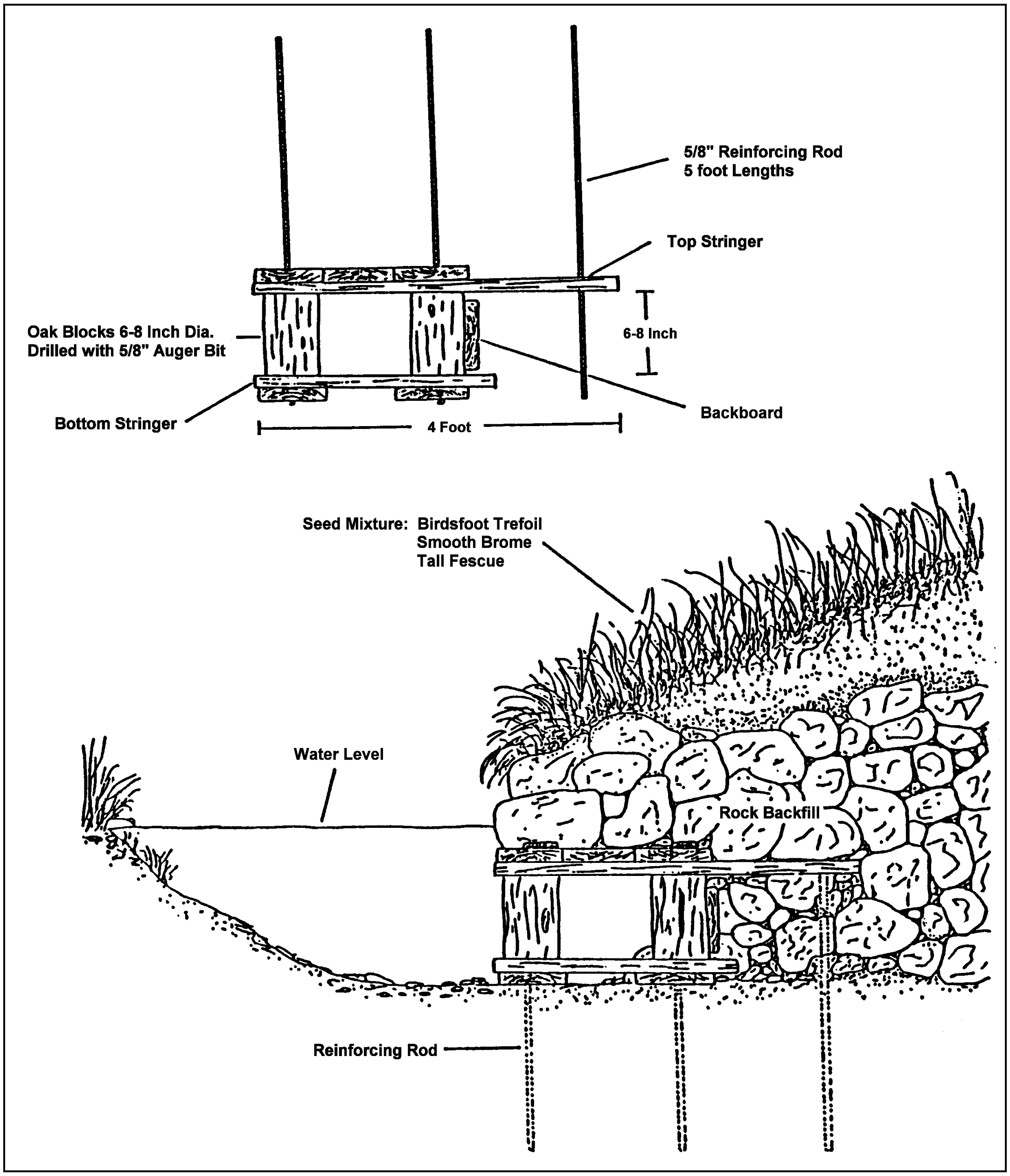


Figure 8 - 8. Lunker. (Source: Vetrano, 1988)

Other Innovative Methods

There are two innovative stabilization techniques that serve multiple-purposes of stabilizing the streambank and the channel, while providing for fish habitat improvement. The native material bank revetment and the log-spur bank feature are shown in Figures 8-9 and 8-10. The native material bank revetment serves many functions. These include:

1. protects the streambank from erosion,
2. provides for instream and overhead cover for fish,
3. provides shade, detritus, terrestrial insect habitat,
4. looks natural, and
5. provides diversity of habitats.

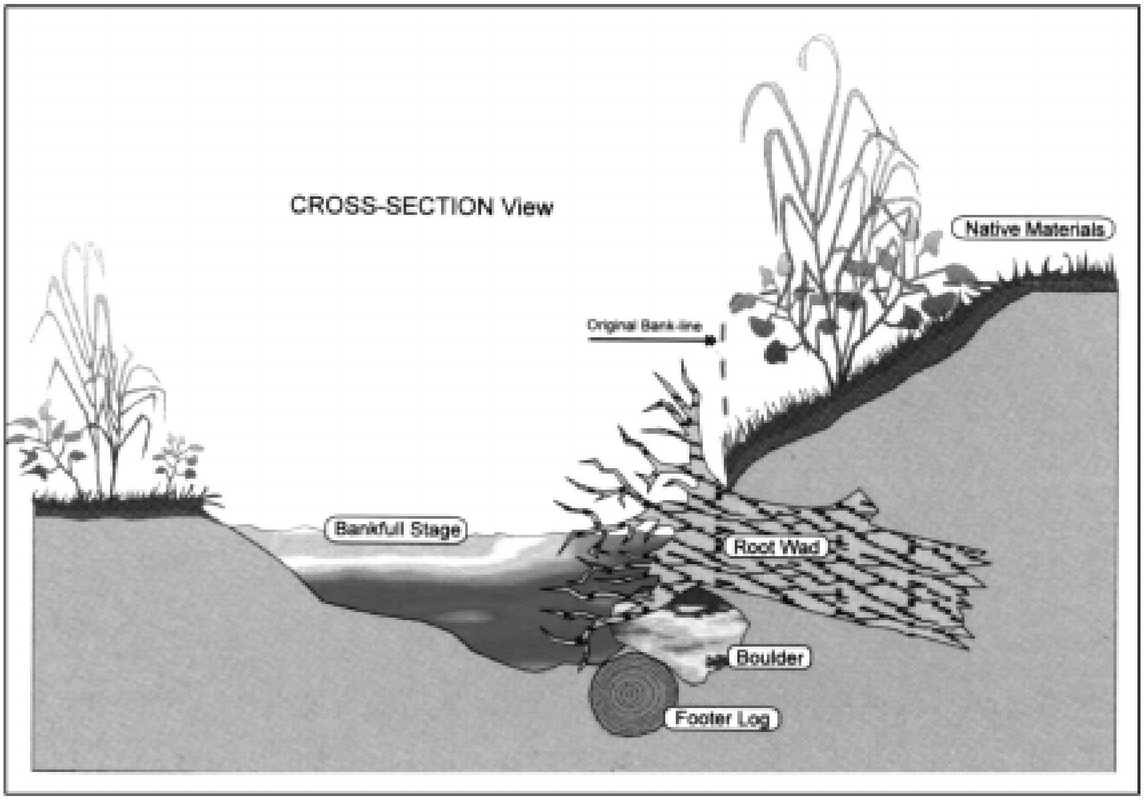


Figure 8 - 9. Native material bank revetment. (Rosgen, 1996)

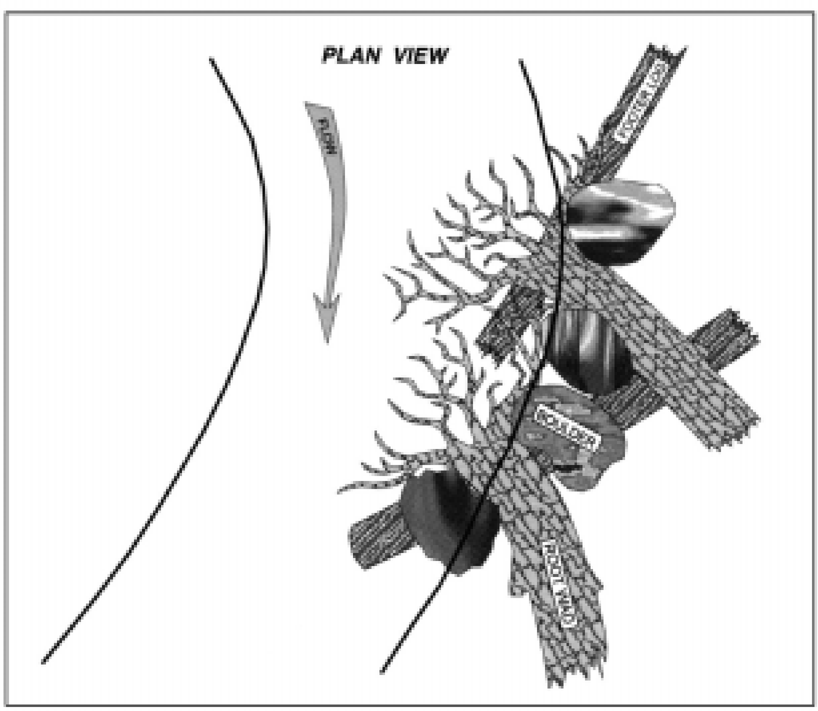


Figure 8 - 10. Native material bank revetment. (Rosgen, 1996)

The log-spur bank feature shown in Figure 8-11 is designed for channel stabilization. It also creates in-stream cover.

Guides and Manuals for Streambank Stabilization

There are numerous manuals and guides available that provide useful information for the design and installation of stream stabilization and enhancement measures. Most newer publications focus on the preferred non-structural approaches, but highlight a variety of techniques.

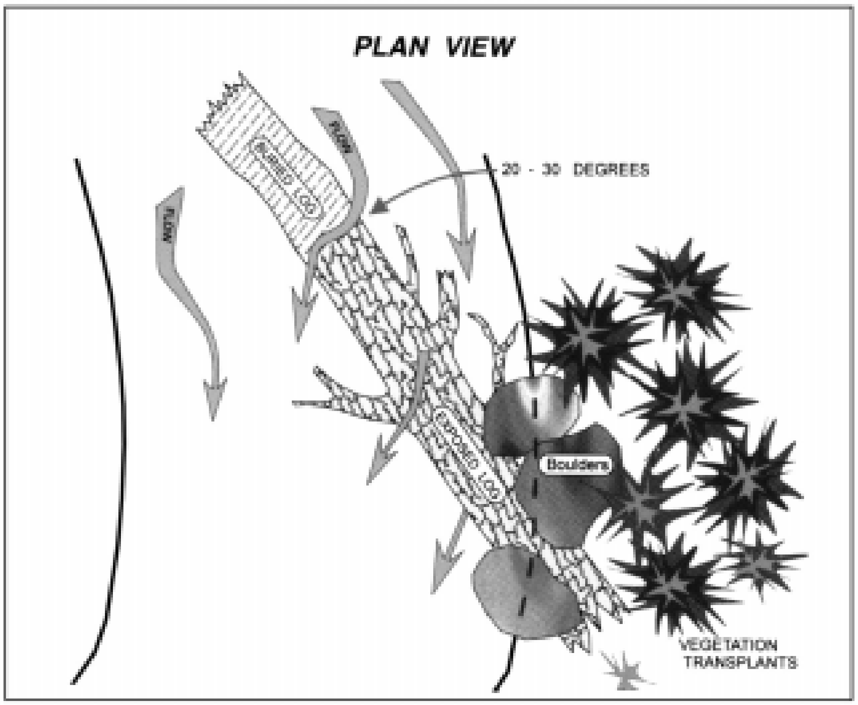


Figure 8 - 11. Log-spur bank feature. (Rosgen, 1996)

The following is a list of useful guides for stream restoration and erosion control.

A Streambank Stabilization and Management Guide for Pennsylvania Landowners

Produced in 1986 by the Department of Environmental Resources for the Pennsylvania Scenic Rivers Program, this 75-page guide provides an excellent overview of the benefits and techniques of streambank protection and stabilization. The guide discusses basics of river character and erosion processes and outlines the technical basics for nine techniques: live staking, live fascines, branch packing, crib walls, riprap, channel blocks deflectors, stone walls, and gabions. Copies of this booklet are available from the State Bookstore, P.O. Box 1365, Harrisburg, PA 17105 or contact the Pennsylvania Scenic Rivers Program, P.O. Box 8761, Harrisburg, PA 17105-8761.

Natural Channel Systems: An Approach to Management and Design

Published in June of 1994, this guide was the result of a cooperative effort among the Ontario Ministry of Natural Resources, Canadian Water Resources Association, Soil and Water Conservation Society and the American Fisheries Society. The guide moves away from traditional techniques of stream armoring and erosion and flood control practices. Drawing from the work of Dave Rosgen, this guide is an excellent overview of the concepts and practices of stream stabilization using a natural channel systems approach. The guide focuses on management and design that identifies ecological relationships between stream channels, their riparian areas and flood plains, and their watersheds. It recognizes the dynamic nature of stream systems and the need to "fit" stabilization practices into the natural processes at work in a watershed. Based on a system of stream classification that characterizes how a channel changes over time, the natural channel systems approach aims to work with altered or eroding streams by mimicking natural form and materials. This approach uses physical processes in the stream to achieve stable but naturally functioning channels.

The publication is available from Ministry of Natural Resources, Natural Resources Information Centre, Room M1-73, MacDonald Block, 900 Bay Street, Toronto ON M7A 2C1, 416-314-2000.

Soil Bioengineering for Upland Slope Protection and Erosion Reduction

This is Chapter 18 of the USDA Natural Resources Conservation Service Engineering Field Handbook (part 650), printed in 1992. The publication provides detailed design and construction descriptions and standards for bioengineering practices such as live stakes, fascines, brush layering, crib walls, branchpacking, and gully repair. The handbook also provides very useful information about cutting and handling live plant materials and site preparation. Chapter 18 of the Handbook can be obtained by contacting The USDA Natural Resources Conservation Service Field Office in your area.

A Citizen's Streambank Restoration Handbook

Written by Karen Firehock and Jacqueline Doherty, this user-friendly handbook was published by the Issak Walton League in January of 1995. The publication provides a great deal of background information helpful in understanding watersheds and the dynamic nature of streams, methods for stream inventories and monitoring, and information on planning a project. The guide includes basic information on bioengineering techniques. Case studies, bibliography, and places to go for technical assistance are also provided. The handbook can be obtained from: Issak Walton League of America, Inc., 707 Conservation Lane, Gaithersburg, MD 20878 or call 1-800-284-4952.

Guidelines for Streambank Restoration

Published in 1993 by the Georgia Soil and Water Conservation Commission with the help of Robbin Sotir, this is another excellent guide to streambank stabilization techniques using plant materials, structural methods, or a combination of both. The techniques described are intended for small streams with relatively straightforward erosion problems. A detailed description of erosion processes and types and detailed drawings and photographs add to the document. Copies may be obtained by calling 706-542-3065.

Stream Obstruction Removal Guidelines

This short 1983 publication is well-illustrated and effective in dealing with a subject rarely addressed by most handbooks – when and where to remove large woody debris in eroding streams. The publication illustrates differences between obstructions and valuable debris and helps guide removal. Copies are available from the American Fisheries Society, 5410 Grosvenor Lane, Bethesda, MD 20814.

Stream Corridor Management: A Basic Reference Manual

New York State's manual on stream corridors is more oriented to planning strategies for corridor protection than to stabilization techniques. However, it provides an excellent overview of assessing land use impacts, establishing planning goals and objectives, and stream corridor management plans, conservation options, best management practices for stream protection and restoration, and local planning and design strategies. The manual is available from the New York State Department of Environmental Conservation, Bureau of Preservation, Protection, and Management, Room 412, 50 Wolf Road, Albany, NY 12233.

Applied River Morphology

Published in 1996 by Dave Rosgen, this book provides a generous and detailed explanation of the Rosgen stream classification system. It describes how it might be used to incorporate the observed processes of river mechanics into restoration designs that enhance the beauty, natural function, and health of stream channels. Both scientific theory and field techniques and principles useful for inventory, evaluation, scientific theory and design are provided with an abundance of detailed color illustrations, diagrams, and photographs. The book is available from Wildland Hydrology Books at 970-264-7100, or fax 970-284-7121.

Unit Construction of Trout Habitat Improvement Structures for Wisconsin Coulee Streams.

Published in 1988 by David Vetrona, this Administrative Report No. 27 provides aid to those unfamiliar with coulee stream habitat improvement. It explains how to implement, with minimum problems, a habitat improvement project using the *Lunkers* design. The text includes a step-by-step description of construction and installation of the *Lunkers* unit, as well as information on site preparation, materials, and the Wisconsin permit process. To obtain more information or a video that describes lunkers, contact Dave Vetrano, 3550 Mormon Coulee Road, LaCrosse, WI 54601 or call 608-785-9009.

Ohio Stream Management Guide No. 12 Evergreen Revetments.

This guide was prepared by Jim Bishop, Kathy Smith, Randy Hoover, and Margo Fulmer of the Ohio Department of Natural Resources. It discusses where to use tree revetments, and design and construction guidelines. To obtain copies, contact the ODNR Public Information Center, 1952 Belcher Drive, Building C-1, Columbus, OH 43224-1386, or call 614-265-6791.

Section IX

Agricultural/Rural Aspects

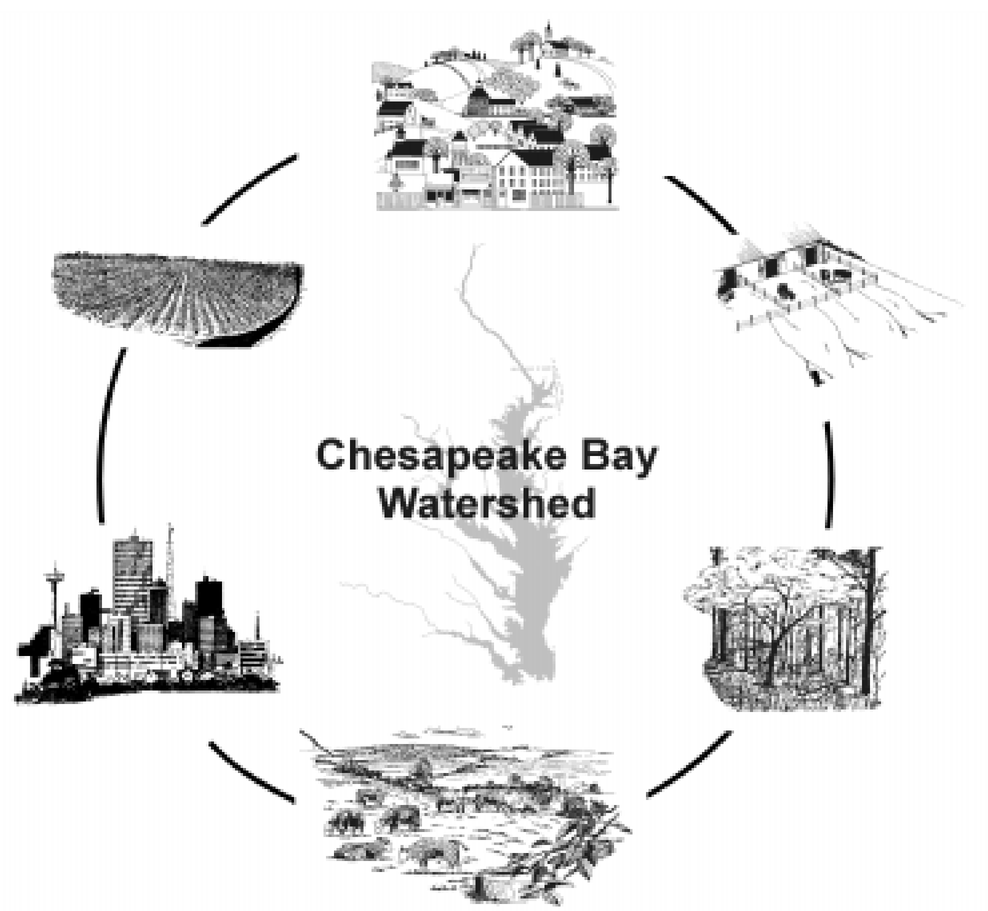
Agricultural/Rural Aspects

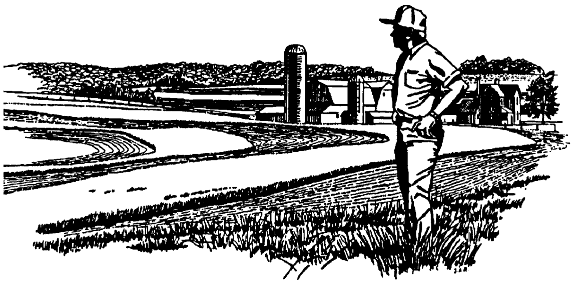
Introduction

This section addresses the application of riparian forest buffers in an agricultural setting. While it is readily recognized that riparian forest buffers provide many benefits, this chapter primarily focuses on their importance in planning and applying a conservation program on a farm for the protection or maintenance of water quality. Other benefits will be briefly discussed to demonstrate how they interact in the decision process to determine the extent or application of the buffers or other conservation practices.

Collectively, the fields and forests, lakes and rivers, towns and cities make up an ecosystem. Farm management, to a large extent, determines the impacts a farm operation can have on the larger ecosystem, in this case the Chesapeake Bay Watershed.

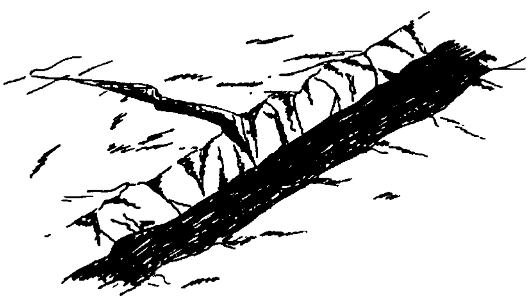
Improvement and maintenance of water quality is the single most important component for the protection and restoration of the Chesapeake Bay. Some farm operators have resource problems or concerns that they must address to meet their needs and/or the community's needs.





The farmer who develops a conservation plan or program for the farm will meet the objectives of the farm unit and contribute to meeting the Chesapeake Bay restoration objectives. This is accomplished with planning that meets the agricultural producer's objectives while protecting the resources of the Bay. To do this, the entire farm must be viewed, each field, forest, and stream, to assess the potential for the degradation and protection of the water resource. If a stream is running through the farm, it is important to inventory the condition of that stream.

The Stream System

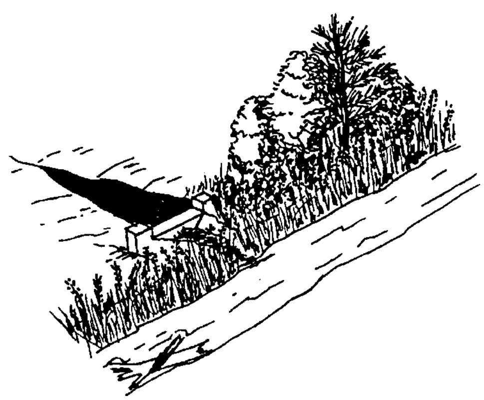


Streams and the associated riparian vegetation provide the linkage from one land use to another and affect what conditions exist on farms downstream. Therefore, in conservation planning it is important to inventory the stream system and analyze its condition as impacted by adjoining land uses and farms.

Examples of items that might be inventoried in relation to the stream with consideration of landowner objectives are as follows:

- *The hydrologic setting*. This information helps determine the flow of water in the stream system and the effectiveness of practices like riparian forest buffers for treating pollutants.
- *Soils along the stream channel.* This provides information on species that are suitable for planting on a particular soil.
- *The stream channel condition*. This focuses on channel agradation or degradation. It determines whether practices adjacent to the stream will be successful. Major problems in stream degradation often require action by many landowners or a whole community.
- *Streambank erosion.* Streambank erosion degrades water quality and indicates the stability of the system.
- *Streambank vegetation*. Existing vegetation is also an indication of the stability of the system.
- *Existing water quality entering the farm.*
- *Existing canopy over stream channel*. This provides guidance about water temperature.
- *Large woody debris in the stream channel*. This provides an indication of the biological quality of the stream. Large log jams that restrict or impede flow also indicate potential problems that increase flooding and streambank erosion.
- *Existing wetlands along streams.*
- *Existing water entry points along stream.*

Example practices that address water quality concerns along streams are:



- *Stream channel stabilization.* This involves the use of structures, such as vortex rock or "W" rock weirs to control where and how the water flows.

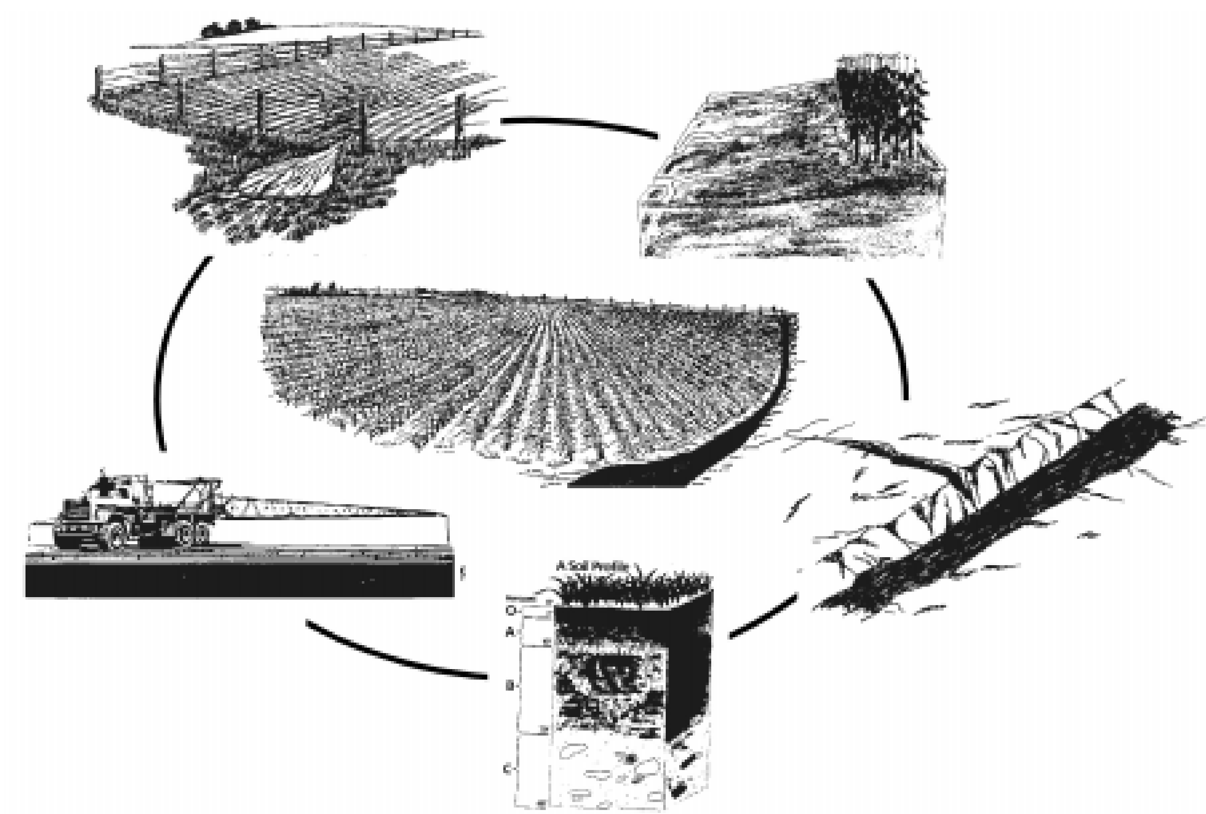
- *Streambank stabilization (discussed in Section VIII).* This is the establishment of vegetation or supportive structural measures along the streambanks.
- *Grade stabilization structure.* This practice may be used to control how water enters the stream system and prevents gullies.
- *Wetland restoration.* Restoring wetlands can aid in the treatment of pollutants.
- ***Riparian Forest Buffer.*** This practice removes sediment and associated chemical pollutants. It also intercepts and processes nitrates and other potential pollutants in shallow groundwater passing through the riparian area.
- *Clearing and snagging.* This is the removal of log jams that are detrimental to the hydrology of the stream system. Care must be taken to protect large woody debris that are not threatening the hydrology of the system, because it improves the biological food chain.

Cropland

Because of the management inputs and intensity of use, croplands are considered potential nonpoint source water quality problems. To address the water quality concerns from cropland, the existing resource conditions must be inventoried and analyzed to assess the impact of the land use and management on water.

Examples of the inventory items that affect water quality concerns relating to landowner objectives are:

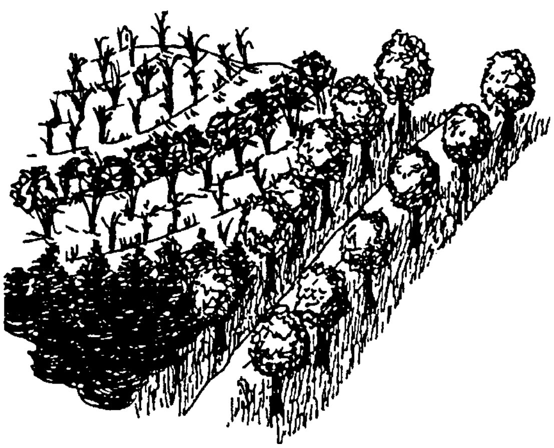
- *The soils of the cropland field.* This provides information on the movement of nutrients and chemicals through the soil or the potential for chemical loss through runoff and erodibility of the field.
- *The proximity of the cropland to a stream or other body of water.* Generally the closer the source of pollution, the greater the risk to water quality concerns.



The hydrologic setting. This information can be used to help *estimate* the flow path of water to the stream system and the effectiveness of planned practices.

- *The present condition of the stream or water body.*
- *The designated uses of the stream or water body.*
- *The amount and kinds of erosion evident on the cropland field.*
- *The types of crops grown.*
- *The lime, fertilizer, and pesticide application program.*
- *Other land uses associated with the cropland and stream system.*

Conservation practices that address water quality concerns include the following:



- *Conservation tillage and crop rotation.* This helps reduce sheet and rill erosion and improve soil tilth and infiltration.
- *Terraces.* This reduces sheet and rill, ephemeral, and gully erosion.
- *Nutrient and pesticide management.* This assures proper application rates and times. It also confirms appropriate chemicals are matched to the crop and site conditions to minimize risk of leaching or runoff.
- ***Riparian Forest Buffer*.** Depending upon the hydrologic setting and the soils of the site, this practice becomes the last means of intercepting sediment, chemicals, and associated pollutants in runoff or shallow groundwater before they enter the stream. Riparian forest buffers generally include a grass filter component when adjacent to cropland fields. This reduces the risk of erosion and concentrated flow or runoff.
- *Land use changes.* Conversion from cropland to a less intensive land use, such as hayland or forest on areas adjacent to stream systems, generally reduces the risk of pollutants entering the stream system.

A combination of these or similar practices generally will assure an adequate plan to protect the water resource from degradation. The farmer can select the combination of practices that best meets his objectives and achieves the identified resource needs for water quality.

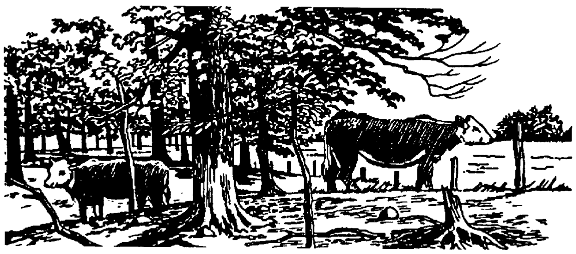
Riparian Buffer Design for Cropland

The National Agroforestry Center in Lincoln, Nebraska, the USDA Forest Service, and the Natural Resources Conservation Service recommend a general, multi-purpose, riparian buffer design that consists of the three-zone concept described in Section I. The zones consist of grass, shrubs, and trees between the normal bank-full water level and cropland ranging from 50 to 95 feet in width. This general design requires 6 to 24 acres of land per mile on each side of the streambank.

The general design works well in relatively flat areas where streambanks are stable. Where nutrients are a problem, the buffer should be widened to 100 feet or more.

Pastureland

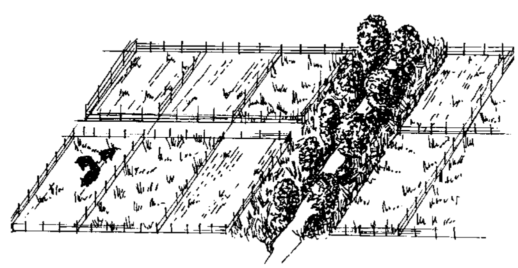
Grazing lands are considered a major source of nonpoint water quality problems in some areas depending upon management. Most often problems relate to confinement of livestock or livestock's access to streams. To address the water quality concerns of pastureland, the existing resource conditions should be inventoried and analyzed to assess the impact of the land use and management on water. Examples of the inventory items that affect water quality concerns relating to landowner objectives are:



- *The hydrologic setting of the stream valley.* This information is used to determine the hydrologic flow of water to the stream system.
- *The soils in the pasture or grazing unit.* This provides information on the movement of nutrients and chemicals through the soil, or the potential for chemical loss through runoff and erodibility of the field.
- *The present condition of the stream or water body.*
- *The designated uses of the stream or water body.*
- *The kind and condition of the forage species.*
- *The amount and kinds of erosion evident on the pasture.*
- *The kind and numbers of livestock.*
- *The grazing duration and time of grazing.*
- *Livestock concentration areas, i.e. the location, size, aspect, and slope.*
- *The proximity to the stream.*
- *Nutrient or chemical application.*

Example practices that address the identified concerns on pastureland include:

- *Prescribed and rotational grazing.* Good grassland serves as an effective cover to control erosion and filter sediment. A healthy well managed stand of grass effectively utilizes the available nutrients and prevents nutrient transport to the streams. A grazing management plan can be designed to rotate pastures or to limit the intensity and duration of grazing and animal access to the streams.
- *Nutrient and pesticide management.* The application of fertilizers is done when optimum utilization of the grass is realized. Pesticides, when appropriate for pest control, are applied for the target species at the prescribed rates and timing to reduce potential off-site damage.
- *Livestock watering facilities.* This provides livestock water from ponds, pipelines, or controlled access to streams. It also improves grazing distribution. This aids in reducing the impact and erosion potential on concentration areas. It also prevents long-term uncontrolled access to streams.
- *Livestock exclusion.* This practice protects the streamside vegetation from overgrazing, trampling, or other impacts that degrade riparian vegetation or the stability of the stream. Depending on the water quality concern and the intensity of the grazing management, livestock access to streams may be permissible as long as the grazing intensity does not negatively impact the stream or filtering function of the streamside vegetation.

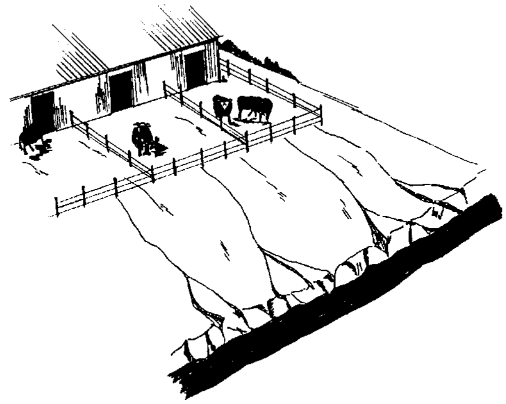


- ***Riparian Forest Buffer.*** This practice is the last line of defense for intercepting sediment, chemicals, and associated pollutants in runoff or shallow groundwater before they enter the stream. This practice often becomes the last means of intercepting pollutants in the form of sediment or chemicals in runoff or shallow groundwater before it enters the streams.

  The riparian forest buffer provides shade to small streams for temperature control and aids in streambank stabilization. Riparian forest buffers generally do not require a grass filter, i.e. Zone 3, when the area is adjacent to grassland.

- *Other special conservation practices.* Stream crossings, pasture planting, or fencing may be needed to facilitate livestock management and improve the vigor of vegetation to effectively prevent water quality degradation.

A combination of these or similar practices generally will assure an adequate plan to protect the water resource from degradation due to production activities on the pasture fields. The landowner or user must select the combination of practices that best meets the planned objectives for the farm and achieves the identified resource needs for water quality.

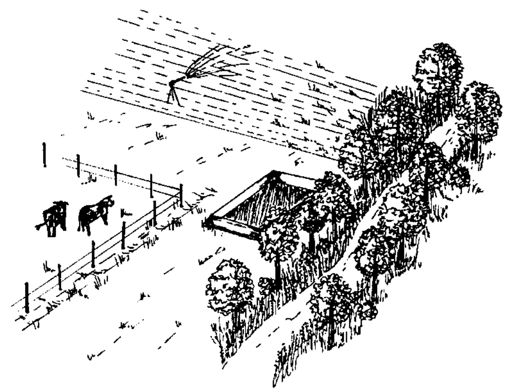


Livestock Confinement or Concentration Areas

Livestock confinement systems or concentration areas are readily identified as potential sources for the degradation of water quality on many farms. To assess the potential contribution of pollutants, an inventory of the resource conditions and an analysis of their impact must be made. The inventory relating to landowner objectives should include:

- *The soils of the livestock confinement area and the soils of the area directly adjacent to it.* This provides information on the movement of nutrients and chemicals through the soil or the potential for nutrient loss through runoff and shallow groundwater flows.
- *The proximity of the livestock confinement area to a stream or other body of water.*
- *The hydrologic setting.* This information is used to help determine the hydrologic flow of water to the stream system and the effectiveness of practices like riparian forest buffers in treating pollutants of concern.
- *The amount of animal waste produced (nutrients).*
- *The land uses within the farm boundaries or available to the landowner.*
- *Existing water quality.*

Example practices that address potential pollutants produced in animal confinement systems are:



- *Animal Waste Management Plan with the following components:*
  1. waste collection and treatment.
  2. a waste distribution system such as a honeywagon or fertigation system.
  3. a soil plant filter – an area where animal waste can be applied and plants will utilize the nutrients.
- *Nutrient management.* Application and timing of nutrients must be according to the plants' ability to utilize nutrients and the soils limitations.
- ***Riparian Forest Buffers.*** Concentration areas compact the soil, retard infiltration, and destroy vegetative cover. This may result in

excessive nutrient laden runoff during rainfall events. When streams or channels are down gradient from concentration areas, riparian forest buffers are essential because they can intercept nutrients from overland flow or interflow. They should also be considered as a component of a waste management system between areas of wastewater application and the stream system.

Farm Woodlots or Forests

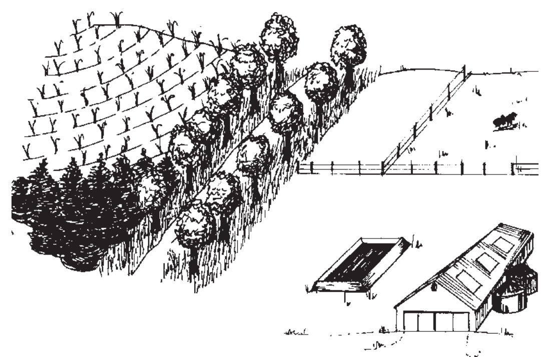
The farm woodlots or forests should go through a similar inventory and analysis to determine management activities that may impact water quality. Practices are assessed to determine their effectiveness in maintaining or enhancing water quality. This is covered in a separate section.

Putting It All Together

Once all land uses on the farm have been inventoried and evaluated, the farmer and the natural resources professional decide together the combination of practices that will address water quality concerns. All the pieces have been put together from cropland, pasture, forest, and feedlot to form a <u>Resource Plan</u>. A <u>Resource Plan</u> addresses the needs of one or more resources. In this case, the resource plan addresses water quality concerns. In some locales, this is called a Water Quality Management Plan.

Farmers who manage or have forests in addition to crop or pastureland may want to contact their State Forestry Agency to participate in a Forest Stewardship Plan.

A resource plan does not usually address all the farm objectives. Other plans that do address all the objectives of a farm are known as One Plans, Conservation Plans, or Total Resource Management Plans. These other objectives could be such things as improved crop yields, livestock and wood production, development or enhancement of wildlife habitat, improved income, or outdoor recreation. A Conservation Plan addresses the total resource concerns of the landowner and the community, and it is made up of several layers of resource plans.

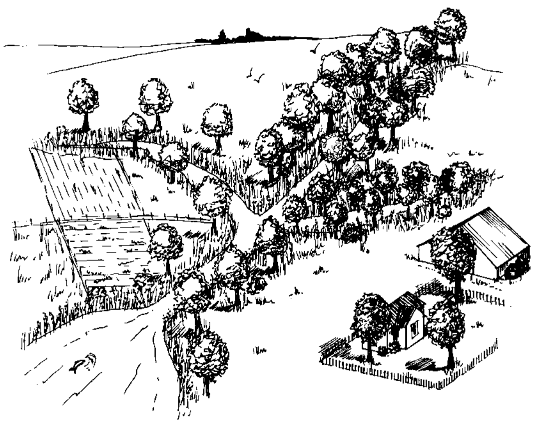


Addressing the total resource concerns may change the combination of practices or the extent of a practice to help it meet more than one goal. For instance, the species or width of a riparian forest buffer may not depend only upon its water quality functions, but also on its ability to provide habitat for the specific wildlife species targeted.

Plan Implementation and Riparian Forest Buffers

Once the planned decisions have been made, implementation is required to produce the desired results. The role riparian forest buffers play in protecting or enhancing water quality is dependent upon the characteristics of the soils, hydrology, and potential vegetation.

The dimensions of the riparian forest buffers depend on the existing and potential nonpoint source pollutant loads and the minimum width required to sustain the aquatic system. The maximum width riparian forest buffer may be required in order to maintain the effectiveness of the practice because of the potential for excess sediment and other pollutants to overload the system. For long-term sustainability, riparian forest buffers should be applied in an orderly schedule with sound upland practices that include nutrient management and erosion control.



Riparian areas provide the interface between the uplands where pollutants are produced and the stream systems where they are transported off-site. Since it is such a fragile area, forest buffers are recommended as part of an overall water quality management strategy in the Chesapeake Bay. Riparian forest buffers also provide many other benefits to the health of the stream environments. These benefits include: modifying stream temperatures and light penetration, enhancing habitat diversity and serving as travel lanes for wildlife, contributing to bank stability, and providing a source of large woody debris that enhances the food chain and species richness. These benefits are realized on all streams regardless of the hydrologic setting, thus 35 feet along all streams is recommended as a minimum. The final dimensions of riparian forest buffers and the inclusion of the three-zone concept discussed in Section I are dependent upon the soils and hydrology of the site. The soils and hydrology determine the effectiveness of the riparian forest buffer in intercepting and treating the pollutant and the required width to meet other associated benefits desired by the landowner or decisionmaker.

Examples of How Riparian Forest Buffers Can Be Integrated Into Farm Streamside Management Systems

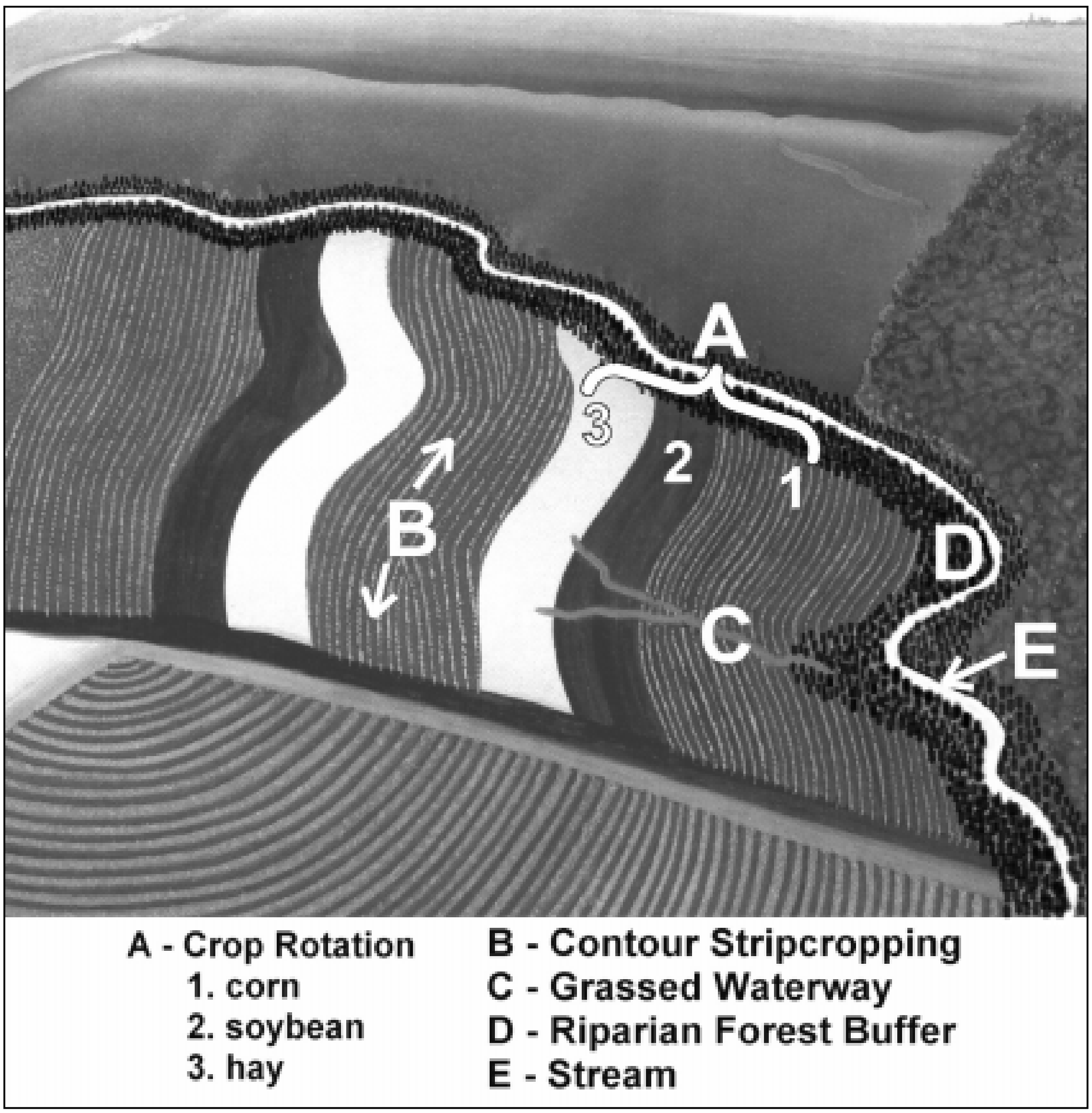
Three examples follow that use riparian forest buffers as a conservation practice on a: 1) crop farm, 2) livestock farm with pasture, and 3) a dairy farm. Conservation practices are listed under each example. It is easy to see that each practice is designed to be used with other practices to form an efficient system that protects soil and water resources. Specific recommendations are given for establishment and/or protection of the riparian forest buffer on each farm.

Example 1: A crop production farm with fields of 8 percent slope, planting a corn, soybean, and hay rotation.

Conservation practices that will be installed are:

- Crop rotation - This practice alternates row crop production from a high residue-producing crop, corn, to a low residue-producing crop, soybeans. Crop rotations work best with conservation tillage, contour stripcropping, and grassed waterways. Crop rotation can be used to help control corn rootworms.
- Contour stripcropping - Tilling, planting, and harvesting are done around the hill nearly on the level, rather than up and down the hill. Crop strips are 100 feet wide.
- Conservation tillage leaving 30 percent residue - Conservation tillage is a cropping system that leaves at least 30 percent ground cover after planting. Soil is worked with a chisel and disk instead of a conventional moldboard plow.

- Nutrient management - First a nutrient management plan is developed. There are nine steps in the process. They are:
  - ➢ test soil
  - ➢ analyze animal manure
  - ➢ calculate residual nitrogen from previous legume crops and manure
  - ➢ determine the nutrients in the manure and their value
  - ➢ determine how and when the manure should be applied
  - ➢ determine what rate to use to apply the manure
  - ➢ choose proper supplemental fertilizers
  - ➢ calibrate manure spreader
  - ➢ install proper erosion and surface runoff control measures
- Pesticide management - A system of controlling agricultural pest infestations that includes cultural, mechanical, chemical, and biological control of weeds, insects, diseases, and other pests. Proper pesticide management reduces amount of pesticides used,



Example 1. A crop production farm with fields of 8 percent slope, planting a corn, soybean, and hay rotation.

costs, and potential for water contamination by pesticides. Use erosion control practices in conjunction with pest management to minimize soil loss. This is especially important in areas adjacent to riparian areas where pesticides may be toxic to fish and other aquatic life.

- Grassed waterway - These are areas planted to grass where water usually concentrates as it runs off a crop field. Grass is planted in the waterway, which results in slowing the water and guiding it off the field, significantly reducing the chance of gully erosion.
- **Riparian forest buffer** - This is part of the proper erosion and surface control measures for the farm. On flat land portions, a three-zone buffer was established that is 50 feet wide. Width is increased on steeper slopes to ensure that sediment can be captured. A general approach sometimes used is to add 4 feet of buffer for every percent of adjacent slope over 5 percent. An additional grass filter strip at least 20 feet wide is also added here as Zone 3.

Example 2: A 90-unit beef cattle operation with 220 acres of pasture with a stream running through a portion of it.

Conservation practices that will be installed:

- Stream crossing - This is a controlled area where cattle are permitted to cross the stream. It is placed in a narrow portion of the stream, perpendicular to the stream. Ideally, the stream should have sloped banks and a hard rock bottom. The crossing is made from 4-foot-by-12-foot-long concrete waffle slats (Figures 9-1 and 9-2). They can be purchased as seconds from a concrete products manufacturer in your area. Each one weighs 2,200 pounds. This type of crossing provides excellent streambank stabilization and sure footing for the livestock. Water flows over the slats so debris does not accumulate at the crossing. Cows tend to linger in the crossing and use it as a watering source. If this is a problem, an alternative water source will have to be developed.

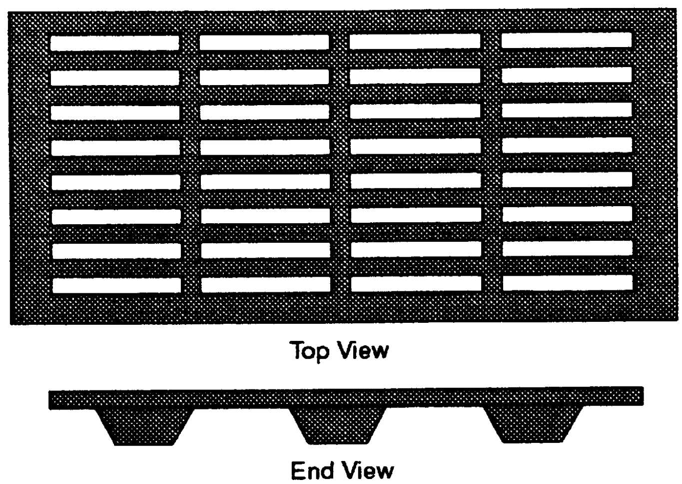


Figure 9 - 1. Top and end views of concrete slats. (Source: Penn State Cooperative Extension, Pequea-Mill Creek Information Series #22)

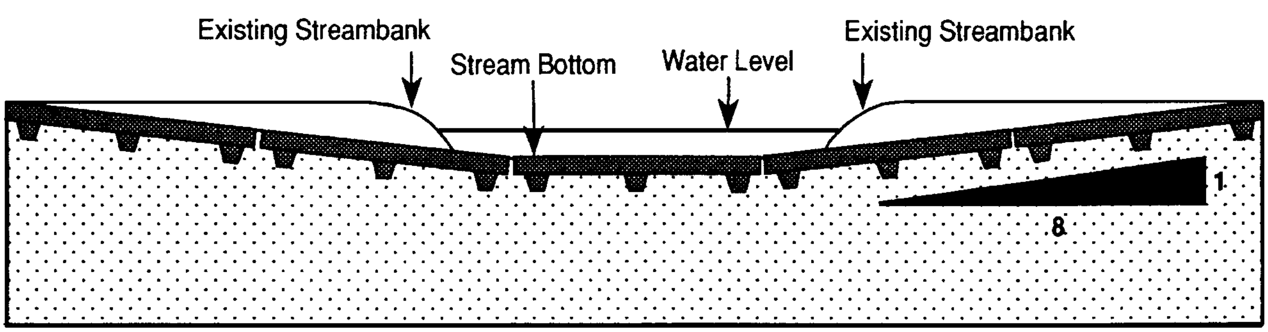
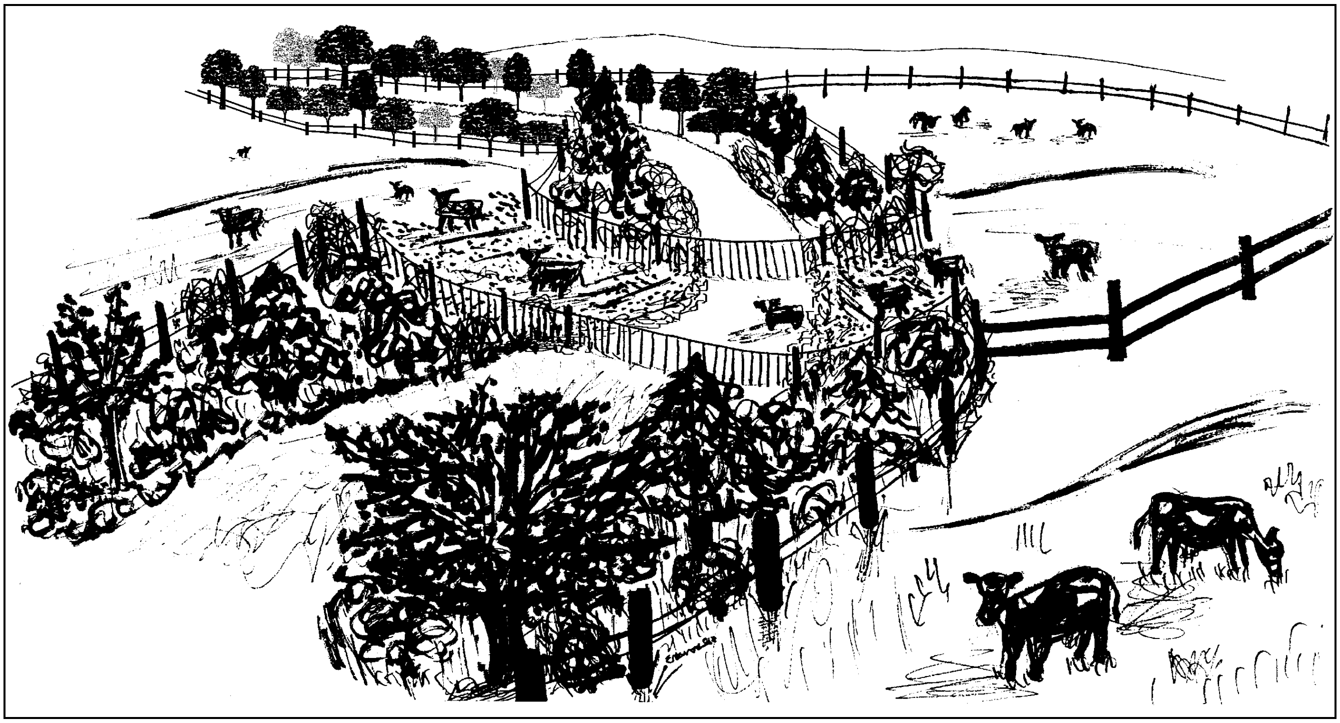


Figure 9 - 2. Cross section of parallel concrete slat crossing. (Source: Penn State Cooperative Extension, Pequea-Mill Creek Information Series #22)

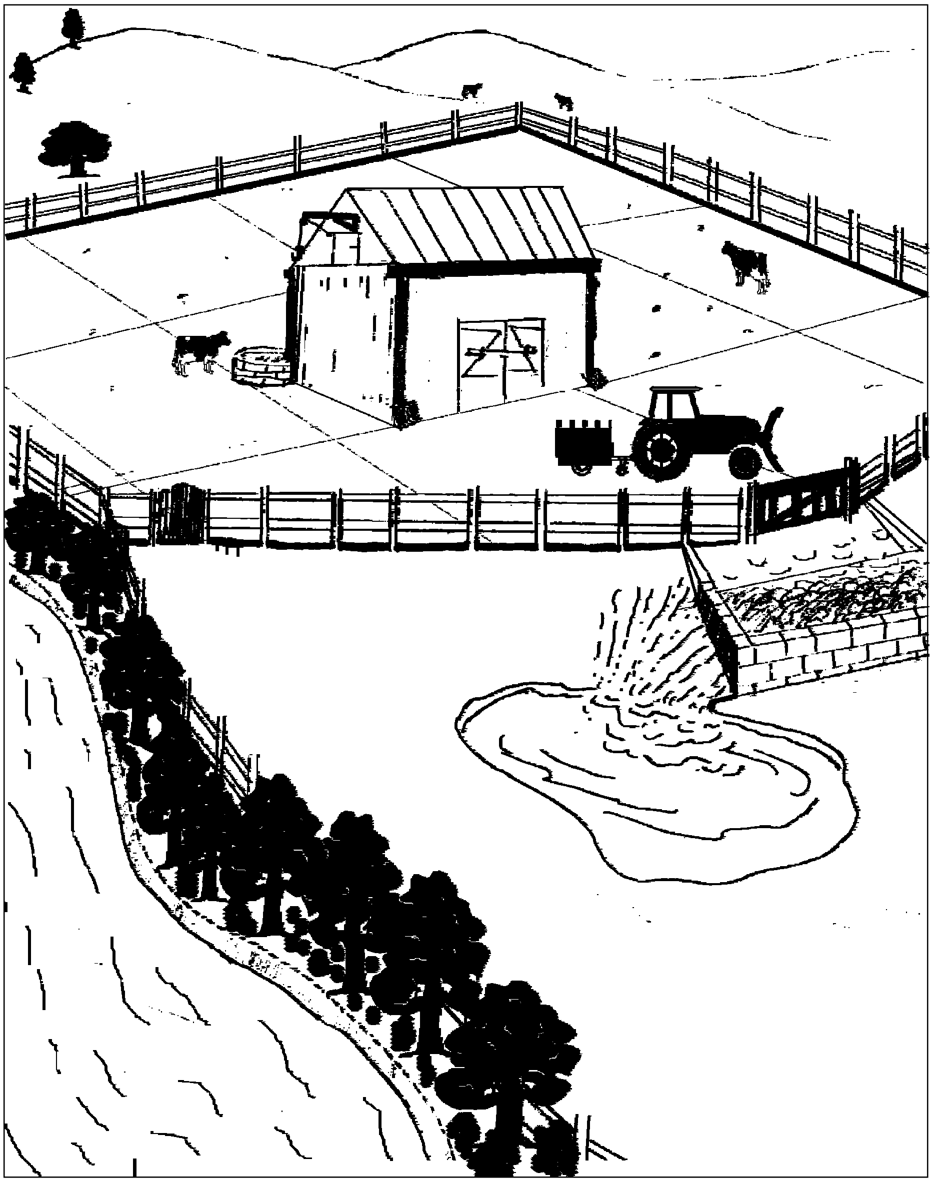


Example 2. Beef cattle pasture that illustrates the use of a riparian forest buffer, stream crossing, and fencing for stream protection.

- Fencing - Fencing prevents streambanks from eroding, reduces the amount of animal waste entering streams, and protects vegetation. One or two strands of electrical fencing are sufficient for cattle. Drop wires prevent cattle from entering the stream at the cattle crossing. Woven wire fence is not recommended for use in the flood plain because debris can damage it. Fencing is set back from the edge of the stream 35 feet or more to prevent flood damage and allow for natural stream meandering.
- Streambank stabilization - After fencing is installed, the streambank should be stabilized if necessary.
- Rotational grazing system - Cattle are rotated among 12 small pasture subunits called paddocks. Each paddock is grazed for two days, and then allowed to regrow for several days, ungrazed, until ready for another grazing.
- Pasture improvement - The soil is tested, then proper amounts of lime and fertilizer are added to the pasture. Planting of forage crops is done to improve vigor and density of pasture.
- **Riparian forest buffer** - After fencing, the riparian area can begin to grow in naturally, or trees and shrubs can be planted.

Example 3: Dairy farm barnyard with 100 cows located 300 feet from a stream.

Barnyards can be a major source of water pollution when heavy rains flush animal wastes into streams. The cows in this example produce 1,300 gallons of manure a day. There are two steps to controlling barnyard runoff: 1) reduce the amount of clean water entering the barnyard, and 2) clean up and control polluted water leaving the barnyard.



Example 3. A dairy farm barnyard that illustrates the use of a riparian forest buffer, roof runoff management, curbing, animal waste storage, and fencing for stream protection.

Conservation practices that will be installed:

- Roof runoff management - This is a simple system of gutters and downspouts on barns that keeps clean water from washing into the barnyard. It is an effective way to control and reduce runoff.

- Animal Waste Management - The barnyard is concrete with curbing. New facilities will have barns with floor grates (slats) that allow animal wastes to be washed directly into an animal waste facility.

  1. The barnyard has a scrapeoff area where wastes are scraped into a waste storage facility. This is a two-part system. One part holds solid waste, and the other part is a pond, at a lower level, into which liquid flows by gravity. The solid waste and liquid separate into two areas. Waste scrape schedule must be maintained.

  2. Milk house water, which includes leftover milk, water from washing down the milking parlor, must be directed into the waste storage facility.

  3. Nutrient management - These are the same steps described in Example 1.

- **Riparian forest buffer** - Forested portion, Zones 1 and 2, are 100 feet wide.

- Fencing - This is described in Example 2.

Planning and Application Assistance

Assistance for resource planning at the field, farm, or watershed level is available to landowners and groups or units of government from several local, state, or federal agencies. They are the:

- USDA Natural Resources Conservation Service
- USDA Forest Service
- Local Conservation District
- Local Agent of the Cooperative Extension Service
- State Forestry Agency
- Private crop consultants
- USDA Farm Service Agency

References

Dosskey, M., D. Schultz, and T. Isenhart. 1997. A riparian buffer design for cropland. AF Note-5. National Agroforestry Center, Lincoln, NE.

Dosskey, M., D. Schultz, and T. Isenhart. 1997. How to design a riparian buffer for agricultural land. AF Note-4. National Agroforestry Center, Lincoln, NE.

Dosskey, M., D. Schultz, and T. Isenhart. 1997. Riparian buffers for agricultural land. AF Note-3. National Agroforestry Center, Lincoln, NE

FACTS ABOUT COWS IN THE STREAM

Did you know that…?

- One cow produces approximately 5.4 billion fecal coliforms per day. If a cow is allowed to graze for a 24-hour period with unrestricted access to a stream, approximately 565 million fecal coliforms could enter the stream!
- One defecation by a dairy cow produces enough bacteria to make the equivalent of six backyard swimming pools unsafe for swimmers!
- Water with a fecal coliform count of 100 per 100 ml is unsafe for swimming!
- Fifty cows allowed unrestricted access to a stream for a 24-hour period could contaminate the equivalent of one day's untreated water supply for the city of Baltimore!
- Water with a fecal coliform count of 2 per 100 ml is unsafe to drink!
- Bacteria entering the stream can result in disease transmission between and within livestock herds.
- Persistent exposure to wet conditions can lead to soft hooves and lame cows.
- Persistent access to streambanks can eliminate fish habitat by trampling and silting, destroying insect habitat, and elevating stream temperature.

Adapted from Upper Thames River Conservation Authority, Rural Clean Water Quality Program publication.

Section X

Silvicultural/Forest Management Aspects

Silvicultural/Forest Management Aspects

Introduction

The management and protection of the forest resource plays an important role in maintaining and improving the health, productivity, and diversity of riparian areas which are vital to water quality. Impacts to riparian forest buffers can have both positive and negative outcomes. Properly managed riparian forests can produce forest products while protecting the stream and continuing to provide diverse living resource habitat. The role of riparian forest management is to provide for the prudent sustainable use of renewable natural resources while ensuring their natural functions and values are not diminished over time.

The following section outlines those specific areas important to the active management of the riparian area. Information regarding management includes: Factors Influencing Forest Resource Management, Landowner Types and Their Objectives in Riparian Management, Summary and Review of Silvicultural Systems, Managing the Riparian Forest Buffer, Example Prescriptions, and Forest Resources Protection.

Scope

Forestry activities are generally considered to be among the least impacting land uses relative to water quality. In the Chesapeake Bay, for example, nutrients that result from forest management activities are estimated at two percent of the total controllable loads. While forests alone cannot cure the troubled condition of the Chesapeake Bay's many watersheds, "forestry solutions" can help reduce pollution, restore and protect habitat, and provide watershed sustainability over the long term. Riparian forest buffers are one such solution.

Streamside management zones (SMZ), also commonly referred to as riparian management areas, generally serve the same function on forested lands as riparian forest buffers do on agricultural and urban lands (see definitions in Section I). Many states specifically define the width of SMZs by regulation and limit the type of harvesting, timing of operations, amount harvested, or reforestation methods used. SMZs are managed with only those silvicultural practices that will prevent soil disturbance within the zone.

Factors Influencing Forest Resources Management

Merchandising and Markets

The merchandising and subsequent marketing of wood products are the key components to a profitable timber harvesting operation. The principles involved are the same no matter whether the operation is in the riparian area or not. Both of these activities are dependent on the volume, type, quality, and species of the product harvested. Merchandising is the organized sale of a particular product based on the highest value obtainable and the available market. For example, in the riparian area, the value of one particular length of green ash sawlog might cause the logger to harvest the product to maximize its merchantability.

Marketing is defined as the business activity involved in moving the product from the production arena to the consumer. Using the example above, if the market for the green ash sawlog was too far away to make it profitable, the logger would have to re-consider his merchandising and market availability.

Riparian area product marketing typically involves the merchandising of hardwoods such as green ash, several varieties of oak, black walnut, baldcypress, and other species. Hardwood lumber is traditionally sold by the thousand board feet in random-length, random-width loads. Furniture, millwork, and cabinets are the major uses. The export market has grown significantly since the mid-1970's and continues to be a major influence on local hardwood sales.

Access

The ability to access a riparian area for forest management purposes can dictate the profitability of an operation. Access to paved roads where loggers can travel easily without risking equipment breakdown or excessive cost is a plus when seeking riparian area harvesting and management. Road building within 100 feet of stream courses should be avoided, except where stream crossings are required. Utilize existing road layout and/or plan carefully using Best Management Practices (BMPs) to limit riparian area degradation.

Timber Quality

The value of the existing merchantable timber is called the stumpage value. Stumpage values directly influence the profitability of timber growing as a business whether in the riparian area or not. Stumpage value and quality are interrelated. The better the quality, the higher the stumpage value. The number, type, and size of trees available for harvesting within the riparian area will dictate the stumpage value. Proper management should always promote quality enhancement. State or local Natural Resource Agency personnel should always be consulted when considering riparian forest management activities.

Public Acceptance to Forest Management Activities

The public's view of timber management has changed most dramatically in areas where urban dwellers move into the rural fringe. The general public is aware of the potential impacts of timber management activities. Some of these activities can alter the landscape significantly, even within the riparian area. The public outcry to these activities can lead to problems for both land manager and landowner and can influence the extent to which landowners can practice forest management. Forest management is sometimes viewed only as timber management, but forest management includes soil and water protection, wildlife habitat enhancement, and outdoor recreation amenities. Land managers should use every opportunity to inform the public that forest management is not just managing for timber.

Public acceptance can be increased if land managers follow guidelines that include the public's concerns. First and foremost, land managers must have a pre-harvest plan that outlines the activities that will take place, the time line, and how they will be implemented. Items to be included are property boundaries, streams and drainages, soil restrictions, slope, threatened and endangered species, road locations, equipment limitations, and timing of the activity.

Second, land managers should identify through public display the nature of the activity. For example, a road sign indicating a timber harvesting operation is taking place allows the public to understand what is occurring within the community.

Third, if any problems occur from the activity such as mud on the highway during timber transport, act immediately to correct the situation. Delay in correcting the situation will be perceived as not caring and will result in negative public opinion.

Site Conditions and Site Quality

The timing of the management activity is dependent on the ability of the site to withstand equipment. Any activity that causes excessive soil erosion leading to sedimentation, or soil rutting, should be halted until the activity can take place without degradation. In conjunction with the pre-harvest plan, sensitive areas should be identified and extra care taken to protect these areas. Examples may include springs or seeps, non-tidal or tidal wetlands, rare, threatened, and endangered (RTE) species, or limiting soil types. Sensitive areas, equipment limitations, and soil types can often be found in the local county soil survey available from the Natural Resources Conservation Service (NRCS).

Site Quality is a measure of the productivity of the soil and is tied directly to timber quality. Site Index (SI) is the quantitative instrument and is defined as the height in feet of a tree in a certain number of years, usually 50. Site Indices of 50 to 70 are considered poor to fair, 70 to 80 good, and 90 and above excellent.

Landowner Types and Their Objectives in Riparian Management

Traditionally, there have been three different types of forest landowners within the Chesapeake Bay Watershed:

1. non-industrial private,
2. industrial private, and
3. public.

Each landowner may have a different perspective in terms of forest management. These differences were more distinct in the past than they are now. However, a discussion of these differences may be useful in assessing the feasibility of riparian forest restoration efforts.

Non-Industrial Private Forest (NIPF) Landowners

More than 77 percent of the land in the Chesapeake Bay Watershed is privately owned. This is very important to the land manager because these are the people with which he will have the most contact. The value and beliefs system of non-industrial private landowners stems from long-held traditions of land holding with roots from Colonial America. In addition, more non-traditional forest landowners, such as urban dwellers and absentee landowners, offer a new clientele. NIPF landowners hold multiple values regarding management of their lands. They use it as a place to live while enjoying the natural and cultural resources of their property to enhance the quality of life. In addition to this, many landowners have adopted and practiced voluntary conservation measures as a way to maintain and manage their property. This "stewardship" ethic involves both conservation elements as well as economic investments. Any riparian restoration and maintenance program must be sensitive to both elements. In turn, however, much progress in riparian forest conservation can be made through these landowners.

Industrial Private Forest Landowners

Forest product companies hold 10 percent of the land base in the Bay watershed. Reasons for land ownership historically have been more "economic" in nature than NIPF landowners. Forest industry typically practices "sustained yield" whereby land is managed for continual return of forest products rather than for other non-commodity reasons. The situation has changed, however, to an adoption of Sustainable Forestry Principles. The principles constitute the American Forest & Paper Association members' commitment to sustainable forestry. These Principles include practicing forestry that will ensure that the resources will be there in the future, protection of the environment, forest health and productivity, protection of special sites, and continuous improvement of forest management.

Forest industry can now be more fully aligned with the NIPF landowner than before, including the restoration and maintenance of riparian areas. Cooperation with State and local agencies is part of the Sustainable Principles and objectives.

Public Forest Landowners

Public lands occupy about 13 percent of the land base in the Chesapeake Bay Watershed. Accessibility by the general public has been and continues to be the cornerstone to the existence of these lands. Public participation and collaboration in the planning and decision-making process for these lands is a key difference from private land holdings. The term “Ecosystem Management” has been coined as the definition of public land management. Protecting and restoring the function and health of forest ecosystems, while providing for their sustainable use, is the goal. This concept includes looking at forests over time in the context of their landscape. Riparian area management is a key component of this sustainable management. The location of these lands, typically in the more mountainous regions of the watershed, is exceedingly important due to the nature of the resource. Wildlife habitat including native trout waters, RTE species, as well as unique forest ecosystems, inhabit these lands – requiring special consideration when planning management activities.

Summary and Review of Silvicultural Systems

Silviculture is the art and science of tending a forest. Silva is latin for forest, and cultura is latin for tending. A more technical definition of silviculture is the theory and practice of controlling forest establishment, composition, and growth. Silviculture can be practiced at different intensities, depending on the landowner objectives and the amount of time and money that is available for management. Very extensive silviculture may be only fire protection. Extensive silviculture implies small expenditures on a stand, perhaps fire protection plus some improvement cutting. Intensive silviculture often requires large expenditures of time and money on productive sites. Silvics, or forest ecology, is the basis of all silviculture, and a thorough understanding of the principles of ecology is essential for good silviculture practice. The adoption of various silvicultural systems available depends on balancing competitive uses and objectives within the riparian area. The stewardship ethic of an interdisciplinary approach that considers all aspects of forest management is crucial to the success of riparian area management and maintaining and improving water quality.

Often, however, the overriding factor in the choice of a silvicultural system or systems is the stumpage within the riparian area. The stumpage amount, value, and location dictates the appropriateness of any one system. Any silvicultural system can work with any other riparian value, such as wildlife habitat or aesthetics. A complete evaluation of the riparian area prior to any management action is imperative so all appropriate forest resources can be determined.

In this section, tree establishment within the riparian area will be discussed as well as those silvicultural systems most likely to be utilized. Some of the systems are more likely to be used than others, however, a basic understanding of these systems is useful to determine applicability to the local situation. As always with any riparian management activity, local site knowledge and management system feasibility are best obtained through the state forestry agency.

Tree Establishment

Tree establishment within riparian areas falls into two land use classifications: agricultural and urban. More specifically, tree planting near streams involves other management actions and is wholly dependent on the site itself. Tree establishment within these areas deals with matching tree to site and ensuring survival by instituting protective measures. Tree establishment is discussed in length in Section VII “Site Evaluation, Planning, and Establishment.”

Tree establishment, whether in the agricultural or urban setting, has several important common elements. They are as follows:

1. maintenance of the riparian area width through fencing or other means,
2. matching the best suited trees for that particular site,
3. tree protection through the critical early period, and

4. post-planting management to ensure survival.

Maintenance of the riparian area width means the long-term protection of the trees from any outside factors such as human or animal intrusion. Human intrusion is more likely in urban situations while cattle intrusion or mowing equipment damage are more likely in agricultural settings. Fencing is the most sure way to protect this area. Cattle normally require electric or multi-wire fencing. Maintenance of the fence throughout the early years of the practice is important to achieve planting success.

Another key element is matching the vegetation present on the site to what one wants to plant in the riparian area. Walking over the site during the planning phases will determine which tree species are already present. The county soil survey has information related to which trees are native to the area (see Section IV). Tree species typically found in the Chesapeake Bay Watershed riparian areas are sycamore, green ash, river birch, black walnut, red maple, willow oak, water oak, willow, baldcypress, and yellow-poplar. Loblolly and white pine are also present in more limited amounts. A diversity of species should be planted. State and local nurseries can also assist in determining which tree species match a particular site.

Just before and during planting, one must consider the competition the tree will encounter and the protection necessary to fend off the competitors. In areas of heavy grass growth or weeds, site preparation methods may be *chemical* or *mechanical.* Chemical is the use of herbicides, and some types require an applicator's license that is issued by the state. A simple hand-sprayer can be utilized to direct spray where the tree will be placed. Each tree placement may require approximately one foot diameter of applied chemical.

Mechanical site preparation involves eliminating the vegetative material through the use of equipment. Plowing, disking, or subsoiling will reduce the vegetation and expose mineral soil. Care must be taken not to induce soil erosion and sedimentation with the mechanical method.

The use of tree shelters is recommended for riparian area plantings where deer predation or human intrusion may be a problem. Tree shelters come in various widths and diameters to match with the individual planting stock. The use of chemical spray with shelters during the first growing season is an added plus to ensure less competition. A simple directed spray around the shelter will stop encroaching grass and weeds. Tree planting without shelters puts the seedling at risk from grass competition and wildlife. Tree shelters should be removed 2 to 3 years after plants emerge from them. The use of shelters is probably the most important protective measure a landowner can use to help with planting.

The actual planting can be accomplished by *hand* or *machine*. Hand planting involves the use of a dibble bar or hoedad to open up the planting hole. The depth of the hole is determined by the length of the roots. Care should be used not to damage the root systems of the planting stock. The tree shelter is installed at the time of planting. Machine planting can utilize a hydraulic auger on a tractor or gas-powered hand auger.

Another method is the planting of larger potted or balled and burlapped trees as the outermost row from the stream to provide a visual barrier to encroachment on new plantings. This technique is especially useful in urban areas.

Post-planting efforts involve the inspection and maintenance of fences, planting area, and the trees themselves to ensure the highest survival possible. A program of weekly inspection of the planting area is suitable during the first year and after any major storm event. If a drought situation is apparent, one should water the trees, especially the first growing season. The use of chemical spray is recommended during years one and two to limit vegetative competition.

Natural regeneration can also be utilized to establish a forest system. For both the agricultural and urban settings, fencing continues to be recommended to protect the newly-establishing system against human or animal intrusion. The following are lists of advantages and disadvantages of natural regeneration:

Advantages of Natural Regeneration

- *lower establishment costs*
- *less labor/heavy equipment required*
- *better root system from natural method*
- *future harvesting decisions easier*
- *less soil movement*

Disadvantages of Natural Regeneration

- *less control over spacing/stocking*
- *risk of seed tree loss*
- *no use of genetically improved stock*
- *greater need for thinning*
- *regeneration delay causes growth loss*

Typically, cost-sharing for forest establishment plus a careful planting plan will cause most landowners to choose planting rather than natural regeneration to accomplish their restoration goals. Tree establishment is discussed in Section VII.

Forest Management Systems – Types and Implications for Riparian Areas

Forest management methods should be based on both riparian buffer objectives and condition of the forest stand. Before choosing a forest management method, the manager should determine if a forest stand is even-aged, two-aged, or uneven-aged. This is referred to as the form of the stand. Even-aged stands have trees of the same age or about the same age. For a stand to be even-aged, the total variation in ages can only be 1/5 of the total rotation length. Uneven-aged stands have at least three age classes. Two-storied stands are kept separate as they often represent the transition. They are neither even-aged nor uneven-aged, and are never handled as uneven-aged stands.

Most forest management, or silvicultural systems, may be used to develop a stand from day one. It involves use of intermediate cuttings and regeneration methods to the end of a rotation. It denotes a comprehensive planned program of treatments, broken down in steps, and implemented in a logical order, during the life of a stand. This ranges from 40 years to 80 years for pine and 80 to 150 years or longer for hardwoods. These numbers are site dependent and subject to riparian objectives.

Regeneration Methods

Basically, there are six types of regeneration methods. They are:

High forest methods/producing stands originating from seed-

Even-aged stands:

- Clearcutting
- Seed-Tree Method
- Shelterwood Method

Uneven-aged stands:

- Selection Method

Coppice forest methods/producing stands originating primarily from vegetative regeneration-

- Coppice Method
- Coppice-with-Standards Method

Even-Aged Stands

Clearcutting is the removal of the entire stand in one cutting. Reproduction is usually obtained by planting or from a nearby seed source. This system is more widely used than any other cutting/regeneration method in Virginia and Maryland.

This method is not recommended for use in riparian areas for many reasons. Most states have best management practices that require a buffer be left between the stream and the timber harvest area. Clearcutting produces an even-aged stand. The goal for eastern riparian forests is to maximize ecological benefits by producing all age classes in the riparian area to ensure vigorous growth in trees that will filter nutrients and trap sediments. Good professional judgment would not allow the clearcut of a riparian forest. At most, 50 percent of the basal area can be removed.

Advantages of Clearcutting

- *easy to implement*
- *less damage to residual stand because it is only visited once*
- *lends itself to most tree species*
- *cheaper costs-concentrates logging on one area*
- *trees do not have to be marked for cutting*
- *best method to remove overmature timber*
- *avoids danger of losing valuable seed trees by windfall*
- *excellent way to regenerate shade intolerant species*
- *lends itself to mechanized silvicultural practices*

Disadvantages of Clearcutting

- *may not be legal in some areas*
- *produces an even-aged stand with all trees maturing at the same time*
- *is not aesthetically pleasing*
- *is not suitable for riparian buffer*
- *on wet sites, the water table may rise*
- *poor protection of the site in regard to watershed values such as stream temperature moderation and nutrient reduction*

The Seed Tree Method is the removal of the old stand in one cutting except for a small number of trees left singly, in groups, or narrow strips, as a source of seed for natural regeneration. One percent or more of the volume is left, usually one to ten trees per acre. This method always produces an even-aged stand, and it is best applied in an even-aged stand. After regeneration is established, these seed trees may be removed in a second cutting or left indefinitely. This system does not provide shelter for the new trees and may result in less than adequate regeneration. It is not suited to shallow soils or wet areas.

Advantages of Seed Tree Method

- *concentrates logging on one area, resulting in lower costs*
- *easy to practice*
- *easy for the landowner to understand*
- *good for light-seeded intolerant, windfirm species*
- *can cut larger area than with clearcutting*
- *name sounds much better to the public than clearcutting*

Disadvantages of Seed Tree Method

- *poor site protection from erosion, windthrow*
- *value of seed trees may offset cost of planting*
- *seed trees can be lost before they can be salvaged*
- *amount of seed produced annually is sporadic*
- *does not work well on shallow or wet soils*
- *not suitable for short-rotation pulp production*
- *produces an even-aged forest*

The Shelterwood Method is a series of cuttings designed to foster seedling growth under the present stand. Typically, two or three cuttings are conducted within a four to six year time span. The key to this system is that the new stand is established prior to the complete removal of the present stand. The sequence of operations involves two or three different kinds of cutting applied in the following order:

1.) Preparatory cuttings, which set the stage for regeneration. This cutting opens up the stand to stimulate seed production. Sometimes, this cut is not needed.

2.) Establishment or seeding cuttings, which promote the actual establishment of seedlings. Only one cut is made to open the canopy enough to allow seedlings to become established and survive. Generally, between 25 and 75 percent of the trees are removed.

3.) Removal cuttings, which release the established seedlings. This occurs 3 to 5 years after the establishment cut. There may be one or more cuttings made, followed by a final cut that removes the remaining overstory. This method is the most aesthetic of the even-aged regeneration methods. As in the Seed Tree Method, regeneration of a new stand is more risky with this method.

Advantages of Shelterwood Method

- *easily modified until desired regeneration is achieved*
- *more aesthetically pleasing than other methods*
- *good for oak and beech species*
- *regeneration is more complete and certain than with other methods*
- *good site protection, especially in riparian areas*
- *limits the amount of undesirable intolerant species of trees, shrubs, vines, and herbaceous plants*

Disadvantages of Shelterwood Method

- *more intensive than other methods*
- *need trained technical persons to implement*
- *have to work through areas where regeneration is becoming established*

Uneven-Aged Stands

Riparian area management will more typically involve the hardwood resource as opposed to the pine resource. Hardwood stands in the Chesapeake Bay Watershed may be even-aged. The ideal situation would be to change the stands from even-aged to uneven-aged. The hardwood resource can be managed using a variety of techniques which may better suit the sensitive riparian areas, allowing the riparian forest buffer functions and values to be fully utilized.

The Selection Method of regeneration is the removal of the mature timber, usually the oldest or largest trees either as single individuals or in small groups at relatively short intervals, repeated indefinitely, resulting in the continuous establishment of reproduction and the maintenance of an uneven-aged stand.

Advantages of Selection Method

- *aesthetically pleasing and acceptable*
- *high degree of protection of site and water resources such as soil, water temperature, and nutrient reduction*
- *can be applied where only sawlogs are merchantable*
- *promotes reproduction of tolerant trees*
- *only way of maintaining an uneven-aged stand*

Disadvantages of Selection Method

- *more expensive to mark and log trees*
- *timber may be of lower grade than that of an even-aged system*
- *favors reproduction of tolerant species; not applicable to most intolerant species*
- *must plan carefully, so as not to high-grade the stand*
- *results in damage to residual stand*

Coppice-Forest Method

This method relies on stump-sprouts or root suckers as the main source of regeneration, although some seedlings and seedling sprouts may form part of the new crop. The stand is clearcut so that nothing is left to reduce the vigor of sprouting. Usually, the objective of the management is to produce fuelwood, pulpwood, and animal browse. Rotation is between 30 and 40 years. The coppice system is used to manage root-suckers of aspen, hybrid poplar, and other species.

Coppice-With-Standards Method

This method allows the manager to produce products associated with coppicing along with sawtimber. This is done by reserving a few of the better trees, called standards, at the time each crop of coppice material is cut.

Intermediate Cuttings as Part of a Silvicultural System

In addition to regeneration cuts, a silvicultural system may require intermediate cuts to produce the desired goals of the landowner. The following summarizes information on the more important types of intermediate cuts:

- An improvement cutting is a cutting made in a stand past the sapling stage for the purpose of improving its composition and character by removing trees of undesirable species, form, and condition occupying positions in the main crown canopy. Primary emphasis is placed on the removal of dominants and co-dominants of undesirable species. In the watershed, most forest stands have been "culled-over" repeatedly, and are comprised of many unmerchantable trees that lack vigor. Several light improvement cuttings will provide the manager with a better stand.

Improvement cuttings are extremely beneficial to many species of wildlife. The term timber stand improvement (TSI) is sometimes used instead of improvement cutting.

- A thinning is a cutting made in an immature stand for the purpose of increasing the rate of growth or improving the form of the trees that remain – increasing the total merchantable production of the stand. The term thinning is used very loosely in many forestry publications, and by many foresters, resulting in confusion in the literature. Thinnings should not be confused with improvement cuttings. The cuts in a selection cutting anticipate the establishment of regeneration. Thinnings are not made with stand regeneration in mind. Thinnings make temporary openings in the crown canopy that are gradually closed by the expansion of the crowns of surrounding trees.

Thinnings can be *commercial*, which indicates some economic value attributable to the cutting for the landowner, or *non-commercial*, which indicates no value to the landowner. Through thinning, a manager can utilize the material that would ordinarily die and rot in the woods, bringing no income. In addition, the growth of the remaining trees is accelerated. The growth rate in cubic feet of wood fiber laid down is apt to be about the same in a thinned or unthinned stand, but in a thinned stand, the wood production is concentrated on selected, outstanding trees.

- A salvage cutting is cutting done for the purpose of removing trees killed or damaged by various injurious agents. The purpose of this cutting is to utilize this material before it becomes worthless. Examples include trees injured by the gypsy moth caterpillar or by ice storms. Cuttings made in anticipation of the need for salvage work are called pre-salvage cuttings.

Selection System

The term selection system or selection cutting is applied to any silvicultural program aimed at the creation and maintenance of uneven-aged stands. The oldest and the largest trees are harvested periodically. After one or more years, similar cutting is repeated. The interval at which the cuts are made is referred to as the cutting cycle. Cutting cycles may be 5, 10, 20 years or longer.

Single tree selection involves the removal of older, large, high-value individual trees. Group selection removes old, large trees in groups large enough to allow regeneration to take place. One disadvantage is that either method requires frequent entry into the forest for an indefinite time period which may not be the landowner's desire. Also, one must be careful not to overcut at any one particular time causing too great an intrusion. This may interfere with the landowner's desired future condition of either timber value or other considerations such as wildlife or recreation.

Trees that are removed are chosen on the basis of age and maturity, and they may be removed individually. Trees can be managed to produce sawlogs 12 inches or larger, with cutting occurring every 10 years to maintain a planned number of trees per acre after each harvest. This method produces a lower rate of return for the landowner compared to that obtain from diameter limit cutting.

Other methods of selection include strip selection cutting and group selection cutting. In strip selection cutting, the cut is concentrated in one area, not more than 100 feet wide, and the strip is clearcut. It can be used for black cherry in Pennsylvania. Group selection removes trees in groups rather than singly. The size of the opening is one-tenth to one-half acre.

Uneven-aged management can be practiced in riparian areas to produce both sawtimber and pulpwood trees (5.0 inches dbh and larger). Selected trees can be cut every 10 years to establish reproduction and stimulate growth in all diameter classes. This will control the number of trees in each diameter class. The manager must know the site, what residual basal area to leave, and what size tree he wants to grow. The goal is the q value, that is, what is the number of trees that should be on each acre in each class? It will take several cuttings to reach q, then the surplus can be cut. Trees cut should be high-risk, poor form, and short-lived species that will not make it to the next cutting cycle. Trees produced using this system will be of very high economic value.

The term "selective cutting" is sometimes used erroneously for selection cutting. Selective cutting is more correctly used to describe cutting known as high-grading or logger's choice.

To conclude, in order to maintain an uneven-aged stand, care must be given to regulate the cut by diameter distribution. Cutting is based on basal area, q-factor, stand structure, and largest tree diameter. Some of these terms may be hard to explain to landowners.

Diameter Limit Cutting

In a strict diameter limit cutting, a definite diameter is predetermined, such as 14 inches, and all trees above this diameter limit are removed, and all trees below this diameter are left. Many companies buy stumpage from the landowner using this type of cutting. All trees of a certain diameter must be removed, not just those trees that are economically valuable. Diameter limit cutting done properly is very profitable and results in a very high rate of return.

A modification of the strict diameter limit is the flexible diameter limit, often called a semi-diameter limit. Large thrifty trees larger than the diameter limit are left, if it is good for the stand. This may include fast-growing species, trees left for seed, valuable wildlife trees, or a tree in the midst of smaller trees that the landowner does not want to damage. Trees smaller than the diameter limit can also be cut if they are slow growers, diseased, dying, or undesirable.

Another type of diameter limit cutting is the differential diameter limit. In this method, a different diameter is placed on each species. For example, white pine over 22 inches may be cut, oak over 16 inches may be cut, other hardwoods 14 inches, and blackgum 6 inches. Setting a very low diameter limit for a species should, over a long period of time, eliminate that species from the stand.

Crop Tree Management System

Crop Tree Management in Immature Stands

Crop tree release is a cutting done on saplings, 3 to 6 inches in diameter, at age 12 to 20 years. Select trees over 25 feet tall that are in a dominant or codominant crown. After crop trees are selected, each of their crowns is released by cutting competing trees that touch or interfere with the crop tree's crown. The least expensive way to release crop trees is by using a chainsaw. All undesirable trees do not have to be cut, only those that are competing with the crop tree. About 50 to 75 trees per acre are initially selected to be crop trees. Extras are selected as many may die. Crop trees should be spaced throughout each acre. The selection is based on desirable species, straight form, no major forks, and lack of disease and insect problems. All grape vines and other vines should be cut from each crop tree.

Crop Tree Management in Mature Stands

This system of forest resources management offers private, non-industrial forest landowners a means of accomplishing single or multiple stewardship goals. It focuses on releasing individual trees that have been selected to produce benefits consistent with stand-specific objectives. This system is based on application of the crown-touching release that is described in the paragraph above. Crop tree management involves the following steps:

1. Identify the landowner's property goals.
2. Establish stand-specific objectives to define how each stand will be managed to meet the landowner's goals.
3. Develop crop tree selection criteria for each crop tree category. Generally, crop trees are classified as wildlife, timber, aesthetic, or water quality crop trees.
4. Inventory the property in order to analyze the number of crop trees per acre to be released, the number of trees to be cut, and the total number of trees left in the stand.
5. Explain the proposed treatment to the landowner.
6. Decide how many crop trees to release per acre, based on how many trees meet the selection criteria and how many the landowner is willing to release.
7. Decide which trees to cut to release the crop trees. Trees whose crowns are within two feet of the crop tree crown should be cut. Crop trees must be released on at least three sides.

Water-Quality Crop Tree Selection Criteria

- Dominant/codominant trees
    - Healthy crown; large in relation to dbh
    - A few dead, upper-crown branches are acceptable
    - Stump-sprout or seedling-origin stems are acceptable
- Expected longevity of 20+ years
- Species that are good nutrient accumulators
    - Young trees
    - Deciduous trees
- Trees tolerant to flooding

Crop tree management should not be confused with thinning or improvement cutting. When practiced in an immature stand, it is usually considered an intermediate cutting. Thinning, especially from below, may not open up a stand enough to allow adequate sunlight to reach trees to promote good growth. Thinning may not remove enough trees to combat competition for soil moisture in the residual stand.

Crop tree management is a good system to use in riparian areas. Crop trees can be chosen using water quality criteria, and a moderate release can be performed. Moderate cutting will result in an aesthetically-pleasing forest.

Table 10-1 compares crop tree management and uneven-aged management. Both systems can be used in Zone 2 of a riparian forest buffer.

If it is the first time a particular riparian area has been managed for any use including timber, a land manager must be prepared to be creative and utilize all the "tools" in the silvicultural toolbag. Oftentimes, mismanaged land requires harvest cutting and a fresh start using the previously mentioned ideas on tree establishment. Cost-sharing and other incentives can help offset any initial establishment costs resulting from harvest cutting.

Stream Health

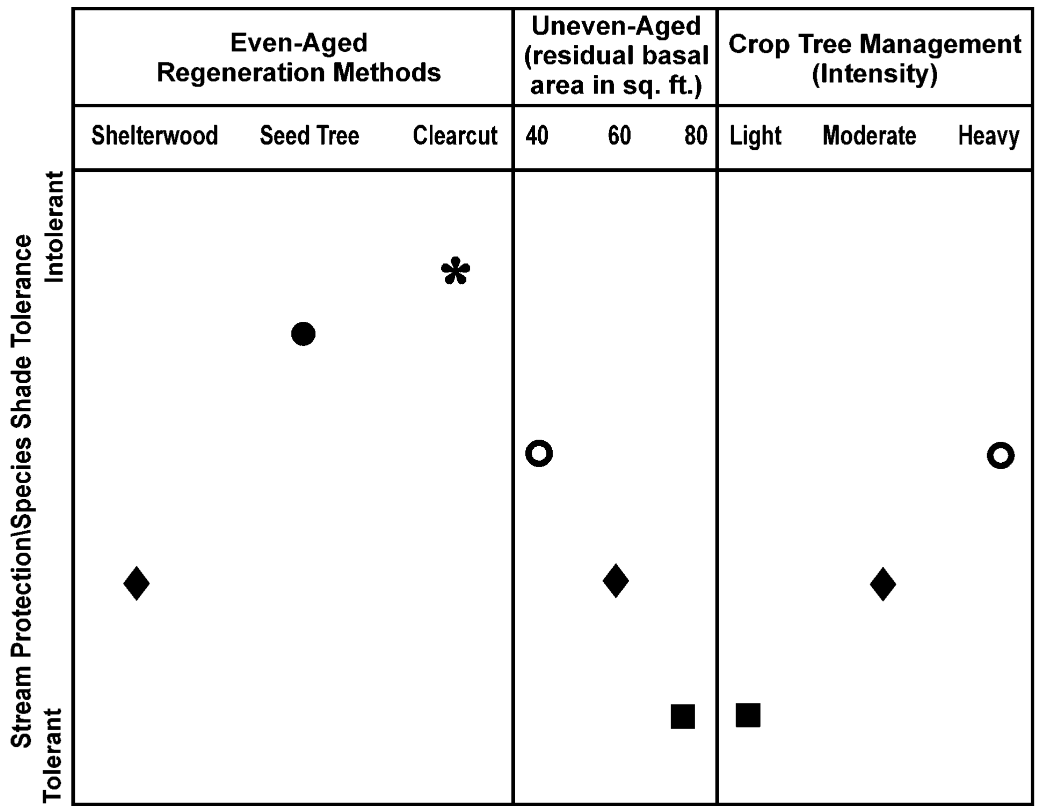
The type of forest management system chosen affects the stream ecosystem through time by altering the tree overstory component. All forest management systems mentioned previously must always consider stream health as a prime focus. For example, crown cover should always occur along streams to ensure overall health. Any forest management system can be abused and negatively affect stream health despite the original intent of being less intrusive.

Table 10-2 is a summary of silvicultural methods and how each one affects stream temperature and how, at the same time, each one relates to the shade tolerance of tree species. The symbols represent similar degrees of stream temperature moderation and shade tolerance of regeneration species five years after treatment. As an example from the table, the shelterwood method, uneven-aged management leaving 60 square feet, and a moderate crop tree release will offer the same amount of stream protection. The immediate degree of crown closure is the same, but there are implications for later treatments that will vary among the three. For example, using the shelterwood method, the overstory will be removed in 5 to 10 years.

Table 10 - 1
Comparison of Crop Tree Management and Uneven-Aged Management

Parameter	Uneven-aged Management	Crop Tree Management
Purpose	To produce an even flow of timber products	To meet stand-specific landowner objectives
Marking Guides	• Basal Area • Structure • Largest Diameter Tree (LDT)	• Crop tree selection criteria • Number of trees released
Requirements	• Intensive inventories • Complex marking decision criteria	• Clear communication with landowner • Simple marking decision criteria
Effect on Species	Favors shade tolerant species	Favors either tolerant or intolerant species
Provides	• Continuous cover • Periodic income	• Option of continuous cover • Option of periodic income

Table 10 - 2
Summary of Silvicultural Practices and Their Effects on Stream Temperature and Species Regeneration



Using the uneven-aged methods, no cutting will occur until the next cutting cycle, 25 years. If using the crop tree management system, there may be a subsequent removal of crop trees over a period of time from 10 to 40 years. The manager must think in long-term solutions to stream protection.

Forest management planning is critical to both restoring and protecting riparian systems. Through planning efforts including on-the-ground examinations, specific emphasis can be placed on important ecological features such as coarse woody debris in streams, wildlife crop trees, and the aesthetic component. Overall forest health is dependent on sound management actions accomplished by thorough planning efforts.

Managing the Riparian Forest Buffer

The riparian forest needs special consideration in its management. The desired function of the buffer must be maintained. The main goal is to minimize the soil disturbance to Zones 1 and 2 and sustain a healthy, vigorous, and diverse stand, in both species and age. The soil's duff layer and organic matter, which affect infiltration, denitrification, and water holding capacity, should be protected.

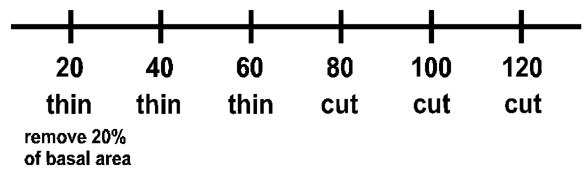
Management of the riparian forest should have these main objectives – diversity, uneven-aged management (biomass storage and nutrient recycling), surface roughness, and multistoried habitat structure.

The following are recommendations for management of the riparian forest buffer:

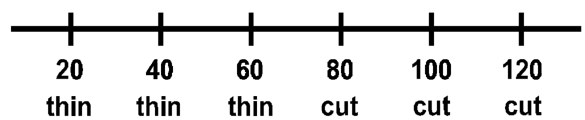
- Zone 1 should not be harvested, except to remove disease or insect-infested trees, or to cut a tree that is ready to fall, and in doing so, will cause the streambank to become unstable. In most cases, cut trees should be left as woody debris.
- Zone 2 should be managed to produce different age classes, and a combination of diverse herbaceous, midstory and overstory plants.
- Manage for a diversity of species. Do not plant and manage monocultures, such as loblolly pine, in riparian areas. Diversity is valuable in terms of functions and health, long-term stability, and the ability to control invasives, especially in urban areas.
- Manage for hardwood species. Conifers are good for diversity, but limit them to 25 percent of species in riparian areas. Hardwood species ensure maximum functions for denitrification; understory, structural wildlife habitat; and woody debris recruitment and maintenance.
- Hardwood species are more nutrient demanding. Manage for hardwood species that use excess nutrients that may enter the riparian areas adjacent to agricultural areas.
- Manage using a system of selection, uneven-aged management, or crop tree management. This means that species that are shade intolerant, such as black cherry or yellow-poplar, will not be the selected species in riparian areas.
- If thinning is done, it should be light, removing only 20 percent of basal area at one time. Remove trees that are diseased, stagnant, and over mature.
- Retain trees that uptake nutrients. Red and white oak, red maple, quaking aspen, white ash, basswood, and yellow-poplar can use excess nitrogen.
- Retain basswood, yellow-poplar, dogwood, and redcedar for uptake of excess calcium, phosphorus, and potassium.
- Do not be afraid to harvest. Riparian forest buffer is not equal to preservation.

Example Prescriptions

Example 1: Mixed Oak-Hickory – Group Selection, ¼-Acre, 20-Year Cutting Cycle



Example 2: Cove Hardwoods – Group Selection, ½-Acre, Well Scattered Groups, 20-Year Cutting Cycle



Example 3: Mixed Bottomland Hardwoods, Age 65, Light Crop Tree Release. Select Water Quality Crop Trees – Release 15 trees/acre

Crop tree selection criteria:

- **cavity trees**
- **favor trees that live long**
- **select trees with good nutrient uptake**
- **favor species such as river birch, red maple, elm, sycamore, green ash, silver maple, yellow-poplar, and hackberry**

Forest Resources Protection

Water Resources

The Water Quality Act of 1987 considers a "best management practice" (BMP) to be any method, measure, or practice used to protect and preserve water quality including, but not limited to, control of water-caused erosion. For any forest harvesting operation, a single BMP or combination of BMPs are usually sufficient to mitigate any potential silvicultural sources of erosion and sedimentation. BMPs are usually voluntary in nature and most states have developed their own extensive BMPs for controlling nonpoint source (NPS) pollution from forestry, agriculture, and development.

The Coastal Zone Act Reauthorization Amendments of 1990 considers a “management measure” (MM) to be an economically achievable measure to control an addition of nonpoint source pollutants to coastal waters, which reflects the greatest degree of pollutant reduction achievable through the application of the best available nonpoint source pollution control practices, technologies, processes, siting criteria, operating methods or other alternatives. MMs are mandatory in nature since they must be enforceable by some level of state or local regulations. In many cases they are the same as the BMPs developed for forestry in the Mid-Atlantic region.

The BMPs and MMs that have been developed for silviculture should be used by natural resource professionals as an overall system of practices to address NPS pollution sources on any given site undergoing silvicultural treatments. In most cases, not all the potential practices will be needed to address the NPS sources of a specific site. However, most forestry operations have more than one phase of operation that needs to be addressed and will need to employ two or more practices to address multiple NPS sources. When more than one phase exists, the application of the practice needs to be coordinated to produce an overall system that can satisfactorily address all sources of NPS pollution for the site and does not cause unnecessary expenditure on the site by the operator or landowner.

Voluntary and Mandatory Programs

There are two basic types of state forestry NPS pollution control programs-voluntary and mandatory. Thirty-five states currently implement voluntary programs, with six of these states having the authority to make the voluntary programs regulatory and ten states backing the voluntary program with a regulatory program for non-compliers. Nine states have developed regulatory programs.

Voluntary programs rely on a set of BMPs as guidelines to forest products operators. Logger education and technology transfer are also the responsibility of most state forestry agencies. Workshops, brochures, and field tours are used to educate and demonstrate to forest products operators the latest water quality and aesthetic management techniques. Landowners are encouraged to use operators who have a thorough working knowledge of state forestry BMPs and MMs. Transfer of information on NPS pollution control methods to forest landowners is also an important element of these state programs.

Regulatory programs often involve mandatory controls and enforcement strategies defined in Forest Practice Rules based on a state’s Forest Practice Act, Water Quality Statute, or other local government regulations and ordinances. These programs usually require the implementation of BMPs and MMs based on site-specific conditions and water quality goals, and they have enforceable requirements. Often streams are classified based on their most sensitive designated use, such as importance for municipal water supply or for coldwater fisheries. Since many BMPs and MMs also improve harvesting operation efficiency, they can be applied in the normal course of forest harvesting with few significant added costs. Harvest operations plans or applications to perform a timber harvest are frequently reviewed by the responsible state and/or local agency. Present State Coastal Zone Management (CZM Sec. 6217) and Clean Water Act (CWA Sec. 319) programs already include specific BMP and MM regulations or guidelines for forestry activities in many cases. In some states, CZM programs have adopted state forestry regulations and BMPs through reference or as part of a linked program.

Counties, municipalities, and local Conservation Districts may also impose additional requirements on landowners and operators conducting forestry activities. In urbanizing areas, these requirements often relate to concerns regarding the conversion of forested lands to urban uses or changes in private property values due to aesthetic changes resulting from forestry practices. In rural areas additional requirements for forestry activities may be implemented to protect public property. Local forestry regulations tend to be stricter in response to residents' complaints.

The types of forestry activities affecting NPS pollution include road construction and use, timber harvesting, mechanical equipment operation, prescribed burning, and fertilizer and pesticide application. Most States with forestry activities have developed BMPs and MMs to control silviculturally-related NPS water quality problems. Often water quality problems are not due to ineffectiveness of the practices themselves, but to the failure to implement them appropriately.

Best Management Practices/Management Measure Guidance

The following are generic BMP/MM guidelines that address the most common phases of forestry operations relevant to the control of silvicultural sources of NPS pollution (see the appendix for specific Bay State BMPs):

Pre-Harvest Planning

Perform advance planning for forest harvesting that includes the following elements where appropriate:

1. Identify the area to be harvested including location of water bodies and sensitive areas such as wetlands, threatened or endangered aquatic species habitat areas, or high erosion hazard areas (landslide-prone areas) within the harvest unit.

2. Time the activity for the season or moisture conditions when the least impact occurs.

3. Consider potential water quality impacts and erosion and sedimentation control in the selection of silvicultural and regeneration systems, especially for harvesting and site preparation.

4. Reduce the risk of occurrence of landslides and severe erosion by identifying high erosion hazard areas and avoiding harvesting in such areas to the extent practical.

5. Consider additional contributions from harvesting or roads to any known existing water quality impairments or problems in watersheds of concern.

Perform advance planning for forest road systems. Consider the following elements where appropriate:

1. Locate and design road systems to minimize, to the extent practical, potential sediment generation and delivery to surface waters. Key components are:

   - locate roads, landings, and skid trails to avoid steep grades and steep hillslope areas, and to decrease the number of stream crossings;

   - avoid locating new roads and landings in Streamside Management Areas (SMAs); and

   - design roads with a minimum of 2 percent slope, and a maximum of 10 percent slope. Where absolutely necessary, grades of 15-20 percent can be used for short distances.

2. Locate and design temporary and permanent stream crossings to prevent failure and control impacts from the road system. Key components are:

   - size and site crossing structures to prevent failure;

   - for fish-bearing streams, design crossings to facilitate fish passage.

3. Ensure that the design of road prism and the road surface drainage are appropriate to the

terrain and that road surface design is consistent with the road drainage structures.

4. Use suitable materials to surface roads planned for all-weather use to support truck traffic.

5. Design road systems to avoid high erosion or landslide hazard areas. Identify these areas and consult a qualified specialist for design of any roads that must be constructed through these areas.

Each State in the Chesapeake Bay Region has developed a process that ensures that the BMPs are implemented. Such a process includes appropriate notification, compliance audits, and/or other mechanisms for forestry activities with the potential for significant adverse nonpoint source effects based on the type and size of operation and the presence of stream crossings or SMAs.

Streamside Management Areas

Establish and maintain a streamside management area along surface waters, which is sufficiently wide and which includes a sufficient number of canopy species to buffer against detrimental changes in the temperature regime of the water body, to provide bank stability, and to withstand wind damage. Manage the SMA in such a way as to protect against soil disturbance in the SMA and delivery to the stream of sediments and nutrients generated by forestry activities, including harvesting. Manage the SMA canopy species to provide a sustainable source of large woody debris needed for instream channel structure and aquatic species habitat.

Road Construction/Reconstruction

1. Follow pre-harvest planning when constructing or reconstructing the roadway.

2. Follow designs planned under the pre-harvest planning BMP for road surfacing and shaping.

3. Install road drainage structures according to designs planned under the pre-harvest planning BMP and regional storm return period and installation specifications. Match these drainage structures with terrain features and with road surface and prism designs.

4. Guard against the production of sediment when installing stream crossings.

5. Protect surface waters from slash and debris material from roadway clearing.

6. Use straw bales, silt fences, mulching, or other favorable practices on disturbed soils on unstable cuts, fills, etc.

7. Avoid constructing new roads in SMAs to the extent practical.

Road Management

1. Where possible, avoid timber hauling or heavy traffic during wet or thaw periods on roads not designed and constructed for these conditions.

2. Evaluate the future need for a road and close roads that will not be needed. Leave closed roads and drainage channels in a stable condition to withstand storms.

3. Remove drainage crossings and culverts if there is a reasonable risk of plugging or failure from lack of maintenance.

4. Following completion of harvesting, close and stabilize temporary spur roads and seasonal roads to control and direct water away from the roadway. Remove all temporary stream crossings.

5. Inspect roads to determine the need for structural maintenance. Conduct maintenance practices, when conditions warrant, including cleaning and replacement of deteriorated structures and erosion controls, grading or seeding of road surfaces, and, in extreme cases, slope stabilization or removal of road fills where necessary to maintain structural integrity.

6. Conduct maintenance activities, such as dust abatement, so that chemical contaminants or pollutants are not introduced into surface waters.

7. Properly maintain permanent stream crossings and associated fills and approaches to reduce the likelihood (a) that stream overflow will divert onto roads, and (b) that fill erosion will occur if the drainage structures become obstructed.

Timber Harvesting

1. Timber harvesting operations with skid trails or cable yarding follow layouts determined by Pre-harvest Planning.

2. No haul roads or skid trails should be within the buffer unless there is a stream crossing. Felled trees must be cabled out of the buffer zone.

3. Timber harvests within the flood plain, wetlands, and/or saturated soils, should be done in the driest months of the year, normally August through October.

4. Install landing drainage structures to avoid sedimentation to the extent practical. Disperse landing drainage over sideslopes.

5. Construct landings away from steep slopes and reduce the likelihood of fill slope failures. Protect landing surfaces used during wet periods. Locate landings outside of SMAs.

6. Protect stream channels and significant ephemeral drainages from logging debris and slash material.

7. Use appropriate areas for petroleum storage, draining, and dispensing. Establish procedures to contain and treat spills. Recycle or properly dispose of all waste materials.

<u>For cable yarding</u>:

- Limit yarding corridor gouge or soil plowing by properly locating cable yarding landings.

- Locate yarding corridors for SMAs following SMA BMPs.

<u>For ground skidding</u>:

- Within SMAs, operate ground skidding equipment only at stream crossings to the extent practical. In SMAs, fell and endline trees to avoid sedimentation.

- Use improved stream crossings for skid trails which cross flowing drainages. Construct skid trails, with adequate drainage structures, to disperse runoff.

- On steep slopes where ground skidding may cause excessive sedimentation, use cable systems.

Site Preparation and Forest Regeneration

Confine on-site potential NPS pollution and erosion resulting from site preparation and the regeneration of forest stands. The components of the management measure for site preparation and regeneration are:

1. Select a method of site preparation and regeneration suitable for the site conditions.

2. Conduct mechanical tree planting and ground-disturbing site preparation activities on the contour of sloping terrain.

3. Do not conduct mechanical site preparation and mechanical tree planting in streamside management areas.

4. Protect surface waters from logging debris and slash material.

5. Suspend operations during wet periods if equipment used begins to cause excessive soil disturbance that will increase erosion.

6. Locate windrows at a safe distance from drainages and SMAs to control movement of the material during high runoff conditions.

7. Conduct bedding operations in high-water-table areas during dry periods of the year. Conduct bedding in sloping areas on the contour.

8. Protect small ephemeral drainages when conducting mechanical tree planting.

Fire Management

Prescribe fire for site preparation and control or suppress wildfire in a manner which reduces potential nonpoint source pollution of surface waters:

1. Intense prescribed fire should not cause excessive sedimentation due to the combined effect of removal of canopy species and the loss of soil-binding ability of subcanopy and herbaceous vegetation roots, especially in SMAs, in streamside vegetation for small ephemeral drainages, or on very steep slopes.

2. Prescriptions for prescribed fire should protect against excessive erosion or sedimentation.

3. All bladed firelines, for prescribed fire and wildfire, should be plowed on contour or stabilized with water bars and/or other appropriate techniques if needed to control excessive sedimentation or erosion of the fireline.

4. Wildfire suppression and rehabilitation should consider possible NPS pollution of watercourses, while recognizing the safety and operational priorities of fighting wildfires.

Revegetation of Disturbed Areas

Reduce erosion and sedimentation by rapid revegetation of areas disturbed by harvesting operations or road construction:

1. Revegetate disturbed areas (using seeding or planting) promptly after completion of the earth-disturbing activity. Local growing conditions will dictate the timing for establishment of vegetative cover.

2. Use mixes of species and treatments developed and tailored for successful vegetation establishment for the region or area.

3. Concentrate revegetation efforts initially on priority areas such as disturbed areas in SMAs or the steepest areas of disturbance near drainages.

Forest Chemical Management

Use chemicals when necessary for forest management in accordance with the following measures to reduce nonpoint source pollution impacts due to the movement of forest chemicals off-site during and after application:

1. Conduct applications by skilled and, where required, licensed applicators according to the registered use, with special consideration given to impacts to nearby surface waters.

2. Carefully prescribe the type and amount of pesticides appropriate for the insect, fungus, or herbaceous species.

3. Prior to applications of pesticides and fertilizers, inspect the mixing and loading process and the calibration of equipment, and identify the appropriate weather conditions, the spray area, and buffer areas for surface waters.

4. Establish and identify buffer areas for surface waters. (This is especially important for aerial applications.)

5. Immediately report accidental spills of pesticides or fertilizers into surface waters to the appropriate State agency. Develop an effective spill contingency plan to contain spills.

Wetland Forest Management

Plan, operate, and manage normal, ongoing forestry activities (including harvesting, road design and construction, site preparation and regeneration, and chemical management) to adequately protect the aquatic functions of forested wetlands.

Forest Resources - Protecting the Forest From Injurious Agents

Weather

In many parts of the country, including the Chesapeake Bay Region, weather can have major impact on the health of forest ecosystems. Wind damage often results from such atmospheric disturbances as hurricanes, tornadoes, and violent thunderstorms. It is not unusual for wind speeds to exceed 40 mph in violent localized thunderstorms. During the Atlantic hurricane season, June through September, storms passing offshore can produce sustained wind speeds topping 80 mph for several hours. The occasional tornado, though limited in its impact range per event, can be highly destructive with wind speeds of over 200 mph in the vicinity of the funnel cloud. Besides breaking limbs and the upper portions of boles, wind events can cause windthrow (especially in shallow rooted species such as Virginia pine or timber on thin xeric soils) and winter desiccation of foliage above the snow line.

Winter storms can be equally injurious to forests due to ice, snow, and hail damage. Ice storms resulting from freezing rain and sleet as well as heavy wet snow storms can cause trees to suffer limb failure, and in the case of small trees, particularly pines, main stem failure. Late season frosts often cause die-back of shoots and buds resulting in deformed growth and vigor. Though relatively infrequent, hailstones can cause shoot and bark damage, particularly in thin barked species like beech, birch, and aspen as well as many other species while they are juveniles.

Besides wind, most storms in the humid east are accompanied by precipitation during the growing season. Localized flooding is relatively common in mountainous areas during the late winter and early spring, especially during "breakup" (ice). When streams and creeks come up out of their banks during this time of year the accompanying ice floes can be particularly destructive to riparian vegetation including tree species. When the ground is saturated, tree roots are subjected to anaerobic conditions which normally only riparian species are capable of tolerating for any length of time. Saturated soil conditions can also lead to slope failure and other forms of mass wasting which dramatically affect site index of the area. Lack of rain can be equally as destructive as too much rain. Drought is one of the major reasons young tree plantations fail after establishment. In most cases these types of water related stresses do not normally cause widespread tree mortality, rather they predispose the affected trees to secondary and tertiary pathogens which eventually cause loss of vigor and death.

Though often impossible to predict, the effects of weather on the health of the forest can be ameliorated by the forest manager by promoting vigorous growth via thinning to reduce competition. However, in many cases Mother Nature has the last word and the only recourse for the forest manager is to salvage the impacted timber, clean-up, and start over by ensuring desirable regeneration.

Insects

The family *Insecta* includes the oldest members of the animal kingdom and the largest number of animal species (90 percent of all species) at over one million, of which over 10,000 live in the United States. Insects are by far the most destructive injurious agent to forest ecosystems, destroying 10 times the acreage that fire usually does on an annual basis.

Forest insects are usually broken down into three major groups: defoliators, borers, and stem feeders. Examples of defoliators affecting the forests of the Mid-Atlantic and Chesapeake Bay Region include: gypsy moth, eastern tent caterpillar, fall cankerworms, red headed pine sawfly, pear thrips, and holly leaf miner. Examples of borers include: southern pine beetle, two-lined chestnut borer, locust borer, and metallic beetles. Stem feeders include: beech scales, Saratoga spittlebugs, Paley's weevil, and woolly adelgids.

Though forest insects can impact trees in many different ways, insect infestation usually results in a few generalized types of damage. Generally, the first sign of insect activity in the forest is the loss of tree and/or stand vigor and growth, especially when the agent is a defoliator. Stem and shoot feeders often alter tree form and shape, thus affecting tree quality. Insects can be destructive enough by themselves to kill individual trees or sometimes whole stands. Usually, however, insects also introduce other pathogens while feeding, which further stresses the tree and makes mortality all the more likely. If an insect prefers one tree species in particular, which is often the case, then widespread infestations can also affect stand composition and diameter distribution.

When natural factors fail to hold insect populations to economically tolerable levels, it may be necessary to resort to artificial controls depending on the insect and its biology. Artificial controls are applied by forest managers to regulate insect activity, distribution, and abundance through the use of practices that mimic natural control. The most often prescribed practices include: silvicultural control, biological control, and chemical control.

The possibilities for silvicultural control occur during the establishment and throughout the lives of forest stands by selecting the more resistant tree species for planting, by putting them on sites best suited for them, or by controlling their composition and density. Stand conditions may be created or modified as needed by thinnings or cuttings to maintain or improve their growth and vigor. Pure stands may be broken up into mixtures of age-classes in small units, with no two contiguous units of the same age-class. Mixed stands may be broken up by cutting in small groups to maintain and promote diversity in species composition and density. Over mature trees may be removed or stands can be harvested as soon as they are mature. High risk or affected trees may be removed in sanitation-salvage cuttings and the area regenerated.

In general, biological control efforts against forest insects have been limited to the:

- importation and establishment of foreign parasites and predators of introduced pests;
- transfer of parasites, predators, and disease pathogens from one region to another;
- augmentation of established parasite and predator populations with field-collected or lab reared individuals; and
- use of microbial sprays to control outbreaks.

Viruses and bacteria are usually applied as sprays, but they can also be applied as dusts if first incorporated with a powder. Sprays may be applied by hand-operated sprayers, mist blowers, or aircraft.

The use of chemical insecticides to suppress forest insect populations is the method of last resort. It is a sound policy to use them only when other forms of control have failed or threaten to fail. Depending on the situation, chemicals may be applied to a single tree or to forested areas covering thousands of acres. The aim, therefore, is usually limited to the suppression of injurious populations to tolerable levels.

The concept of integrated pest management (IPM) utilizes a combination of two or more of the above control strategies that can and should be used to achieve effective insect population control without relying exclusively on one particular method. In the context of the associated environment and the population dynamics of the pest to be controlled, this system utilizes all suitable techniques and methods in as compatible a manner as possible and maintains the pest populations at levels below that causing economic injury. Most of the important pest species in the Mid-Atlantic and Chesapeake Bay Regions lend themselves to some form of IPM. The long life of the forest and the fact that many species of commercially important trees can withstand some degree of infestation without serious damage provides the opportunity to use different methods of control.

Diseases

There are over 1,000 tree diseases which can cause tree mortality in the United States, making disease pathogens the second most destructive agent to forest ecosystems.

Plant or tree pathogens can be broken down into three common types of diseases: foliage, stem and root. Examples of foliage diseases affecting the forests of the Mid-Atlantic and Chesapeake Bay Region include: anthracnose, leaf spot, powdery mildew, leaf blister, and needle blight. Examples of stem diseases include: Nectria canker, fusiform rust, oak wilt, Dutch elm disease, elm phloem necrosis, and chestnut blight. Examples of root diseases include: various root rots and damping-off fungi.

Though forest pathogens can impact trees in many different ways, disease outbreak usually results in a few generalized types of damage. Usually the first sign of disease in the forest is the loss of tree and/or stand vigor and growth, especially when the agent is a foliar pathogen. Stem and shoot cankers often alter tree form and shape, thus affecting tree quality. Diseases can be destructive enough by themselves to kill individual trees or sometimes whole stands. Usually, however, insects also further stress the tree which makes mortality all the more likely. If a disease prefers one tree species in particular, then widespread infestations can also affect stand composition and diameter distribution.

Forest diseases have a tendency to become problematic primarily because:

1. modern high-production forestry emphasizes tightly spaced pure stands or conversion to pure stands.
2. a common aspect of high-production forestry is to grow the same species for many rotations on the same site.
3. a common feature of high-production forestry is the emphasis of growing the most valuable species without enough regard for important differences in site requirements.
4. the use of selective harvest techniques produces large numbers of infection sites and creates situations that favor disease pathogens.

The forest manager can use many of the same types of control techniques for diseases that are used to suppress insect populations, with the notable exception of biological control. Fungicides are most commonly used for high value individuals or under nursery conditions, but not under forested conditions because they would not be cost effective. Silvicultural control methods rely mostly on sanitation/salvage harvesting to remove and dispose of the infected timber and to promote less susceptible regeneration. Removal of the alternate host for many fungal pathogens, as in the case of white pine blister rust, can often prove beneficial. The most important overall silvicultural practice is to maintain or improve forest growth and vigor through periodic thinning so that the affected tree has the opportunity to compartmentalize and thus contain the invading pathogen. As with insect outbreaks, disease outbreaks tend to lend themselves to IPM techniques.

Wildfire

Unprescribed wildland fire is the third most damaging injurious agent in terms of tree mortality in the United States. While other agents impact forest ecosystems negatively for the most part, wildfire can have some beneficial effects.

Wildland fire can be typed into three basic categories: ground, surface and crown. Ground fires burn underground in either deep peat or humus layers and can be very difficult to control. Coal seam fires are an example of one form of ground fire. Surface fires burn the leaf cover, understory vegetation and some low growing trees. These fires have a slow to moderate rate of spread (5-10 chains/hour) and short flame lengths (12 inches). (One chain = 66 feet). Crown fires are the most spectacular and destructive, with rapid rates of spread (20+ chains/hour) and long flame lengths (10+ feet). Crown fires burn the foliage and the canopy of mostly coniferous scrub and plantation forests in the Mid-Atlantic and Chesapeake Bay Regions.

Wildland fire negatively impacts forest ecosystems in several ways. Fire results in the loss of ground cover and its capacity for water infiltration and absorption, thus encouraging erosion and sedimentation. Burning of the understory vegetation and loss of the A soil horizon also results in loss of important wildlife habitat, both terrestrial and aquatic. Loss of soil structure and function through compaction and the creation of hydrophobic conditions severely limit the nutrient buffering capacity of riparian forests within a burned area. Fire, if it does not kill a tree outright, will seriously weaken it and predispose it to other injurious agents such as insects and disease, eventually resulting in mortality.

The need to control wildland fire was the primary reason that many of the State forestry agencies were created in the early part of this century. Fire control methods include direct and indirect techniques both with and without the use of water. The forest manager can take a number of precautions to help prevent the loss of natural resources to fire:

1. establish fire breaks in natural cover fuels, especially in coniferous timber types and maintain them on an annual basis;

2. establish and/or maintain a system of fire access trails sufficient to accommodate wildland fire suppression equipment. Access to the trail system should be controlled by gates to limit usage during high fire danger;

3. manage the fuel load and stocking by resource utilization and extraction or by a planned understory ignition for hazardous fuel reduction;

4. where water sources exist, establish one or more dry hydrants to facilitate the drafting and refilling of fire suppression equipment; and

5. network with adjacent forest landowners to pool resources and share the burden of trail and fuel break maintenance.

Invasive and/or Exotic Plants

Though not normally a major impact on established forest ecosystems, invasive and/or exotic plant species can overwhelm more desirable native vegetation at the local level. Examples of invasive exotics include: kudzu, multi-flora rose and Japanese honeysuckle. Exotic or invasive plants can be a problem especially on newly established buffers on disturbed lands like those commonly found in agricultural and urban areas. Examples of invasive natives are grapevine, greenbrier, wild garlic mustard and tear-a-thumb. Parasitic plants like mistletoe can also overwhelm their hosts and become quite invasive either on a per tree or per stand basis.

Invasive and/or exotic vegetation tends to retard or eliminate more desirable regeneration following silvicultural treatments and natural disturbances. In doing so, these noxious plants occupy sites otherwise suitable for native species. Because of their aggressive nature, invasive/exotics out compete both native and desirable threatened and endangered species for critical habitat.

Controlling invasive/exotics is challenging at best, often requiring the most aggressive of treatments. Mechanical control normally involves rootraking using a bulldozer or mowing using a tractor and bush-hog implement. Depending on the species to be controlled, the species to be released, and specific site requirements, prescribed burning has been used successfully to control unwanted vegetation. Silvicultural control methods for invasive/exotics might include maintaining understory light levels by proposing lighter intensity thinning prescriptions or widening buffer recommendations to reduce invasion by intolerant invasive/exotic species. Normally, most forest managers resort to herbicide application for the most cost-effective means of controlling stubborn invasive/exotics. The principles of IPM apply equally well for invasive/exotics as they do for insects or diseases.

Domestic Livestock and Wildlife

While not an insurmountable problem in most of the Mid-Atlantic and Chesapeake Bay Region, unrestrained livestock and/or an overpopulation of wildlife can have detrimental effects on forest ecosystems. Grazing livestock in forests, especially cattle, goats, and swine, has the greatest potential for permanent loss of site productivity.

Too many stock animals in a woodlot causes soil compaction which inhibits the capacity of fine root hairs to function properly, reduces infiltration rates thus increasing erosion and sedimentation, and creates an impenetrable soil layer hindering seed establishment and successful regeneration. Grazing and selective browsing removes seed and desirable reproduction, making any possibility of advanced reproduction or desirable regeneration an impossibility. Trampling and rubbing also causes physical damage to stems of juveniles as well as more mature trees.

Overpopulation of wildlife species can have many of the same impacts as unrestricted grazing of livestock. Larger animals like deer can over graze and browse a forest in the same manner goats do. Common field mice and voles along with rabbits can reek havoc with reforestation and afforestation efforts if no effort is made to control their impacts. Beaver and porcupine readily girdle small trees for food and building material, often devastating riparian areas and making unwanted in-stream "improvements" at the same time.

There are a number of things the prudent forest manager can do to mitigate or compensate for the impacts from livestock and wildlife. Eliminate forest grazing by providing alternative watering facilities, shade, and loafing areas for domestic livestock. Shade and loafing areas can be provided by installing a fence 20-50 feet inside the border of a woodlot. While making the outside edge of a woodlot available to livestock, the inside contiguous block of forest is protected from grazing and can be managed as a productive forest and an integral part of the overall farming operation. The re-establishment of a more or less complete food chain, including predators, may be necessary to maintain sustainable wildlife populations. If this is not feasible, then the use of controlled hunting with bag limits is the most practical way of maintaining acceptable population levels of wildlife.

References

American Forest and Paper Association. 1995. Sustainable forestry principles and implementation guidelines. Washington DC.

American Forest and Paper Association. 1995. U.S. forests facts and figures.

Davis, K.P. 1996. Forest management: regulation and valuation. McGraw-Hill, Inc.

Foreman, J.M., E. Frame, J. Carroll, and J. Wagner. 1995. Virginia's forests, our commonwealth. Virginia Department of Forestry.

Hepting, G.H. 1971. Diseases of forest and shade trees of the United States. USDA Forest Service Ag. Handbook No. 386. Washington, DC.

Lowrance, R., L. Altier, J.D. Newbold, R. Schnabel, P.M. Groffman, J.M. Denver, D.L. Correll, J.W. Gilliam, J.L. Robinson, R.B. Brinsfield, K.W. Staver, W.L. Lucas, and A.H. Todd. 1995. Water quality functions of riparian forest buffer systems in the Chesapeake Bay watershed. EPA 903-R-95-004. CPB/TRS 134/95.

Perkey, A.W., B.L. Wilkins and H.C. Smith. 1993. Crop tree management in eastern hardwoods. USDA Forest Service, Northeastern Area, State & Private Forestry. Morgantown, WV. NA-TP-19-93.

Sinclair, S.A. 1992. Forest products marketing. McGraw-Hill, Inc.

Smith, D.M. 1986. The practice of silviculture. Rev. ed. of: The practice of silviculture/Ralph C. Hawley. 7th ed. 1962. John Wiley & Sons.

Virginia Department of Forestry. 1994. Annual best management practices report.

Virginia Department of Forestry. 1989. Forestry best management practices for water quality.

Welsch, D.J. 1991. Riparian forest buffers, function and design for protection and enhancement of water resources. USDA Forest Service, Northeastern Area, State and Private Forestry. Radnor, PA. NA-PR-07-91.

Wenger, K.F. editor. 1984. The forestry handbook. second edition. John Wiley and Sons

Section XI

Urban/Suburban Aspects

Urban/Suburban Aspects

Introduction

Riparian forest buffers provide critical transitions between surrounding land uses and streams, rivers, and other receiving waters. In urban areas, riparian areas are extremely critical because they are often the last line of defense for the protection of water quality, flow regime, and habitat, both aquatic and terrestrial (Table 11-1). Although urban forest buffers may have similar appearances to their counterparts in rural areas, there are significant differences. This section outlines how these differences must be addressed both in the planning and implementation for forest buffer restoration in urban riparian areas. It is the area of transition between urban and rural areas where the greatest land use change is occurring and where the greatest potential value of riparian forest buffers can be realized.

Comparison of Urban and Rural Riparian Buffers

A primary difference between urban and rural forest buffers is the level of disturbance that occurs both within and adjacent to them. Although stream channels are, by nature, areas of high disturbance, urban stream channels are subject to elevated levels of disturbance because of urban land development (Figure 11-1). Altered flow regimes and levels of human activity create notable changes in both the structure and function of urban riparian forests.

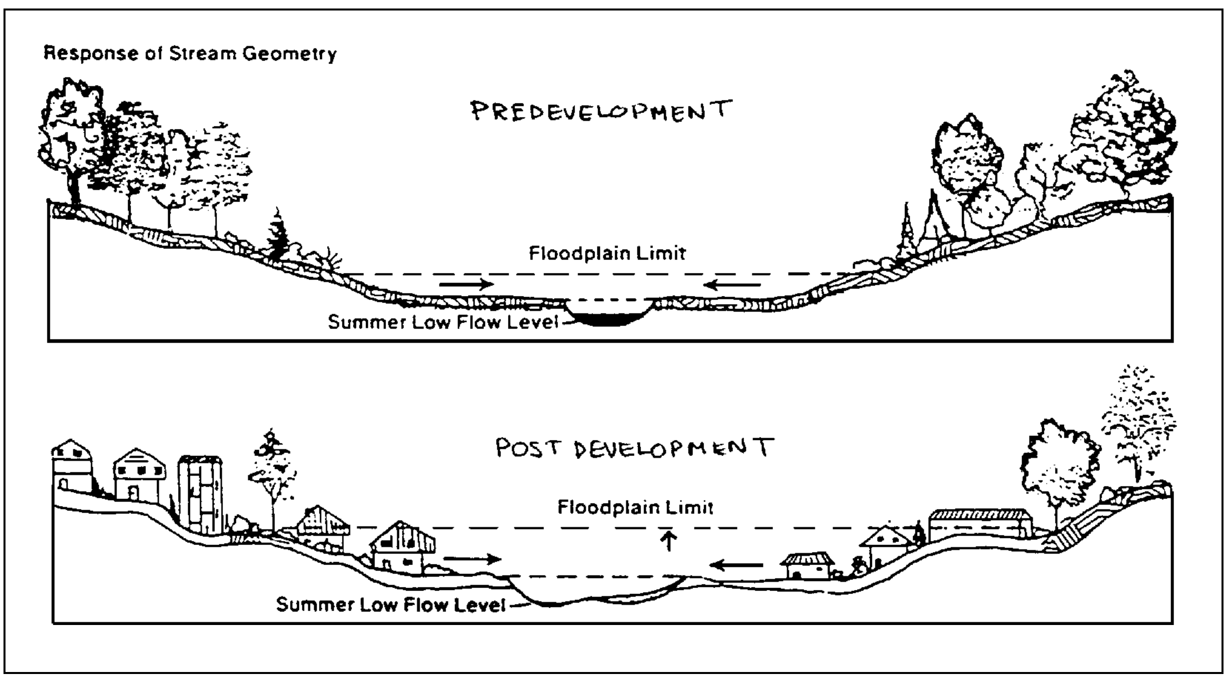


Figure 11 - 1. Effect of Urbanization on Stream Channels. The increase in the peak discharge rates following urbanization shifts the elevation of the 100-year flood plain upward, which may put more property and structures at risk. (Source: Schueler, 1987)

Table 11 - 1

Benefits of Urban Riparian Forest Buffers

Reduce Runoff Volume	Watershed imperviousness can be reduced by as much as five percent by setting aside 100-foot buffer areas.
Reduce Small Drainage Problems	Buffers can reduce complaints from property owners regarding flooding, erosion, and drainage problems by allowing space for the natural meandering of stream channels.
Stabilize Banks and Limit Channel Erosion	The roots of native grasses and woody plants preserved along the shoreline help stabilize stream banks and limit channel erosion.
Increase Property Values	Ninety percent of buffer administrators surveyed believe that buffers and other forested lands have a positive impact on property values.
Reduce Pollutant Loads	When properly designed, buffers can provide effective pollutant removal for development when located within 150 feet of the buffer boundary. A buffer's long-term pollutant removal capacity depends on a number of factors, including soil conditions, vegetative character, and buffer size and slope.
Provide a Foundation for Greenways	The systematic protection or creation of riparian buffers can connect non-contiguous fragments of forest that create a valuable community resource.
Provide Food and Habitat for Wildlife	Leaf litter is a base food source for many stream ecosystems. Forested buffers also provide woody debris that creates cover and habitat structure for aquatic insects and fish.
Preserve Important Terrestrial Habitat	Riparian corridors are important transition zones that are rich in species. A mile of stream buffer can provide 25 to 40 acres of habitat area. Unbroken stream buffers provide corridors for conservation that are highways for migration of plant and animal populations.
Maintain an Essential Habitat for Amphibians	Preservation of flood plains in a forested state effectively protects aquatic and terrestrial habitats that are dependent on riparian environments to protect their life cycles.
Mitigate Stream Warming	Shading provided by a forest canopy protects the thermal regime of streams. This is especially important in urban areas where stream warming is a significant cause of in-stream species mortality.
Preserve Wetlands	Urban buffers offer protection of associated wetlands that are frequently found along stream corridors. Wetlands are critical to the control of both the quantity and quality of stormwater runoff, with direct contributions to nutrient recycling.
Protect Steep Slopes	Areas that should be excluded from development, like steep slopes, can be set aside to reduce soil erosion if located in riparian areas.

For example:

- Urban riparian forests incur increased levels of bank erosion and subsequent tree-fall into streams because of the high volume and velocity of storm events.
- Flood plains in urban areas are favored sites for utility lines, gravity-fed sewer systems, and stormdrain outfalls.
- Needs of urban recreational facilities are often targeted toward riparian areas because of their linear nature and contiguous forest.
- Adjacent land use can be a source of disturbance affecting the buffer, with problems such as vandalism, excessive foot traffic, and dumping.

Hydrologically, urban forest buffers may have few similarities with rural buffers. In heavily urbanized watersheds, the stream channel itself becomes hydrologically disconnected with adjacent riparian areas because of channel incising and bank armoring. Patterns of flow to a stream channel shift from infiltration and subsurface flow to rapid surface runoff. Roads and other impervious areas adjacent to or within forested buffers further disconnect buffers from surface and subsurface flows. Direct discharges of storm drains downstream of riparian buffers are the most common examples of the disrupted hydrological patterns and potential for decreased water quality benefits associated with urban riparian buffers.

After riparian forest buffers are established, many forces can affect the structure and function of these areas. Encroachment of buffers is a common problem found in all types of adjacent land uses. The expansion of turfgrass, excessive foot traffic, removal of understory plants, and introduction of invasive plants can seriously degrade the natural functions of forest buffers. The result is reduction in the interception and treatment of stormwater. Any of these factors (singularly or combined) has a detrimental effect on the condition of urban forest buffers.

Riparian Forest Buffers as Urban Best Management Practices (BMPs)

In recent years, it has been discovered that buffers have a role in the treatment of stormwater. However, they are only one component in a multifaceted approach. Although riparian forest buffers can provide effective treatment for as much as 10 percent of the contributing watershed to the stream, it is important to understand that buffers cannot treat all the stormwater runoff generated within a watershed. Communities frequently cite pollutant removal as a primary objective of buffer programs, although riparian buffers in urban areas vary greatly in their abilities to remove pollutants. Many reasons for this were discussed in the previous section. To determine capacities for stormwater treatment, the size and condition of the urban stream buffer must be assessed in relation to the land use of contributing drainage areas. In many cases, urban buffers are inadequate in terms of area, detention times, and infiltration capacities to treat the quantities and concentrations of flow that enter from urban land uses.

When conditions are favorable, a buffer may continue to adequately treat subsurface flow, but treat only a limited amount of surface runoff from a particular catchment area. Surface flow patterns are the main factor determining whether a forest buffer is suitable to serve as a BMP. Forest buffers provide natural mechanisms for physical filtering, infiltration, and biological uptake. For these processes to be effective, surface flow must not be concentrated. As shown in Figure 11-2, surface flow has a tendency to concentrate after it has passed over distances of 150 to 200 feet. In urban areas, the concentration of flow is accelerated by impervious surfaces and stormwater conveyance systems. Once concentrated, surface flow forms a channel that can make a stable urban buffer ineffective.

Certainly, ideal buffer conditions are rarely encountered in urban watersheds. However, even in the best of circumstances, the capability of urban forest buffers to remove pollutants and sediment (Table 11-2) borne in stormwater is diminished by harsh stormwater delivery systems that are

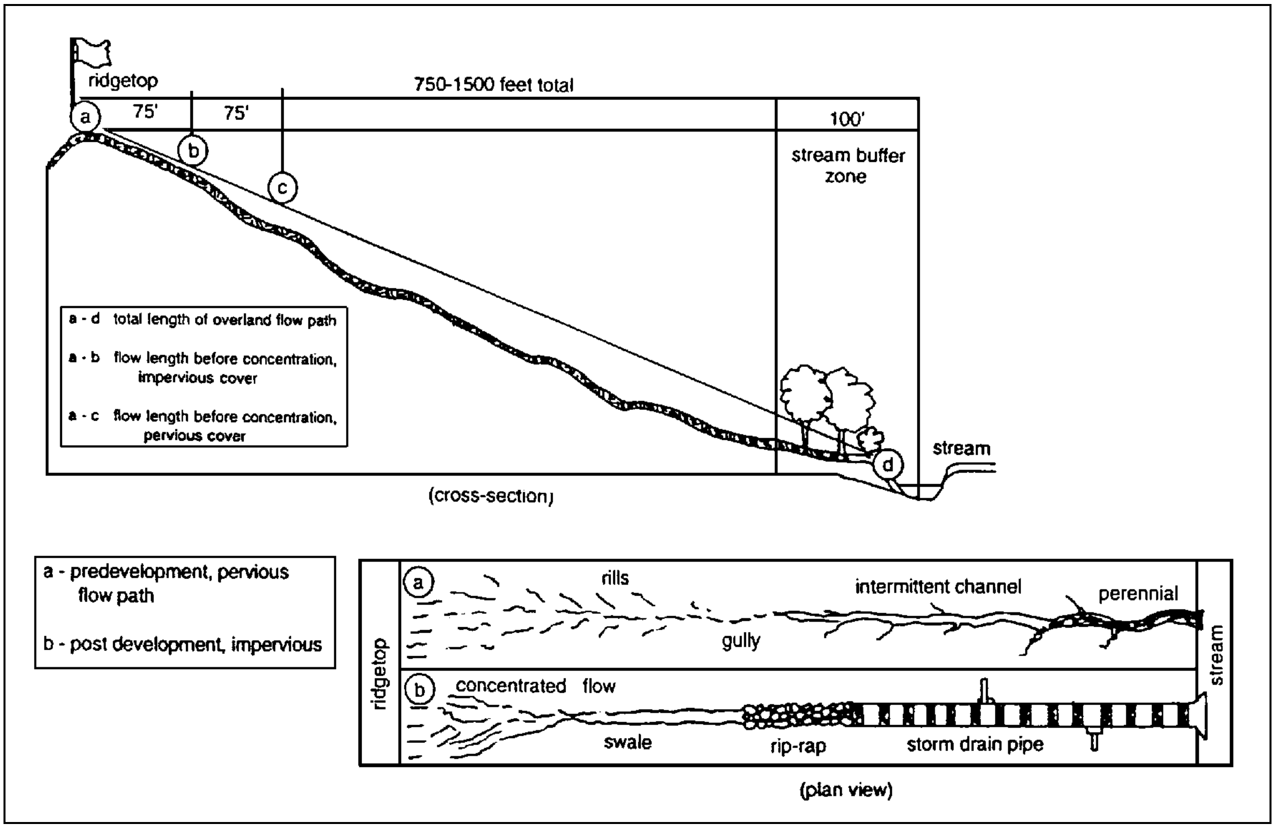


Figure 11 - 2. Overland Flow Patterns in Urban Areas. The distance between the ridgetop and the stream is known as the overland flow path (cross-section view). Even in undisturbed watersheds, flow tends to quickly concentrate over a short distance (plan view, panel a). In urban watersheds, flow tends to concentrate even more quickly, requiring stabilization of the intermittent channel (panel b). In a, more water can soak into the ground so stormwater flow is less intense. While b not only has concentrated flow, it has a greater quantity because of the imperviousness. (Source: Metropolitan Washington COG, 1995)

designed to remove surface drainage in the shortest amount of time. Developers and planners are beginning to recognize the role of conveyance systems in this loss of treatment, and they are making changes in the design and approval of the systems. Stormwater management strategies are beginning to focus more on infiltration techniques, which can shift the imbalance created by loss of groundwater.

If a buffer receives flow directly from impervious areas, the design should include flow-spreading mechanisms, such as multiple curb cuts, spacers, or other devices to evenly distribute runoff over the forest buffer. A stone flow spreader typically consists of a narrow band of stone, layered at the pavement edge, 3 to 6 inches below the pavement surface to prevent sediment deposits from blocking inflow to the filter strip.

Riparian forest buffers can provide stormwater filtering benefits only if regular inspection and fundamental maintenance can be guaranteed. An example of such maintenance is periodic mowing of turf filters at higher than normal heights. Another example is the annual removal of accumulated sediments at the border of the impervious area and the grass filter (more frequent maintenance may be required during periods of high sediment deposits). These techniques will ensure the long-term effectiveness of the forest buffer BMP.

Table 11 - 2

Approximate Pollutant Removal Efficiencies of Buffer Mechanisms in Riparian Buffers Designed for Urban Areas*

Pollutant Removal Mechanism:	Type of Pollutant					
	Total Suspended Solids	Total Phosphorus	Total Nitrogen	Metals	Hydrocarbons	Solubles
Erosion Control/Bank Stability	High	NA	NA	NA	NA	NA
Limiting Imperviousness	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Filtration and Settling	High	Low	Low	Moderate	Moderate	Low
Cation Exchange	NA	Low	Moderate	Moderate	Moderate	Moderate
Plant Uptake	NA	Moderate	Moderate	Moderate	NA	Moderate
Denitrification	NA	NA	Moderate	NA	NA	Moderate[1]

[1] Nitrogen only.

Low ~ 0 - 40 percent
Moderate ~ 40 - 70 percent
High ~ 70 - 100 percent
NA = Not applicable

* Over time, a buffer's pollution removal rate is dependent on its capacity to store and recycle nutrients. Where pollutant loads exceed this long-term capacity, the amount of pollutants in the runoff flowing across a buffer may increase. For example, in urban areas, sediment often builds up in buffer areas until a major stormwater flow washes much of it into the water. (Source: Metropolitan Washington COG, 1996)

In summary, the size, slope, vegetation, soils, and contributing drainage area of a buffer are all factors that determine its ability to act as a BMP. For this reason, buffers must be carefully selected for their capability to handle more than small volumes of stormwater. For instance, design criteria of buffers as BMPs is particularly sensitive to site-specific and local conditions. Regardless of the buffer's ability to handle stormwater runoff, it must be properly managed and maintained to ensure that design values are not altered and pollutant removal efficiency is retained.

As a consequence, many communities have adopted stream buffer requirements as one element of an overall urban watershed protection strategy. According to recent studies, when buffers are designed with realistic objectives in mind, programs are better accepted by the community and developers, alike. The uniform buffer designs of the past offered increased susceptibility to disturbance and encroachment and often became imperceptible components of the landscape to contractors, property owners, and even local governmental agencies.

Recreation and Riparian Buffers

Riparian buffers and streamside corridors serve different community needs. Some people view these green corridors as park and recreation areas, while others value their natural aesthetic beauty and wildlife habitat potential. These perceptions have evolved in recent years as the broad benefits provided by riparian buffers and other natural areas are being realized – whether for stream protection, wildlife habitat, or recreational facilities. Despite the differing perspectives of the importance and use of forest buffers, they are key features of the urban landscape. They provide multiple recreational and environmental benefits for adjacent communities.

Many urban communities have become interested in greenways or green corridor initiatives that attempt to marry all of the riparian buffer benefits and tie into recreational aspects, such as jogger and hiker/biker trails. A greenway is defined as: "[a] linear open space established along either a natural corridor, such as a riverfront, stream valley, or ridgeline, or overland along a railroad right-of-way converted to recreational use, a canal, a scenic road, or other route," or, "[a]ny natural or landscaped course for pedestrian or bicycle passage."

Greenways act as transportation routes for bicycles, pedestrians, recreation, wildlife education, or simply as greenspace for the sheer enjoyment they provide. Greenways or other linear green corridors improve environmental quality by reducing vehicle emissions through trip reduction, providing water quality benefits, wildlife habitat, and expanding forest cover.

There are many missed opportunities for the general public to have green corridors in urban areas because of encroachment, private landownership, or severe channel degradation along urban streams. However, partnerships among adjacent communities, recreation and transportation officials, stream protection advocates, and local governmental agencies can effectively change urban stream corridors into functioning greenways. This partnership approach has paid off in cities like Boston, Boulder, Cleveland, Harrisburg, Minneapolis/St. Paul, Seattle, San Diego, and Washington, DC, where miles of quality trail systems have been established. These cities and many like them across the country have developed greenways systems in conjunction with existing linear natural areas or stream corridors.

As expected, difficulties can be encountered when attempting to acquire new rights-of-way or even in redesignating existing rights-of-way. People along these greenways worry about crime, viewshed degradation, and loss of their privacy and safety. Other considerations revolve around conflicts between users, policing, maintenance, and trail design considerations, such as interpretive signage, access points, and trail width.

The establishment of greenspace is encouraging because it increases forest cover, habitat, recreation, and other benefits. However, it must be understood that as we demand more use of our green corridors in urban areas, there is a direct relationship to the uses and the maintenance required. The impact on the resource, monetary costs of increasing its size to meet recreational needs, and the impact of limiting its use should always be considered.

Wildlife Habitat Values of Urban Buffers

Riparian areas and wetlands contain the greatest diversity of species. Urban forest buffers help protect this resource and provide critical habitat for wildlife. Many wildlife species need both aquatic and terrestrial habitat. Riparian buffers provide detritus and large woody debris for instream aquatic life. As the urban landscape becomes more developed, establishment and protection of forest habitat along streams becomes even more critical.

Buffer Specification Guidance

As previously mentioned, riparian buffer corridors can be designed to accommodate a broad range of goals and objectives, including stormwater management, wildlife habitat, bank stabilization, erosion control, and recreation. When examined closely, these objectives tend to complement rather than oppose each other. At different locations along the corridor, however, the primary function of the buffer may change as physical and social conditions change. For example, a small buffer adjacent to an apartment complex, with high levels of imperviousness, may not be able to provide stormwater treatment, but may have an important role in protecting streambanks and providing recreational needs for the community.

Urban stream buffers are an integral element of any local stream protection program. By adopting some of these rather simple performance criteria, communities can make their stream buffers more than just a designation on a map. Better design and planning also ensure that communities realize the full environmental and social benefits of stream buffers.

The ability of an existing buffer to provide particular benefits depends on how well the buffer is planned, designed, and managed for the specific situation. The following information is offered as practical guidance for the development of an urban buffer program. Much of the guidance reflects issues and solutions used by planning agencies across the country to meet a variety of program objectives.

Buffer Widths

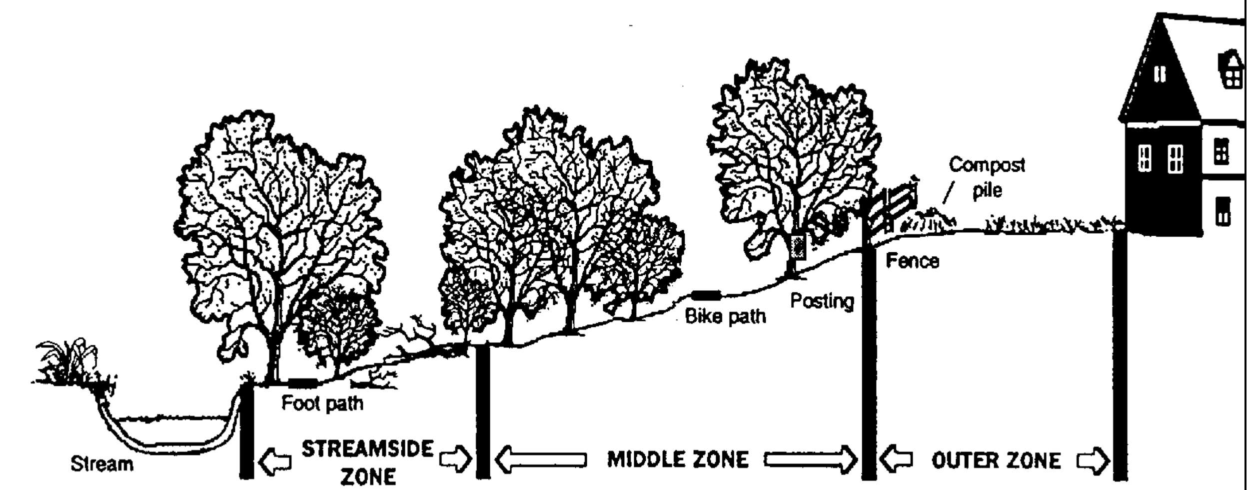
Surveys of local forest buffer criteria reveal that stream buffers are typically required to be a uniform width from the adjacent stream channel. Buffer width specifications range from 20 to 200 feet on either side of the stream, with a median width of 100 feet. In most cases, the jurisdictions used state or local width criteria without clear understanding of the scientific rationale or purpose. These criteria were sometimes altered to meet political needs for compromise. Most programs required that all lands within the 100-year flood plain be included within the buffer width, with some jurisdictions expanding buffer areas to include wetlands, steep slopes, and critical habitat areas.

Buffer slope, vegetation, soils, and other features should be used to determine the width required to achieve water quality objectives. A minimum width of 75 to 100 feet is recommended to provide effective stream protection. In most survey locations, this translates into a buffer that is three to five mature trees wide on each side of the stream channel. Often, trees in the riparian area are not mature, and not evenly dispersed. A buffer 100 feet wide may be eight to ten trees in width, depending on species, stocking density, and other factors. The removal of sediments and particulate pollutants from surface runoff, for instance, may require widths of between 50 and 2,025 feet. A buffer's ability to treat stormwater from adjacent land uses also depends on the extent to which that flow becomes channelized before it reaches the buffer. Adequate structures and space should be used on adjacent land to spread out channelized flow, known as sheetflow. It is important to consider the costs of various width requirements in light of anticipated benefits. The analysis should consider the cost of administering and maintaining the buffer program.

Three-Zone Buffer System

As shown in Figure 11-3, an effective urban stream buffer can be divided into three lateral zones, each performing a different function. The zones also have varying widths, vegetative targets, and management schemes. The three zones include:

- The <u>Streamside Zone</u> – It protects the physical and ecological integrity of the stream ecosystem. The vegetative target is mature riparian forest that can provide shade, leaf litter, woody debris, and erosion protection to the stream. The minimum width is 25 feet from each streambank (approximately the distance of one or two mature trees from the streambank), and land use is highly restricted. In urban situations, this includes preexisting conditions, such as confined stormwater channels, footpaths, and utility and roadway crossings. Ideally, in a new development, these attributes would be minimized substantially.
- The <u>Middle Zone</u> – It extends from the outward boundary of the streamside zone and varies in width depending on stream order, the extent of the 100-year flood plain, adjacent steep slopes, and protected wetland areas. The middle zone protects key components of



CHARACTERISTICS	STREAMSIDE ZONE	MIDDLE ZONE	OUTER ZONE
FUNCTION	Protect the physical integrity of the stream ecosystem	Provide distance between upland development and streamside zone	Prevent encroachment and filter backyard runoff
WIDTH	Min. 25 feet, plus wetlands and critical habitats	50 to 100 feet, depending on stream order, slope, and 100 year floodplain	25 foot minimum setback to structures
VEGETATIVE TARGET	Undisturbed mature forest. Reforest if grass	Managed forest, some clearing allowable	Forest encouraged, but usually turfgrass
ALLOWABLE USES	***Very Restricted*** e.g., flood control, utility right of ways, footpaths, etc.	***Restricted*** e.g., some recreational uses, some stormwater BMPs, bike paths, tree removal by permit	***Unrestricted*** e.g., residential uses including lawn, garden, compost, yard wastes, most stormwater BMPs

Figure 11 - 3. Three-Zone Urban Buffer System. Three lateral zones comprise the foundation of an effective urban stream buffer zone. The width, function, management and vegetative target vary by zone. (Sources: Schueler, 1995 and Metropolitan Washington COG, 1995)

the stream and provides further distance between upland development and the stream. The minimum width of the middle core is approximately 50 feet, but it is often expanded based on stream order, slope of the presence of critical habitats, and the impact of recreational or utility uses. The vegetative target for this zone is also mature forest, but some clearing is permitted for stormwater management Best Management Practices (BMPs), site access, and passive recreational uses. Recreational activities include: biking, hiking, nature trails, and picnic areas.

- The <u>Outer Zone</u> – It is the “buffer's buffer.” It is an additional 25-foot setback from the outward edge of the middle zone to the nearest permanent structure. In many urban situations, this area is a residential backyard. The vegetative character of the outer zone is usually turf or lawn, although the property owner is encouraged to plant trees and shrubs to increase the total width of the buffer. Use restriction in this zone is minimal. Indeed, gardening, compost piles, yard wastes, and other common residential actions occur within this zone, not all of which are promoted. The only significant restrictions include septic systems and new permanent structures.

With reference to stormwater management, the outer and middle zones of the stream buffer may be used as a combination grass/forest filter strip under very limited circumstances. For example, if the buffer cannot treat more than 75 feet of overland flow from impervious areas or 150 feet of pervious areas (rooftop, driveway, concrete patio that is discharged to the backyard), the maximum runoff velocity should be calculated for both the six-month and two-year storm designs. The evaluation should include numbers from each of the contributors to the overland flow path, based on the slope, soil, and vegetative cover present. If the calculation indicates that velocities will be erosive under either condition (greater than three feet-per-second (fps) for six-month storm, five fps for two-year storm), the allowable length of contributing flow should be reduced.

Width Flexibility Planning

Streamside forest buffers should be flexible in order to conform to topography, flood plains, and existing drainage patterns that take advantage of existing forest cover. Many buffers' specifications are inflexible, requiring a uniform width for conformity to a pre-established development design. As defined earlier, the streamside zone is somewhat inflexible in that it must be afforded minimal disturbance; however, it is flexible in the sense that it will always include the immediate flood plain and intersecting streams. The middle and outer zones will fluctuate according to the proposed adjacent land use and in accordance with other topographic features to the greatest extent possible.

The middle zone can be expanded to include the following:

- The full extent of the 100-year flood plain (required in many areas)
- All undevelopable steep slopes (>25%)
- Steep slopes (5 to 25% slope, at four additional feet of slope per percent increment of slope above 5%)
- Adjacent delineated wetlands or critical habitats

The middle zone also expands to protect streams and related ecosystems of significant quality or higher order streams within the watershed. For example, the width of the middle zone may increase from 75 feet (for first and second order streams) to 100 feet (for third and fourth order streams) and as much as 125 feet for fifth or higher order streams and rivers. A very localized buffer width modification can be allowed in some circumstances to accommodate unusual or historical development patterns, shallow lots, stream crossings, or stormwater ponds.

Vegetative Target

The ultimate vegetative target for the streamside and middle zone of most urban stream buffers should be the pre-development riparian plant community, which in temperate eastern climates is forest cover. In general, the target should be based on the natural vegetative community present in the adjacent flood plain or from reference riparian areas.

The vegetative target for the streamside zone is related to the specific goals of the buffer. To meet objectives of stormwater management, a high density, stable cover is critical to treatment goals. Buffers designed primarily for wildlife purposes will be valued according to their ability to provide food, forage, and cover for target wildlife species (see Section III, for information on species selection for riparian reforestation).

Buffer Delineation

The process of delineating buffer areas will vary for different sizes or orders of streams. For example, a buffer on a first or second order stream can be most easily defined by using the stream centerline as the inner edge of the buffer (see Figures 11-4 and 11-5). As stream order increases, the inner edge of the buffer is better defined as edge of the stream channel.

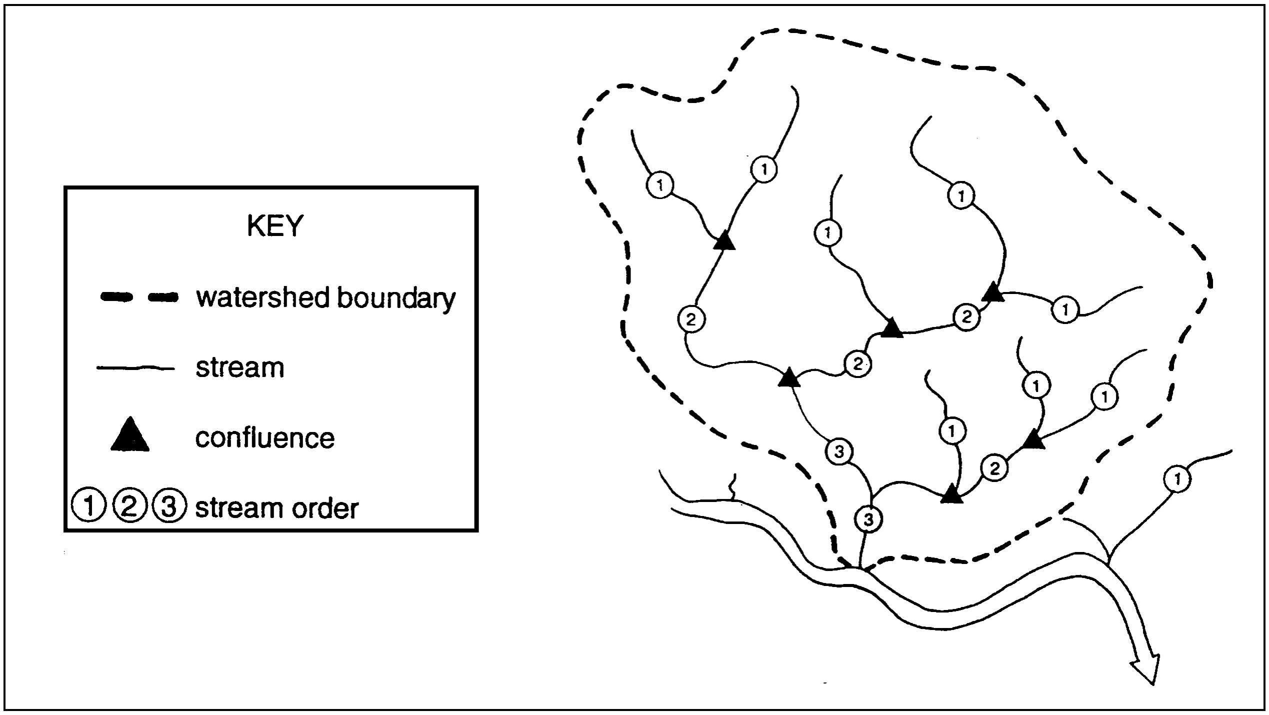


Figure 11 - 4. Stream Order Concept. Stream order is a useful tool to classify the many elements of the stream network. (Source: Metropolitan Washington COG, 1995)

Traditionally, the mapping scale used to define stream order is the USGS 7.5-minute quadrangle maps (1 inch = 2,000 feet). Perennial streams at this topographic scale are depicted as "bluelines." However, a considerable number of smaller drainages exist, such as intermittent, small swales, or ditches that are not shown at this scale. Larger scale maps and field verification are the only foolproof technique to determine the actual location of all drainage at the site.

Stream origin points may be in dispute if no definite source can be determined. For land clearing purposes, the conservative approach defines stream origin as the point where several minute, intermittent streams form a distinct channel(s). This is indicated by the presence of a largely unvegetated streambed and high water marks. A more hydrologically conscientious approach would be to evaluate topography more closely through the use of more detailed maps, field inspections, and a visit to the site during a rain event. For the sake of comparison, arid geographic regions of the country have defined stream origin as *the upper limit of running water during the annual wet season*. However stream origin is defined, expect conflicts resulting from the altering of drainage from agricultural and development activities.

Buffer Crossings

Stream crossings for roads, railways, underground utilities, and open and enclosed storm drains have direct effects on forest buffers and the associated stream network. These structures fragment forest and create both surface and subsurface barriers to wildlife and fish passage and hydrologic flows.

The following criteria should be followed to minimize the impact to urban buffer systems (see Figure 11-5). Any performance criteria established should specifically describe the conditions under which the stream or its buffers can be crossed.

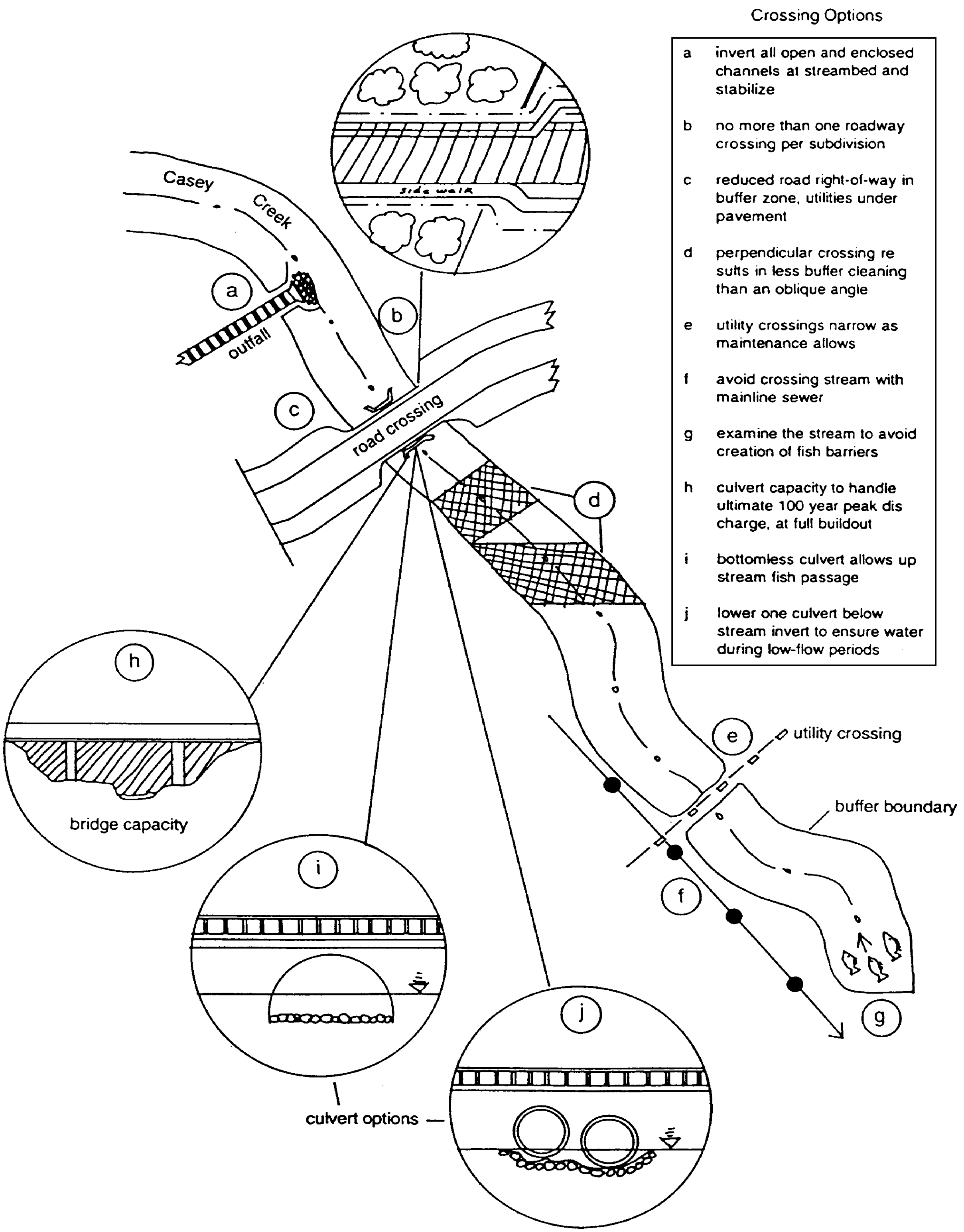


Figure 11 - 5. Crossing the Stream Buffer. Two major goals of a stream buffer are to maintain an unbroken riparian corridor and to allow for fish passage. Therefore, the conditions under which the buffer can be crossed should be clearly defined. (Source: Schueler, 1995)

Examples of these performance criteria are:

- Crossing Width – Minimum width to allow for maintenance access.
- Crossing Angle - Direct right angles are preferred over oblique crossing angles, since they require less clearing in the buffer.
- Crossing Frequency - Only one road crossing is allowed within each subdivision, and no more than one fairway crossing is allowed for every 1,000 feet of buffer.
- Crossing Elevation - All direct outfall channels should discharge at the invert elevation of the stream. Underground utility and pipe crossings should be located at least three feet below the stream invert, so that future channel erosion does not expose them, creating unintentional fish barriers. All roadway crossings and culverts should be capable of passing the ultimate 100-year flood event. Bridges should be used in lieu of culverts when stream crossings require a 72-inch or greater pipe. Small stream crossings should be avoided, as they tend to create fish barriers. Slab, arch, or box culverts are better alternatives to round, metal culverts for small stream crossings. Where possible, the culvert should be "bottomless" to ensure passage of water during dry weather periods.

Locating Stormwater Ponds and Wetlands Within the Buffer

Stormwater ponds and wetlands, types of BMPs, can be located within the buffer area, but there can be adverse effects. If constructed within the buffer, there will be:

- localized clearing of trees
- alteration of surface and subsurface flow regimes
- potential barriers to fish migration
- alteration of the receiving stream ecology
- stream warming

However, an advantage of placing the BMP within the buffer is that the facility is likely to treat a larger drainage area than if placed in other locations on the site. Other benefits of siting within the buffer include:

- Reducing the costs of the project due to savings in materials such as pipe, trench, and excavation.
- Reduced clearing and grading on the designated developable land where ponds and other stormwater structures are typically located, providing a bargaining chip for seeking the preservation of buffers on-site.
- Aesthetic considerations such as the removal of unsightly stormwater ponds and structures from prominent points in the project site.
- Most important, adjacent or instream facilities can enhance habitat and structural diversity to the buffer and ecosystem.

These benefits do not mean that stormwater ponds and wetlands should always be placed within the buffer in all situations. Instead, thoughtful consideration should be given to the impacts and the performance potential for the facility over the long-term. In cases where abnormal levels of pollution and sediment deposition are anticipated, location of BMPs within the buffer areas may be the most practical solution, given their effectiveness in removing pollutants.

Criteria for restricting the use of BMPs in buffer areas are as follows:

- Confine the contributing area to a maximum suitable for that BMP,
- Restrict use within the first 500 feet of stream channel, or
- Limit clearing of the streamside buffer zone to the outflow channel only (if the pond is discharging from the middle zone into the stream), or to off-line locations within the middle or outer zone of the buffer, or to use ponds only to manage stormwater quantity within the buffer.

Management of Forest Buffers During Plan Review and Construction

Having well-defined criteria for the delineation, use, and protection during construction and post construction management of riparian areas is essential to implementing a riparian forest buffer/BMP program. A well-managed system for planning and tracking these areas will encourage full participation by those in the land planning/development process. It will prevent the degradation of habitat and aesthetic quality and ensure that a particular stream system does not receive excessive stormflows. Some helpful guidelines are:

- Require preliminary buffer delineation on conceptual and final plans
- Confirm that buffer delineations and subsequent changes are calculated and mapped properly
- Field verify stream delineations as drawn
- Check buffer size calculations for suitability against the proposed use as a stormwater treatment facility
- Determine that other BMPs within and outside of the proposed project can perform to specified parameters, and that they have been properly integrated into the buffer system
- Carefully review all buffer crossings to minimize impact

Buffer Education, Encroachment, and Enforcement

Treatment of forest areas and stream buffers during construction is tenuous because of mixed perceptions of the susceptibility of forested areas to disturbance. Education of site level personnel is imperative to maintain protection around these areas. Other site level safeguards include:

- Clearly designating buffer boundaries with durable, brightly colored signage that describes protection guidelines.
- Inviting construction personnel and adjacent property owners to presentations, field demonstrations, and stream walks.
- Providing concise information about the benefits and uses of the buffer, as well as follow-up meetings with homeowner associations.
- Providing a program whereby property owners are fully informed about buffer limits and uses at the point of sale for property or property transfers.
- Establishing a resident's buffer stewardship program for monitoring, reforestation, and backyard buffer enhancement that includes annual inspections.

The point of providing information about the functions of forest buffers and impacts of human interference is to prevent the degradation of the buffer's usefulness as a BMP and as a habitat area. Encroachment is a major problem in urban areas; individual landowners believe that their actions will not harm the buffer's functions. The cumulative effects of dumping, understory removal, and drainage path alteration are difficult for the individuals to perceive. Awareness and education measures are intended to increase the recognition of the buffer within the community. It is advisable to establish an enforcement mechanism to resolve conflicts with violators. These restoration measures should have the "teeth" necessary to achieve restoration of the damaged areas and to levy fines, but only as a last resort. Some program administrators have had success in placing the full cost of buffer restoration on the violators through the imposition of property liens.

Existing Urban Buffers

In most regions of the country, a 100-foot buffer will remove approximately five percent of the developable land of the total land area from development. Although this is a small percentage, combined with other regulations, such as setbacks, roads, recreation set-asides, and easements, it can be a significant additional impact on the developable portion of the property. In preexisting communities, it is difficult to establish protection for forest buffers without strong opposition by the property owners adjacent to the stream. If easements, tax credits, or donation of private land cannot be accomplished, the identified tract(s) may need to be purchased outright to avoid litigation over "takings" issues. It should be understood that obtaining all of the desired parcels cannot be immediate, in fact, some parcels may never be obtained. Goals that are realistic and tempered with a flexible attitude will be the most successful. The basic intent of the buffer program is to modify development location in relation to the stream, not the development's intensity.

Private Ownership of Buffers

Retrofitting buffer protective measures in existing communities is the most problematic of any buffer protection program. From a maintenance perspective, private property ownership of riparian forest buffers is preferable to public ownership. The cost and responsibility of the buffer is not the community's. Incentives, such as increased property values associated with forested tracts as well as aesthetic and recreational benefits, are all important in maintaining private buffers for the future. A key strategy in preserving private buffers is that the reservation of the buffer cannot take away all economically beneficial use for the property. Four techniques – buffer averaging, density compensation, conservation easements, and variances – are used to ensure that the interests of the property owners are protected. These techniques for buffer acquisition are as follows:

1. Buffer Averaging

This basic concept permits the buffer to become narrower at some points along the stream to allow for preexisting structures or to recover parcels reserved for their exceptional natural value, provided that the minimum width is not compromised. In general, buffer narrowing is limited, such that the streamside zone is not disturbed, and no new structures are allowed within the 100-year flood plain (whichever distance is greater).

2. Density Compensation

Density compensation grants a developer a credit for additional density allowances elsewhere on the same site in exchange for developable land that was reserved for the buffer requirement. Developable land is determined after subtracting the portion of the buffer area remaining after the 100-year flood plain, wetland(s), and steep slope areas. Credits are granted when more than five percent of developable land is consumed, using the scale shown in Table 11-3. The density credit is accommodated at the development site by allowing greater flexibility in setbacks, frontage distances, and minimum lot sizes. Cluster development also allows the developer to recover lots that are taken out of production due to buffers and other requirements in exchange for higher

Table 11 - 3

Sample Schedule for the Use of Density Credits in Compensation to Developers for Land Consumed by Stream Buffers

Percent of Site Lost to Buffers	Density Credit*
1 to 10%	1.0
11 to 20%	1.1
21 to 30%	1.2
31 to 40%	1.3
41 to 50%	1.4
51 to 60%**	1.5
61 to 70%**	1.6
71 to 80%**	1.7
81 to 90%**	1.8
91 to 99%**	1.9

* Additional dwelling units allowed over base density (1.0).

** Credit may be transferred to a different parcel.

(Adapted from Burns, 1992)

density on developable portions of the property. Again, the intent of the stream buffer is to modify the location, not the intensity of development. Buffer averaging, density compensation, and variances also minimize the responsibility of those private property owners that are adjacent to the stream.

3. Conservation Easements

This type of easement allows for the donation to a land trust as a charitable contribution that can reduce an owner's tax burden. Some jurisdictions have afforded landowners the option of the perpetual conservation easement. Variations allow for the easement to be donated to a local government in exchange for an amortized reduction and/or elimination of property tax on the parcel.

4. Variances

The buffer ordinance should have provisions that enable an existing property owner to be granted a variance or waiver, if the owner can demonstrate severe economic hardship or unique circumstances in meeting some or all of the buffer requirements. Similar to the zoning variance process, property owners should be provided an appeals process in the event of a variance denial.

Planning Reforestation Sites in Urban Areas

During the planning process, one of the main considerations should be acquiring permission and negotiating with the landowner. A great deal of time and effort must be devoted to this process. It is a critical first step in developing a successful urban reforestation project.

Plantings are frequently chosen on the basis of available land, ease of access, or aesthetics – none of which may be the best site in terms of effectiveness or overall watershed need. To target areas for reforestation, watershed need must first be determined by examining watershed health and existing conditions. This is not to say that trees planted on a randomly selected streamside location are not helpful to the stream and existing forest habitat, only that the optimal benefit is not realized. This is an important point because all of the sites cannot be reforested at once, if at all, given limited financial resources and sites available.

Identifying Riparian Buffer Planting Sites

In 1994, a new technique called the Urban Riparian Restoration Project (URRP) was developed to evaluate a watershed for suitable riparian reforestation sites. This technique is an assessment tool to:

1. Target restoration resources to the most environmentally effective sites, and
2. Prevent project failure resulting from other environmental conditions that may be overlooked in the project planning stage.

The URRP method is a three-tiered system to evaluate the health of the watershed using land use, topographic, soils, and other maps. It also uses aerial photographs, watershed imperviousness, natural resource data, and landownership to rank areas for restoration activities.

This strategy aspires to examine all potential projects, natural or unnatural occurrences or effects to a stream system, and habitat and survivability potential. For example, if an eroding riparian are is reforested before examining the hydrologic fluctuations of the stream system, the trees may be washed away before they can establish and stabilize the area. Prior to a project such as this, it would be more prudent to examine the solutions to the peak streamflow that is accelerating the erosion. This may involve tandem engineering solutions that would require bank stabilization and upstream/ instream activity that would obliterate the reforestation project. Of course, it is impossible to anticipate all potential problems, but this strategy can dramatically diminish conflicts.

American Forests has developed a computer software program called "City Green" that uses satellite imagery and standard aerial photographs to evaluate a number of criteria for ecosystem health. Some of these criteria are imperviousness, forest cover, population, and

Pre-Planting Field Visit Check List

- *Identify site access*
- *Verify site boundaries*
- *Calculate actual planting space*
- *Calculate plant spacing*
- *Assess soil condition (type, compaction)*
- *Identify surrounding vegetation*
- *Check sun/wind exposure*
- *Note presence of invasive plants*
- *Note erosion/sedimentation problems*
- *Proximity of residences/facilities*
- *Volunteer parking/restrooms*
- *Need for bushogging (weeding)*
- *Water sources*
- *Mulch dumping location*

land use. All of these are tabulated to determine the level of degradation of that watershed.

Planting Season

Typically, the planting seasons for reforestation projects in the Mid-Atlantic Region (USDA Zones 6, 7, and 8) are as follows:

- March through Late-May – seedlings and container/balled and burlapped plants
- Late September through November – container/balled and burlapped plants

While this window may seem narrow, reforestation projects are frequently performed with volunteers and with minimal financial support; therefore, return site visits for watering, weeding, and other maintenance are frequently minimal. Since the plant's survival is left to the elements, the timing of the planting must be when the elements are the most beneficial to the plants. Reforestation projects other than those stated are not recommended as weather conditions can be extremely harsh and severely affect plant survivability.

Planting Site Visit

Once the site is identified, a site visit is necessary to measure the planting area, assess planting conditions, soils, current vegetative cover, and other factors. If possible, schedule this visit during the growing season to observe what growing conditions will be like for the plants and to develop an idea of site preparations and future maintenance needs. The information in this section will describe how to plan and execute a reforestation project.

Items Needed for Planting at the Site

- *Shovel*
- *Stakes*
- *Swinging Blade*
- *Work boots*
- *Measuring Tape*
- *Calculator*
- *Hammer*
- *Flagging*
- *Sketch-Pad*
- *Camera*
- *Plant I.D. Book*
- *Gloves*

The items listed above should be on hand during the site visit. They will be used to gather the information specified in the site visit checklist.

Since property owners of riparian areas in urban areas will frequently be a public agency, coordination will be with the local government. However, whether public or private, the following procedures for meeting to discuss the project will be primarily the same.

1. Meet with property owners on-site to establish a clear understanding of planting boundaries and mark the locations in their presence. Check for the presence of overhead utility lines, and find out what underground utility lines are in the area. Establish acceptable access point(s) to the site for plant and mulch delivery, volunteer parking, and other neighborhood concerns. Together, note any site irregularities, such as trash/debris, erosion, and flooding. Take

notice of adjacent forestland for garbage or natural debris, such as grass clippings, pruning clippings, and other yard waste. This material should be removed prior to the planting, and adjacent property owners must be encouraged to keep the area clean.

2. Sample digging conditions at several locations. Note any potential difficulties, such as hard, compacted, or rocky soil; insufficient or excess soil moisture; landfill materials; or roots. If the soil is particularly hard, for example, bring additional tools for the task. Also, consider reducing the project scope to match the trees planted with the number of volunteers anticipated for the planting. (*See Urban Soils below.*)
3. If the site is an unattended field, mowing will most likely be necessary to access the planting area. In subsequent years, grass around the plants will need to be trimmed manually until the plants are established. High grass and weeds can be beneficial as a shield from winter winds or drought, although they will compete for moisture and nutrients under newly planted trees. If grass is not mowed, plan two to three site visits per season to remove competing plants in the immediate root zone of the trees for the first few seasons.

Urban Soils

<u>Soil type is the most important factor</u> in determining the kinds of plants that will grow on a specific site. There are 16 different nutrients that are essential for plant growth. Of these 16 nutrients, 13 are derived primarily from the soil. Soil also provides water storage and support for plant roots. Soil type dictates moisture retention, nutrient absorption, nutrient composition and availability, and compactability. Soils in urban areas are typically poor as a result of:

- original topsoil being removed during land clearing for construction,
- compaction by machines and/or people,
- years of erosion , and
- poor soil management.

Many sites in urban areas that are prime for reforestation projects have the poorest soils. In many cases, urban soils have an upper soil layer devoid of organic material. These soils frequently contain mixtures of backfill soils, construction debris, and other non-indigenous soil compositions that are devoid of nutrients.

The question of how to correct urban soil problems is complex. In many cases, nothing is done to improve soil quality because of time, materials, equipment, and funding. Certainly, it is recommended that a soil test be conducted from several locations throughout the site. While corrective measures should strive to achieve the optimum soil quality, the reality in many situations is that any improvement will be welcome (See Table 11-4). Some inexpensive options include: soil aeration; compost application; and cultivation in conjunction with a topsoil, gypsum, lime, or other soil improvement catalyst as recommended by the soil test results. If soil is severely compacted, it is virtually pointless to plant anything before the compaction problem has been resolved. Compacted soil contains no oxygen (oxygen being a necessary soil component for root growth) and is impervious to moisture absorption; both are key factors for the survival of young plants.

This section does not presume to provide an exhaustive list of recommendations for solving soil problems in urban areas. The goal is to introduce the various possibilities and to strongly encourage that they be addressed where possible.

Visible soil properties are key indicators of the quality of a soil (Section IV). These properties include color, texture, structure, and depth. Each of these soil properties is closely correlated to one or more properties that actually control plant growth; therefore, one can infer the ability of a soil to support plants from these four properties.

Soil Color

Soil color is an indicator of soil properties that affect plant development. The overall color of the soil is an indicator of organic matter content,

Table 11 - 4. Soil Amendments for Urban Tree Plantings

Soil Characteristics	Problematic Range[1] Low	Medium	High	Corrective Measures for Consideration
Physical				
Soil Textures				
Sand	<50%	>75%	>90%	Add organic matter (OM), irrigate frequently.
Clay, Kaolinitic[2]	<25%	>50%	>65%	Add OM, DO NOT over irrigate, reduce traffic, and compaction.
Clay, Expandable[2]	none	any	>10%	Reclaim with gypsum and leaching, DO NOT plant perennials until reclaimed.
Clay & Silt	<30%	>50%	>75%	Add OM, irrigate correctly, deep till, aerate and reduce compaction and traffic.
Structure		variable		Eliminate compaction, traffic, add OM; manage beneficial micro-organism and root growth; reduce sodium concentrations. DO NOT over till, especially at high RPMs.
Bulk Density[2], Mg/m^3				
Clay	<1.1	<1.4	>1.5	Add OM; deep till.
Loam	<1.2	>1.5	>1.7	Same as above.
Soil Crusting		variable		DO NOT leave bare soil; add OM and mulch; grow groundcovers; eliminate traffic; and reduce droplet size of irrigation spray.
Aeration Porosity[2], % large pore volume	>5	<2	<1	Add OM; deep till, eliminate traffic and compaction; increase earthworm population.
Soil Permeability, Infiltration and Percolation Rates, in./hr.	>0.50	<0.25	<0.20	Add OM; deep till, aerate; use mulches, adjust irrigation rates accordingly.
Debris and Litter		variable		Remove from soil surface and profile where possible.
Temperature	Extreme hot or cold soil is influenced by exposure, elevation, latitude, water content, nearness to a large body of water, etc. Select adapted plants, use mulch, shade soils; use raised beds with heavy, wet soils and maintain adequate soil moisture; drain wet soils.			

1. Approximate determinations, subject to site parameters and subjective judgment.
2. Requires determination in a soil testing laboratory.

Table 11 - 4. Soil Amendments for Urban Tree Plantings (*cont.)*

Soil Characteristics	Problematic Range[1] Low	Medium	High	Corrective Measures for Consideration
Morphological				
Depth to bedrock	>10'	<4'	<2'	Add top soil.
Seasonal Water Table Depth	>10'	<4'	<2'	Remove source, improve surface drainage, install subsoil drains, Select trees tolerant of short-term standing water.
Apparent Water Table Depth	>10'	<6'	<4'	Same as above.
Restrictive Horizons	>10'	<6'	<4'	Improve structure and/or install surface and subsurface drainage.
Impermeable Layers	>10'	<6'	<4'	Deep till to break up or same as above or both.
Disturbed and Mixed Horizons and Profiles		variable		Add organic matter (OM) and mix well, DO NOT bring subsoil to surface.
Cuts, Remaining Top Soil Depth	>4'	<2'	<1'	Replace top soil (blend into top of subsoil), DO NOT remove topsoil to subsoil.
Fill Soil		variable		Match new texture and structure with original soil and blend into existing soil. Deep, uniform fill is best.
Fill Depth Over Roots	<6"	1'	>1'	Soil porosity dependent; avoid fine-textured and poor-structured fill. Add OM; install aeration tile at root level before covering.
Excessive Slope		variable		Stabilize mechanically. Terrace, add top soil and OM, drip irrigate, eliminate traffic, plant soil-stabilizing species.
Soil Erosion, in./yr.	<0.1"	<0.25"	>0.25"	Reduce slopes, irrigation rates, wind and traffic. Plant groundcovers and windbreaks; mulch and terrace.
Wet, Putrid Soils	Brown	Tan	Gray, Black	Remove source of stagnant water; install surface and subsoil drainage, then incorporate coarse OM.
Soil Structure - Massive, Platy		present vs. absent		Provide drainage, incorporate coarse OM, deep till.

1. Approximate determinations, subject to site parameters and subjective judgment.
2. Requires determination in a soil testing laboratory.

Table 11 - 4. Soil Amendments for Urban Tree Plantings (*cont.)*

Soil Characteristics	Problematic Range[1] Low	Medium	High	Corrective Measures for Consideration
Chemical				
pH[2]				
Acid Soils	<7-6	<6.0	<4.0	Add lime, select low pH-adapted species.
Alkaline Soils	7-<7.5	>7.5	>8.5	Add OM, sulfur, and acidifying fertilizers. Select high pH-adapted species.
Cation Exchange Capacity[2] (CEC) meg/100g	>10	>5	<3	Add OM and soil amendments with high CEC; fertilize regularly.
Fertility[2]		variable		Test N, P, and K levels and micro-nutrients commonly deficient or toxic; add OM and encourage micro-organism growth; adjust the pH; use low demand, adapted plants. If deficient, DO NOT over water. Leach if toxic levels occur.
Salt-Affected Soils[2]				
Saline; EC mmhos/cm (dS/m), pH < 8.5, ESP (SAR) < 15%	<2.0	<4.0	>4.0	Sensitivity is species specific, leach saline soil, add OM, use good quality leach and irrigation water.
Sodic; EC mmhos/cm (dS/m), pH ≥ 8.5, ESP (SAR) ≥ 15%	4.0	<6.0	>6.0	Add gypsum and leach. In calcareous soils add sulfur, lime sulfur, iron sulfate, aluminum sulfate and leach; add OM.
Sodic-Saline; EC mmhos/cm, pH < 8.5, ESP (SAR) ≥ 15%	4.0	<6.0	>6.0	Same as above.
Chemically Polluted[2] Soils	numerous chemicals & concentrations			Identify the polluting chemicals; detoxify, leach, remove or abandon site; train personal to prevent; stockpile construction materials and chemicals off site; avoid spilling pollutants; monitor storage tanks for leaks, repair immediately.

1. Approximate determinations, subject to site parameters and subjective judgment.
2. Requires determination in a soil testing laboratory.

drainage, and aeration. Some soil colors and characteristics associated with them are:

Black—High in organic matter and may be poorly drained. Soil becomes darker as organic matter increases from 0 to 8 percent. At 8 percent or above, soil is essentially black.

Brown—Good organic matter content and well drained.

Red—Low in organic matter and well drained. Redness is due to oxidized iron or red parent material.

Gray—Low in organic matter and poorly drained. Gray color is due to excess water and poor aeration.

Yellow—Low in organic matter and well drained.

Organic matter coats soil particles and masks their natural color. The natural color of soil particles is determined by their mineralogy. Since the abundance of many plant nutrients is also related to mineralogy, the unmasked color of soil particles becomes a key to potential nutrient availability. For example, quartz is a common translucent mineral that contains no plant nutrients; while feldspars, which are opaque white to pink or green minerals, are high in plant nutrients. In general, the greater the diversity of colors among soil particles, the higher and more balanced is the potential nutrient-supplying power of the soil.

Plant Selection

Plants should be selected based on the geographic region, plant height and form, and the native vegetation present at the site. If the site is unvegetated, survey adjacent sites along the stream. The list created from this survey will be the basis for researching the other species for the final plant list. Do not assume that if a particular species exists at a site, it is native. Use a reference guide (such as the *Manual of Woody Landscape Plants* by Michael A. Dirr) that contains information on plant history and other factors affecting plant selection.

A limiting factor in obtaining native plant material is availability at local nurseries. A regional nursery may need to be contacted to receive the material desired. When possible, try to purchase plants that normally grow in the reforestation area. Plants grown in different climatic conditions, (milder or more severe winter moisture conditions) will not adapt as readily as a locally grown plant. As a rule, try to purchase plants within one USDA hardiness zone of where they will be planted before searching suppliers in other zones. Although there are several "native plant nurseries" in the Mid-Atlantic Region, species selection and quantities are not always plentiful in the sizes desired. When developing the plant list, be prepared to make species and size substitutions.

Know plant species' characteristics and needs prior to ordering; for example, moisture requirements, shade tolerance, height, and drought tolerance. If planting trees under utility wires, select trees that are no taller than 20 feet high when mature. Map their locations and numbers accordingly. Many plant species adapted to wetland, lowland, or riparian soils will tolerate excessive moisture; however, planting sites are not always directly adjacent to water-bodies or may exhibit upland site conditions and may require the use of some more upland species depending on soil type and moisture content at the site.

Container-stock and bare-root seedlings are the simplest product to use for reforestation projects. Transportation and handling are significant concerns when equipment availability or site access is limited. Delivery of plants to the site is the most convenient, and most nurseries will deliver sizable orders to the site for a nominal fee depending on the distance traveled. Plan to order plants early in the season to get the widest selection and best quality stock. When plants are delivered, check the manifest against items delivered. Nurseries ship large quantities of plants in spring and fall, and errors are possible. Have a knowledgeable person present to identify plant species, particularly when plants are not in-leaf. Segregating plants by species at the time of delivery is necessary to know how to properly geographically distribute plants on the site and successfully execute the planting plan.

Wildlife Habitat Considerations

Diverse communities of plants and animals in urban areas contribute to the overall health of an urban ecosystem and are important indicators of livability for humans. Plant selection for wildlife habitat creation is an important part of this urban ecosystem. Native forests and forest edge ecosystems contain a variety of small trees, shrubs, and herbaceous vegetation. In particular, the forest edge areas usually contain a diverse population of plants that offer wildlife a variety of sources for food and shelter. Many wildlife species thrive in the edge, or transition zone, where two different cover-types merge. This forest edge zone provides a wildlife border between an open area and the forest, and between the border and the forest.

When properly planned and executed, a human-created forest edge zone can be established through plantings that will enhance forest buffers and encourage the natural expansion of forested areas, improve forest density and wildlife cover, and provide a wildlife food source. Select some plants for the project that provide food for wildlife. In the Mid-Atlantic region, trees that produce nuts or berries, such as oak, hickory, cherry, dogwood, holly, or walnut, should be encouraged where possible. Flowering dogwood, serviceberry, and American holly are small trees suitable for wildlife. Viburnums, blueberry, sumac, elderberry, and bayberry are examples of acceptable shrub species. Running cedar and Virginia creeper are suitable vines. Herbaceous vegetation may include native grasses, legumes, and wildflowers. Vines and herbaceous vegetation should be planted in the zone between the shrubs and the open area. Select only native species and be careful that invasive species, such as honeysuckle, multiflora rose, or English ivy, are not planted as they can quickly crowd-out all other plant species.

Existing forestland adjacent to planting areas should not be disturbed except in the following situations. To:

- remove hazardous trees within close proximity to human activity,
- remove garbage and other unrelated debris that has been dumped,
- remove sediment deposits,
- remove exotic vegetation that has taken control, or to
- plant native understory when it is necessary for forest cover enhancement.

When areas are disturbed, some requisite replanting of understory and overstory vegetation may be needed to more quickly reestablish the area. Do not attempt to remove naturally deposited forest debris, such as branches, leaves, stumps, and decaying logs. Forest debris creates nesting and cover areas for wildlife and is necessary for the recycling of nutrients in the forest ecosystem.

Plant Spacing

Some questions arise regarding plant layout and spacing. Generally, there are two schools of thought on this subject: Uniform Plant Distribution vs. Random Plant Distribution. The benefits of uniform distribution are that layout and maintenance are much simpler, particularly when using volunteer labor for installation. Variability and the natural appearance of a Uniform Plant Distribution planting can be enhanced by mixing species randomly within the planting. A disadvantage to this approach is that the reforestation project becomes “too structured and unnatural” in appearance. The answer to this criticism is that plant mortality will compensate for uniformity and leave vacant spaces between plants as well as opportunities for germination from natural seed dispersion of existing plants. Random distribution provides the initial “natural spacing” appearance, but creates difficulties when attempting to perform survivability counts, as well as maintenance activities, such as mulching and the sickle-blading of grass. Whichever method is chosen, plant spacing should be close enough to reflect a forested situation and not landscaping. It should also provide enough distance for adequate plant establishment before root systems begin to compete within the limited growing space. Some examples of plant spacing are listed in Table 11-5.

These spacings are presented to provide an understanding of plant/spacing relation ships. Once the size of the site is calculated, determine appropriate spacings based on the specifics of that site.

Table 11 - 5
Plant Spacing for Various Size Stock

Number of Trees/Acre	Tree Size (inches)	Spacing (feet)	Planting Area/Per Tree (square feet)
100	2 caliper	20 x 20	400
200	1 caliper	15 x 15	225
435	< 1 caliper container-stock	10 x 10	100
680	seedlings	8 x 8	64

Invasive/Weed Control

Native plants are those that are historically, naturally occurring in a given geographical area and exist in balance with the natural diversity of that area. Exotic plants are those plants that are not currently growing in their native habitat and, therefore, may not have any natural limiting factors to their proliferation.

An important issue to consider while planning a reforestation project is the impact of existing invasive or exotic plant materials. When non-native or exotic plants are introduced by humans into an ecosystem, a myriad of management problems may arise. The common offenders to forest invasion are kudzu, loosestrife, multiflora rose, trumpet vine or wisteria, privet, mile-a-minute weed, and bamboo. Ground covers, such as English ivy, that have escaped from residential properties can also be damaging. Not surprisingly, the plant characteristics that made the plants desirable are the very characteristics that make them invasive – ease of propagation, hardiness, food and cover for wildlife, pest and disease resistance, or form and growth habit.

Control measures must be considered in areas where exotic plants are taking control. First, identify seed source locations and restrict their movement until the appropriate control measure(s) can be determined and executed. Control measures can be as simple as grubbing or digging out the unwanted species or spot-treating plants with a herbicide during the growing season (See Figure 11-6). However, both methods can be harmful to the forest ecosystem if done haphazardly and improperly. For some species, control can be attained with a regular mowing program. The timing of these control methods is most important to prevent seed heads from forming and dispersing. The best control method involves the initial understanding of the life cycle of the species being controlled, as well as the effectiveness of the control measure.

Certainly the most obvious concern for control of exotic/invasives is to prevent their being planted and becoming established. Encourage the planting of native plant species in public information campaigns, meetings, and brochures. Local, state, and federal native plant conservation groups typically publish lists of native plants for specific geographic areas. These groups also have information on where these plants can be purchased in your area.

It is important, however, to remember that not all exotic plants are invasive and not all invasives are exotic. Some plants are merely very opportunistic and, therefore, overpopulate an area where other plants are not establishing. Section VII and the appendix provide a list of species considered to be exotic and invasive and a list of desirable native plant species for the Mid-Atlantic Region.

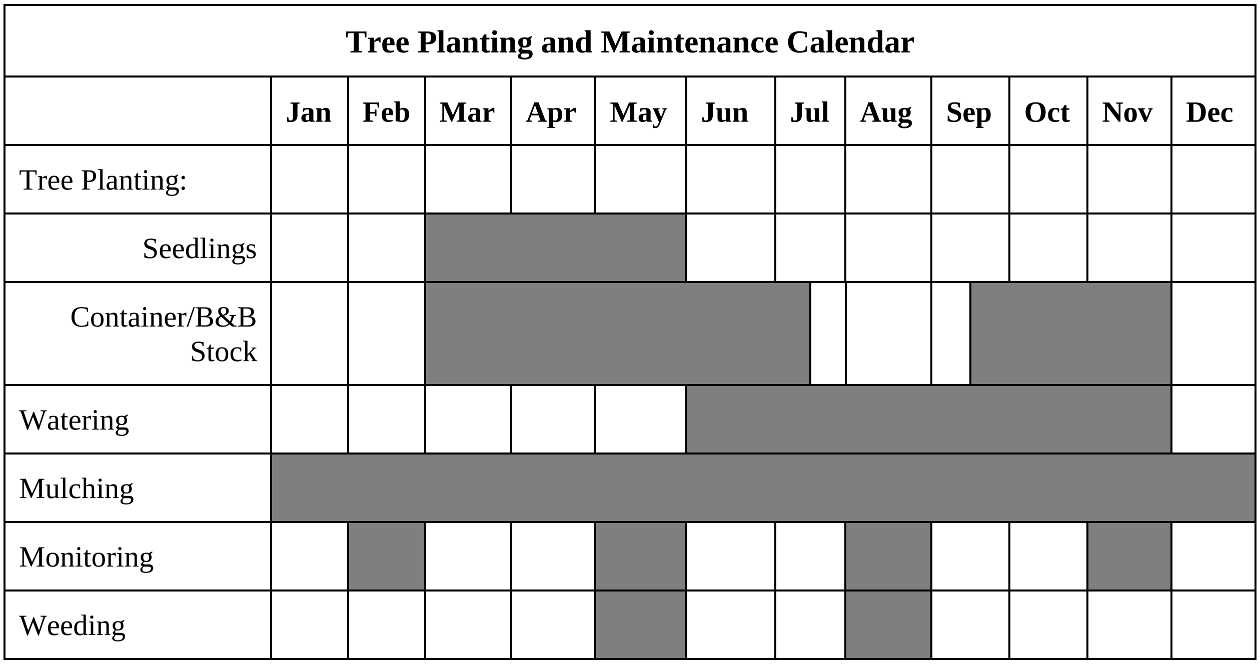


Figure 11 - 6. Tree Planting/Maintenance Schedule.

Public Safety

Trails and other recreation facilities associated with a reforestation project have tangential concerns from environmental restoration, particularly in urban areas. Crime and physical hazards should be considered and addressed during project planning for the benefit of the users of the recreation facility. Many jurisdictions have regulations specifying a minimum distance for vegetation to exist when associated
with a recreational facility, particularly bikeways, jogging trails, or other greenway facilities. To provide a safely reforested and landscaped environment, borrow ideas from the concept of Crime Prevention Through Environmental Design or **CPTED**.

According to Officer Josh D. Brown of the Fairfax County, VA, Police Crime Prevention Unit, assigning community members to serve as caretakers to communal areas can increase territorial loyalty. A housing development in Louisville, Kentucky, planted a flower garden, and the maintenance was assigned to several members of the community. This provided a regular visual inspection by those responsible for the garden. Community members discouraged loitering, crime, and vandalism through their visibility.

Transitional plantings, lighting, and plant selection are important to consider for safety when planning projects through these areas. Native annual and perennial flowers, wildflowers, and other herbaceous plants can be used to help ease the transition. Consider the maturity height of the plants selected before planting. Avoid using tall plants such as those that will attain a height of three or more feet and obstruct views along the corridor.

Many times a crime problem is recognized after the fact, long after a facility is completed and landscaping is installed. A safer environment can be achieved by merely redesigning and rearranging the existing landscape. Trees and shrubs directly adjacent to trails, through neglect, can gradually establish places for crimes to occur. Existing vegetation within approximately ten feet of the center-line of the trail should be limbed or pruned up to eight feet from the ground. There is a difference in philosophy when trying to establish a “natural area.” For this reason, planting anything other than low-growing annual or perennial herbaceous vegetation or forest understory vegetation is not recommended. Concentrate naturalizing efforts on the area where reforestation is permitted by planting the lower-growing plants at the edge, then planting rows of medium-height plants, and ending with rows of plants that are tall at maturity. Use evergreens sparingly in these areas as they can be of particular concern to those trying to maintain trail safety while allowing the planting to occur. In some cases, trees with drooping limbs, such as weeping willow, should be trimmed higher to maintain adequate visibility.

Lighting, used correctly, can make the difference between a safe or unsafe landscape. Whether on buildings, under trees and shrubs, or on lampposts, lighting can be used effectively to illuminate the surroundings, without blinding pedestrians and residents. It should be mentioned, however, that certain types of lights illuminate more effectively without "overlighting" the landscape. Select the types of lighting that achieve specific lighting needs and avoid confusing the landscape with too many poles, fixtures, and electric cables. Also, select lights that provide similar light intensity. For example, incandescent, fluorescent, mercury, and sodium lamps generate different ranges of illumination and should not be used together in a lighting scheme to avoid lighting "hot spots" and shadows. Some lights, such as mercury vapor lamps, produce 50 percent more light and use less energy than conventional lighting.

The key points to remember are:

- maintain landscapes near trails or walkways,
- reduce obstructions to view,
- use native thorny shrubs as a natural barrier to traffic and as a deterrent to concealment, and
- do not create dimly lit areas by allowing landscaping to become overgrown.

Citizen groups or networks can be established to regularly monitor and care for trail areas, which will create a safer environment. Areas for native and non-invasive wildflower plantings can be designated to create a neighborhood connection and human presence at the trail site.

Ordinances/Zoning

Zoning is commonly used as a tool to guide activities in riparian areas. Zoning ordinances set aside areas specifically for the preservation and planting of trees under existing flood plain regulations and building setback regulations. Other ordinances include the set-aside of forested land under easements, environmental quality corridors, and forest conservation programs based on tax-based incentive vehicles on a watershed-wide basis. There are some specific protection strategies that municipalities are using to protect the riparian area.

Tree plantings are sometimes discouraged within the flood plain of flood control projects because of the potential impacts on peak water levels. Wetland area activities, such as tree plantings, are closely regulated by various state and federal agencies. Permission must be granted before planting occurs in these areas. Some jurisdictions also may have concerns about riparian plantings in areas of potential archeological significance.

Some of the major riparian corridor protection strategies are:

1. *Fee Simple Acquisition* - The municipality purchases the riparian area outright, guaranteeing its protection and public access. This can be very expensive.
2. *Easement Purchase* - The municipality purchases limited rights to the riparian area, and the landowners receive tax benefits. This is cheaper than acquisition, but the municipality must ensure that it gets the rights it needs to ensure protection and public access.
3. *Overlay Zoning* - Overlay zones are a type of resource protection zoning that are superimposed on traditional zoning to protect riparian areas, while still allowing the underlying use in suitable forms. As an example, a municipality produces and adopts an

official map that complies with the Federal Flood Insurance Program and regulates what can be done in the riparian area. The map delineates the area known as an Overlay District. Several riparian corridor protection standards are written into a zoning ordinance to regulate use and intensity of riparian area activities. This strategy gives the municipality legal control of the area without having to own the property. This strategy is well suited to municipalities with riparian areas of varied type, serving several functions and having many values to the citizens. This strategy considers all the land uses that are adjacent to the riparian area.

4. *Transfer of Development Rights* - A transfer of development rights (TDR) program allows municipalities to preserve unique and environmentally-sensitive riparian areas. This is a form of overlay zoning that targets specific segments of a riparian corridor for preservation. Landowner property values are protected because they are permitted to transfer their right to develop, based on the underlying zoning district, to a portion of the municipality designated for more intensive development. This allows the riparian corridors to be permanently deed-restricted from development, while maintaining the land's value.

5. *Bonus/Incentive Zoning* - Bonus zoning is similar to transferable development rights, except that the additional development rights are generated and used by the developer rather than purchased from another landowner. Incentive zones set both a standard set of conditions and an optional set of incentives that the developer may choose to meet in exchange for greater flexibility. For example, an incentive zoning law may allow a developer in a zone to build at a higher density than is normally allowed if the developer agrees to set aside more open space or adopt certain energy saving or transportation measures.

6. *Large Lot Zoning* - Large lot zoning requires that each house be constructed on a lot of certain size, typically from 5 to 30 acres. The theory is that spreading occupancy thinly across the area will conserve open space and reduce adverse impacts on wildlife and water resources. Large lot zoning has some disadvantages, such as promoting sprawl, fragmentation of habitat, increased pressure on public services, and the exclusion of lower income families who do not have the means to purchase large lots.

7. *Clustering* - This strategy, sometimes called open space zoning, allows municipalities to offer incentives or to use regulation to ensure that new subdivisions cluster homes on smaller lots, leaving some land as a common green space for the whole community. Homes can be clustered in upland areas, allowing the riparian area to be set aside and protected as a common area for those who live in the community to enjoy.

8. *Performance-based Zoning* - This type of subdivision expands on the overlay concept. The municipality identifies the performance criteria that must be met by any development in the zone. The developer is given flexibility in planning and developing the subdivision, as long as the criteria are met. For example, the developer is required to subtract all or a portion of his land that is in flood plain, riparian areas, road rights-of-way, and steep slopes before calculating the permitted density of the proposed housing units. Then he can design his units and lots as he sees fit.

9. *Streambank Setback, or Resource Protection Zones* - The municipality can protect riparian areas through use of an established riparian forest buffer. The buffer is similar to a utility right-of-way. The width of the setback is determined before construction of the subdivision begins. Zoning ordinances use two approaches – a fixed buffer or a floating buffer. A fixed buffer may prohibit development within 200 feet of the high water line of a perennial stream. A floating

buffer may vary in width depending on site, soil, and runoff characteristics.

10. *Agricultural Protection Zoning* - This strategy is used to preserve agricultural lands and prevent them from being developed. It is done by requiring cluster development on agricultural lands, or by requiring that lots be large, such as 100 acres. The areas not used for homes are required to stay in agricultural use.

11. *Urban Growth Boundaries* - This is a zoning district that is set up to encourage development within it, but development is discouraged outside the district boundaries.

Implementing a Riparian Reforestation Plan

After the initial planning stages, the reforestation plan is ready to be implemented. Several issues need to be addressed to ensure effective implementation of the planting plan. Key issues include: procuring a planting labor force, obtaining necessary tools, watering, mulching, and long-term maintenance of planted areas.

Volunteer Support

The first place to look for volunteer support is within the community or watershed where the proposed project will occur. Contact existing or established community-based organizations that may lend their support for the project. Notices posted at community centers, recreation facilities, and announcements at public meetings are the best and most appropriate ways of garnering support for the restoration activities. Canvass the neighborhood through flyers notifying the community of the intent and focus of the project and ask for comments and support. In a strong and well-established community organization, this will be a relatively simple task. However, in a community where a loosely-structured or non-existent organizational structure exists, support for the project will be needed from those outside of the immediate neighborhood on a watershed level.

Many volunteer organizations exist in major metropolitan areas, as well as in suburban and rural areas, that are dedicated to a variety of issues. Some groups are specifically dedicated to the cause of environmental protection and restoration. They frequently sponsor projects of this nature and will be interested in a team approach to the project. Given advance notice, these groups can publicize the project within their contact network. These volunteer organizations may have sites currently designated and approved for restoration activities that could be useful when searching for sites within the watershed.

Sources of Community Support

- *Local Utility Companies*
- *Local Businesses*
- *The Neighborhood*
- *Established Community-Based Groups*
- *Recreation Centers*
- *Schools*
- *Civic Organizations*
- *Resource Conservation and Development Councils*
- *Government Social Services/Criminal Justice System*
- *Local Church Groups*

The day of the planting or other restoration activity, plan for a short demonstration of how to proceed safely and properly to achieve project goals. Explain the goals of the project and how their efforts will be valuable toward achieving those goals. Volunteers bring a variety of experiences to the project that may be useful in performing the task at hand. When at the site, ask for assistance in the demonstration from a volunteer who has some experience planting trees. Although it is difficult to find two horticultural professionals that can agree on how a tree is to be planted, there may be some common-ground to provide an effective demonstration. Provide an explanation for each tool and instruction in its use. Some volunteers may be inexperienced in tree planting. Take time to demonstrate the proper techniques to all participants and to provide guidance as needed, explaining its importance as you proceed.

Entrusting long-term site monitoring to volunteers is particularly important as it provides a sense of ownership and pride in the project. Try to enlist volunteers to provide monitoring activities in the coming months following the project. These activities will be most convenient for a nearby resident.

Obtaining Tools

Obtaining tools to equip large numbers of workers for a one-day event can be a challenge. Listed below are some suggestions for locating and obtaining tools:

- Contact participating local government agencies for help. They may be willing to lend equipment for a one-day weekend event if the tools are retrieved and returned in a timely manner.
- If funds are available, some essential tools could be purchased and used for subsequent projects provided that adequate transportation and storage are available.
- Sponsor an event with an established restoration group that has access to the necessary equipment. Long-term restoration goals are often more successful when they include other community organizations and groups with similar goals.
- Request volunteers to bring their own tools for the event.

Whatever option or combination of options is chosen, tag or mark tools with the owner's name or identification number to ensure their return. Table 11-6 on the following page lists some of the tools that will prove helpful, contingent upon the type and scope of the project.

Watering

Watering at many reforestation sites, even in urban areas, is difficult. Typically, water is not readily available. Frequently, plants rely on rainfall for watering. For this to be successful, plantings must be timed to coincide with seasonal rains. Rainfall must be monitored well in advance of the planting date to ensure that the surface soil has received adequate moisture and that there is time for additional rainfall in the post-planting period (see Figure 11-6). Although this method seems somewhat precarious, the success rates are higher than might be expected. This is one reason why the timing of plantings discussed earlier is so critical (see Page 11-16, *Planting Season*). Success is contingent on having plant root-balls (in the case of container-grown or balled and burlapped plants) or root mats (for seedlings) sufficiently moist at the time of planting. Coordinate with the plant supplier to ensure that plants will be watered a day or so before delivery. As an insurance policy, have several buckets of water on-site during the planting in which to dip the plants prior to planting.

Occasionally, local sources may be helpful in providing initial or post installation watering. Some options are to haul a watering tank or barrel to the site or to request assistance from the local fire department or forest fire protection units and public works departments. These agencies can also provide additional assistance and may appreciate the opportunity to participate in the project. Whatever the watering method, moisture should be monitored carefully during the first season after the planting to prevent wholesale loss of plants due to drought.

Mulching

Mulch the soil surface around the plants with two or three inches of a coarse slow-decomposing medium, such as shredded bark, compost, leaf mulch, or wood chips. Organic mulches retain moisture, retard evaporation, moderate soil temperatures, control weeds, and improve appearance. Uncomposted mulches, such as grass clippings and sawdust, decompose rapidly and require more frequent applications resulting in reduced benefits. They are not recommended. Do not place mulches directly against the tree trunk as this creates a moist area that can provide a favorable environment for boring insects or fungi.

Mulch is considered by many to be a cosmetic top-dressing. However, the proper type of mulch can have many benefits. Research results suggest that height growth and trunk diameter base increase significantly if the ground near the tree is kept free of grass. Besides the clear advantage of preventing turf competition to young trees, expect fewer tree injuries caused by mowing equipment.

Table 11 - 6

Types of Tools Needed for Reforestation Projects

Tool	Use
Shovels	General planting activities
Dibble Bars or Planting Bars	A tool for planting seedlings swiftly
Edging Spade	Breaking sod or backfill material
Pickaxe(s) or Mattock(s)	Cutting through sod and root mats
Pick(s)	Digging through compacted soil
Pitchfork/Mulch Fork	Eases the transfer of mulch to wheelbarrows/buckets
Lopping Shears	For cutting through large roots and containers
Hand Pruners	Trimming excess roots and broken branches
5 Gallon Buckets	For carrying water and mulch
Wheelbarrow(s)	For carrying large quantities of mulch
Mallet & Stakes	For marking site boundaries and tree shelter installation
Flagging	To ease locating plants for maintenance activities
Signage	For public notification of the site location
Volunteer Items	
Work boots	For safety while using tools, and in case of wet, muddy conditions
Gloves	Inexpensive cotton gloves to prevent blisters
Refreshments	For volunteer comfort

There are several different types of mulch available, most of which are shredded or chipped tree bark. Typically, chipped mulch is from pine trees and shredded mulch is from deciduous hardwood trees. Sometimes the two types are blended for color and final appearance. Pine bark has a high acid content that slowly leaches into the soil and may not be favored by certain plants. The exclusive use of pine bark does not provide good moisture retention and weed control because it does not compact well when spread in open planting beds. The loose spread of pine bark also makes it susceptible to redistribution by wind and heavy rain. Similar problems occur with leaf mulch, straw, and pine tags – particularly if not kept moist.

If mulch is plentiful for the reforestation project, the site can benefit from having an edge to edge covering of the entire site. Spread 3 to 4 inches deep, mulch will discourage weeds, retain moisture, reduce maintenance activities, and result in increased plant survivability.

Types of Mulch Available

- ✓ Shredded hardwood mulch
- ✓ Chipped pine bark
- ✓ Composted twigs, leaves, wood chips, or grass clippings
- ✓ Straw or Salt Hay
- ✓ Leaf Humus
- ✖ DO NOT USE Fresh or "green" wood, twigs, or other wood waste

In general, shredded hardwood mulch has good moisture retention and weed control benefits and is relatively unaffected by wind and rain. Shredded hardwood mulch is marketed in coarse, medium, and fine grinds. The more coarse the grind, the greater the moisture retention and weed control benefits. Coarse ground mulch is also less susceptible to dispersement by wind and rain.

Whichever mulch type is selected for use, make sure that it has been properly composted before use to minimize the ensuing leachate. Uncomposted yard waste, such as grass clippings, twigs, branches, and leaves, can be harmful to plants when used as mulch, because they compete with the plant for soil nitrogen to continue decomposition. Improperly composted wood chips from tree chippers can also be harmful to plants. Although this material can be obtained free at landfills, utility companies, and tree maintenance companies, in most cases, it has not been properly composted to neutralize the decomposing microorganisms. When the chips are stored in large piles, sufficient amounts of alcohol and/or acetic acid can accumulate and kill plants when the chips are later used as mulch. Another concern of using this freshly chipped waste is that the composition is unknown. If the material being chipped was dead, diseased, or insect infested, and not properly sterilized, these problems can be spread by using this material as mulch.

Not surprisingly, the mulches used most frequently on reforestation sites are a combination of wood chips/leaves/twigs because they are readily available and may at most require a nominal delivery fee. Since most reforestation projects operate on a very limited budget, groups, either knowingly or unknowingly, take the risk of damage from the wood chips to the plants. If possible, try to stockpile this type of mulch for six months to a year before use or reserve funds in the reforestation budget for obtaining composted mulch.

Of the types of mulch listed, salt hay may require an explanation. Salt hay or *Spartina sp*. is a wetland plant that is cut and dried for use as a mulch when establishing a seeded bed where contamination from seeds contained in bedding straw or hay is a concern. It is commonly used in the establishment of a wildflower meadow or a new lawn. It is not recommended for use in forest establishment or for large landscape areas because of product availability and cost. For this reason, salt hay is typically used in small areas where the need is justified by the benefits derived.

There are some problems with heavy mulching. Many riparian sites are subject to flooding and the mulch could just end up downstream.

Mulching can destroy the open meadow habitat and prevent natural succession from field to shrub/scrub. Mulching can be detrimental to wildlife habitat.

Planting Protection

In most urban areas, the best protection for any reforestation project is communication, visibility, and maintenance. Communication through recurrent signage, fencing, and flagging are all effective physical protection measures from unintentional mowing, traffic, or other damaging activity. Coordination and regular communication with property owners, public or private, is an effective method of protection from unintentional mowing or other seasonal maintenance activities at the project site. Regular maintenance, such as weeding and mulching, (Figure 11-6) improves project visibility through both aesthetic appearance and a human presence at the site. Substantial signage that describes the nature of the restoration activity in bright colors and large print placed at a height of five to six feet every 75 or 100 feet provides good public awareness of the project.

For public properties, arrange meetings with maintenance personnel through the supervisory staff. These members will establish and confirm the existence and need for protection of the reforestation project. Reaffirm this recognition of the location of the project annually as maintenance personnel are often seasonal hires and will not know about the project. Staking connected with rope or string draped with brightly colored flagging is also a relatively economical visibility measure. Flagging on individual trees may be all that is necessary in some instances. In many urban situations or other high traffic areas, nothing short of fencing of the entire site will be sufficient. However, whole-site fencing is expensive if purchased outright and is not affordable for most restoration project budgets. For fencing and other more elaborate protection measures, seek donations of materials from local agencies or businesses. There may be an opportunity to acquire used fencing from a demolition or construction company at a nominal charge for delivery. Once acquired, the fencing may be reused at subsequent reforestation sites.

Localized and individual plant protection is also available for planting sites, especially when planting seedlings. Tree protectors or shelters are products that have been designed to provide extra protection for seedlings from deer browsing, beaver damage, or lawn mower injury. Tree shelters are cylindrical plastic sheaths that are placed around individual seedlings to protect them from harsh winter winds, human, or animal damage. They provide a high degree of visibility for the planting site after summer grasses grow tall. The shelters also prevent invasive or aggressive annual plants from overtaking the much slower-growing trees.

Their use is recommended for deciduous trees only, and they must be installed carefully to ensure the potential benefits. Netting placed at the top of the tube has been added to address the concern for birds becoming trapped inside the cylinder. Although tree protectors are biodegradable, they should be removed within the first two or three years after installation. After two years, they can restrict growth and encourage weak trunk development by restricting the development of flexible/structural wood. Tree shelters also require maintenance to keep them in place because they can become unstable from wind, animal disturbance, or vandalism.

Certain tree species have performed better than others in tree shelters. Fast-growing species, such as green ash, sweetgum, and sycamore have all performed consistently well in tree shelters. However, slower-growing species, such as oak, have not performed as well as other species in the urban setting. Red oak that is root pruned can do very well in shelters. Typically, tree shelters offer less benefits in strictly urban situations than they do in rural settings. Tree shelters can keep saplings from being mowed or run over, and they also help prevent mortality from drought. In some cases, even those benefits have been compromised because of vandalism as a result of the increased visibility.

Insect and Disease Control

Typically, a healthy forest and newly established reforestation sites have minimal insect and disease problems. Control measures in a healthy forest ecosystem are not employed as a rule, except with massive infestations of gypsy moth or other devastating pest or disease problems. Diseases are usually confined to individual or small groups of trees or specific species and do not usually threaten diverse forest stands; therefore, they will rarely need control measures.

This is not always the case in urban areas where insect and disease problems can often be traced to stress from the surrounding urban environment. There are many stresses in urban areas, such as root suffocation and compaction, air pollution, grade changes that affect moisture conditions, poor soils, and trunk injury. When trees are subjected to higher than normal stress levels, the opportunities for insect and disease infestations increase. Certainly, the best control method in any situation is prevention; try to alleviate the factors that are contributing to the trees' stress. If specific pests can be identified as part of the problem and can be controlled, that may only be part of the problem. If the poor environmental/growing conditions continue, pest control measures are merely treating the symptoms of a larger problem. If forest stress factors are not corrected, the insect and/or disease infestation is likely to recur.

When insect and disease problems are suspected, it is advised to seek professional help. Professional consultants or the local agricultural extension agent are good sources for disease or pest identification and recommendations on control measures. Preliminary information about symptoms of the suspected problem will be useful when contacting the professional. Compare suspected unhealthy trees with others of the same species to verify evidence of the problem.

Examine all available control methods before the application of any remedies. Chemicals are not always the answer to a problem. The extension agent will usually provide several control options from which to choose. Some problems will require a series of measures to be applied over the life cycle of the pest depending on the season. Be aware that some pests cannot be controlled, while for others, the problem is short-lived, and control is unnecessary.

Following are four options available for the control of pest and disease problems once properly identified; non-chemical control, biological control, chemical control, and integrated pest management.

1. Non-Chemical Control

This control method focuses on a program of preventive maintenance that provides very effective control of insects and disease through proper silvicultural practices.

Wounds

Prevent mechanical damage inflicted by vehicles, lawn mowers, and string trimmers by discouraging mechanical maintenance. Wounds provide an entry point for insects and disease organisms.

Mulching

Maintain a mulched area, three to five feet in diameter at a three- to four-inch depth around each tree, and increase as the tree matures to discourage competition from weeds and encroachment from close mowing and trimming.

Sanitation and Vector Control

Some disease organisms and insects can "overwinter" or hibernate in the organic debris of dead plant material. Eliminating such material for identified pest or disease problems can reduce infestation potential. However, do not remove any other debris because it is a vital component of the forest ecosystem.

2. Biological Control

This control method focuses on insect populations that are becoming increasingly resistant to chemical pesticides from their overuse. As the costs and regulation on the use of most commercial insecticides rise, biological control of insects has presented an innovative option to pest control. Biological controls reduce chemical pesticide applications, use materials that are non-toxic to mammals, and affect only the target pest. Some types of biological controls are:

- introduction of bacterial and viral organisms that prey on pests
- introduction of parasites and predators that prey on pests
- the use of insect sterilizing agents and lures

3. Chemical Control

If used properly, chemicals can be an invaluable forest management tool for controlling insects, diseases, and undesirable competition. Proper use of chemicals requires an understanding of insect and disease life cycles as well as a knowledge of commercial fungicides, insecticides, and state and federal regulations for their use.

There are several chemicals available that may control a particular pest; however, they may be toxic to beneficial insects, animals, and humans. Many chemicals for insect control are *non-selective*, meaning that they are not limited to the control of one or two pests. For this reason, it is imperative that the proper chemical is selected and applied safely. Recommendations for specific chemical controls should be obtained from qualified individuals.

Pesticide applications on a small scale by individuals is not regulated; however, many state regulations require professional chemical applicators to obtain a license. Pesticide applicator training and certification programs through state and federal agencies are designed to ensure the safe and appropriate use of pesticides. Before the community association contracts with a pesticide applicator, ensure that the company or individual is licensed and is currently certified for your area.

4. Integrated Pest Management

Integrated Pest Management (IPM) is a conservation practice based on the knowledge of the components of the ecosystem and their interaction. Also, IPM explores all possible pest control options after evaluating the biology of the plant species involved, the life cycles of existing and potential pests, and the acceptable pest population and damage levels. If a chemical or other control measure is necessary, then a pest specific control measure is determined for that situation. IPM is most effective for controlling pests that threaten large plant populations, but can be applied to individual plants. IPM programs have proven that they can reduce chemical use, expense, and citizen complaints resulting from chemical use.

References

Brown, R.G. and M.L. Brown. 1972. Woody plants of Maryland. Baltimore, MD: Port City Press.

Burns, D. 1992. Environmental protection and resource conservation plan. City of Lacey, WA. 169 pp.

Carlson, L. 1989. Artificial wetlands for stormwater treatment. St. Michaels, MD: Environmental Concern.

Desbonnet, A., P. Pogue, V. Lee, and N. Wolff. 1994. Vegetated buffers in the coastal zone: a summary review and bibliography. Coastal Resources Center. University of Rhode Island. 72 pp.

Dirr, M.A. 1983. Manual of woody landscape plants: their identification, ornamental characteristics, culture, propagation and uses. 3rd ed. Univ. of GA, Athens. Stipes Publishing Co. Champaign, IL.

Galli, J., Engineer. Personal communication. Metropolitan Washington Council of Governments.

Greenfeld, J. and B. LeCouteur. 1994. The Chesapeake Bay community action guide: a step-by-step guide to improving the environment in your neighborhood.

Harris, R.W., W.D. Hamilton, W.D. David, and A.T. Leiser. 1981. Pruning landscape trees. University of California Division of Agricultural Sciences Leaflet 2574, April.

Hornbach, W. 1993. Private property and community rights—what communities can still do after development. Lucas 3(1):14.

Heraty, M., L.M. Herson-Jones, and B. Jordan. 1995. Riparian buffer strategies for urban watersheds. September.

Heraty, M. 1993. Riparian buffer programs: a guide to developing and implementing a riparian buffer program as an urban stormwater best management practice. Metropolitan Washington Council of Governments, U.S. EPA Office of Oceans, Wetlands and Watersheds. 152 pp.

LeCouteur, B. and The Metropolitan Community Forestry Network. (in review) Community forestry management handbook: a guide for citizens and homeowner associations to manage the urban forest. Published under the Community Forestry Network and the Metropolitan Washington Council of Governments.

LeCouteur, B., J. Brown, and Fairfax County Police Department. 1994. Community forestry information bulletin: designing safe landscaping. Published under the Community Forestry Network and the Metropolitan Washington Council of Governments.

LeCouteur, B., R. Everett, M. Foreman, J. Frazier, K. Hawkins, L. Herson-Jones, M. Mohan, J. Okay, and D. Plummer. 1994. Urban riparian restoration strategy: a guide to assist planners, local governments and others in prioritizing watersheds for protection, habitat restoration reforestation, and afforestation.

Leopold, L.B., M.G. Wolman, and J.P. Miller. 1964. Fluvial processes in geomorphology. W.H. Freeman and Company, San Francisco, CA. 509 pp.

Niering, W.A. 1990. Effects of stormwater runoff on wetland vegetation (final draft). New London, CT: Department of Botany, Connecticut College.

NVPDC, Northern Virginia Planning District Commission. 1993. Greenways for northern Virginia, a resource guide for open space planning. 68 pp.

Schueler, T. 1994. The stream protection approach. Center for Watershed Protection. Terrene Institute, Washington, DC. 66 pp.

Schueler, T. 1995. The importance of imperviousness. Watershed Protection Techniques. 1(3): pp. 100-111.

Schueler, T. Site planning for urban stream protection. Center for Watershed Protection/Metropolitan Washington Council of Governments. Silver Spring, MD. 320 pp.

Schueler, T. 1995. The architecture of urban stream buffers. Center for Watershed Protection 1(4) pp. 155-164.

USDA Forest Service. 1990. Urban and community forestry: a guide for the eastern United States.

Section XII

Economics of Riparian Forest Buffers

Economics of Riparian Forest Buffers

Introduction

The term ***value***, in the context of riparian forest buffers, can have different meanings for those with different interests.

- To a hydrologist, the value of trees growing along rivers and streams might mean the significance or importance of lowering water temperature, intercepting nutrients and sediment, or stabilizing streambanks. All improve water flow and quality.
- To an ecologist, the value might be associated with the streamside forest habitat for its impact on the diversity of plant and other living resource communities.
- To an environmental engineer, the value of forests along watercourses may be linked to their ability to lower the costs of stormwater management.
- To a forester, the value may be in the harvestable trees.
- To others, there may be no obvious value, and the buffers may even be seen as a nuisance.
- But, for an economist, the term value has a precise definition – it is the price that individuals are willing to pay in order to obtain a good or service. It is measured in units (typically money) that are mathematical and attempts to quantify the worth of goods or services for a market.

However, it is important to note that these values do exist whether or not humans prefer them or are even aware of them.

Characteristics of Economic Value

- Products or services typically have value only if humans value them, directly or indirectly.
- Value is measured in terms of trade-offs, because of scarce resources like money, land, or high environmental quality.
- Typically, money is used as a unit to account value. But, sometimes monetary values cannot be assigned to environmental services.
- Individual values are combined to determine value to society as a whole.

Economic Value

Economic value is comprised of several key elements that fall into two broad groups – use values (to use a resource today, or the option for future use), and non-use or existence values (benefits gained without use today or in the future). When people talk about the economic value of a thing or a place, they are frequently referring to its "intrinsic" value. That is, its value for consumption or use by people, plus its value for non-consumptive use (to look at, or simply because it is there).

For example, the intrinsic value of a stream is linked to the *direct use benefits* of recreational or commercial activities (agricultural irrigation, for cooling or washing industrial processes, or for drinking water). *Indirect use benefits* result when the stream adds to nearby activities (good water quality results in an attractive place to hunt, fish, picnic, or bird watch). *Non-use* *benefits* result from good stewardship (conserving the water quality of the stream for one's family, future generations, or simply because its good for the Bay).

Economists attempt to isolate the various value elements to determine what is important to people, to make priority decisions for policy, and to put a price on nature's goods and services in order to estimate the value of protecting a resource or to predict what it might cost to repair it once its been degraded. But, this is a difficult task.

The tools that economists use for this evaluation are crude and cannot count all of the value that nature provides, and they have difficulty dealing with risk and uncertainty. For example, we do not know, with certainty, all the costs if a stream is lost or significantly degraded in quality, or the real value of the current benefits or unknown future benefits.

- What beneficial plant or animal could be lost, and what value could it have to people down the road?
- What will be the cost to fix it?
- What effects will it have on property value or human health to an individual or group of people in a watershed?

These questions are tough, but we can assume that conserving a healthy, viable resource will bring us more value in the long run than the risk and uncertainty of costs to restore or replace the resource. However, even with this limited information, economics can help us make better decisions. To do this, we need to use the best quantitative economic information available to make comparisons between management and policy options and their impacts, consider the non-market values (those that do not have prices, such as a bird or view), and look to anecdotal information and case studies to give examples of possible outcomes.

Economic Benefits Associated with Riparian Forest Buffers

What is the Value of Water Quality and Environmental Benefits?

Clean streams, rivers, and the Bay offer many benefits. Riparian forest buffers help ensure those benefits and avoid costs to repair damaged and degraded natural systems. As a Best Management Practice (BMP), riparian forest buffers typically perform these functions for free.

Stream Stability - Urban retrofits and stormwater management technology is expensive. Studies indicate that urban stream systems may fail to function if the watershed is at 15 percent or greater impervious surface, resulting in "blown-out" streams that silt downstream areas and increase flood potential. Forests help retain stream integrity.

- *Stormwater treatment options that integrate natural systems, such as grass swales and bioretention areas like forest, are less expensive to construct than stormdrain systems and provide better environmental results. In fact, costs of engineered stormwater BMPs range from $500 to $10,000 per acre, and will cost that much again over 20 to 25 years.*
- *After public outcry about degrading streams, Montgomery County, MD, is spending $20,000 to $50,000 per housing lot in some areas to repair damaged streams and restore riparian forests.*
- *In Fairfax County, VA, a local bond issue provided nearly $1.5 million dollars to restore two miles of degraded stream and riparian area—that's more than $750,000 per mile.*

Nutrient Removal - Adequate buffers can reduce costly water treatment.

- *The Interstate Commission for the Potomac River Basin (ICPRB) estimates that urban retrofit of BMPs to remove 20 percent of current nutrient runoff will cost approxi-*

mately $200 per acre, or $643,172,600 for the Bay basin.

- *In the same study, estimated costs of reducing runoff from highly erodible agricultural land are $130 per acre, or $68,758,430 for the basin.*
- *Wastewater treatment facilities in the Washington, DC, area have annual costs of $2 to $10 million per year per facility, which equates to $3 to $5 per pound of nitrogen removed.*
- *Maryland's Tributary Strategies show that, to reach a 40 percent reduction of nutrients by the year 2000, forest buffers and non-structural controls are significantly more cost effective than engineered approaches. Where forest buffers are estimated to cost $671,000, and nonstructural shore erosion prevention/control $1.6 million per year, comparable structural techniques could cost $3.7 million to $4.3 million per year.*

<u>Pollution Prevention</u> - Air pollution and deposit of airborne pollutants are a multi-billion-dollar problem nationally that affect human health, damage vegetation, and reduce visibility. Trapping and filtering atmospheric pollution is a benefit that trees provide, as well as riparian buffers.

- *In 1991, trees in Chicago removed an estimated 17 tons of carbon monoxide, 98 tons of nitrogen dioxide, and 210 tons of ozone.*
- *Reducing air pollution by 20 percent would cut agriculture losses in half, saving Maryland farmers $20 million.*
- *In Fairfax, VA, open space trees and buffers are estimated to have reduced the cost of traditional air pollution controls by over $4.5 million in 1995.*
- *Energy savings of 10 percent can result by adding as little as 10 percent tree cover to buffers near buildings.*
- *Forest conservation has been estimated to reduce the amount of urban runoff generated from development in Utah by 17 percent.*
- *A single mature tree releases about 100 gallons of clean water vapor per day into the atmosphere and provides the cooling equivalent of nine room air conditioners operating at 8000 BTUs per hour for twelve hours a day.*

<u>Stream Temperature</u> - The absence of streamside trees can have a dramatic effect on aquatic life through increased water temperature. Cold water trout streams were once common in the Mid-Atlantic states, but they have been greatly reduced due to loss of riparian trees.

- *The relationship between stream shade and trout production is firmly linked. Studies have shown that when stream surface shade is reduced to 35 percent, trout populations can drop by as much as 85 percent.*
- *In 1991, Maryland recreational fishers contributed $467 million to the state economy.*

What is the Value of Services Provided by a Wooded Stream Corridor?

Riparian forests are integral to the health of the Bay and its rivers. Their position on the landscape makes them excellent buffers between upland areas and waters that eventually enter the Bay. Scientific studies have shown dramatic reductions of 30 percent to 95 percent in nutrients (nitrogen and phosphorus), sediment, pesticides, and other pollutants in surface and groundwater. Riparian trees provide deep root systems that hold soil in place, thereby stabilizing streambanks and reducing erosion. And, riparian forests offer a tremendous diversity of habitat. Habitat layers provided by trees, shrubs, and grasses make these areas critical to life stages of over half of all native Bay species.

<u>Erosion Control</u> - Erosion and sediment control produces significant costs during development and in maintenance to communities down the road. Buffers mitigate some of these costs for free and add quantifiable and non-quantified benefits.

- *Current state and local requirements for erosion and sediment control (ESC) increase the cost of development. On a typical site,* *costs of ESC average $500 to $1500 per cleared acre. Forest conservation, riparian buffers, and clustering sharply reduce ESC costs and provide services for free.*

- *Average costs for subdivision developments include clearing (forest) $4000 per acre, and sediment control $800 per acre. However, forest conservation keeps soil on site, resulting in less time and labor re-grading, stabilizing, and re-landscaping the site.*
- *It costs $10 to $11.5 million annually to dredge and dispose sediments deposited into Baltimore Harbor to keep it navigable. Sediment produced by forestland is the lowest of all land uses.*

Flooding - When floods pass through a forested stream corridor or flood plain, the roughness of the forest and its lush vegetation help to reduce the energy of the water flow, thereby reducing damage to riverbanks and the effects of downstream flooding. Forests reduce the quantity of water for stormwater.

- *Retaining forest area and buffers has reduced stormwater costs in Fairfax County, VA, by $57 million.*
- *Observations made after the 1993 floods in the Midwest showed that where forests were retained in the flood plain or where levees had overgrown with trees, damage to the levee system and the river were less than areas maintained in grass or farmland. Although these benefits are difficult to put a price on, property damage exceeded $50,000 to $250,000/mile.*
- *Similar observations of damage to river banks and adjacent farmlands were recorded following floods in Virginia in 1994-95 where statewide damage totaled more than $10 million.*

Increased Property Values - Frequently seen as a "loss," forests and buffers have been found to increase the value of property, and to provide important environmental and recreational benefits.

- *Property values grow with trees. When surveyed by the Bank of America Mortgage, real estate agents say that homes with treed lots are 20 percent more salable.*
- *In Maryland, the Forest Conservation Act is working. Forest and buffers are being conserved, and developers say that they are receiving 10 to 15 percent premiums for lots adjacent to forest and buffers.*
- *A recent economic study done for areas in southern California states that home prices increase an average of 17 percent because of trees and buffers.*
- *Builders in Amherst, MA, reported that added costs of forest retention on site are always recouped in increased sales prices.*

Recreational Greenways - Linear forests along our rivers attract revenue and are an important recreation resource to communities.

- *Housing prices were 32 percent higher when located next to a greenbelt buffer in Boulder, CO. In one neighborhood, increased property value of $5.4 million attributable to the greenway results in additional annual property tax revenues of over $500,000.*
- *Greenways offer business opportunities. Evidence shows that the quality of life for a community is an increasingly important factor in corporate relocation decisions. Greenways are often cited as an important contributor to quality of life.*
- *According to a 1995 attitude survey, 77 percent of Maryland resident respondents said that it is important to have natural areas close to where they work and live. Almost half said that they would be inclined to move if existing open space in their community were lost.*

Wildlife Habitat - Buffers provide valuable wildlife habitat. Many species use riparian areas at various stages of their life cycles and as travel corridors. Organic matter produced by riparian trees is the foundation of the food web in most stream environments.

- *Each mile of 100-foot buffer on both sides of a stream protects 24 acres of high-quality habitat along shorelines and creeks.*
- *Tourists and residents place a high premium on wildlife watching. A 1994 report says that nearly 60 percent of suburban residents actively engage in wildlife viewing near their homes and are willing to pay premiums for locations in settings that attract wildlife.*
- *In 1989, the Maryland Department of Economic and Employment Development (DEED) estimated the economic importance of the Chesapeake Bay to be $678 billion to the economies of Maryland and Virginia through commercial fishing, marine trade, tourism, port activities, and land values.*
- *Marylanders spent $270 million observing, feeding, and photographing wildlife in 1991 as reported by the U.S. Fish and Wildlife Service.*
- *The Department of Natural Resources of Maryland reports that $133 million was spent in the 1991-1992 hunting season. Hunting-related industries support an estimated 4,600 jobs in the state.*

Timber Production

In 1992, timber products composed the largest portion of the total agricultural crop value in the United States. The total value is listed at $23.8 billion, passing corn and soybeans as the leading agricultural commodity. Figure 12-1 shows the percentage breakdown of the value of agricultural crops and timber in 1992.

Due to the high value of timber products, harvest level changes can dramatically affect local economies. All regions of the United States, including the Chesapeake Bay drainage area, help supply the demand for forest products. Four of the top five states in the United States in terms of volume of hardwood growing stock are in the Bay – (#1) Pennsylvania, (#3) Virginia, (#4) New York, and (#5) West Virginia. In Virginia, $9.8 billion per year is generated by the sale of forest products. In Pennsylvania, the timber industry employs 94,000 people in 2,200 locations with an annual payroll of $2.3 billion. In West Virginia, the business volume from the wood-products industry totals $3.2 billion annu-

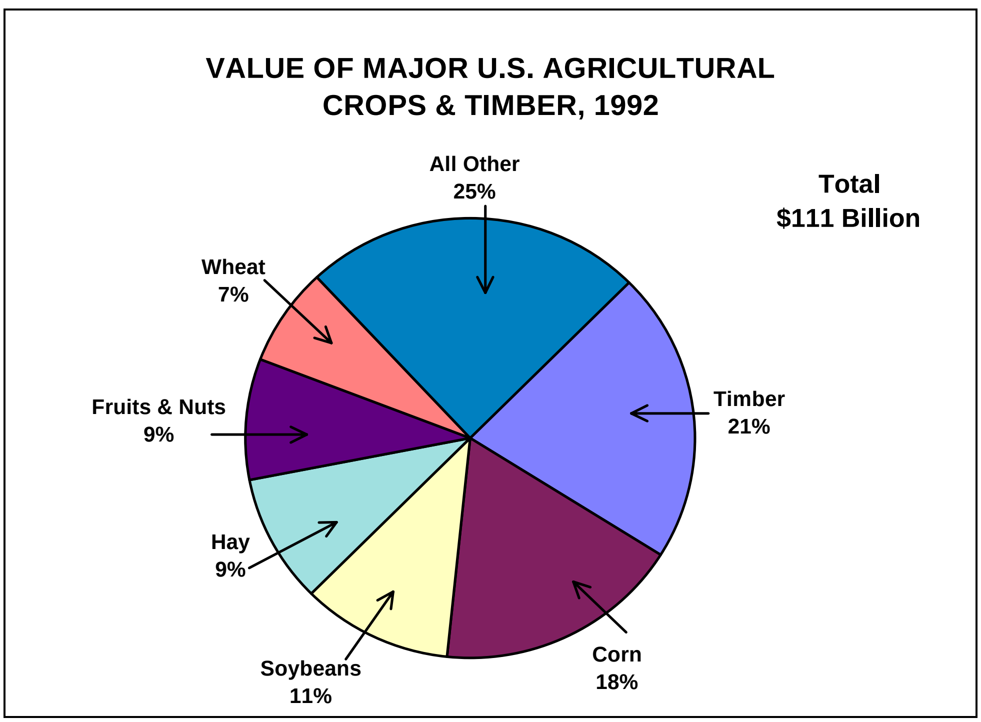


Figure 12 - 1. Timber value estimated from Forest Service Timber Cut/Sold Reports adjusted for value added to local points of delivery. (Source: USDA Economic Research Service Crop Values.)

ally. Table 12-1 is an example of recent stumpage and millage values for Southeastern Pennsylvania. Timber products produced include sawlogs, pulpwood, firewood, posts, and fence rails.

Crop Alternatives and Specialty Forest Products - Trees and other alternative products grown in the streamside forest can bring big rewards.

- ***Aromatics*** - *Essential oils are concentrated in plant leaves, flowers, seeds, bark, and roots. Examples of trees cultivated for their oils include cedar, sweet birch, and sassafras. These oils are used for scenting soaps, polishes, deodorants, and personal care products. They are at the core of a $10 billion a year flavoring and cosmetic industry. Cedar oil is especially profitable at 25 metric tons produced per year at about $9.50 per pound (1978 price).*

- ***Cooking Wood: smoke wood and flavor wood*** - *Woods such as alder, apple, and cherry are used as flavor enhancers in grill cooking either in homes or restaurants. Annual gross sales in cooking wood are estimated at $18 million to $20 million. Unfortunately, profit margins are thin with a retail price of $3 to $3.50 for a 5-pound bag, but a profit of only $0.06 to $0.08 per bag.*

- ***Nuts*** - *Nut trees are an excellent alternative crop that can be raised in the riparian corridor. They include acorns, black walnuts, butternuts, pecans, and hickory nuts. Black walnut meat can bring $6 a pound or more, while uncracked nuts range from $0.75 to $1.25 per pound.*

- ***Wildlife Recreation*** - *The management of forests for recreation and wildlife-based enterprises has good potential benefits to private landowners. Both consumptive and non-consumptive uses can be developed, from access for hunting and fishing to photography and informal field education of school children. In Maryland, deer and bird hunting fees to private landowners range from $3 to $5 per acre per year, and up to $80 per hunter per day for waterfowl hunting access.*

- ***Weaving and Dying Materials*** - *A great variety of native materials that grow in or near woodlands and buffers can be used for weaving, decorating, and dyeing. While few are used on a commercial scale, many products can be used to produce a cottage indus-*

Table 12 - 1

Southeastern Pennsylvania Average Prices of Selected Species, September 1996

International ¼ Inch Rule

SPECIES	STUMPAGE PRICES Thousand board-feet	MILL PRICES Thousand board-feet
northern red oak	$419	$579
white oak	$314	$551
mixed oak	$324	$517
black cherry	$248	$800
white ash	$386	$406
hard maple	$235	$625
soft maple	$149	$300
yellow-poplar	$210	$383
miscellaneous hardwoods	$142	$300
pine - hemlock	$109	$270

try, such as weaving and basket making. Species that offer good material include bark from alder, brown ash, birch, hickory, poplar, and willow. Also popular are native vines from bittersweet, honeysuckle, and Virginia creeper.

- ***Shiitake Mushrooms*** - *The shiitake has been popular for centuries in Japan, where it is known as the forest mushroom. It originally grew wild on the shii tree, which is closely related to the oak. During the last 20 years, hundreds of shiitake growers have begun cultivating the mushroom in the United States. Since the 1940's, worldwide demand for shiitake mushrooms has placed its market volume second only to that of the common white mushroom. Its market potential is great because of its unusually high nutritional value and the fact that it can be grown in every part of the country. Shiitakes are grown using oak logs, particularly white oak, that have been thinned from woodlots. Retail prices are about $9-$12 a pound.*

- ***Decorative Cones*** - *A wide variety of cones are used in floral, wreath, and potpourri products. They are used in gift and fragrance items, as ornaments and table decorations, and in a variety of small niche products, such as jewelry, grave blankets, and bird feeders. Cones can be dipped in wax and used as fire starters and decorations, or crushed and molded into Presto-log shapes for fire starters. Cones from hemlock, loblolly pine, white pine, red pine, and spruce are all marketable. Landowners can make $7-$24 per bushel, depending on the species.*

- ***Ginseng*** - *Ginseng is a wild forest herb that was first discovered in China 5,000 years ago. Ginseng is used as a medicinal plant – mainly the root. Ginseng acts as an antidepressant, increases resistance to disease, and improves both physical and mental performance. American wild ginseng is so much sought after that much of it has disappeared. It sells for as much as $360 per dried pound, and over $70 million worth of ginseng root, both wild and cultivated, is now exported annually.*

Other examples of special products are listed in Table 12-2.

Costs Associated with Riparian Forest Buffers

The Costs of Establishment and Management

The Natural Resources Conservation Service defines a riparian forest buffer strip as an area of trees and shrubs, at least 50 feet wide, located between cropland and watercourses. The riparian buffer is effective in controlling erosion and attached nutrients, reducing instream sediment loads during flooding, reducing nutrients in overland and subsurface flow, moderating stream temperatures, and providing habitat.

One tool that can be used for establishment planning is the riparian forest buffer specification developed in 1990 by the USDA Forest Service. That specification, as described in this manual, outlines three distinct zones. Zone 1 is nearest the streambank, has a recommended fixed 15-foot width, and is a no management zone to achieve streambank stabilization. Zone 2 is recommended to be at least 60-feet wide and is geared to nutrient removal. Zone 3 is hoped to be 20-feet wide and consists of dense grasses and forbs to convert concentrated water flow to uniform sheet flow. With this basic outline we can begin to plan establishment costs, and then, estimate maintenance cost for a 10-year period. The costs shown in Table 12-3 are derived from USDA Forest Service, Stewardship Incentive Program (SIP) cost-share rate structure guidance for SIP Practice 6 - Riparian and Wetland Protection and Improvement for Various States within the Northeastern Area. All costs shown are the price of practices installed and include labor.

Table 12 - 2

Special Forest Products of the Northeastern United States

(Adapted from Inside Agroforestry, Winter 1996 Issue)

Specialty Products	Examples	Use
Food	Shiitake and matsuki mushrooms	food, medicinals
	Black locust and plum honey	food, candy
	Walnuts, acorns, pecans, and Pinyon pine nuts	food, dyes
	Blueberries, huckleberries, and other berries	food, dyes
	Maple, birch, and boxelder sap	syrups, candy
Specialty Items	Cedar and pine oils	aromatics, crafts
	Poplar, willow, and switchgrass biomass plantings	fuel, paper
	Cedar, poplar, and willow residues	mulches, animal bedding, litter products
	Walnut crotches, wormy chestnut, diamond willow, and cedar veneer	wood, decorations and carvings
Decoratives	Club fern, Spanish moss, and other mosses	decorations, craft projects
	Wild grape, kudzu, vine maple, and other vines	crafts
Medicinals	Ginseng	longevity, general strengthening, teas, herbs
	Goldenseal	eyewash, laxative, tonic hemor-rhagic
Herbs	Slippery elm bark	food flavoring, laxative
	Elder flowers	food flavoring, eye and skin health

Table 12 - 3
Riparian Forest Buffer Installation Estimated Costs

COMPONENT	MATERIALS	UNIT	ESTIMATED COST
	ESTABLISHMENT		
Preparation	**Light site prep**		
	- mow, disking	acre	$12.00
Planting	**Tree Seedlings**		
	8x8 spacing; 430 trees/acre	acre	$495.00
	(Hardwoods - $1.15/seedling)		
	12-18' seedling with labor included		----------
Subtotal			**$507.00**
	MAINTENANCE		
Reinforcement	Seedlings 50/acre	acre	$58.00
Planting	Year 2 after establishment		----------
			$58.00
TOTAL COST	Planting and Establishment	acre	**$565.00**
	OPTIONAL COSTS		
Establishment			
	Shelters ($5.00/tree Installed)	acre	$2150.00
	Fencing (1 acre=282 linear feet)	acre	$564.00
Maintenance			
	Competition control		
	- Herbicide treatment	acre	$54.00
	- mowing	acre	$12.00

** Labor cost included in estimates could be saved with help by volunteers for establishment.

Economic Impacts of Riparian Forest Buffers

The cost impacts of riparian buffers are site specific and determined by a variety of factors. Such considerations as dominant-land use, landowner objectives, and opportunity costs or foregone production, dictate the total cost that retaining or restoring riparian forest will impose. Following are three hypothetical scenarios that are intended to illustrate economic impacts for "typical" situations in the Chesapeake Bay Watershed - a coastal plain agricultural field, a forestry site, and a tract of new subdivision development near an urban center. Thanks goes to Dr. Ian Hardie, University of Maryland; John Long and Patty Engler, NRCS, and Scott Crafton, Virginia Chesapeake Bay Local Assistance Department for their assistance and review of these scenarios.

SCENARIO # 1: AGRICULTURAL FIELD

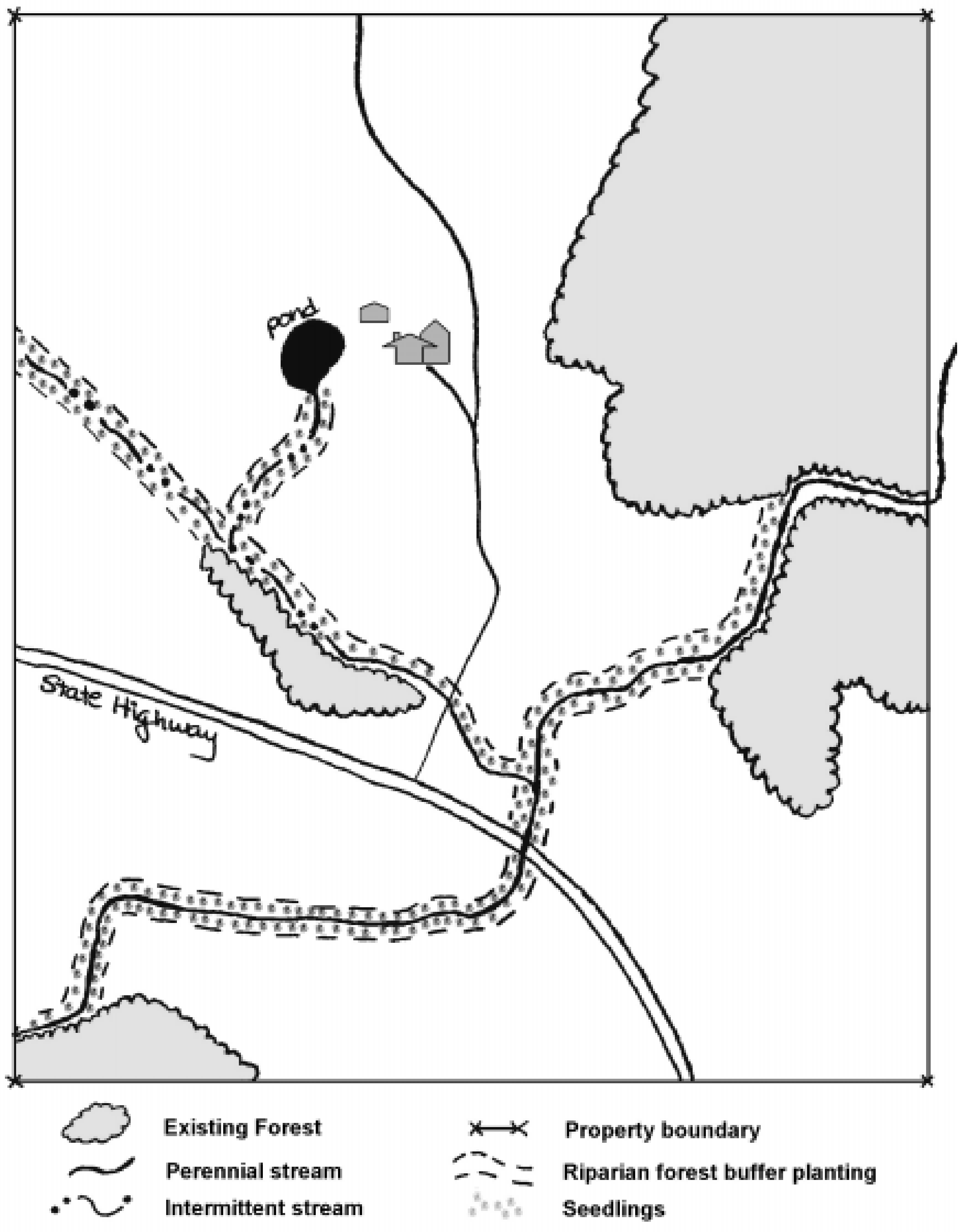


Figure 12 - 2. Agricultural Field: Riparian Forest Buffer Establishment.

This example occurs in the Coastal Plain area of Maryland and is a hypothetical farm. The costs of riparian forest buffers on agricultural lands include buffer establishment, maintenance, and the opportunity cost of installing a buffer – foregone income from lost production in the riparian area.

Scenario:

> *A 140-acre farm field located on the Eastern Shore of Maryland. The landowner manages the field in a two-crop (corn, soybeans), 2-year rotation. The field has 1307 feet of perennial and intermittent streams running through it. The farmer has agreed to establish a 50-foot wide forest buffer on both sides of the stream on the advice of his NRCS District Conservationist. The result will be a 3-acre riparian buffer.*

Assumptions:

- Yield over the entire field. In many cases the area adjacent to a stream or river is considered marginal land because of erosion or drought-prone soils, steep or rolling slopes, poor drainage, and low soil fertility. However, in some cases this area is influenced by the flood plain and can be highly productive. Therefore, we assume a consistent yield.
- No existing buffer. The buffer to be established is calculated for both sides of stream at 50'.
- Land Capability Class - IIe or IIIe (few to moderate limitations).
- Production costs represent variable and fixed costs.

Income to the Farmer:

This amount represents the cost to the producer in lost crop income. Installing a forest buffer changes the land use for a long period of time. Therefore, total net income is the net present value of crop income for 20 years with a discount rate of 4 percent, the length of time before one may see a return from the new timber resource. Net income above variable and fixed costs is 1996 Crop Budgets of $84.00 per acre and assumes crop price/yields for corn ($3.60/100) and soybeans ($7.85/35) from MD Cooperative Extension Service.

Figures are shown in dollars per acre. *Dollars/acre*

Net Income $1,141.00

Cost of Buffer Establishment and Maintenance:

Installing a forest buffer involves site preparation, tree planting, and some second year reinforcement planting. Additional maintenance is sometimes employed to reduce competition and promote tree growth. Refer to preceding cost sheet for itemized costs.

Cost of Forest Buffer.. $565.00

Total Cost of Riparian Forest Buffer to the Landowner $1,706.00

Incentive Programs that Reduce Costs of Forest Buffers to Landowners

State and federal programs exist which cost-share best management practices (BMP) and the establishment of riparian forest buffers on agricultural lands. These programs can frequently be combined, or "piggy-backed," into a financial assistance package. An examination of programs and incentives available for buffers in the Bay states appears later in this chapter. Below are examples of program combinations for each state and the bottom-line cost over a 20-year period to the private landowner if these programs are used. These figures are net present values for direct comparison to landowner costs.

Maryland:

- Conservation Reserve Program (CRP)
  - 50% cost-share reduces buffer installation cost (one time) $283.00
  - Annual rental payments - $81/acre (15 years) $901.00
  - Riparian Forest Buffer 20% incentive and $5 maintenance (15 years) $235.00
- MD Buffer Incentive Program - $300/acre (one time) $300.00

THE COST TO A MARYLAND LANDOWNER PER ACRE $0.00

The Maryland landowner makes $13.00 per acre

Virginia:

- CRP package $1,419.00
- Woodland Buffer Filter Area - $100/acre (one time) $100.00

THE COST TO A VIRGINIA LANDOWNER PER ACRE $187.00

The Virginia landowner loses income per acre over a 20-year period

Pennsylvania:

- CRP package $1,419.00
- Streambank Fencing Program
  (if >12-foot buffer, then fencing provided for free) ----------

THE COST TO A PENNSYLVANIA LANDOWNER PER ACRE $287.00

The Pennsylvania landowner loses income per acre over a 20-year period.

DISCUSSION:

- State and federal conservation programs can reduce or eliminate landowner costs for restoring riparian buffers on their land. This scenario shows that cost-share and incentive programs can lead to break even or better over a 20-year period. However, crop income opportunity is still lost as time continues.

- Riparian forests can provide additional and diversified economic returns to the agricultural producer. For example, timber that is selectively harvested can still provide annual equivalent of $8.00/acre (red oak - 60-year rotation) to $34.00/acre (loblolly pine – 35-year rotation). Also, allowing hunting access can return $3.00-$5.00 in lease fees per acre every year.

SCENARIO # 2: FOREST SITE

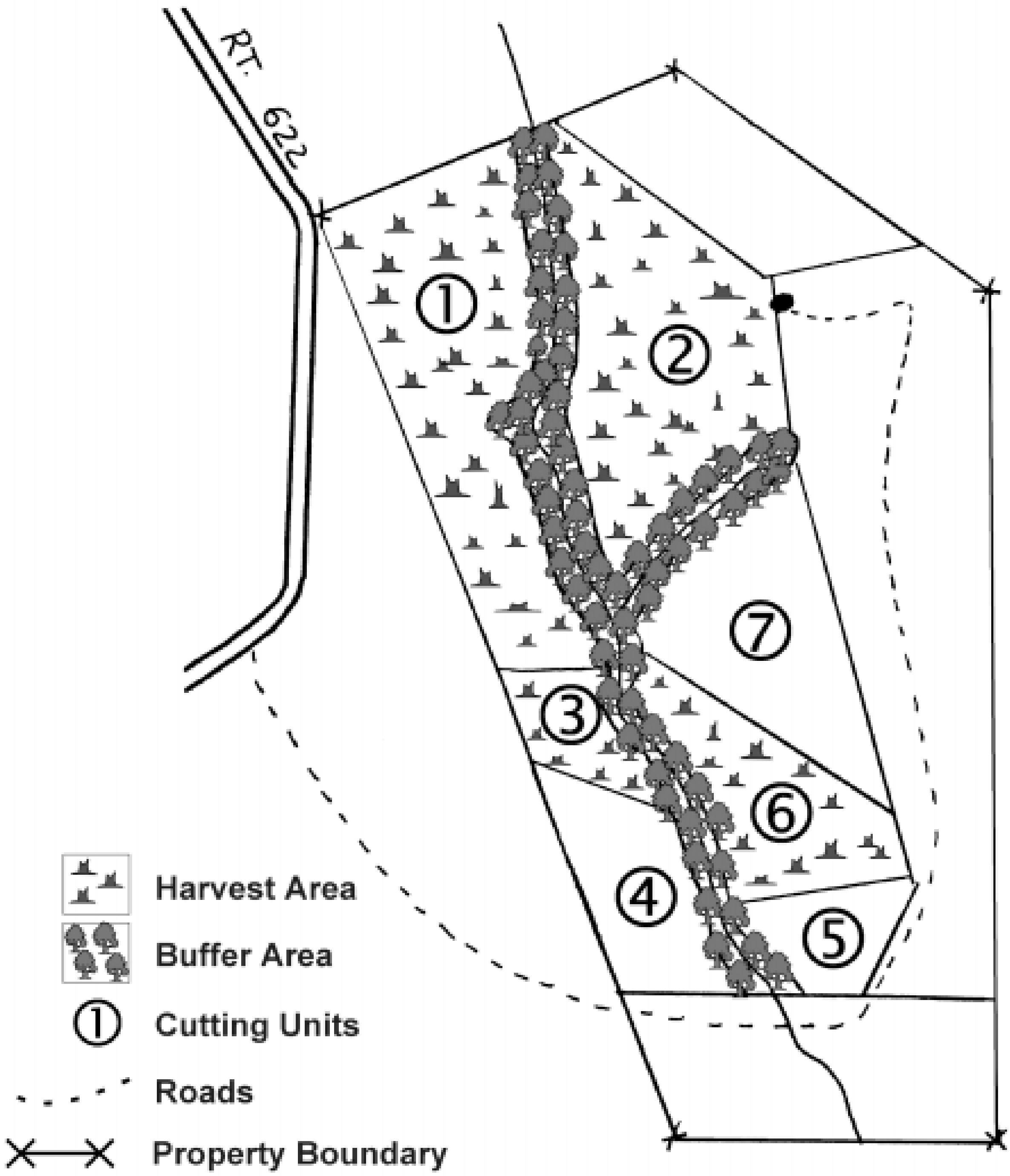


Figure 12 - 3. Forest: Streamside Management Zone Designation.

This example occurs in the Coastal Plains area of Virginia's western shore. It was selected because it is based on an actual situation encountered by a leading forest products company in the region working with a private landowner. The costs, or in this case the foregone income, to retain the forest buffer are from the private landowner perspective.

Scenario:

> *A 54-acre land parcel in private non-industrial land ownership located in the Middle Neck region of Virginia. It is a mixed pine/hardwood site with 3920 feet of perennial stream running through the area scheduled for timber harvesting. A local ordinance requires a 50-foot wide buffer or streamside management zone to protect water quality. The result is a 4.5 acre total area impacted by retaining the buffer.*

Income from Timber Production:

Income figures are shown per acre. Reforestation is optional in this region because natural regeneration occurs well on these sites. The reforestation cost is included to show potential costs to the landowner, and it assumes that they may choose selected species management.

- Gross Timber Income (per acre) $1,268.00
- Production Costs to Landowner (per acre)
  Harvest - payment to logger (estimate of labor, equipment
  maintenance, hauling, insurance, FOB).. -634.00
  Reforestation - species enhancement/management (optional) .... -200.00
- **Net Income to Landowner.. $434.00**

Cost of a Buffer to the Landowner

The figures in Table 12-4 show the income potential of the entire 54-acre land parcel and the impact of lost income for using alternative harvesting techniques within the 4.5-acre forest buffer. The preferred management approach is to clearcut the entire parcel. Each alternative harvesting technique reflects the adjusted Total Return, the exact dollar change (loss) and percentage change in return to the landowner. Total returns were calculated at $634.00 per acre to reflect the impact of the buffer on the timber sale only.

Table 12 - 4
Cost of Buffer to Landowner Using Various Management Regimes

Harvesting Alternatives	Total Return	Change	% Change
1. Total clearcut of the entire parcel	$34,250		
2. Partial Cut - All sawtimber in Buffer (>50% basal area)	$33,991	($259)	-1.00%
3. Partial Cut - High quality in sawtimber in Buffer (< or = 50% basal area)	$31,602	($2,648)	-7.70%
4. No Harvest in Buffer	$28,531	($5,719)	-16.70%

Program Opportunities – Reforestation and Buffer Implementation

For private landowners, state and federal programs exist which cost-share reforestation, best management practices (BMP), and establishment of riparian forest buffers. These programs can frequently be combined, or "piggy-backed," into a financial assistance package. An examination of programs and incentives available for buffers in the Bay states appears later in this chapter. Below are examples of program combinations for each state that reduce the costs of buffers on private lands and the total net income if these programs are used.

Federal Programs:

- Stewardship Incentive Program: 65% cost-share (includes riparian zone enhancement)
- Conservation Reserve Program: 50% cost-share (new added incentive for riparian areas)
- Environmental Quality Incentives Program: 75% cost-share (includes riparian forest buffers)
- Public Law 96-451: 10 percent investment tax credit up to $10,000 for reforestation

Virginia:

- <u>Water Quality Law</u>: The state's voluntary BMP guidelines recommend a 50-foot wide buffer on which 50 percent of the basal area in the buffer can be harvested.
- <u>Woodland Erosion Stabilization:</u> Cost-share provided to establish permanent vegetation on eroding areas of forestry sites, but grass and legumes are commonly used.

- A combination of federal programs would reduce reforestation costs by $170.00 per acre.
    - SIP cost-share (65 percent) = $150.00
    - Federal Tax incentive = $20.00 per year for 7 years

This would raise Net Income per acre to $604.00

Maryland:

- <u>Forest Harvest Guidelines</u>: A minimum 50-foot wide no-cut buffer is required for perennial streams. If Buffer Management Plan is implemented, selective harvesting is allowed.
- <u>Buffer Incentive Program</u>: $300 per acre of buffer one-time payment.
- <u>Woodland Incentive Program</u>: Cost-share 50 percent private forest management activities.
- <u>Reforestation/Timber Stand Improvement Tax Deduction</u>: Small forestry operation can deduct from adjusted gross income double cost of reforestation activities, including buffers.

- A combination of federal and state programs would eliminate cost of reforestation.
    - With Buffer Management Plan - 60 percent basal area harvestable = $380.00
    - SIP cost-share (65 percent) = $150.00
    - MD BIP ($300/acre)= $300.00

This would raise Net Income per acre to $830.00

Pennsylvania:

- <u>Voluntary Guidelines</u>: There are no mandatory requirements in the riparian zone on private forestland, although a 50-foot buffer is recommended.
- A combination of federal programs would reduce reforestation cost to $170.00 per acre

This would raise Net Income per acre to $604.00

DISCUSSION:

- Added incentives such as preferential tax treatment of riparian areas and conservation easements that allow selective harvest of streamside timber would reduce costs further.

- Allowing forest management within the riparian forest buffer or Streamside Management Zones is an effective way to protect water quality and provide economic return to private landowners. Forestry activities are a compatible land use with environmental protection and open space retention. It keeps the land economically viable and provides multiple benefits.

SCENARIO #3: SUBDIVISION DEVELOPMENT SITE

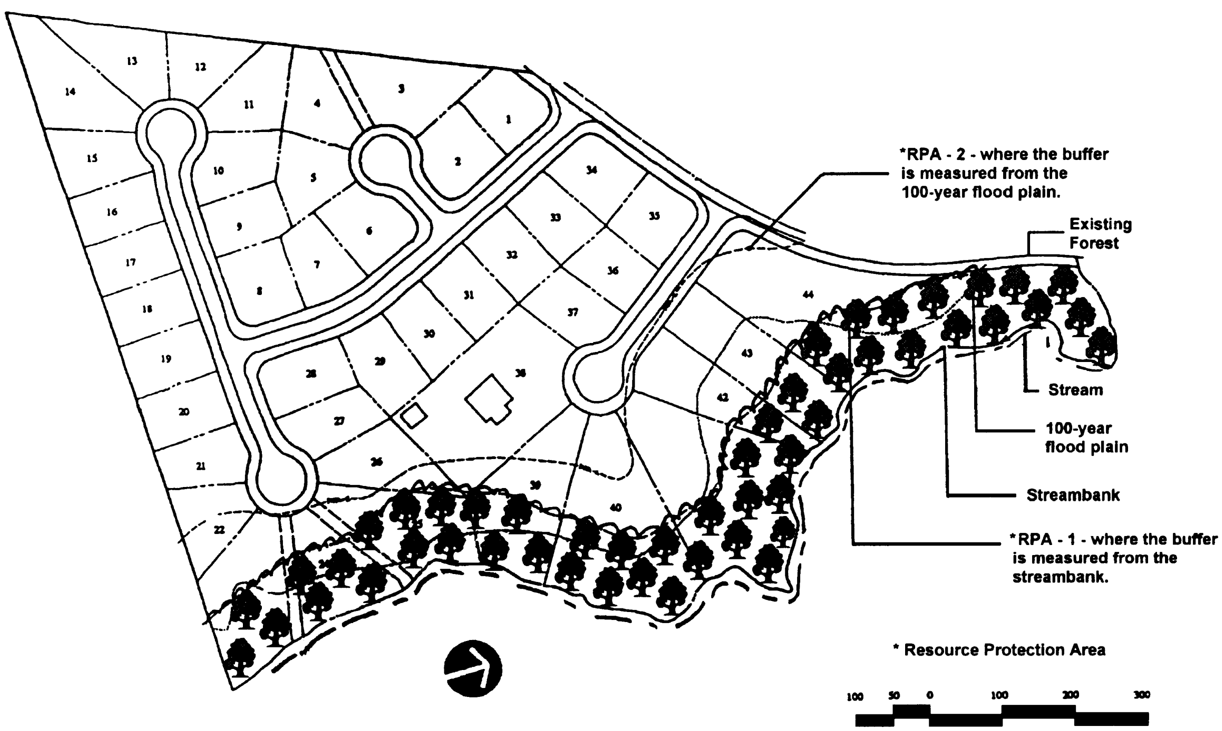


Figure 12 - 4. Development: Riparian Forest Buffer Retention/Establishment.

This example occurs in the Tidewater area of Virginia and is therefore subject to Chesapeake Bay Preservation Act (CBPA) regulations. It was selected because of CBPA's recognition of riparian buffer areas as important to conserve during the development process, and its flexible guidelines to protect the resource while allowing development. The guidelines stress that development is expected to minimize land disturbance and impervious cover while preserving indigenous (native) vegetation to the degree possible, consistent with an approved project plan. The CBPA criteria tend to affect how a project is planned and need not result in increased project costs.

Although hypothetical, this scenario is based on an actual project included in a "Study of the Cost of Complying with the Chesapeake Bay Preservation Act Regulations" prepared by Chesapeake Bay Local Assistance Department of Virginia. Circumstances vary from site-to-site that can impact costs such as steep slopes, erosion control devices, and stormwater management requirements. This scenario illustrates the impact of preserving a 50-foot buffer adjacent to a perennial stream only.

Scenario:

A single family small subdivision in the Virginia Chesapeake Bay Preservation Area with a Resource Protection Area (a bordering stream) on the project site. The 17.6-acre subdivision contains 44 platted lots according to current zoning, and it is subject to Designation and Management Regulations.

Zoning Allowances:

- Minimum lot size .... 9000 sq.ft.
- Current Number of Platted Buildable Lots .... 44 Lots
- Finished Lot Price $61,000
- **Total Sale Value** $2,684,000

Cost Impact of Retaining 50-Foot Wide Buffer

The previous illustration shows retaining the riparian buffer on the project site.

- 50-foot buffer   Possible Result - 1 lost lot $61,000

Additional Elements and Cost Estimates for CBPA and Buffer

These elements are shown to illustrate the range of planning, engineering, and facilities that could be included to meet the performance criteria of CBPA. Most are already required by state erosion and sediment control laws. However, the integration of buffers and other natural systems can actually reduce development costs and add value to the site.

- Site Plan, Erosion Control Plan (already required) $0.00
- Water Quality Stormwater Plan (engineering time) $650.00
- Installation and maintenance of erosion control devices (already required) $0.00
- Installation of on-site stormwater controls (excluded on this site)........ $0.00
- Minimize land disturbance and natural vegetation removal $0.00
  (could show a net savings)
- Review fees (could be $0) $0.00

TOTAL COST TO DEVELOPER $61,650.00

Implementing 50-foot wide buffer results in:
1 lot lost @ $61,000 each = $61,000 + $650 (added costs)

Total Per-lot Cost $61,000÷43 lots = ... $1,434.00

Buffer Cost as a Percentage of Total Value $61,650 ÷ $2,684,000.00 = ...-2.3%

DISCUSSION:

- The impact of the costs in this example reflects the application of buffer requirements to a subdivision that was platted prior to implementation of CBPA regulatory requirements, and therefore, did not account for those requirements in the planning and layout of the lots. Consultants suggest that an alternative plat plan, that accounted for CBPA rules such as the buffer requirement, might still accommodate 44 lots. Local subdivision rules, allowing for clustering, or zoning rules, allowing for density compensation for buffers (i.e. allowing the same number of slightly smaller lots to be platted than would be allowed if no buffers were implemented), could eliminate the risk of lost lots.

- Market research indicates that the value of lots where buffers are present is often 5% or higher than the value of lots where no buffers are present. That would result in a $3,050.00 premium for each lot sold adjacent to the buffer.

Comparison of Trees, Row Crops, and Pasture on Land with Class IIIe Capability

Item	Row Crops	Pasture	Trees
Cash Flow	Annual	Annual	Revenues and expenses occur periodically
Income Tax Treatment	Ordinarily taxable income	Ordinary taxable income	Amortization and investment credit on reforestation costs
Supply/Demand Outlook	Oversupply of most crops; low prices	Oversupply of beef; fluctuating prices	USDA predicted shortage of high quality timber; price increasing
Market	Usually must sell at current price; relatively perishable product		Multiple products can be held for good markets
Financial Returns from Investment	At current prices, rates of return are below interest earned on saving account and may be negative		Better than long-term Certificate of Deposit
Soil Conservation Protection from Erosion	Requires expensive maintenance	Moderate maintenance	Excellent: builds soil
Drought	High risk of loss of investment	Moderate risk, percent loss of vegetative cover	Low risk, once established
Management	Annual intensive time and labor	Moderate time requirement	Very low time requirement
Investment Length	One year	1 to 10 years	Usually longer than 15 years prior to thinning

Source: USDA Soil Conservation Service and USDA Forest Service, Northeastern Area, State and Private Forestry. Forest Management: A Viable Alternative on Marginal Croplands Eligible for the Conservation Reserve Program, Fiscal Year 1991.

Finance Tools and Economic Incentives

Because so much of the protection of riparian areas relies on voluntary participation, a central element of riparian forest buffer conservation and restoration involves economic incentives to landowners and developers. The financial benefit a landowner receives can have a significant impact on his or her willingness to protect and restore riparian buffers. Incentives programs are delivered through a host of agents such as Natural Resources Conservation Service (NRCS), Farm Service Agency (FSA), the USDA Forest Service, state and local natural resource agencies, private industry, and citizen groups, and are designed to provide technical and financial assistance directly to landowners and communities. In developed areas, zoning, land use, and stormwater provisions may provide opportunities for greater use of riparian forest buffers. In October 1996, the Riparian Forest Buffer Panel recommended to the Chesapeake Executive Council to enhance incentives and *"Develop and promote an adequate array of incentives for landowners and developers to encourage voluntary riparian buffer retention and restoration."* This is an overview of several financial tools and incentive programs that exist in the Chesapeake Bay states. A complete analysis of state and federal stream protection programs and identified gaps appears in Section XIV of this handbook.

Recognized Cost-Share Programs

Although productivity is often a priority for those whose livelihood depends on the land, a balance needs to be struck between productivity and natural resource protection. For stream protection on agricultural land, site-specific management and integration of a range of conservation practices are the rule. There are many best management practices (BMPs) that can be applied to farms to protect water quality, and financial support is available to help landowners offset costs to install such practices. Table 12-5 is a list of some federal cost-share programs that are frequently used to encourage riparian forest conservation and restoration and can be combined with state programs to increase incentives and reduce costs to landowners.

Maryland has the Buffer Incentive Program, Woodland Incentive Program, and Maryland Agriculture Water Quality Cost-share Program.

Table 12 - 5
Recognized Cost-Share Programs

Program	Agency	Eligibility
Conservation Reserve Program	NRCS	HEL land, wetlands, wildlife forested riparian areas. 50% cost-share, annual payments up to $50,000 for 10-15 years, 20% incentive for trees and continuous sign-up.
Forestry Incentives Program	NRCS/ USFS	Up to 65% cost-share for tree planting and prep. Area must be 10-100 acres.
Stewardship Incentive Program	USFS	Private forests 1-1000 acres. Up to 65% cost-share for SIP practices including riparian & wetland protection and improvement. Maintain for 10 years.
Environmental Quality Incentives Program	NRCS	Agricultural land, including forests. Up to 75% cost-share for riparian forest buffers and related practices. Must sign long-term agreement.
Wetlands Reserve Program	NRCS	Riparian areas can be restored. Up to 75% cost-share of restoration activity. Maintain for at least 10 years.

Virginia has the Woodland Buffer Filter Area and Loafing Lot Management System. Pennsylvania has the Streambank Fencing Program.

Tax Incentives & Credits

Tax incentives and credits are frequently identified as a desirable approach to encourage resource conservation. Property and income tax relief can be a powerful tool to balance maintaining economic viability of resource-land use and the protection of valuable water resources. The Riparian Forest Buffer Panel saw this and recommended to the Chesapeake Executive Council that tax strategies be examined as an incentive to landowners to conserve and restore riparian areas.

The Bay states of Maryland, Pennsylvania, and Virginia have some type of preferential tax assessment program for land kept in resource use or open space, such as prime agricultural land or private woodlots. These programs reduce the assessed value of the land, resulting in lower property taxes, but often lack any definition for riparian area protection. On the other hand, federal income tax credits exist and can include reforestation efforts in riparian areas. Table 12-6 has examples of tax incentive programs in the Bay states. Call the state forestry or agriculture agency for more information about the programs and eligibility of your land.

Table 12 - 6
Tax Incentive Programs

	PROGRAM	DESCRIPTION
FEDERAL:		
	Public Law 96-451	Provides federal income tax incentives to reduce reforestation costs. The law permits up to $10,000 of capitalized reforestation costs each year to be eligible for an investment tax credit and 7-year amortization.
MARYLAND:		
	Reforestation/Timber Stand Improvement Tax Deduction Program	Allows landowners of small forestry operations to deduct from their adjusted gross income double the costs of reforestation.
	Forest Conservation and Management Program	Provides special tax assessments on forestland, if landowner agrees to adhere to a forest stewardship plan.
	Agricultural Use Assessment	Provides a preferential assessment on the value of land in agricultural use. Woodlots can also receive an agricultural assessment.
VIRGINIA:		
	Use-Value Assessment	Counties provide preferential assessments on agricultural and forestlands.
PENNSYLVANIA:		
	Farmland and Forest Land Assessment Act (Clean and Green Act)	County can grant a preferential assessment for 10 or more contiguous acres of land devoted to agriculture, forest reserve, or open space.

Conservation Easements

Many landowners find that placing their land in an easement is a smart financial strategy for themselves and their families. It is also a way to contribute to protecting their local environment. Conservation easements are a "market-based" approach to land conservation. They offer landowners who sell certain rights to their property a high portion of fair market value as compensation, can yield significant tax savings to those who donate land, and allow them to retain private ownership.

A conservation easement is a voluntary legal agreement between a willing property owner and a qualified party, such as a land trust, public agency, or conservation organization. Each easement is individual and is tailored to the particular property and the interests of the owner. The specific rights a property owner forgoes when granting a conservation easement are spelled out in an easement document. The owner and prospective easement holder identify the areas that the owner wants to protect and the rights and restrictions on use that are necessary to meet those goals – deciding together what can and cannot be done to the property.

To understand the easement concept, think of owning land as holding a bundle of rights. The landowner may sell or give away the whole bundle, or just one or two of those rights. These include the right to construct buildings, to subdivide the land, to restrict access, or to harvest timber. If the goal is to preserve a natural area, for example, an easement may prohibit construction and activities that would destroy the protected area. On the other hand, many easements do not require public access and even the most restrictive easement usually allows continued farming and forestry.

A conservation easement can be written so that it lasts forever. This is known as a perpetual easement. Where state laws allow, an easement can be written for a specific period of years, and it is known as a term easement. Only gifts of perpetual easements, however, can qualify a donor for income and estate tax benefits. And, the easement runs with the land – that is, the original owner and all future owners are bound by its restrictions. It is recorded at the county or town records office so that future owners will learn about the easement when they obtain title reports.

Conservation easements can reduce a property owner's income tax. According to Internal Revenue Code Section 170(h) a donated conservation easement is a tax-deductible charitable gift, provided that it is perpetual and is donated "exclusively for conservation purposes" to a qualified conservation organization or public agency. Conservation purposes are defined by the IRS as the:

- preservation of land areas for outdoor recreation by, or the education of, the general public;
- protection of relatively natural habitats of fish, wildlife, plants, or similar ecosystems;
- preservation of open space – including farmland and forestland – for scenic enjoyment or pursuant to an adopted-governmental policy. In either case, such open space preservation must yield a significant public benefit; and
- preservation of historically important land areas or buildings.

Conservation easements can reduce a property owner's estate taxes. If the owner grants a perpetual easement before his or her death, the property must be valued in the estate at its lowered, restricted value. To the extent that the restricted value is lower than the unrestricted value, the value of the estate is reduced, and thus subject to less taxes. Also, if owners donate the land into an easement during their lifetime, they also realize income tax savings. If owners do not want to restrict the property during their life, they can still specify the conservation easement in their will and receive the same reduced tax results.

Conservation easements can reduce an owner's property tax. If a conservation easement reduces the development potential of the property, it may reduce the level of assessment and the amount of the owner's property taxes. State law and local assessments may influence or determine actual property tax relief to easement grantors.

Unfortunately, the application of conservation easements to the protection of riparian forest zones is not frequently used. State land protection programs, perhaps coupled with federal programs, may provide for riparian area protection and restoration easements in the future. For more information on current programs to protect your land through conservation easement and how to receive tax benefits, contact your state agricultural, forestry agency, or local land trust.

References

Brabec, E. 1992. Trees make cents. Scenic America Technical Information Series, Volume 1, No. 1. Annapolis MD. 8p.

Brabec, E. 1992. On the value of open spaces. Scenic America Technical Information Series, Volume 1, No. 2. Annapolis MD. 8p.

Chesapeake Bay Local Assistance Department. 1992. Study of the costs of complying with the Chesapeake Bay preservation act regulations. Richmond, VA. 42p.

Chesapeake Bay Foundation. 1996. A dollars and sense partnership: economic development and environmental protection. Annapolis, MD. 21p.

Cooksey, R.A. and A. Todd. 1996. Conserving the forests of the Chesapeake: the status and trends, and importance of forests for the Bay's sustainable future. Tech. Paper-03-96. Radnor, PA. USDA Forest Service, Northeastern Area. 35p.

Lipton, D.W., K. Wellman, I.C. Sheifer, and R.F. Weiher. 1995. Economic valuation of natural resources - a handbook for coastal resource policymakers. NOAA Coastal, Ocean Program Decision Analysis Series No.5. NOAA Coastal Ocean Office, Silver Spring, MD. 131p.

McPherson, E.G., D. Nowak, and R.A. Rowntree. 1994. Chicago's urban forest ecosystem: results of the Chicago urban forest climate project. Gen. Tech. Report NE-186. Radnor, PA. USDA Forest Service, Northeastern Forest Experiment Station. 201p.

Thomas, M.G. and D.R. Schumann. 1993. Income opportunities in special forest products - self-help suggestions for rural entrepreneurs. Ag. Info. Bulletin-666. Washington, D.C. USDA Forest Service. 206p.

USDA Forest Service. 1991. Forest management - a viable alternative on marginal croplands eligible for the conservation reserve program. Tech. Transfer Brochure. USDA Forest Service, Northeastern Area and Soil Conservation Service. 12p.

Section XIII

Information and Education Strategies

Information and Education Strategies

Introduction

This section discusses natural resource professional training; and information and education for working with landowners, volunteers, and the media. It includes a list of valuable publications that can be used as informational tools for education strategies.

Natural Resource Professional Training

There is a great opportunity for educating both landowners and natural resource professionals about the functions, values, proper use, establishment, enhancement, and maintenance of riparian forest buffers. Natural resource professionals should be given the opportunity to sharpen their skills and gain new knowledge on riparian forest buffers prior to any aggressive landowner awareness and implementation program.

As already stated in earlier sections, the science of riparian forest buffers is complex, and new knowledge is being gained everyday through research. This new research and knowledge needs to be transferred into the field where land managers are dealing with private landowners and planning and zoning issues. Public agencies and other groups should offer continuing education sessions on riparian buffers.

To be successful, training sessions on riparian buffers should be at least two days in length, with both classroom and field studies. This approach will educate resource professionals through lectures, presentations, active participation in discussions, and hands-on activities in the field. Both of these components (classroom and field study) are extremely important in this learning process.

The training sessions should be organized by local steering committees, so that local needs are addressed. To obtain a wide cross section of participants, these steering committees should consist of a wide and diverse membership. Course curriculum should be consistent from state to state, recognizing uniqueness in physiographic regions and forest types. Handbooks and fact sheets will be necessary for the program participants to use as study guides and future reference.

Materials for workshop participants should include the following to assist the resource professionals when dealing with riparian forest buffer issues and needs in their local areas:

- Information on the scientific knowledge to date.
- This handbook.
- Fact sheets on the functions and values of riparian forest buffers (suitable for photocopying).
- Locations of demonstration sites and a brief history of each site to describe the reasons for the buffer.
- Plant materials list (including trees, shrubs, and grasses) for establishing riparian forest buffers.
- Possible cost-share or tax-based programs to assist in establishing, enhancing, or maintaining these buffers.
- Resource professional list (names, addresses, and phone numbers) for technical assistance needs.
- Nursery list for local plant material needs.
- Videos available with a brief description of content.
- Other training opportunities available.
- Any other research-based information that the steering committee may find useful in their local area.

If these continuing educational programs are offered through the State Cooperative Extension Service, there may be an opportunity to establish graduate credits, as well as continuing forestry education (CFE) credits. Many professional groups offer this, such as the Society of American Foresters (SAF). Every effort should be made to involve a wide range of program participants in this educational opportunity. For example, the Resource Conservation and Development (RC&D) Councils, The Nature Conservancy, Izaak Walton League, Soil & Water Conservation Districts, Alliance for the Chesapeake Bay, State and Federal Forest and Wildlife Agencies, Natural Resources Conservation Service, Cooperative Extension Service, Trout Unlimited, and local Land Conservancy Groups should be asked to participate.

Demonstration sites for field study need to be identified and/or established strategically throughout each state. These demonstration sites will be used for both the field study exercises with the resource professionals and later for private landowners to observe and study. Depending on needs and funding opportunities, there may be an additional opportunity for some applied research to occur within these demonstration plots. When locating these demonstration areas, try to establish a diverse type, such as: one already established, one that is presently being established, maintenance examples, urban and rural settings, agricultural and forest settings, different forest or tree types, and different functional values (i.e. water quality versus wildlife habitat).

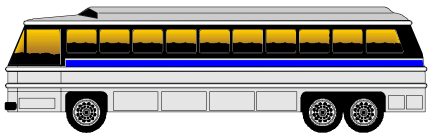
Landowner Information and Education

Information and education activities are essential to a successful riparian forest management effort. Successful information and education strategies will result in landowners actively managing and protecting their riparian areas. Such efforts will also ensure public acceptance of the Bay Programs in both rural and urban areas.

Workshops

Once natural resource professionals have the opportunity to attend these training programs, actions should be taken to organize landowner educational programs. These landowner programs will depend on local needs (i.e. rural or urban audience). Landowner workshops can be conducted throughout each state to focus on riparian forest buffers. In addition, presentations on the functions and values of riparian forest buffers can be incorporated into existing forestry seminars or programs.

Tours and Demonstration Sites



When conducting landowner workshops, there should be an effort made to commit part of a day to a field visit of the local demonstration site. Bus tours of local demonstration sites can also be designed to educate decision-makers, landowners, and/or private citizen volunteers. Many people find this type of educational approach more valuable than sitting in a classroom listening to a lecture. Research has shown that more people learn by actively being involved in hands-on learning experiences.

There are several projects within the Chesapeake Bay that can serve as demonstration areas for educational purposes. Some of the sites are:

1. *Donegal Creek Restoration Project, Lancaster County, PA* – The Lancaster County Conservation District and the Donegal Fish and Conservation Association have teamed up to restore 6.7 miles of limestone trout stream in the northwest corner of the county. Contact: Mark Metzler at 717-299-5361.

2. *Hampshire County Riparian Task Force, Hampshire County, WV* – The task force has established four riparian forest buffer demonstration sites in the county. All sites are fenced and planted with native seedlings. One demonstration site is pristine and fenced to show how a healthy riparian forest functions. Contact: Roger Boyer, Potomac Headwaters RC&D Council at 304-267-8953.

3. *Headwaters of the Shenandoah River: Riparian Easement Program, Augusta County, VA* – Five easements have been established in the three counties of the Shenandoah Region. Riparian areas have a management plan that includes livestock exclusion and protection of the area. Contact: Robert Whitescarver at 540-248-4328.

4. *Riparian Greenway System, Newport News, VA* – The city committed to the establishment of a riparian greenway system that is included in its Comprehensive Plan Map. The greenway includes more than 7,000 feet of stream that will be protected. Contact: Paul Miller at 804-247-8428.

5. *Small Habitat Improvement Program in Urban Areas, Washington, DC* – The Watts Branch of the Anacostia River has had two miles of riparian forest buffers re-established. More than 1,000 stormdrains were stenciled with the message “Don’t Dump – Anacostia River Drainage.” Contact: Lynn Stabenfeldt at 202-962-3363.

6. *Difficult Run Watershed, Fairfax County, VA* – Priority areas were identified in the watershed, and impaired flood plain areas were targeted for tree planting. About 8,000 tree seedlings have been planted, and a 150-foot wide buffer was established near a residential subdivision. Contact: Judy Okay at 703-324-1489.

Find out about other local demonstration areas that can be visited, or consider establishing a demonstration site in the local area.

Landowners also enjoy raft, boat, or canoe trips on streams. In agricultural areas, it has been shown that these trips give farmers new understanding about riparian ecosystems. Each boat or canoe has a natural resource professional and one or two landowners who can share with each other concerns, points of view, and values. The day can be enjoyed by stopping at a nice area along the stream for lunch. These trips are organized and advertised during the warm months of the year.

Videos

In addition to training opportunities, riparian forest buffer videos should be developed to address local needs. One such video titled "Riparian Forest Buffers: the Link Between Land and Water" has been developed to provide an overview for landowners and managers on the functions and values of riparian areas. An additional goal of the video is to motivate landowners to take action, either through establishing, enhancing, or maintaining a buffer or via a planning and zoning concern. Either way, the video is educational, with the private citizen as the audience. The length of the video is 21 minutes.

If under 30 minutes, videos can also be shown on cable and educational TV. This would give the video a greater range of exposure to a larger audience. Additional videos targeted to urban audiences or detailing techniques for stream restoration and buffer planting may be needed. Riparian forest buffer videos should be made available to landowners to view at their leisure. These videos can be shown at local community service clubs, such as the Rotary, Ruritan, Lions, and federation of women's clubs.

Disseminating Information

There are several ways to reach the public about riparian forest buffers and programs that affect the forests of the Bay. Use special events, such as Earth Day or Arbor Day, to distribute information at large gatherings. Sometimes a natural disaster really wakes people up about the forces of nature and the need to manage and protect our forests. For example, after the effects of gypsy moths, fires, hurricanes, or floods are felt and dealt with, there may be a time to introduce the concepts of riparian forests and good stewardship to landowners. Some examples of methods of dissemination are:

- Flyers distributed by volunteers who go door-to-door
- Inserts in local newspapers
- Inserts in utility bills
- Newspaper special editions
- New articles
- Articles by natural resource professionals
- Television and radio news
- Direct mailings
- Public meetings
- Conservation district or extension service newsletters

Fact sheets are useful, and can be used as inserts or direct mailings. Fact sheets should accompany the videos and presentations. These fact sheets should cover the following subjects:

- Cost-share programs
- Federal/state income tax and property tax programs
- Technical assistance available
- Plant material listings
- Locations of nurseries to obtain planting materials
- Wildlife habitat needs
- Cross references of food, cover, and nesting
- Specific values of plant materials
- Functions and values – utilizing the three-zone concept
- Description of water quality functions in different physiographic regions

There may be other fact sheet needs identified by the local steering committee or cooperative extension service.

Public Meetings

There are several occasions for holding public meetings – to announce a new program, to get input on planning decisions, to promote cooperation and partnerships, or to face the wrath of stakeholders after a decision has been made. An effective meeting achieves goals, maximizes time, makes decisions, tells everyone their responsibilities, lets everyone contribute who wants to, and supports varying opinions. Effective public meetings take careful planning.

Planning for the Meeting

Follow these steps:

1. Gather input and ideas from colleagues and landowners. List them as ideas, goals, or inputs.
2. Use these ideas to list agenda items, and put them in priority order.
3. Develop an agenda, putting the most important items first.
4. Decide the desired outcome of the meeting. For example, what, if any, decisions are to be made? Is it for information only? Are concerns to be raised and noted?
5. State the desired outcome or goal next to each item on the agenda.
6. Reserve the room and equipment.
7. Decide whom to invite to the meeting. Some participants may only be interested in portions of the meeting.
8. Allocate a set time for each agenda item.
9. Circulate the agenda to participants.
10. Assign a person to prepare and present each agenda item at the meeting.
11. Assemble information packets to be handed out at the meeting.

Conducting the Meeting

Landowners and stakeholders are taking time from their busy lives to attend the meeting. Make sure it is time well spent by following these guidelines:

1. START ON TIME. Do not wait for a particular speaker. If a person is late, rearrange the agenda item so the speaker can address it after arriving.
2. Stick to the agenda items.
3. Make sure events of the meeting are recorded.
4. If you get bogged down, save the item for last, or defer it to another meeting.
5. Do not make the meeting too long. If you have several agenda items, you should schedule another meeting to address more issues.
6. Schedule a short break after one hour.

Awards and Recognition

Recognition and awards programs can be set up to recognize landowners and/or citizens who have participated in educational programs; taken action to establish, enhance, or maintain a riparian forest buffer; taken steps to change a land planning or zoning issue involving riparian forest buffers; or gone above and beyond the normal establishment, enhancement, and maintenance of riparian buffers.

These awards and recognition programs will assist in program acceptance and program delivery. Citizens and landowners will be appropriately acknowledged for their efforts and positive actions, and they will feel good about what they have done.

Working with Volunteers

There are opportunities, especially in urban areas, for using volunteers in planting riparian forest buffers, cleaning trash from riparian areas, improving wildlife habitat, distributing information, conducting landowner outreach, and other tasks. Volunteers are part of the general public. They must understand what is being done in riparian areas, why it is necessary, and that it is being done correctly.

Using volunteers requires planning and coordination. Volunteer projects should be site specific and require only one or two days to complete. Following are some guidelines:

- Solicit volunteers; they usually do not seek out specific projects.
- Choose volunteers who are interested in or who will benefit from the project. Volunteers will have a sense of ownership in the project if allowed to help.
- When asking for volunteers, clearly define why the project is important, and give complete information on when, where, and what to bring, including food and clothing.
- Contact local organizations for help. Ask a member to distribute flyers about the project and round-up volunteers for you.
- Welcome each volunteer on the day of the project. Check to see that each one has what he needs. Train each group of volunteers on project essentials.
- Check on volunteers throughout the day.
- Involve the media, making sure the credit goes to the volunteers.
- Thank the volunteers in a special way.

Working with the Media

In order to convey the importance of the work that is being accomplished in the Chesapeake Bay Watershed, it is sometimes necessary for the natural resources manager to work with the media – newspapers, television, and radio. The media is used to introduce a new program, to summarize results of a recent study, or to announce a landowner workshop. Governmental agencies and non-profit organizations have their own rules and guidelines in working with the media that must be followed, but there are general things to remember – the most important of which is to take a PRO-ACTIVE POSITION.

General guidelines for talking to a reporter:

- Be polite, and never lose your temper.
- Use a helpful, informative demeanor.
- Know what you're talking about; be sure the information you give is accurate.
- Be honest about not knowing the answer to a particular question; offer to find out.
- Always tell the truth. If you are not allowed to give information, state why.
- Stick to your area of expertise and responsibility.
- Answer questions, but always return to your main theme.
- Ask the reporter to repeat a question if you are unclear about it.
- Put the event or issue into proper context. If you accomplished a "first" in the watershed, say so.
- Stick to the facts, and keep your opinions to yourself.
- Anticipate the reporter's needs, and bring along fact sheets.
- Repeat messages. Each time a message is repeated, the chances of it being in the final story increase.
- Respect reporter's time and deadlines.

- Call back when you promised.
- Keep track of what was said during the interview.
- Watch closely for the resulting story.

A good pro-active tool to use is the news release, but use them sparingly and only when there is something truly newsworthy to announce. Work on establishing a lasting relationship with a person at the newspaper who writes about natural resource issues. These are guidelines to follow in writing a news release:

- Make sure the announcement is newsworthy and of wide interest.
- Decide what media should receive it.
- Limit the length to one or two pages.
- Write in an "inverted pyramid" style. The most important information goes in the first paragraph, followed by progressively less important material.
- Use only one topic of information per paragraph.
- Use the past tense.
- Remember to address the "5 W's" and "H". Who, what, when, where, why, and how.
- Every news release should have a title, date, and location of announcement.
- Use some direct quotes, after seeking permission from the speaker.
- List a contact and phone number for further information.
- If the news release is going to a TV or Radio station, consider an audio or video clip to accompany the release.

Information Resources

The following is a partial list of information resources and where to obtain them. They are helpful in getting the message out about the importance of riparian forest buffers.

Fact Sheets

Riparian Forest Buffers in the Chesapeake Bay Watershed. Call 1-800-662-2747 or 1-800-YOUR-BAY.

Pequea-Mill Creek Information Series:

- *Barnyard Runoff Management*
- *Streambank Fencing*
- *Farmstead Assessment*
- *Pequea-Mill Creek Cost-Share Practices*
- *Nutrient Management Planning*
- *Rotational Lot Management System*
- *Integrated Crop Management*
- *Constructing Mud-Free Cow Lanes*
- *Pasture Watering Systems*
- *Financial Assistance for Practices*
- *Sample Nutrient Management Plan and Guidelines*
- *Stream and Waterway Crossings*
- *Benefits of Streambank Fencing*

Contact Jerry Martin, Cooperative Extension Service, at 717-396-9423.

Directive

Chesapeake Executive Council Directive No. 94-1: Riparian Forest Buffers (October 1994). Call 1-800-662-2747 or 1-800-YOUR-BAY

Video

Riparian Forest Buffers: The Link Between Land & Water. Prepared by the University of Maryland Cooperative Extension Service. This 21-minute video serves as an introduction to the concept of forest buffers and how they benefit the environment. Copies of the video are available from the University of Maryland Cooperative Extension Service at 410-827-8056. The cost is $15 each.

Publications

Conserving the Forests of the Chesapeake: The Status, Trends, and Importance of Forests for the Bay's Sustainable Future. Prepared by Richard Cooksey and Albert Todd. (1996). USDA Forest

Service publication NA-TP-03-96. The publication provides historical background, importance of the forests, status of the Bay's forest, trends in forest change, forest conservation issues, and recommendations for ensuring the forest's future. Call 1-800-662-2747 or 1-800-YOUR-BAY.

Streamside Forests: The Vital, Beneficial Resource. Prepared by the University of Maryland Cooperative Extension Service and the U.S. Fish and Wildlife Service. (1988). This publication provides an overview of the many benefits provided by streamside forests, the historic loss of the resource, and what can be done to restore it. Copies can be obtained from the Cooperative Extension Service at 410-827-8056 or the USDI Fish and Wildlife Service at 410-573-4500.

Riparian Forest Buffers: Function and Design for Protection and Enhancement of Water Resources. Prepared by David J. Welsch. (1991). USDA Forest Service publication NA-PR-07-91. This publication provides a comprehensive description of the functions of riparian forest buffers and guidelines for their establishment. This publication can be ordered for $2.00 from the Superintendent of Documents at 202-512-1800. The stock number is 001-001-00657-2.

The Role and Function of Forest Buffers in the Chesapeake Bay Basin for Nonpoint Source Management. Prepared by the Forestry Workgroup, Nutrient Subcommittee, Chesapeake Bay Program. (February 1993). Publication number CBP/TRS 91/93. This publication is a position paper intended to provide information for planning for control of nonpoint source pollutants reaching the Chesapeake Bay and its tributaries. The components and functions of a forest buffer are described, research needs identified, and specific goals and recommendations regarding the use of these buffers offered. Call 1-800-662-2747 or 1-800-YOUR-BAY.

Forestry and the Chesapeake Bay Program. Prepared by the Forestry Workgroup. (March 1993). CSC.NPS1C.3/93. This color brochure was produced as general information about forests and the Bay, the problems occurring in the Bay, several solutions, and where to get assistance. Call 1-800-662-2747 or 1-800-YOUR-BAY.

Riparian Forest Buffers: Restoring and Managing a Vital Chesapeake Resource: Proceedings from the October 5-6, 1994. Conference in Ellicott City, MD. Prepared by the Forestry Workgroup and the Nutrient Subcommittee, Chesapeake Bay Program (October 1994). Publication Number EPA 903-R-95-008. This conference was intended to expand the level of both technical and practical knowledge related to forest buffer use and to stimulate interest and new energy to address many of the issues of forest buffer implementation in the field. The format of presentations and exhibits attempted to represent the different issues and solutions that are often unique to different land use settings in the Chesapeake Bay Watershed. Call 1-800-662-2747 or 1-800-YOUR-BAY.

An Analysis of Riparian Forest Buffer Policies in Maryland, Virginia, and Pennsylvania. An Issues and Action report prepared by the Chesapeake Bay Commission. (January 1995). This paper examines existing state and federal programs, policies, and regulations to determine their effectiveness in promoting the maintenance and restoration of riparian forests. Call 1-800-662-2747 or 1-800-YOUR-BAY.

Water Quality Functions of Riparian Forest Buffer Systems in the Chesapeake Bay Watershed. Prepared by the Nutrient Subcommittee, Chesapeake Bay Program. (August 1995). Publication Number EPA 903-R-95-004, CBP/TRS 134/95. This document is a research synthesis, focusing on the existing Riparian Forest Buffer System specification developed by the USDA. The report contains a general review of riparian forest and grass vegetated filter strip literature, and uses this literature to help determine the applicability of the forest buffer system recommended by the USDA. Call 1-800-662-2747 or 1-800-YOUR-BAY.

Riparian Forest Buffers. Alliance for the Chesapeake Bay White Paper. (January 1996). This publication describes the current state of scientific knowledge regarding the functions of riparian forest buffers in the Chesapeake Bay Watershed. Call 1-800-662-2747 or 1-800-YOUR-BAY.

Forest and Riparian Buffer Conservation: Local Case Studies from the Chesapeake Bay Program. Prepared by the Forestry Workgroup, Nutrient Subcommittee, Chesapeake Bay Program. (August 1996). USDA Forest Service Publication NA-TP-07-96. This publication, intended as a resource for local organizations, is a collection of case studies that highlight accomplishments of local governments and citizen organizations in recognizing the importance of forests to their communities and taking action to retain and restore them. It illustrates innovative riparian buffer and forest conservation programs initiated and implemented on the local level by private citizens. Call 1-800-662-2747 or 1-800-YOUR-BAY.

Final Report and Adoption Statement of the Riparian Forest Buffer Panel. Prepared by the Riparian Forest Buffer Panel and presented to the Chesapeake Executive Council. (October 1996). Publication Number EPA 903-R-96-015, CBP/TRS 158/96. This document contains the findings of the Riparian Forest Buffer Panel and the Panel's recommendations to the Chesapeake Executive Council, including a riparian forest buffer definition, specific policies, and suggested actions. Call 1-800-662-2747 or 1-800-YOUR-BAY.

Riparian Forest Buffer Panel Report: Technical Support Document. Prepared by the Riparian Forest Buffer Panel Technical Team, Chesapeake Bay Program. (October 1996). Publication Number EPA 903-R-97-007. This document is a compilation of the information used during the Riparian Forest Buffer Panel process, including scientific background, findings, issues addressed, the public involvement process, and participants in the panel process. Call 1-800-662-2747 or 1-800-YOUR-BAY.

Restoring a Bay Resource: Riparian Forest Buffer Demonstration Sites. Prepared by the Forestry Workgroup, Nutrient Subcommittee, Chesapeake Bay Program. (January 1997). Publication Number EPA 903-R-97-001, CBP/TRS 159/97. This document is a compilation of demonstration sites for riparian forest buffers in agricultural, rural, and urban settings. For each demonstration site, a project description, background, monitoring scheme, and contact information is provided. Call 1-800-662-2747 or 1-800-YOUR-BAY.

Chesapeake Bay Riparian Forest Buffer Inventory. Prepared by Rick Day and Paul Richards, Pennsylvania State University (March 1997), for the Chesapeake Bay Program. This document describes the results of an inventory of the extent of forest cover adjacent to streams and rivers in the Chesapeake Bay Watershed using a geographic information system (GIS) approach. Call 1-800-662-2747 or 1-800-YOUR-BAY.

Chesapeake Bay Riparian Handbook: A Guide for Establishing and Maintaining Riparian Forest Buffers. This handbook was edited by Roxane Palone and Albert Todd (May 1997) for the Forestry Workgroup, Nutrient Subcommittee, Chesapeake Bay Program. Publication NA-TP-02-97. This document, intended to provide technical assistance for field personnel, provides detailed information on the planning, design, establishment, and maintenance of riparian forest buffers in the Chesapeake Bay Watershed. Call 1-800-662-2747 or 1-800-YOUR-BAY; or the USDA Forest Service at 304-285-1592.

References

Grey, G.W. 1993. A handbook for tree board members. National Arbor Day Foundation. Nebraska City, NE.

McLoughlin, B. 1990. Communicate with power: encountering the media. Barry McLoughlin Associates, Inc. New York, NY.

McLoughlin, B. 1996. Communicate with power: making effective presentations. Barry McLoughlin Associates, Inc. New York, NY.

Section XIV

Appendices

APPENDIX 1

USDA Forest Service

Specification

Riparian Forest Buffer

USDA FOREST SERVICE RIPARIAN FOREST BUFFER SPECIFICATION

Definition

An area of trees and other vegetation located in areas adjoining and upgradient from surface water bodies and designed to intercept surface runoff, wastewater, subsurface flow, and deeper groundwater flows from upland sources for the purpose of removing or buffering the effects of associated nutrients, sediment, organic matter, pesticides, or other pollutants prior to entry into surface waters and ground water recharge areas.

Scope

This specification establishes the minimally acceptable requirements for the reforestation of open lands, and renovation of existing forest to be managed as Riparian Forest Buffers for the purposes stated.

Purpose

To remove nutrients, sediment, animal-derived organic matter, and some pesticides from surface runoff, subsurface flow, and near root zone groundwater by deposition, absorption, adsorption, plant uptake, denitrification, and other processes, thereby reducing pollution and protecting surface water and groundwater quality.

Conditions Where Practice Applies

Subsurface nutrient buffering processes, such as denitrification, can take place in the soil wherever carbon energy, bacteria, oxygen, temperature, and soil moisture is adequate. Nutrient uptake by plants occurs where the water table is within the root zone. Surficial filtration occurs anywhere surface vegetation and forest litter are adequate.

The riparian forest buffer will be most effective when used as a component of a sound land management system including nutrient management and runoff, and sediment and erosion control practices. Use of this practice without other nutrient and runoff, sediment and erosion control practices can result in adverse impacts on buffer vegetation and hydraulics including high maintenance costs, the need for periodic replanting, and the carrying of excess nutrients and sediment through the buffer by concentrated flows.

This practice applies on lands:

1. adjacent to permanent or intermittent streams which occur at the lower edge of upslope cropland, grassland or pasture;

2. at the margins of lakes or ponds which occur at the lower edge of upslope cropland, grassland or pasture;

3. at the margin of any intermittent or permanently flooded, environmentally sensitive, open water wetlands which occur at the lower edge of upslope cropland, grassland or pasture;

4. on karst formations at the margin of sinkholes and other small groundwater recharge areas occurring on cropland, grassland, or pasture.

   Note*: In high sediment production areas (8-20 in./100 yrs.), severe sheet, rill, and gully erosion must be brought under control on upslope areas for this practice to function correctly*.

Design Criteria

Riparian Forest Buffers

Riparian forest buffers will consist of three distinct zones and be designed to filter surface runoff as sheet flow and downslope subsurface flow, which occurs as shallow groundwater. For the purposes of these buffer strips, shallow groundwater is defined as: saturated conditions which occur near or within the root zone of trees, and other woody vegetation and at relatively shallow depths where bacteria, oxygen, and soil temperature contribute to denitrification. Streamside Forest Buffers will be designed to encourage sheet flow and infiltration and impede concentrated flow.

Zone 1

Location

Zone 1 will begin at the top of the streambank and occupy a strip of land with a fixed width of fifteen feet measured horizontally on a line perpendicular to the streambank.

Purpose

The purpose of Zone 1 is to create a stable ecosystem adjacent to the water's edge, provide soil/water contact area to facilitate nutrient buffering processes, provide shade to moderate and stabilize water temperature encouraging the production of beneficial algal forms, and to contribute necessary detritus and large woody debris to the stream ecosystem.

Requirements

Runoff and wastewater to be buffered or filtered by Zone 1 will be limited to sheet flow or subsurface flow only. Concentrated flows must be converted to sheet flow or subsurface flows prior to entering Zone 1. Outflow from subsurface drains must not be allowed to pass through the riparian forest in pipes or tile, thus circumventing the treatment processes. Subsurface drain outflow must be converted to sheet flow for treatment by the riparian forest buffer, or treated elsewhere in the system prior to entering the surface water.

Dominant vegetation will be composed of a variety of native riparian tree and shrub species and such plantings as necessary for streambank stabilization during the establishment period. A mix of species will provide the prolonged stable leaf fall and variety of leaves necessary to meet the energy and pupation needs of aquatic insects.

Large overmature trees are valued for their detritus and large woody debris. Zone 1 will be limited to bank stabilization and removal of potential problem vegetation. Occasional removal of extreme high value trees may be permitted where water quality values are not compromised. Logging and other overland equipment shall be excluded except for streamcrossings and stabilization work.

Livestock will be excluded from Zone 1 except for designed stream crossings.

Zone 2

Location

Zone 2 will begin at the edge of Zone 1 and occupy an additional strip of land with a minimum width of 60 feet measured horizontally on a line perpendicular to the streambank. Total minimum width of Zones 1 & 2 is therefore 75 feet. Note that this is the minimum width of Zone 2 and that the width of Zone 2 may have to be increased as described in the section "Determining the Total Width of Buffer" to create a greater combined width for Zones 1 & 2.

Purpose

The purpose of Zone 2 is to provide necessary contact time and carbon energy source for buffering processes to take place, and to provide for long term sequestering of nutrients in the form of forest trees. Outflow from subsurface drains must not be allowed to pass through the riparian forest in pipe or tile, thus circumventing the treatment processes. Subsurface drain outflow must be converted to sheet flow for treatment by the riparian forest buffer, or treated elsewhere in the system prior to entering the surface water.

Requirements

Runoff and wastewater to be buffered or filtered by Zone 2 will be limited to sheet flow or subsurface flow only. Concentrated flows must be converted to sheet flow or subsurface flows prior to entering Zone 2.

Predominant vegetation will be composed of riparian trees and shrubs suitable to the site, with emphasis on native species, and such plantings as necessary to stabilize soil during the establishment period. Nitrogen-fixing species should be discouraged where nitrogen removal or buffering is desired. Species suitability information should be developed in consultation with state and federal forestry agencies, Natural Resources Conservation Service, and USDI Fish and Wildlife Service.

Specifications should include periodic harvesting and timber stand improvement (TSI) to maintain vigorous growth and leaf litter replacement, and to remove nutrients and pollutants sequestered in the form of wood in tree boles and large branches. Management for wildlife habitat, aesthetics, and timber are not incompatible with riparian forest buffer objectives as long as shade levels and production of leaf litter, detritus, and large woody debris are maintained. Appropriate logging equipment recommendations shall be determined in consultation with the state and federal forestry agencies.

Livestock shall be excluded from Zone 2 except for necessary designed stream crossings.

Zone 3

Location

Zone 3 will begin at the outer edge of Zone 2 and have a minimum width of 20 feet. Additional width may be desirable to accommodate land-shaping and mowing machinery. Grazed or ungrazed grassland meeting the purpose and requirements stated below may serve as Zone 3.

Purpose

The purpose of Zone 3 is to provide sediment filtering, nutrient uptake, and the space necessary to convert concentrated flow to uniform, shallow, sheet flow through the use of techniques such as grading and shaping, and devices such as diversions, basins, and level lip spreaders.

Requirements

Vegetation will be composed of dense grasses and forbs for structure stabilization, sediment control, and nutrient uptake. Mowing and removal of clippings are necessary to recycle sequestered nutrients, promote vigorous sod, and control weed growth.

Vegetation must be maintained in a vigorous condition. The vegetative growth must be hayed, grazed, or otherwise removed from Zone 3. Maintaining vigorous growth of Zone 3 vegetation must take precedence and may not be consistent with wildlife needs.

Zone 3 may be used for controlled intensive grazing when conditions are such that earthen water control structures will not be damaged.

Zone 3 may require periodic reshaping of earth structures, removal or grading of accumulated sediment, and reestablishment of vegetation to maintain effectiveness of the riparian buffer.

Determining Need For Protection

Buffers should be used to protect any body of water which will not be:

- treated by routing through a natural or artificial wetland determined to be adequate treatment;
- treated by converting the flow to sheet flow and routing it through a forest buffer at a point lower in the watershed.

Determining Total Width of the Buffer

Note that while not specifically addressed, slope and soil permeability are components of the following buffer width criteria.

Each of the following criteria is based on methods developed, or used by persons conducting research on riparian forests.

Streamside Buffers

The minimum width of streamside buffer areas can be determined by any number of methods suitable to the geographic area.

1. Based on soil hydrologic groups as shown in the county soil survey report, the width of Zone 2 will be increased to occupy any soils designated as Hydrologic Group D and those soils of Hydrologic Group C which are subject to frequent flooding. If soils of Hydrologic Groups A or B occur adjacent to intermittent or perennial streams, the combined width of Zones 1 & 2 may be limited to the 75 foot minimum.

2. Based on area, the width of Zone 2 should be increased to provide a combined width of Zones 1 & 2 equal to one third of the slope distance from the streambank to the top of the pollutant source area. The effect is to create a buffer strip between field and stream which occupies approximately one third of the source area.

3. Based on the Land Capability Class of the buffer site as shown in the county soil survey, the width of Zone 2 should be increased to provide a combined width of Zones 1 & 2 as shown below.

Capability Class	Buffer Width
Cap. I, II e/s, V	75'
Cap. III e/s, IV e/s	100'
Cap. VI e/s, VII e/s	150'

<u>Pond and Lake-Side Buffer Strips</u>

The area of pond or lake-side buffer strips should be at least one-fifth the drainage area of the cropland and pastureland source area. The width of the buffer strip is determined by creating a uniform width buffer of the required area between field and pond. Hydrologic Group and Capability Class methods of determining width remain the same as for streamside buffers. Minimum widths apply in all cases.

Environmentally Sensitive Wetlands

Some wetlands function as nutrient sinks. When they occur in fields or at field margins, they can be used for renovation of agricultural surface runoff and/or drainage. However, most wetlands adjoining open water are subject to periodic flushing of nutrient-laden sediments and, therefore, require riparian buffers to protect water quality.

Where open water wetlands are roughly ellipsoid in shape, they should receive the same protection as ponds.

Where open water wetlands exist in fields as seeps along hillslopes, buffers should consist of Zones 1, 2 & 3 on sides receiving runoff and Zones 1 & 3 on the remaining sides. Livestock must be excluded from Zones 1 & 2 at all times and controlled in Zone 3. Where Zones 1 & 3 only are used, livestock must be excluded from both zones at all times, but hay removal is desirable in Zone 3.

Vegetation Selection

Zone 1 & 2 vegetation will consist of native streamside tree species on soils of Hydrologic Groups D and C and native upland tree species on soils of Hydrologic Groups A and B.

Deciduous species are important in Zone 2 due to the production of carbon leachate from leaf litter which drives bacterial processes that remove nitrogen, as well as, the sequestering of nutrients in the growth processes. In warmer climates, evergreens are also important due to the potential for nutrient uptake during the winter months. In both cases, a variety of species is important to meet the habitat needs of insects important to the aquatic food chain.

Zone 3 vegetation should consist of perennial grasses and forbs.

Species recommendations for vegetated buffer areas depend on the geographic location of the buffer. Suggested species lists should be developed in collaboration with appropriate state and federal forestry agencies, the Natural Resources Conservation Service, and the USDI Fish and Wildlife Service. Species lists should include trees, shrubs, grasses, legumes, forbs, as well as site preparation techniques. Fertilizer and lime, helpful in establishing buffer vegetation, must be used with caution and are not recommended in Zone 1.

Maintenance Guidelines

<u>General</u>

Buffers must be inspected annually and immediately following severe storms for evidence of sediment deposit, and erosion, or concentrated flow channels. Prompt corrective action must be taken to stop erosion and restore sheet flow.

The following should be avoided within the buffer areas: excess use of fertilizers, pesticides, or other chemicals; vehicular traffic or excessive pedestrian traffic; and removal or disturbance of vegetation and litter inconsistent with erosion control and buffering objectives.

Zone 1 vegetation should remain undisturbed except for removal of individual trees of extremely high value or trees presenting unusual hazards such as potentially blocking culverts.

Zone 2 vegetation, undergrowth, forest floor, duff layer, and leaf litter shall remain undisturbed except for periodic cutting of trees to remove sequestered nutrients; to maintain an efficient filter by fostering vigorous growth; and for spot site preparation for regeneration purposes. Controlled burning for site preparation, consistent with good forest management practices, could also be used in Zone 2.

Zone 3 vegetation should be mowed and the clippings removed as necessary to remove sequestered nutrients and promote dense growth for optimum soil stabilization. Hay or pasture uses can be made compatible with the objectives of Zone 3.

Zone 3 vegetation should be inspected twice annually, and remedial measures taken as necessary to maintain vegetation density and remove problem sediment accumulations.

<u>Stable Debris</u>

As Zone 1 reaches 60 years of age, it will begin to produce large stable debris. Large debris, such as logs, create small dams which trap and hold detritus for processing by aquatic insects, thus adding energy to the stream ecosystem, strengthening the food chain, and improving aquatic habitat. Wherever possible, stable debris should be conserved.

Where debris dams must be removed, try to retain useful, stable portions which provide detritus storage.

Deposit removed material a sufficient distance from the stream so that it will not be refloated by high water.

Planning Considerations

1. Evaluate the type and quantity of potential pollutants that will be derived from the drainage area.

2. Select species adapted to the zones based on soil, site factors, and possible commercial goals such as timber and forage.

3. Plan to establish trees early in the dormant season for maximum viability.

4. Be aware of visual aspects and plan for wildlife habitat improvement if desired.

5. Consider provisions for mowing and removing vegetation from Zone 3. Controlled grazing may be satisfactory in Zone 3 when the filter area is dry and firm.

Developed by David Welsch and Thomas Iivari

APPENDIX 2

Natural Resources Conservation Service

Conservation Practice Standard

Riparian Forest Buffer

NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

RIPARIAN FOREST BUFFER

(Acre)
CODE 391

DEFINITION

An area of trees and/or shrubs located adjacent to and up-gradient from water bodies.

PURPOSES

- Create shade to lower water temperatures to improve habitat for aquatic organisms.
- Provide a source of detritus and large woody debris for aquatic organisms and habitat for wildlife.
- Reduce excess amounts of sediment, organic material, nutrients and pesticides in surface runoff and reduce excess nutrients and other chemicals in shallow ground water flow.

CONDITIONS WHERE PRACTICE APPLIES

On areas adjacent to permanent or intermittent streams, lakes, ponds, wetlands and areas with ground water recharge.

CRITERIA

General Criteria Applicable To All Purposes Named Above.

The location, layout and density of the riparian forest buffer will accomplish the intended purpose and function. The buffer will consist of a zone (identified as zone 1) that begins at the normal water line, or at the top of the bank, and extend a minimum distance of 15 feet, measured horizontally on a line perpendicular to the water body.

Dominant vegetation will consist of existing or planted trees and shrubs suited to the site and the intended purpose. Occasional removal of some tree and shrub products such as high value trees is permitted provided the intended purpose is not compromised by the loss of vegetation or harvesting disturbance.

Necessary site preparation and planting shall be done at a time and manner to insure survival and growth of selected species. Only viable, high quality, and adapted planting stock will be used. Site preparation shall be sufficient for establishment and growth of selected species and be done in a manner that does not compromise the intended purpose.

Livestock shall be controlled or excluded as necessary to achieve and maintain the intended purpose.

Harmful pests present on the site will be controlled or eliminated as necessary to achieve and maintain the intended purpose.

Additional Criteria To Reduce Excess Amounts of Sediment, Organic Material, Nutrients and Pesticides in Surface Runoff and Reduce Excess Nutrients and Other Chemicals in Shallow Ground Water Flow.

An additional strip or area of land, zone 2, will begin at the edge and up-gradient of zone 1 and extend a minimum distance of 20 feet, measured horizontally on a line perpendicular to the water body. The minimum combined width of zones I and 2 will be 100 feet or 30 percent of the geomorphic flood plain whichever is less, but not less than 35 feet.

Criteria for zone 1 shall apply to zone 2 except that removal of tree and shrub products such as timber, nuts and fruit is permitted on a periodic and regular basis provided the intended purpose is not compromised by loss of vegetation or harvesting disturbance.

Concentrated flow erosion or mass soil movement shall be controlled in the up-gradient area immediately adjacent to zone 2 prior to establishment of the riparian forest buffer.

CONSIDERATIONS

The severity of bank erosion and its influence on existing or potential riparian trees and shrubs should be assessed. Watershed-level treatment or bank stability activities may be needed before establishing a riparian forest buffer.

Where ephemeral, concentrated flow erosion and sedimentation is a concern in the area upgradient of zone 2, consider the application of a vegetated strip consisting of grasses and forbs.

When concentrated flow erosion and sedimentation cannot be controlled vegetatively, consider structural or mechanical treatments.

Favor tree and shrub species that are native and have multiple values such as those suited for timber, biomass, nuts, fruit, browse, nesting, aesthetics and tolerance to locally used herbicides.

Avoid tree and ˙ rub species which may be alternate hosts to undesirable pests. Species diversity should be considered to avoid loss of function due to species-specific pests.

Woody phreatophytes and hydrophytes that deplete ground water should be used with caution in water-deficit areas.

The location, layout and density of the buffer should compliment natural features.

PLANS AND SPECIFICATIONS

Specifications for this practice shall be prepared for each site. Specifications shall be recorded using approved specifications sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

OPERATION AND MAINTENANCE

The following actions shall be carried out to insure that this practice functions as intended throughout its expected life. These actions include normal repetitive activities in the application and use of the practice (operation), and repair and upkeep of the practice (maintenance):

The riparian forest buffer will be inspected periodically and protected to maintain the intended purpose from adverse impacts such as excessive vehicular and pedestrian traffic, pest infestations, pesticide use on adjacent lands, livestock damage and fire.

Replacement of dead trees or shrubs and control of undesirable vegetative competition will be continued until the buffer is, or will progress to, a fully functional condition.

As applicable, control of concentrated flow erosion or mass soil movement shall be continued in the up-gradient area immediately adjacent to zone 2 to maintain buffer function.

Any removals of tree and shrub products shall be conducted in a manner that maintains the intended purpose.

Any use of fertilizers, pesticides and other chemicals to assure buffer function shall not compromise the intended purpose.

APPENDIX 3

USDA Natural Resources Conservation Service

Maryland Conservation Practice Standard

Riparian Forest Buffer

USDA
NATURAL RESOURCES
CONSERVATION SERVICE
MARYLAND
CONSERVATION PRACTICE
STANDARD
RIPARIAN FOREST BUFFER

CODE 391
(Reported in Acres)

DEFINITION

An area of trees and/or shrubs located adjacent to and up-gradient from water bodies.

PURPOSES

1) Reduce excess amounts of sediment, organic material, nutrients, pesticides and other pollutants in surface runoff and reduce excess nutrients and other chemicals in shallow ground water flow.

2) Create shade to moderate water temperatures to improve habitat for fish and other aquatic organisms.

3) Provide a source of detritus and large woody debris for fish and other aquatic organisms.

4) To provide riparian habitat and corridors for wildlife.

CONDITIONS WHERE PRACTICE APPLIES

On stable areas adjacent to permanent or intermittent streams, lakes, ponds, wetlands and areas with ground water recharge. (For areas with unstable banks refer to Streambank Stabilization, practice 580.)

CRITERIA

Criteria Applicable To All Purposes

The location, layout, width, length and woody plant density of the riparian forest buffer will be selected to accomplish the intended purpose and function. The buffer will consist of a zone (identified as zone 1) that begins top of bank, and extends a minimum distance of 15 feet, measured horizontally on a line perpendicular to the water course or water body.

NOTE: The ability to sustain a healthy forest condition, and reduction of sediment, organic material, nutrients and pesticide will be limited if only Zone 1 is established. A minimum buffer width of 35 feet is required in the Chesapeake Bay drainage area.

Dominant vegetation will consist of existing or planted trees and shrubs suited to the site and the intended purpose. Selection of locally native species will be a priority when feasible. Plantings will consist of two or more species in an attempt to achieve greater diversity. Individual plants selected will be suited to the seasonal variation of soil moisture status of individual planting sites. Plant types and species shall be selected based on their compatibility in growth rates and shade tolerance. Select species from the Plant Lists located in Specifications.

Occasional removal of some tree and shrub products such as high value trees is permitted provided the intended purpose is not compromised by the loss of vegetation or harvesting disturbance. *(An approved sediment and erosion control plan is required when harvesting disturbs over 5000 sq. ft., and in the Chesapeake Bay Critical Area a Timber Harvest Plan is required.)*

An adequate upstream or adjacent seed source must be present when using natural regeneration to establish a buffer. Planting is preferred over natural regeneration due to control of plant species present and reduced time for woody plants to reach maturity.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

Necessary site preparation and planting for establishing new buffers shall be done at a time and manner to insure survival and growth of selected species. Refer to Specifications for care, handling, and planting requirements for woody planting stock.

Only viable, high quality, and adapted planting stock will be used. The method of planting for new buffers shall include hand or machine planting techniques, suited to achieving proper depths and placement for intended purpose and function of the buffer.

Site preparation shall be sufficient for establishment and growth of selected species and be done in a manner that does not compromise the intended purpose. Refer to Specifications for woody planting stock quality requirements and detailed site preparation procedures. Supplemental moisture will be applied if and when necessary to assure early survival and establishment of selected species.

Livestock shall be controlled or excluded as necessary to achieve and maintain the intended purpose. Water course crossings and livestock watering shall be located and sized to minimize impact to buffer vegetation and function. (See Fencing, 382 and Stream Crossing, 232 Standards.)

Harmful pests present on the site will be controlled or eliminated as necessary to achieve and maintain the intended purpose.

Additional Criteria Purpose 1

To reduce excess amounts of sediment, organic material, nutrients, pesticides and other pollutants in surface runoff and reduce excess nutrients and other chemicals in shallow ground water flow.

An additional strip or area of land, (Zone 2), will begin at the edge and up-gradient of zone 1 and extend a minimum distance of 20 feet, measured horizontally on a line perpendicular to the water course or water body. The minimum combined width of zones 1 and 2 will be 100 feet OR 30 percent of the geomorphic flood plain whichever is less, but not less than 35 feet. A Geomorphic floodplain is defined as the area adjacent to a river or stream that is built of alluvial sediments that are associated with the present depositional activity. *(Note: The geomorphic floodplain does not include older land forms, such as terraces, that were formed by similar process but under different hydrologic conditions. These upland terrace positions no longer flood and subsequently do not receive additional alluvial sediments.)* Figure 1 illustrates examples of zone 1 and 2 widths for water courses and water bodies.

Zone 2 may need to be adjusted to include important resource features such as wetlands, steep slopes, or critical habitats.

In this zone the removal of tree and shrub products such as timber, nuts and fruit is permitted on regular basis provided the intended purpose is not compromised by loss of vegetation or harvesting disturbance.

Additional Criteria Purpose 2

To create shade to moderate water temperatures to improve habitat for fish and other aquatic organisms.

A buffer for controlling warm-season water temperatures shall consist of at least zone 1 for water course reaches or water bodies less than or equal to 30 feet in width or water bodies greater than 30 feet wide but less than 1 acre. (NOTE: Buffers for wider water courses or larger water bodies may be valuable but will have only site-specific effects.)

Buffers shall be established or maintained on south and west sides of water courses and bodies insofar as practical. The buffer canopy shall be established to achieve at least 50 percent crown cover with average canopy heights equal to or greater than the width of the water course or 30 feet for water bodies. (See figure 2.)

Buffer species shall include those species listed in the Plant List, Table 1, Specifications, with sufficient height potential. Place drooping or wide-crowned trees and shrubs nearest the water course or body. Shoreline or channel relief (e.g., deeply incised channels) and topographic shading will be taken into account in selecting species.

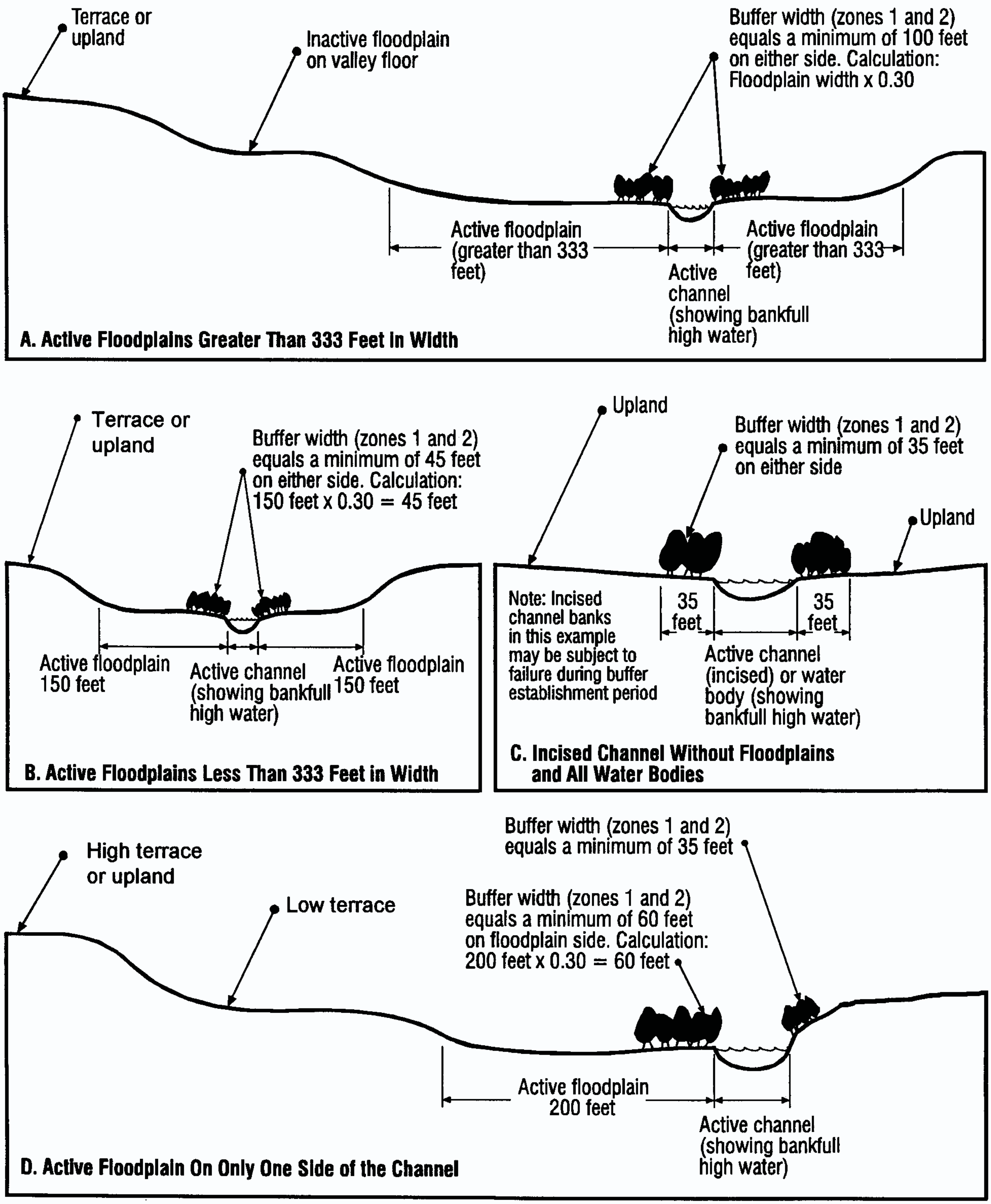


Figure 1. Examples of riparian forest buffer widths for water courses and water bodies.

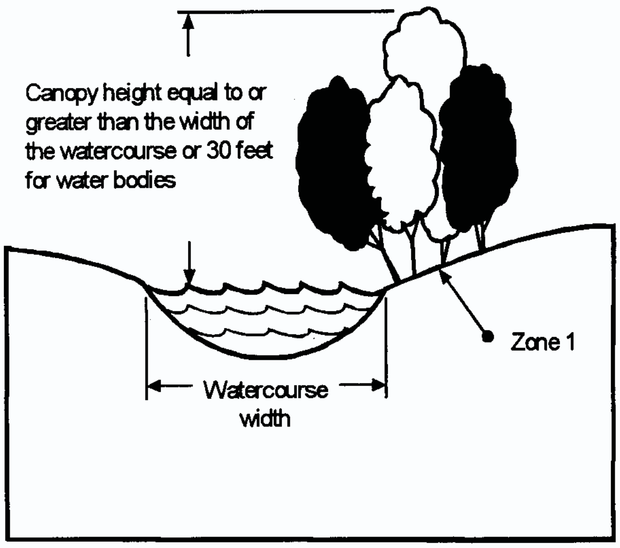


Figure 2. Canopy height for water temperature control.

Additional Criteria Purpose 3

To provide a source of detritus and large woody debris for fish and other aquatic organisms.

Within zone 1 as a minimum, establish, favor or manage species capable of producing stems and limbs of sufficient size to provide an eventual source of large woody debris for instream habitat for fish and other aquatic organisms.

Additional Criteria Purpose 4

To provide wildlife habitat.

Select trees and shrubs that provide food cover and shelter for the targeted wildlife species. See Plant list in the Specifications section and refer to Wildlife/Wetland Habitat Management Standards 644, 645 for more information.

Buffer Width Guide for Selected Wildlife Species.

Widths below include the sum of buffer widths on one or both sides of water courses or water bodies and may extend beyond riparian boundaries (in such cases refer to Tree/Shrub Establishment, 612 for design of upland forests).

Species:	Desired Width in Feet
Bald eagle nesting, cavity nesting ducks, heron rookery	600
Neotropical migrants	300
Beaver, dabbling ducks, mink, salmonids	300
Deer	200
Frog, salamander	100

CONSIDERATIONS

The severity of bank erosion and its influence on existing or potential riparian trees and shrubs should be assessed. Watershed-level treatment or bank stability activities may be needed before establishing a riparian forest buffer. (Refer to Streambank Protection Standard, 580 and to Chapter 18 of the Engineering Field Handbook.)

Complex ownership patterns of riparian areas may require group planning for proper buffer design, function and management.

Where ephemeral, concentrated flow or sheet and rill erosion and sedimentation is a concern in the area up-gradient of zone 2, consider the application of a vegetated strip consisting of grasses and forbs, (Zone 3). Grasses and forbs from plant list #2 established at the up-gradient edge of zone 2 will accelerate deposition of sediment. (See figure 3.) When concentrated flow or excessive sheet and rill erosion and sedimentation cannot be controlled vegetatively, consider structural or mechanical treatments.

Joining existing and new buffers increases the continuity of cover and will further moderate water temperatures, improve habitat and enhance water quality functions. A mix of species with growth forms that are tall and wide-crowned or drooping will increase moderation effects. For water courses, buffers established on both sides will enhance multiple values.

Favor tree and shrub species that are native and have multiple values such as those suited for timber, biomass, nuts, fruit, browse, nesting, aesthetics and tolerance to locally used herbicides. Consider species that resprout when establishing new rows nearest to water courses or bodies. For detritus and large woody debris, use species that will meet the specific requirements of fish and other aquatic organisms for food, habitat, migration and spawning.

Use recommendations from regional or other large-scale evaluations and plans when designing, locating and connecting buffers for indicator and/or target species of wildlife, fish and other aquatic organisms.

Avoid tree and shrub species which may be alternate hosts to undesirable pests or that may be considered noxious or undesirable. Species diversity should be considered to avoid loss of function due to species-specific pests.

The location, layout and density of the buffer should complement natural features. Avoid layouts and locations that would concentrate flood flows or return flows. Low, flexible-stemmed shrubs will minimize obstruction of local flood flows.

Consider the positive and negative impacts beaver, muskrat, deer, rabbits and other local species may have on the successful management of the riparian and stream system.

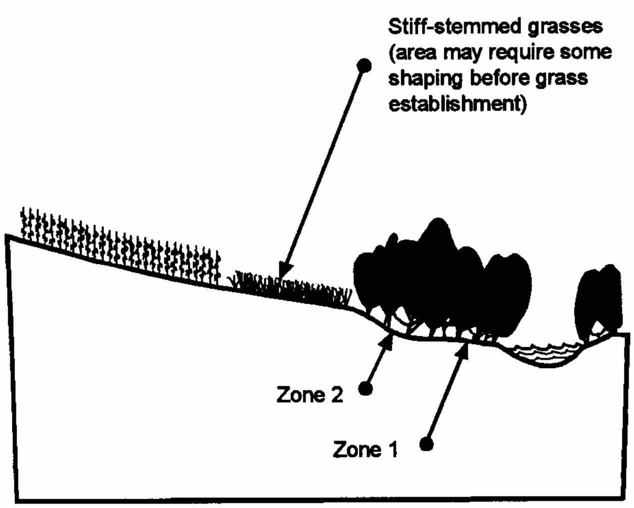


Figure 3. Sediment-trapping above zone 2.

Temporary and local population control methods of these kinds of local species should be used cautiously and within state and local regulations.

Consider the type of human use (rural, suburban, urban) and the aesthetic, social and safety aspects of the area to determine the vegetation selection, arrangement and management. For example, avoiding tall shrubs that block views and pruning low tree branches near recreation trails allows for ease of patrolling.

Species selection criteria to improve aesthetics include seasonal foliage color, showy flowers and fruit, foliage texture, form and branching habit. The layout and design should be appropriate for the setting as determined by adjacent land uses.

SPECIFICATIONS

Specifications for this practice shall be prepared for each site. Requirements for operation and maintenance of the practice shall be incorporated into site specifications.

Procedures, technical details and other information listed below provide additional guidance for carrying out selected components of the named practice. This material is referenced from the conservation practice standard for the named practice and supplements the requirements and considerations listed therein.

Planting Densities

Initial plant-to-plant densities for trees and shrubs will depend on their potential height at 20 years of age. Be sure to consider management when planting. If mowing will be method of weed control, row widths must be wide enough to allow access. Heights may be estimated based on: 1) performance of the individual species (or comparable species) in nearby areas on similar sites, or 2) predetermined and documented heights using Conservation Tree/Shrub Suitability Groups, Section II of the Field Office Technical Guide.

Planting density specifications are:

Plant Types/Heights:	Plant-to-Plant Spacing in feet:
• Shrubs less than 10 feet in height	6
• Shrubs and trees from 10 to 25 feet in height (includes columnar trees)	6 to 8
• Trees greater than 25 feet in height	8 to 12

Plant List

Table 1 lists woody plant species (trees and shrubs) commonly associated with and suited to riparian areas. Key attributes are listed for each plant to assist with the design process for establishing new buffers.

Care, Handling, Size And Planting Requirements For Woody Planting Stock

During all stages of handling and storage, keep stock tops dry and free of mold and roots moist and cool. Destroy stock that has been allowed to dry, to heat up in storage (e.g., within a bale, delivery carton or container), or that has developed mold or other pests.

Seedlings shall no be less than 1/4" in caliper at 1" above the root collar. Rooted planting stock must not exceed a 2:1 shoot-to-root ratio. (See figure 4.) Container stock shall normally not exceed a 1-gallon size.

Roots of bareroot stock shall be kept moist during planting operations by placing in a water-soil (mud) slurry, peat moss, superabsorbent (e.g., polyacrylamide) slurry or other equivalent material. Rooting medium of container or potted stock shall be kept moist at all times by periodic watering. Stock shall not be planted when the soil frozen or dry. Rooted stock will be planted in a vertical position with the root collars approximately 1/2-inch below the soil surface. Insert cuttings to the depth

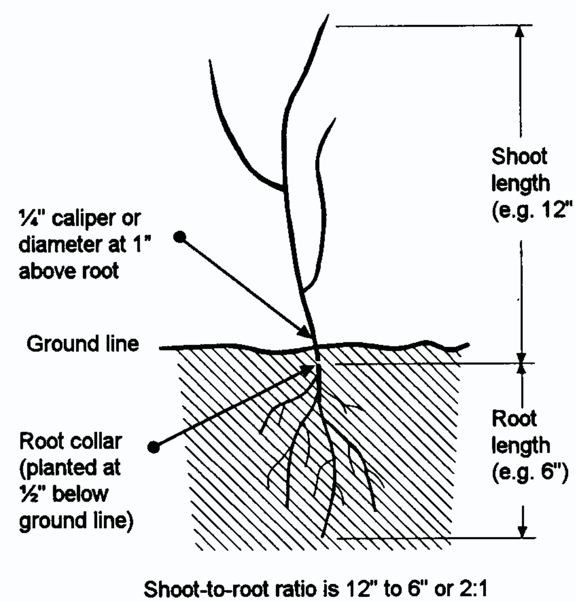


Figure 5. Plant or stock size requirements.

required to reach adequate soil moisture with at least 2-3 buds above ground. The planting trench or hole must be deep and wide enough to permit roots to spread out and down without J-rooting or L-rooting. After planting of rooted stock, pack soil around each plant firmly to eliminate air pockets. (See figure 5.)

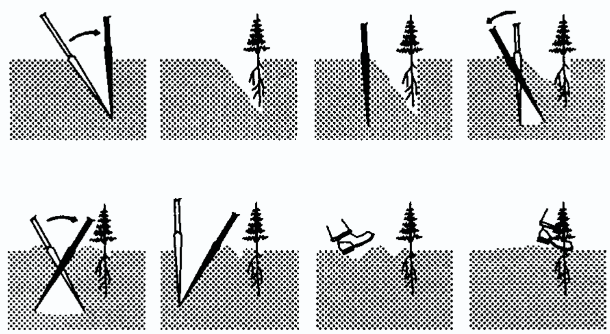


Figure 5. Proper plant and root placement of rooted stock using a planting bar.

Recommended Planting Dates

MLRA 149A, 153C and 153D - March 1 to May 11; planting may be done on sandy soils, when soil is not frozen, during the fall and winter months. (After November 1)

MLRA 148 - March 1 to May 1

MLRA 147 and 130 - March 15 to May 1

MLRA 127 - April 1 to May 15

Containerized stock can be planted at any time the ground is not frozen provided a water source is available.

Preparation Of Planting Sites

Planting sites shall be properly prepared based on the soil type and vegetative conditions listed below. For sites to be tilled, leave a 3-foot undisturbed strip at the edge of the bank or shoreline. Competitive weeds, particularly Canada Thistle and Multiflora Rose should be controlled prior to planting. Avoid sites that have had recent application of pesticides harmful to woody species to be planted. If pesticides are used, apply only when needed and handle and dispose of properly and within federal, state and local regulations. Follow label directions and heed all precautions listed on the container.

Fabric mulch may be used for weed control and moisture conservation for new plantings, particularly those with pronounced growing season moisture deficits or invasive, weedy species. Refer to Mulching, 484, for installation procedures.

Based on site conditions and predominant soil texture of the fine earth fraction, procedures include:

Tillable sites with loamy/clayey soils:

- Sod and alfalfa sites

  Summer fallow 1 year to kill the sod or alfalfa. Till (moldboard plow, disk plow, rototiller or similar equipment) in the spring before planting the stock. A fall-sown crop of oats may be used where needed to control erosion.

  Sod may be killed by non-selective herbicides the year previous to planting stock. Plant stock in the residue. On heavy soils, tillage is usually necessary to achieve a satisfactory planting when a tree planting machine is used.

- Small grain or row crop sites

  If the site is in row crop, till (moldboard plow, disk plow, rototiller or similar equipment) in the fall or in the spring prior to planting the trees or shrubs. If the site has a plow or hard pan in subsoil, perform a deep disking or ripping operation in the fall. A fall-sown crop of oats may be used where needed to control erosion.

  If the site is in small grain stubble, the stock may be planted in the spring without further preparation. If fabric mulch is to be installed, till in the spring before planting.

  Tillage on steep slopes must be on the contour or cross-slope. A cover crop between the rows may be necessary to control erosion and sediment deposition on planted stock.

Tillable sites with sandy soils:

- Sod and alfalfa sites

Till (moldboard plow, disk plow, rototiller or similar equipment) and plant to a spring cover crop (corn, grain, sorghum, etc.) the year prior to planting. Leave a stubble cover in which to plant. A light disking may be needed before planting if fabric mulch is used.

Sod may be killed by nonselective herbicides the year prior to planting. Plant trees or shrubs in the residue.

When hand planting, scalp or strip an area at least 3 feet in diameter and two-to-four inches deep. (place plants in the center of the scalped area.)

Rototill a 3-foot wide strip. (Place plants in the center of the tilled area.) Where a drip watering system will not be used, rototill the strip the year prior to planting.

- Small grain or row crop sites

If the site is in small grain, corn, or similar clean tilled crop, and it is reasonably free of weeds, plant stock in the stubble without prior preparation. It may be necessary to till a narrow strip with a disk or other implement to kill weeds or volunteer grain, or to prevent stalks and other residue from clogging the tree planter. If fabric mulch is used, disking may also be needed. A cover crop or stubble may be needed between the rows to protect the planting from water or wind erosion.

Non-tillable sites and/or erosive sites (including sites with undesirable brushy or herbaceous species):

On sites where it is not practical or possible to operate equipment (steepness, rockiness, etc.), where tillage of the site will cause excessive erosion, or where tillage of the site is impractical, the methods listed below may be used. Sites with undesirable brush will need initial treatments that physically removes and kills the brush species to facilitate planting of desired stock and prevent re-encroachment of the brush. Suitable methods include hand-cutting and removal, brush hogging, brush-blading, or other equivalent procedure with repeated treatment or use of herbicides to control re-sprouting.

Machine or hand scalp an area at least 36 inches in diameter with subsequent plant placement in the center of the scalped area.

Rototill a strip at least 36 inches wide the year prior to tree planting with subsequent plant placement in the center of the tilled strip.

Kill the vegetation in a 36-inch diameter or larger area or in a 36-inch or wider strip with a non-selective herbicide the year prior to planting and plant in the center or along the center-line of the treated area.

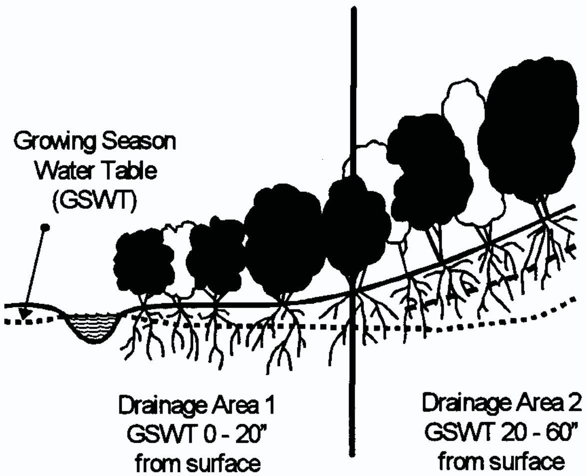


Figure 6. Drainage Class Suitability

This is a simplified drawing depicting the major drainage areas found in a riparian area and is intended to facilitate the plant selection process. Area 1 is made up of poorly drained to somewhat poorly drained soils with the growing season water table (GSWT) fluctuating from 0 to 20" from the soil surface in most years. This area has the greatest potential for inundation.

Area 2 is made up of moderately well to well-drained soils with the GSWT fluctuating from 20" to 60" from the soil surface in most years. This area is prone to moisture stress during the summer months.

The plants in the following tables have been separated according to their suitability for the conditions in Area 1 or 2. Plants with both areas listed are tolerated of a wide range of conditions.

TABLE 1 - TREES

Plant Names	Drainage Area Suitability	Tolerance to Flooding	Shade Value	Height 20 Years	Native Species	Wildlife Value	Notes
ATLANTIC WHITE CEDAR Chamaecyparis thyoides	1	M	M	30'	Y	Low: seed and browsing	cannot compete with hardwoods, best planted in stands
BALD CYPRESS Taxodium distichum	1	H	M	40'	Y	Low: seeds, food for ducks and marsh birds	recommended for lower Eastern Shore only
BLACK ALDER Alnus glutinosa	1	H	M	40'	N	Medium: food for beaver and ruffed goose	seeds freely along banks, nitrogen fixing
BLACK WALNUT Juglans nigra	1	M	H	60'	Y	Medium: twigs and nuts, food for some wildlife	very important lumber tree
BLACK WILLOW Salix nigra	1	H	H	75'	Y	Medium: nesting, food for grouse, beaver, and deer	important for stream stabilization, fast growth rate

TABLE 1 - TREES

Plant Names	Drainage Area Suitability	Tolerance to Flooding	Shade Value	Height 20 Years	Native Species	Wildlife Value	Notes
BOX ELDER Acer negundo	1	H	M	30'	Y	Low: seeds, food for some wildlife	fast growth rate
RIVER BIRCH Betula nigra	1	H	M	40'	Y	Medium: food for ducks, songbirds, rabbits, and fox	unique peeling reddish bark
SANDBAR WILLOW Salix exigua	1	H	M	25'	Y	Low: nesting	forms thickets by suckering
SILVER MAPLE Acer saccharinum	1	M	H	50'	Y	Low: nesting	good source of woody debris
SWAMP WHITE OAK Quercus bicolor	1	H	M	30'	Y	High: acorns, food for quail, turkey, grouse, woodpeckers, raccoons, opossum and deer	good choice for wet sites, important lumber tree
CHINQUAPIN Quercus muehlenbergii	1 & 2	M	M	40'	Y	High: acorns, food for quail, turkey, grouse, and deer	under used, native tree
GREEN ASH Fraxinus pennsylvanica	1 & 2	M	H	50'	Y	Medium: seeds and foliage, food for wood ducks, grosbeaks, squirrels, and deer	important lumber tree
HACKBERRY Celtis occidentalis	1 & 2	M	M	40'	Y	High: fruits and twigs, food for mourning doves, quail, squirrels, and deer	adaptable to a wide range of conditions
OVERCUP OAK Quercus lyrata	1 & 2	M	M	30'	Y	High: same as Swamp White Oak	important lumber tree
PIN OAK Quercus palustris	1 & 2	M	M	40'	Y	High: same as Swamp White Oak	bronze or red fall foliage
RED MAPLE Acer rubrum	1 & 2	H	M	40'	Y	High: seeds and sap, food for songbirds, chipmunks, and deer	red fall color and bloom
SWEET GUM Liquidambar styraciflua	1 & 2	M	H	60'	Y	Low: seeds for mourning doves, beaver, squirrels, and chipmunks	yellow-red fall color

TABLE 1 - TREES							
Plant Names	**Drainage Area Suitability**	**Tolerance to Flooding**	**Shade Value**	**Height 20 Years**	**Native Species**	**Wildlife Value**	**Notes**
SYCAMORE Platanus occidentalis	1 & 2	M	H	60'	Y	Low: nesting cavities, seeds, food for finches, and squirrels	unique peeling bark, fast growth rate
BLACK LOCUST Robinia pseudoacacia	2	L	M	40'	Y	Low: seeds, food for some wildlife	nitrogen fixing, seeds freely and suckers
LOBLOLLY PINE Pinus taeda	2	L	M	60'	Y	Medium: seeds and sap, food for doves, woodpeckers, nut-hatches, and squirrels	recommended for coastal plain area, fast growth rate
RED OAK Quercus rubra	2	L	M	40'	Y	High: same as Swamp White Oak	excellent red fall color
WHITE OAK Quercus alba	2	L	M	30'	Y	High: same as Swamp White Oak	variable fall color, stately tree

TABLE 1 - SHRUBS								
Plant Names	**Drainage Area Suitability**	**Tolerance to Flooding**	**Shade Tolerance**	**Shade Value**	**Height 20 years**	**Native Species**	**Wildlife Value**	**Notes**
BUTTONBUSH Cephalanthus occidentalis	1	H	full sun to partial shade	L	8'	Y	Medium: seeds and nectar, food for hummingbirds, ducks, beavers, and rails	unusual, round white flowers
SILKY DOGWOOD Cornus amomum	1	M	full sun to partial shade	L	10'	Y	High: berries and twigs, food for wood-peckers, pine warblers, finches, cardinals, and deer	produces fruit at 3-5 years of age
SMOOTH ALDER Alnus serrulata	1	H	partial shade	L	10'	Y	Medium: seeds, food for ducks, quail, doves and deer	nitrogen fixing
WINTERBERRY Ilex verticillata	1	M	full sun to partial shade	L	10'	Y	High: berries, food for woodpeckers, waxwings, cardinals, chickadees and deer	need male and female plants for fruit produc-tion
ARROWWOOD VIBURNUM Viburnum dentatum	1 & 2	M	full sun to partial shade	L	10'	Y	Medium: berries and foliage, food for grouse, squirrels, and deer	suckers freely, wood used to make arrows
CRANBERRY BUSH Viburnum trilobum	1 & 2	M	full sun to partial shade	L	12'	Y	Medium: same as Arrowwood Viburnum	yellow to red fall color, white flower clusters
ELDERBERRY Sambucus canadensis	1 & 2	H	full sun to partial shade	L	12'	Y	High: berries and nectar, food for wood-peckers, blue jays, grosbeaks, rabbits, and squirrels	large clusters of white flowers followed by purple berries, fast growth rate
GRAY DOGWOOD Cornus racemosa	1 & 2	L	full sun to shade	L	10'	Y	High: same as Silky Dogwood	White flowers, white berries

TABLE 1 - SHRUBS

Plant Names	Drainage Area Suitability	Tolerance to Flooding	Shade Tolerance	Shade Value	Height 20 years	Native Species	Wildlife Value	Notes
NANNYBERRY Viburnum lentago	1 & 2	L	full sun to shade	M	20'	Y	Medium: same as Arrowwood Viburnum	often suckers
PAWPAW Asimina triloba	1 & 2	M	full sun to partial shade	M	20'	Y	High: important food source for fox and opossum	suckers and forms colonies
REDOSIER DOGWOOD Cornus sericea	1 & 2	L	full sun to shade	L	8'	Y	High: same as Silky Dogwood	good for streambank stabilization
BRISTLY LOCUST Robinia hipsida	2	L	full sun to partial shade	L	8'	N	Low	nitrogen fixing, good for steep sandy slopes
NINEBARK Physocarpus opulifolius	2	M	full sun to partial shade	L	9'	Y	Low	peeling bark, hidden by dense foliage
SPICEBUSH Lindera benzoin	2	M	full sun to partial shade	L	12'	Y	Medium: berries, food for thrushes, catbirds, and kingbirds	fragrant leaves and twigs, yellow fall color

NOTE: Native refers to species that occur naturally in the state of Maryland.

TABLE 2: Zone 3 Planting

1. Native, warm-season grass mix for somewhat poorly to well drained sites

Name	Planting Rate - Pure Live Seed			
	lbs/ac	Drilled: Seeds per linear ft.	Drilled: Row spacing	Broadcast seeds per sq. foot
SWITCHGRASS Panicum virgatum 'shelter'	8	30	36"	40
EASTERN GAMAGRASS Tripsacum dactyloides 'Pete'	10	4	36"	
OATS	20			

For added wildlife and aesthetic value add ¼ lb/ac to ½ lb/ac of a mix of 2 or more of the following:

GREAT ASTER	Aster grandiflorus	(height 2-5')
SMOOTH ASTER	Aster laevis	(height 2-5')
FALL PHLOX	Phlox paniculata	(height 2-5')
SNEEZEWEED	Helenium flexuosum	(height 2-5')
WILD BERGAMONT	Monarda fistulosa	(height 2-4')
PURPLE CONEFLOWER	Echinacea purpurea	(height 3')
MONKEY FLOWER	Mimulus alatus & M. Ringens	(height 1')
BLAZING STAR	Liatris spicata	(height 2-5')
BEE BALM	Monarda didyma	(height 2-4')
GREEN CONEFLOWER	Rudbeckia lanciniata	(height 2-8')

2. Native, warm-season grass for mix moderately well to well drained sites

Name	Planting Rate - Pure Live Seed			
	lbs/ac	Drilled: Seeds per linear ft.	Drilled: Row spacing	Broadcast seeds per sq. foot
BIG BLUESTEM Andropogon gerardii 'niagara'	10	30	30"	40
SWITCHGRASS Panicum virgatum 'shelter'	8	30	36"	40
INDIANGRASS Sorghastrum nutans	5	30	30"	30
OATS	20			

For added wildlife and aesthetic value add ¼ lb/ac to ½ lb/ac of a mix of two or more of the following:

MARYLAND GOLDENASTER	Chrysopsis mariana	(height 1-2')
TICKSEED	Coreopsis tinctoria	(height 2-3')
WILD BLUE INDIGO	Baptisia australis	(height 3-5')
SHOWY ASTER	Aster spectabilis	(height 2-5')
BUTTERFLYWEED	Asclepias tuberosa	(height 1-2')
COMMON MILKWEED	Asclepias syriaca	(height 2-5')
WILD COLUMBINE	Aquilegia canadensis	(height 1-2')
BLACK-EYED SUSAN	Rudbeckia hirta 'golden jubilee'	(height 2-3')

NOTE: On slopes greater than 6% plant a cover crop in the fall, cut in the spring and no-till warm season grass seed into the stubble.

TABLE 2: Zone 3 Planting			
For each of the following mixes, add one of these crops: Winter Rye 20 lbs/ac Winter Wheat 20 lbs/ac Spring Oats 20 lbs/ac			
3. Cool-season grass and legume mix for well drained sites: *(This is a non-competive mix and can be used to stabilize areas where trees and shrubs will be planted.)*			
Name		**Lbs/Ac**	**Planting Date**
CREEPING RED FESCUE	Festuca rubra	10	early spring or fall
HARD FESCUE	Festuca longifolia	10	early spring or fall
WHITE CLOVER	Trifolium repens	2	early spring or fall
Cool-season grass and legume mix for poorly drained sites:			
REED CANARY GRASS	Phalaris arundinacea	10	spring
BIRDSFOOT TREFOIL	Lotus corniculatus	6	
4. Cool-season grass mix for moderately well drained sites			
Name		**Lbs/Ac**	**Planting Date**
KENTUCKY BLUEGRASS	Poa pratensis	25	spring or fall
PERENNIAL RYEGRASS	Lolium perenne	15	spring or fall
RED TOP	Argostis gigantea	5	spring or fall
5. Cool-season grass & wildflower mix for moderately well to excessively drained sites			
Name		**Lbs/Ac**	**Planting Date**
CHEWINGS FESCUE	Festuca rubra L. Ssp. falax	10	spring or early fall
HARD FESCUE	Festuca longifolia	10	spring or early fall
WILDFLOWER SEED MIX (Choose 4 or more species from wildflowers in mix 2)		6	

OPERATION AND MAINTENANCE

The following actions shall be carried out to insure that this practice functions as intended throughout its expected life. These actions include normal repetitive activities in the application and use of the practice (operation), and repair and upkeep of the practice (maintenance):

The riparian forest buffer will be inspected periodically, protected and restored as needed, to maintain the intended purpose from adverse impacts such as excessive vehicular and pedestrian traffic, pest infestations, pesticide use on adjacent lands, livestock damage and fire.

Replacement of dead trees or shrubs and control of undesirable vegetative competition will be continued until the buffer is, or will progress to, a fully functional condition.

As applicable, control of concentrated flow erosion or mass soil movement shall be continued in the up-gradient area immediately adjacent to zone 2 to maintain buffer function.

Any removals of tree and shrub products shall be conducted in a manner that maintains the intended purpose and is consistent with state and local law.

For purposes of moderating water temperatures and providing detritus and large woody debris, riparian forest buffer management must maintain a minimum of 50 percent canopy cover. To achieve benefits provided by large woody debris, natural mortality of trees and large shrubs may need to be supplemented by periodically falling and placing selected stems or large limbs within water courses and water bodies to reach original design specifications.

For providing habitat and corridors for wildlife, manage the buffer to favor food, shelter and nesting cover that would satisfy the habitat requirements of the indicator or target wildlife species. Refer to MD Wildlife Biology and Management Handbook for more information.

For purposes of reducing excess pollutants in surface runoff and shallow groundwater (zone 1 and 2), or providing habitat and corridors for wildlife (zone 1 at a minimum), manage the dominant canopy to maintain maximum vigor of overstory and understory species.

Weeds should be controlled for 2 - 3 years after planting. Any use of fertilizers, mechanical treatments, prescribed burning, pesticides and other chemicals to assure buffer function shall not compromise the intended purpose. *Biological control of undesirable plant species and pests (e.g., using predator or parasitic species), shall be implemented where available and feasible.*

Additional operation and maintenance requirements shall be developed on a site-specific basis to assure performance of the practice as intended.

DATA AND SUPPORTING DOCUMENTATION

The following is a list of information to be recorded in the case file.

1) Purpose of riparian forest buffer

2) Field location and plan view

3) Size of planting

   - width of floodplain (ft)
   - width of planting (ft)
   - length of stream (ft)
   - acres of riparian forest buffer

4) Planting details

   - date planted
   - species planted
   - spacing of planting

5) Operation and maintenance plan

REFERENCES

American Fisheries Society, 1991. Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats. Special Publication 19, Editor: William R. Meehan. Bethesda, MD.

Brown, R.G., Brown, M.L. 1972. Woody Plants of Maryland. Baltimore, MD

California Department of Fish and Game, 1994. California Salmonid Stream Habitat Restoration Manual. Second Edition. Prepared by: Gary Flosi and Forrest L. Reynolds. Sacramento, CA.

Dirr, Michael A. Manual of Woody Landscape Plants. Stipes Publishing Co., Champaign, IL. 1977.

Keller, Cheny M.E., et al. 1993. Avian Communities in Riparian Forest of Different Widths in Maryland and Delaware. Wetlands V.13(2):137-144.

Martin, A.C., H.S. Zim and A.L. Nelson. 1961. American Wildlife & Plants: A Guide to Wildlife Food Habitats. New York, NY. Dover Publications.

Nutrient Subcommittee of Chesapeake Bay Program. 1995. Water Quality Functions of Riparian Buffer Systems in the Chesapeake Bay Watershed. EPA 903-R-95-004.

Olson, Rich and W.A. Hubert, 1994. Beaver: Water Resources and Riparian Habitat Manager. University of Wyoming. Laramie, WY.

Rosgen, David L. 1994. A Classification of Natural Rivers. Catena: An Interdisciplinary Journal of Soil Science, Hydrology, Geomorphology, Vol. 22, No. 3, Elsevier Science. Amsterdam, Netherlands.

Schultz, R.C., J.P. Colletti, T.M. Isenhart, W.W. Simpkings, C.W. Mize, and M.L. Thompson. 1995. Design and Placement of a Multi-species Riparian Buffer Strip. Agroforestry Systems 29:201-225.

State of Maryland, Department of Natural Resources, Public Lands, Forest Service, 1993. Soil Erosion and Sediment Guidelines for Forest Harvest Operations in Maryland. BMP Pocket Guide. Annapolis, MD.

U.S. Department of Agriculture, Forest Service, Northeastern Area State and Private Forestry, 1991. Riparian Forest Buffers -- Function and Design for Protection and Enhancement of Water Resources. NA-PR-07-91. Prepared by. David J. Welsch Altanta, GA.

U.S. Department of Agriculture, Forest Service, Southern Region, 1992. Stream Habitat Improvement Handbook. Tech. Publ. R8-TP 16. Prepared by: :Monte E Seehorn Radnor, PA.

U.S. Department of Agriculture, Forest Service, Intermountain Research Station, 1989. Managing Grazing of Riparian Areas in the Intermountain Region. General Technical Report INT-263. Prepared by: Warren P. Clary and Bert F. Webster. Ogden, UT.

U.S. Environmental Protection Agency, 1991. Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska. EPA/910/9-91-001. Prepared by: Lee H. MacDonald with Alan W. Smart and Robert C. Wissmar. Seattle, WA.

U.S. Fish and Wildlife Service, Chesapeake Bay Field Office with the Natural Science Center and Adkins Arboretum, 1995. Native Plants for Wildlife Habitat. Annapolis, MD.

APPENDIX 4

Program Contacts in the

Chesapeake Bay Watershed

APPENDIX 4

Program Contacts in the Chesapeake Bay Watershed

STATE FORESTERS

Delaware

E. Austin Short III
Department of Agriculture Forest Service
2320 S. DuPont Highway
Dover, DE 19901-5515
302-739-4811
Forest Stewardship Program, Stewardship Incentive Program, Urban and Community Forestry Program, Fire Protection Program, Forestry Incentives Program

Maryland

James Mallow
Department of Natural Resources
Forestry, Wildlife & Heritage Service
580 Taylor Avenue, E-1
Annapolis, MD 21401-2397
410-974-3776
Forest Conservation Act, Forest Stewardship Program, Stewardship Incentive Program, Reforestation Act, Buffer Incentive Program, Woodland Incentive Program, Special Rivers Project, Tree-mendous Maryland, Urban and Community Forestry Program, Forest Conservation and Management Program, Reforestation/Timber Stand Improvement Tax Deduction (TAXMOD) Program

New York

Frank Dunstan
Division of Lands and Forests
50 Wolf Road
Albany, NY 12233-4250
518-457-2475
Forest Stewardship Program, Stewardship Incentive Program, Forestry Incentives Program, Urban and Community Forestry Program

Pennsylvania

James Grace
Bureau of Forestry
PO Box 8552
400 Market Street
Harrisburg, PA 17105-8552
717-787-2703
Forest Stewardship Program, Stewardship Incentive Program, Forestry Incentives Program, Urban and Community Forestry Program

Virginia

James W. Garner
VA Department of Forestry
PO Box 3758
Charlottesville, VA 22903
804-977-6555
Agricultural BMP Cost-share Program, Use/Value Taxation, Chesapeake Bay Preservation Act, Water Quality Law ("Bad Actor" Law), Forest Stewardship Program, Stewardship Incentive Program, Forestry Incentives Program, Urban and Community Forestry Program

West Virginia

Robert Whipkey
Forestry Division
1900 Kanawha Boulevard East
Charleston, WV 25305-0180
304-558-3446
Logging Sediment Control Act, Forestry Incentives Program, Forest Stewardship Program, Stewardship Incentive Program

USDA FOREST SERVICE

Albert Todd
Richard Cooksey
410 Severn Avenue, Suite 109
Annapolis, MD 21403
410-267-5705, 5706
Chesapeake Bay Program

Roxane Palone
Karen Sykes
Northeastern Area
180 Canfield Street
Morgantown, WV 26505
304-285-1592
Watershed Protection and Flood Prevention Act (PL-566), Resource Conservation and Development Program, Economic Action Programs

Gerard Hertel, *Forest Health Programs*
Lloyd Casey, *Reforestation Tax Incentive, PL-96-451*
Northeastern Area
5 Radnor Corporate Center, Suite 200
Radnor, PA 19087-4585
610-975-4124

DELAWARE

Natural Resources Conservation Service
1203 College Park Drive
Suite A
Dover, DE 19901-8713
302-678-4160
Environmental Quality Incentives Program, Conservation Reserve Program, Forestry Incentives Program, Wildlife Habitat Incentives Program, Wetlands Reserve Program, Farmland Protection Program, Swampbuster, Conservation Farm Option, Watershed Protection and Flood Prevention Act

Farm Service Agency
1201 College Park Drive
Suite 101
Dover, DE 19904
302-678-2547

MARYLAND

Farm Service Agency
8335 E. Guilford Road
Columbia, MD 21046
410-381-4550

Natural Resources Conservation Service
339 Busch's Frontage Road, Suite 301
Annapolis, MD 21401
410-757-0861
Environmental Quality Incentives Program, Conservation Reserve Program, Forestry Incentives Program, Wildlife Habitat Incentives Program, Wetlands Reserve Program, Farmland Protection Program, Swampbuster, Conservation Farm Option, Watershed Protection and Flood Prevention Act

Chesapeake Bay Critical Area Commission
45 Calvert Street, 2nd floor
Annapolis, MD 21401
410-974-2426
Chesapeake Bay Critical Area Act

Maryland Department of the Environment
Tawes State Office Building, B-3
580 Taylor Avenue
Annapolis, MD 21401
410-974-3265
Nontidal Wetlands Act

MARYLAND (Cont.)

Chief Planner
Maryland Office of Planning
Comprehensive Planning
301 W. Preston Street
Baltimore, MD 21201-2365
410-767-4562
Economic Growth, Resource, Protection and Planning Act

University of Maryland
Cooperative Extension Service
Wye Research and Education Center
PO Box 169
Queenstown, MD 21658
410-827-8056

Maryland Department of Assessments and Taxation
Real Property Division
300 West Preston Street, Room 511
Baltimore, MD 21201
410-767-1199
Agricultural Use Assessment

NEW YORK

Farm Service Agency
441 S. Salina Street
Suite 356
Syracuse, NY 13202
315-477-6303

Natural Resources Conservation Service
The Galleries of Syracuse
441 S. Salina Street
Suite 354
Syracuse, NY 13202-2450
315-477-6504
Environmental Quality Incentives Program, Conservation Reserve Program, Forestry Incentives Program, Wildlife Habitat Incentives Program, Wetlands Reserve Program, Farmland Protection Program, Swampbuster, Conservation Farm Option, Watershed Protection and Flood Prevention Act

PENNSYLVANIA

Natural Resources Conservation Service
Suite 340
One Credit Union Place
Harrisburg, PA 17110-2993
Environmental Quality Incentives Program, Conservation Reserve Program, Forestry Incentives Program, Wildlife Habitat Incentives Program, Wetlands Reserve Program, Farmland Protection Program, Swampbuster, Conservation Farm Option, Watershed Protection and Flood Prevention Act

Pennsylvania Fish and Boat Commission
450 Robinson Lane
Bellefonte, PA 16823-9616
814-359-5100
Adopt-a-Stream Program

Pennsylvania Game Commission
Bureau of Land Management
2001 Elmerton Avenue
Harrisburg, PA 17110-9797
Streambank Fencing Program

Farm Service Agency
One Credit Union Place, Suite 320
Harrisburg, PA 17110
717-782-4457

Pennsylvania Department of Agriculture
Bureau of Farmland Protection
2301 N. Cameron Street
Harrisburg, PA 17110-9408
Farmland and Forest Land Assessment Act ("Clean and Green")

Pennsylvania Office of Water Management
Bureau of Watershed Conservation
PO Box 8555
Harrisburg, PA 17105-8555
717-787-5267
Stormwater Management Act (Act 167 of 1968);Federal Clean Water Act (PL-92-500), Federal Coastal Zone Management Act of 1972 (PL-92-583), Section 319 Non point source pollution prevention program, PA Chesapeake Bay Program; Bay Financial Assistance Funding Program

Pennsylvania Office of Water Management
Bureau of Water Quality Protection
PO Box 8465
Harrisburg, PA 17105-8465
717-787-2666
Clean Streams Law, Federal Clean Water Act, Pennsylvania Sewage Facilities Act, Dam Safety and Encroachments Act, Conservation District Law

VIRGINIA

USDA-Natural Resources Conservation Service
1606 Santa Rosa Road
Richmond, VA 23229-5014
804-287-1691
Environmental Quality Incentives Program, Conservation Reserve Program, Forestry Incentives Program, Wildlife Habitat Incentives Program, Wetlands Reserve Program, Farmland Protection Program, Swampbuster, Conservation Farm Option, Watershed Protection and Flood Prevention Act

Farm Service Agency
1606 Santa Rosa Road
Culpepper Building, Suite 138
Richmond, VA 23229
804-287-1522

WEST VIRGINIA

Natural Resources Conservation Service
75 High Street, Room 301
Morgantown, WV 26505
304-291-4152
Environmental Quality Incentives Program, Conservation Reserve Program, Forestry Incentives Program, Wildlife Habitat Incentives Program, Wetlands Reserve Program, Farmland Protection Program, Swampbuster, Conservation Farm Option, Watershed Protection and Flood Prevention Act

Farm Service Agency
75 High Street, Room 239
PO Box 1049
Morgantown, WV 26505
304-253-2510

APPENDIX 5

Bay Area Riparian Forest Buffer-Related Programs

Bay Area Riparian Forest Buffer-Related Programs

Program	Chesapeake Bay Critical Area Act	Forest Conservation Act	Nontidal Wetlands Act
Type	Regulatory, State (MD)	Regulatory, State (MD)	Regulatory, State (MD)
Purpose	Controls development within 1,000 feet of tidal waters. 100-foot mandatory buffer required for all tidal waters, tidal wetlands, and tributary streams in Critical Area. Exemptions for agricultural/silvicultural land.	Protects forest cover from development by limiting forest clearing. Requiring replanting where needed. "Priority areas" for retainment/replanting include 50-foot buffer areas streams.	Mandatory 25-foot naturally vegetated buffer required around all nontidal wetlands greater than 5,000 square feet. Provides forested/naturally vegetated buffer in cases where wetland exists within/adjacent to stream.
RFB Emphasis	Yes	No	No
Prot. Level	Indefinite	Indefinite	Duration of the regulated activity
Admin. Agency	Critical Area Commission, MD DNR	Local counties and municipalities with planning and zoning authority and MD DNR - Forest Service.	MD Department of the Environment - Water Resources Administration
Participation	Mandatory	Mandatory	Mandatory
Enforcement	Adequate	Adequate	Adequate to Poor
Barriers	Inconsistent implementation and interpretation by local jurisdictions. Does not enjoy universal acceptance at the local level.	Requires more preconstruction planning. Inconsistent implementation at the local level. Needs to be streamlined to better recognize local development regulations and standard forest management practices.	Spotty enforcement due to insufficient personnel.
$ Level/Source	Varies by local county	Varies by local county. DNR-Forest Service General Fund @ $80,000/yr	Water Resources Administration General Fund
Benefits	Protects the riparian forests on the 60 Timber Harvest Plans submitted to local Forest Conservancy District Boards annually. Protects riparian forests by restricting development in the 1000' Critical Area. Creates zoning with limits on lot size, etc. Requires an approved Timber Harvest plan for all harvests within the Critical Area. The first 50' from mean high tide is a no cut buffer; the next 50' may be thinned selectively or clear-cut in the cases of Loblolly pine and yellow-poplar if a Buffer Management Plan is prepared by a licensed forester as part of the Timber Harvest Plan.	Conserves the forestland base. Prioritizes forest mitigation by encouraging riparian buffer planting. Riparian forests are considered high priority areas for forest retention. Provides long-term protection and management of riparian forest buffers as part of the tract.	Allows for management of forested wetlands through the use of BMPs. Conserves riparian as well as other non-tidal wetland values.

Bay Area Riparian Forest Buffer-Related Programs

Program	Economic Growth, Resource Protection, and Planning Act	Reforestation Act	Chesapeake Bay Preservation Act
Type	Regulatory, State (MD)	Regulatory, State (MD)	Regulatory, State (VA)
Purpose	Encourages riparian protection as part of each county's requirement to develop "sensitive areas element" in comprehensive plans.	Minimizes forest loss, replaces unavoidable losses from highway construction projects. Highest priority on forests near/adjacent to streams.	Establishes "preservation areas" that comprise between 50% - 60% of Virginia's coastal plain. Stream areas, wetlands, tributaries require a 100-foot buffer around tributary streams. Exemptions for agricultural land. Prevents indiscriminate tree cutting.
RFB Emphasis	No	No	Yes, where there are trees.
Prot. Level	Indefinite	Indefinite	Indefinite
Admin. Agency	Local counties and municipalities that have planning and zoning authority with approval of Maryland Office of Planning.	MD DNR-Forest Service	Chesapeake Bay Land Assistance Department working with local jurisdictions through local ordinances.
Participation	Mandatory	Mandatory	Mandatory
Enforcement	Adequate	Adequate	Inadequate local enforcement
Barriers	Inconsistent implementation at the local level. Needs to be streamlined to better recognize local development regulations and standard forest management practices. Insufficient support resources at the local level ($ & people).	Requires more preconstruction planning. Differences between forest values and riparian buffer values is not distinguished.	Public perception of ordinances being inflexible and a form of a "taking".
$ Level/Source	Varies by local county.	MD DNR-Forest Service General Funds @ $30,000/yr.	State General Funds @ $2.3 million/yr. $1.1 million made available to local jurisdictions through 50/50 matching grants. Local jurisdictions generate Special Fund revenue for plan review.
Benefits	Conserves the forestland base by allowing for a comprehensive review of the forest resource. Prioritizes forest mitigation by encouraging riparian buffer planting. Riparian forests are considered high priority areas for forest retention. Provides long-term protection and management of riparian forest buffers as part of the tract.	Mitigated the loss of forestland including riparian areas. Encourages mitigation to occur in riparian areas as a priority.	Improved land use planning. Improvement in oversight of development and conservation planning on forestlands. Reduces NPS pollution by protecting and conserving riparian forest buffers.

Bay Area Riparian Forest Buffer-Related Programs

Program	Dams Safety and Encroachments Act	Local Zoning Ordinances	Forest Harvest Guidelines	Water Quality Law ("Bad Actor" Law)
Type	Regulatory, State (PA)	Regulatory, State (MD, VA, PA)	Regulatory, State (MD)	Regulatory, State (VA)
Purpose	Regulates development in wetlands, stream areas by requiring permit from the Department of Environmental Protection. Applicants must avoid, minimize, or mitigate impacts. No specific buffer requirements.	Forty-two percent of counties in Maryland have regulations requiring stream buffers of 50 to 100 feet on developed land (exclusive of Critical Areas). All tidewater counties in Virginia have adopted Chesapeake Bay Preservation Act regulations into local zoning ordinances, which extends the designation of protection areas to all other areas of the county. Some municipalities in Pennsylvania have ordinances which restrict timber harvesting altogether.	Minimum 50-foot forested, selective-cut buffer required around all perennial streams. 60% crown cover or 60 square feet of basal area per acre must be evenly retained.	Minimum 50-foot forested, selective-cut buffer required around all perennial streams and retention of 50% crown cover or 50 square feet of basal area per acre. Alternative practices that provide equivalent water quality protection may be permitted.
RFB Emphasis	No	Yes (MD, VA), No (PA)	No	No
Prot. Level	Indefinite	Indefinite	Duration of regulated activity	Duration of regulated activity
Admin. Agency	Department of Environmental Protection, Bureau of Land and Water Conservation, and local soil and water conservation districts.	Local counties	Local Soil Conservation Districts, local counties, and the Maryland Department of the Environment.	VA Department of Forestry
Participation	Mandatory	Mandatory	Mandatory	Mandatory
Enforcement	Adequate	Adequate	Adequate	Adequate
Barriers	Burdensome paperwork	N/A	Varying requirements by county. Inconsistent implementation by county. Burdensome paperwork.	Lack of public awareness
$ Level/Source	Department of Environmental Protection, Bureau of Land and Water Conservation, and local soil and water conservation districts.	Varies by local county	Local Soil Conservation Districts, local counties, and the Maryland Department of the Environment. Information not available for forest harvesting.	VA Department of Forestry
Benefits	Reduced NPS pollution	Protect and Maintain riparian forest buffers Conserves forestland base.	Reduce nonpoint source pollution. Protect and maintain stream integrity and bank stability.	Reduce nonpoint source pollution

Bay Area Riparian Forest Buffer-Related Programs

Program	Special Protection Streams	Logging Sediment Control Act
Type	Regulatory, State (PA)	Regulatory, State (WV)
Purpose	Mandatory forested buffers required for commercial logging operations on state forestlands around streams designated for "special protection" by the Bureau of Water Quality Management (100-foot selective-cut buffer) or as Wilderness Trout Streams by the Pennsylvania Fish and Boat Commission (200-foot no-cut buffer).	To protect and maintain forest water and site productivity by minimizing soil erosion from areas disturbed during timber harvesting operations.
RFB Emphasis	Yes	No
Prot. Level	Indefinite	Indefinite
Admin. Agency	Bureau of Water Quality Management or Fish and Boat Commission	WV Division of Forestry
Participation	Mandatory	Mandatory
Enforcement	Adequate	Adequate
Barriers	N/A	Takes foresters away from management activities.
$ Level/Source	Bureau of Water Quality Management or Fish and Boat Commission	Fees collected
Benefits	Reduced NPS pollution. Maintain water quality for fish habitat.	Reduced erosion and sedimentation.

Bay Area Riparian Forest Buffer-Related Programs

Program	Buffer Incentive Program	Virginia Agricultural BMP Cost-Share Program	Virginia Agricultural BMP Cost-Share Program	Streambank Fencing Program, PA Game Commission
Practice	N/A	Woodland Buffer Filter Area	Loafing Lot Management System	N/A
Type	Incentive, State (MD) technical and financial assistance.	Incentive, State (VA) technical and financial assistance	Incentive, State (VA) technical and financial assistance.	Incentive, State (PA) technical and financial assistance.
Purpose	One-time payments of $300 per acre for planting and maintenance of minimum 50-foot forested buffers along streams/shorelines.	One-time payments of $100 per acre to establish minimum 50-foot forested buffers along streams. Permitted only on crop and pasture land that has recently been in production.	Cost-share for rotational grazing system. Requires a minimum 25-foot fenced buffer around streams.	Fencing with minimum 12-foot buffer free to rural landowners by PA Game Commission in exchange for allowing public hunting. Department of Environmental Resources implementing parallel program that omits hunting requirement.
RFB Emphasis	Yes	Yes	No	No
Prot. Level	10 year practice lifespan	10 year practice lifespan	10 year practice lifespan	10 year practice lifespan, PA Game Commission maintains.
Admin. Agency	MD DNR-Forest Service	VA Department of Conservation and Recreation through the soil and water conservation districts.	VA Department of Conservation and Recreation through the soil and water conservation districts.	Department of Environmental Protection - Game Commission through the local soil and water conservation districts.
Participation	Voluntary, 30 sites/yr, averaging 175 acres.	Voluntary, 3 sites/yr for 15 acres.	Voluntary, 10 sites/yr @ 75% c/s up to $7,500 per applicant.	Voluntary (highly supported).
Enforcement	Adequate	Adequate	Adequate	Adequate
Barriers	Burdensome paperwork; payment insufficient for commercial farm owner/operators.	Lack of information and education to improve public awareness. Perceived risk of practice loss due to flood risk.	Expensive to install. With the cap, the cost-share is often not even 50% of the total actual cost.	Perception of giving up use of fenced land for 10 years. Insufficient funds, a limiting factor for participation.
$ Level/Source	MD DNR-Forest Service @ 111,000/yr.	VA Department of Conservation and Recreation via Federal Funds through a CBI Grant, average $1.1 million/yr.	VA Department of Conservation and Recreation via Federal Funds through a CBI Grant, average $1.1 million/yr.	Department of Environmental Protection - Game Commission through a CBI Grant.
Benefits	Creation and maintenance of RFBs for 10 years. Reduction of NPS pollution.	Creation of riparian forest buffers. Reduction of NPS pollution. Payment can be “piggybacked” onto other cost-share practices.	Stream bank stabilization from livestock. Improved herd health. Creation of riparian forest buffers. Reduction of NPS pollution.	Stream bank stabilization from livestock. Reduced NPS pollution.

Bay Area Riparian Forest Buffer-Related Programs

Program	Environmental Quality Incentives Program	Environmental Quality Incentives Program	Environmental Quality Incentives Program	Conservation Reserve Program
Practice	Permanent Vegetative Cover (SL1)	Stream Protection (WP2)	Riparian Forest Buffer Establishment (WP7)	N/A
Type	Incentive, Federal (MD, VA, PA) technical and financial assistance.	Incentive, Federal (MD, VA, PA) technical and financial assistance.	Incentive, Federal (CFSA) technical and financial assistance.	Incentive, Federal (CFSA) technical and financial assistance.
Purpose	Cost-share for establishing trees, grasses, shrubs in eroding areas, including riparian zone.	Cost-share for establishing permanent vegetative cover, which can include trees, along the banks of streams, as well as related items such as remote watering systems, stream crossings for livestock, and stream fencing.	Provides a number of cost-share practices designed to solve soil, water, and related environmental problems in agricultural areas, including small woodlands. Most notably: Minimum 95-foot forested Riparian Buffer Strips.	Takes highly erodible land out of production for at least ten years. Cost-share for tree establishment, other vegetative cover. Annual rental payments on land taken out of production.
RFB Emphasis	No	No	Yes	Yes, special practices
Prot. Level	10 year practice lifespan	10 year practice lifespan	10 year practice lifespan	10 year practice lifespan
Admin. Agency	Farm Services Agency	Farm Services Agency	Farm Services Agency	Farm Services Agency
Participation	Voluntary, MD 35 farms for 613 acres PA 265 farms for 3,165 acres	Voluntary, MD 8 farms for 191 acres/yr PA 30 farms for 360 acres/yr VA 4 farms for 81.2 acres/yr	Voluntary	Voluntary
Enforcement	Adequate	Adequate	Adequate	Adequate
Barriers	Insufficient funds. Burdensome paperwork.	Insufficient funds. Burdensome paperwork.	Buffer requirements perceived as too wide. Insufficient funding. Burdensome paperwork.	Insufficient funding. Burdensome paperwork.
$ Level/Source	Community Credit Corporation, funds vary from year to year.	Community Credit Corporations, funds vary from year to year.	Community Credit Corporations, funds vary from year to year.	Community Credit Corporations, funds vary from year to year.
Benefits	Reduce nonpoint source pollution.	Reduce nonpoint source pollution. Establish and protect riparian forest buffers.	Reduce nonpoint source pollution. Establish and protect riparian forest buffers.	Reduced NPS pollution. Riparian forest buffers may be established in environmentally sensitive areas.

Bay Area Riparian Forest Buffer-Related Programs

Program	Wetlands Reserve Program	Woodland Incentive Program	Virginia Agricultural BMP Cost-Share Program	Forest Stewardship Program
Practice	N/A	N/A	Woodland Erosion Stabilization	N/A
Type	Incentive, Federal (CFSA) technical and financial assistance.	Incentive, State (MD) technical and financial assistance.	Incentive, State (VA) technical and financial assistance.	Incentive, Federal (USFS) technical assistance.
Purpose	Allows farmers to sell permanent or 30 year easements to U.S.D.A. Cost-share to restore altered wetlands to natural condition. Eligible land includes prior converted cropland, farmed wetlands, riparian areas along streams or water courses that link protected wetlands.	Cost-share provided to non-industrial private woodland owners for tree planting, including riparian forest buffer establish-ment.	Cost-share to establish permanent vegetation on eroding areas on forest harvesting sites.	Provides technical assistance to private landowners for imple-menting conservation practices while meeting harvesting needs. Forest Stewardship Plans required for participation in other federal cost-share programs for forestry.
RFB Emphasis	Yes	No	No	No
Prot. Level	Indefinite	15 year practice lifespan	5 year practice lifespan	N/A
Admin. Agency	Natural Resources Conservation Service	MD DNR-Forest Service	Department of Conservation & Recreation, through the local soil and water conservation districts.	US Forest Service through State forestry agencies.
Participation	Voluntary	Voluntary (Tree planting not distinguished from buffer planting.)	Voluntary, 20-30 sites/yr for 65-80 acres.	Voluntary, MD 570 plans/yr for 40,000 acres.
Enforcement	Adequate	Adequate	Adequate	Adequate
Barriers	Long term nature of agreement Insufficient funds, not available in all states Burdensome paperwork	Cost-share payment 15% less than other available programs.	Some sites no longer eligible because they are now captured by the “Bad Actor” Law. Public Awareness	Availability of service personnel or others qualified to provide technical advise.
$ Level/Source	Natural Resources Conservation Service, varies year to year.	MD DNR-Forest Service @ $60,000/yr General Funds.	VA Department of Conservation and Recreation via Federal Funds through a CBI Grant, average $1.1 million/yr.	USFS through state forestry agencies, MD $136,000/yr.
Benefits	Protects wetlands and riparian forests.	Establishment and maintenance of riparian forest buffers.	Reduce nonpoint source pollution. Improved wildlife habitat.	Sustainable multiple use management. BMPs used during forest harvesting. Establishment and maintenance of riparian forest buffers recommended.

Bay Area Riparian Forest Buffer-Related Programs

Program	Forestry Incentives Program	Stewardship Incentive Program	Special Rivers Project	Tree-Mendous Maryland
Type	Incentive, Federal (CFSA) technical and financial assistance.	Incentive, Federal (USFS/CFSA) technical and financial assistance.	Incentive, Federal (EPA, Bay Program) technical assistance.	Incentive, State (MD).
Purpose	Cost-share for tree planting, including in forested wetlands and riparian areas on private, non-industrial forestland.	Cost-sharing for tree planting, stream fencing, riparian and wetland improvement, tree shelters, and fisheries habitat improvement on non-industrial private forestland.	Fosters forest stewardship and best management practices in both rural and urban watersheds to improve water quality. Limited to the Susquehanna, Monocacy, and Anacostia river basins.	Local businesses, regional corporations, citizen groups, and local governments conduct community plantings on public land. Also trains people to lead tree-planting efforts in their communities.
RFB Emphasis	No	Yes, for SIP 6	No	No
Prot. Level	10 year practice lifespan	10 year practice lifespan	N/A	N/A
Admin. Agency	Farm Services Agency and the State Forestry Agencies.	US Forest Service and Farm Services Agency through the State forestry agencies.	Environmental Protection Agency through the Maryland Department of the Environment and the DNR- Forest Service.	DNR-Forest Service
Participation	Voluntary, MD 60 sites/yr for 2,300 acres	Voluntary SIP 6: MD 3.5 applications for 25 acres/yr VA 4.0 applications for 20 acres/yr PA 3.0 applications for 16.6 acres/yr	Voluntary	Voluntary, 42,000 volunteers/yr, plant 800,000 trees/yr on 1,200 acres.
Enforcement	Adequate	Adequate	N/A	N/A
Barriers	Insufficient funding. Lack of stable fund source. 10 acre minimum requirement.	Insufficient funding. Lack of stable fund source. Burdensome paperwork.	Insufficient funding via a CBI Grant. Limited personnel due to high turnover.	Securing protection and maintenance for long-term (vandalism). Insufficient resources (e.g. funding and personnel).
$ Level/Source	Consolidated Farm Services Agency, MD FY94 $126,000 FY95 $ 63,000.	SIP 6 MD average $6,000/yr.	Environmental Protection Agency through the Maryland Department of the Environment and the DNR- Forest Service @ $190,000/yr.	DNR-Forest Service @ $150,000/yr Special Funds.
Benefits	Establishment and maintenance of riparian forest buffers. Vigorous growth promoting increased nutrient uptake and an increase of buffer effectiveness.	Riparian forest buffer and wetland establishment. Reduce nonpoint source pollution. Protect and maintain stream integrity and bank stability.	Sustainable multiple use management. BMPs used during forest harvesting. Riparian forest buffer and wetland establishment. Reduce nonpoint source pollution. Protect and maintain stream integrity and bank stability.	Increases forestland base in urban areas. Prevents and reduces NPS pollution. Decreases impervious surface area. Educates people to the value of trees and forests and their relationship to water quality.

Bay Area Riparian Forest Buffer-Related Programs

Program	Forest Conservation and Management Program	Reforestation/Timber Stand Improvement Tax Deduction (TAXMOD) Program	Agricultural Use Assessment	Use-Value Taxation
Type	Incentive, State (MD)	Incentive, State (MD)	Incentive, State (MD)	Incentive, State (VA)
Purpose	Special tax assessments on forestland, if the landowner agrees to adhere to a forest stewardship plan.	Allows landowners of small forestry operations to deduct double the costs associated with reforestation activities, including those in the riparian zone.	Preferential assessment on value of land used for agriculture. Woodlots can also receive an agricultural assessment. No specific requirements for riparian areas.	Counties provide preferential assessments on use value of agricultural and forestland. No specific requirements for riparian areas.
RFB Emphasis	No	No	No	No
Prot. Level	15 year agreement.	15 year maintenance requirement.	3 years with compliance checks and verification.	Duration of participation.
Admin. Agency	DNR-Forest Service and Department of Assessment and Taxation	DNR-Forest Service and Office of Treasurer	Department of Assessment and Taxation	Virginia Department of Agriculture and Consumer Services through the local tax assessors.
Participation	Voluntary, 60 sites/yr for 1,500 acres	Voluntary	Voluntary	Voluntary
Enforcement	Adequate	Adequate	Adequate	Local Departments of Taxation
Barriers	Fees and penalties. Short-term ownership trend. Burdensome paperwork.	Lack of public awareness. Burdensome paperwork.	Lack of public awareness. Little or no demand in rural areas where agricultural use assessment is common.	No clearly defined conservation requirements. Local jurisdictions experience loss of tax base. Not available in all counties (65 of 95).
$ Level/Source	Program funded by participants.	N/A	N/A	N/A
Benefits	Protects forestland base. Reduced carrying costs for participants. Sustainable multiple use management. BMPs used during forest harvesting. Establishment and maintenance of riparian forest buffers recommended.	More tree planting and riparian forest buffer establishment. Reduced carrying costs.	Protects forestland base. Reduced carrying costs for participants. Sustainable multiple use management. BMPs used during forest harvesting. Establishment and maintenance of riparian forest buffers recommended.	Reduced carrying costs. Encourages preservation of open space.

Bay Area Riparian Forest Buffer-Related Programs

Program	Farmland and Forestland Assessment Act ("Clean and Green Act")	Public Law 96-451
Type	Incentive, State (PA)	Incentive, Federal (IRS)
Purpose	County can grant a preferential assessment for ten or more contiguous acres of land devoted to agricultural, forest reserve, or open space purposes. Can apply to land in the riparian zone, although no specific requirements in riparian areas.	Federal tax incentives to reduce reforestation costs. Can include reforestation efforts in riparian areas.
RFB Emphasis	No	No
Prot. Level	10 year agreement	N/A
Admin. Agency	Pennsylvania Department of Agriculture through local jurisdictions.	Internal Revenue Service
Participation	Voluntary	Voluntary
Enforcement	Adequate	Adequate
Barriers	Perception of loss of property rights. Penalties for non-compliance.	Lack of public awareness. Burdensome paperwork.
$ Level/Source	N/A	N/A
Benefits	Conservation of Open Space. Protects forest and agriculture land base. Reduces carrying costs.	More tree planting and riparian forest buffer establishment. Reduced carrying costs.

APPENDIX 6

Excerpts from the

Chesapeake Bay Riparian Forest Buffer

Inventory

APPENDIX 6

Excerpts from the Chesapeake Bay Riparian Forest Buffer Inventory

Introduction

This Geographical Information System (GIS) assessment and analysis was conducted by The Pennsylvania State University, Land Analysis Laboratory, Department of Agronomy, College of Agricultural Sciences, with Dr. Rick L. Day as the principal investigator.

The purpose of the project was to evaluate the extent, location, and condition of forest cover next to the streams, rivers, and shorelines throughout the Chesapeake Bay Watershed. The Chesapeake Bay drainage encompasses 64,000 square miles and has over 110,000 miles of waterways. Using a GIS approach, the purpose was to provide information that would be useful to resource managers, policy decision-makers, and scientists. **The completed inventory produced the following benefits:**

- A determination of the extent and location of riparian for the entire Chesapeake Bay Watershed – each state within the basin and each subwatershed.
- A riparian forestland cover GIS layer that is compatible for each state and the Bay Program.
- A useful tool for resource managers to target forest buffer and habitat restoration projects.
- A foundation or baseline of information useful for future monitoring and more detailed surveys.

The products produced as a result of the project include:

- A GIS land use/land cover data layer of riparian forests for the Chesapeake Bay Watershed, with separate a file for each state and subwatershed in ARC/INFO format.
- Statistical summaries of stream miles and percentage of riparian forest within 100 feet and 300 feet of each stream in the Chesapeake Bay Watershed, and of land use for each subwatershed, state, and the entire Bay basin.
- Map sets of the percentage of riparian forest cover for each subwatershed.
- A detailed accuracy assessment using aerial photography and field verification.

How Do You Use the Inventory?

The results of the inventory indicate that approximately 59.8 percent of the streams, rivers, and shorelines in the Bay watershed have at least 100 feet of forest buffer on one side. That leaves about 40 percent of the basin with less than 100 feet of forest buffer, or none at all, on both sides. The accuracy assessment confirmed the validity of the inventory methodology with an average absolute error of only 5 to 8 percent. However, predicting forest buffers between 100 feet and 300 feet was most difficult and saw as much as 18 percent error.

Reviewing the enclosed tables along with subwatershed maps is the most effective way to gain perspective from the inventory. Also, looking at a state or subwatershed in isolation is probably better than making general assumptions for the Bay in total. Because the data for streams are not consistent for each state across the Bay watershed, comparison of watersheds within a state will yield the best results. This is consistent with the goal of this project to provide information useful to the states in the Bay watershed and from which management and policy decisions can be made.

Table 2 summarizes the extent of riparian forest buffers for each state within the Bay watershed. **Table 3** summarizes the condition for the 54 8-digit hydrologic units for the Chesapeake Bay Watershed. It divides the watershed into major river drainages. The table offers information on total stream miles and forest buffer cover for 100 feet and 300 feet on one side and both sides in stream miles and percentage of forest buffer. **Table 5** summarizes riparian forest buffer statistics for each 11-digit subwatershed in Maryland. **Table 7** summarizes riparian forest buffer statistics for each 11-digit subwatershed in Pennsylvania. **Table 9** summarizes riparian forest buffer statistics for each 11-digit subwatershed in Virginia.

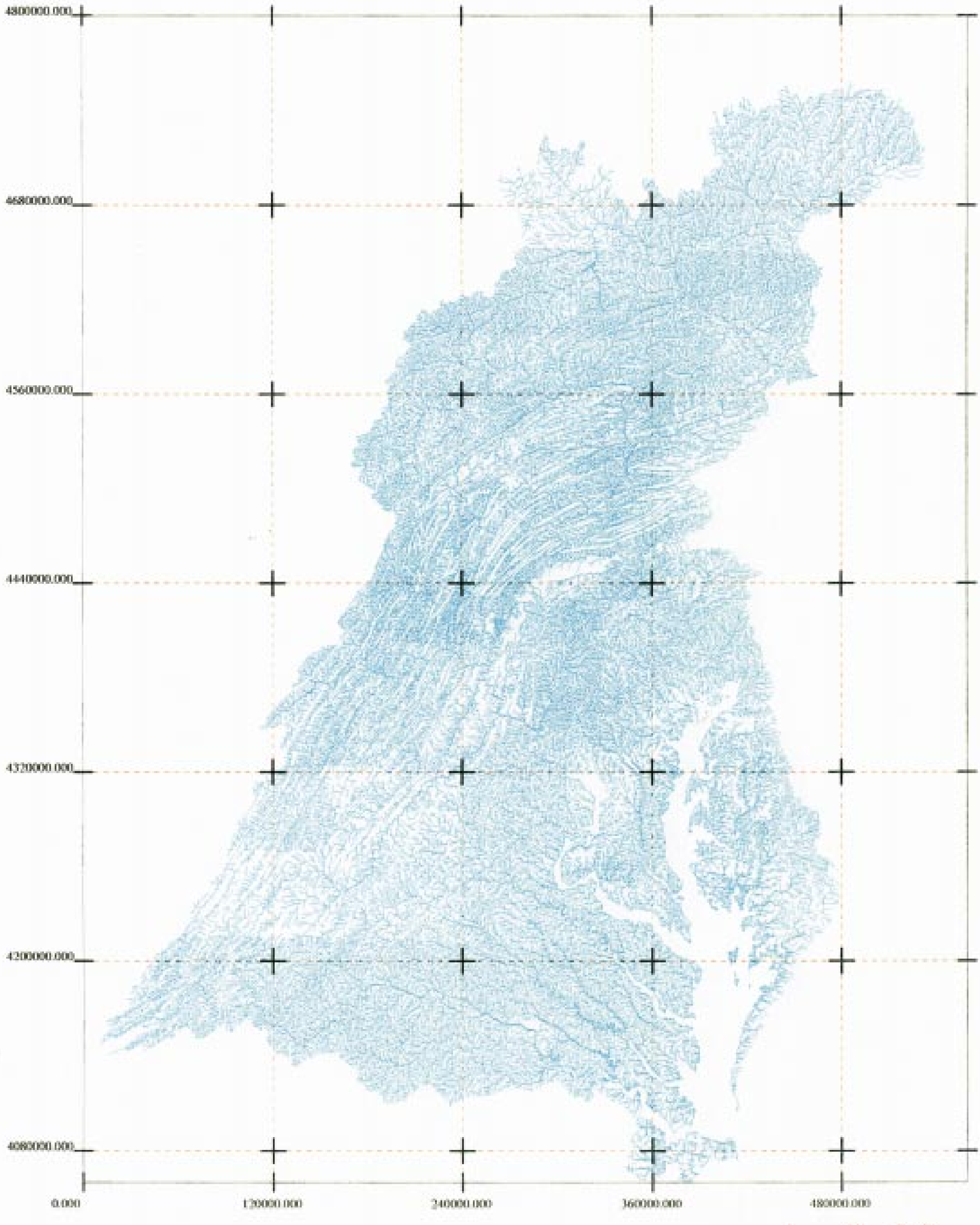


Figure 2

Digital streams layer used in the study
Projection UTM, Zone 18

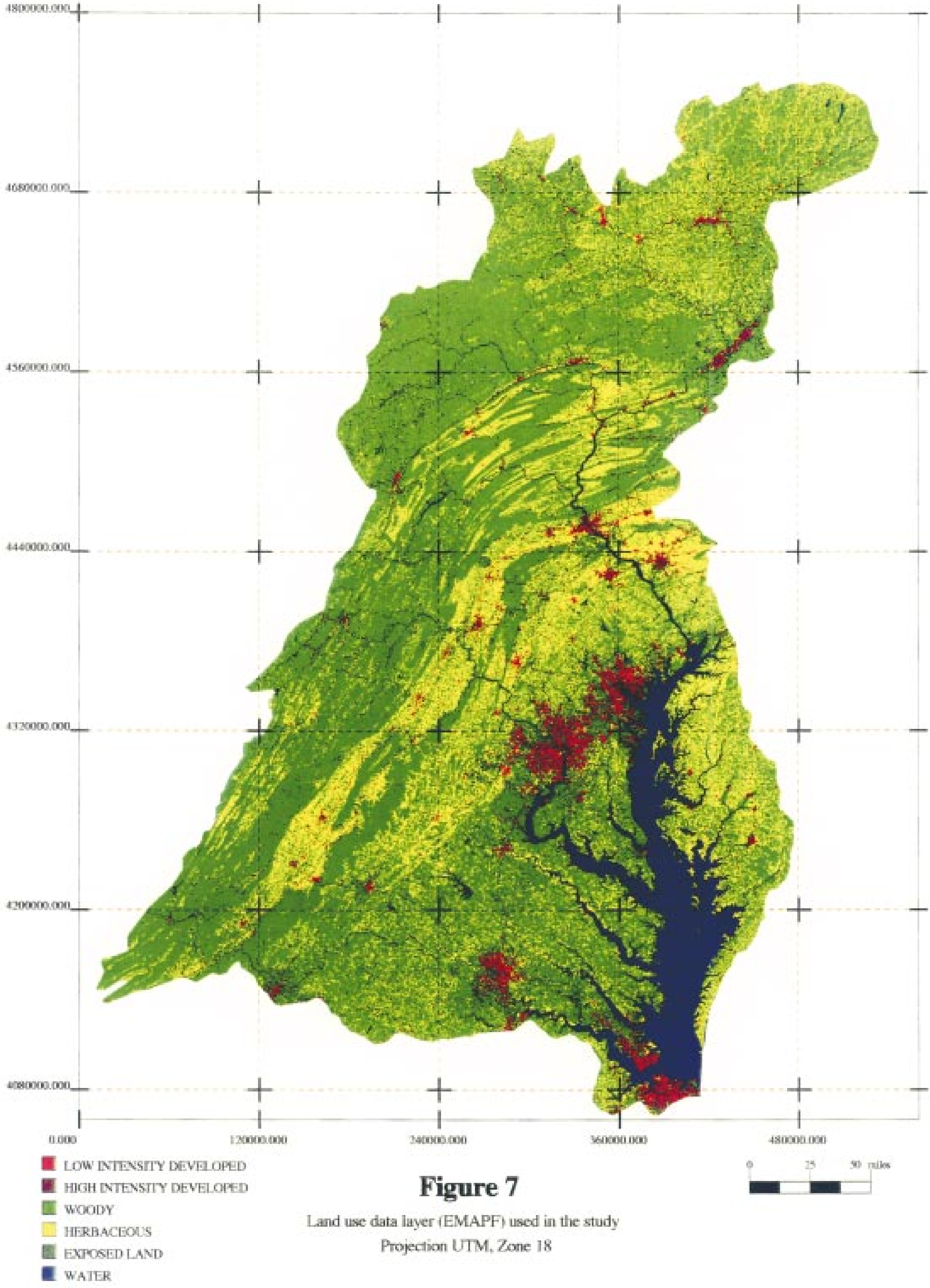


Figure 7

Land use data layer (EMAPF) used in the study

Projection UTM, Zone 18

Table 2. Riparian forest buffer statistics for each state in the Chesapeake Bay watershed.

State	Stream length		Both sides 300' +		Both sides 100' - 300'		One side 300' +		One side 100' - 300'		Both sides < 100'	
	miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
Deleware	1091	1.0	326	29.8	572	52.4	558	51.2	638	58.5	453	41.5
Maryland[1]	16756	14.9	4487	26.8	8032	47.9	7658	45.7	9050	54.0	7706	46.0
New York[2]	8015	7.1	2006	25.0	3744	46.7	3699	46.2	4353	54.3	3662	45.7
Pennsylvania	47585	42.2	17720	37.2	26938	56.6	26750	56.2	30450	64.0	17135	36.0
Virginia[3]	34381	30.5	11971	34.8	17857	51.9	18216	53.0	20065	58.4	14316	41.6
West Virginia	4956	4.4	1840	37.1	2582	52.1	2671	53.9	2913	58.8	2042	41.2
Chesapeake Bay Total	112784	100.0	38350	34.0	59726	53.0	59553	52.8	67470	59.8	45314	40.2

NOTES:

1. Does not include the District of Columbia
2. 1:100,000 scale streams only. Does not include intermittant streams.
3. Mixed 1:100,000 and 1:24,000 scale streams. Not all areas include intermittant streams.

Table 3. Riparian forest buffer statistics for 8-digit hydrologic units in the Chesapeake Bay watershed.

Watershed	HUC code	Stream length		Both sides 300' +		Both sides 100' - 300'		One side 300' +		One side 100' - 300'		Both sides < 100'	
		miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
UPPER SUSQUEHANNA	2050101	3399	2.96	801	23.6	1573	46.3	1554	45.7	1856	54.6	1544	45.4
CHENANGO	2050102	2226	1.94	662	29.7	1115	50.1	1102	49.5	1270	57.0	956	43.0
OWEGO-WAPPASENING	2050103	1786	1.56	426	23.9	782	43.8	773	43.3	907	50.8	879	49.2
TIOGA	2050104	1824	1.59	487	26.7	942	51.7	928	50.9	1105	60.6	718	39.4
CHEMUNG	2050105	1500	1.31	314	20.9	660	44.0	655	43.7	775	51.6	726	48.4
UPPER SUSQUEHANNA-TUNKHANNOCK	2050106	4498	3.92	1176	26.1	2243	49.9	2235	49.7	2625	58.4	1873	41.6
UPPER SUSQUEHANNA-LACKAWANNA	2050107	3478	3.03	1349	38.8	2136	61.4	2117	60.9	2393	68.8	1084	31.2
UPPER WEST BRANCH SUSQUEHANNA	2050201	3379	2.94	2068	61.2	2598	76.9	2737	81.0	2821	83.5	559	16.5
SINNEMAHONING	2050202	2183	1.90	1466	67.1	1707	78.2	1733	79.4	1806	82.7	377	17.3
MIDDLE WEST BRANCH SUSQUEHANNA	2050203	1428	1.24	995	69.7	1129	79.1	1151	80.6	1188	83.2	239	16.8
BALD EAGLE	2050204	1480	1.29	643	43.5	875	59.1	888	60.0	972	65.7	508	34.3
PINE	2050205	1893	1.65	1062	56.1	1324	70.0	1366	72.1	1436	75.9	457	24.1
LOWER WEST BRANCH SUSQUEHANNA	2050206	3994	3.48	1627	40.7	2346	58.7	2349	58.8	2608	65.3	1386	34.7
LOWER SUSQUEHANNA-PENNS	2050301	3459	3.01	746	21.6	1417	41.0	1357	39.2	1727	49.9	1731	50.1
UPPER JUNIATA	2050302	1942	1.69	849	43.7	1220	62.8	1229	63.3	1366	70.3	576	29.7
RAYSTOWN	2050303	2465	2.15	939	38.1	1383	56.1	1419	57.6	1576	64.0	888	36.0
LOWER JUNIATA	2050304	2962	2.58	1067	36.0	1617	54.6	1606	54.2	1843	62.2	1118	37.8
LOWER SUSQUEHANNA-SWATARA	2050305	3834	3.34	911	23.8	1735	45.3	1621	42.3	2063	53.8	1771	46.2
LOWER SUSQUEHANNA	2050306	5063	4.41	946	18.7	2119	41.8	1934	38.2	2517	49.7	2546	50.3
UPPER CHESAPEAKE BAY	2060001	263	0.23	2	0.8	9	3.5	9	3.3	13	4.9	250	95.1
CHESTER-SASSAFRAS	2060002	1981	1.73	347	17.5	845	42.7	749	37.8	972	49.1	1009	50.9
GUNPOWDER-PATAPSCO	2060003	2162	1.88	629	29.1	1185	54.8	1140	52.7	1340	62.0	822	38.0
SEVERN	2060004	702	0.61	197	28.1	312	44.5	308	43.8	342	48.8	359	51.2
CHOPTANK	2060005	1739	1.51	212	12.2	518	29.8	460	26.5	606	34.9	1132	65.1
PATUXENT	2060006	1770	1.54	678	38.3	1124	63.5	1079	60.9	1230	69.5	541	30.5
BLACKWATER-WICOMICO	2060007	1031	0.90	71	6.9	187	18.2	169	16.4	225	21.8	806	78.2
NANTICOKE	2060008	1451	1.26	349	24.1	658	45.3	637	43.9	739	50.9	712	49.1
POCOMOKE	2060009	1172	1.02	277	23.7	447	38.1	448	38.2	495	42.3	677	57.7
SOUTH BRANCH POTOMAC	2070001	2033	1.77	788	38.7	1003	49.3	1045	51.4	1112	54.7	922	45.3
NORTH BRANCH POTOMAC	2070002	2476	2.16	1080	43.6	1483	59.9	1530	61.8	1633	65.9	844	34.1
CACAPON-TOWN	2070003	1984	1.73	982	49.5	1353	68.2	1392	70.2	1491	75.1	493	24.9
CONOCOCHEAGUE-OPEQUON	2070004	4038	3.52	1238	30.7	2031	50.3	1971	48.8	2321	57.5	1717	42.5

Table 3. Riparian forest buffer statistics for 8-digit hydrologic units in the Chesapeake Bay watershed.

Watershed	HUC code	Stream length		Both sides 300'		Both sides 100'		One side 300'		One side 100'		Both sides < 100'	
		miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
SOUTH FORK SHENANDOAH	2070005	1666	1.45	479	28.8	658	39.5	649	38.9	751	45.1	915	54.9
NORTH FORK SHENANDOAH	2070006	1135	0.99	381	33.5	516	45.5	520	45.9	573	50.5	562	49.5
SHENANDOAH	2070007	449	0.39	72	16.1	131	29.2	138	30.7	167	37.2	282	62.8
MIDDLE POTOMAC-CATOCTIN	2070008	1826	1.59	386	21.1	866	47.5	804	44.0	1023	56.0	803	44.0
MONOCACY	2070009	2225	1.94	437	19.6	963	43.3	852	38.3	1151	51.7	1074	48.3
MIDDLE POTOMAC-ANACOSTIA-OCCOQUAN	2070010	1690	1.47	415	24.6	825	48.8	783	46.3	954	56.5	736	43.5
LOWER POTOMAC	2070011	2731	2.38	1157	42.4	1618	59.3	1637	59.9	1751	64.1	980	35.9
GREAT WICOMICO-PIANKATANK	2080102	1066	0.93	408	38.2	543	50.9	563	52.8	590	55.3	477	44.7
RAPIDAN-UPPER RAPPAHANNOCK	2080103	1923	1.68	477	24.8	786	40.9	785	40.8	914	47.5	1009	52.5
LOWER RAPPAHANNOCK	2080104	2102	1.83	851	40.5	1211	57.6	1246	59.3	1339	63.7	763	36.3
MATTAPONI	2080105	1626	1.42	892	54.8	1200	73.8	1228	75.5	1288	79.2	338	20.8
PAMUNKEY	2080106	2473	2.15	1000	40.4	1443	58.3	1481	59.9	1591	64.3	882	35.7
YORK	2080107	616	0.54	147	23.9	243	39.5	267	43.2	290	47.1	326	52.9
LYNNHAVEN-POQUOSON	2080108	1482	1.29	88	5.9	206	13.9	209	14.1	271	18.3	1211	81.7
WESTERN LOWER DELMARVA	2080109	813	0.71	35	4.3	111	13.7	106	13.0	144	17.7	669	82.3
UPPER JAMES	2080201	3137	2.73	1540	49.1	1951	62.2	1998	63.7	2114	67.4	1023	32.6
MAURY	2080202	1051	0.92	403	38.3	576	54.8	584	55.5	639	60.8	412	39.2
MIDDLE JAMES-BUFFALO	2080203	3357	2.92	1403	41.8	2026	60.3	2092	62.3	2258	67.3	1099	32.7
RIVANNA	2080204	1000	0.87	272	27.2	463	46.3	477	47.6	543	54.3	457	45.7
MIDDLE JAMES-WILLIS	2080205	1525	1.33	536	35.1	857	56.2	883	57.9	978	64.1	547	35.9
LOWER JAMES	2080206	2819	2.46	795	28.2	1306	46.3	1339	47.5	1498	53.1	1321	46.9
APPOMATTOX	2080207	2505	2.18	1115	44.5	1654	66.1	1696	67.7	1820	72.7	685	27.3

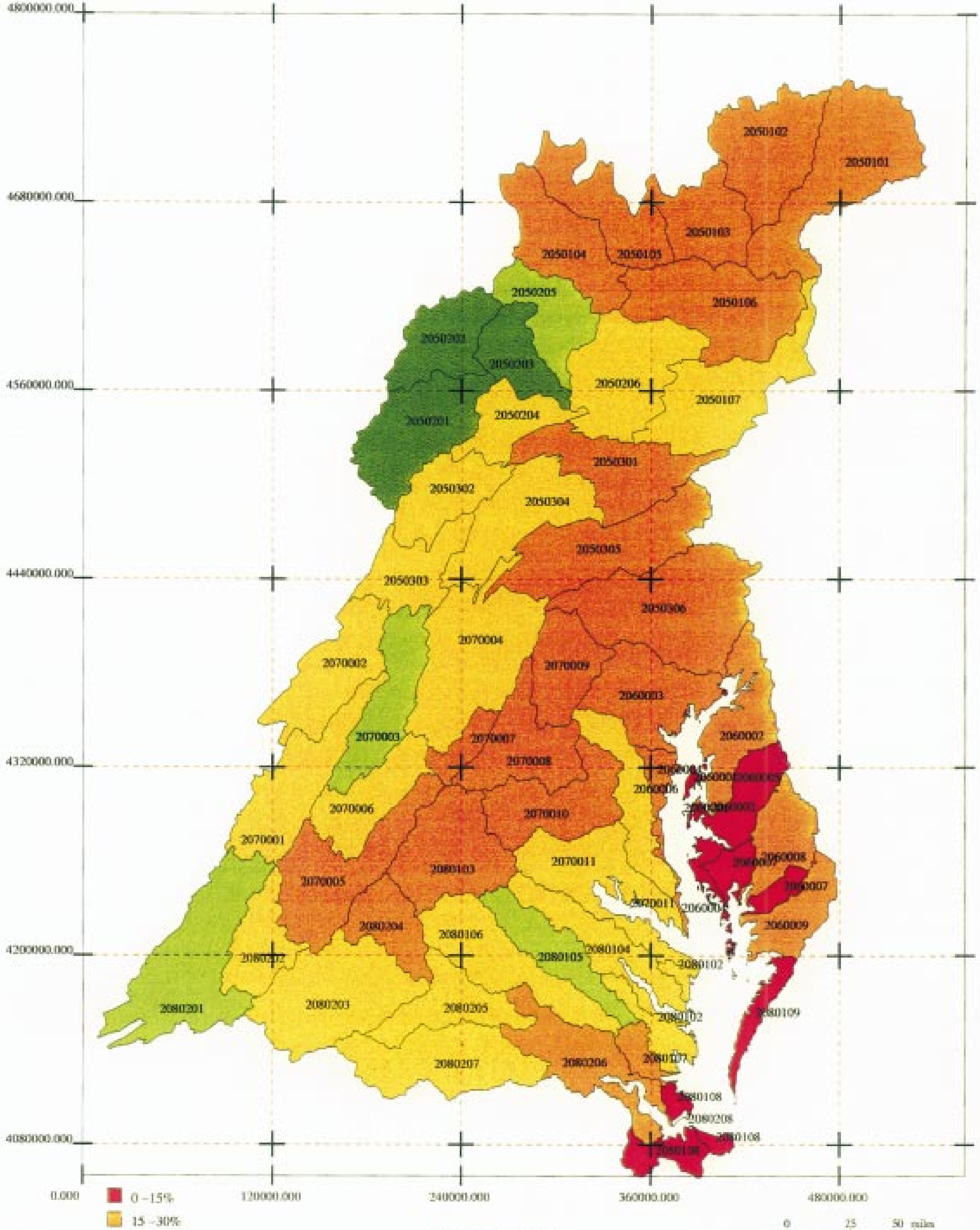


Figure 10

Percentage of 8 digit watershed streams buffered
300 ft or more on both sides
Projection UTM, Zone 18

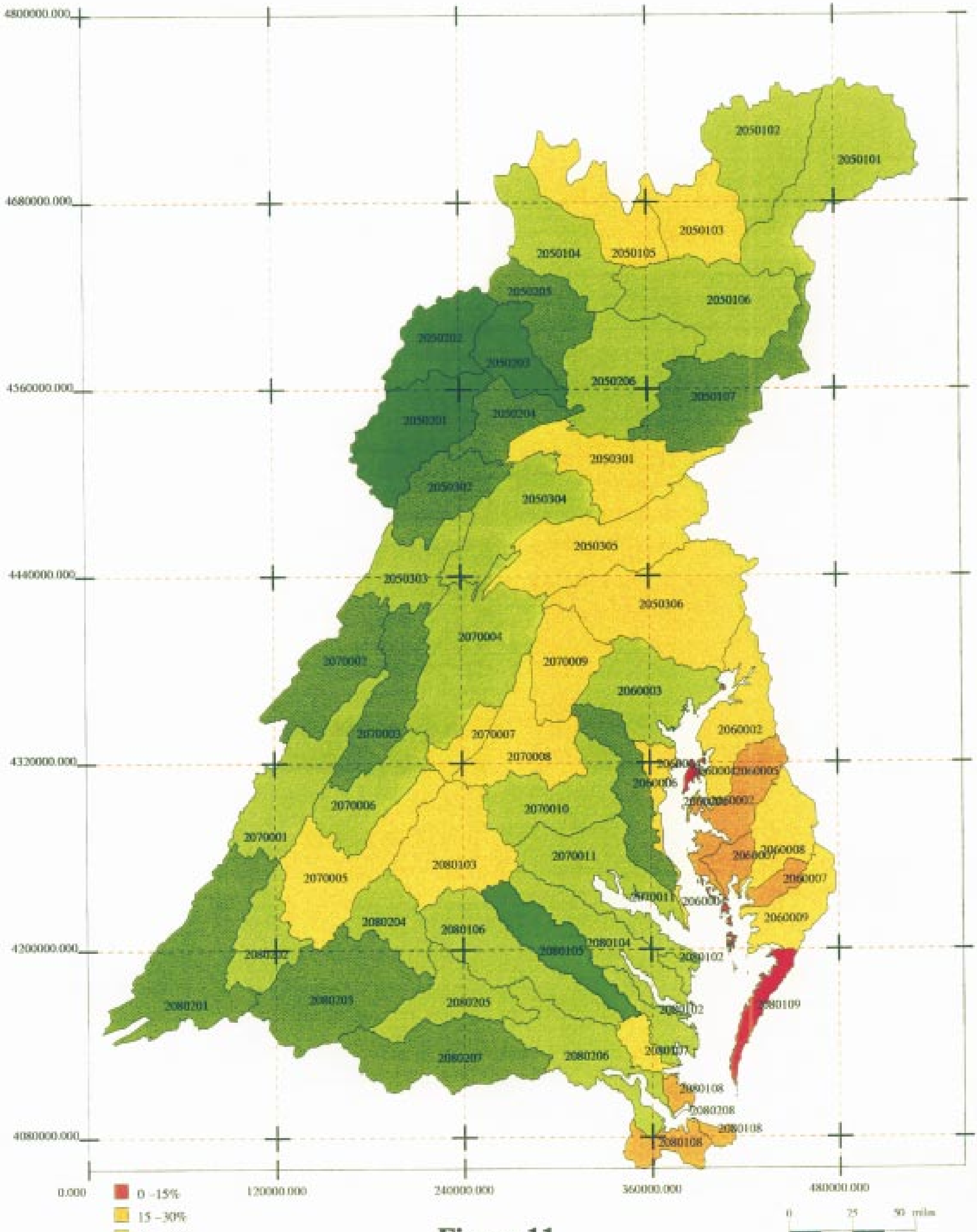


Figure 11

Percentage of 8 digit watershed streams buffered
300 ft or more on at least one side
Projection UTM, Zone 18

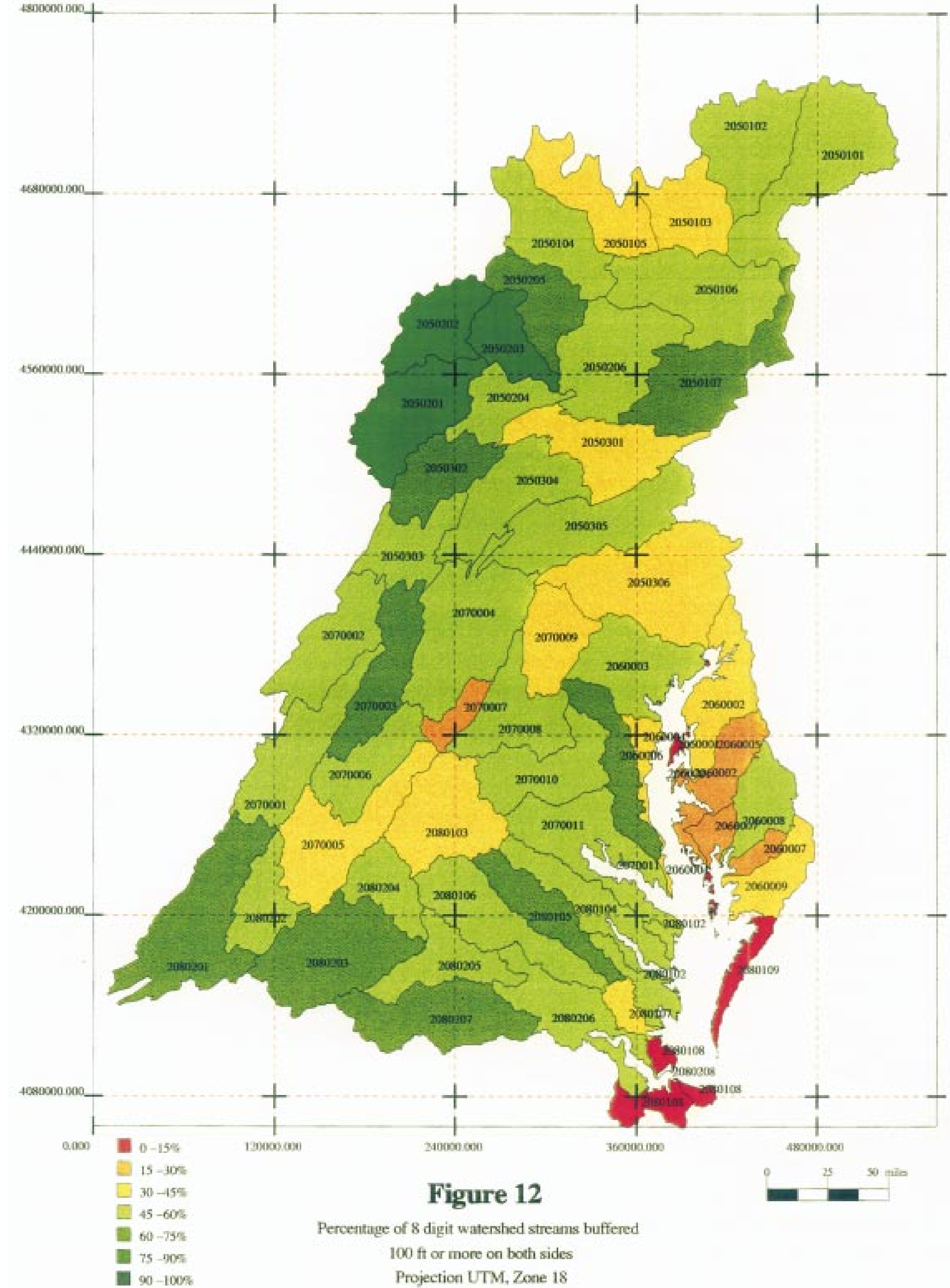


Figure 12

Percentage of 8 digit watershed streams buffered
100 ft or more on both sides
Projection UTM, Zone 18

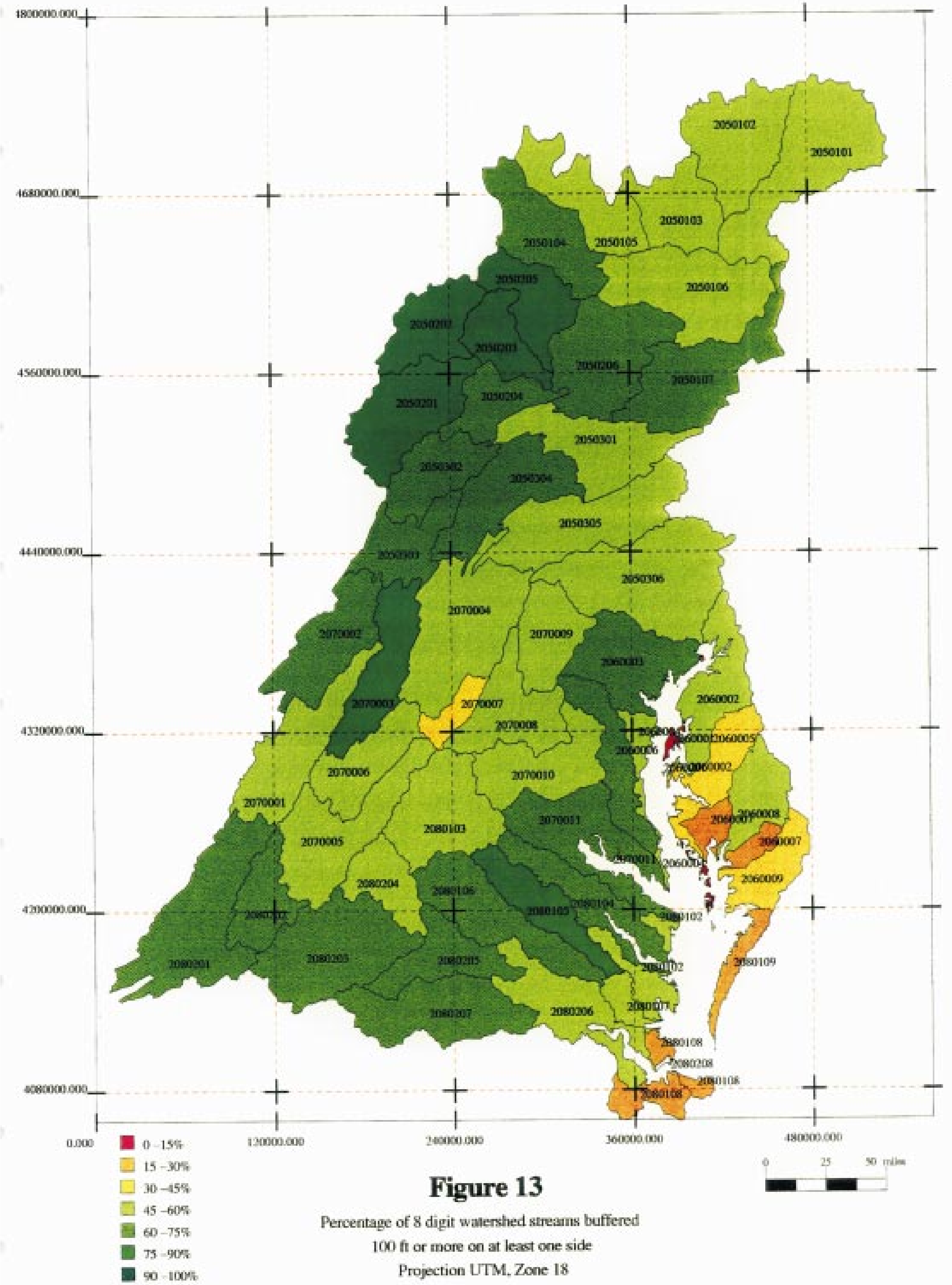


Figure 13

Percentage of 8 digit watershed streams buffered
100 ft or more on at least one side
Projection UTM, Zone 18

Table 5. Riparian forest buffer statistics for 11-digit hydrologic units in Maryland

ID	Watershed	Md-ID	Stream Length		Both sides 300'+		Both sides 100-300'		One side 300'+		One side 100-300'		Both sides < 100'	
			miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
1	BROAD CREEK	2120205	62.0	0.33	19.3	26.3	37.8	54.4	36.7	50.7	43.1	59.7	18.8	40.3
7	POCOMOKE SOUND	2130201	150.8	0.80	9.8	31.5	30.2	66.4	29.1	63.9	37.7	75.1	113.0	24.9
8	LOWER POCOMOKE RIVER	2130202	201.8	1.07	69.3	42.5	126.2	61.0	127.9	62.5	138.8	65.2	63.1	34.8
9	UPPER POCOMOKE RIVER	2130203	125.8	0.67	56.7	31.2	72.8	61.0	72.8	59.3	75.5	69.6	50.3	30.4
10	DIVIDING CREEK	2130204	57.4	0.30	40.9	26.4	49.9	35.4	50.2	37.2	51.3	37.5	6.1	62.5
11	NASSAWANGO CREEK	2130205	60.2	0.32	34.9	6.5	44.4	20.0	44.3	19.3	46.2	25.0	14.0	75.0
12	TANGIER SOUND	2130206	215.1	1.14	0.5	34.4	2.8	62.5	2.6	63.4	4.2	68.8	210.9	31.2
13	BIG ANNEMESSEX RIVER	2130207	115.7	0.61	6.0	45.0	17.4	57.8	17.9	57.9	22.3	60.0	93.4	40.0
14	MANOKIN RIVER	2130208	204.4	1.08	23.9	71.2	50.0	86.9	48.4	87.4	59.1	89.4	145.3	10.6
15	LOWER WICOMICO RIVER	2130301	206.9	1.10	15.1	57.9	47.9	73.8	41.3	73.7	55.8	76.7	151.2	23.3
16	MONIE BAY	2130302	73.2	0.39	3.3	0.2	6.0	1.3	5.9	1.2	6.8	2.0	66.4	98.0
17	WICOMICO CREEK	2130303	44.4	0.24	6.1	5.2	14.3	15.0	12.6	15.5	16.7	19.2	27.7	80.8
18	WICOMICO RIVER HEAD	2130304	62.6	0.33	14.3	11.7	32.2	24.5	29.5	23.7	36.1	28.9	26.5	71.1
19	NANTICOKE RIVER	2130305	404.4	2.14	50.6	7.3	101.0	23.2	97.2	19.9	117.4	27.0	287.0	73.0
20	MARSHYHOPE CREEK	2130306	291.7	1.55	60.1	4.5	136.3	8.2	128.3	8.1	154.8	9.3	136.9	90.7
21	FISHING BAY	2130307	499.1	2.64	10.9	13.8	28.6	32.3	26.0	28.3	37.0	37.6	462.0	62.4
22	TRANSQUAKING RIVER	2130308	246.6	1.31	22.1	22.9	58.7	51.4	54.3	47.2	72.9	57.6	173.8	42.4
23	HONGA RIVER	2130401	212.2	1.12	6.1	12.5	8.8	25.0	9.7	24.0	11.3	29.0	200.9	71.0
24	LITTLE CHOPTANK	2130402	222.7	1.18	4.8	20.6	11.0	46.7	12.3	44.0	14.6	53.1	208.1	46.9
25	LOWER CHOPTANK	2130403	603.0	3.20	15.6	2.2	78.3	5.7	63.7	5.2	101.9	7.4	501.1	92.6
26	UPPER CHOPTANK	2130404	539.7	2.86	100.9	9.0	245.8	23.8	217.8	22.0	278.7	29.5	261.0	70.5
27	TUCKAHOE CREEK	2130405	352.1	1.87	51.3	2.9	124.6	4.2	105.5	4.6	147.5	5.3	204.6	94.7
28	EASTERN BAY	2130501	104.8	0.56	0.7	2.1	3.9	5.0	3.6	5.5	5.7	6.6	99.0	93.4
29	MILES RIVER	2130502	133.6	0.71	5.2	2.6	18.3	13.0	15.2	10.6	23.8	16.9	109.9	83.1
30	WYE RIVER	2130503	175.2	0.93	11.5	18.7	44.7	45.5	36.5	40.4	55.2	51.6	120.0	48.4
31	KENT NARROWS	2130504	49.9	0.26	0.1	14.6	2.0	35.4	1.9	30.0	3.2	41.9	46.7	58.1
32	LOWER CHESTER RIVER	2130505	201.0	1.06	9.4	0.7	33.7	3.7	29.7	3.4	41.1	5.5	159.8	94.5
33	LANGFORD CREEK	2130506	93.3	0.49	6.8	3.9	25.4	13.7	20.1	11.4	29.9	17.8	63.4	82.2
34	CORSICA RIVER	2130507	65.4	0.35	9.8	6.6	32.4	25.5	23.5	20.8	36.0	31.5	29.3	68.5
35	SOUTHEAST CREEK	2130508	99.8	0.53	14.1	0.3	50.7	3.9	40.2	3.8	58.0	6.4	41.7	93.6
36	MIDDLE CHESTER RIVER	2130509	88.6	0.47	7.9	4.7	31.5	16.8	25.6	14.8	36.1	20.5	52.4	79.5
37	UPPER CHESTER RIVER	2130510	219.9	1.17	42.2	7.3	108.8	27.2	94.3	21.6	124.2	32.1	95.6	67.9

Table 5. Riparian forest buffer statistics for 11-digit hydrologic units in Maryland

ID	Watershed	Md-ID	Stream Length		Both sides 300'+		Both sides 100-300'		One side 300'+		One side 100-300'		Both sides < 100'	
			miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
38	KENT ISLAND BAY	2130511	34.1	0.18	0.5	15.1	2.6	49.5	1.8	36.0	3.2	55.1	31.0	44.9
39	LOWER ELK RIVER	2130601	95.5	0.51	24.6	14.1	41.2	50.8	41.2	40.3	46.4	58.2	49.1	41.8
40	BOHEMIA RIVER	2130602	76.4	0.41	11.8	8.9	35.3	35.6	33.2	29.0	42.6	40.8	33.8	59.2
41	UPPER ELK RIVER	2130603	81.7	0.43	33.2	19.2	48.5	49.5	50.4	42.9	52.8	56.5	28.9	43.5
42	BACK CREEK	2130604	29.4	0.16	5.4	1.5	12.7	7.5	11.9	5.4	14.5	9.2	15.0	90.8
43	LITTLE ELK CREEK	2130605	39.5	0.21	12.9	25.7	27.4	43.2	25.2	43.2	30.8	48.6	8.7	51.4
44	BIG ELK CREEK	2130606	26.2	0.14	13.4	15.5	21.2	46.2	20.9	43.4	22.9	55.7	3.3	44.3
45	CHRISTIANA RIVER	2130607	1.0	0.01	0.2	40.7	0.5	59.4	0.5	61.7	0.6	64.6	0.4	35.4
46	NORTHEAST RIVER	2130608	116.3	0.62	46.0	18.3	74.5	43.2	72.7	40.3	80.7	49.2	35.6	50.8
47	FURNACE BAY	2130609	41.8	0.22	11.9	32.5	24.3	69.2	22.3	63.7	27.8	78.0	13.9	22.0
48	SASSAFRAS RIVER	2130610	143.8	0.76	16.2	51.1	51.3	80.7	44.7	79.7	62.9	87.4	80.9	12.6
49	STILLPOND-FAIRLEE	2130611	110.6	0.59	11.1	20.7	39.1	53.8	34.6	53.4	46.2	59.5	64.4	40.5
50	BUSH RIVER	2130701	49.4	0.26	18.6	39.6	31.2	64.1	29.5	62.5	34.4	69.4	15.0	30.6
51	LOWER WINTERS RUN	2130702	21.9	0.12	6.3	28.4	13.3	58.1	12.8	53.4	15.4	66.7	6.5	33.3
52	ATKISSON RESERVOIR	2130703	56.4	0.30	19.7	11.3	38.3	35.7	36.9	31.1	42.9	43.7	13.5	56.3
53	BYNUM RUN	2130704	25.4	0.13	8.7	10.0	16.5	35.3	15.6	31.3	18.4	41.7	6.9	58.3
54	ABERDEEN PROVING GROUND	2130705	39.5	0.21	12.3	37.6	17.8	63.2	17.6	59.8	19.0	69.7	20.4	30.3
55	SWAN CREEK	2130706	36.1	0.19	13.4	28.7	25.3	60.9	24.1	58.4	27.5	70.2	8.6	29.8
56	GUNPOWDER RIVER	2130801	67.3	0.36	2.6	34.9	9.3	68.0	10.4	65.5	12.2	76.1	55.1	23.9
57	LOWER GUNPOWDER FALLS	2130802	49.1	0.26	15.9	34.2	26.3	65.1	26.2	61.4	29.8	72.7	19.3	27.3
58	BIRD RIVER	2130803	35.3	0.19	3.4	31.1	11.4	45.0	11.0	44.5	13.5	48.2	21.7	51.8
59	LITTLE GUNPOWDER FALLS	2130804	78.9	0.42	32.5	37.2	56.5	70.0	53.8	66.7	62.0	76.2	17.0	23.8
60	LOCH RAVEN RESERVOIR	2130805	426.4	2.26	174.4	3.9	288.4	13.8	278.5	15.5	318.1	18.1	108.2	81.9
61	PRETTYBOY RESERVOIR	2130806	136.4	0.72	36.0	32.5	74.3	53.5	75.0	53.4	86.3	60.7	50.1	39.3
62	MIDDLE RIVER BROWNS	2130807	35.2	0.19	0.2	9.8	1.6	32.4	2.0	31.1	2.4	38.4	32.8	61.6
63	BACK RIVER	2130901	89.2	0.47	3.2	41.2	14.1	71.6	11.7	68.2	18.8	78.5	70.4	21.5
64	BODKIN CREEK	2130902	25.9	0.14	1.6	40.9	5.1	67.7	5.3	65.3	5.9	74.6	20.0	25.4
65	BALTIMORE HARBOR	2130903	163.2	0.87	2.1	26.4	11.9	54.4	10.5	55.0	15.2	63.3	148.1	36.7
66	JONES FALLS	2130904	93.2	0.49	21.2	0.5	44.8	4.5	40.8	5.7	52.0	6.9	41.2	93.1
67	GWYNNS FALLS	2130905	109.0	0.58	18.0	3.6	44.0	15.8	40.3	13.1	54.0	21.1	55.0	78.9
68	PATAPSCO RIVER - L.N. BR.	2130906	220.7	1.17	76.1	6.2	126.7	19.5	125.0	20.5	142.1	22.8	78.6	77.2
69	LIBERTY RESERVOIR	2130907	350.3	1.86	110.9	1.3	222.7	7.3	215.3	6.4	250.1	9.3	100.2	90.7

Table 5. Riparian forest buffer statistics for 11-digit hydrologic units in Maryland

ID	Watershed	Md-ID	Stream Length		Both sides 300'+		Both sides 100-300'		One side 300'+		One side 100-300'		Both sides < 100'	
			miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
70	PATAPSCO RIVER - S. BR.	2130908	203.6	1.08	55.5	22.7	120.1	48.1	113.8	43.8	138.3	55.8	65.2	44.2
71	MAGOTHY RIVER	2131001	85.7	0.45	5.3	16.5	18.2	40.4	16.7	37.0	21.8	49.5	63.9	50.5
72	SEVERN RIVER	2131002	173.5	0.92	32.2	34.5	62.7	57.4	60.3	56.7	71.2	64.4	102.3	35.6
73	SOUTH RIVER	2131003	131.5	0.70	43.5	31.7	61.8	63.6	60.3	61.5	65.0	71.4	66.5	28.6
74	WEST RIVER	2131004	80.7	0.43	13.7	27.3	27.4	59.0	26.2	55.9	31.1	68.0	49.6	32.0
75	WEST CHESAPEAKE BAY	2131005	220.5	1.17	86.5	6.1	118.1	21.3	120.7	19.5	127.8	25.4	92.8	74.6
76	PATUXENT RIVER - FERRY LDG. TO MOUT	2131101	763.3	4.04	285.9	18.6	430.0	36.1	425.8	34.7	461.0	41.1	302.3	58.9
77	PATUXENT RIVER - RT. 214 TO FERRY LDG	2131102	234.6	1.24	78.9	33.1	152.6	47.0	145.1	45.8	170.1	49.4	64.5	50.6
78	WESTERN BRANCH	2131103	110.1	0.58	37.2	17.0	66.7	33.9	64.2	32.5	74.6	38.5	35.5	61.5
79	PATUXENT RIVER - UPPER	2131104	161.9	0.86	84.6	39.2	123.5	53.6	119.7	54.7	132.3	57.9	29.5	42.1
80	LITTLE PATUXENT RIVER	2131105	186.2	0.99	54.4	37.5	106.0	56.3	95.7	55.8	120.9	60.4	65.2	39.6
81	PATUXENT RIVER - MIDDLE	2131106	111.8	0.59	45.1	33.6	80.0	65.1	74.4	61.8	89.2	72.5	22.7	27.5
82	ROCKY GORGE DAM	2131107	121.6	0.64	51.7	33.8	85.3	60.6	85.0	58.3	93.1	67.7	28.5	32.3
83	BRIGHTON DAM	2131108	177.8	0.94	59.1	52.3	112.3	76.3	102.8	74.0	126.1	81.8	51.6	18.2
84	POTOMAC RIVER - L. TIDAL	2140101	256.3	1.36	39.6	29.2	64.6	57.0	64.9	51.4	75.1	65.0	181.2	35.0
85	POTOMAC RIVER	2140102	71.7	0.38	27.3	40.3	34.8	71.5	37.3	66.5	38.6	79.7	33.1	20.3
86	'ST. MARY"S RIVER'	2140103	174.4	0.92	67.7	42.6	94.7	70.1	95.0	69.9	100.7	76.6	73.7	23.4
87	BRETON BAY	2140104	80.5	0.43	33.0	33.3	46.5	63.2	46.4	57.8	49.4	70.9	31.2	29.1
88	ST. CLEMENT BAY	2140105	81.3	0.43	27.9	15.5	41.4	25.2	40.2	25.3	43.9	29.3	37.4	70.7
89	WICOMICO RIVER	2140106	187.9	1.00	64.8	38.1	98.5	48.6	96.3	52.0	105.5	53.8	82.4	46.2
90	GILBERT SWAMP	2140107	101.0	0.54	52.8	38.8	76.7	54.3	75.6	54.5	81.7	57.7	19.3	42.3
91	ZEKIAH SWAMP	2140108	241.8	1.28	154.4	41.0	202.3	57.7	198.7	57.7	210.8	61.3	31.0	38.7
92	PORT TOBACCO RIVER	2140109	89.8	0.48	40.7	34.3	58.8	50.9	58.7	49.5	63.2	54.0	26.7	46.0
93	NANJEMOY CREEK	2140110	138.4	0.73	73.6	34.5	91.0	52.4	92.5	51.3	95.8	56.1	42.6	43.9
94	MATTAWOMAN CREEK	2140111	158.6	0.84	82.7	52.3	114.0	76.0	115.5	74.8	122.8	80.9	35.7	19.1
95	POTOMAC RIVER - U. TIDAL	2140201	36.9	0.20	10.4	63.8	19.3	83.7	18.0	82.2	22.8	87.2	14.1	12.8
96	POTOMAC RIVER - MO CTY.	2140202	198.4	1.05	50.0	45.4	110.9	65.5	112.7	65.4	132.2	70.3	66.2	29.7
97	PISCATAWAY CREEK	2140203	70.1	0.37	29.7	53.2	53.0	65.8	49.9	66.9	57.6	69.2	12.5	30.8
98	OXEN CREEK DR.	2140204	9.8	0.05	0.9	52.2	4.1	71.9	3.2	72.9	4.7	77.5	5.1	22.5
99	ANACOSTIA RIVER	2140205	166.2	0.88	39.4	28.1	78.9	52.2	71.7	48.9	91.6	61.8	74.6	38.2
100	ROCK CREEK	2140206	52.5	0.28	18.3	25.2	37.0	55.9	32.4	56.8	40.2	66.6	12.3	33.4
101	CABIN JOHN CREEK	2140207	20.9	0.11	6.8	42.4	13.5	75.6	11.3	71.2	14.9	82.2	6.0	17.8

Table 5. Riparian forest buffer statistics for 11-digit hydrologic units in Maryland

ID	Watershed	Md-ID	Stream Length		Both sides 300'+		Both sides 100-300'		One side 300'+		One side 100-300'		Both sides < 100'	
			miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
102	SENECA CREEK	2140208	195.7	1.04	60.1	9.3	124.7	41.5	112.4	32.6	139.6	47.8	56.1	52.2
103	POTOMAC RIVER	2140301	119.3	0.63	7.7	23.7	34.2	47.5	32.8	43.2	45.5	55.1	73.8	44.9
104	LOWER MONOCACY RIVER	2140302	743.0	3.94	151.5	34.8	327.2	70.4	301.3	61.7	389.0	76.5	354.0	23.5
105	UPPER MONOCACY RIVER	2140303	518.7	2.75	118.3	32.6	220.6	64.7	199.3	54.1	263.4	71.1	255.3	28.9
106	DOUBLE PIPE CREEK	2140304	410.2	2.17	47.2	30.7	152.9	63.7	124.2	57.5	190.1	71.3	220.0	28.7
107	CATOCTIN CREEK	2140305	209.5	1.11	35.0	6.5	81.1	28.7	71.9	27.5	98.0	38.2	111.4	61.8
108	POTOMAC RIVER	2140501	194.9	1.03	24.0	20.4	64.2	44.0	68.7	40.6	87.8	52.4	107.1	47.6
109	ANTIETAM CREEK	2140502	230.7	1.22	27.9	22.8	67.6	42.5	58.1	38.4	83.5	50.8	147.2	49.2
110	MARSH RUN	2140503	16.3	0.09	1.0	11.5	2.5	37.3	2.1	30.3	3.3	46.4	13.0	53.6
111	CONOCOCHEAQUE CREEK	2140504	89.4	0.47	2.2	16.7	11.6	38.7	10.4	34.3	16.3	46.8	73.1	53.2
112	LITTLE CONOCOCHEAQUE	2140505	20.4	0.11	4.8	12.3	9.1	33.0	8.6	35.2	10.9	45.1	9.5	54.9
113	LICKING CREEK	2140506	39.8	0.21	25.1	12.1	33.6	29.3	34.5	25.2	35.9	36.2	3.9	63.8
114	TONOLOWAY CREEK	2140507	3.8	0.02	0.8	5.9	2.7	15.3	2.8	12.8	3.2	20.2	0.6	79.8
115	POTOMAC RIVER - AL CTY.	2140508	123.9	0.66	38.3	2.4	61.4	13.0	71.8	11.6	79.6	18.2	44.3	81.8
116	LITTLE TONOLOWAY CREEK	2140509	23.5	0.12	11.5	23.6	18.7	44.6	19.0	42.3	20.4	53.6	3.1	46.4
117	SIDELING HILL CREEK	2140510	32.7	0.17	23.8	63.1	28.2	84.5	28.4	86.8	29.2	90.2	3.5	9.8
118	FIFTEEN MILE CREEK	2140511	81.4	0.43	66.0	20.5	73.0	70.4	74.2	73.3	75.5	83.2	5.8	16.8
119	TOWN CREEK	2140512	125.5	0.67	58.9	30.9	87.3	49.6	89.9	57.9	96.9	64.2	28.6	35.8
120	POTOMAC RIVER - L.N. BR.	2141001	340.6	1.81	129.8	48.8	187.4	79.8	193.2	81.0	212.3	87.0	128.4	13.0
121	EVITTS CREEK	2141002	73.6	0.39	22.7	72.9	36.2	86.3	38.4	87.0	42.1	89.2	31.5	10.8
122	WILLS CREEK	2141003	107.2	0.57	48.1	81.1	67.7	89.6	70.4	91.1	75.5	92.8	31.7	7.2
123	GEORGES CREEK	2141004	117.9	0.62	61.2	46.9	85.9	69.6	87.1	71.6	92.1	77.2	25.8	22.8
124	POTOMAC RIVER - U.N. BR.	2141005	219.4	1.16	88.5	38.1	126.9	55.0	135.2	56.7	141.7	62.3	77.6	37.7
125	SAVAGE RIVER	2141006	244.3	1.29	111.0	30.8	130.7	49.1	133.1	52.1	135.2	57.2	109.1	42.8
128	DEEP CREEK LAKE	5020203	8.7	0.05	1.1	44.9	2.4	63.1	2.5	65.7	2.6	70.4	6.1	29.6
130	MAIN BAY WATERSHED	2999	140.1	0.74	0.2	51.9	1.4	72.9	2.1	73.9	2.9	78.1	137.3	21.9
131	CONOWINGO DAM	2120204	34.8	0.18	14.8	40.4	21.3	57.8	21.8	61.6	22.7	64.6	12.1	35.4
132	L. SUSQUEHANNA RIVER	2120201	73.3	0.39	19.3	45.4	39.9	53.5	37.2	54.5	43.8	55.3	29.6	44.7
133	DEER CREEK	2120202	266.9	1.41	94.2	12.8	169.7	27.7	163.6	28.3	192.5	30.1	74.4	69.9
134	OCTORARO CREEK	2120203	66.2	0.35	20.8	0.1	44.0	1.0	42.3	1.5	49.7	2.0	16.5	98.0

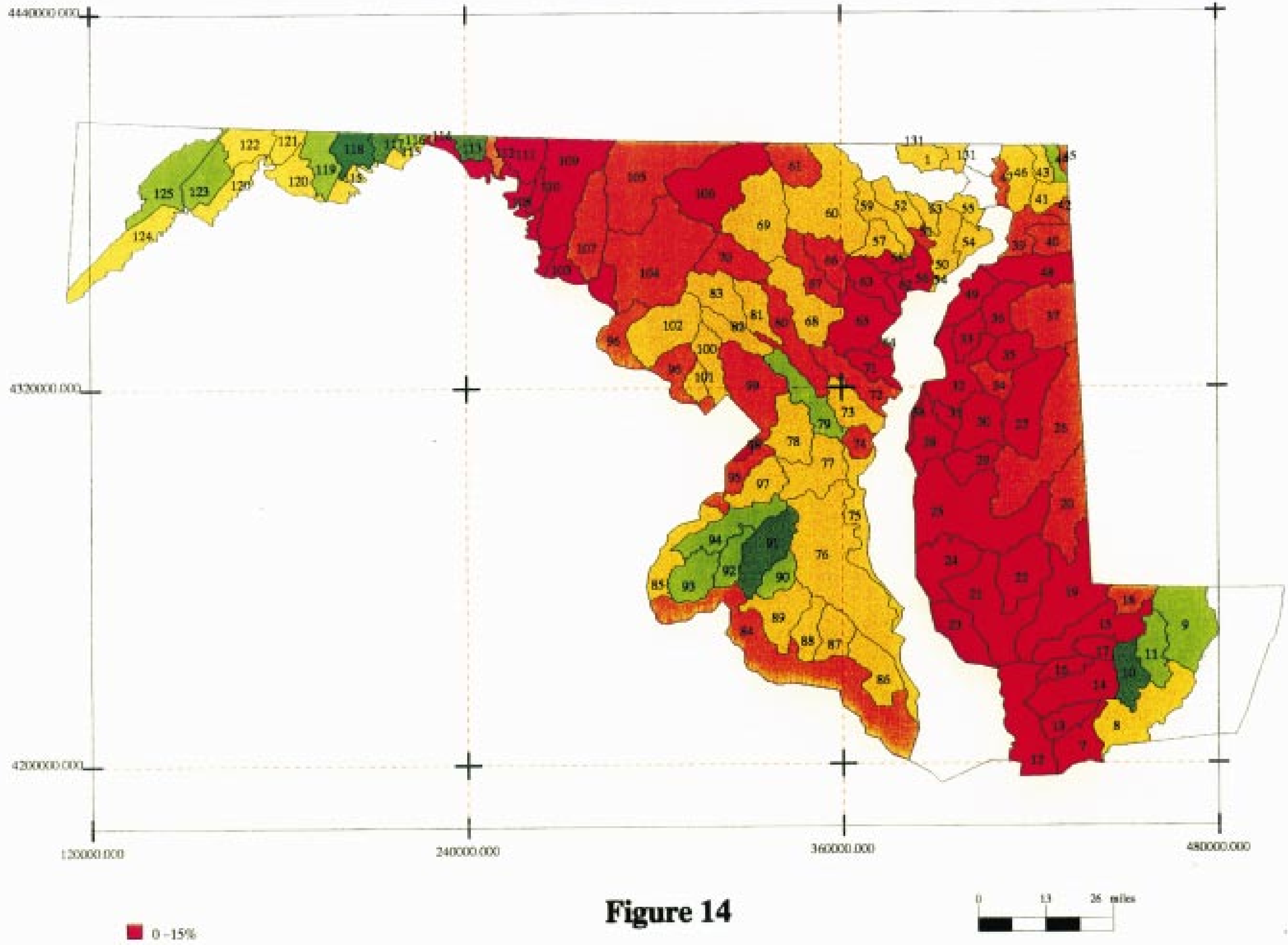
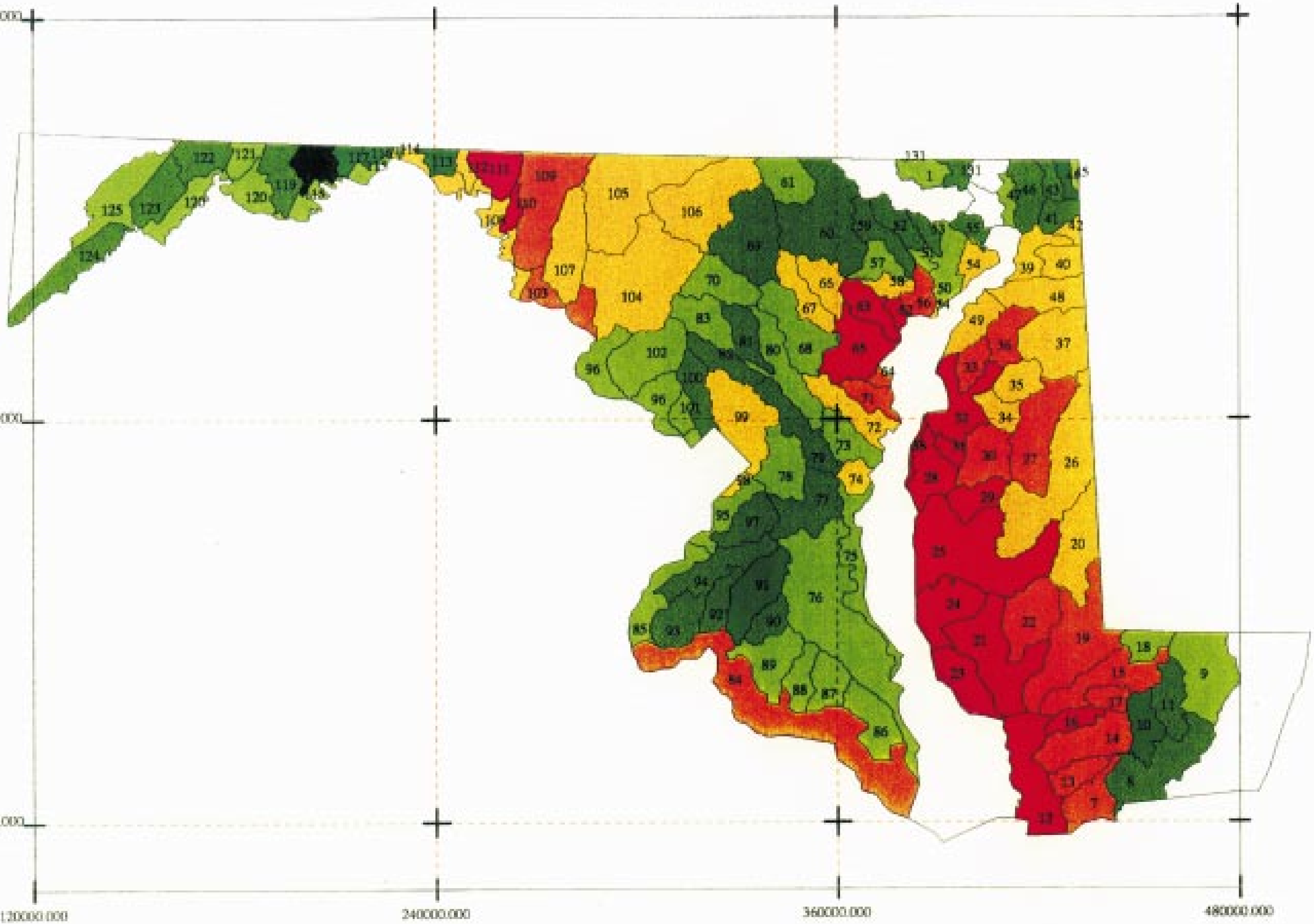


Figure 14

Percentage of streams buffered 300 ft or more on both sides in 11 digit watersheds of Maryland
Projection UTM, Zone 18



0 13 26 miles

Figure 15

Percentage of streams buffered 300 ft or more on one side only in 11 digit watersheds of Maryland
Projection UTM, Zone 18

- 0 -15%
- 15 -30%
- 30 -45%
- 45 -60%
- 60 -75%
- 75 -90%
- 90 -100%

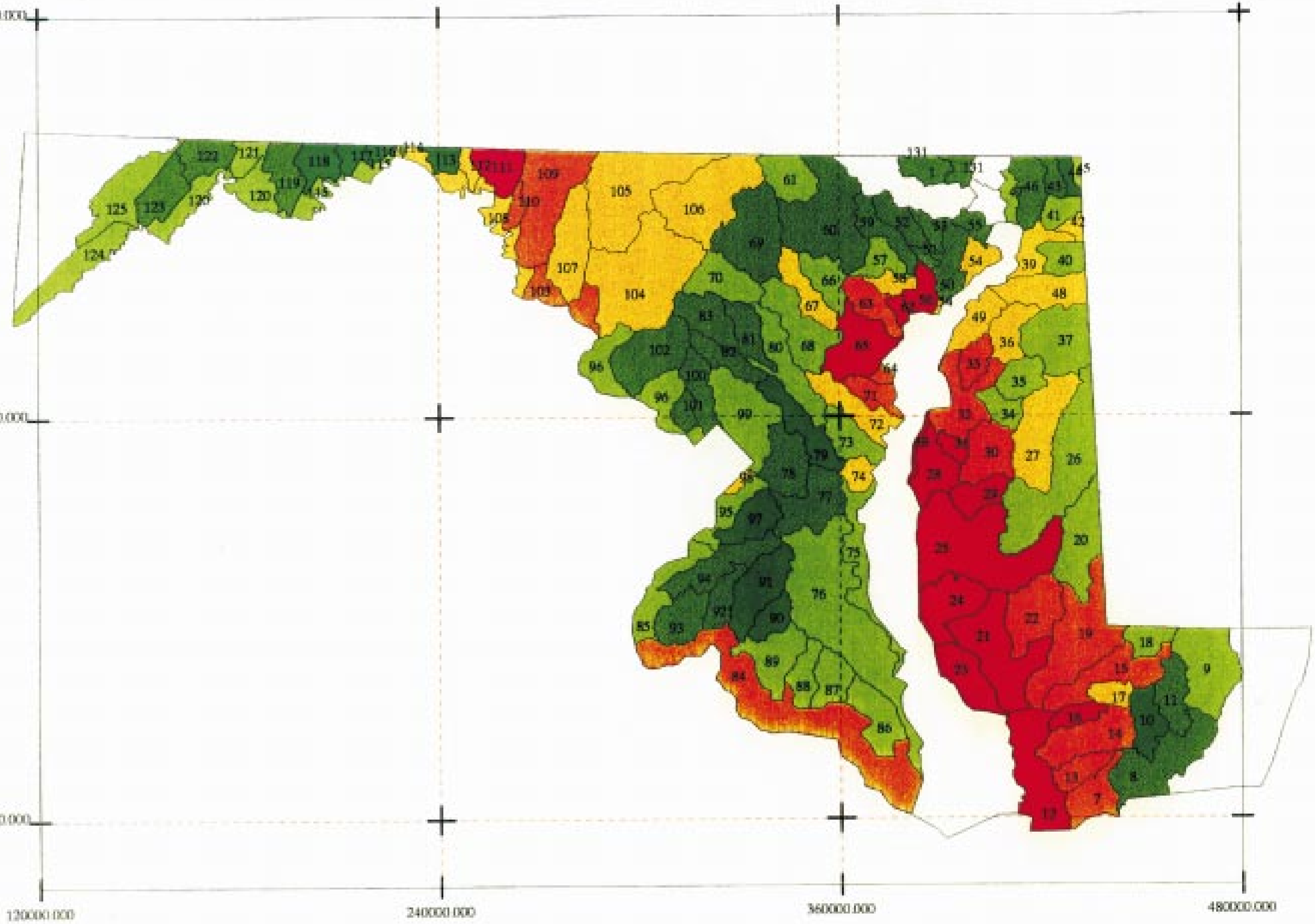


Figure 16

0 13 26 miles

- 0 -15%
- 15 -30%
- 30 -45%
- 45 -60%
- 60 -75%
- 75 -90%
- 90 -100%

Percentage of streams buffered 100 ft or more on both sides in 11 digit watersheds of Maryland
Projection UTM, Zone 18

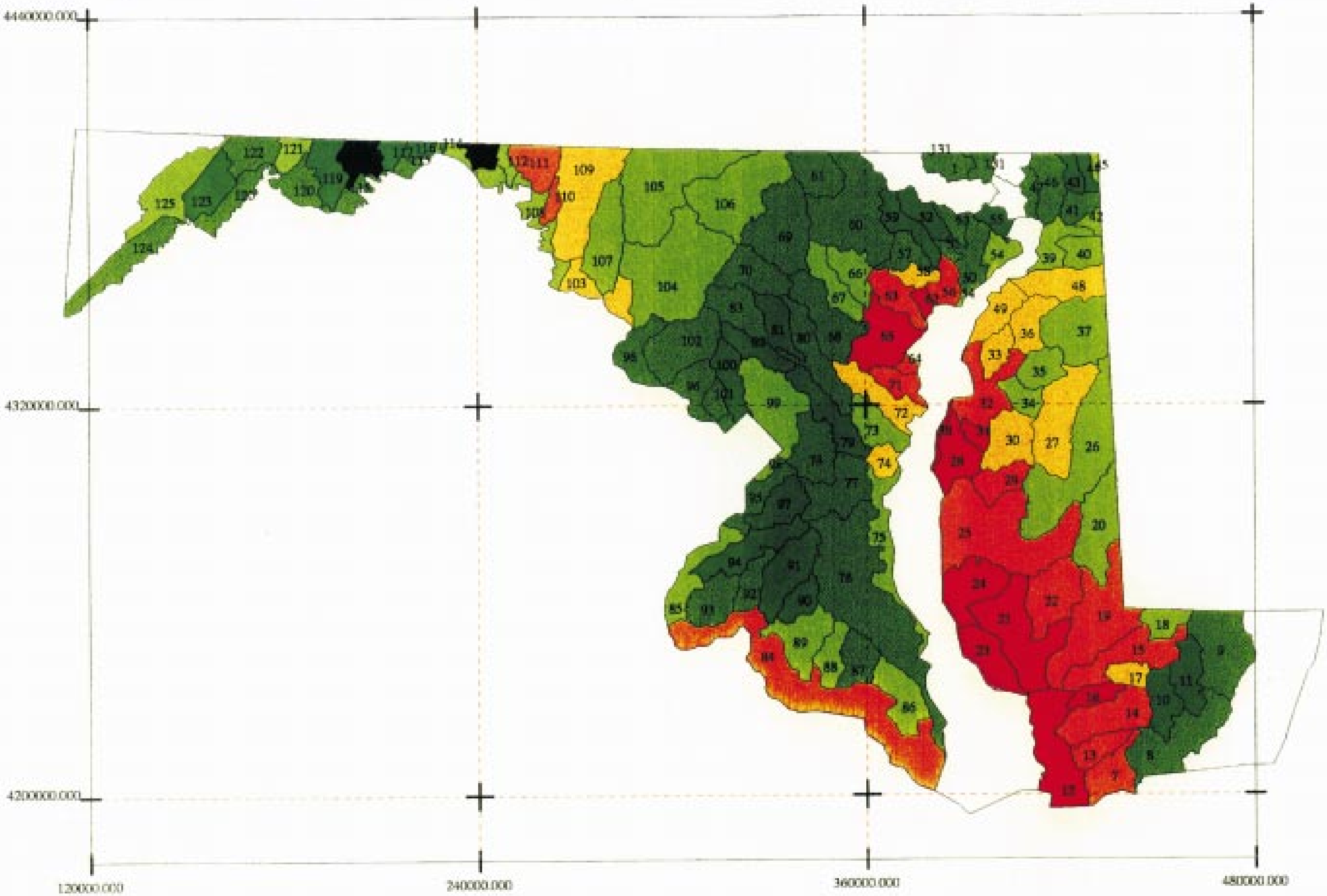


Figure 17

0 -15%
15 -30%
30 -45%
45 -60%
60 -75%
75 -90%
90 -100%

Percentage of streams buffered 100 ft or more on one side only in 11 digit watersheds of Maryland
Projection UTM, Zone 18

Table 7. Riparian forest buffer statistics for 11-digit hydrologic units in Pennsylvania.

ID	11 digit HUC code	Stream length		Both sides 300'+		Both sides 100-300'		One side 300'+		One side 100-300'		Both sides <100'	
		miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
1	2050101220	5.6	0.01	0.5	8.3	1.7	30.8	2.2	40.4	2.4	43.1	3.2	56.9
2	2050101230	4.2	0.01	1.3	31.4	2.6	60.9	2.5	58.8	2.9	69.4	1.3	30.6
3	2050101250	198.3	0.42	63.9	32.2	107.6	54.2	111.2	56.1	123.4	62.2	74.9	37.8
4	2050101280	159.2	0.34	46.4	29.1	80.4	50.5	80.5	50.6	91.7	57.6	67.5	42.4
5	2050101290	140.4	0.30	34.4	24.5	62.8	44.7	64.2	45.7	72.6	51.7	67.7	48.3
6	2050101320	180.6	0.38	42.4	23.5	89.3	49.4	89.7	49.6	106.2	58.8	74.4	41.2
7	2050101340	13.2	0.03	2.3	17.4	5.3	40.1	4.9	37.4	6.1	46.1	7.1	53.9
8	2050101370	6.3	0.01	1.5	23.3	2.3	37.3	2.4	38.2	2.6	41.3	3.7	58.7
9	2050103050	68.5	0.14	18.8	27.4	35.9	52.4	35.8	52.3	40.9	59.7	27.6	40.3
10	2050103090	42.3	0.09	12.4	29.3	22.1	52.1	21.1	49.9	24.7	58.3	17.7	41.7
11	2050103190	146.8	0.31	32.1	21.9	64.7	44.0	64.4	43.9	75.6	51.5	71.2	48.5
12	2050103200	2.2	0.00	0.1	3.1	0.4	19.5	0.4	16.1	0.5	23.8	1.7	76.2
13	2050103210	67.4	0.14	15.0	22.3	31.8	47.2	31.1	46.1	38.0	56.3	29.4	43.7
14	2050103220	3.6	0.01	0.1	4.0	1.5	41.0	1.2	32.7	1.7	47.9	1.9	52.1
15	2050104010	117.6	0.25	29.4	25.0	61.6	52.4	57.5	48.9	73.2	62.2	44.4	37.8
16	2050104020	233.1	0.49	74.8	32.1	132.2	56.7	129.7	55.6	154.4	66.2	78.8	33.8
16	2050104110	28.2	0.06	8.3	29.6	16.7	59.4	16.2	57.7	19.5	69.2	8.7	30.8
17	2050104130	380.3	0.80	88.9	23.4	201.6	53.0	194.3	51.1	238.7	62.8	141.6	37.2
18	2050104170	518.6	1.09	148.1	28.6	247.1	47.7	250.9	48.4	292.5	56.4	226.1	43.6
19	2050105190	46.1	0.10	2.2	4.8	10.4	22.7	10.6	23.1	14.2	30.8	31.9	69.2
20	2050105200	40.4	0.09	2.0	5.0	11.7	29.1	9.4	23.2	15.7	38.9	24.7	61.1
21	2050105230	93.3	0.20	20.6	22.1	45.0	48.3	45.8	49.1	53.1	56.9	40.2	43.1
22	2050105240	52.3	0.11	6.4	12.3	20.3	38.8	20.5	39.2	25.2	48.2	27.1	51.8
23	2050105270	73.3	0.15	13.4	18.2	33.1	45.1	32.4	44.2	39.4	53.8	33.9	46.2
24	2050106010	322.9	0.68	78.2	24.2	170.0	52.7	160.0	49.5	201.3	62.4	121.5	37.6
25	2050106020	181.5	0.38	104.0	57.3	131.9	72.7	137.5	75.7	142.9	78.7	38.6	21.3
26	2050106030	450.9	0.95	117.3	26.0	231.7	51.4	224.8	49.9	274.0	60.8	176.9	39.2
27	2050106040	238.5	0.50	41.6	17.4	101.9	42.7	101.0	42.4	121.9	51.1	116.6	48.9
28	2050106050	371.4	0.78	61.9	16.7	144.1	38.8	140.8	37.9	176.8	47.6	194.7	52.4
29	2050106060	156.5	0.33	23.4	14.9	61.7	39.4	60.2	38.5	76.9	49.2	79.6	50.8
30	2050106070	348.6	0.73	71.9	20.6	152.7	43.8	154.8	44.4	182.2	52.3	166.4	47.7
31	2050106080	252.3	0.53	49.7	19.7	117.8	46.7	113.6	45.0	136.6	54.2	115.6	45.8
32	2050106090	245.1	0.52	138.6	56.5	175.3	71.5	180.8	73.8	190.1	77.5	55.1	22.5

Table 7. Riparian forest buffer statistics for 11-digit hydrologic units in Pennsylvania.

ID	11 digit HUC code	Stream length		Both sides 300'+		Both sides 100-300'		One side 300'+		One side 100-300'		Both sides <100'	
		miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
33	2050106100	167.0	0.35	46.2	27.7	93.6	56.0	94.2	56.4	108.0	64.7	59.0	35.3
34	2050106110	235.8	0.50	66.3	28.1	129.4	54.9	129.8	55.1	150.8	64.0	84.9	36.0
35	2050106120	611.4	1.29	128.0	20.9	281.6	46.1	284.8	46.6	339.4	55.5	272.0	44.5
36	2050106130	193.2	0.41	105.4	54.6	142.2	73.6	144.0	74.6	153.5	79.5	39.7	20.5
37	2050106140	566.0	1.19	111.0	19.6	246.9	43.6	244.8	43.2	298.2	52.7	267.9	47.3
38	2050107010	755.2	1.59	289.5	38.3	439.2	58.1	446.4	59.1	494.2	65.4	261.0	34.6
39	2050107020	282.0	0.59	79.0	28.0	139.1	49.3	141.3	50.1	165.5	58.7	116.5	41.3
40	2050107030	467.0	0.98	213.3	45.7	319.6	68.4	324.1	69.4	355.9	76.2	111.1	23.8
41	2050107040	302.7	0.64	147.3	48.7	205.7	67.9	206.5	68.2	220.4	72.8	82.3	27.2
42	2050107050	220.9	0.46	111.6	50.5	163.9	74.2	164.9	74.6	179.3	81.2	41.5	18.8
43	2050107060	137.6	0.29	48.1	34.9	85.8	62.4	82.1	59.6	95.3	69.3	42.3	30.7
44	2050107070	414.3	0.87	170.3	41.1	268.9	64.9	265.0	64.0	296.7	71.6	117.6	28.4
45	2050107080	271.9	0.57	146.2	53.8	203.4	74.8	201.1	73.9	216.2	79.5	55.7	20.5
46	2050107090	155.4	0.33	49.1	31.6	89.9	57.8	86.2	55.5	102.4	65.9	53.0	34.1
47	2050107100	418.2	0.88	68.2	16.3	185.8	44.4	164.6	39.4	232.8	55.7	185.4	44.3
48	2050201010	293.6	0.62	165.1	56.2	227.6	77.5	237.7	81.0	249.0	84.8	44.6	15.2
49	2050201020	144.6	0.30	109.1	75.4	126.5	87.4	127.6	88.2	131.1	90.6	13.6	9.4
50	2050201030	612.2	1.29	331.0	54.1	428.1	69.9	447.7	73.1	469.2	76.6	142.9	23.4
51	2050201040	790.4	1.66	495.6	62.7	623.6	78.9	657.0	83.1	677.1	85.7	113.3	14.3
52	2050201050	613.5	1.29	350.5	57.1	468.5	76.4	510.6	83.2	525.8	85.7	87.7	14.3
53	2050201060	154.7	0.33	127.0	82.1	139.5	90.1	141.4	91.4	142.7	92.2	12.1	7.8
54	2050201070	711.6	1.50	452.9	63.6	537.1	75.5	573.7	80.6	582.2	81.8	129.4	18.2
55	2050202010	176.3	0.37	115.4	65.5	131.8	74.8	134.2	76.1	138.1	78.3	38.2	21.7
56	2050202020	543.6	1.14	357.1	65.7	425.7	78.3	435.8	80.2	457.4	84.1	86.2	15.9
57	2050202030	719.3	1.51	514.7	71.6	597.2	83.0	601.3	83.6	623.6	86.7	95.7	13.3
58	2050202040	596.8	1.26	377.1	63.2	443.6	74.3	452.0	75.7	472.4	79.2	124.4	20.8
59	2050202050	136.3	0.29	89.4	65.6	97.1	71.3	98.1	72.0	104.5	76.7	31.8	23.3
60	2050203010	518.5	1.09	388.0	74.8	433.1	83.5	444.6	85.8	452.7	87.3	65.7	12.7
61	2050203020	203.0	0.43	129.4	63.7	148.8	73.3	152.5	75.1	159.2	78.4	43.8	21.6
62	2050203030	132.3	0.28	114.5	86.5	121.5	91.8	122.7	92.7	123.4	93.3	8.9	6.7
63	2050203040	577.8	1.22	362.3	62.7	425.7	73.7	432.0	74.8	454.2	78.6	123.6	21.4
64	2050204010	215.7	0.45	38.2	17.7	71.7	33.2	67.2	31.1	86.4	40.0	129.3	60.0

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ID	11 digit HUC code	Stream length		Both sides 300'+		Both sides 100-300'		One side 300'+		One side 100-300'		Both sides <100'	
		miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
65	2050204020	370.3	0.78	233.8	63.1	283.9	76.7	303.5	82.0	310.8	83.9	59.5	16.1
66	2050204030	269.7	0.57	109.8	40.7	148.3	55.0	143.3	53.1	164.5	61.0	105.2	39.0
67	2050204040	616.8	1.30	255.8	41.5	364.3	59.1	369.2	59.9	405.4	65.7	211.4	34.3
68	2050204050	0.8	0.00	0.8	100.0	0.8	100.0	0.8	100.0	0.8	100.0	0.0	0.0
69	2050205010	154.0	0.32	118.3	76.8	133.7	86.8	136.5	88.7	138.1	89.7	15.9	10.3
70	2050205020	421.6	0.89	250.9	59.5	321.1	76.2	324.2	76.9	339.6	80.5	82.0	19.5
71	2050205030	146.3	0.31	59.2	40.5	86.8	59.3	86.0	58.8	96.0	65.6	50.3	34.4
72	2050205040	225.2	0.47	101.7	45.1	134.6	59.7	142.5	63.3	153.1	68.0	72.1	32.0
73	2050205050	346.9	0.73	180.0	51.9	238.4	68.7	247.1	71.2	262.3	75.6	84.6	24.4
74	2050205060	582.7	1.23	342.1	58.7	398.5	68.4	417.3	71.6	433.8	74.4	148.9	25.6
75	2050206010	167.4	0.35	97.8	58.4	128.3	76.7	128.4	76.7	135.7	81.1	31.7	18.9
76	2050206020	620.9	1.31	334.2	53.8	436.7	70.3	442.2	71.2	470.9	75.8	150.0	24.2
77	2050206030	300.0	0.63	189.2	63.1	232.7	77.6	243.3	81.1	248.3	82.8	51.7	17.2
78	2050206040	186.4	0.39	65.7	35.3	111.0	59.6	112.0	60.1	126.5	67.9	59.9	32.1
79	2050206050	594.6	1.25	328.1	55.2	417.4	70.2	426.1	71.7	447.4	75.2	147.2	24.8
80	2050206060	408.1	0.86	116.6	28.6	187.2	45.9	189.6	46.5	219.1	53.7	189.0	46.3
81	2050206070	196.1	0.41	50.5	25.7	107.7	54.9	105.4	53.8	126.7	64.6	69.4	35.4
82	2050206080	282.8	0.60	124.9	44.2	179.0	63.3	185.9	65.7	198.4	70.2	84.4	29.8
83	2050206090	125.1	0.26	61.3	49.0	89.3	71.4	85.8	68.6	96.4	77.1	28.7	22.9
84	2050206100	262.6	0.55	97.5	37.1	151.8	57.8	146.4	55.7	168.0	64.0	94.6	36.0
85	2050206110	273.0	0.57	40.4	14.8	83.4	30.6	74.7	27.4	102.5	37.5	170.5	62.5
86	2050206120	533.8	1.12	105.8	19.8	197.2	37.0	184.9	34.6	237.2	44.4	296.6	55.6
87	2050301010	257.4	0.54	62.7	24.4	113.2	44.0	108.6	42.2	134.2	52.1	123.2	47.9
88	2050301020	137.4	0.29	56.7	41.3	74.0	53.8	73.5	53.5	80.2	58.4	57.2	41.6
89	2050301030	418.1	0.88	118.9	28.4	200.7	48.0	193.5	46.3	232.4	55.6	185.7	44.4
90	2050301040	626.1	1.32	194.6	31.1	281.9	45.0	281.0	44.9	327.2	52.3	298.9	47.7
91	2050301050	284.0	0.60	56.7	20.0	104.3	36.7	108.7	38.3	129.1	45.5	154.9	54.5
92	2050301060	224.1	0.47	39.6	17.7	91.7	40.9	92.1	41.1	111.2	49.6	112.9	50.4
93	2050301070	112.4	0.24	22.7	20.2	58.8	52.4	52.4	46.6	70.5	62.7	41.9	37.3
94	2050301080	232.4	0.49	10.9	4.7	54.2	23.3	41.2	17.7	77.1	33.2	155.2	66.8
95	2050301090	241.1	0.51	64.4	26.7	119.3	49.5	110.3	45.7	137.1	56.9	104.0	43.1
96	2050301100	873.4	1.84	106.9	12.2	299.8	34.3	276.3	31.6	407.2	46.6	466.2	53.4

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ID	11 digit HUC code	Stream length		Both sides 300'+		Both sides 100-300'		One side 300'+		One side 100-300'		Both sides <100'	
		miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
97	2050302010	305.4	0.64	103.0	33.7	153.6	50.3	155.2	50.8	177.3	58.1	128.1	41.9
98	2050302020	164.3	0.35	71.5	43.5	106.0	64.6	105.5	64.2	118.0	71.9	46.2	28.1
99	2050302030	367.6	0.77	101.8	27.7	178.3	48.5	186.1	50.6	219.5	59.7	148.2	40.3
100	2050302040	131.7	0.28	42.0	31.9	66.0	50.1	63.9	48.5	74.6	56.6	57.1	43.4
101	2050302050	461.6	0.97	252.2	54.6	344.1	74.6	348.3	75.5	376.6	81.6	84.9	18.4
102	2050302060	126.0	0.27	62.1	49.3	87.1	69.1	86.6	68.7	97.0	76.9	29.1	23.1
103	2050302070	233.3	0.49	140.7	60.3	178.7	76.6	178.3	76.4	188.7	80.9	44.6	19.1
104	2050302080	135.3	0.28	55.3	40.9	83.1	61.4	86.1	63.7	93.9	69.4	41.4	30.6
105	2050303010	404.0	0.85	171.8	42.5	255.0	63.1	254.2	62.9	282.6	69.9	121.4	30.1
106	2050303020	159.8	0.34	59.7	37.4	82.4	51.5	80.5	50.3	90.7	56.7	69.1	43.3
107	2050303030	343.6	0.72	96.7	28.2	161.0	46.9	157.5	45.8	186.3	54.2	157.3	45.8
107	2050303040	209.8	0.44	81.7	38.9	138.2	65.9	138.0	65.8	157.5	75.1	52.2	24.9
109	2050303050	481.1	1.01	187.1	38.9	273.1	56.8	283.0	58.8	314.1	65.3	167.0	34.7
110	2050303060	236.9	0.50	68.3	28.8	99.2	41.9	99.1	41.8	111.1	46.9	125.7	53.1
111	2050303070	214.4	0.45	110.3	51.4	148.5	69.3	149.4	69.7	161.4	75.3	53.0	24.7
112	2050303080	407.5	0.86	167.8	41.2	229.2	56.2	259.0	63.6	273.9	67.2	133.6	32.8
113	2050304010	204.7	0.43	89.1	43.5	117.1	57.2	121.0	59.1	134.2	65.5	70.5	34.5
114	2050304020	242.0	0.51	135.9	56.2	188.6	77.9	189.8	78.4	202.4	83.6	39.6	16.4
115	2050304030	106.0	0.22	38.0	35.9	61.5	58.1	60.6	57.2	70.5	66.5	35.5	33.5
116	2050304040	341.8	0.72	146.4	42.8	215.5	63.1	220.4	64.5	244.7	71.6	97.1	28.4
117	2050304050	249.2	0.52	71.0	28.5	97.8	39.2	98.4	39.5	118.8	47.7	130.4	52.3
118	2050304060	138.6	0.29	74.0	53.4	92.0	66.3	91.2	65.8	98.5	71.0	40.2	29.0
119	2050304070	171.9	0.36	42.2	24.5	66.7	38.8	65.3	38.0	74.2	43.2	97.7	56.8
120	2050304080	254.9	0.54	62.4	24.5	112.9	44.3	104.1	40.8	136.5	53.5	118.4	46.5
121	2050304090	599.9	1.26	227.8	38.0	354.7	59.1	349.0	58.2	398.9	66.5	201.1	33.5
122	2050304100	130.1	0.27	28.7	22.1	55.0	42.3	56.2	43.2	65.1	50.1	65.0	49.9
123	2050304110	162.3	0.34	70.4	43.4	109.7	67.6	105.4	64.9	121.1	74.7	41.1	25.3
124	2050304120	311.8	0.66	69.5	22.3	126.0	40.4	121.7	39.1	153.6	49.3	158.1	50.7
125	2050305010	511.7	1.08	186.8	36.5	277.2	54.2	273.1	53.4	317.5	62.1	194.1	37.9
126	2050305020	261.2	0.55	100.1	38.3	163.5	62.6	153.5	58.7	183.7	70.3	77.5	29.7
127	2050305030	447.7	0.94	106.6	23.8	213.9	47.8	192.2	42.9	256.6	57.3	191.1	42.7
128	2050305040	259.5	0.55	16.4	6.3	70.7	27.2	61.1	23.5	98.4	37.9	161.1	62.1

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		miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
129	2050305050	386.5	0.81	128.8	33.3	213.0	55.1	209.9	54.3	246.5	63.8	140.0	36.2
130	2050305060	314.4	0.66	107.9	34.3	176.2	56.0	173.2	55.1	200.4	63.7	114.0	36.3
131	2050305070	169.5	0.36	8.0	4.7	34.0	20.1	29.5	17.4	45.9	27.1	123.6	72.9
132	2050305080	97.1	0.20	7.9	8.1	17.6	18.1	15.8	16.3	21.7	22.4	75.4	77.6
133	2050305090	508.2	1.07	48.7	9.6	157.7	31.0	127.4	25.1	202.1	39.8	306.1	60.2
134	2050305100	802.7	1.69	185.0	23.0	387.4	48.3	360.9	45.0	459.5	57.2	343.2	42.8
135	2050306010	165.7	0.35	13.6	8.2	52.1	31.5	43.1	26.0	65.8	39.7	99.9	60.3
136	2050306020	406.3	0.86	69.7	17.2	172.5	42.5	146.8	36.1	209.0	51.4	197.4	48.6
137	2050306030	238.9	0.50	29.8	12.5	107.4	45.0	83.7	35.0	130.6	54.7	108.3	45.3
138	2050306040	152.4	0.32	15.2	10.0	61.6	40.4	45.6	29.9	74.8	49.1	77.6	50.9
139	2050306050	304.5	0.64	82.7	27.2	146.3	48.0	138.1	45.3	175.6	57.7	128.9	42.3
140	2050306060	204.3	0.43	37.7	18.4	97.4	47.7	88.7	43.4	116.1	56.9	88.1	43.1
141	2050306070	327.3	0.69	43.2	13.2	121.6	37.2	107.5	32.8	146.6	44.8	180.8	55.2
142	2050306080	229.5	0.48	15.9	6.9	67.1	29.3	49.2	21.4	85.6	37.3	143.8	62.7
143	2050306090	233.1	0.49	35.2	15.1	77.1	33.1	69.1	29.6	93.4	40.1	139.7	59.9
144	2050306100	83.5	0.18	11.3	13.5	26.2	31.3	23.6	28.3	30.8	36.8	52.8	63.2
145	2050306110	438.2	0.92	31.9	7.3	92.9	21.2	81.9	18.7	114.6	26.1	323.6	73.9
146	2050306120	285.4	0.60	44.6	15.6	93.9	32.9	85.3	29.9	109.5	38.4	175.9	61.6
147	2050306150	248.8	0.52	92.6	37.2	169.4	68.1	161.4	64.9	188.4	75.7	60.4	24.3
148	2050306160	691.9	1.46	143.1	20.7	287.3	41.5	287.5	41.6	346.2	50.0	345.6	50.0
149	2050306180	194.9	0.41	38.1	19.5	81.8	42.0	75.8	38.9	97.5	50.0	97.4	50.0
150	2050306200	43.1	0.09	9.3	21.7	20.5	47.6	18.4	42.6	24.1	56.0	18.9	44.0
151	2050306220	246.0	0.52	53.7	21.8	109.7	44.6	104.4	42.5	129.5	52.7	116.5	47.3
152	2060002020	82.3	0.17	23.2	28.2	50.9	61.9	45.7	55.6	57.1	69.4	25.2	30.6
153	2060002040	21.0	0.04	2.9	13.6	10.8	51.7	9.4	44.7	12.7	60.6	8.3	39.4
155	2060002080	13.2	0.03	2.1	16.2	5.7	43.2	4.7	35.4	6.6	49.5	6.7	50.5
156	2060003120	18.2	0.04	1.3	7.4	4.5	24.7	3.5	19.2	5.6	30.9	12.6	69.1
157	2070002070	408.9	0.86	213.0	52.1	274.9	67.2	281.6	68.9	295.8	72.3	113.1	27.7
158	2070002130	155.5	0.33	80.0	51.4	103.2	66.4	106.8	68.7	113.1	72.7	42.4	27.3
159	2070003060	213.9	0.45	131.9	61.7	169.3	79.2	171.3	80.1	179.2	83.8	34.7	16.2
160	2070003100	31.2	0.07	22.5	72.2	26.9	86.1	27.0	86.5	28.2	90.2	3.1	9.8

Table 7. Riparian forest buffer statistics for 11-digit hydrologic units in Pennsylvania.

ID	11 digit HUC code	Stream length		Both sides 300'+		Both sides 100-300'		One side 300'+		One side 100-300'		Both sides <100'	
		miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
161	2070003130	229.2	0.48	129.9	56.7	178.5	77.9	178.1	77.7	190.5	83.1	38.7	16.9
162	2070004010	234.4	0.49	47.4	20.2	101.8	43.4	88.1	37.6	121.2	51.7	113.2	48.3
163	2070004020	345.2	0.73	92.7	26.8	151.9	44.0	138.9	40.2	175.6	50.9	169.6	49.1
164	2070004030	475.6	1.00	172.2	36.2	268.6	56.5	254.1	53.4	303.8	63.9	171.7	36.1
165	2070004120	363.2	0.76	192.2	52.9	282.5	77.8	279.2	76.9	303.8	83.7	59.4	16.3
166	2070004220	530.9	1.12	274.9	51.8	402.2	75.8	400.2	75.4	431.7	81.3	99.2	18.7
167	2070004310	106.5	0.22	9.1	8.5	29.4	27.6	25.0	23.5	38.6	36.3	67.8	63.7
168	2070004400	162.8	0.34	49.3	30.3	64.0	39.3	61.7	37.9	70.8	43.5	92.0	56.5
169	2070009030	114.9	0.24	53.7	46.8	77.1	67.1	74.7	65.1	85.0	74.0	29.9	26.0
170	2070009040	436.7	0.92	69.3	15.9	187.6	43.0	155.8	35.7	225.8	51.7	210.9	48.3

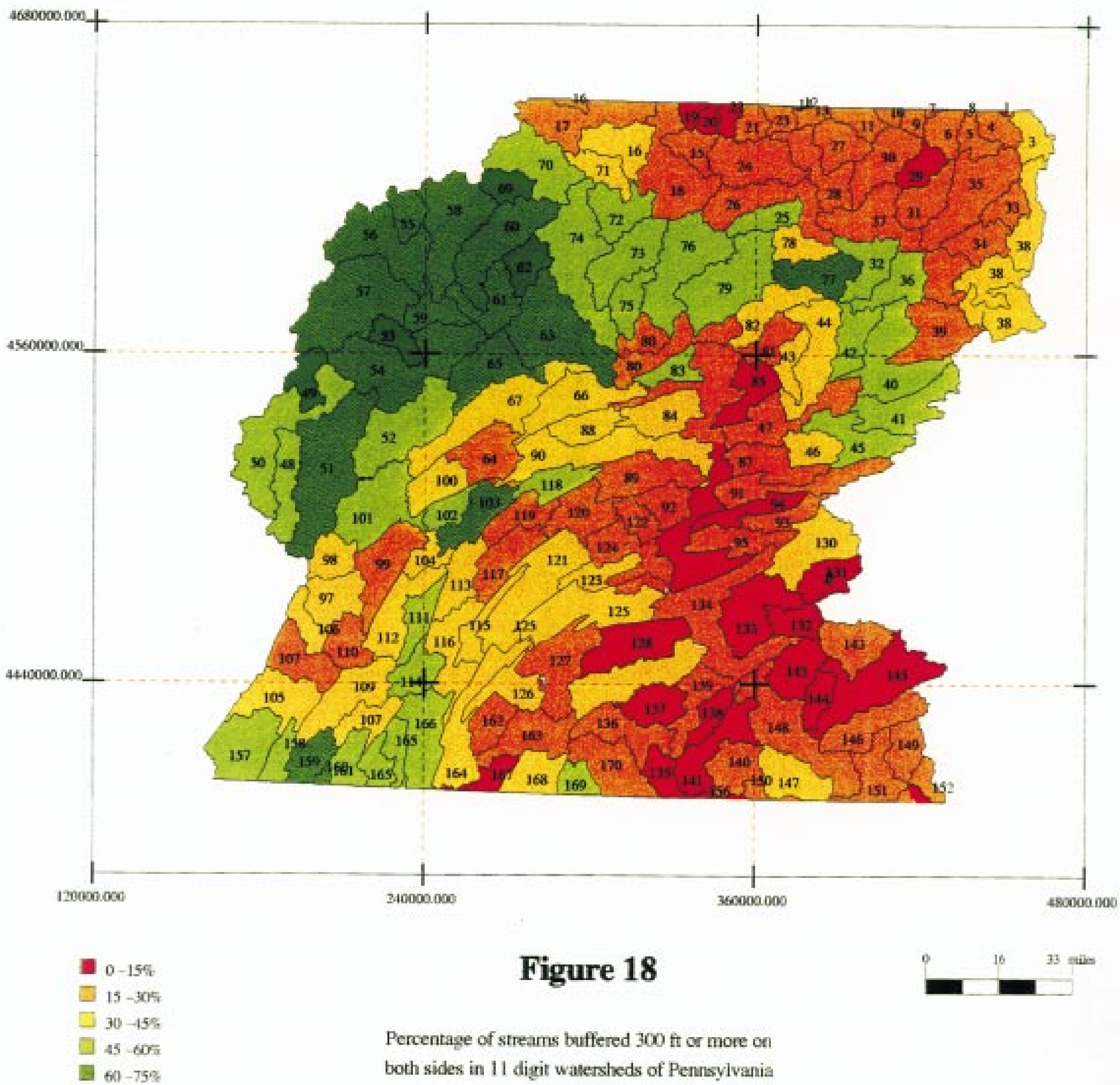

Figure 18

Percentage of streams buffered 300 ft or more on both sides in 11 digit watersheds of Pennsylvania
Projection UTM, Zone 18

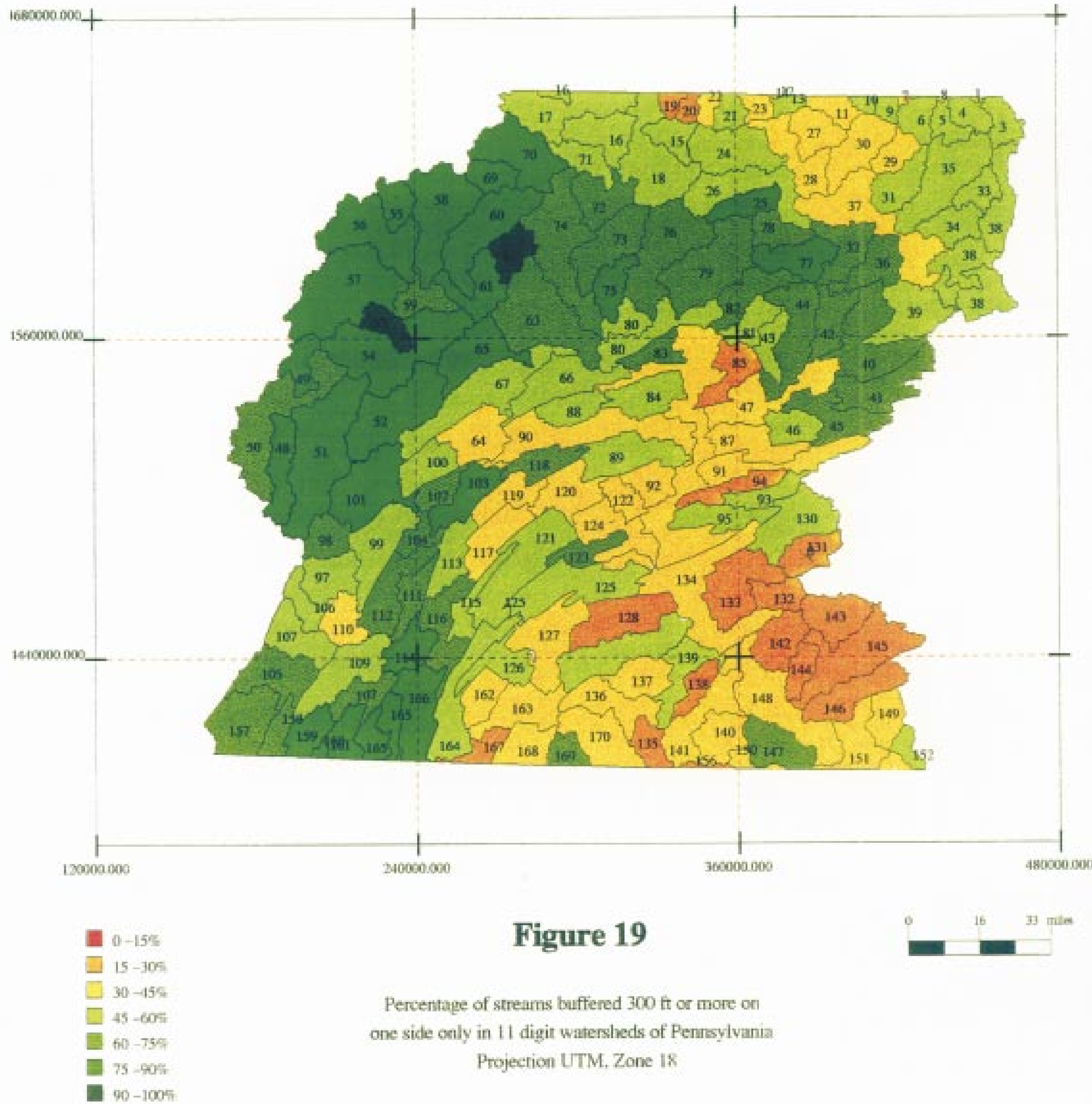

Figure 19

Percentage of streams buffered 300 ft or more on one side only in 11 digit watersheds of Pennsylvania
Projection UTM, Zone 18

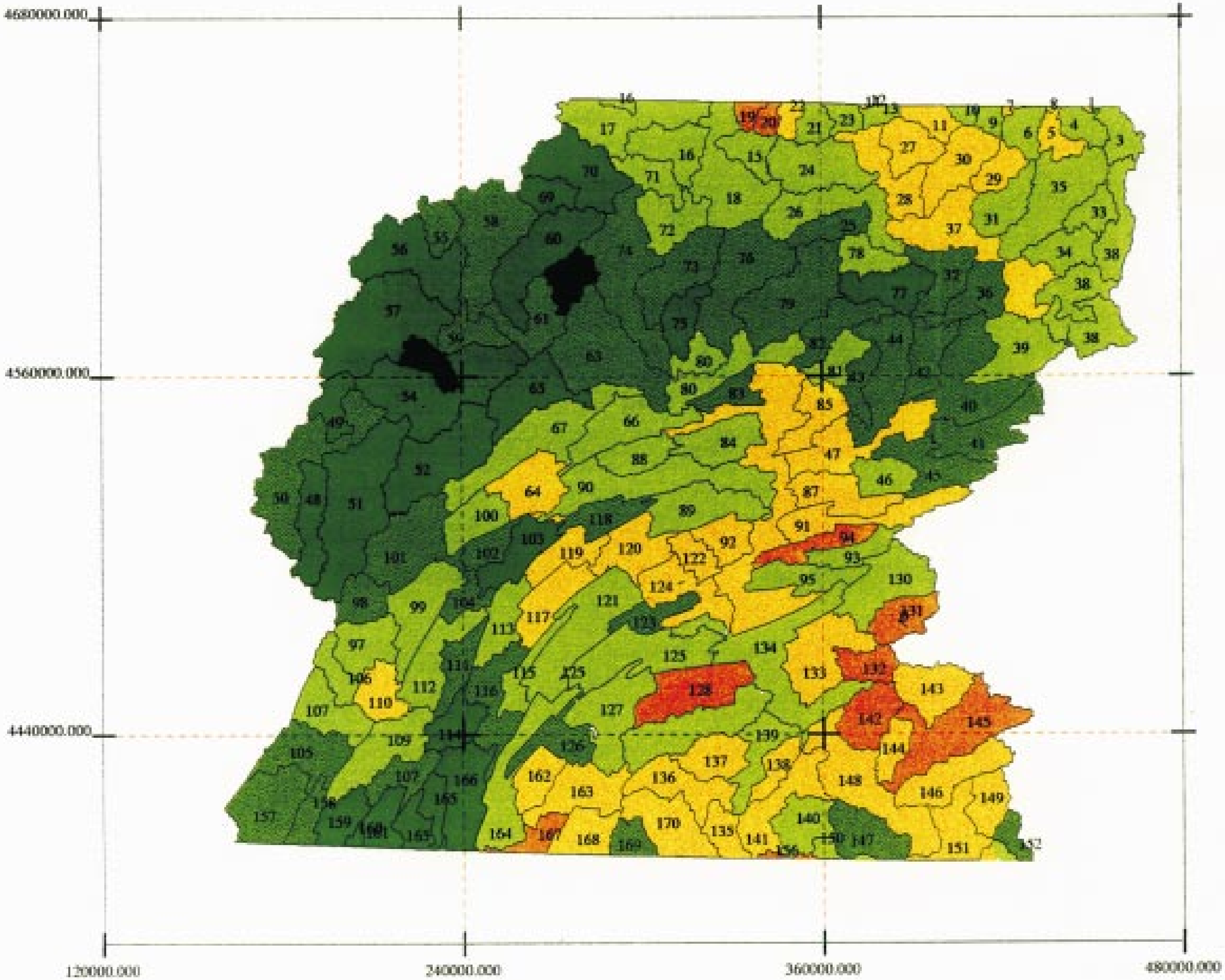

Figure 20

Percentage of streams buffered 100 ft or more on both sides in 11 digit watersheds of Pennsylvania
Projection UTM, Zone 18

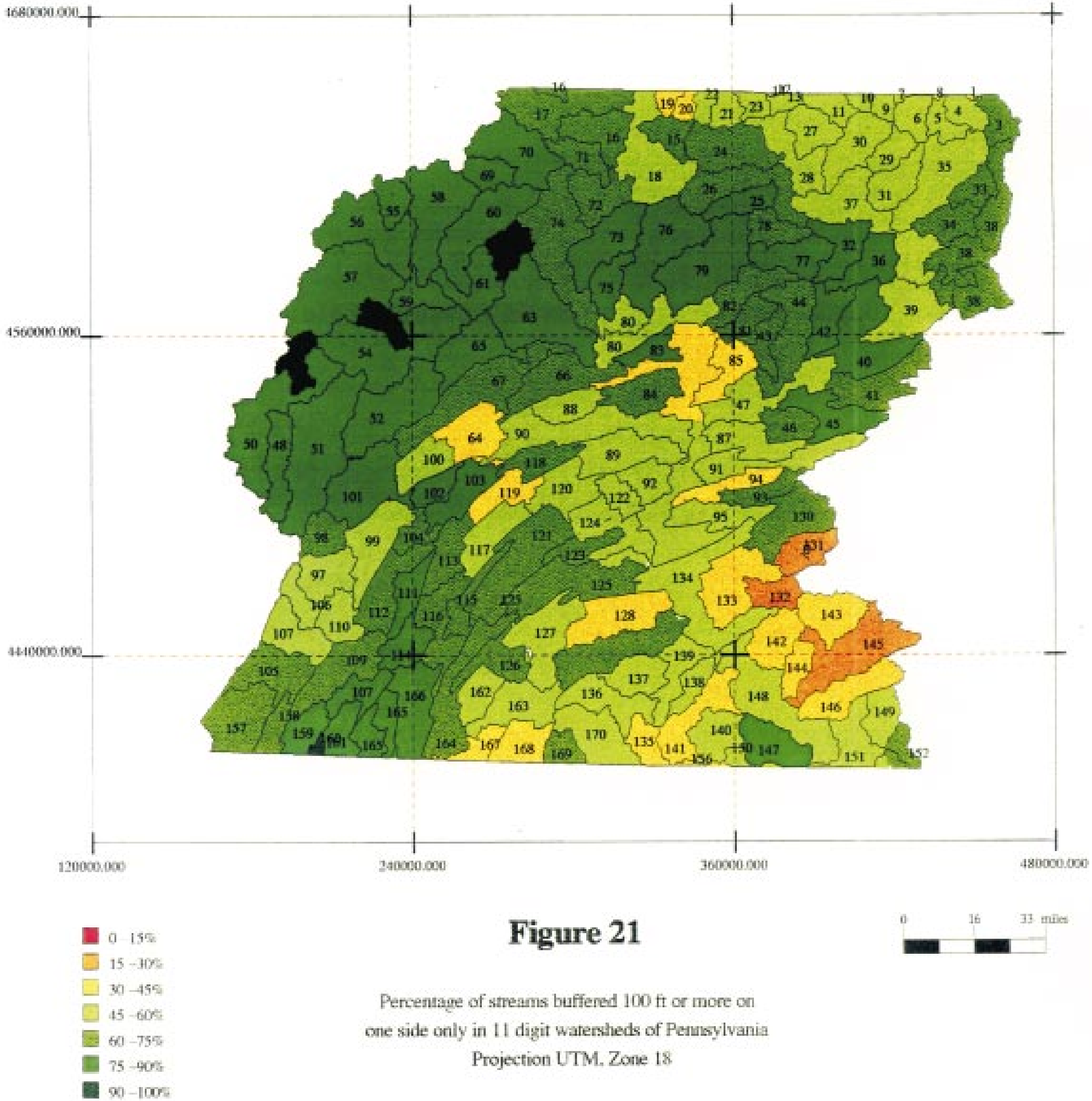

Figure 21

Percentage of streams buffered 100 ft or more on one side only in 11 digit watersheds of Pennsylvania
Projection UTM, Zone 18

Table 9. Riparian forest buffer statistics for 11-digit hydrologic units in Virginia.

ID	Watershed	HUC code	Stream Length		Both 300'+		Both 100'-300'		One side 300'+		One side 100'-300'		Both sides < 100'	
			miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
A01	POTOMAC RIVER/PINEY RUN/DUTCHMAN CREEK	2070008	51	0.15	12.4	24.4	26.0	51.1	26.6	52.2	32.3	63.5	18.6	36.5
A02	CATOCTIN CREEK	2070008	136	0.39	18.6	13.7	52.2	38.5	45.4	33.4	64.2	47.3	71.4	52.7
A03	POTOMAC RIVER/LIMESTONE BRANCH	2070008	75	0.22	10.8	14.3	27.0	35.8	25.4	33.6	34.4	45.6	41.0	54.4
A04	UPPER GOOSE CREEK/GAP RUN	2070008	113	0.32	21.2	18.8	45.9	40.8	41.6	36.9	55.2	49.0	57.5	51.0
A05	MIDDLE GOOSE CREEK/PANTHER SKIN CREEK	2070008	126	0.36	27.0	21.4	63.3	50.1	59.9	47.4	73.9	58.5	52.4	41.5
A06	NORTH FORK GOOSE CREEK	2070008	66	0.19	9.3	14.2	25.1	38.4	21.9	33.4	30.3	46.2	35.3	53.8
A07	BEAVERDAM CREEK	2070008	75	0.21	14.6	19.6	35.4	47.4	32.2	43.1	42.3	56.6	32.4	43.4
A08	LOWER GOOSE CREEK/LITTLE RIVER	2070008	165	0.47	32.5	19.7	69.6	42.2	64.7	39.2	83.2	50.4	81.9	49.6
A09	POTOMAC RIVER/BROAD RUN	2070008	132	0.38	26.7	20.2	58.6	44.3	55.1	41.7	69.0	52.2	63.3	47.8
A10	SUGARLAND RUN	2070008	36	0.10	6.2	17.3	16.6	46.3	14.7	40.9	19.9	55.4	16.0	44.6
A11	POTOMAC RIVER/DIFFICULT RUN	2070008	144	0.41	47.8	33.2	91.3	63.4	91.0	63.2	104.3	72.5	39.6	27.5
A12	POTOMAC RIVER/FOURMILE RUN/PIMMIT RUN	2070010	47	0.14	3.9	8.1	14.5	30.5	10.8	22.8	18.4	38.8	29.1	61.2
A13	CAMERON RUN	2070010	48	0.14	3.6	7.5	15.0	31.4	11.1	23.2	17.6	37.0	30.1	63.0
A14	POTOMAC RIVER/DOGUE CREEK/LITTLE HUNTING CREEK	2070010	54	0.16	6.6	12.1	16.6	30.5	15.2	27.9	20.6	37.8	33.8	62.2
A15	ACCOTINK CREEK	2070010	82	0.23	19.3	23.7	39.8	48.8	35.2	43.2	46.1	56.6	35.4	43.4
A16	POHICK CREEK	2070010	58	0.16	14.5	25.2	31.2	54.1	29.2	50.6	36.9	63.9	20.9	36.1
A17	UPPER CEDAR RUN/LICKING RUN	2070010	160	0.46	26.1	16.3	62.6	39.0	61.1	38.1	74.2	46.3	86.1	53.7
A18	LOWER CEDAR RUN/TOWN RUN	2070010	151	0.43	50.3	33.2	80.5	53.2	79.2	52.4	90.6	59.9	60.6	40.1
A19	BROAD RUN/KETTLE RUN	2070010	208	0.59	43.6	21.0	89.0	42.8	85.2	41.0	104.7	50.4	103.0	49.6
A20	UPPER OCCOQUAN RIVER/LAKE JACKSON	2070010	50	0.14	21.9	43.7	33.6	67.2	34.7	69.3	38.0	75.9	12.1	24.1
A21	UPPER BULL RUN/LITTLE BULL RUN	2070010	141	0.40	40.0	28.3	82.2	58.2	76.9	54.5	91.8	65.0	49.4	35.0
A22	CUB RUN	2070010	74	0.21	15.9	21.6	33.7	45.8	30.4	41.3	38.5	52.3	35.1	47.7
A23	LOWER BULL RUN/POPES HEAD CREEK	2070010	76	0.22	27.8	36.4	47.8	62.6	48.6	63.7	53.6	70.2	22.7	29.8
A24	OCCOQUAN RIVER - RESERVOIR	2070010	70	0.20	14.8	21.0	33.8	48.1	35.7	50.8	43.1	61.4	27.1	38.6
A25	POTOMAC RIVER/LOWER OCCOQUAN RIVER/NEABSCO CREEK	2070010	102	0.29	21.8	21.3	43.0	42.0	43.7	42.7	51.4	50.2	51.0	49.8
A26	POTOMAC RIVER/QUANTICO CREEK/CHOPAWAMSIC CREEK	2070011	167	0.48	89.9	53.7	113.4	67.8	115.5	69.0	121.5	72.6	45.8	27.4
A27	UPPER AQUIA CREEK/BEAVERDAM RUN	2070011	93	0.27	53.7	57.7	70.6	75.8	73.5	79.0	76.0	81.6	17.1	18.4
A28	LOWER AQUIA CREEK	2070011	53	0.15	11.5	21.7	21.2	40.2	22.3	42.4	24.8	47.0	28.0	53.0
A29	POTOMAC RIVER/POTOMAC CREEK	2070011	203	0.58	104.0	51.2	135.1	66.5	140.2	69.0	145.7	71.7	57.6	28.3
A30	POTOMAC RIVER/UPPER MACHODOC CREEK	2070011	110	0.31	52.7	48.0	65.5	59.7	69.1	63.0	71.4	65.1	38.3	34.9
A31	POTOMAC RIVER/MATTOX CREEK/POPES CREEK/ROSIER CREEK	2070011	166	0.47	59.0	35.5	83.4	50.2	85.6	51.6	91.8	55.3	74.2	44.7
A32	POTOMAC RIVER/NOMINI CREEK/LOWER MACHODOC CREEK	2070011	185	0.53	47.6	25.7	74.0	40.0	75.3	40.7	84.0	45.4	101.0	54.6

Table 9. Riparian forest buffer statistics for 11-digit hydrologic units in Virginia.

ID	Watershed	HUC code	Stream Length		Both 300'+		Both 100'-300'		One side 300'+		One side 100'-300'		Both sides < 100'	
			miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
A33	POTOMAC RIVER/YEOCOMICO RIVER	2070011	147	0.42	42.3	27.8	73.6	48.4	72.7	47.8	82.1	54.0	65.3	46.0
A34	POTOMAC RIVER/COAN RIVER/LITTLE WICOMICO RIVER	2070011	210	0.60	33.9	14.1	69.6	29.0	76.8	32.0	87.2	36.3	123.1	63.7
B01	UPPER NORTH FORK SOUTH BRANCH POTOMAC RIVER/LAUREL FORK	2070001	39	0.11	25.7	65.2	27.7	70.4	28.6	72.5	28.6	72.7	10.8	27.3
B02	UPPER SOUTH BRANCH POTOMAC RIVER	2070001	49	0.14	5.2	10.8	9.5	19.5	10.6	21.8	11.5	23.6	37.1	76.4
B03	UPPER SOUTH FORK SOUTH BRANCH POTOMAC RIVER	2070001	8	0.02	1.1	13.9	2.8	33.8	3.3	39.9	3.3	40.3	4.9	59.7
B04	SLEEPY CREEK	2070004	29	0.08	12.0	41.2	16.7	57.1	16.8	57.6	18.5	63.4	10.7	36.6
B05	UPPER BACK CREEK/ISAACS CREEK	2070004	115	0.33	36.6	31.9	60.4	52.7	62.1	54.1	69.5	60.6	45.2	39.4
B06	HOGUE CREEK	2070004	61	0.17	19.9	32.7	29.6	48.8	29.8	49.1	33.2	54.7	27.5	45.3
B07	LOWER BACK CREEK/BRUSH CREEK/BABBS RUN	2070004	68	0.19	17.8	26.1	32.6	47.7	34.2	50.1	38.1	55.8	30.2	44.2
B08	UPPER OPEQUON CREEK	2070004	72	0.21	5.1	7.1	20.7	28.7	17.1	23.7	26.5	36.8	45.6	63.2
B09	LOWER OPEQUON CREEK	2070004	99	0.28	2.8	2.8	18.4	18.6	15.7	15.9	25.0	25.3	73.6	74.7
B10	UPPER MIDDLE RIVER	2070005	36	0.10	0.2	0.4	1.6	4.5	1.2	3.4	3.6	9.9	32.2	90.1
B11	MIDDLE RIVER/JENNINGS BRANCH	2070005	54	0.15	20.0	37.1	27.3	50.6	27.9	51.7	30.4	56.3	23.6	43.7
B12	MIDDLE RIVER/LEWIS CREEK	2070005	59	0.17	0.7	1.2	9.9	16.9	8.3	14.2	14.4	24.5	44.3	75.5
B13	MOFFETT CREEK	2070005	17	0.05	2.2	12.9	2.9	16.9	3.1	18.0	3.5	20.1	13.7	79.9
B14	CHRISTIANS CREEK	2070005	73	0.21	2.7	3.7	11.5	15.8	10.4	14.2	17.2	23.6	55.7	76.4
B15	LOWER MIDDLE RIVER	2070005	37	0.11	0.3	0.9	3.9	10.5	2.7	7.1	7.2	19.3	30.2	80.7
B16	UPPER NORTH RIVER	2070005	69	0.20	58.0	84.2	62.5	90.8	64.0	93.0	64.5	93.7	4.4	6.3
B17	MIDDLE NORTH RIVER	2070005	35	0.10	3.7	10.8	8.2	23.9	7.5	21.8	10.6	30.7	23.9	69.3
B18	BRIERY BRANCH	2070005	38	0.11	19.6	52.1	22.8	60.7	23.4	62.3	24.5	65.1	13.1	34.9
B19	MOSSY CREEK	2070005	14	0.04	0.0	0.0	0.1	0.8	0.2	1.5	0.2	1.5	13.4	98.5
B20	UPPER DRY RIVER	2070005	95	0.27	86.0	91.0	88.7	93.8	90.1	95.3	90.3	95.4	4.3	4.6
B21	LOWER DRY RIVER	2070005	15	0.04	1.5	9.9	3.3	21.3	3.3	21.0	3.9	25.0	11.6	75.0
B22	MUDDY CREEK	2070005	28	0.08	3.0	10.8	4.1	14.5	4.1	14.7	4.6	16.2	23.5	83.8
B23	LOWER NORTH RIVER	2070005	69	0.20	0.1	0.1	1.7	2.5	1.7	2.4	4.6	6.6	64.5	93.4
B24	LONG GLADE CREEK	2070005	17	0.05	0.0	0.0	0.2	1.3	0.3	1.6	0.3	1.9	16.4	98.1
B25	COOKS CREEK	2070005	14	0.04	0.0	0.0	0.1	0.6	0.0	0.2	0.2	1.5	13.7	98.5
B26	BLACKS RUN	2070005	11	0.03	0.0	0.0	0.1	0.5	0.0	0.4	0.2	1.5	11.1	98.5
B27	PLEASANT RUN	2070005	6	0.02	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.7	6.3	99.3
B28	NAKED CREEK	2070005	19	0.06	0.4	1.9	0.9	4.8	1.3	6.5	1.5	7.6	18.0	92.4
B29	MILL CREEK	2070005	16	0.05	0.1	0.5	0.7	4.4	0.6	3.6	1.0	6.4	14.8	93.6
B30	UPPER SOUTH RIVER	2070005	62	0.18	18.8	30.5	26.1	42.4	25.5	41.5	29.0	47.1	32.6	52.9

Table 9. Riparian forest buffer statistics for 11-digit hydrologic units in Virginia.

ID	Watershed	HUC code	Stream Length		Both 300'+		Both 100'-300'		One side 300'+		One side 100'-300'		Both sides < 100'	
			miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
B31	MIDDLE SOUTH RIVER/BACK CREEK	2070005	108	0.31	52.6	48.8	67.6	62.7	68.9	64.0	73.6	68.2	34.2	31.8
B32	LOWER SOUTH RIVER	2070005	105	0.30	31.6	30.0	52.7	50.1	47.1	44.7	60.6	57.6	44.6	42.4
B33	UPPER SOUTH FORK SHENANDOAH RIVER	2070005	49	0.14	24.7	50.8	27.6	56.8	27.3	56.2	28.5	58.7	20.1	41.3
B34	CUB RUN	2070005	17	0.05	2.9	16.8	5.0	28.8	4.2	24.3	6.0	34.3	11.4	65.7
B35	SOUTH FORK SHENANDOAH RIVER/ELK RUN/BOONE RUN	2070005	134	0.38	39.2	29.3	49.7	37.1	50.2	37.5	55.2	41.2	78.7	58.8
B36	NAKED CREEK	2070005	42	0.12	23.1	55.1	27.9	66.5	28.0	66.7	29.2	69.5	12.8	30.5
B37	SOUTH FORK SHENANDOAH RIVER/CUB RUN	2070005	94	0.27	22.6	24.0	34.2	36.3	34.4	36.5	41.1	43.7	53.1	56.3
B38	SOUTH FORK SHENANDOAH RIVER/MILL CREEK	2070005	57	0.16	7.0	12.2	14.2	24.9	13.9	24.3	19.4	34.0	37.7	66.0
B39	HAWKSBILL CREEK	2070005	74	0.21	14.8	19.9	23.9	32.2	22.9	30.9	26.8	36.1	47.4	63.9
B40	SOUTH FORK SHENANDOAH RIVER/GOONEY RUN	2070005	149	0.43	36.8	24.6	64.6	43.3	63.3	42.4	80.5	53.9	68.8	46.1
B41	LOWER SOUTH FORK SHENANDOAH RIVER	2070005	53	0.15	6.6	12.3	13.8	25.9	12.9	24.2	18.4	34.4	35.0	65.6
B42	UPPER NORTH FORK SHENANDOAH RIVER/GERMAN RIVER	2070006	73	0.21	41.5	56.8	52.5	71.7	53.3	73.0	56.2	76.8	16.9	23.2
B43	NORTH FORK SHENANDOAH RIVER/LITTLE DRY RIVER	2070006	71	0.20	49.9	70.0	54.9	77.0	55.8	78.3	56.7	79.6	14.5	20.4
B44	NORTH FORK SHENANDOAH RIVER/SHOEMAKER RIVER	2070006	74	0.21	36.0	48.5	45.8	61.6	47.2	63.5	50.0	67.2	24.4	32.8
B45	NORTH FORK SHENANDOAH RIVER/HOLMANS CREEK	2070006	86	0.25	0.3	0.3	3.4	4.0	3.1	3.6	6.1	7.1	80.2	92.9
B46	LINVILLE CREEK	2070006	42	0.12	0.3	0.8	1.2	2.8	1.3	3.1	2.2	5.2	39.8	94.8
B47	SMITH CREEK	2070006	88	0.25	15.2	17.2	23.3	26.4	22.5	25.4	28.1	31.8	60.2	68.2
B48	NORTH FORK SHENANDOAH RIVER/MILL CREEK	2070006	87	0.25	23.3	26.9	31.4	36.3	31.9	36.9	34.9	40.3	51.7	59.7
B49	STONY CREEK	2070006	127	0.36	41.9	32.9	62.6	49.1	63.9	50.1	71.4	56.0	56.1	44.0
B50	NORTH FORK SHENANDOAH RIVER/NARROW PASSAGE CREEK	2070006	90	0.26	10.3	11.4	19.3	21.4	19.1	21.2	24.1	26.8	65.9	73.2
B51	LOWER NORTH FORK SHENANDOAH RIVER/TUMBLING RUN	2070006	69	0.20	8.9	12.8	16.3	23.4	16.4	23.6	20.1	28.9	49.4	71.1
B52	UPPER CEDAR CREEK	2070006	119	0.34	73.9	62.0	98.9	83.1	99.2	83.3	105.3	88.4	13.8	11.6
B53	LOWER CEDAR CREEK	2070006	102	0.29	24.0	23.5	39.3	38.5	38.2	37.4	45.6	44.6	56.6	55.4
B54	PASSAGE CREEK	2070006	98	0.28	53.6	54.4	64.8	65.9	65.8	66.9	69.2	70.3	29.2	29.7
B55	UPPER SHENANDOAH RIVER	2070007	92	0.26	16.3	17.8	29.0	31.6	30.5	33.2	37.0	40.3	54.7	59.7
B56	CROOKED RUN	2070007	67	0.19	7.5	11.2	16.8	25.1	18.7	27.9	21.6	32.3	45.3	67.7
B57	SHENANDOAH RIVER/SPOUT RUN	2070007	104	0.30	22.6	21.8	39.1	37.7	38.5	37.1	47.1	45.4	56.7	54.6
B58	LOWER SHENANDOAH RIVER	2070007	69	0.20	15.0	21.6	22.7	32.7	23.5	33.9	27.7	39.9	41.7	60.1
C01	CHESAPEAKE BAY/GREAT WICOMICO RIVER	2080102	190	0.54	75.8	20.7	119.1	32.4	128.1	34.9	142.6	38.8	47.1	61.2
C02	DRAGON SWAMP	2080102	303	0.86	221.6	73.2	275.8	91.1	277.6	91.7	285.5	94.3	17.2	5.7
C03	PIANKATANK RIVER	2080102	63	0.18	49.0	31.5	69.1	44.4	76.5	49.1	81.1	52.1	-17.8	47.9

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			miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
C04	CHESAPEAKE BAY/EAST RIVER/NORTH RIVER	2080102	291	0.83	30.7	8.9	49.0	14.2	56.7	16.4	62.4	18.0	228.5	82.0
C05	WARE RIVER	2080102	152	0.43	56.3	37.2	83.2	54.9	85.8	56.6	91.1	60.1	60.4	39.9
C06	CHESAPEAKE BAY/SEVERN RIVER	2080102	131	0.37	9.2	7.0	12.6	9.6	13.2	10.1	14.4	10.9	116.9	89.1
C07	CHESAPEAKE BAY/BACK RIVER/POQUOSON RIVER	2080108	366	1.04	9.8	2.5	30.5	7.7	32.1	8.1	43.1	10.8	322.7	89.2
C08	LYNNHAVEN RIVER/LITTLE CREEK	2080108	334	0.95	37.4	10.5	70.0	19.6	70.9	19.9	89.9	25.3	244.4	74.7
C09	POCOMOKE RIVER/PITTS CREEK	2060009	45	0.13	9.9	22.0	19.9	44.5	19.7	43.9	23.1	51.5	21.8	48.5
C10	CHESAPEAKE BAY/HOLDENS CREEK	2080109	418	1.19	17.0	4.1	48.7	11.7	44.4	10.6	57.9	13.8	360.2	86.2
C11	CHESAPEAKE BAY/ONANCOCK CREEK	2080109	135	0.39	0.9	0.7	6.3	4.7	5.3	3.9	8.4	6.2	126.9	93.8
C12	PUNGOTEAGUE CREEK	2080109	39	0.11	4.4	11.1	8.1	20.6	8.4	21.5	9.3	23.8	29.9	76.2
C13	NANDUA CREEK/OCCOHANNOCK CREEK/NASSAWADOX CREEK	2080109	253	0.72	8.7	3.4	26.4	10.4	26.8	10.6	35.6	14.1	217.4	85.9
C14	CHESAPEAKE BAY/HUNGARS CREEK	2080109	94	0.27	1.9	2.0	10.6	11.4	10.1	10.8	16.3	17.4	77.3	82.6
C15	CHERRYSTONE INLET/KINGS CREEK	2080109	51	0.14	1.0	2.1	6.1	12.1	6.2	12.2	9.1	18.0	41.6	82.0
C16	CHESAPEAKE BAY/OLD PLANTATION CREEK	2080109	45	0.13	0.8	1.7	5.5	12.3	5.2	11.6	8.3	18.7	36.2	81.3
D06	MAGOTHY BAY/MOCKHORN BAY	2080109	3	0.01	0.0	0.5	0.2	8.0	0.3	11.9	0.4	14.1	2.3	85.9
E01	UPPER RAPPAHANNOCK RIVER/THUMB RUN/JORDAN RIVER	2080103	150	0.43	39.8	26.5	68.4	45.5	68.8	45.8	80.5	53.5	69.9	46.5
E02	RAPPAHANNOCK RIVER/CARTER RUN/GREAT RUN	2080103	207	0.59	56.6	27.3	96.2	46.5	94.4	45.6	112.2	54.2	94.7	45.8
E03	HUGHES RIVER	2080103	55	0.16	18.8	34.2	23.1	42.1	23.1	42.0	25.4	46.3	29.5	53.7
E04	UPPER HAZEL RIVER	2080103	94	0.27	23.4	25.0	37.4	39.9	38.1	40.6	43.6	46.5	50.1	53.5
E05	UPPER THORNTON RIVER	2080103	84	0.24	26.4	31.4	39.4	47.0	40.2	47.9	43.9	52.3	40.0	47.7
E06	LOWER THORNTON RIVER	2080103	68	0.19	7.6	11.3	19.5	28.9	20.3	30.0	26.5	39.2	41.1	60.8
E07	LOWER HAZEL RIVER/MUDDY RUN/INDIAN RUN	2080103	88	0.25	18.9	21.4	35.2	39.9	33.7	38.3	41.9	47.6	46.1	52.4
E08	RAPPAHANNOCK RIVER/MARSH RUN	2080103	116	0.33	16.4	14.2	40.6	35.1	38.4	33.2	49.6	42.9	66.1	57.1
E09	MOUNTAIN RUN	2080103	131	0.37	10.4	7.9	28.6	21.8	29.3	22.3	37.6	28.7	93.6	71.3
E10	RAPPAHANNOCK RIVER/DEEP RUN/ROCK RUN	2080103	120	0.34	54.2	45.3	77.3	64.7	80.8	67.6	85.6	71.6	33.9	28.4
E11	UPPER RAPIDAN RIVER/CONWAY RIVER	2080103	71	0.20	36.0	50.6	40.5	56.9	41.5	58.3	43.6	61.2	27.6	38.8
E12	RAPIDAN RIVER/SOUTH RIVER	2080103	63	0.18	12.6	19.9	19.7	31.2	19.7	31.2	22.5	35.5	40.7	64.5
E13	RAPIDAN RIVER/BLUE RUN/BEAUTIFUL RUN	2080103	123	0.35	11.9	9.6	32.7	26.5	30.8	25.0	41.5	33.7	81.8	66.3
E14	UPPER ROBINSON RIVER/WHITE OAK RUN	2080103	90	0.26	26.2	29.1	32.2	35.7	33.6	37.2	35.6	39.5	54.7	60.5
E15	LOWER ROBINSON RIVER/CROOKED RUN/DEEP RUN	2080103	121	0.35	16.5	13.6	31.2	25.8	31.9	26.3	38.8	32.0	82.3	68.0
E16	RAPIDAN RIVER/CEDAR RUN	2080103	70	0.20	12.0	17.2	25.5	36.4	20.2	28.8	30.1	42.9	40.0	57.1
E17	RAPIDAN RIVER/MINE RUN/MOUNTAIN RUN	2080103	157	0.45	41.4	26.4	73.5	47.0	71.4	45.6	82.9	52.9	73.7	47.1
E18	LOWER RAPIDAN RIVER	2080103	116	0.33	47.6	41.2	65.1	56.3	68.3	59.0	72.5	62.6	43.2	37.4

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			miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
E19	RAPPAHANNOCK RIVER/MOTTS RUN	2080104	78	0.22	33.9	43.4	51.9	66.5	58.0	74.3	60.6	77.6	17.5	22.4
E20	RAPPAHANNOCK RIVER/MASSAPONAX CREEK	2080104	152	0.43	53.2	35.0	88.7	58.4	87.0	57.3	99.4	65.4	52.5	34.6
E21	RAPPAHANNOCK RIVER/MILL CREEK/GOLDENVALE CREEK	2080104	372	1.06	163.7	44.0	238.5	64.1	246.2	66.2	264.3	71.0	107.8	29.0
E22	RAPPAHANNOCK RIVER/OCCUPACIA CREEK/PEEDEE CREEK	2080104	330	0.94	113.4	34.3	167.0	50.5	165.0	49.9	184.3	55.8	146.2	44.2
E23	RAPPAHANNOCK RIVER/CATPOINT CREEK/PISCATAWAY CREEK	2080104	484	1.38	235.6	48.7	309.1	63.9	313.0	64.7	328.9	68.0	154.8	32.0
E24	RAPPAHANNOCK RIVER/TOTUSKEY CREEK	2080104	174	0.50	85.1	49.0	112.2	64.6	115.2	66.3	120.6	69.5	53.0	30.5
E25	RAPPAHANNOCK RIVER/LAGRANGE CREEK/LANCASTER CREEK	2080104	298	0.85	98.9	33.2	143.2	48.0	148.8	49.9	158.4	53.2	139.6	46.8
E26	LOWER RAPPAHANNOCK RIVER/CORROTOMAN RIVER	2080104	260	0.74	81.0	25.1	123.0	38.2	139.0	43.1	152.0	47.1	107.6	52.9
F01	UPPER SOUTH ANNA RIVER	2080106	93	0.27	22.2	23.8	38.1	40.8	37.7	40.4	45.9	49.2	47.3	50.8
F02	SOUTH ANNA RIVER/ROUNDABOUT CREEK	2080106	149	0.42	62.7	42.1	89.4	60.1	93.0	62.5	98.6	66.3	50.2	33.7
F03	SOUTH ANNA RIVER/TAYLORS CREEK	2080106	280	0.80	142.1	50.7	199.3	71.2	201.0	71.8	214.7	76.7	65.3	23.3
F04	LOWER SOUTH ANNA RIVER	2080106	97	0.28	42.1	43.3	68.1	70.1	70.2	72.3	75.0	77.2	22.2	22.8
F05	NEWFOUND RIVER	2080106	61	0.17	32.9	54.0	47.9	78.6	48.4	79.4	51.6	84.7	9.3	15.3
F06	UPPER NORTH ANNA RIVER	2080106	168	0.48	52.4	31.2	75.7	45.0	79.5	47.3	85.6	51.0	82.4	49.0
F07	LAKE ANNA/PAMUNKEY CREEK	2080106	304	0.87	58.3	17.6	104.4	31.5	117.1	35.3	130.6	39.4	172.9	60.6
F08	CONTRARY CREEK	2080106	30	0.09	10.8	35.8	14.6	48.4	16.2	53.5	17.2	56.9	13.0	43.1
F09	LOWER NORTH ANNA RIVER/NORTHEAST CREEK	2080106	204	0.58	132.7	60.1	175.9	79.7	178.1	80.7	186.0	84.3	18.4	15.7
F10	UPPER LITTLE RIVER	2080106	83	0.24	36.6	43.9	55.0	66.0	56.3	67.5	59.7	71.6	23.6	28.4
F11	LOWER LITTLE RIVER	2080106	122	0.35	74.5	61.3	99.1	81.5	100.7	82.8	104.5	86.0	17.1	14.0
F12	UPPER PAMUNKEY RIVER/MECHUMPS CREEK	2080106	163	0.47	71.4	43.7	103.7	63.5	105.5	64.6	115.4	70.7	47.8	29.3
F13	MIDDLE PAMUNKEY RIVER/BLACK CREEK/TOTOPOTOMOY CREEK	2080106	411	1.17	203.0	49.3	287.2	69.8	288.5	70.1	311.1	75.6	100.3	24.4
F14	LOWER PAMUNKEY RIVER	2080106	307	0.88	68.0	22.1	101.8	33.2	108.0	35.2	117.5	38.2	189.7	61.8
F15	NI RIVER	2080105	83	0.24	45.7	55.4	61.5	74.5	63.0	76.4	66.4	80.5	16.1	19.5
F16	PO RIVER	2080105	133	0.38	81.4	61.3	102.4	77.1	105.6	79.5	108.6	81.8	24.2	18.2
F17	UPPER MATTAPONI RIVER/PONI RIVER	2080105	137	0.39	75.4	55.1	102.6	75.0	106.1	77.6	111.2	81.3	25.6	18.7
F18	MATTA RIVER	2080105	90	0.26	56.5	62.9	72.3	80.4	73.5	81.8	77.0	85.7	12.9	14.3
F19	SOUTH RIVER	2080105	93	0.26	55.0	59.3	71.6	77.3	72.1	77.8	75.5	81.5	17.2	18.5
F20	POLECAT CREEK	2080105	89	0.25	48.9	54.8	64.6	72.4	66.0	74.0	68.7	77.0	20.5	23.0
F21	MATTAPONI RIVER/HERRING CREEK/CHAPEL CREEK	2080105	305	0.87	188.8	61.8	252.7	82.8	256.6	84.1	268.1	87.8	37.2	12.2
F22	MARACOSSIC CREEK/BEVERLY RUN	2080105	248	0.71	152.3	61.5	199.4	80.5	205.1	82.8	212.8	85.9	35.0	14.1
F23	MATTAPONI RIVER/GARNETTS CREEK	2080105	204	0.58	91.8	45.0	140.0	68.6	142.0	69.5	154.0	75.4	50.1	24.6

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F24	MATTAPONI RIVER/COURTHOUSE CREEK	2080105	142	0.40	54.2	38.3	78.3	55.2	81.7	57.6	86.9	61.3	54.9	38.7
F25	LOWER MATTAPONI RIVER	2080105	103	0.29	41.9	40.5	54.5	52.7	55.6	53.8	58.4	56.5	45.0	43.5
F26	UPPER YORK RIVER/POROPOTANK RIVER/QUEEN CREEK/WARE CREEK	2080107	442	1.26	125.0	28.1	198.9	44.7	217.5	48.9	233.6	52.5	208.2	47.5
F27	LOWER YORK RIVER/CARTER CREEK/KING CREEK	2080107	182	0.52	22.6	12.4	44.4	24.5	48.8	26.9	56.5	31.1	125.1	68.9
G01	JAMES RIVER/FALLING CREEK/PROCTORS CREEK	2080206	229	0.65	43.0	18.8	102.0	44.5	96.7	42.2	119.3	52.1	109.7	47.9
G02	JAMES RIVER/TURKEY ISLAND CREEK/FOURMILE CREEK	2080206	228	0.65	55.5	24.4	89.4	39.3	93.2	41.0	103.9	45.7	123.7	54.3
G03	JAMES RIVER/POWELL CREEK/WEST RUN/BAILEY CREEK	2080206	244	0.70	80.5	33.0	118.5	48.5	124.1	50.8	132.4	54.2	111.8	45.8
G04	JAMES RIVER/WARDS CREEK/UPPER CHIPPOKES CREEK	2080206	257	0.73	77.0	30.0	113.4	44.2	120.0	46.7	128.2	49.9	128.7	50.1
G05	UPPER CHICKAHOMINY RIVER/UPHAM BROOK/STONY RUN	2080206	154	0.44	43.4	28.3	84.2	54.8	80.7	52.5	96.8	63.1	56.7	36.9
G06	CHICKAHOMINY RIVER/WHITE OAK SWAMP/BEAVERDAM CREEK	2080206	293	0.83	154.8	52.9	216.4	74.0	218.3	74.6	233.3	79.7	59.2	20.3
G07	CHICKAHOMINY RIVER/RUMLEY MARSH	2080206	175	0.50	90.4	51.6	120.1	68.6	123.7	70.7	129.4	73.9	45.7	26.1
G08	LOWER CHICKAHOMINY RIVER/MORRIS CREEK/LOWER DIASCUND CREEK	2080206	278	0.79	120.2	22.0	221.6	40.5	233.9	42.7	274.6	50.2	3.1	49.8
G09	UPPER DIASCUND CREEK/DIASCUND CREEK RESERVOIR	2080206	91	0.26	37.9	41.6	52.3	57.5	55.4	60.9	59.1	64.9	31.9	35.1
G10	JAMES RIVER/POWHATAN CREEK/GRAYS CREEK	2080206	286	0.82	102.2	28.3	168.8	46.8	174.4	48.3	193.6	53.6	92.4	46.4
G11	JAMES RIVER/PAGEN RIVER/WARWICK RIVER/CHUCKATUCK CREEK	2080206	650	1.85	76.5	11.8	181.8	28.0	188.7	29.0	230.4	35.5	419.5	64.5
G12	SPEIGHTS RUN/LAKE COHOON/LAKE MEADE/LAKE KILBY	2080208	82	0.23	11.5	9.5	28.6	23.6	30.1	24.9	36.0	29.7	46.0	70.3
G13	NANSEMOND RIVER/BENNETT CREEK	2080208	254	0.72	25.1	9.9	50.6	19.9	48.6	19.1	62.6	24.6	191.5	75.4
G14	WESTERN BRANCH RESERVOIR	2080208	90	0.26	16.6	10.3	42.6	26.6	45.0	28.1	55.6	34.7	34.4	65.3
G15	HAMPTON ROADS/ELIZABETH RIVER	2080208	489	1.39	11.5	2.4	33.0	6.7	34.2	7.0	45.7	9.4	443.2	90.6
H01	JAMES RIVER/REED CREEK	2080203	189	0.54	92.0	48.8	109.4	58.0	112.8	59.8	116.5	61.8	72.1	38.2
H02	PEDLAR RIVER	2080203	177	0.51	111.0	62.6	132.7	74.8	136.4	76.9	140.5	79.2	37.0	20.8
H03	JAMES RIVER/BLACKWATER CREEK/IVY CREEK	2080203	220	0.63	59.4	27.0	102.7	46.7	104.4	47.5	116.9	53.2	103.0	46.8
H04	HARRIS CREEK	2080203	87	0.25	34.4	39.3	52.9	60.6	55.2	63.2	60.5	69.2	26.9	30.8
H05	JAMES RIVER/BEAVER CREEK/BECK CREEK	2080203	303	0.86	114.8	38.0	180.9	59.8	188.5	62.3	201.4	66.6	101.1	33.4
H06	WRECK ISLAND CREEK	2080203	90	0.26	32.0	35.5	55.1	61.2	54.3	60.2	62.2	69.0	27.9	31.0
H07	BENT CREEK	2080203	43	0.12	20.9	48.5	29.0	67.5	30.5	71.0	33.1	76.9	9.9	23.1
H08	JAMES RIVER/DAVID CREEK	2080203	123	0.35	58.8	47.7	83.4	67.7	86.4	70.1	91.7	74.4	31.6	25.6
H09	UPPER TYE RIVER	2080203	210	0.60	90.9	43.2	127.6	60.7	132.6	63.1	142.4	67.7	67.8	32.3
H10	PINEY RIVER	2080203	115	0.33	54.1	47.0	72.4	62.9	72.8	63.3	79.0	68.6	36.1	31.4
H11	UPPER BUFFALO RIVER	2080203	155	0.44	50.0	32.3	79.7	51.5	84.7	54.7	92.9	60.0	62.0	40.0
H12	LOWER BUFFALO RIVER	2080203	95	0.27	41.5	43.8	66.3	69.9	68.0	71.7	73.2	77.2	21.6	22.8
H13	LOWER TYE RIVER/RUCKER RUN	2080203	97	0.28	35.4	36.6	52.6	54.3	54.9	56.7	60.5	62.5	36.3	37.5

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H14	JAMES RIVER/SYCAMORE CREEK	2080203	136	0.39	62.1	45.5	85.1	62.4	88.7	65.1	96.2	70.6	40.2	29.4
H15	NORTH FORK ROCKFISH RIVER/SOUTH FORK ROCKFISH RIVER	2080203	152	0.43	64.8	42.6	90.6	59.6	91.6	60.2	100.2	65.8	52.0	34.2
H16	LOWER ROCKFISH RIVER	2080203	253	0.72	120.7	47.8	159.6	63.2	168.5	66.7	177.3	70.1	75.4	29.9
H17	JAMES RIVER/TOTIER CREEK/ROCK ISLAND CREEK	2080203	188	0.53	65.6	35.0	102.4	54.6	106.0	56.5	117.4	62.6	70.2	37.4
H18	NORTH FORK HARDWARE RIVER/SOUTH FORK HARDWARE RIVER	2080203	107	0.31	33.9	31.5	52.5	48.9	55.4	51.6	61.4	57.1	46.1	42.9
H19	HARDWARE RIVER	2080203	91	0.26	25.7	28.3	47.8	52.7	50.1	55.3	55.7	61.4	35.0	38.6
H20	JAMES RIVER/BEAR GARDEN CREEK/SOUTH CREEK	2080203	159	0.45	52.0	32.7	80.9	50.8	83.4	52.4	94.0	59.0	65.2	41.0
H21	UPPER SLATE RIVER	2080203	241	0.69	137.6	57.0	189.5	78.5	192.8	79.9	203.6	84.3	37.8	15.7
H22	LOWER SLATE RIVER	2080203	126	0.36	45.8	36.4	72.9	57.8	73.7	58.5	81.6	64.8	44.3	35.2
H23	MECHUMS RIVER	2080204	136	0.39	35.7	26.3	67.4	49.8	68.2	50.3	80.0	59.0	55.5	41.0
H24	MOORMANS RIVER	2080204	76	0.22	37.5	49.1	51.6	67.6	51.1	66.9	56.3	73.7	20.1	26.3
H25	BUCK MOUNTAIN CREEK	2080204	38	0.11	10.0	26.5	15.5	41.2	16.0	42.6	18.1	48.1	19.5	51.9
H26	SOUTH FORK RIVANNA RIVER/IVY CREEK	2080204	71	0.20	14.5	20.3	30.9	43.3	33.4	46.7	38.5	53.9	32.9	46.1
H27	NORTH FORK RIVANNA RIVER/SWIFT RUN/PREDDY CREEK	2080204	198	0.56	40.6	20.6	70.9	35.8	76.3	38.6	85.7	43.3	112.1	56.7
H28	UPPER RIVANNA RIVER/MOORES CREEK	2080204	70	0.20	16.3	23.2	28.4	40.3	27.7	39.2	33.0	46.9	37.4	53.1
H29	MIDDLE RIVANNA RIVER/BUCK ISLAND CREEK	2080204	115	0.33	31.4	27.2	51.0	44.3	53.0	46.0	60.9	52.8	54.3	47.2
H30	MECHUNK CREEK	2080204	87	0.25	19.2	22.0	37.5	43.0	37.6	43.2	44.8	51.5	42.3	48.5
H31	LOWER RIVANNA RIVER/BALLINGER CREEK	2080204	153	0.44	46.2	30.2	76.9	50.3	79.6	52.0	89.3	58.4	63.7	41.6
H32	CUNNINGHAM CREEK	2080204	56	0.16	21.0	37.5	32.6	58.4	33.7	60.3	36.5	65.4	19.3	34.6
H33	JAMES RIVER/DEEP CREEK/MUDDY CREEK	2080205	286	0.82	89.0	31.1	145.3	50.8	155.1	54.2	170.4	59.5	116.0	40.5
H34	BYRD CREEK	2080205	165	0.47	60.6	36.6	98.0	59.2	101.2	61.2	110.1	66.5	55.4	33.5
H35	UPPER WILLIS RIVER	2080205	178	0.51	78.7	44.2	116.3	65.4	118.9	66.8	129.5	72.8	48.5	27.2
H36	LOWER WILLIS RIVER	2080205	269	0.77	118.2	44.0	179.8	66.9	183.5	68.3	198.3	73.8	70.3	26.2
H37	BIG LICKINGHOLE CREEK	2080205	110	0.31	37.9	34.4	63.0	57.2	64.3	58.4	72.4	65.8	37.6	34.2
H38	JAMES RIVER/BEAVERDAM CREEK/FINE CREEK	2080205	166	0.47	49.1	29.5	83.2	50.0	87.8	52.8	98.1	59.0	68.2	41.0
H39	JAMES RIVER/TUCKAHOE CREEK/NORWOOD CREEK	2080205	350	1.00	102.3	29.2	171.8	49.0	172.4	49.2	199.4	56.9	151.0	43.1
I01	UPPER JACKSON RIVER	2080201	110	0.31	27.5	25.0	45.5	41.3	46.7	42.4	52.5	47.7	57.5	52.3
I02	BACK CREEK	2080201	116	0.33	39.0	33.7	51.9	44.9	54.4	47.1	57.3	49.6	58.2	50.4
I03	LAKE MOOMAW/HUGHES DRAFT	2080201	72	0.20	26.2	36.5	34.3	47.9	36.6	51.1	38.4	53.6	33.3	46.4
I04	JACKSON RIVER/FALLING SPRING CREEK	2080201	111	0.32	55.1	49.7	66.1	59.6	68.4	61.7	72.9	65.8	37.9	34.2
I05	CEDAR CREEK	2080201	44	0.13	24.1	54.8	29.9	68.0	31.4	71.3	32.2	73.3	11.8	26.7
I06	COVE CREEK/SWEET SPRINGS CREEK	2080201	16	0.05	5.5	34.2	7.0	43.6	6.9	43.0	7.7	47.6	8.4	52.4

Table 9. Riparian forest buffer statistics for 11-digit hydrologic units in Virginia.

ID	Watershed	HUC code	Stream Length		Both 300'+		Both 100'-300'		One side 300'+		One side 100'-300'		Both sides < 100	
			miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
I07	DUNLAP CREEK	2080201	144	0.41	85.6	59.3	102.6	71.1	105.1	72.9	109.8	76.1	34.5	23.9
I08	OGLE CREEK	2080201	70	0.20	31.2	44.5	38.5	54.8	40.6	58.0	42.2	60.2	27.9	39.8
I09	LOWER JACKSON RIVER/WILSON CREEK/KARNES CREEK	2080201	166	0.47	102.7	61.8	120.6	72.6	122.3	73.6	127.2	76.6	38.9	23.4
I10	UPPER POTTS CREEK	2080201	115	0.33	77.3	67.1	89.8	78.0	91.4	79.4	95.3	82.7	19.9	17.3
I11	LOWER POTTS CREEK	2080201	124	0.35	74.3	60.0	92.0	74.4	93.1	75.2	99.6	80.4	24.2	19.6
I12	UPPER COWPASTURE RIVER	2080201	67	0.19	29.3	43.7	39.5	59.0	41.6	62.1	44.5	66.5	22.4	33.5
I13	BULLPASTURE RIVER	2080201	82	0.23	17.9	21.9	27.8	34.1	28.6	35.0	32.3	39.5	49.4	60.5
I14	COWPASTURE RIVER/THOMPSON CREEK/DRY RUN	2080201	77	0.22	32.4	42.1	50.8	66.0	51.4	66.8	55.9	72.5	21.1	27.5
I15	STUART RUN	2080201	52	0.15	21.1	41.0	33.1	64.3	35.1	68.1	37.7	73.1	13.9	26.9
I16	COWPASTURE RIVER/MILL CREEK	2080201	83	0.24	48.7	58.7	60.8	73.3	62.7	75.6	65.1	78.6	17.8	21.4
I17	LOWER COWPASTURE RIVER/SIMPSON CREEK/PADS CREEK	2080201	121	0.34	81.5	67.6	96.7	80.2	98.3	81.5	100.5	83.3	20.1	16.7
I18	UPPER JAMES RIVER/SINKING CREEK/MILL CREEK	2080201	156	0.44	76.1	48.9	99.9	64.1	102.4	65.7	107.9	69.2	47.9	30.8
I19	UPPER CRAIG CREEK	2080201	180	0.51	124.0	69.0	141.1	78.5	142.9	79.5	147.5	82.1	32.2	17.9
I20	MEADOW CREEK	2080201	12	0.04	1.9	15.0	3.3	26.6	3.6	28.9	3.9	31.3	8.5	68.7
I21	JOHNS CREEK	2080201	193	0.55	121.9	63.0	146.4	75.7	149.2	77.2	155.5	80.4	37.9	19.6
I22	LOWER CRAIG CREEK/PATTERSON CREEK/LOWER BARBOURS CREEK	2080201	207	0.59	119.2	57.5	158.2	76.3	159.8	77.1	171.2	82.6	36.1	17.4
I23	UPPER BARBOURS CREEK	2080201	50	0.14	42.2	83.7	45.5	90.4	46.0	91.4	46.5	92.3	3.9	7.7
I24	JAMES RIVER/LAPSLEY RUN	2080201	118	0.34	27.3	23.1	48.4	41.0	51.5	43.6	58.6	49.6	59.4	50.4
I25	CATAWBA CREEK	2080201	192	0.55	61.7	32.2	87.4	45.6	90.8	47.4	98.7	51.5	92.9	48.5
I26	LOONEY CREEK/MILL CREEK	2080201	116	0.33	20.4	17.5	33.4	28.7	34.7	29.8	39.8	34.2	76.6	65.8
I27	JAMES RIVER/JENNINGS CREEK	2080201	130	0.37	60.3	46.3	73.3	56.3	73.5	56.4	77.5	59.5	52.8	40.5
I28	JAMES RIVER/ELK CREEK/CEDAR CREEK	2080201	106	0.30	51.7	48.8	67.9	64.1	69.4	65.6	73.7	69.6	32.2	30.4
I29	UPPER CALFPASTURE RIVER	2080202	83	0.24	52.9	64.0	64.1	77.5	65.7	79.4	67.7	81.9	15.0	18.1
I30	LOWER CALFPASTURE RIVER/MILL CREEK	2080202	129	0.37	57.0	44.3	82.8	64.4	83.8	65.2	92.1	71.7	36.4	28.3
I31	BRATTONS RUN	2080202	43	0.12	31.4	72.3	37.6	86.5	37.8	87.1	38.7	89.0	4.8	11.0
I32	LITTLE CALFPASTURE RIVER	2080202	80	0.23	27.6	34.3	44.7	55.6	44.0	54.7	49.9	62.1	30.5	37.9
I33	UPPER MAURY RIVER/KERRS CREEK	2080202	133	0.38	37.8	28.4	58.6	43.9	59.9	44.9	67.2	50.4	66.3	49.6
I34	HAYS CREEK	2080202	91	0.26	17.5	19.3	31.1	34.3	31.4	34.5	36.7	40.4	54.1	59.6
I35	MIDDLE MAURY RIVER/MILL CREEK	2080202	66	0.19	9.4	14.2	20.5	30.9	19.6	29.5	25.6	38.6	40.7	61.4
I36	SOUTH RIVER	2080202	153	0.44	77.6	50.7	94.7	61.8	96.9	63.3	101.9	66.5	51.2	33.5
I37	LOWER MAURY RIVER/POAGUE RUN	2080202	98	0.28	40.2	41.0	48.9	49.8	48.8	49.7	53.0	54.0	45.2	46.0
I38	BUFFALO CREEK	2080202	174	0.50	51.4	29.5	93.2	53.5	95.7	54.9	105.9	60.8	68.2	39.2

Table 9. Riparian forest buffer statistics for 11-digit hydrologic units in Virginia.

ID	Watershed	HUC code	Stream Length		Both 300'+		Both 100'-300'		One side 300'+		One side 100'-300'		Both sides < 100'	
			miles	%	miles	%	miles	%	miles	%	miles	%	miles	%
J01	UPPER APPOMATTOX RIVER	2080207	314	0.90	144.4	46.0	222.2	70.7	225.9	71.9	244.6	77.8	69.6	22.2
J02	BUFFALO CREEK/SPRING CREEK	2080207	184	0.52	81.5	44.3	118.2	64.3	123.4	67.1	130.8	71.1	53.2	28.9
J03	SANDY RIVER	2080207	65	0.19	29.2	44.9	43.9	67.5	44.4	68.2	47.8	73.5	17.2	26.5
J04	BUSH RIVER	2080207	98	0.28	47.4	48.4	68.6	70.0	70.1	71.5	73.7	75.3	24.2	24.7
J05	BRIERY CREEK	2080207	67	0.19	18.8	28.2	31.4	47.1	32.4	48.5	35.6	53.3	31.2	46.7
J06	APPOMATTOX RIVER/BIG GUINEA CREEK/SAYLERS CREEK	2080207	249	0.71	101.6	40.8	165.5	66.4	168.7	67.7	183.5	73.7	65.6	26.3
J07	APPOMATTOX RIVER/SKINQUARTER CREEK/ROCKY FORD CREEK	2080207	174	0.50	81.7	46.8	122.5	70.2	124.7	71.5	134.1	76.9	40.4	23.1
J08	FLAT CREEK	2080207	178	0.51	79.3	44.7	122.0	68.7	123.2	69.4	134.3	75.6	43.3	24.4
J09	NIBBS CREEK	2080207	35	0.10	10.8	30.4	21.4	60.4	21.6	61.1	25.4	72.0	9.9	28.0
J10	APPOMATTOX RIVER/SMACKS CREEK/SAPPONY CREEK	2080207	85	0.24	46.8	54.9	61.3	71.9	63.8	74.8	66.7	78.2	18.6	21.8
J11	DEEP CREEK	2080207	316	0.90	147.2	46.6	214.2	67.8	219.2	69.4	233.5	73.9	82.4	26.1
J12	LAKE CHESDIN/WINTERPOCK CREEK/WINTICOMACK CREEK	2080207	129	0.37	73.4	57.1	95.3	74.1	98.6	76.7	102.8	79.9	25.8	20.1
J13	NAMOZINE CREEK	2080207	92	0.26	57.2	61.8	71.4	77.3	72.6	78.5	75.2	81.4	17.2	18.6
J14	LAKE CHESDIN/WHIPPONOCK CREEK	2080207	75	0.21	16.9	22.7	33.3	44.7	38.2	51.3	42.4	56.9	32.1	43.1
J15	LOWER APPOMATTOX RIVER/ASHTON CREEK	2080207	160	0.46	31.0	19.4	64.2	40.1	64.0	40.0	74.9	46.8	85.3	53.2
J16	UPPER SWIFT CREEK/SWIFT CREEK RESERVOIR	2080207	102	0.29	55.0	54.0	70.7	69.5	72.9	71.7	75.8	74.5	25.9	25.5
J17	LOWER SWIFT CREEK	2080207	183	0.52	93.2	50.9	129.0	70.5	133.2	72.8	139.1	76.0	43.8	24.0
K15	LITTLE NOTTOWAY RIVER	3010201	1	0.00	0.0	3.2	0.2	25.4	0.3	30.8	0.3	36.1	0.6	63.9

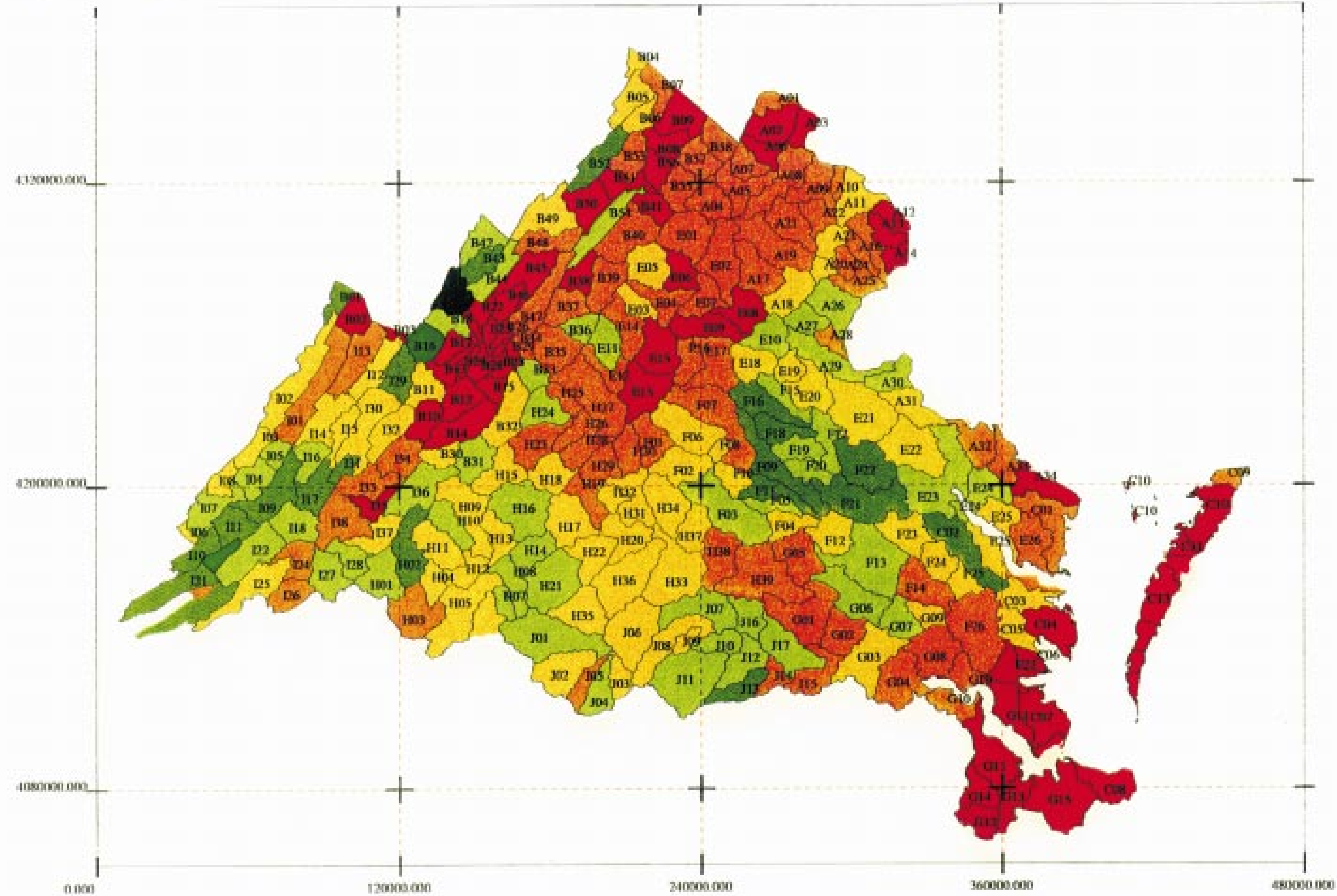


Figure 22

Percentage of streams buffered 300 ft or more on
both sides in 11 digit watersheds of Virginia
Projection UTM, Zone 18

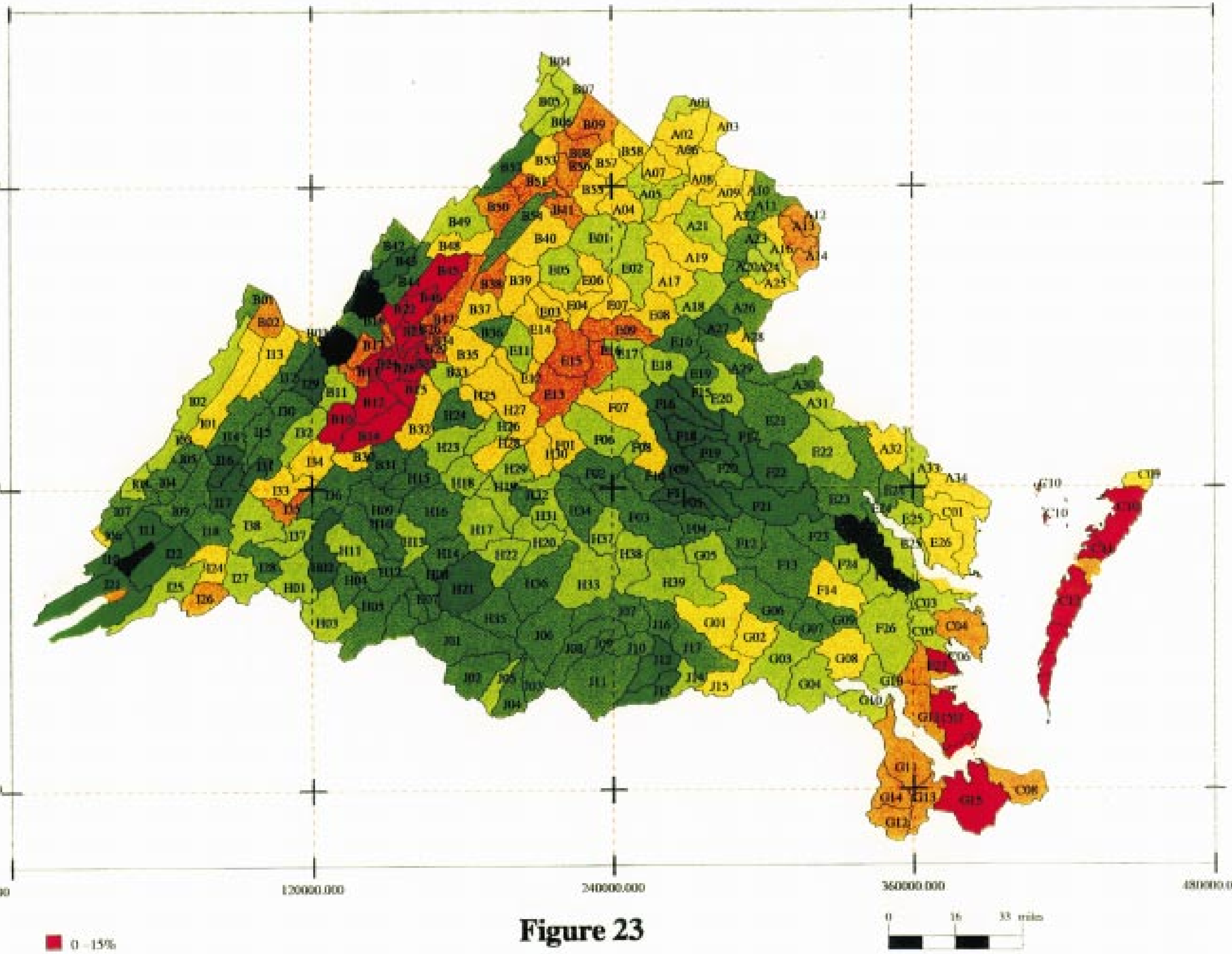


Figure 23

- 0 -15%
- 15 -30%
- 30 -45%
- 45 -60%
- 60 -75%
- 75 -90%
- 90 -100%

Percentage of streams buffered 300 ft or more on one side only in 11 digit watersheds of Virginia
Projection UTM, Zone 18

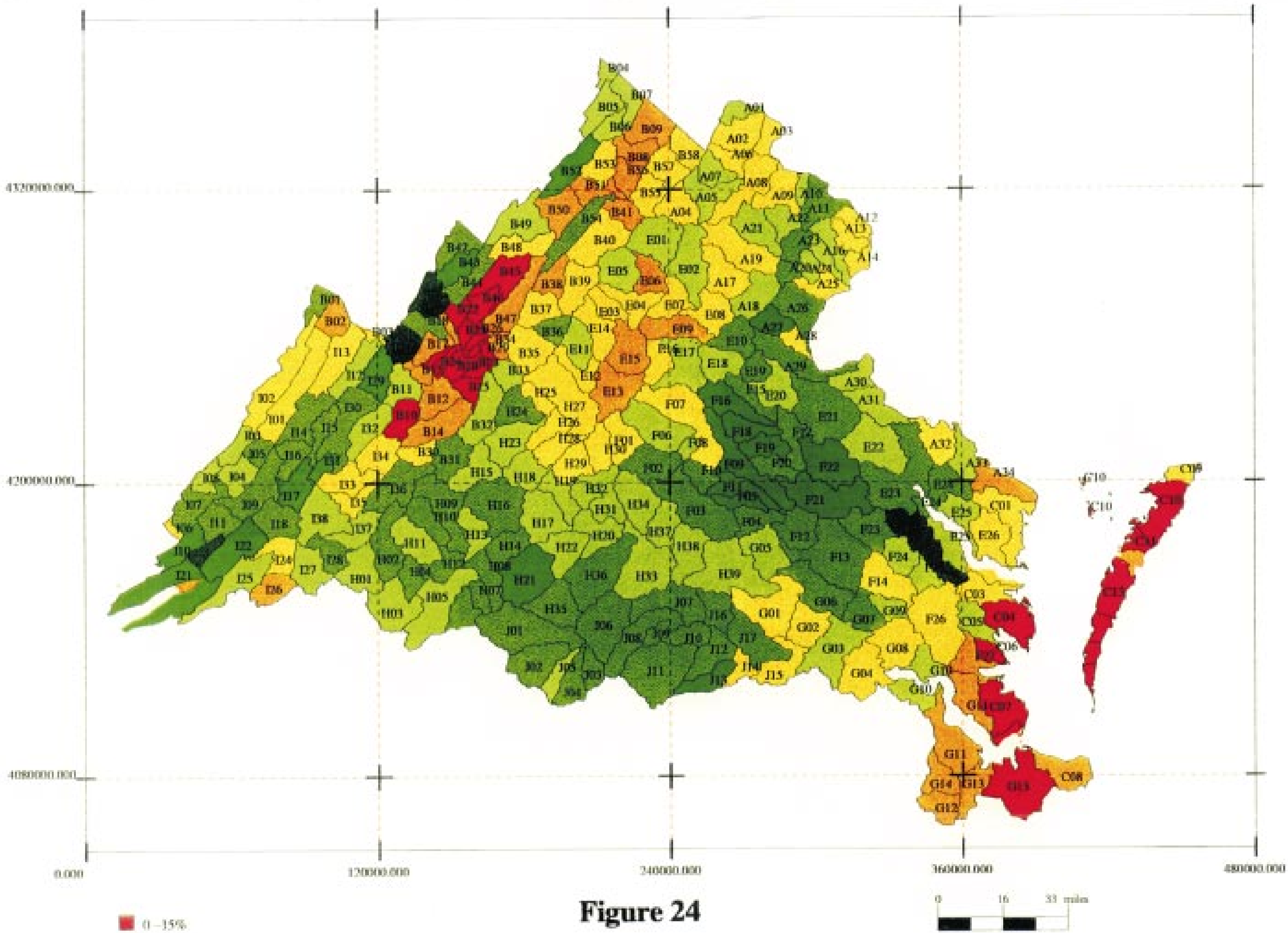
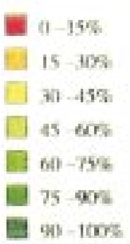


Figure 24



Percentage of streams buffered 100 ft or more on both sides in 11 digit watersheds of Virginia
Projection UTM, Zone 18

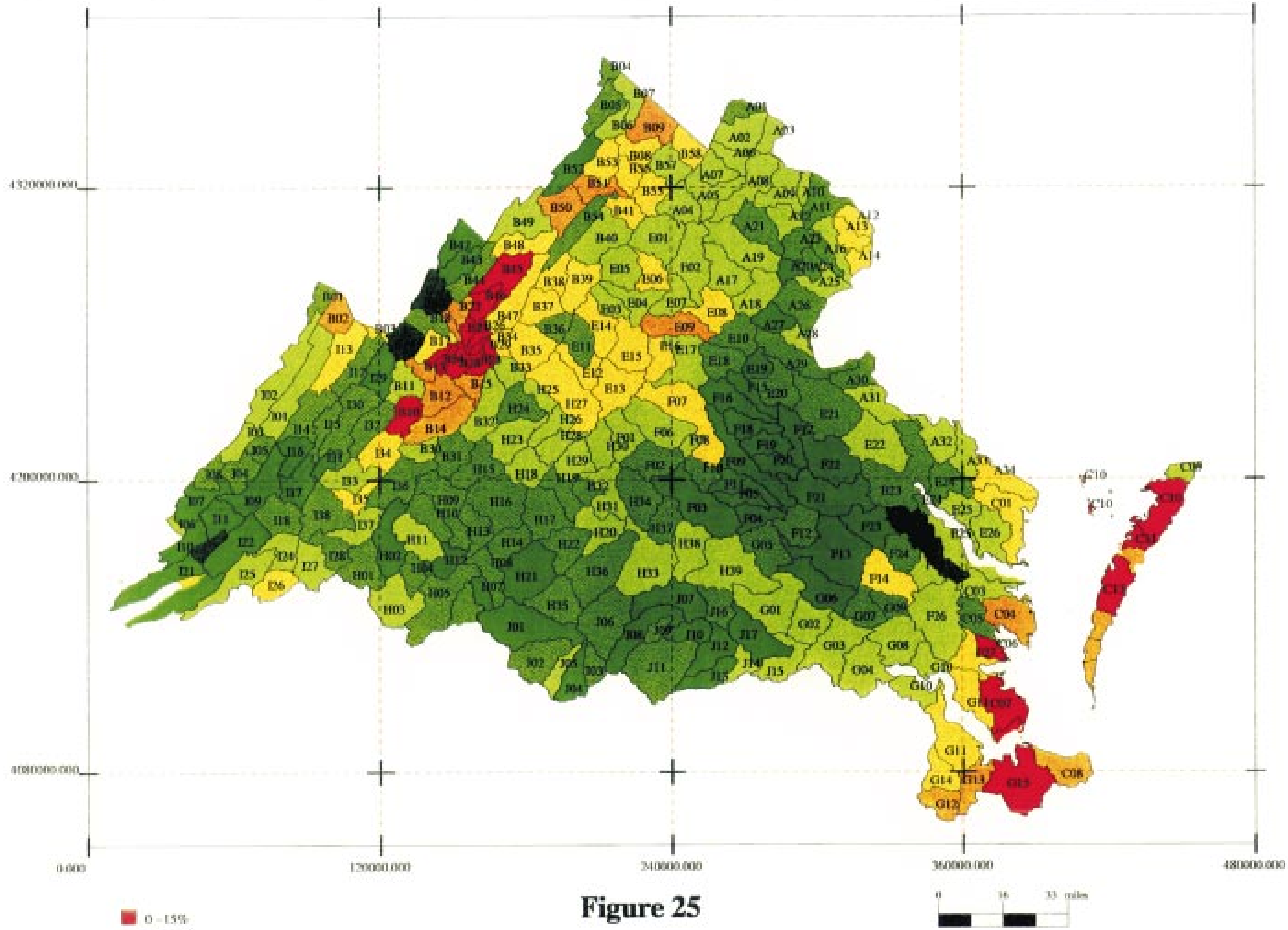


Figure 25

Percentage of streams buffered 100 ft or more on one side only in 11 digit watersheds of Virginia
Projection UTM, Zone 18

APPENDIX 7

Native Plant Guide for

Planting Along Streams and Ponds

NATIVE PLANT GUIDE FOR PLANTING ALONG STREAMS AND PONDS

PLANT NAME	HARDINESS ZONE	FORM	AVAILABLE	INUNDATION TOLERANCE	WILDLIFE VALUE	NOTES
<u>Trees and Shrubs</u>						
American beech ***Fagus grandifolia***	**5,6**	**deciduous tree**	**no**	**no**	**high; mammals and birds**	**prefers shade; rich, well-drained soils**
American holly ***Ilex opaca***	**5,6**	**persistent tree**	**yes**	**limited**	**high; songbirds-food, cover, nesting**	**Coastal Plain; prefers shade and rich soils**
American hornbeam ***Carpinus caroliniana***	**4,5**	**deciduous tree**	**yes**	**limited**	**moderate; food, browse**	**common in flood plains and bottomlands of Piedmont and mountains**
Arrowwood ***Viburnum dentatum***	**3,4**	**deciduous shrub**	**yes**	**yes**	**high; songbirds and mammals**	**grows best in sun to partial shade**
Baldcypress ***Taxodium distichum***	**3,4**	**deciduous tree**	**yes**	**yes**	**little food value; perching site for waterfowl**	**forested Coastal Plain wetlands; north of normal range; tolerates drought**
Bayberry ***Myrica pensylvanica***	**4,5,6**	**deciduous shrub**	**yes**	**yes**	**high; nesting, food, cover; persistent berries**	**Coastal Plain only; roots fix N and tolerate slightly acidic soil**
Butternut hickory ***Carya cordiformis***	**4,5,6**	**deciduous tree**	**no**	**no**	**high; food**	**moist soils or wet bottomlands**
Black cherry ***Prunus serotina***	**5,6**	**deciduous tree**	**yes**	**no**	**high; fruit is eaten by many birds**	**temporarily flooded forests; possible fungus infestation**
Black walnut ***Juglans nigra***	**5,6**	**deciduous tree**	**yes**	**limited**	**high; food**	**temporarily flooded flood plains and wetlands; well-drained, deep soils**
Blackgum ***Nyssa sylvatica***	**4,5,6**	**deciduous tree**	**yes**	**yes**	**high; songbirds, egrets, herons, raccoons, owls**	**difficult to transplant; prefers sun to partial shade**
Black willow ***Salix nigra***	**3,4,5**	**deciduous tree**	**yes**	**yes**	**high; browse and cavities**	**rapid growth; stabilizes streambanks; full sun**
Buttonbush ***Cephalanthus occidentalis***	**2,3,4,5**	**deciduous shrub**	**yes**	**yes**	**high; ducks and shorebirds; seeds, nectar, and nesting**	**full sun to partial shade; will grow in dry areas**
Chestnut oak ***Quercus prinus***	**5,6**	**deciduous tree**	**no**	**no**	**high; cover, browse, food**	**gypsy moth target; dry soils**

PLANT NAME	HARDINESS ZONE	FORM	AVAILABLE	INUNDATION TOLERANCE	WILDLIFE VALUE	NOTES
Common chokecherry ***Prunus virginiana***	**5,6**	**deciduous tree**	**no**	**no**	**high; birds, mammals; food and cover**	**prefers dry sites**
Common spicebush ***Lindera benzoin***	**3,4,5**	**deciduous shrub**	**yes**	**yes**	**very high; songbirds**	**shade and rich soils; tolerates acidic soils; good understory species**
Eastern cottonwood ***Populus deltoides***	**4,5**	**deciduous tree**	**yes**	**yes**	**moderate; cover and food**	**shallow rooted; subject to windthrow; invasive roots; rapid growth**
Eastern hemlock ***Tsuga canadensis***	**5,6**	**coniferous tree**	**yes**	**yes**	**moderate; cover and some food**	**tolerates all light conditions; tolerates acidic soil**
Eastern hophornbeam ***Ostrya virginiana***	**5,6**	**deciduous tree**	**yes**	**limited**	**moderate; food and browse**	**tolerates all light conditions**
Eastern larch ***Larix laricina***	**3,4**	**deciduous tree**	**no**	**yes**	**low; nest tree and seeds**	**rapid initial growth; full sun; acidic bogs**
Eastern redcedar ***Juniperus virginiana***	**4,5,6**	**coniferous tree**	**yes**	**no**	**high; food for birds, some cover**	**full sun to partial shade; common in wetlands, shrub bogs, riparian areas**
Elderberry ***Sambucus canadensis***	**3,4,5,6**	**deciduous shrub**	**yes**	**yes**	**extremely high; food and cover for birds and mammals**	**full sun to partial shade**
Flowering dogwood ***Cornus florida***	**6**	**deciduous tree**	**yes**	**no**	**high; bird food**	**prefers rich, moist soil; dogwood anthracnose a problem**
Fringetree ***Chionanthus virginicus***	**3,4,5**	**deciduous shrub or small tree**	**yes**	**limited**	**moderate; food and cover**	**full sun to partial shade; tolerates acidic soil**
Green ash ***Fraxinus pennsylvanica***	**4,5**	**deciduous tree**	**yes**	**yes**	**moderate; songbirds**	**rapid growing; streambank stabilizer; full sun to partial shade**
Hackberry ***Celtis occidentalis***	**5,6**	**deciduous tree**	**yes**	**limited**	**high; food and cover**	**full sun to partial shade**
Hazel alder ***Alnus serrulata***	**3,4,5**	**deciduous tree**	**no**	**yes**	**high; food and cover**	**rapid growth; stabilizes streambanks**
Loblolly pine ***Pinus taeda***	**5,6**	**coniferous tree**	**yes**	**limited**	**moderate; food, nesting for squirrels**	**Coastal Plain mainly; tolerant of extreme soil conditions**

PLANT NAME	HARDINESS ZONE	FORM	AVAILABLE	INUNDATION TOLERANCE	WILDLIFE VALUE	NOTES
Mountain-laurel ***Kalmia latifolia***	**6**	**evergreen shrub**	**no**	**no**	**low; cover and nectar; foliage is toxic to deer**	**partial shade; acidic soils**
Pin oak ***Quercus palustris***	**3,4,5,6**	**deciduous tree**	**yes**	**yes**	**high; mast**	**gypsy moth target; tolerates acidic soil; prefers sun to partial shade**
Red chokeberry ***Aronia arbutifolia***	**3,4,5**	**deciduous shrub**	**no**	**yes**	**moderate; songbirds**	**bank stabilizer; partial sun**
Red maple ***Acer rubrum***	**3,4,5,6**	**deciduous tree**	**yes**	**yes**	**high; seeds and browse**	**rapid growth; tolerates acidic soil**
Red oak ***Quercus rubra***	**5,6**	**deciduous tree**	**yes**	**no**	**high; food and cover**	**gypsy moth target; prefers well-drained, sandy soil**
River birch ***Betula nigra***	**3,4,5**	**deciduous tree**	**yes**	**yes**	**low; but good cavities**	**bank erosion control; full sun**
Scarlet oak ***Quercus coccinea***	**5,6**	**deciduous tree**	**yes**	**no**	**high; food and cover**	**gypsy moth target; difficult to transplant**
Serviceberry ***Amelanchier arborea***	**4,5,6**	**deciduous tree**	**yes**	**yes**	**high; nesting, cover and food for birds and mammals**	**prefers partial shade; common in forested wetlands and uplands**
Silky dogwood ***Cornus amomum***	**3,4,5**	**deciduous shrub**	**yes**	**yes**	**high; songbirds and mammals**	**shade and drought tolerant; good bank stabilizer**
Sourwood ***Oxydendrum arboreum***	**5,6**	**deciduous tree**	**yes**	**no**	**moderate; food**	**ornamental**
Swamp white oak ***Quercus bicolor***	**3,4,5**	**deciduous tree**	**yes**	**yes**	**high; mast**	**full sun to partial shade; good bottomland tree**
Sweetgum ***Liquidambar styraciflua***	**4,5,6**	**deciduous tree**	**yes**	**yes**	**moderate; songbirds**	**tolerates acidic or clay soils; sun to partial shade**
Sycamore ***Platanus occidentalis***	**4,5,6**	**deciduous tree**	**yes**	**yes**	**low; food, cavities for nesting**	**rapid growth; common in flood plains and alluvial forest**
White ash ***Fraxinus americana***	**5,6**	**deciduous tree**	**yes**	**no**	**high; food**	**all light conditions; well-drained soils**
White oak ***Quercus alba***	**5,6**	**deciduous tree**	**yes**	**limited**	**high; food and cover**	**gypsy moth target; prefers well-drained soils**
Willow oak ***Quercus phellos***	**4,5,6**	**deciduous tree**	**yes**	**yes**	**high; mast**	**full sun to partial shade; common in temporarily flooded forested wetlands**

PLANT NAME	HARDINESS ZONE	FORM	AVAILABLE	INUNDATION TOLERANCE	WILDLIFE VALUE	NOTES
Winterberry ***Ilex verticillata***	**3,4,5**	**deciduous shrub**	**yes**	**yes**	**high; cover and fruit for birds; holds berries into winter**	**full sun to partial shade; seasonally flooded areas**
Witch-hazel ***Hamamelis virginiana***	**4,5**	**deciduous shrub**	**yes**	**no**	**low; food for squirrels, deer, and ruffed grouse**	**prefers shade**
Yellow-poplar ***Liriodendron tulipifera***	**5,6**	**deciduous tree**	**yes**	**no**	**moderate; seeds and nest sites**	**full sun to partial shade; well-drained soils; rapid growth**
<u>Wetland Plants</u>						
Arrow arum ***Peltandra virginica***	**2,3**	**emergent**	**yes**	**up to 1 foot**	**high; berries are eaten by wood ducks**	**full sun to partial shade**
Arrowhead/Duck potato ***Saggitaria latifolia***	**2,3**	**emergent**	**yes**	**up to 1 foot**	**moderate; tubers and seeds eaten by ducks**	**aggressive colonizer**
Broomsedge ***Andropogon virginicus***	**2,3**	**emergent**	**yes**	**up to 3 inches**	**high; songbirds and browsers; winter food and cover**	**tolerant of fluctuating water levels and partial shade**
Bushy beardgrass ***Andropogon glomeratus***	**2,3**	**emergent**	**yes**	**up to 1 foot**	**unknown**	**requires full sun**
Cattail ***Typha spp.***	**2,3**	**emergent**	**yes**	**up to 1 foot**	**low; except as cover**	**aggressive; may eliminate other species; volunteer; high pollutant treatment**
Coontail ***Ceratophyllum demersum***	**1**	**submergent**	**no**	**yes**	**low food value; good habitat and shelter for fish and invertebrates**	**free floating; shade tolerant; rapid growth**
Common three-square ***Scirpus pungens***	**2**	**emergent**	**yes**	**up to 6 inches**	**high; seeds, cover for waterfowl and songbirds; high metal removal**	**fast colonizer; can tolerate periods of dryness; full sun**
Duckweed ***Lemna spp.***	**1,2**	**submergent/ emergent**	**yes**	**yes**	**high; food for waterfowl and fish**	**high metal removal**
Lizard's tail ***Saururus cernuus***	**2**	**emergent**	**yes**	**up to 1 foot**	**low; except wood ducks**	**rapid growth; shade tolerant**

PLANT NAME	HARDINESS ZONE	FORM	AVAILABLE	INUNDATION TOLERANCE	WILDLIFE VALUE	NOTES
Marsh hibiscus ***Hibiscus moscheutos***	**2,3**	**emergent**	**yes**	**up to 3 inches**	**low; nectar**	**full sun; can tolerate periodic dryness**
Pickerelweed ***Pontederia cordata***	**2,3**	**emergent**	**yes**	**up to 1 foot**	**moderate; ducks; nectar for butterflies**	**full sun to partial shade**
Pond weed ***Potamogeton pectinatus***	**1**	**submergent**	**yes**	**yes**	**extremely high; waterfowl, marsh and shorebirds**	**removes heavy metals**
Rice cutgrass ***Leersia oryzoides***	**2,3**	**emergent**	**yes**	**up to 3 inches**	**high; food and cover**	**full sun to partial shade; shoreline stabilization**
Sedges ***Carex spp.***	**2,3,4**	**emergent**	**yes**	**up to 3 inches**	**high; waterfowl, songbirds**	**many wetland and upland species**
Soft-stem bulrush ***Scirpus validus***	**2,3**	**emergent**	**yes**	**up to 1 foot**	**moderate; good cover and food**	**fun sun; aggressive colonizer; high pollutant removal**
Smartweed ***Polygonum spp.***	**2,3,4**	**emergent**	**yes**	**up to 1 foot**	**high; waterfowl, songbirds; seeds and cover**	**fast colonizer; avoid weedy aliens such as *P. perfoliatum***
Soft rush ***Juncus effusus***	**2,3,4**	**emergent**	**yes**	**up to 3 inches**	**moderate**	**tolerates wet or dry conditions**
Spatterdock ***Nuphar luteum***	**2**	**emergent**	**yes**	**up to 3 feet**	**moderate for food; high for cover**	**fast colonizer; tolerant of fluctuating water levels**
Switchgrass ***Panicum virgatum***	**2,3,4,5,6**	**perimeter**	**yes**	**up to 3 inches**	**high; seeds, cover for waterfowl and songbirds**	**tolerates wet/dry conditions**
Sweet flag ***Acorus calamus***	**2,3**	**perimeter**	**yes**	**up to 3 inches**	**low**	**drought tolerant; not a rapid colonizer; tolerates acidic conditions**
Waterweed ***Elodea canadensis***	**1**	**submergent**	**yes**	**yes**	**low**	**good water oxygenator; high nutrient, copper, manganese, and chromium removal**
Wild celery ***Valisneria americana***	**1**	**submergent**	**yes**	**yes**	**high; food for waterfowl**	**tolerant of murky water and high nutrient loads; habitat for fish and invertebrates**
Wild rice ***Zizania aquatica***	**2**	**emergent**	**yes**	**up to 1 foot**	**high; food for birds**	**prefers full sun**

APPENDIX 8

Sources of Planting Stock

APPENDIX 8

Sources of Planting Stock

The following are Plant Materials Centers operated by the Natural Resources Conservation Service. Once they have fulfilled their obligations to the NRCS, they may be able to sell excess plant materials.

Rose Lake Plant Materials Center
7472 Stoll Road
East Lansing, MI 48823
Phone: 517-641-6300

Big Flats Plant Materials Center
RR #1, Box 360A # 352
Corning, NY 14830
Phone: 607-562-8400
(willows, red-osier dogwood, buttonbush)

Elsberry Plant Materials Center
Rt. 1 Box 9
Elsberry, MO 63343
Phone: 573-898-2012

Cape May Plant Materials Center
1536 Route 9 North
Cape May Courthouse
Cape May, NJ 08210
Phone: 609-465-5901

The Bureau of Forestry, Pennsylvania has one nursery in operation.

Alex Day, Superintendent
Penn Nursery
RD#1, Box 127
Spring Mills, PA 16875
Phone: 814-364-5150

The Pennsylvania Game Commission has one nursery in operation. Plants are provided free of charge to landowners who cooperate in the Game Commission's programs.

Howard Nursery
Pennsylvania Game Commission
197 Nursery Road
Howard, PA 16841
Phone: 814-355-4434

The state of Delaware has one nursery in operation.

DE Department of Agriculture
2320 South DuPont Highway
Dover, DE 19901
Phone: 302-739-4811
800-282-8685

The State of Maryland has one nursery in operation.

Preston Tree Nursery
3424 Gallagher Road
Preston, MD 21655
Phone: 410-673-2467
800-873-3763

The Division of Forestry, West Virginia, has one nursery in operation.

Clements State Tree Nursery
PO Box 8
West Columbia, West Virginia 25287
Phone: 304-675-1820
(white pine, Scots pine, Virginia pine, black locust, Norway spruce, Japanese larch, Siberian crabapple, gray/silky dogwood, black walnut, purpleosier willow, Chinese chestnut, chinquapin, red oak)

The Commonwealth of Virginia, Department of Forestry, operates one state nursery.

Augusta Forestry Center
PO Box 160
Crimora, VA 24431
Phone: 703-363-7000

There are numerous private nurseries that supply bulk plant stock for conservation plantings. Some that are used by natural resource managers who work in the watershed are:

Austree East, Inc.
PO Box 6121
Annapolis, MD 21403
800-258-7336
410-269-7541

C. P. Daniels
PO Box 119
Waynesboro, GA 30830
404-554-2446

Environmental Concern
PO Box P
210 West Chew Avenue
St. Michaels, MD 21663
410-745-9620

Flickinger's Nursery
Sagamore, PA 16250
800-368-7381

Hess' Nurseries, Inc.
P. O. Box 326
Cedarville, NJ 08311
609-447-4213

Hillis Nursery Co., Inc.
Rt. 2, Box 142
McMinnville, TN 37110
615-668-4364

Holly Hill Farms
P. O. Box 1
Earleville, MD 21919
410-275-2805

Kester's Wild Game Food Nurseries, Inc.
PO Box 516
Omro, WI 54963
414-685-2929

Lawyer Nursery, Inc.
950 Highway 200 West
Plains, MT 59859
406-826-3881

Musser Forests, Inc.
PO Box 340
Indiana, PA 15701
412-465-5686

Octoraro Wetland Nurseries, Inc.
PO Box 24
Oxford, PA 19363
717-529-3160

Oikos Tree Crops
PO Box 19425
Kalamazoo, MI 49019
616-624-6233

Red Oak Nurseries, Inc.
Rt. 2 Box 375
Montross, VA 22520
804-493-8282
800-541-0905

F. W. Schumacher Co., Inc.
36 Spring Hill Road
Sandwich, MA 02563-1023
508-888-0659

Sharp Brothers Seed Co.
PO Box 140
Healy, KS 67850
316-398-2231

Sylva Native Nursery & Seed Co.
1927 York Road
Timonium, MD 21093
301-560-2504

Vans Pines, Inc.
7550 144th Avenue
West Olive, MI 49460-9707

Warren County Nursery, Inc.
6492 Beersheba Highway
McMinnville, TN 37110
615-668-8941

Western Maine Nurseries, Inc.
Fryeburg, ME 04037
800-447-4745

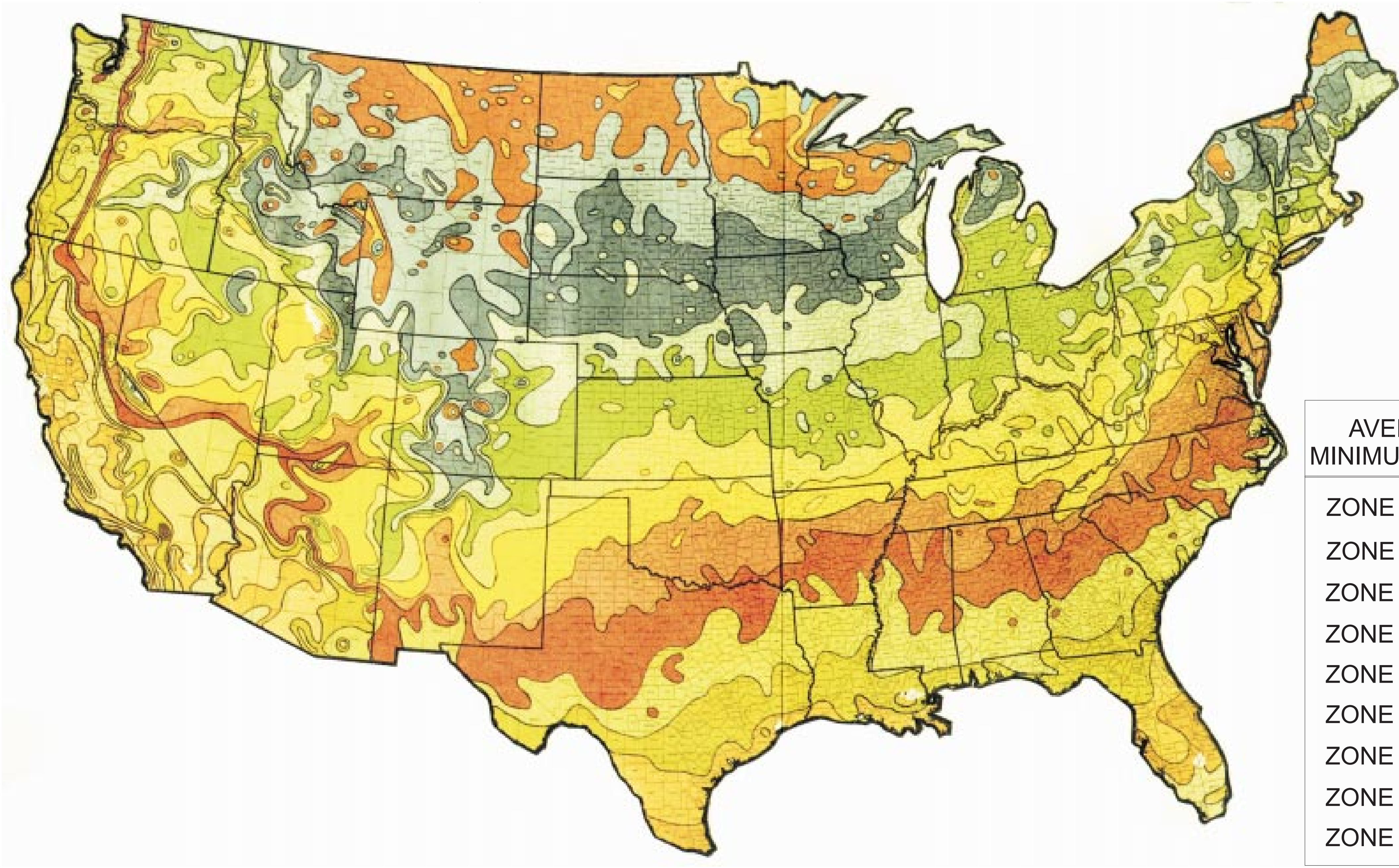
Wild Earth Native Plant Nursery
49 Mead Avenue
Freehold, NJ 07728
908-780-5661

Bill Wolter
Owens Station Shooting Preserve
RD#1 Box 101C
Greenwood, DE 19950
302-349-4478
302-349-4334

APPENDIX 9

USDA Plant Hardiness Zone Map

USDA Plant Hardiness Zone Map



AVERAGE ANNUAL MINIMUM TEMPERATURE	
ZONE 2	-50° to -40°
ZONE 3	-40° to -30°
ZONE 4	-30° to -20°
ZONE 5	-20° to -10°
ZONE 6	-10° to -0°
ZONE 7	0° to 10°
ZONE 8	10° to 20°
ZONE 9	20° to 30°
ZONE 10	30° to 40°

APPENDIX 10

Sources of Tree Shelters

APPENDIX 10

SOURCES OF TREE SHELTERS

TUBEX Tree Shelters
(now marketed as Supertubes)

Treessentials Company
PO Box 7097
75 Bidwell Street, Suite 105
St. Paul, MN 55107
800-248-8239

TreePee

Baileys
44650 Hwy 101
PO Box 550
Laytonville, CA 95454
707-984-6133

Tree Pro

Tree Pro Tree Protectors
445 Lourdes Lane
Lafayette, IN 47905
317-463-1011

Tree Pro
James L. McConnell
3699 Wentworth Lane
Lilburn, GA 30247
404-923-1681

Tree Sentry

Tree Sentry
PO Box 607
Perrysburg, OH 43552
419-874-1159

BLUE-X

All Season Wholesale Nursery
10656 Sheldon Woods Way
Elk Grove, CA 95624
916-689-0902

Charles Thomas
3120 High Street
Sacramento, CA 95815

Other

Quadra Tree Shelters
Albert Kubiske
3825 Highridge Road
Madison, WI 53704
608-837-9093

International Reforestation Suppliers
John Ellis
PO Box 5547
2100 Broadway
Eugene, OR 97405

Norplex, Inc.
Joe Mack
111 3rd Street, NW
Auburn, WA 98003

APPENDIX 11

Companies that Provide Materials and Services in the

Areas of Streambank Stabilization,

Erosion and Sediment Control, and

Geotextiles

APPENDIX 11

Companies that Provide Materials and Services in the Areas of Streambank Stabilization, Erosion and Sediment Control, and Geotextiles

Advanced Drainage Systems, Inc.
3300 Riverside Drive
Columbus, OH 43221
Phone: 614-457-3051
FAX: 614-459-0169

A. H. Harris & Sons, Inc.
321 Ellis Street
New Britain, CT 06051
Phone: 860-223-3772
FAX: 860-224-8400

American Excelsior Co.
PO Box 5067
Arlington, TX 76011
Phone: 817-640-1555
FAX: 817-649-7816

Amoco Fabrics and Fibers Company
900 Circle 75 Parkway, Suite 300
Atlanta, GA 30339
Phone: 800-445-SPEC
FAX: 770-956-2430

Atlantic Construction Fabrics, Inc.
1801-A Willis Road
Richmond, VA 23237
Phone: 800-448-3636
FAX: 804-271-3074

Attala Lining Systems, Inc.
PO Drawer 1138
Kosciusko, MS 39090
Phone: 601-289-1659
FAX: 601-289-3993

Belton Industries, Inc.
8613 Roswell Road
Atlanta, GA 30350
Phone: 800-225-4099
FAX: 770-992-6361

Bonded Fiber Products, Inc.
2748 Tanager Avenue
Commerce, CA 90040
Phone: 213-726-7820
FAX: 213-726-1087

Bradley Industrial Textiles, Inc.
PO Box 254
Valparalso, FL 32580
Phone: 904-678-6111
FAX: 904-729-1052

Buckley Powder Company
42 Inverness Drive East
Englewood, CO 80112
Phone: 303-790-7007
FAX: 303-790-7033

Carriff Corporation, Inc.
810 NC 24/27 West
Midland, NC 28107
Phone: 800-845-5184
FAX: 704-888-1246

Carthage Mills
4243 Hunt Road
Cincinnati, OH 45242
513-794-1600
Phone: 800-543-4430
FAX: 513-794-3434

C.F.P. Inc.
PO Box 567
Pineville, NC 28134
Phone: 803-548-3148
FAX: 803-548-0037

Civil Engineered Products
PO Box 12194
Charlotte, NC 28220-2194
Phone: 803-802-3705
FAX: 803-802-3705

C & K Industries
3451 E. Maiden Road
Maiden, NC 28650
Phone: 704-428-8042
FAX: 704-428-0830

Construction Techniques, Inc.
PO Box 360007
Cleveland, OH 44136
Phone: 800-563-5047
Phone: 216-572-8300
FAX: 216-572-5533

Dandy Products, Inc.
2011R Harrisburg Pike
Grove City OH 43123
Phone: 614-875-2284
Phone: 800-591-2284
FAX: 614-875-6305

Eastern Products, Inc.
1162 Sycamore Lane
Mahwah, NJ 07430
Phone: 800-934-0809
FAX: 201-934-8686

Environmental Design & Construction
7787 West Mom's Street
Indianapolis, IN 46231
Phone: 317-243-6326
FAX: 317-243-6247

Fluid Systems
1245 Corporate Boulevard, Suite 300
Aurora, IL 60504
Phone: 800-346-9107
FAX: 630-898-1179

GSE Lining Technology, Inc.
19103 Gundle Road
Houston, TX 77073-3598
Phone: 800-435-2008
Phone: 281-443-8564
FAX: 281-875-6010

Huesker Inc.
PO Box 411529
Charlotte, NC 28241
Phone: 704-588-5500
FAX: 704-588-5988

Integra Plastics, Inc.
500 12th Street, SE
Madison, SD 57042
Phone: 800-578-5257
FAX: 605-256-2629

Kan Du Manufacturing
1710 Madison
Maywood, IL 60153
Phone: 708-681-0370
FAX: 708-681-0373

Lafayette Farm & Industry
27180 Red School Road
Cuba City, WI 53807
Phone: 608-744-3434
FAX: 608-744-3733

Land Use Environmental Corp.
2576 Sound Avenue
Baiting Hollow, NY 11933
Phone: 516-727-2400
FAX: 516-727-2605

LINQ Industrial Fabrics, Inc.
2550 West Fifth North Street
Summersville, SC 29483
Phone: 803-873-5800
FAX: 803-875-8276

Manhattan Environmental, Inc.
111 W. 5th Street, Suite 810
Tulsa, OK 74103
Phone: 918-582-7078
FAX: 918-582-1025

MPC Containment Systems, Ltd.
4834 South Oakley
Chicago, IL 60609
Phone: 773-927-4120
FAX: 773-650-6028

National Seal Company
1245 Corporate Boulevard, Suite 300
Aurora, IL 60504
Phone: 630-898-1161
FAX: 630-898-6556

Nilex Corporation
6810 S. Jordan Road
Englewood, CO 80112
Phone: 303-766-2000
FAX: 303-766-1110

North American Green
14649 Highway 41 North
Evansville, IN 47711
Phone: 800-772-2040
FAX: 812-867-0247

Novaweld
12150 Race Street, Unit L-104
Northglenn, CO 80241
Phone: 303-452-0872
FAX: 303-452-2733

Pallen Enterprises, Inc.
1695 Farmer Road
Conyers, GA 30207
Phone: 770-922-1812
FAX: 770-922-1897

Presto Products Co.
670 N. Perkins Street
Appleton, WI 54913-2399
Phone: 414-739-9471
FAX: 414-738-1418

RoLanka International Inc.
6476 Mill Court
Morrow, GA 30260
Phone: 800-760-3215
Phone: 770-961-0331
FAX: 770-961-1480

Solmax Geosynthetics
4691 Commercial Drive, Suite 345
New Hartford, NY 13413
Phone: 315-853-8930
FAX: 315-853-8944

Synthetic Industries/Geosynthetic Products
4019 Industry Drive
Chattanooga, TN 37416
Phone: 800-621-0444
Phone: 423-899-0444
FAX: 423-899-7619

Tenax Corporation
4800 East Monument Street
Baltimore, MD 21205
Phone: 410-522-7000
FAX: 410-522-7015

Webtec Inc.
PO Box 241166
Charlotte, NC 28224
Phone: 800-438-0027
FAX: 704-394-7946

Wickoren & Associates
17096 West 295th Street
Paola, KS 66071
Phone: 913-294-4618
FAX: 913-294-3457

APPENDIX 12

Herbicide Labels

Specimen Label

Dow AgroSciences

Garlon* 4

Specialty Herbicide

*Trademark of Dow AgroSciences LLC

For the control of woody plants and broadleaf weeds on rights-of-way, industrial sites, non-crop areas, non-irrigation ditch banks, forests, and wildlife openings, including grazed areas on these sites.

Active Ingredient:
triclopyr: 3,5,6-trichloro-2-pyridinyloxyacetic acid, butoxyethyl ester 61.6%
Inert Ingredients 38.4%
Total 100.0%

Contains petroleum distillates
Acid Equivalent:
triclopyr - 44.3% - 4 lb/gal

EPA Reg. No. 62719-40

Precautionary Statements

Hazards to Humans and Domestic Animals

Keep Out of Reach of Children

CAUTION PRECAUCION

Si usted no entiende la etiqueta, busque a alguien para que se la explique a usted en detalle. (If you do not understand the label, find someone to explain it to you in detail.)

Harmful If Swallowed, Inhaled, Or Absorbed Through Skin

Avoid contact with eyes, skin, or clothing. Avoid breathing mists or vapors. Avoid contamination of food.

Personal Protective Equipment (PPE)

Some materials that are chemical-resistant to this product are listed below. If you want more options, follow the instructions for category E on an EPA chemical resistance category selections chart.

WPS Uses: Applicators and other handlers who handle this pesticide for any use covered by the Worker Protection Standard (40 CFR Part 170) -- in general, agricultural-plant uses are covered -- must wear:

- Long-sleeved shirt and long pants
- Chemical-resistant gloves such as Barrier Laminate, Nitrile Rubber, Neoprene Rubber, or Viton
- Shoes plus socks

Non-WPS Uses: Applicators and other handlers who handle this pesticide for any use NOT covered by the Worker Protection Standard (40 CFR Part 170) -- in general, only agricultural-plant uses are covered by the WPS -- must wear:

- Long-sleeved shirt and long pants
- Shoes plus socks

Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

User Safety Recommendations

Users should:
- Wash hands before eating, drinking, chewing gum, using tobacco, or using the toilet.
- Remove clothing immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.

First Aid

If on skin: Flush skin with plenty of water. Get medical attention if irritation persists.
If swallowed: Do not induce vomiting. Call a physician.

Environmental Hazards

This pesticide is toxic to fish. Do not apply directly to water, to areas where surface water is present, or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment washwaters.

Physical or Chemical Hazards

Do not use or store near heat or open flame. Do not cut or weld container.

Notice: Read the entire label. Use only according to label directions. **Before buying or using this product, read "Warranty Disclaimer" and "Limitation of Remedies" elsewhere on this label.**

In case of emergency endangering health or the environment involving this product, call 1-800-992-5994. If you wish to obtain additional product information, visit our web site at www.dowagro.com.

Agricultural Chemical: Do not ship or store with food, feeds, drugs or clothing.

Directions for Use

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.
Read all Directions for Use carefully before applying.

Do not use for manufacturing or formulating.

Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application. For any requirements specific to your state or tribe, consult the agency responsible for pesticide regulation.

Agricultural Use Requirements

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR part 170. This standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment (PPE) and restricted-entry interval. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard.

Do not enter or allow worker entry into treated areas during the restricted entry interval (REI) of 12 hours.

PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water, is:
- Coveralls
- Chemical-resistant gloves such as Barrier Laminate, Nitrile Rubber, Neoprene Rubber, or Viton
- Shoes plus socks

Storage and Disposal

Do not contaminate water, food, or feed by storage or disposal. Open dumping is prohibited.
Storage: Store above 28°F or agitate before use.
Pesticide Disposal: Pesticide, spray mixture, or rinse water that cannot be used according to label instructions must be disposed of according to applicable federal, state, or local procedures.
Plastic Container Disposal: Triple rinse (or equivalent). Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or by incineration, or, if allowed by state and local authorities, by burning. If burned, stay out of smoke.
Metal Container Disposal: Triple rinse (or equivalent). Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or by other procedures approved by state and local authorities.
Container Disposal for Refillable Containers: Replace the dry disconnect cap, if applicable, and seal all openings which have been opened during use. Return the empty container to a collection site designated by Dow AgroSciences. If the container has been damaged and cannot be returned according to the recommended procedures, contact the Dow AgroSciences Customer Service Center at 1-800-258-1470 to obtain proper handling instructions.
General: Consult federal, state, or local disposal authorities for approved alternative procedures.

General Information

Garlon* 4 herbicide is recommended for the control of unwanted woody plants and annual and perennial broadleaf weeds in forests, and on non-crop areas including industrial manufacturing and storage sites, rights-of-way such as electrical power lines, communication lines, pipelines, roadsides and railroads, fence rows, non-irrigation ditch banks, and around farm buildings. Use on these sites may include application to grazed areas as well as establishment and maintenance of wildlife openings.

General Use Precautions

Agricultural Use Requirements for Forestry Uses: For use of this product on forestry sites, follow PPE and Reentry restrictions in the Agricultural Use Requirements section of this label.
Use Requirements for Non-cropland Areas: No Worker Protection Standard worker entry restrictions or worker notification requirements apply when this product is applied to non-cropland.

In Arizona: The state of Arizona has not approved Garlon 4 for use on plants grown for commercial production; specifically forests grown for commercial timber production, or on designated grazing areas.

Chemigation: Do not apply this product through any type of irrigation system.

Other Precautions:
- When applying this product in tank mix combination, follow all applicable use directions and precautions on each manufacturer's label.
- Do not apply on ditches used to transport irrigation water. Do not apply where runoff or irrigation water may flow onto agricultural land as injury to crops may result.
- Do not apply this product using mist blowers unless a drift control additive, high viscosity inverting system, or equivalent is used to control spray drift.
- Sprays applied directly to Christmas trees may result in conifer injury. When treating unwanted vegetation in Christmas tree plantations, care should be taken to direct sprays away from conifers.
- Do not apply Garlon 4 directly to, or otherwise permit it to come into direct contact with grapes, tobacco, vegetable crops, flowers, or other desirable broadleaf plants and do not permit spray mists containing it to drift onto them.
- It is permissible to treat non-irrigation ditch banks, seasonally dry wetlands, flood plains, deltas, marshes, swamps, bogs, and transitional areas between upland and lowland sites. Do not apply to open water such as lakes, reservoirs, rivers, streams, creeks, salt water bays, or estuaries.

Avoid Injurious Spray Drift
Applications should be made only when there is little or no hazard from spray drift. Very small quantities of spray, which may not be visible may seriously injure susceptible plants. Do not spray when wind is blowing toward susceptible crops or ornamental plants near enough to be injured. It is suggested that a continuous smoke column at or near the spray site or a smoke generator on the spray equipment be used to detect air movement, lapse conditions, or temperature inversions (stable air). If the smoke layers or indicates a potential of hazardous spray drift, do not spray.

Aerial Application (Helicopter Only): For aerial application on rights-of-way or other areas near susceptible crops, use an agriculturally registered spray thickening drift control additive as recommended by the manufacturer or apply through the Microfoil† boom, Thru-Valve boom, or equivalent drift control system. Thickened sprays prepared by using high viscosity invert systems or other drift reducing systems may be utilized if they are made as drift-free as are mixtures containing an agriculturally registered thickening agent or applications made with the Microfoil boom or Thru Valve boom. If a spray thickening agent is used, follow all use recommendations and precautions on the product label. Do not use a thickening agent with the Microfoil boom, Thru Valve boom, or other systems that cannot accommodate thick sprays.

†Reference within this label to a particular piece of equipment produced by or available form other parties is provided without consideration for use by the reader at its discretion and subject to the reader's independent circumstances, evaluation, and expertise. Such reference by Dow AgroSciences is not intended as an endorsement of such equipment, shall not constitute a warranty (express or implied) of such equipment, and is not intended to imply that other equipment is not available and equally suitable. Any discussion of methods of use of such equipment does not imply that the reader should use the equipment other than is advised in directions available from the equipment's manufacturer. The reader is responsible for exercising its own judgment and expertise, or consulting with sources other than Dow AgroSciences, in selecting and determining how to use its equipment.

With aircraft, drift can be lessened by applying a coarse spray; by using a spray boom no longer than 3/4 the rotor length; by spraying only when wind velocities are low; or by using an approved drift control system. Keep operating spray pressures at the lower end of the manufacturer's recommended pressures for the specific nozzle type used. Low pressure nozzles are available from spray equipment manufacturers. Select nozzles and pressures which provide adequate plant coverage, but minimize the production of fine spray particles.

Ground Equipment: To aid in reducing spray drift potential when making ground applications near susceptible crops or other desirable broadleaf plants, Garlon 4 should be applied through large droplet producing equipment, such as the Radiarc sprayer or in thickened spray mixtures using an agriculturally registered drift control additive, or high viscosity invert systems. When using a spray thickening or inverting additive, follow all use directions and precautions on the product label. With ground equipment, spray drift can be reduced by keeping the spray boom as low as possible; by applying 20 gallons or more of spray per acre; and by spraying when wind velocity is low. Do not apply with nozzles that produce a fine droplet spray. Keep operating spray pressures at the lower end of the manufacturer's recommended pressures for the specific nozzle type used. Low pressure nozzles are available from spray equipment manufacturers. Select nozzles and pressures which provide adequate plant coverage, but minimize the production of fine spray particles.

High Volume Leaf-Stem Treatment: To minimize spray drift, keep sprays no higher than brush tops and keep spray pressures low enough to provide coarse spray droplets. A spray thickening agent may be used to reduce spray drift.

Grazing and Haying Restrictions

Grazing or harvesting green forage:

1) Lactating dairy animals
   Two quarts per acre or less: Do not graze or harvest green forage from treated area for 14 days after treatment.
   Greater than 2 to 6 quarts per acre: Do not graze or harvest green forage until the next growing season.
2) Other Livestock
   Two quarts per acre or less: No grazing restrictions.
   Greater than 2 to 6 quarts per acre: Do not graze or harvest green forage from treated area for 14 days after treatment. **Note:** If less than 25% of a grazed area is treated, there is no grazing restriction.

Haying (harvesting of dried forage):

1) Lactating dairy animals
   Do not harvest hay until the next growing season.
2) Other Livestock
   Two quarts per acre or less: Do not harvest hay for 7 days after treatment.
   Greater than 2 to 4 quarts per acre: Do not harvest hay for 14 days after treatment.
   Greater than 4 quarts per acre: Do not harvest hay until the next growing season.

Slaughter Restrictions:
Withdraw livestock from grazing treated grass or consumption of treated hay at least 3 days before slaughter. This restriction applies to grazing during the season following treatment or hay harvested during the season following treatment.

Plants Controlled by Garlon 4

Woody Plants Controlled

alder	chinquapin	madrone	scotch broom
arrowwood	choke cherry	maples	sumac
ash	cottonwood	mulberry	sweetbay magnolia
aspen	Crataegus (hawthorn)	oaks	sweetgum
bear clover (bearmat)	dogwood	persimmon	sycamore
beech	Douglas-fir	pine	tanoak
birch	elderberry	poison ivy	thimbleberry
blackberry	elm	poison oak	tree-of-heaven (*Ailanthus*)†
blackgum	gallberry	poplar	
boxelder†	gorse	salmonberry	tulip poplar
Brazilian pepper	hazel	salt-bush	wax myrtle
buckthorn	hickory	(*Braccharis* spp.)	wild rose
cascara	hornbeam	salt-cedar†	willow
Ceanothus	kudzu††	sassafras	winged elm
cherry	locust		

†For best control, use either a basal bark or cut stump treatment.
††For complete control, retreatment may be necessary.

Annual and Perennial Broadleaf Weeds Controlled

black medic	curly dock	matchweed	sweet clover
bull thistle	dandelion	mustard	vetch
burdock	field bindweed	Oxalis	wild carrot
Canada thistle	goldenrod	plantain	(Queen Anne's lace)
chicory	ground ivy	purple loosestrife	wild lettuce
clover	lambsquarters	ragweed	wild violet
creeping beggarweed	lespedeza	smartweed	yarrow

Table 1 (Maximum Application Rate): The following table is provided as a guide to the user to achieve the proper rate of Garlon 4 without exceeding the maximum use rate of 8 quarts per acre:

Spray Volume Per Acre	Quarts of Garlon 4 Per 100 Gallons of Spray (Not to Exceed 8 qt/Acre)
400	2
300	2.7
200	4
100	8
50	16
20	40
10	80

Approved Uses

Foliar Applications

Use Garlon 4 at rates of 1 to 8 quarts per acre to control broadleaf weeds and woody plants. In all cases use the amount specified in enough water to give uniform and complete coverage of the plants to be controlled. The recommended order of addition to the spray tank is water, spray thickening agent (if used), surfactant (if used), additional herbicide (if used), and Garlon 4. If a standard agricultural surfactant is used, use at a rate of 1 to 2 quarts per acre. Use continuous adequate agitation.

Before using any recommended tank mixtures, read the directions and all precautions on both labels.

For best results applications should be made when woody plants and weeds are actively growing. When hard-to-control species such as ash, blackgum, choke cherry, elm, maples (other than vine or big leaf), oaks, pines, or winged elm are prevalent, and during applications made during late summer when the plants are mature, or during drought conditions, use the higher rates of Garlon 4 alone or in combination with Tordon* 101 Mixture herbicide.

When using Garlon 4 in combination with 3.8 pounds per gallon 2,4-D low volatile ester herbicide generally the higher rates should be used for satisfactory brush control.

Use the higher dosage rates when brush approaches an average of 15 feet in height or when the brush covers more than 60% of the area to be treated. If lower rates are used on hard-to-control species, resprouting may occur the year following treatment.

On sites where easy to control brush species dominate, rates less than those recommended may be effective. Consult state or local extension personnel for such information.

Foliar Treatment With Ground Equipment

High Volume Foliar Treatment
For control of woody plants, use Garlon 4 at the rate of 1 to 3 quarts per 100 gallons of spray mixture, or Garlon 4 at 1 to 3 quarts may be tank mixed with labeled rates of 2,4-D low volatile ester herbicide, Tordon 101 Mixture herbicide, or Tordon K herbicide and diluted to make 100 gallons of spray. Apply at a volume of 100 to 400 gallons of total spray per acre depending on size and density of woody plants. Coverage should be thorough to wet all leaves, stems, and root collars. See Table 1 for relationship between spray volume and maximum application rate. When tank mixing, follow applicable use directions and precautions on each manufacturer's label.

Low Volume Foliar Treatment
To control susceptible woody plants, mix up to 20 quarts of Garlon 4 in 10 to 100 gallons of finished spray. The spray concentration of Garlon 4 and total spray volume per acre should be adjusted according to the size and density of target woody plants and kind of spray equipment used. With low volume sprays, use sufficient spray volume to obtain uniform coverage of target plants including the surfaces of all foliage, stems, and root collars (See General Use Precautions). For best results, a surfactant should be added to all spray mixtures. Match equipment and delivery rate of spray nozzles to height and density of woody plants. When treating tall, dense brush, a truck mounted spray gun with spray tips that deliver up to 2 gallons per minute at 40 to 60 psi may be required. Backpack or other types of specialized spray equipment with spray tips that deliver less than 1 gallon of spray per minute may be appropriate for short, low to moderate density brush. See Table 1 for relationship between mixing rate, spray volume and maximum application rate.

Tank Mixing: As a low volume foliar spray, up to 12 quarts of Garlon 4 may be applied in tank mix combination with labeled rates of Tordon K or Tordon 101 Mixture in 10 to 100 gallons of finished spray.

Broadcast Applications With Ground Equipment

Make application using equipment that will assure thorough and uniform coverage at spray volumes applied.

Woody Plant Control

Foliage Treatment: Use 4 to 8 quarts of Garlon 4 in enough water to make 5 or more gallons per acre of total spray, or Garlon 4 at 1 1/2 to 3 quarts may be combined with labeled rates of 2,4-D low volatile ester, Tordon 101 Mixture, or Tordon K in sufficient water to make 5 or more gallons per acre of total spray.

Broadleaf Weed Control
Use Garlon 4 at rates of 1 to 4 quarts in a total volume of 5 or more gallons per acre as a water spray mixture. Apply at any time weeds are actively growing. Garlon 4 at 0.25 to 3 quarts may be tank mixed with labeled rates of 2,4-D amine or low volatile ester, Tordon K, or Tordon 101 Mixture to improve the spectrum of activity. For thickened (high viscosity) spray mixtures, Garlon 4 can be mixed with diesel oil or other inverting agent. When using an inverting agent, read and follow the use directions and precautions on the product label.

Aerial Application (Helicopter Only)

Aerial sprays should be applied using suitable drift control (See "General Use Precautions").

Foliage Treatment (Utility and Pipeline Rights-of-Way)
Use 4 to 8 quarts of Garlon 4 alone, or 3 to 4 quarts Garlon 4 in a tank mix combination with labeled rates of 2,4-D low volatile ester Tordon 101 Mixture or Tordon K and apply in a total spray volume of 10 to 30 gallons per acre. Use the higher rates and volumes when plants are dense or under drought conditions.

Basal Bark and Dormant Brush Treatments

To control susceptible woody plants in rights-of-way, and other non-crop areas, and in forests, use Garlon 4 in oil or oil-water mixtures prepared and applied as described below. When preparing mixtures, use as oils either a commercially available basal oil, diesel fuel, No. 1 or No. 2 fuel oil, or kerosene. Substitute other oils or diluents only as recommended by the oil or diluent's manufacturer. When mixing with a basal oil or other oils or diluents, read and follow the use directions and precautions on the product label prepared by the oil or diluent's manufacturer.

Oil Mixture Sprays
Add Garlon 4 to the required amount of oil in the spray tank or mixing tank and mix thoroughly. If the mixture stands over 4 hours, reagitation is required.

Oil Mixtures of Garlon 4 and Tordon K: Tordon K and Garlon 4 may be used in tank mix combination for basal bark treatment of woody plants. These herbicides are incompatible and will not form a stable mixture when mixed together directly in oil. Stable tank mixtures for basal bark application can be made if each product is first combined with a compatibility agent prior to final mixing in the desired ratio.
(See product bulletin for mixing instructions.)

Oil-Water Mixture Sprays
First, premix the Garlon 4, oil and surfactant in a separate container. Do not allow any water or mixtures containing water to get into the Garlon 4 or the premix. Fill the spray tank about half full with water, then slowly add the premix with continuous agitation and complete filling the tank with water. Continue moderate agitation.

Note: If the premix is put in the tank without any water, the first water added may form a thick "invert" (water in oil) emulsion which will be hard to break.

Basal Bark Treatment
To control susceptible woody plants with stems less than 6 inches in basal diameter, mix 1 to 5 gallons of Garlon 4 in enough oil to make 100 gallons of spray mixture. Apply with knapsack sprayer or power spraying equipment using low pressure (20-40 psi). Spray the basal parts of brush and tree trunks to a height of 12 to 15 inches from the ground. Thorough wetting of the indicated area is necessary for good control. Spray until runoff at the ground line is noticeable. Old or rough bark requires more spray than smooth young bark. Apply at any time, including the winter months, except when snow or water prevent spraying to the ground line.

Low Volume Basal Bark Treatment
To control susceptible woody plants with stems less than 6 inches in basal diameter, mix 20 to 30 gallons of Garlon 4 in enough oil to make 100 gallons of spray mixture. Apply with a backpack or knapsack sprayer using low pressure and a solid cone or flat fan nozzle. Spray the basal parts of brush and tree trunks in a manner which thoroughly wets the lower stems, including the root collar area, but not to the point of runoff. Herbicide concentration should vary with size and susceptibility of species treated. Apply at any time, including the winter months, except when snow or water prevent spraying to the ground line or when stem surfaces are saturated with water.

Garlon 4 Plus Tordon K in Oil Tank Mix: Garlon 4 and Tordon K may be applied as a low volume basal bark treatment to improve control of certain woody species such as ash, elm, maple, poplar, aspen, hackberry, oak, oceanspray, birch, hickory, pine, tanoak, cherry, locust, sassafras, and multiflora rose. (See product bulletin for mixing instructions.)

Streamline Basal Bark Treatment (Southern States)
To control or suppress susceptible woody plants for conifer release, mix 20 to 30 gallons of Garlon 4 in enough oil to make 100 gallons of spray mixture. Apply with a backpack or knapsack sprayer using equipment which provides a directed straight stream spray. Apply sufficient spray to one side of stems less than 3 inches in basal diameter to form a treated zone that is 6 inches in height. When the optimum amount of spray mixture is applied, the treated zone should widen to encircle the stem within approximately 30 minutes. Treat both sides of stems which are 3 to 4 inches in basal diameter. Direct the spray at bark that is approximately 12 to 24 inches above ground. Pines (loblolly, slash, shortleaf, and Virginia) up to 2 inches in diameter breast height (dbh) can be controlled by directing the spray at a point approximately 4 feet above ground. Vary spray mixture concentration with size and susceptibility of the species being treated. Best results are achieved when applications are made to young vigorously growing stems which have not developed the thicker bark characteristic of slower growing, understory trees in older stands. This technique is not recommended for scrub and live oak species, including blackjack, turkey, post, live, bluejack and laurel oaks, or bigleaf maple. Apply from approximately 6 weeks prior to hardwood leaf expansion in the spring until approximately 2 months after leaf expansion is completed. Do not apply when snow or water prevent spraying at the desired height above ground level.

Low Volume Stem Bark Band Treatment (North Central and Lake States)
To control susceptible woody plants with stems less than 6 inches in basal diameter, mix 20 to 30 gallons of Garlon 4 in enough oil to make 100 gallons of spray mixture. Apply with a backpack or knapsack sprayer using low pressure and a solid cone or flat fan nozzle. Apply the spray in a 6 to 10 inch wide band that completely encircles the stem. Spray in a manner that completely wets the bark, but not to the point of runoff. The treatment band may be positioned at any height up to the first major branch. For best results apply the band as low as possible. Spray mixture concentration should vary with size and susceptibility of species to be treated. Applications may be made at any time, including winter months.

Thinline Basal Bark Treatment
To control susceptible woody plants with stems less than 6 inches in diameter, apply Garlon 4 either undiluted or mixed at 50-75% v/v with oil in a thin stream to all sides of the lower stems. The stream should be directed horizontally to apply a narrow band around each stem or clump. Use a minimum of 2 to 15 milliliters of Garlon 4 or oil mixture with Garlon 4 to treat single stems and from 25 to 100 milliliters to treat clumps of stems. Use an applicator metered or calibrated to deliver the small amounts required.

Dormant Stem Treatment
Dormant stem treatments will control susceptible woody plants and vines with stems less than 2 inches in diameter. Plants with stems greater than 2 inches in diameter may not be controlled and resprouting may occur. This treatment method is best suited for sites with dense, small diameter brush. Dormant stem treatments of Garlon 4 can also be used as a chemical side-trim for controlling lateral branches of larger trees that encroach onto roadside, utility, or other rights-of-way.

Mix 4 to 8 quarts of Garlon 4 in 2 to 3 gallons of crop oil concentrate or other recommended oil and add this mixture to enough water to make 100 gallons of spray solution. Use continuous adequate agitation. Apply with Radiarc, OC or equivalent nozzles, or handgun using 70 to 100 gallons of spray per acre to ensure uniform coverage of stems. Garlon 4 may be mixed with 4 quarts of Weedone 170 herbicide to improve the control of black cherry and broaden the spectrum of herbicidal activity. In western states, apply anytime after woody plants are dormant. In other areas apply anytime within 10 weeks of budbreak, generally February through April. Do not apply to wet or saturated bark as poor control may result.

Cut Stump Treatment
To control resprouting of cut stumps of susceptible species, mix 20 to 30 gallons of Garlon 4 in enough oil to make 100 gallons of spray mixture. Apply with a backpack or knapsack sprayer using low pressures and a solid cone or flat fan nozzle. Spray the root collar area, sides of the stump, and the outer portion of the cut surface including the cambium until thoroughly wet, but not to the point of runoff. Spray mixture concentration should vary with size and susceptibility of species treated. Apply at any time, including in winter months, except when snow or water prevent spraying to the ground line.

Treatment of Cut Stumps in Western States
To control resprouting of salt-cedar and other *Tamarix* species, bigleaf maple, tanoak, Oregon myrtle, and other susceptible species, apply undiluted

Garlon 4 to wet the cambium and adjacent wood around the entire circumference of the cut stump. Treatments may be applied throughout the year; however, control may be reduced with treatment during periods of moisture stress as in late summer. Use an applicator which can be calibrated to deliver the small amounts of material required.

Note: All basal bark and dormant brush treatment methods may be used to treat susceptible woody species on range and permanent pasture land provided that no more than 1.5 quarts of Garlon 4 are applied per acre. Large plants or species requiring higher rates of Garlon 4 may not be completely controlled.

Forest Management Applications

For broadcast applications apply the recommended rate of Garlon 4 in a total spray volume of 5 to 25 gallons per acre by air or 10 to 100 gallons per acre by ground. Use spray volumes sufficient to provide thorough coverage of treated foliage. Use application systems designed to prevent spray drift to off-target sites. Nozzles or additives that produce larger droplets may require higher spray volumes to provide adequate coverage.

Plant Back Interval for Conifers: Conifers planted sooner than 1 month after treatment with Garlon 4 at less than 4 quarts per acre or sooner than 2 months after treatment at 4 to 8 quarts per acre may be injured. When tank mixtures of herbicides are used for forest site preparation, labels for all products in the mixture should be consulted and the longest recommended waiting period observed.

Broadcast Treatments for Forest Site Preparation (Not For Conifer Release)

Southern States Including Alabama, Arkansas, Delaware, Florida, Georgia, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia: To control susceptible woody plants and broadleaf weeds, apply Garlon 4 at a rate of 4 to 8 quarts per acre. To broaden the spectrum of woody plants and broadleaf weeds controlled, apply 2 to 4 quarts per acre of Garlon 4 in tank mix combination with labeled rates of Tordon 101 Mixture or Tordon K. Tordon 101 Mixture and Tordon K are not registered for use in the states of California and Florida. Where grass control is also desired, Garlon 4, alone or in combination with Tordon K or Tordon 101 Mixture, may be tank mixed with labeled rates of other herbicides registered for grass control in forests. Use of tank mix products must be in accordance with the most restrictive of label limitations and precautions. No label application rates should be exceeded. Garlon 4 cannot be tank mixed with any product containing a label prohibition against such mixing.

In Western, Northeastern, North Central, and Lake States (States Not Listed Above As Southern States): To control susceptible woody plants and broadleaf weeds, apply Garlon 4 at a rate of 3 to 6 quarts per acre. To broaden the spectrum of woody plants and broadleaf weeds controlled, apply 1.5 to 3.0 quarts per acre of Garlon 4 in tank mix combination with labeled rates of Tordon 101 Mixture, Tordon K, or 2,4-D low volatile ester. Tordon 101 Mixture and Tordon K are not registered for use in the states of California and Florida. Where grass control is also desired, Garlon 4, alone or in tank mix combination with Tordon 101 Mixture or Tordon K, may be applied with labeled rates of other herbicides registered for grass control in forests. When applying tank mixes, follow applicable use directions and precautions on each product label.

Applications for Site Preparation in Southern Coastal Flatwoods: To control susceptible broadleaf weeds and woody species such as gallberry and wax-myrtle, and for partial control of saw-palmetto, apply 2 to 4 quarts per acre of Garlon 4. To broaden the spectrum of species controlled to include fetterbush, staggerbush, titi, and grasses, apply 2 to 3 quarts per acre of Garlon 4 in tank mix combination with labeled rates of Arsenal Applicator's Concentrate herbicide. Where control of gallberry, wax-myrtle, broadleaf weeds, and grasses is desired, 2 to 3 quarts per acre of Garlon 4 may be applied in tank mix combination with labeled rates of Accord herbicide.

These treatments may be broadcast during site preparation of flat planted or bedded sites or, on bedded sites, applied in bands over the top of beds. For best results, make applications in late summer or fall. Efficacy may not be satisfactory when applications are made in early season prior to August. **Note: Do not apply after planting pines.**

Applications for Conifer Release

Note: Applications for conifer release may cause temporary damage and growth suppression where contact with conifers occurs; however, injured conifers should recover and grow normally. Over-the-top spray applications can kill pines.

Directed Sprays

To release conifers from competing hardwoods and brush such as red maple, sugar maple, striped maple, sweetgum, red and white oaks, ash, hickory, alder, birch, aspen, pin cherry, *Ceanothus* spp., blackberry, chinquapin, and poison oak, mix 4 to 20 quarts of Garlon 4 in enough water to make 100 gallons of spray mixture. This spray should be directed onto foliage of competitive hardwoods using knapsack or backpack sprayers with flat fan nozzles or equivalent any time after the hardwoods and brush have reached full leaf size, but before autumn coloration. The majority of treated hardwoods and brush should be less than 6 feet in height to ensure adequate spray coverage. Care should be taken to direct spray solutions away from conifer foliage, particularly foliage of desirable pines. See Table 1 for relationship between mixing rate, spray volume and maximum application rate.

Broadcast Applications for Mid-Rotation Understory Brush Control in Southern Coastal Flatwoods Pine Stands (Ground Equipment Only)

For control of susceptible species such as gallberry and wax-myrtle and broadleaf weeds, apply 2 to 4 quarts per acre of Garlon 4. To broaden the spectrum of woody plants controlled to include fetterbush, staggerbush, and titi, apply 2 to 3 quarts per acre of Garlon 4 in tank mix combination with labeled rates of Arsenal Applicator's Concentrate. Saw-palmetto will be partially controlled by use of Garlon 4 at 4 quarts per acre or by mixtures of Garlon 4 at 2 to 3 quarts per acre in tank mix combination with either Arsenal Applicator's Concentrate or Escort herbicide.

These mixtures should be broadcast applied over target understory brush species, **but to prevent injury to pines, make applications underneath the foliage of pines.** It is recommended that sprays be applied in 30 or more gallons per acre of total volume. For best results, make applications in late summer or fall. Efficacy may not be satisfactory when applications are made in early season prior to August.

Broadcast Applications for Conifer Release in the Pacific Northwest and California

On Dormant Conifers Before Bud Swell (Excluding Pines): To control or suppress deciduous hardwoods such as vine maple, bigleaf maple, alder, scotch broom, or willow **before leaf-out** or evergreen hardwoods such as madrone, chinquapin, and *Ceanothus* spp., use Garlon 4 at 1 to 2 quarts per acre. Diluents used may be diesel or fuel oil. Or, water plus 1 to 2 gallons per acre of diesel oil or a suitable surfactant or oil substitute at manufacturer's recommended rates may be used.

On Conifer Plantations (Excluding Pines) After Hardwoods Begin Growth and Before Conifer Bud Break ("Early Foliar" Hardwood Stage): Use Garlon 4 at 1.0 to 1.5 quarts alone or plus 2,4-D low volatile ester herbicide in water carrier to provide no more than 3 pounds acid equivalent per acre from both products. After conifer bud break, these sprays may cause more serious injury to the crop trees. Use of a surfactant may cause unacceptable injury to conifers especially after bud break.

On Conifer Plantations (Excluding Pines) After Conifers Harden Off In Late Summer and While Hardwoods Are Still Growing Actively: Use Garlon 4 at rates of 1.0 to 1.5 quarts per acre alone or plus 2,4-D low volatile ester to provide no more than 3 pounds acid equivalent per acre from both products. Treat as soon after conifer bud hardening as possible so that hardwoods and brush are actively growing. Use of oil, oil substitute, or surfactant may cause unacceptable injury to the conifers.

Broadcast Applications for Conifer Release in the Eastern United States

To release spruce, fir, red pine, and white pine from competing hardwoods such as red maple, sugar maple, striped maple, alder, birch (white, yellow, and grey), aspen, ash, pin cherry, and *Rubus* spp. and perennial and annual broadleaf weeds, use Garlon 4 at rates of 1.5 to 3.0 quarts per acre alone or plus 2,4-D amine or low volatile ester to provide no more than 4 pounds acid equivalent per acre from both products. Applications should be made in late summer or early fall after conifers have formed their overwintering buds and hardwoods are in full leaf and prior to autumn coloration.

Broadcast Applications for Conifer Release in the Lake States Region

To release spruce, fir, and red pine from competing hardwoods such as aspen, birch, maple, cherry, willow, oak, hazel, and *Rubus* spp. and perennial and annual broadleaf weeds, use Garlon 4 at rates of 1.5 to 3.0 quarts per acre. Applications should be made in late summer or early fall after conifers have formed their overwintering buds and hardwoods are in full leaf and prior to autumn coloration.

Warranty Disclaimer

Dow AgroSciences warrants that this product conforms to the chemical description on the label and is reasonably fit for the purposes stated on the label when used in strict accordance with the directions, subject to the inherent risks set forth below. Dow AgroSciences MAKES NO OTHER EXPRESS OR IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR ANY OTHER EXPRESS OR IMPLIED WARRANTY.

Inherent Risks of Use

It is impossible to eliminate all risks associated with use of this product. Plant injury, lack of performance, or other unintended consequences may result because of such factors as use of the product contrary to label instructions (including conditions noted on the label, such as unfavorable temperature, soil conditions, etc.), abnormal conditions (such as excessive rainfall, drought, tornadoes, hurricanes), presence of other materials, the manner of application, or other factors, all of which are beyond the control of Dow AgroSciences or the seller. All such risks shall be assumed by buyer.

Limitation of Remedies

The exclusive remedy for losses or damages resulting from this product (including claims based on contract, negligence, strict liability, or other legal theories), shall be limited to, at Dow AgroSciences' election, one of the following:

1. Refund of purchase price paid by buyer or user for product bought, or
2. Replacement of amount of product used

Dow AgroSciences shall not be liable for losses or damages resulting from handling or use of this product unless Dow AgroSciences is promptly notified of such loss or damage in writing. In no case shall Dow AgroSciences be liable for consequential or incidental damages or losses.

The terms of the "Warranty Disclaimer" above and this "Limitation of Remedies" cannot be varied by any written or verbal statements or agreements. No employee or sales agent of Dow AgroSciences or the seller is authorized to vary or exceed the terms of the "Warranty Disclaimer" or this "Limitation of Remedies" in any manner.

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Label Code: D02-102-023
Replaces Label: D02-102-022

EPA-Accepted 07/22/97

Revisions:
Minor corrections to EPA accepted text dated 7-22-97

Specimen Label

Dow AgroSciences

Tordon* RTU

Specialty Herbicide

*Trademark of Dow AgroSciences LLC

For controlling unwanted trees via cut surface treatments in forests and non-cropland areas such as fence rows, roadsides, and rights-of-way.

Active Ingredient(s):

picloram: 4-amino-3,5,6-trichloropicolinic acid, triisopropanolamine salt	5.4%
2,4-dichlorophenoxyacetic acid, triisopropanolamine salt†	20.9%
Inert Ingredients	73.7%
Total	100.0%

Acid equivalents:
picloram - 3.0%
2,4-dichlorophenoxyacetic acid - 11.2%
†Isomer Specific by AOAC Method No. 978.05 (15th Ed.)

EPA Reg. No. 62719-31

Keep Out of Reach of Children

Precautionary Statements

Hazards to Humans and Domestic Animals

WARNING AVISO

Si usted no entiende la etiqueta, busque a alguien para que se la explique a usted en detalle. (If you do not understand the label, find someone to explain it to you in detail.)

Causes Substantial But Temporary Eye Injury • Harmful If Swallowed, Inhaled, Or Absorbed Through Skin

Do not get in eyes or on clothing. Avoid contact with skin.

Personal Protective Equipment (PPE)

Some materials that are chemical-resistant to this product are listed below. If you want more options, follow the instructions for category C on an EPA chemical resistance category selections chart.

Applicators and other handlers, including persons repairing or cleaning equipment, must wear:
- Long-sleeved shirt and long pants
- Chemical-resistant gloves such as Barrier Laminate, Butyl Rubber, Nitrile Rubber, Neoprene Rubber, Polyvinyl Chloride (PVC), or Viton
- Shoes plus socks
- Protective eyewear
- **For containers over 1 gallon, but less than 5 gallons:** Mixers and loaders who do not use a mechanical system (such as probe and pump or spigot) to transfer the contents of this container must wear coveralls or a chemical-resistant apron in addition to other required PPE.

Discard clothing and other absorbent materials that have been drenched or heavily contaminated with this product's concentrate. Do not reuse them. Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry. After each day of use, clothing or PPE must not be reused until it has been cleaned.

Engineering Controls Statements

For containers of 5 gallons or more: Do not open pour from this container. A mechanical system (such as probe and pump or spigot) must be used for transferring the contents of this container. If the contents of a non-refillable pesticide container are emptied, the probe must be rinsed before removal. If the mechanical system is used in a manner that meets the requirements listed in the Worker Protection Standard (WPS) for agricultural pesticides [40 CFR 170.240(d) (4)], the handler PPE requirements may be reduced or modified as specified in the WPS.

User Safety Recommendations

Users should:
- Wash hands before eating, drinking, chewing gum, using tobacco or using the toilet.
- Remove clothing immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.
- Remove PPE immediately after handling this product. Wash the outside of gloves before removing. As soon as possible, wash thoroughly and change into clean clothing.

First Aid

If in eyes: Flush with plenty of water for at least 15 minutes. Get medical attention.
If on skin: Wash with plenty of soap and water. Get medical attention.
Contains ethylene glycol.
If swallowed: Call a doctor or get medical attention. Do not induce vomiting. Drink promptly a large quantity of milk, egg whites, gelatin solution, or if these are not available, drink large quantities of water. Avoid alcohol.
If inhaled: Remove victim to fresh air. If not breathing, give artificial respiration, preferably mouth-to-mouth. Get medical attention.

Environmental Hazards

Drift or runoff may adversely affect non-target plants. Do not apply directly to water, to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment washwaters.

Picloram is a chemical which can travel (seep or leach) through soil and under certain conditions has the potential to contaminate groundwater which may be used for irrigation and drinking purposes. Users are advised not to apply picloram where soils have a rapid to very rapid permeability throughout the profile (such as loamy sand to sand) and the water table of an underlying aquifer is shallow **or** to soils containing sinkholes over limestone bedrock, severely fractured surfaces, and substrates which would allow direct introduction into an aquifer. Your local agricultural agencies can provide further information on the type of soil in your area and the location of groundwater.

An aquifer is defined as "an underground, saturated, permeable, geologic formation capable of producing significant quantities of water to a well or spring. It is the ability of the saturated zone, or portion of that zone, to yield water which makes it an aquifer" (American Chemical Society, 1983).

Physical or Chemical Hazards

Do not use or store near heat or open flame. Do not cut or weld container.

Notice: Read the entire label. Use only according to label directions. **Before buying or using this product, read "Warranty Disclaimer" and "Limitation of Remedies" elsewhere on this label.**

In case of emergency endangering health or the environment involving this product, call 1-800-992-5994. If you wish to obtain additional product information, visit our web site at www.dowagro.com.

Agricultural Chemical: Do not ship or store with food, feeds, drugs or clothing.

Directions for Use

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.
Read all Directions for Use carefully before applying.

Use undiluted only as indicated below.

Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application. For any requirements specific to your state or tribe, consult the agency responsible for pesticide regulation.

Agricultural Use Requirements

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR part 170. This Standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about Personal Protective Equipment (PPE), and restricted entry interval. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard.

Do not enter or allow worker entry into treated areas during the restricted entry interval (REI) of 48 hours.

PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water, is:

- Coveralls
- Chemical-resistant gloves such as Barrier Laminate, Butyl Rubber, Nitrile Rubber, Neoprene Rubber, Polyvinyl Chloride (PVC), or Viton
- Shoes plus socks
- Protective eyewear

Storage and Disposal

Do not contaminate water, food, fertilizer or feed by storage or disposal.
Storage: Keep container tightly closed when not in use.
Pesticide Disposal: Pesticide wastes are toxic. Improper disposal of excess pesticide, spray mixture, or rinsate, is a violation of Federal law and may contaminate groundwater. If these wastes cannot be disposed of by use according to label instructions, contact your state pesticide or environmental control agency, or the hazardous waste representative at the nearest EPA regional office for guidance.
Rinse application equipment after use, at least three times with water, and dispose of rinse water in a non-cropland area away from water supplies.

Metal Container Disposal: Do not reuse container. Triple rinse (or equivalent). Puncture and dispose of in a sanitary landfill, or by other procedures approved by state and local authorities.
Plastic Container Disposal: Do not reuse container. Triple rinse (or equivalent). Puncture and dispose of in a sanitary landfill, or by incineration, or, if allowed by state and local authorities, by burning. If burned, stay out of smoke.
Consult federal, state, or local disposal authorities for approved alternative procedures.

General Information

Tordon RTU herbicide is a **ready-to-use product** that is effective in cut surface applications for killing unwanted trees and preventing undesirable sprouting of cut trees in forest and other non-crop areas such as fence rows, roadsides and rights-of-way.

General Use Precautions

Use this product only as specified on this label.

Be sure that use of this product conforms to all applicable regulations.

Tordon RTU is highly active as a herbicide, is water soluble, can move with surface runoff water, and can remain phytotoxic for a year or more if it gets into the soil.

Tordon RTU should not be applied on residential or commercial lawns or near ornamental trees and shrubs. Untreated trees can occasionally be affected by root uptake of herbicide through movement into the top soil or by excretion of the product from the roots of nearby treated trees. Do not apply Tordon RTU within the root zone of desirable trees unless such injury can be tolerated.

Do not contaminate cropland, water, or irrigation ditches.

Do Not Contaminate Water Intended for Irrigation or Domestic Purposes. To avoid injury to crops or other desirable plants, do not treat or allow spray drift or run-off to fall onto banks or bottoms of irrigation ditches, either dry or containing water, or other channels that carry water that may be used for irrigation or domestic purposes. Do not apply to snow or frozen ground.

Do not rotate food or feed crops on treated land if they are not registered for use with picloram until an adequately sensitive bioassay or chemical test shows that no detectable picloram is present in the soil.

Do not apply on or in the vicinity of sensitive crops of desirable broadleaf plants. Small amounts can cause injury to plants.

Do not allow careless application or spray drift. Do not permit any spray or spray drift to contact desirable plants. Use only gravity flow or very low spray pressure.

Do not remove product from original container except to apply as indicated under Use Directions.

Mixing and Loading: Most cases of groundwater contamination involving phenoxy herbicides such as 2,4-D have been associated with mixing/loading and disposal sites. Caution should be exercised when handling 2,4-D pesticides at such sites to prevent contamination of groundwater supplies. Use of closed systems for mixing or transferring this pesticide will reduce the probability of spills. Placement of the mixing/loading equipment on an impervious pad to contain spills will help prevent groundwater contamination.

Woody Plants Controlled by Tordon RTU

ailanthus	elm	maples
alder	firs	oaks
aspen	green ash	pecan
birch	gum	persimmon
cedar	hawthorn	serviceberry
cherry	hickory	sourwood
dogwood	hornbeam	sweetbay

Approved Uses

Forest Uses

Agricultural Use Requirements for Forest Use: For the following forestry uses, follow PPE and Reentry instructions in the "Agricultural Use Requirements" section of this label.

Non-crop Uses Such As Fence Rows, Roadsides and Rights-of-Way

Use Requirements for Non-cropland Areas: No Worker Protection Standard worker entry restrictions or worker notification requirements apply when this product is applied to non-cropland areas.

Application Methods

Tree Injection Treatment
Use 1 milliliter of undiluted Tordon RTU solution through the bark completely around the tree trunk at intervals of 2 to 3 inches between edges of the injector wounds. Make injections near ground level when using the tree injector or 2 to 4 feet above the ground when using a Hypohatchet Injector or similar device. Treatments can be made in any season. Maples should not be treated during the spring sap flow. With some difficult to control species such as dogwood, hickory, sugar maple, bigleaf maple, tanoak, and some firs, application to a continuous cut rather than to spaced cuts may be more uniformly effective. **Note: No Worker Protection Standard worker entry restrictions or worker notification requirements apply when this product is directly injected into agricultural plants.**

Frill or Girdle Treatment
Make a single hack girdle or "frill" of overlapping axe cuts through the bark completely around the tree as close to the ground as feasible. Spray or paint the injured surface with undiluted Tordon RTU, using enough volume to wet treated areas.

Stump Treatment
Spray or paint the cut surfaces of freshly cut stumps and stubs with undiluted Tordon RTU. The cambium area next to the bark is the most vital area to wet.

Warranty Disclaimer

Dow AgroSciences warrants that this product conforms to the chemical description on the label and is reasonably fit for the purposes stated on the label when used in strict accordance with the directions, subject to the inherent risks set forth below. Dow AgroSciences MAKES NO OTHER EXPRESS OR IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR ANY OTHER EXPRESS OR IMPLIED WARRANTY.

Inherent Risks of Use

It is impossible to eliminate all risks associated with use of this product. Plant injury, lack of performance, or other unintended consequences may result because of such factors as use of the product contrary to label instructions (including conditions noted on the label, such as unfavorable temperature, soil conditions, etc.), abnormal conditions (such as excessive rainfall, drought, tornadoes, hurricanes), presence of other materials, the manner of application, or other factors, all of which are beyond the control of Dow AgroSciences or the seller. All such risks shall be assumed by buyer.

Limitation of Remedies

The exclusive remedy for losses or damages resulting from this product (including claims based on contract, negligence, strict liability, or other legal theories), shall be limited to, at Dow AgroSciences' election, one of the following:

1. Refund of purchase price paid by buyer or user for product bought, or
2. Replacement of amount of product used

Dow AgroSciences shall not be liable for losses or damages resulting from handling or use of this product unless Dow AgroSciences is promptly notified of such loss or damage in writing. In no case shall Dow AgroSciences be liable for consequential or incidental damages or losses.

The terms of the "Warranty Disclaimer" above and this "Limitation of Remedies" cannot be varied by any written or verbal statements or agreements. No employee or sales agent of Dow AgroSciences or the seller is authorized to vary or exceed the terms of the "Warranty Disclaimer" or this "Limitation of Remedies" in any manner.

Dow AgroSciences LLC • Indianapolis, IN 46268 U.S.A.

Label Code: D01-046-006
Replaces Label: 112-46-004

EPA-Accepted 07/21/95

Revisions:

DowElanco notified the EPA that its legal name will change to Dow AgroSciences LLC effective January 1, 1998. The following label changes are being made via non-notification as a result of this company name change:

- Company name changed from DowElanco to Dow AgroSciences LLC (logo, trademark reference, address line, warranty statement)
- Emergency telephone number updated to include a web site address (PR Notice 97-4)

The name of this product and its EPA registration number remain the same. No other changes are being made to the label at this time.

H - 63085

DUPONT®

Escort®

herbicide

®

"......... A Growing Partnership With Nature"

DU PONT

Escort®

herbicide

Dry Flowable

Active Ingredient	*By Weight*
Metsulfuron methyl Methyl 2-[[[[(4-methoxy-6-methyl- -1,3,5-triazin-2-yl)amino]- carbonyl]-amino]sulfonyl]benzoate}	60%
Inert Ingredients	40%
TOTAL	100%

EPA Reg. No. 352-439

KEEP OUT OF REACH OF CHILDREN

CAUTION

STATEMENT OF PRACTICAL TREATMENT

In case of contact with eyes, immediately flush with plenty of water. If on skin, wash with plenty of soap and water. Get medical attention if irritation persists.

For medical emergencies involving this product, call toll free 1-800-441-3637.

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS AND DOMESTIC ANIMALS

CAUTION! Causes eye irritation. Avoid contact with skin, eyes or clothing. Avoid breathing dust or spray mist.

PERSONAL PROTECTIVE EQUIPMENT

Applicators and other handlers must wear:

Long-sleeved shirt and long pants.

Shoes plus socks.

Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

USER SAFETY RECOMMENDATIONS

Users should: Wash hands before eating, drinking, chewing gum, using tobacco or using the toilet.

ENVIRONMENTAL HAZARDS

Do not apply directly to water, or to areas where surface water is present, or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment washwaters.

This herbicide is injurious to plants at extremely low concentrations. Nontarget plants may be adversely effected from drift and run-off.

IMPORTANT

DO NOT USE ON FOOD OR FEED CROPS EXCEPT AS RECOMMENDED BY THIS LABEL OR SUPPLEMENTAL LABELING. Injury to or loss of desirable trees or other plants may result from failure to observe the following: Do not apply "Escort" Herbicide (except as recommended), or drain or flush equipment on or near desirable trees or other plants, or on areas where their roots may extend or in locations where the chemical may be washed or moved into contact with their roots. Do not use on lawns, walks, driveways, tennis courts, or similar areas. Prevent drift of spray to desirable plants. Do not contaminate any body of water, including irrigation water. Keep from contact with fertilizers, insecticides, fungicides and seeds.

Following an "Escort" application, do not use sprayer for application to crops. This is extremely important, as low rates of "Escort" can kill or severely injure most crops (except small grains).

GENERAL INFORMATION

Do not use this product in California nor in the following counties of Colorado: Saguache, Rio Grande, Alamosa, Costilla and Conejos.

Du Pont "Escort" Herbicide is a dispersible granule to be mixed in water and applied as a foliar spray for control of unwanted woody plants and annual and perennial broadleaf weeds, basal soil treatment of multiflora rose, for preemergence and postemergence industrial weed control, and for the growth suppression of certain desirable grasses in noncrop areas such as airports, highways, roadsides, utility and pipeline rights-of-ways, petroleum tank farms, storage areas, pumping installations, plant sites, industrial turf, roadside turf, railroad rights-of-way and fence rows.

Do not apply to open water (such as lakes, reservoirs, rivers, streams, creeks, salt water bays or estuaries) nor while water is present in fresh water wetlands (such as marshes, swamps, bogs or potholes) nor to salt water marshes within tidal areas nor to areas where the herbicide is likely to move into water (such as insides of ditches, steep banks along waterways or impervious substrates) nor to areas near desirable plants where roots of these plants may extend. It is permissible to treat the berm of ditches, seasonally dry flood plains, deltas, marshes, swamps, bogs and transitional areas between upland and lowland sites.

Warm, moist conditions following treatment promote the activity of "Escort", while cold, dry conditions may reduce or delay activity. Weeds and brush hardened off by cold weather or drought stress may not be controlled. Degree of control and duration of effect are dependent on the rate used, sensitivity and size of target species, as well as soil moisture and soil temperature.

Following the use of "Escort", some naturally-occurring biotypes of pest species listed on this label may not be effectively controlled. Biotypes are individuals of the species which have a slightly different genetic makeup. Resistant biotypes may look exactly the same as susceptible biotypes but are able to survive a use rate several times higher than needed to control susceptible biotypes. To delay the occurrence of resistant biotypes, use "Escort" in tank mixes and/or sequential treatments with other registered herbicides effective on the same broadleaf weed species. Do not let weed escapes go to seed; time postemergence treatments before seed formation. Respray problem areas in a timely and effective manner using a herbicide with a different mode of action.

"Escort" is noncorrosive, nonflammable, nonvolatile and does not freeze.

MODE OF ACTION

"Escort" rapidly stops growth of susceptible plant species; however, typical symptoms (discoloration) may not be noticeable for several weeks after application, depending on growing conditions and susceptibility. Weeds absorb "Escort" through both the foliage and roots resulting in visual effects progressing from growth inhibition to reddish-purplish coloration, chlorosis, necrosis, vein discoloration and death of terminal. Initial effects are usually seen 2 or 3 weeks following application; however, the final effects on weeds are evident at about 4 to 6 weeks after application. On brush, ultimate effects occur during the season after treatment.

DIRECTIONS FOR USE

It is a violation of federal law to use this product in a manner inconsistent with its labeling.

Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application. For any requirements specific to your State or Tribe, consult the agency responsible for pesticide regulation.

"Escort" Herbicide should be used only in accordance with recommendations on this label or in separate published Du Pont recommendations available through local suppliers..

Du Pont will not be responsible for losses or damages resulting from the use of this product in any manner not specifically recommended by Du Pont. User assumes all risks associated with such nonrecommended use.

Du Pont "Escort" Herbicide is recommended as a postemergence application for control of brush and certain perennial broadleaf weeds and preemergence and postemergence for weed control on noncropland. "Escort" is also recommended for weed control on established, unimproved, industrial turf and native perennial grasses. On fescue/bluegrass turf, "Escort" is recommended for growth suppression and seedhead inhibition.

For tank mixes, use the most restrictive limitations from labeling of both products.

Consult your chemical supplier, applicator, consultant, appropriate state agricultural extension service representative or your local Du Pont representatives for specific recommendations.

AGRICULTURAL USES

AGRICULTURAL USE REQUIREMENTS

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR part 170. This Standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment(PPE) and restricted-entry interval. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard.

Do not enter or allow worker entry into treated areas during the restricted entry interval (REI) of 4 hours.

PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water, is:

Coveralls.
Shoes plus socks.

WEED AND BRUSH CONTROL

CONIFER PLANTATIONS

SITE PREPARATION

Loblolly Pine and Slash Pine Only

For control of blackberry and other broadleaf weeds (see listing under Non-crop Weed Control), apply 1/2 to 1-1/2 ozs "Escort" per acre (plus surfactant) by air or ground equipment. Treat blackberry plants after they have reached full leaf, but before leaf tissue has hardened in the fall. Use sufficient spray volume for complete coverage of these plants. For control of diffuse knapweed, Japanese honeysuckle, palmetto, black cherry and black locust, apply 3-1/3 ozs "Escort" per acre (plus surfactant).

For broader spectrum control, tank mix with:

- "Arsenal" (as registered) for dewberry, greenbrier, honeysuckle, morningglory, poison ivy, redvine, trumpet creeper, wild grape, sumac, beech, aspen, black gum, box elder, chinaberry, dogwood, hickory, persimmon, red maple, sassafras, sourwood, sweetgun, yellow poplar and others (see container label).
- "Velpar" L (as registered) for bracken fern, ash, aspen, balsam, blackgum, cherry, poplar, birch, box elder, brambles, cherry (black and pin), elm, winged elm, hawthorne, hazel, honeysuckle, oaks (red, black and white), and willow(see container label).
- "Accord" (or "Roundup"[3] both as registered) for blackgum, braken fern, cherry, Virginia creeper, dewberry, honeysuckle, black locust, persimmon, poison ivy, sassafras, sourwood, sumac, sweet gum, hawthorn, trumpet creeper, wax myrtle and others (see container label).
- "Oust" at 2 to 3 ozs per acre (loblolly pine only) for many herbaceous annual broadleaves and grasses, such as, fireweed, horseweed, common ragweed, annual sowthistle, black mustard, bur clover, sweet clover, curly dock, barnyardgrass, panicums, reed canarygrass, pokeweed, signalgrass and others (see container label). Apply to seedling weeds.

Douglas Fir

For control of blackberry and other broadleaf weeds, apply 1/2 to 1 oz "Escort" per acre (plus surfactant) in the spring. Douglas fir may be transplanted in treated areas the next season.

For broader spectrum control, "Escort" should be tank-mixed with "Velpar" L Herbicide. Use "Velpar" L as directed on the package for ground equipment.

RELEASE

Loblolly Pine (established plantations)

For control of blackberry, apply 1/2 to 1-1/2 ozs "Escort" per acre in a minimum of 10 gals water per acre by air or ground equipment, plus surfactant. Treat plants when they have reached full leaf but before leaf tissue has hardened in the fall. Treatment will also control many annual broadleaf weeds (see Weed Control); best results occur when annuals are treated in the seedling stage.

For broader spectrum control, "Escort" should be tank-mixed as follows:

- "Arsenal" - Apply 1/2 to 1-1/2 ozs "Escort" plus 1 pt "Arsenal" (plus surfactant) per acre. Apply during summer to late fall (preferred) as described on the "Arsenal" container label. The combination controls or improves control of blackberry, black gum, elm, winged elm, and cherry and controls many weeds as shown on product labels.
- "Velpar" L (or "Velpar") - For brush control and herbaceous weed control (see container labels for species controlled), apply 1/2 to 1-1/2 ozs "Escort" plus 1-1/2 to 6 qts "Velpar" L (or equivalent "Velpar") per acre. Do not use surfactant.
- "Oust" at 2 to 3 ozs per acre for herbaceous weed control. Do not use surfactant. Apply late winter through spring after the soil has settled around the pines.

Do not apply where conifers are suffering from loss of vigor caused by insects, disease, drought, winter damage, or other stresses, as injury may result. Excessive injury may result to conifers less than 4 years of age from transplanting on coarse-textured soils, and less than 3 years of age from transplanting on medium and fine-textured soils. Use on gravelly or rocky soils and exposed subsoils may cause injury or mortality to conifers. Poor weed and brush control may occur from application made when the soil is saturated with water and rain is imminent within 24 hours. Do not use on poorly drained or marshy sites but it may be used where pines are planted on beds. A foam-reducing agent may be added at the recommended rate, if needed.

Apply as a full coverage spray to foliage and stems. Total spray volume per acre will depend upon plant height and density of growth and the type of equipment used. See " Recommended Minimum Spray Volumes."

Loblolly pine may be transplanted into treated areas 4 months after application; slash pine the following season, at least 6 months after application; Douglas fir the following season after treatment of "Escort".

For application of "Escort" alone or in combination on loblolly pine and slash pine, follow directions on the package label of the companion product in addition to "Escort" directions above; see labels for additional plants controlled. Follow all restrictions on labeling of both products in the tank mixes.

"Escort" is not recommended for weed control to facilitate the harvesting of pine straw.

Livestock may graze treated areas 0 days after application of up to and including 1 2/3 oz "Escort" per acre. For combinations, use the most restrictive recommendation of products used.

RECOMMENDED MINIMUM SPRAY VOLUMES

PRODUCT SITE PREPARATION FOR LOBLOLLY AND SLASH PINES	SPRAY GROUND	VOLUME - GALS/ACRE AERIAL - HELICOPTER ONLY*	RATE NONIONIC SURFACTANT QTS/100 GALS
"Escort"	10	10	1
"Escort" + "Arsenal"	15	10	1
"Escort" + "Velpar" L	25	10	1
"Escort" + "Accord" or Roundup	10	10	2
"Escort" + "Oust"	15	10	1
PRODUCT SITE PREPARATION FOR DOUGLAS FIR	**SPRAY GROUND**	**VOLUME - GALS/ACRE AERIAL - HELICOPTER ONLY***	**RATE NONIONIC SURFACTANT QTS/100 GALS**
"Escort"	10	10	1
"Escort" + "Velpar" L	25	10	1
PRODUCT RELEASE FOR LOBLOLLY PINE	**SPRAY GROUND**	**VOLUME - GALS/ACRE AERIAL - HELICOPTER ONLY***	**RATE NONIONIC SURFACTANT QTS/100 GALS**
"Escort"	10	10 Pines established 1 yr.	1
"Escort" + Arsenal"	15	10 Pines established 2 yrs.	1
"Escort" + "Oust"	10	10 Pines established 1 yr.	0
"Escort" + "Velpar" L	25	10 Pines established 1 yr.	0

*Do not apply by air (helicopter) within 200 feet of any homestead, agricultural land or other desirable plantings.Extreme care much be taken to prevent drift or runoff to homesteads, desirable plantings, agricultural land or any body of water.Do not apply when weather conditions favor drift from treated areas.

NON-AGRICULTURAL USES

NON-AGRICULTURAL USE REQUIREMENTS

The requirements in this box apply to uses of this product that are NOT within the scope of the Worker Protection Standard for agricultural pesticides (40 CFR Part170). The WPS applies when this product is used to produce agricultural plants on farms, forests, nurseries, or greenhouses.

Non-crop industrial weed control and selective weed control in turf (industrial, unimproved only) are not within the scope of the Worker Protection Standard.

NON-CROP (INDUSTRIAL) WEED CONTROL

"Escort" is recommended for use for general weed control on non-crop, industrial sites such as airports, military installations, fence rows, roadsides and associated rights-of-ways, lumberyards, petroleum tank farms, pipeline and utility rights-of-ways, pumping installations, railroads, storage areas, plant sites and other similar areas including governmental and private lands.

When applied at lower dosage rates (as listed below), "Escort" provides short term control of weeds listed; usage at higher rates increases length and degree of weed control. Combinations with other herbicides such as 2,4-D, dicamba, Karmex® DF, Hyvar® X and Krovar® I DF increases the spectrum of weeds controlled. Bare ground objectives can be achieved with higher rates of "Escort" plus residual-type companion herbicides.

"Escort" may be applied preemergence or postemergence to the weeds, but for best results, apply postemergence to young, actively growing weeds (less than 2" tall or 2" across) at any time of the year, except when ground is frozen. For postemergence treatment add surfactant.

"Escort" should be used during seasons when rainfall normally occurs as moisture is required to move "Escort" into the root zone of weeds before they develop an established root system. Preemergence treatments control or suppress weeds through root uptake, while postemergence works through root uptake and foliar uptake. Under limited rainfall conditions, "Escort" may not provide satisfactory weed control.

Treated soils should be left undisturbed to reduce the potential for "Escort" movement by soil erosion due to wind or water. Injury to crops may occur when treated soil is blown or moved onto land used to produce crops.

Rate selection is based on weed species, weed size and soil texture. Use the higher rates on established plants and on fine textured soils, and lower rates on smaller weeds and coarse textured soils.

Since the degree of control and duration of effect will vary with the amount of chemical applied, soil texture, soil pH, soil organic matter, weed size, rainfall and other conditions, it is suggested that users limit their first use to small areas.

For broadcast spray, apply "Escort" in a minimum of 10 gallons of water per acre. Spray volumes of 20 to 40 gallons per acre and pressures of 25 to 35 psi are preferred. Use coarse spray nozzles.

Application may also be made with a hand gun using 100 to 300 gals water per acre (as needed for coverage of weed growth).

Use the following rates of "Escort" (including surfactant at 0.25% to 0.5% by volume) to control weeds listed:

1/3 to 1/2 ounce "Escort"/acre

Annual broomweed	Goldenrod
Annual sowthistle	Gumweed
Aster	Henbit
Bahiagrass	Lambsquarters
Beebalm	Marestail
Bittercress	Maximillion sunflower
Bitter sneezeweed	Miners lettuce
Blackeyed-susan	Pennsylvania smartweed
Blue mustard	Plains coreopsis
Bur buttercup	Plantain
Chicory	Redroot pigweed
Clover	Redstem filaree
Cocklebur	Rough fleabane
Common chickweed	Shepherd's purse
Common groundsel	Smallseed falseflax
Common mullein	Smooth pigweed
Common purslane	Sweet clover
Common yarrow	Tansymustard
Conical catchfly	Treacle mustard
Corn cockle	Tumble mustard
Cow cockle	Wild carrot
Crownvetch	Wild lettuce
Dandelion	Wild mustard
Dogfennel	Wooly croton
False chamomile	Wood sorrel
Fiddleneck tarweed	Yankeeweed
Field pennycress	
Flixweed	

1/2 to 1 ounce "Escort"/acre

Blackberry	Gorse
Broom snakeweed (apply fall-spring)	Common sunflower
Buckhorn plantain	Prostrate knotweed
Canada thistle*	Hoary cress (whitetop)
Curly dock	Multiflora rose and other wild roses
Dyer's woad	Rosering gaillardia

1 ounces"Escort"/acre

Perrenial Pepperweed	Teasel

1 to 2 ounces "Escort"/acre

Bull thistle	Scouringrush
Common tansy	Salsify
Field bindweed*	Snowberry
Poison hemlock	Musk thistle
Scotch thistle	

1 1/2 to 2 ounces "Escort"/acre

Dunecap larkspur	Tall larkspur

3 to 4 ounces

Kudzu

*Suppression

SPECIAL WEED PROBLEMS

Since kochia, Russian thistle and prickly lettuce are known to have biotypes resistant to "Escort", tank mixture combinations should be used involving herbicides with different modes of action such as "Karmex" DF, "Hyvar" X, and "Krovar" I DF. These weeds should not be allowed to form mature seed and should be treated postemergence with herbicides registered for control of these weeds such as 2, 4-D and dicamba.

SELECTIVE WEED CONTROL IN TURF

(INDUSTRIAL, UNIMPROVED ONLY)

"Escort" is recommended for use on unimproved industrial turf where certain grasses are well-established and desired as ground cover. An application of "Escort" may cause temporary discoloration of the grasses.

Applications can be made anytime, except when ground is frozen. Apply uniformly with properly calibrated ground equipment, using 10 to 100 gallons of spray solution per acre. Sprayer pressures of 25 to 35 psi are preferred.

Avoid overlapping and shut off spray booms while starting, turning, slowing or stopping when spraying. Extreme care must be taken to prevent drift; add a drift control agent to reduce drift use at least 10 gals water per acre.

Do not apply "Escort" to turf that is under stress from drought, insects, disease, cold temperatures or poor fertility, as injury may result.

Do not apply to turf less than 1 year old.

Do not use on bahiagrass turf , as severe injury will result.

Use the lower rates for minimum effect (chlorosis) of turf, particularly fescue and ryegrass.

Livestock may graze treated areas 0 days after application of up to and including 1 2/3 oz "Escort" per acre. Do not use on grasses grown for seed

FESCUE/BLUEGRASS: Apply 1/4 to 1/2 ounce "Escort" per acre. Sequential applications made during the same or consecutive growth periods (spring and fall) may result in excessive injury to turf. When a spring application is made a second application may be made during the summer after full seedhead maturation and the beginning of summer dormancy..

CRESTED WHEATGRASS AND SMOOTH BROME: Apply 1/4 to 1 ounce "Escort" per acre for weed control in these grasses. Some chlorosis or stunting may occur following the application.

BERMUDAGRASS: Apply 1/4 to 2 ounces "Escort" per acre for weed control.

Some chlorosis or stunting may occur following the application.

Treatments listed will control the following weeds:

1/4 to 1/3 ounce "Escort"/acre

Bittercress	Chicory
Bur buttercup	Field pennycress
Blue mustard	Redstem filaree
Chickweed	Wild carrot

1/3 to 2 ounces "Escort"/acre

(See listing under "NON-CROP WEED CONTROL")

GROWTH SUPPRESSION
***AND SEEDHEAD INHIBITION* ("Chemical Mowing")**

Fescue/Bluegrass: "Escort" is recommended for use on unimproved turf in noncropland areas for growth suppression and seedhead inhibition of well-established turf. Apply 1/4 to 1/2 ounce "Escort" after at least 2 to 3 inches of new growth has emerged until seed stalk (boot) appearance. For improved performance, apply 1/4 to 1/3 ounce "Escort" plus 1/8 to 1/4 pint "Embark" 2-S[1] per acre. Addition of a nonionic surfactant at 0.25% by volume (1 qt per 100 gals) provides maximum performance, but may temporarily increase chlorosis of turf.

SELECTIVE WEED CONTROL IN NATIVE GRASSES

BLUE GRAMA, BLUESTEMS (BIG, LITTLE, PLAINS, SAND, WW SPAR), BROMEGRASSES (MEADOW), BUFFALOGRASS, GREEN SPRANGLETOP, INDIANGRASS, KLEINGRASS, LOVEGRASSES (ATHERSTONE, SAND, WEEPING, WILMAN), ORCHARDGRASS, SIDEOATS GRAMA, SWITCHGRASS (BLACKWELL), WHEATGRASS (BLUEBUNCH, INTERMEDIATE, PUBESCENT SIBERIAN, SLENDER, STREAMBANK, TALL, THICKSPIKE, WESTERN), AND WILDRYE GRASS (RUSSIAN):

Apply 1/10 oz "Escort" in a minimum of 10 gals water per acre; add 0.25% surfactant by volume where weeds have emerged.

New Seedings

Apply preplant or preemergence where soil (seed bed) has been cultivated. Do not treat orchardgrass or Russian wildrye grass.

Established Grasses

Treat when in the seedling stage for control of:

Bur buttercup (testiculate)	Marestail*
Common purslane	Pigweed - redroot and tumble
Common sunflower*	Snow speedwell
Cutleaf eveningprimrose*	Tansymustard*
Flixweed*	Tumble mustard (Jim Hill)
Lambsquarters* - common and slimleaf	

* Weed suppression is a visual reduction in weed competition (reduced population or vigor) as compared to untreated area. Degree of suppression will vary with size of weed and environmental conditions following treatment.

BRUSH CONTROL

Foliar applications should be made after brush is fully leafed until the beginning of fall leaf coloration. Complete coverage of all foliage and stems is required for brush control. Effectiveness may be reduced if rainfall occurs within 24 hours after application.

High Volume Foliar Ground Applications: Apply as a full coverage spray to foliage, stems and limbs using up to 400 gallons of total spray per acre depending on plant species, height and density of growth and on the type of spray equipment used. On tall, dense brush, it is often necessary to spray from both sides to obtain adequate coverage. Use the following amounts of "Escort" per 100 gallons of water (include surfactant at 1 quart/100 gallons) and spray to runoff for control of:

1/2 to 1 Ounce*

Ash	Multiflora rose
Aspen	Salmonberry
Blackberry	Snowberry
Cherry	Thimbleberry
Elm	Wild roses
Hawthorn	Willow

1 to 2 Ounces*

Elder	Osage orange
Oaks	Red maple
Ocean spray (Holodiscus)	Cottonwood

* Where mixed stands occur, use the higher rate for the most difficult-to- control species.

For broader spectrum of control, "Escort" may be tank mixed with Du Pont Krenite® S, "Arsenal"[2], triclopyr or glyphosate using labeled use rates for each product.

"Escort" at 1/2 to 1 oz plus "Krenite" S at 1 1/2 to 3 gals (plus surfactant) per 100 gals water provides improved control of black cherry and red maple; do not exceed 6 gals "Krenite" S per acre.

Low Volume Foliar Ground Applications: Apply 1 to 3 ounces "Escort" per acre in 25 to 50 gals of water plus 0.25% surfactant by volume for control of ash, cherry, elm, winged elm, black locust, red oak, tuliptree and mulberry.

For improved control of black cherry and red maple, apply 1/2 to 2 ozs "Escort" plus 1-1/2 to 3 gals "Krenite" S (plus surfactant) per acre.

Spotgun Basal Soil Treatment: For control of multiflora rose, prepare a spray suspension of "Escort" using 1 ounce product per gallon of water. Mix vigorously until "Escort" is dispersed and agitate periodically while applying the spray suspension.

Apply the spray preparation with an exact-delivery hand gun applicator. This equipment delivers a thin stream of a predetermined volume when triggered. Apply at the rate of 4 milliliters for each 2 feet of rose canopy diameter. Direct the treatment to the soil within 2 feet of the stem union of the rose to be controlled. When treating large plants and more than one delivery of "Escort" dispersion is required, make applications on opposite sides of the plant.

Applications should be made from early spring to summer, when the ground is not frozen.

USE PRECAUTIONS

Do not apply to any body of water, including streams, irrigation water or wells. Do not apply where runoff water may flow onto agricultural land, as injury to crops may result.

Do not apply "Escort" during periods of intense rainfall or to water-saturated soils as off-target movement may occur.

Do not apply to impervious substrates such as paved or highly compacted surfaces nor to frozen ground as off-target movement will occur.

Do not allow spray to drift onto adjacent crops or other desirable plants or trees as injury may occur.

Do not use on lawns, golf courses, athletic fields, commercial sod operations, or other high-maintenance, fine turfgrass areas.

Do not apply this product through any type of irrigation system.

In areas where sensitive crops are grown, make applications to soils whose surface has been settled by rain. Do not treat powdery dry soil or light sandy soils, when there is little likelihood of rainfall soon after treatment, as wind may cause off-target movement.

Following an "Escort" application, do not use sprayer for application to crops. This is extremely important, as low rates of "Escort" can kill or severely injure most crops except small grains.

SPRAY PREPARATION

Fill the spray tank half full of water and, with agitator running, add the proper amount of "Escort". Finish adding the required amount of water. Continuous agitation is required to keep the product in suspension. For postemergence applications, a nonionic surfactant of at least 80% active ingredient should be added(unless specified otherwise) to improve wetting and/or contact activity. To minimize drift, a drift control agent may be added at the recommended label rate. "Escort" spray preparations may degrade in acidic solutions below pH 7 if not used in 24 hours; they are stable in alkaline solutions. Thoroughly reagitate before using. Tank mixes with other registered herbicides should be tested for compatibility before full scale mixing.

Sprayer Agitation: Use mechanical or bypass agitation to thoroughly mix the spray solution. After initial mixing, do not use excessive agitation when using a surfactant as foaming problems may result. To avoid foaming problems, use antifoam agents.

SPRAYER CLEANUP

Immediately after spraying, thoroughly remove all traces of "Escort" from mixing and spray equipment as follows:

1. Drain tank, rinse interior surfaces of tank; then flush tank, boom and hoses with clean water for a minimum of 5 minutes.
2. Partially fill the tank with clean water, then add cleaning solution*. Complete filling of the tank with clean water. Flush solution through boom, hoses, and nozzles, then allow to sit for 15 minutes with agitation running: then drain.
3. Repeat Step 2.
4. Repeat Step 1.
5. Nozzles, screens, and strainers should then be removed and cleaned separately.
6. To remove traces of cleaning solution, rinse the tank thoroughly with clean water and flush through hoses and boom.
7. Flush boom and hoses with clean water for 5 minutes just prior to using the sprayer for the first time after the "Escort" application.

* Use any of the following cleaning solutions:

1. One gallon ammonia (containing 3% active ingredient) per 100 gallons of water.
2. Nutra-sol[4] (carefully read and follow Nutra-sol label directions).
3. Loveland Spray Tank Cleaner[5] (carefully read and follow Loveland Spray Tank Cleaner label directions).
4. Tank-Aid[6] (carefully read and follow Tank-Aid label directions).

CAUTION: Do not use chlorine bleach with ammonia. All traces of liquid fertilizer containing ammonia, ammonium nitrate or ammonium sulphate must be rinsed with water from the mixing and application equipment before adding chlorine beach solution. Failure to do so will release a gas with a musty chlorine odor which can cause eye, nose, throat and lung irritation. Do not clean equipment in an enclosed area.

STORAGE AND DISPOSAL

Storage: Store product in original container only. Do not contaminate water, other pesticides, fertilizer, food or feed in storage.

Product Disposal: Do not contaminate water, food or feed by disposal or cleaning of equipment. Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.

Container Disposal: Triple rinse (or equivalent) the container and then offer for recycling or reconditioning, or puncture and dispose of in a sanitary land fill, or by incineration, or, if allowed by state and local authorities, by burning. If burned, stay out of smoke.

NOTICE TO BUYER: Purchase of this material does not confer any rights under patents of countries outside of the United States.

NOTICE OF WARRANTY

Du Pont warrants that this product conforms to the chemical description on the label thereof and is reasonably fit for purposes stated on such label only when used in accordance with directions under normal use conditions. It is impossible to eliminate all risks inherently associated with the use of this product. Crop injury, ineffectiveness, or other unintended consequences may result because of such factors as weather conditions, presence of other materials, or the manner of use or application, all of which are beyond the control of Du Pont. In no case shall Du Pont be liable for consequential, special or indirect damages resulting from the use or handling of this product. All such risks shall be assumed by the buyer. DU PONT MAKES NO WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE NOR ANY OTHER EXPRESS OR IMPLIED WARRANTY EXCEPT AS STATED ABOVE.

[1] Registered trademark of PBI-Gordon Corp.

[2] Registered trademark of American Cyanamid Company.

[3] Registered trademark of Monsanto Company

[4] Sold by Thomas G. Kilfoil

[5] Registered trademark of Loveland Tank Cleaner

[6] Manufactured for Cornbelt Chemical Company

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DUPONT®

Oust®

herbicide

®

"......... A Growing Partnership With Nature"

“OUST” HERBICIDE HIGHLIGHTS

- OUST is recommended for preemergence and postemergence control of many annual and perennial grasses and broadleaf weeds.
- OUST is recommended for conifer and hardwood site preparation and release; applications may be made by ground equipment or helicopter.
- OUST is recommended for general weed control in noncrop industrial sites; applications must be made using ground equipment.
- For best results, apply postemergence to young, actively growing weeds under favorable moisture conditions at any time of the year, except when the ground is frozen.
- Do not apply more than 8 oz per acre per year.
- Use a drift control agent when spraying near cropland, open water, or desirable vegetation.
- OUST can be tank mixed with other herbicides for use in forestry and noncrop sites; when tank mixing, use the most restrictive limitations from labeling of both products.
- Consult label text for complete instructions. Always read and follow label directions for use.

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Oust®

herbicide

Dispersible Granules

Active Ingredient	*By Weight*
Sulfometuron methyl {Methyl 2-[[[[(4,6-dimethyl-2-pyrimidinyl)amino]-carbonyl]amino] sulfonyl]benzoate}	75%
Inert Ingredients	*25%*
TOTAL	100%

EPA Reg. No. 352-401

KEEP OUT OF REACH OF CHILDREN

CAUTION

STATEMENT OF PRACTICAL TREATMENT

IF IN EYES: Flush eyes with plenty of water. Call a physician if irritation persists.

For medical emergencies involving this product, call toll free 1-800-441-3637.

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS AND DOMESTIC ANIMALS

CAUTION! Causes (moderate) eye injury (irritation). Avoid contact with eyes or clothing.

PERSONAL PROTECTIVE EQUIPMENT

Applicators and other handlers must wear:

Long-sleeved shirt and long pants.
Shoes plus socks.

Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

USER SAFETY RECOMMENDATIONS

USERS SHOULD: Wash hands before eating, drinking, chewing gum, using tobacco or using the toilet.

ENVIRONMENTAL HAZARDS

Do not apply directly to water, or to areas where surface water is present, or to intertidal areas below the mean high water mark. Do not contaminate water by cleaning of equipment or disposal of equipment washwaters.

GENERAL INFORMATION

DuPont OUST® Herbicide is a dispersible granule that is mixed in water and applied as a spray. OUST controls many annual and perennial grasses and broadleaf weeds in forestry and noncrop sites.

OUST may be used for general weed control on industrial noncrop sites and for selective weed control in certain types of unimproved turf grasses on industrial sites. It can also be used for selective weed control in forest site preparation and in the release of several types of pines and certain hardwoods.

OUST controls weeds by both preemergence and postemergence activity. Preemergence treatments control or suppress weeds through root uptake while postemergence control works through root and foliar uptake. The best results are obtained when the application is made before or during the early stages of weed growth before weeds develop an established root system. Moisture is required to move OUST into the root zone of weeds for preemergence control. When rainfall is low, OUST may not provide satisfactory control.

It is noncorrosive, nonflammable, nonvolatile, and does not freeze.

For best postemergence results, apply OUST to young, actively growing weeds. The use rate depends upon the weed species, weed size at application, and soil texture. The degree and duration of control may depend on the following:

- weed spectrum and infestation intensity
- weed size at application
- environmental conditions at and following treatment
- soil pH, soil moisture, and soil organic matter

Use a high rate on established plants and on fine-textured soils and a lower rate on smaller weeds and coarse-textured soils.

ENVIRONMENTAL CONDITIONS AND BIOLOGICAL ACTIVITY

OUST is absorbed by both the roots and foliage of plants, rapidly inhibiting the growth of susceptible weeds. Two to 3 weeks after application to weeds, leaf growth slows, and the growing points turn reddish-purple. Within 4 to 6 weeks of application, leaf veins and leaves become discolored, and the growing points subsequently die.

Warm, moist conditions following application accelerate the herbicidal activity of OUST; cold, dry conditions delay the herbicidal activity. In addition, weeds hardened-off by drought stress are less susceptible to OUST.

Rainfall is needed to move OUST into the soil for preemergence weed control, but postemergence weed control may be reduced if rainfall occurs too soon after application.

RESISTANCE

When herbicides with the same mode of action are used repeatedly over several years to control the same weed species in the same field, naturally-occurring resistant weed biotypes may survive a correctly applied herbicide treatment, propagate, and become dominant in that field. These resistant weed biotypes may not be adequately controlled. Cultural practices such as tillage, preventing weed escapes from going to seed, and using herbicides with different modes of action within and between crop seasons can aid in delaying the proliferation and possible dominance of herbicide resistant weed biotypes.

DIRECTIONS FOR USE

It is a violation of federal law to use this product in a manner inconsistent with its labeling.

OUST should be used only in accordance with recommendations on this label or in separately published DuPont recommendations.

DuPont will not be responsible for losses or damages resulting from the use of this product in any manner not specifically recommended by DuPont. User assumes all risks associated with such nonrecommended use.

Do not use on food or feed crops.

Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application. For any requirements specific to your State or Tribe, consult the agency in your State responsible for pesticide regulation.

AGRICULTURAL USES

AGRICULTURAL USE REQUIREMENTS

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR part 170. This Standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment(PPE) and restricted-entry interval. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard.

Do not enter or allow worker entry into treated areas during the restricted entry interval (REI) of 4 hours.

PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water, is:

Coveralls.
Waterproof gloves.
Shoes plus socks.

FORESTRY

Application Information

OUST is recommended to control many broadleaf weeds and grasses in forestry sites. Apply by ground equipment or by air (helicopter only).

Application Timing

Apply OUST before herbaceous weeds emerge or shortly thereafter. Apply only during seasons when rainfall is sufficient to activate the herbicide in the soil.

Weeds Controlled

OUST effectively controls the following weeds when applied at the use rates indicated for the respective crop species:

Chickweed	Nutsedge (yellow)
Crabgrass	Panicums (broadleaf, fall, narrow)
Dogfennel	Pokeweed
Fescue	Ragweed
Fireweed (willowweed)	Shepherd's purse
Goldenrod	White snakeroot
Horseweed	Yellow sweetclover
Kentucky bluegrass	

See also weeds controlled under **Application Information—Noncrop (Industrial) Sites**

Application Rates

Apply OUST at the rates indicated by region. Use a low rate on coarse-textured soils (i.e., loamy sands, sandy loams) and a higher rate on fine-textured soils (i.e. sandy clay loams and silty clay loams).

CONIFERS

Conifer Site Preparation —Application Before Transplanting

Make all applications before transplanting to control herbaceous weeds.

Southeast—Apply 2 to 8 oz per acre for loblolly, longleaf, slash, and Virginia pine. Transplant longleaf pine at least 60 days after treatment.

Northeast and Lake States—Apply 2 to 4 oz per acre for black spruce. Transplant at least 13 months after treatment.

Apply 2-1/2 to 4 oz OUST plus Accord[1] (as registered) for larch and tamarack. Transplant the following spring or summer but not less than 8 months after treatment.

West—Apply 2 to 4 oz per acre for coastal redwood, Douglas fir, grand fir, lodgepole pine, ponderosa pine, western larch, western white pine, and white fir. For ponderosa pine in California and other arid areas, apply in the fall and transplant the following spring.

Conifer Release —Application After Transplanting

Apply OUST after transplanting to control herbaceous weeds.

Southeast—Apply 2 to 8 oz per acre for loblolly, longleaf, slash or Virginia pine. Apply 1 to 1 1/2 oz per acre for eastern white pine.

Tank Mix Combinations (Southeast only)—To control a broader spectrum of weeds in stands of loblolly, longleaf, or slash pine, apply 2 to 4 oz of OUST plus 2 to 3 pt of DuPont Velpar L Herbicide or 2/3 to 1 lb of DuPont Velpar DF Herbicide. Tank mix may injure or kill trees when applied during high humidity and temperature.

To enhance control of bermudagrass and Johnsongrass in stands of loblolly pine, apply 2 oz of OUST plus 4 to 6 fl oz of Arsenal[2] Applicators Concentrate. For the best results, make the application during late winter through spring when weeds first emerge. Arsenal may temporarily inhibit pine growth if it is applied when pine is actively growing.

For control of many annual weeds particularly on cropland conversion areas, apply 2 to 4 oz of OUST plus 4 to 8 pt of Aatrex[3] 4L per acre. Use the higher rates on medium to fine texture soils where organic matter exceeds 2%. Use only on tree species specifically listed on both the OUST and "Aatrex 4L" labels.

Northeast and Lake States—Apply 2 to 8 oz per acre for jack or Virginia pine. Apply 1 to 1-1/2 oz per acre for eastern white pine. Apply 1-1/2 to 3 oz per acre for white spruce. Make applications when trees are dormant. Applications at budbreak and later stages of active growth may severely injure or kill trees.

West—Apply 2 to 4 oz per acre for coastal redwood, Douglas fir, grand fir, lodgepole pine, ponderosa pine, western larch, or western white pine. Applications made after dormancy break in the spring and before the final resting bud has hardened in the fall may severely injure or kill trees. For ponderosa pine in California and other arid areas, treatments applied over the top of transplant stock in the first year outplanted should be made in the fall, following transplanting in the spring after the final resting bud has hardened, or the following spring (second year outplanted).

HARDWOODS

Hardwood Site Preparation —Application Before Transplanting

Apply 3 to 5 oz on sites where northern red oak, white oak, chestnut oak, American sycamore, ash (white or green), red maple, sweetgum, or yellow poplar are to be planted. Make all applications before transplanting.

Hardwood Release —Application After Transplanting

Apply 1 to 4 oz per acre in stands of American sycamore, ash (white or green), bald cypress, oaks (such as chestnut, northern red, southern red, overcup, pin, swamp chestnut, cherrybark, water, white, pin, etc.), red maple, sweetgum, or yellow poplar.

OUST should be applied before the hardwood tree seedlings or transplants break dormancy (bud swell stage). Applications made over the top after the trees have broken dormancy may injure or kill the trees.

IMPORTANT PRECAUTIONS—FORESTRY ONLY

- Applications of OUST made to trees, conifers, or hardwoods that are suffering from loss of vigor caused by insects, diseases, drought, winter damage, animal damage, excessive soil moisture, planting shock, or other stresses, may injure or kill the trees.
- Applications of OUST made for release (trees present) should only be made after adequate rainfall has closed the planting slit and settled the soil around the roots following transplanting.
- Do not apply OUST to conifers or hardwoods grown for Christmas trees or ornamentals.

- If a surfactant is used with OUST, allowing the spray to contact tree foliage may injure or kill trees. The user assumes all responsibility for tree injury if a surfactant is used with OUST treatments applied after planting.
- OUST applications may result in damage and mortality to other species of trees when they are present on sites with those listed in the preceding recommendations for forestry uses.
- Use on hardwood trees growing in soils having a pH of 7 or greater may injure or kill the trees.
- Careful consideration must be given by an experienced and knowledgeable forester to match the requirements of the hardwood tree species to the conditions of the site. Treatment of species mismatched to the site may injure or kill the trees.
- OUST is not recommended for use on poorly drained or marshy sites, but it may be used where plantings are on raised beds.

NON-AGRICULTURAL USES

NON-AGRICULTURAL USE REQUIREMENTS

The requirements in this box apply to uses of this product that are NOT within the scope of the Worker Protection Standard for agricultural pesticides (40 CFR Part170). The WPS applies when this product is used to produce agricultural plants on farms, forests, nurseries, or greenhouses.

Selective non-crop industrial weed control and weed control in turf(industrial, unimproved only) are not within the scope of the Worker Protection Standard.

NONCROP (INDUSTRIAL) SITES

Application Information

OUST is recommended for use for general weed control on noncrop, industrial sites such as airports, military installations, fence rows, roadsides and associated rights-of-way, lumberyards, petroleum tank farms, pipeline and utility rights-of-way, pumping installations, railroads, storage areas, plant sites, and other similar areas including governmental and private lands. Apply by ground equipment only unless directed otherwise by supplemental labeling.

Combination with other herbicides broadens the spectrum of weeds controlled. In addition, total vegetation control can be achieved with higher rates of OUST plus residual-type companion herbicides. To improve the control of weeds, add surfactant at 0.25% by volume.

AREAS OF 20" OR LESS ANNUAL RAINFALL (ARID AREAS)

Application Timing

Apply OUST as a preemergence or early postemergence spray during the rainy season when weeds are actively germinating or growing.

Weeds Controlled

OUST effectively controls the following broadleaf weeds and grasses when applied at the rates shown.

Application Rates

Apply OUST at the rates indicated by weed type. When applied at lower rates, OUST provides short-term control of weeds listed; when applied at higher rates, weed control is extended.

Broadleaf Weeds—1-1/3 to 2 oz per acre

Annual sowthistle	Common yarrow
Black mustard	Curly dock
Buckhorn plantain	Prickly coontail
Burclover	Seaside heliotrope
Carolina geranium	Spreading orach
Chickweed	Sunflower
Common mallow	Western ragweed
Common speedwell	Whitestem filaree

Grasses (up to 6 to 12" tall)—1-1/3 to 2 oz per acre

Annual bluegrass	Red brome
Barnyardgrass	Reed Canarygrass
Cheat	Ripgut brome
Foxtail barley	Seashore saltgrass
Foxtail fescue	Signalgrass
Italian ryegrass	Yellow foxtail
Jointed goatgrass	

Grasses —2 to 3 oz per acre

Smooth brome

The weeds listed in **Areas Of 20" Or More Annual Rainfall** can also be controlled in arid areas; however, OUST must be applied at 3 to 8 oz per acre to control those weeds. These higher rates also provide control of severe infestations and longer term control of weeds listed for arid areas.

AREAS OF 20" OR MORE ANNUAL RAINFALL

Application Timing

Apply OUST as a preemergence or early postemergence spray during the rainy season when weeds are actively germinating or growing.

Weeds Controlled

OUST effectively controls the following broadleaf weeds and grasses when applied at the rates shown.

Application Rates

Apply OUST at the rates indicated by weed type. When applied at lower rates, OUST provides short term control of weeds listed; when applied at higher rates, weed control is extended.

Broadleaf Weeds—3 to 5 oz per acre

Bouncingbet	Pigweed
Burclover	Purple starthistle
Carolina geranium	Ragweed
Common chickweed	Sowthistle (annual)
Common dandelion	Sunflower
Common speedwell	Sweet clover
Common yarrow	Tansymustard
Crimson clover	Tansy ragwort
Dogfennel	Tumble mustard
Hoary cress (whitetop)	Vetch
Little mallow	Wild carrot
Mustard	Wild oats
Ox-eye daisy	Yellow rocket
Pepperweed	

Broadleaf Weeds—6 to 8 oz per acre

Bedstraw	Horsetail (Equisetum)
Canada thistle	Kudzu
Curly dock	Musk thistle
Redstem filaree	Turkey mullein
Goldenrod	Wild blackberry

Grasses—3 to 5 oz per acre

Alta fescue	Kentucky bluegrass
Annual bluegrass	Little barley
Annual ryegrass	Red brome
Bahiagrass	Red fescue
Barnyardgrass	Reed canarygrass
Downy brome	Ripgut brome
Fescue	Ryegrass
Foxtails (except green)	Smooth brome
Foxtail barley	Sprangletop (annual)
Indiangrass	Wheat (volunteer)
Italian ryegrass	

Grasses—6 to 8 oz per acre

Johnsongrass

For short-term (up to 3 months) control of johnsongrass, apply early postemergence. Repeat treatment if additional control is desired or if regrowth occurs.

Note: Use the higher level of recommended dosage ranges under the following conditions:

- heavy weed growth
- soils containing more than 2-1/2% organic matter
- high soil moisture areas, such as along road edges or railroad shoulders

Specific Weed Problems —Noncrop (Industrial) Sites

Kochia, Russian Thistle, and Prickly Lettuce

Since biotypes of kochia, Russian thistle, and prickly lettuce are known to be resistant to OUST, tank mixture combinations with herbicides having different modes of action, such as KARMEX DF, HYVAR X or KROVAR I DF, must be used. In areas where resistance is known to exist, these weeds should be treated postemergence with other herbicides registered for their control, such as 2,4-D or dicamba. Do not allow kochia, Russian thistle, or prickly lettuce to form mature seed.

TANK MIX COMBINATIONS

To improve preemergence to early postemergence control of weeds and grasses, add 2 to 8 oz of OUST per acre to the recommended rates of the following herbicides: DuPont HYVAR® X Herbicide, DuPont KARMEX® DF Herbicide, DuPont KROVAR® I DF Herbicide, DuPont VELPAR® L Herbicide, DuPont VELPAR® Herbicide, DuPont ESCORT® Herbicide (do not use in California), DuPont TELAR® Herbicide, glyphosate, dicamba, or 2,4-D.

Apply OUST plus a companion herbicide at the rates and timing as shown on package labels for target weeds. For application method and other use specifications, use the most restrictive directions for the intended combination.

Do not tank mix OUST with DuPont HYVAR® XL Herbicide.

UNDER ASPHALT AND CONCRETE PAVEMENT

Application Information

OUST can be used to control weeds under asphalt and concrete pavement, such as that used in parking lots, highway shoulders, median strips, roadways, and other industrial sites.

OUST will not control tubers, rhizomes, woody vegetation such as small trees, brush or woody vines.

OUST should only be used in an area that has been prepared according to good construction practices. Use sufficient water to ensure uniform coverage, generally 100 gal per acre. Agitate the tank continuously to keep OUST in suspension.

Application Timing

OUST should be applied immediately before paving to avoid lateral movement of the herbicide as a result of soil movement due to rainfall or mechanical means.

Application Rate

Apply OUST at 4 to 8 oz per acre. Use a higher rate on hard-to-control weeds and for long-term control.

Tank Mix Combinations —Under Asphalt and Concrete Pavement

For broader spectrum control or for an extended period of control under asphalt or concrete pavement, OUST may be applied as a tank mix with HYVAR X at 6 to 15 lb per acre or KROVAR I DF at 7 to 15 lb per acre.

IMPORTANT PRECAUTIONS—UNDER ASPHALT ONLY

- Do not use OUST under pavement in residential properties such as driveways, or in recreational areas, including jogging or bike paths, tennis courts, or golf cart paths.
- Desirable plants may be injured if their roots extend into treated areas or if planted in treated areas.

TURF, INDUSTRIAL (UNIMPROVED ONLY)

Application Information

OUST is recommended to control weeds on unimproved industrial turf, on roadsides, or on other noncrop sites where the turf is well established as a ground cover. Applications may temporarily suppress grass growth and inhibit seedhead formation (chemical mowing).

Bermudagrass Release

Application Timing

Apply OUST after bermudagrass has broken dormancy and is well established, usually 30 days after initial spring flush. If additional applications are necessary, apply OUST again during late spring to early summer. On established weeds, apply OUST 1 to 2 weeks after mowing for the best results.

OUST may also be applied in late fall or early winter. Use the lower rates on small seedling weeds and a higher rate on larger weeds. Also, refer to the listing of Weeds Controlled under Noncrop (Industrial) Weed Control.

Weeds Controlled

OUST may be used to control the following weeds when applied at the use rates shown.

Late Spring to Early Summer—1 to 2 oz/acre

Carolina Geranium	Goldenrod
Fescue	Spotted Spurge
Foxtail	Wild carrot

Spring to Fall—2 to 3 oz/acre

Johnsongrass

Late Fall to Early Winter—1 to 4 oz/acre

Carolina geranium	Little barley
Common chickweed	Wild blackberry
Fescue	

Tank Mix Combinations—Bermudagrass (South Only)

Apply 1 to 2 oz OUST per acre as a tank mix with 3 to 4 lb active ingredient of MSMA per acre on well-established bermudagrass during the summer. Refer to the MSMA package label for a list of additional weeds that may be controlled. Two or more sequential applications of MSMA alone may be necessary to maintain weed control.

Centipedegrass Release

Application timing

Apply 1 to 2 ounces of OUST in the fall or early winter, or in the early summer following greenup of the centipede. Refer to the listing of Weeds Controlled under Bermudagrass Release.

Bahiagrass Release and Seedhead Suppression

Application Timing

Apply 1/2 to 1 oz OUST per acre to turf after green-up and before seedheads emerge (boot stage). Ensure that desirable grasses are well-established at application, as premature treatment may result in top kill and stand reduction of desirable turf. Make only one application per year.

Smooth Brome and Crested Wheatgrass Release and Suppression

Application Timing

Apply 1 oz OUST per acre to turf after green-up and before seedheads emerge (boot stage). Ensure that desirable grasses are well-established at application, as premature treatment may result in top kill and stand reduction of desirable turf. Make only one application per year.

Weeds Controlled

OUST may be used to control the following weeds when applied at the use rates shown.

Late Spring to Early Summer—1 oz/acre

Downy Brome	Goldenrod
Foxtail	

IMPORTANT PRECAUTIONS —INDUSTRIAL, UNIMPROVED TURF

- Excessive injury to turf may result if a surfactant is used with OUST applications made to actively growing turf. The user assumes all responsibility for turf injury if a surfactant is used with OUST treatments applied to actively growing turf.
- OUST may temporarily discolor or cause top kill of turf grasses. Applications made while turf is dormant may delay green-up in the spring.
- Annual retreatments may reduce vigor, particularly at the higher recommended rates, where bahiagrass, crested wheatgrass and smooth brome are grown.
- OUST application on turf that is under stress from drought, insects, disease, cold temperatures or late spring frost, may result in injury.
- Do not apply OUST to turf within 1 year of planting as stand reduction may result.

SPRAY EQUIPMENT

Following an OUST application, do not use sprayer for application to agricultural or ornamental crops. The mixing and application equipment must be used for forestry and noncrop applications only. This is extremely important as low rates of OUST can kill or severely injure most crops.

BROADCAST APPLICATION

Ground

Use 15 to 40 gal of water per acre when applying OUST as a broadcast application. Select a spray volume and delivery system that will ensure thorough coverage and a uniform spray pattern. Be sure the sprayer is calibrated before use. Avoid overlapping and shut off spray booms while starting, turning, slowing, or stoping to avoid injury to desired species.

Air (Helicopter Only)

Use 5 to 15 gal of water per acre when applying OUST. Select a spray volume and delivery system that will ensure thorough coverage and a uniform spray pattern. Do not use fixed-wing aircaft. Be sure the sprayer is calibrated. Avoid overlapping and shut off spray booms while starting, turning or slowing to avoid injury to desired species.

MIXING INSTRUCTIONS

1. Fill spray tank 1/2 full of water.
2. With the agitator running, add the proper amount of OUST.
3. If using a companion product, add the recommended amount.
4. For postemergent applications, add the proper amount of spray adjuvants (i.e. surfactants, drift control agents, etc.).
5. Add the remaining water.
6. Agitate the spray tank thoroughly.

Use the spray preparation within 24 hours to avoid product degradation. If the spray preparation is left standing, agitate it thoroughly before using.

SPRAYER CLEANUP

Thoroughly clean all mixing and spray equipment following applications of OUST as follows:

1. Drain tank; thoroughly rinse spray tanks, boom, and hoses with clean water.
2. Fill the tank with clean water and 1 gal of household ammonia (contains 3% active) for every 100 gal of water. Flush the hoses, boom, and nozzles with the cleaning solution. Then add more water to completely fill the tank. Circulate the cleaning solution through the tank and hoses for at least 15 min. Flush the hoses, boom, and nozzles again with the cleaning solution, and then drain the tank.

   Equivalent amounts of an alternate-strength ammonia solution or a commercial cleaner can be used in the cleanout procedure. If a commercial cleaner is used, carefully read and follow the individual cleaner instructions.
3. Remove the nozzles and screens and clean separately in a bucket containing cleaning agent and water.
4. Repeat step 2.
5. Rinse the tank, boom, and hoses with clean water.
6. Dispose of the rinsate on a labeled site or at an approved waste disposal facility. If a commercial cleaner is used follow the directions for rinsate disposal on the label.

Notes:

1. **Caution:** Do not use chlorine bleach with ammonia as dangerous gases will form. Do not clean equipment in an enclosed area.
2. Steam-cleaning aerial spray tanks is recommended before performing the above cleanout procedure to facilitate the removal of any caked deposits.
3. When OUST is tank mixed with other pesticides, all required cleanout procedures should be examined and the most rigorous procedure should be followed.

SPRAY DRIFT MANAGEMENT

The interaction of many equipment and weather-related factors determines the potential for spray drift. The applicator is responsible for considering all these factors when making application decisions.

AVOIDING SPRAY DRIFT IS THE RESPONSIBILITY OF THE APPLICATOR.

IMPORTANCE OF DROPLET SIZE

The most effective way to reduce drift potential is to apply large droplets (>150 - 200 microns). The best drift management strategy is to apply the largest droplets that provide sufficient coverage and control. The presence of sensitive species nearby, the environmental conditions, and pest pressure may affect how an applicator balances drift control and coverage. APPLYING LARGER DROPLETS REDUCES DRIFT POTENTIAL, BUT WILL NOT PREVENT DRIFT IF APPLICATIONS ARE MADE IMPROPERLY OR UNDER UNFAVORABLE ENVIRONMENTAL CONDITIONS! See **Wind**, **Temperature and Humidity**, and **Temperature Inversions** sections of this label.

Controlling Droplet Size - General Techniques

- **Volume** - Use high flow rate nozzles to apply the highest practical spray volume. Nozzles with higher rated flows produce larger droplets.
- **Pressure** - Use the lower spray pressures recommended for the nozzle. Higher pressure reduces droplet size and does not improve canopy penetration. WHEN HIGHER FLOW RATES ARE NEEDED, USE A HIGHER-CAPACITY NOZZLE INSTEAD OF INCREASING PRESSURE.
- **Nozzle Type** - Use a nozzle type that is designed for the intended application. With most nozzle types, narrower spray angles produce larger droplets. Consider using low-drift nozzles.

Controlling Droplet Size - Aircraft

- **Number of Nozzles** - Use the minimum number of nozzles with the highest flow rate that provide uniform coverage.
- **Nozzle Orientation** - Orienting nozzles so that the spray is emitted backwards, parallel to the airstream will produce larger droplets than other orientations.
- **Nozzle Type** - Solid stream nozzles (such as disc and core with swirl plate removed) oriented straight back produce larger droplets than other nozzle types.

BOOM LENGTH AND HEIGHT

- **Boom Length (aircraft)** - For helicopters use a boom length and position that prevents droplets from entering the rotor vortices.
- **Boom Height (aircraft)** - Application more than 10 ft above the canopy increases the potential for spray drift.
- **Boom Height (ground)** Setting the boom at the lowest labeled height (if specified) which provides uniform coverage reduces the exposure of droplets to evaporation and wind. The boom should remain level with the crop and have minimal bounce.

WIND

Drift potential increases at wind speeds of less than 3 mph (due to variable direction and inversion potential) or more than 10 mph. However, many factors, including droplet size and equipment type determine drift potential at any given wind speed. AVOID GUSTY OR WINDLESS CONDITIONS.

Note: Local terrain can influence wind patterns. Every applicator should be familiar with local wind patterns and how they effect spray drift.

TEMPERATURE AND HUMIDITY

When making applications in hot and dry conditions, set up equipment to produce larger droplets to reduce effects of evaporation.

SURFACE TEMPERATURE INVERSIONS

Drift potential is high during a surface temperature inversion. Surface inversions restrict vertical air mixing, which causes small suspended droplets to remain close to the ground and move laterally in a concentrated cloud. Surface inversions are characterized by increasing temperature with altitude and are common on nights with limited cloud cover and light to no wind. They begin to form as the sun sets and often continue into the morning. Their presence can be indicated by ground fog; however, if fog is not present, inversions can also be identified by the movement of smoke from a ground source or an aircraft smoke generator. Smoke that layers and moves laterally in a concentrated cloud (under low wind conditions) indicates a surface inversion, while smoke that moves upward and rapidly dissipates indicates good vertical air mixing.

SHIELDED SPRAYERS

Shielding the boom or individual nozzles can reduce the effects of wind. However, it is the responsibility of the applicator to verify that the shields are preventing drift and not interfering with uniform deposition of the product.

IMPORTANT PRECAUTIONS

Injury to or loss of desirable trees or other plants may result from failure to observe the following:

- If equipment is drained or flushed on or near desirable trees or other plants, or on areas where their roots may extend, or in locations where the chemical may be washed or moved into contact with their roots.
- Treatment of powdery, dry soil or light, sandy soil when there is little likelihood of rainfall soon after treatment may result in off target movement and possible damage to susceptible crops when soil particles are moved by wind or water. Injury to crops may result if treated soil is washed, blown, or moved onto land used to produce crops. Exposure to OUST may injure or kill most crops. Injury may be more severe when the crops are irrigated.
- Applications made where runoff water flows onto agricultural land may injure crops. Applications made during periods of intense rainfall, to soils saturated with water, surfaces paved with materials such as asphalt or concrete, or soils through which rainfall will not readily penetrate may result in runoff and movement of OUST. Do not treat frozen soil. Treated soil should be left undisturbed to reduce the potential for OUST movement by soil erosion due to wind or water.

Do not use on lawns, walks, driveways, tennis courts, or similar areas.

Keep from contact with fertilizers, insecticides, fungicides, and seeds.

Do not apply in or on irrigation ditches or canals including their outer banks.

Do not apply through any type of irrigation system.

Do not use the equipment used to mix or apply OUST on crops. The mixing and application equipment may be used for forestry and noncrop applications only.

If noncrop or forested sites treated with OUST are to be converted to a food, feed, or fiber agricultural crop, or to a horticultural crop, do not plant the treated sites for at least one year after the OUST application. To avoid damage to crops planted in these areas, and to ensure complete OUST dissipation in treated sites, soil samples should be quantitatively analyzed, and a bioassay should be conducted before planting.

Do not use this product in the following counties of Colorado: Saguache, Rio Grande, Alamosa, Costilla and Conejos.

STORAGE AND DISPOSAL

STORAGE: Store product in original container only. Do not contaminate water, other pesticides, fertilizer, food or feed in storage.

PRODUCT DISPOSAL: Do not contaminate water, food or feed by disposal. Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.

CONTAINER DISPOSAL: Triple rinse (or equivalent) the container. Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or by incineration, or, if allowed by state and local authorities, by burning. If burned, stay out of smoke.

NOTICE TO BUYER: Purchase of this material does not confer any rights under patents of countries outside of the United States.

LIMITATION OF WARRANTY AND LIABILITY

NOTICE: Read This Limitation of Warranty and Liability Before Buying or Using This Product. If the Terms Are Not Acceptable, Return the Product at Once, Unopened, and the Purchase Price Will Be Refunded.

It is impossible to eliminate all risks associated with the use of this product. Such risks arise from weather conditions, soil factors, off target movement, unconventional farming techniques, presence of other materials, the manner of use or application, or other unknown factors, all of which are beyond the control of DuPont. These risks can cause: ineffectiveness of the product; crop injury, or; injury to non-target crops or plants.

DuPont does not agree to be an insurer of these risks. WHEN YOU BUY OR USE THIS PRODUCT, YOU AGREE TO ACCEPT THESE RISKS.

DuPont warrants that this product conforms to the chemical description on the label thereof and is reasonably fit for the purpose stated in the Directions for Use, subject to the inherent risks described above, when used in accordance with the Directions for Use under normal conditions.

DUPONT MAKES NO OTHER EXPRESS OR IMPLIED WARRANTY OF FITNESS OR OF MERCHANTABILITY OR ANY OTHER EXPRESS OR IMPLIED WARRANTY.

IN NO EVENT SHALL DUPONT OR SELLER BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL OR SPECIAL DAMAGES RESULTING FROM THE USE OR HANDLING OF THIS PRODUCT. BUYER'S OR USER'S BARGAINED-FOR EXPECTATION IS CROP PROTECTION. THE EXCLUSIVE REMEDY OF THE USER OR BUYER AND THE EXCLUSIVE LIABILITY OF DUPONT OR SELLER, FOR ANY AND ALL CLAIMS, LOSSES, INJURIES OR DAMAGES (INCLUDING CLAIMS BASED ON BREACH OF WARRANTY OR CONTRACT, NEGLIGENCE, TORT OR STRICT LIABILITY), WHETHER FROM FAILURE TO PERFORM OR INJURY TO CROPS OR OTHER PLANTS, AND RESULTING FROM THE USE OR HANDLING OF THIS PRODUCT, SHALL BE THE RETURN OF THE PURCHASE PRICE OF THE PRODUCT, OR AT THE ELECTION OF DUPONT OR SELLER, THE REPLACEMENT OF THE PRODUCT.

DuPont or its Ag Retailer must have prompt notice of any claim so that an immediate inspection of buyer's or user's growing crops can be made. Buyer and all users shall promptly notify DuPont or a DuPont Ag Retailer of any claims, whether based on contract, negligence, strict liability, other tort or otherwise or be barred from any remedy.

This Limitation of Warranty and Liability may not be amended by any oral or written agreement.

1 Registered trademark of Monsanto Company

2 Registered trademark of American-Cyanamide Company

3 Registered trademark of Ciba-Geigy Corporation.

SL - 628 9048 3/27/98

For product information call 1-888-6-DUPONT

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DUPONT®

Velpar® ULW

herbicide

®

"......... A Growing Partnership With Nature"

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Velpar® ULW

herbicide

Soluble Granules

Active Ingredient	*By Weight*
Hexazinone [3-cyclohexyl-6-(dimethylamino) -1-methyl-1,3,5-triazine-2,4(1H,3H)-dione]	75%
Inert Ingredients	25%
TOTAL	100%

EPA Reg. No. 352-450

KEEP OUT OF REACH OF CHILDREN

DANGER PELIGRO

Si usted no entiende la etiqueta, busque a alguien para que se la explique a usted en detalle. (If you do not understand this label, find someone to explain it to you in detail.)

STATEMENT OF PRACTICAL TREATMENT

IF IN EYES: Hold eyelids open and flush with steady, gentle stream of water for 15 minutes. Get medical attention.

IF ON SKIN: Wash with plenty of soap and water. Get medical attention if irritation persists.

IF SWALLOWED: Call a physician or poison control center. Do not induce vomiting. Drink promptly a large quantity of milk, egg whites, gelatin solution or if these are not available, drink large quantities of water. Avoid alcohol.

NOTE TO PHYSICIAN: Probable mucosal damage may contraindicate the use of gastric lavage.

For medical emergencies involving this product, call toll free 1-800-441-3637.

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS AND DOMESTIC ANIMALS

DANGER! CAUSES EYE DAMAGE.

Corrosive, causes irreversible eye damage. Harmful if swallowed. Do not get in eyes or on clothing. Wash thoroughly with soap and water after handling.

PRECAUTIONARY STATEMENTS(continued)

PERSONAL PROTECTIVE EQUIPMENT

Applicators and other handlers must wear:

Long-sleeved shirt and long pants.
Waterproof gloves.
Shoes plus socks.
Protective eyewear.

Discard clothing and other absorbent materials that have been drenched or heavily contaminated with this product's concentrate. Do not reuse them. Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

USER SAFETY RECOMMENDATIONS

USERS SHOULD: Wash hands before eating, drinking, chewing gum, using tobacco or using the toilet.

ENVIRONMENTAL HAZARDS

Do not apply directly to water, or to areas where surface water is present, or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment washwaters.

The active ingredient, hexazinone, in this product is known to leach through soil into ground water under certain conditions as a result of agricultural use. Use of this chemical in areas where soils are permeable, particularly where the water table is shallow, may result in ground-water contamination.

GENERAL INFORMATION

DuPont VELPAR® ULW Herbicide is a special granular product that is used to control undesirable woody and herbaceous plants in reforestation and noncrop sites. It is applied dry to the soil surface in a broadcast pattern.

Velpar ULW is noncorrosive to equipment.

ENVIRONMENTAL CONDITIONS AND BIOLOGICAL ACTIVITY

Rainfall dissolves the VELPAR ULW granules, releasing the active ingredient (hexazinone) into the root zone, where it is absorbed during periods of vigorous plant growth. On herbaceous plants, symptoms usually appear within 3 to 4 weeks after activation by moisture. Activity may be reduced when vegetation is dormant, semidormant, or under stress. On woody plants, symptoms usually appear within 4 to 8 weeks after activation by moisture. Defoliation and subsequent refoliation may occur, but susceptible plants are killed. Results may develop slowly, and maximum effects may not be achieved until 12 to 24 months after activation.

The degree and duration of control may depend on the following:

- use rate
- soil texture
- pest spectrum and size at application
- environmental conditions at and following treatment

DIRECTIONS FOR USE

It is a violation of federal law to use this product in a manner inconsistent with its labeling.

VELPAR ULW should be used only in accordance with recommendations on this label or in separate published DuPont recommendations available through local suppliers.

The correct use rates by crop and geographical area, specified on the label, and proper mixing/loading site considerations and application procedures must be followed to minimize potential for hexazinone movement into ground water. We encourage you to consult with your state Department of Agriculture, Extension Service, or other pesticide lead agency for information regarding soil permeability, aquifer vulnerability, and best management practices for your area.

Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application. For any requirements specific to your state or tribe, consult the agency responsible for pesticide regulation.

AGRICULTURAL USES

AGRICULTURAL USE REQUIREMENTS

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR part 170. This Standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment(PPE) and restricted-entry interval. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard.

Do not enter or allow worker entry into treated areas during the restricted entry interval(REI) of 24 hours.

PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water, is :

Coveralls
Waterproof gloves
Shoes plus socks
Protective eyewear

FORESTRY

VELPAR ULW is recommended for site preparation and conifer release in areas where the following crop species will be grown:

- Loblolly pine
- Longleaf pine
- Shortleaf pine
- Slash pine
- Virginia pine

APPLICATION INFORMATION

VELPAR ULW is recommended for general brush control for site preparation and conifer release in forested areas. It may be applied using ground equipment, and, where permitted, aerial equipment. Use rates and other application information are described in the various use categories.

VELPAR ULW should be applied as a broadcast treatment only.

APPLICATION TIMING

For best results, apply in the spring after the danger of a killing frost has passed. Weeds and brush should be actively growing at application. Weed and brush control is dependent on sufficient rainfall following treatment to activate VELPAR ULW.

APPLICATION EQUIPMENT

VELPAR ULW can be applied using appropriately modified ground equipment or aerial equipment. A Solo® backpack equipped with a granular applicator that has been modified to handle recommended use rates is recommended (for site preparation only). For aerial application, apply the VELPAR ULW granules directly using the DuPont ULW Applicator by helicopter only for site preparation and release.

All application equipment should be adjusted to ensure that distribution across the treatment swath is uniform.

Thoroughly clean all traces of VELPAR ULW Herbicide from application equipment immediately after use. Wash equipment thoroughly with water.

USE RATES

Velpar ULW use rates for site preparation and conifer release are shown in Tables 1 and 2, respectively. The rates are based on soil texture and weed species. Use the lower rates on coarse-textured soils and soils low in organic matter; use the higher rates on fine-textured soils and on soils high in organic matter. Use the higher rates where hard-to-kill species predominate.

TABLE 1. ***USE RATES FOR SITE PREPARATION***

Soil Texture Description	VELPAR ULW (lb per acre)
Sand, Loamy Sand, Sandy Loam	2.5 to 4
Loam, Sandy Clay Loam, Silt Loam	4 to 5.33
Clay Loam, Sandy Clay, Silty Clay Loam, Silty Clay, Clay	5.33 to 6.33

TABLE 2. ***USE RATES FOR CONIFER RELEASE***

Soil Texture Description	VELPAR ULW (lb per acre)
Sand, Loamy Sand, Sandy Loam	1 to 2
Loam, Sandy Clay Loam, Silt Loam	2 to 3
Clay Loam, Sandy Clay, Silty Clay Loam, Silty Clay, Clay	3 to 4

PLANTS CONTROLLED—FORESTRY

VELPAR ULW controls the following herbaceous and woody plants when applied at the rates shown in Tables 1 (site preparation) and 2 (conifer release):

Herbaceous Plants

Annual Bluegrass	Goldenrod*
Barnyardgrass	Heath aster*
Bentgrass	Horseweed*
Catsear (false dandelion)	Orchardgrass*
Common groundsel	Oxeye daisy
Common ragweed	Ryegrass
Curly dock*	Smartweed
Dandelion*	Velvetgrass
Fescue*	Wild carrot
Fleabane	Willowweed*(fireweed)
Foxtail	

Woody Plants

American elder	Hornbeam
Ashes* (green, white)	Mulberry
Birch	Multiflora rose
Blackgum*	Red maple*
Brambles (such as blackberry dewberry, raspberry)	Oaks (such as post, southern red, turkey, water and white)
Cherry* (black, choke)	
Dogwood* (flowering)	Russian olive
Eastern red cedar*	Sumac*
Elm	Sweetgum
Hawthorn	Wild plum
Hickory*	Willow
Honeysuckle	

* Partial control; use the higher rates for the soil textures indicated in Table 1 or 2.

IMPORTANT PRECAUTIONS—FORESTRY

- Do not cut for forage or hay nor graze domestic animals on treated areas for 60 days following application.
- On tracts of land where various soil types are present and VELPAR ULW rate selection is difficult, conifer damage or less-than-expected vegetation suppression may occur due to the rate differences required for various soil types.
- Injury to or loss of desirable trees or other plants may result if VELPAR ULW
  - granules drift onto desirable plants,
  - is applied on or near desirable trees or other plants, or areas where the roots may extend,
  - if equipment washwater is drained or flushed on or near desirable trees or other plants, on areas where their roots may extend, or
  - is applied in locations where the chemical may be washed or moved into contact with roots of desirable trees or other plants.
- Following harvest, stumps and injured trees should be allowed sufficient time to adequately resprout before VELPAR ULW application.
- Where burning is desired in site preparation applications, burn only after the residual stand is completely defoliated (at least twice), allowing for sufficient root uptake of VELPAR ULW.
- Do not apply to frozen soil.
- Poor weed and brush control may result from the following:
  - use on poorly drained sites
  - applications made when the soil is saturated with water
  - applications to soils high in organic matter (greater than 5%)
  - spring applications that do not receive adequate rainfall for activation
  - uneven distribution of product across the treatment swath
- Excessive conifer injury may occur when VELPAR ULW is applied for release in the following situations:
  - on trees that show poor vigor, or damage by insects, disease, winter injury drought, or other stress conditions
  - on any soil containing less than 1% organic matter
  - on loamy sand or sandy loam with less than 2% organic matter
  - on conifers growing on gravelly or rocky soils, exposed subsoils or clay knobs, or sand or sandy soil with 85% or more sand
  - on conifer species not listed on this label
  - on southern pines outplanted less than 4 years on coarse-textured soils or less than 3 years on fine-textured soils
  - in an uneven distribution pattern of product across the treatment swath

NON-AGRICULTURAL USES

NON-AGRICULTURAL USE REQUIREMENTS

The requirements in this box apply to uses of this product that are NOT within the scope of the Worker Protection Standard for agricultural pesticides (40 CFR Part 170). The WPS applies when this product is used to produce agricultural plants on farms, forests, nurseries, or greenhouses.

Noncrop, Industrial Brush Control, as described on this label, is not within the scope of the Worker Protection Standard.

NONCROP, INDUSTRIAL BRUSH CONTROL

VELPAR ULW is recommended for the control of undesirable woody plants in noncrop sites.

APPLICATION INFORMATION

VELPAR ULW is recommended for general brush control in noncrop areas such as railroads, highways, utility and pipeline rights-of-way, petroleum tank farms, storage areas, industrial plant sites, and other similar areas.

VELPAR ULW should be applied as a broadcast treatment using ground application only.

APPLICATION TIMING

Apply VELPAR ULW from late winter through summer, from pre-budbreak through periods of active growth, when adequate rainfall can be expected for activation. In areas where the soil remains frozen during the winter, and spring rains are usually inadequate for soil activation, a fall or winter treatment may be applied before the soil freezes.

APPLICATION EQUIPMENT

VELPAR ULW should be applied using appropriately modified ground equipment only. A Solo® backpack equipped with a granular applicator that has been modified to handle prescribed use rates is recommended.

All application equipment should be adjusted to ensure that distribution across the treatment swath is uniform.

Thoroughly clean all traces of VELPAR ULW Herbicide from application equipment immediately after use. Wash equipment thoroughly with water.

USE RATES

VELPAR ULW use rates for woody plants are shown in **Plants Controlled—Noncrop**. Use the lower rates on coarse-textured soils and soils low in organic matter; use the higher rates on fine-textured soils and on soils high in organic matter.

PLANTS CONTROLLED—NONCROP

VELPAR ULW controls the following woody plants when applied at the rates shown:

5 1/3 to 10 2/3 lb per acre

Alder	Hackberry	Persimmon*
American elm	Hawthorn	Privet*
Ash*	Hazel	Red maple*
Aspen	Hickory*	Sassafrass*
Balsam poplar	Huisache	Small soapweed
Black cherry	Juniper	Snowbrush
Blackgum*	Lotebush	Sourwood*
Birch	Locust	Sumac
Catclaw acacia	Manzanita	Sweet bay
Chinaberry*	Mesquite	Sweet gum
Chinese elm	Mulberry	Whitebrush
Chinese tallow*	Multiflora rose	Whitehorn
Deerbrush	Myrtle	Wild plum
Dogwood	Oaks	Willow
Eastern red cedar*	Osage orange	Yellow poplar*

* Difficult to control

3 2/3 to 5 1/3 lb per acre

Brazilian pepper

IMPORTANT PRECAUTIONS—NONCROP

- Do not use on lawns, walks, driveways, tennis courts, or similar residential areas.
- Do not cut for forage or hay nor graze domestic animals on treated areas for 60 days following application. For rates above 8 lb per acre, do not cut for forage or hay nor graze domestic animals for 1 year.
- Injury to or loss of desirable trees or other plants may result if VELPAR ULW
  - granules drift onto desirable plants,
  - is applied on or near desirable trees or other plants, or areas where the roots may extend,
  - if equipment washwater is drained or flushed on or near desirable trees or other plants, on areas where their roots may extend, or
  - is applied in locations where the chemical may be washed or moved into contact with roots of desirable trees or other plants.
- Following mechanical cutting or clearing, stumps and injured trees should be allowed sufficient time to adequately resprout before VELPAR ULW application.

- Poor brush control may result from the following:
  - use on poorly drained or marshy sites
  - applications made when the soil is saturated with water
  - applications to soils high in organic matter (greater than 5%)
  - applications that do not receive adequate rainfall for activation
  - uneven distribution of product across the treatment swath
  - treatment of target plants that are under stress
- Do not use on frozen soils.
- Do not use on soil with 85% or more sand and less than 1% organic matter.

STORAGE AND DISPOSAL

STORAGE: Store product in original container only. Do not contaminate water, other pesticides, fertilizer, food or feed in storage.

PRODUCT DISPOSAL: Do not contaminate water, food or feed by disposal. Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.

CONTAINER DISPOSAL: Triple rinse (or equivalent) the container. Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or by incineration, or, if allowed by state and local authorities, by burning. If burned, stay out of smoke.

NOTICE TO BUYER: Purchase of this material does not confer any rights under patents of countries outside of the United States.

LIMITATION OF WARRANTY AND LIABILITY

NOTICE: Read This Limitation of Warranty and Liability Before Buying or Using This Product. If the Terms Are Not Acceptable, Return the Product at Once, Unopened, and the Purchase Price Will Be Refunded.

It is impossible to eliminate all risks associated with the use of this product. Such risks arise from weather conditions, soil factors, off target movement, unconventional farming techniques, presence of other materials, the manner of use or application, or other unknown factors, all of which are beyond the control of DuPont. These risks can cause: ineffectiveness of the product; crop injury, or; injury to non-target crops or plants.

DuPont does not agree to be an insurer of these risks. WHEN YOU BUY OR USE THIS PRODUCT, YOU AGREE TO ACCEPT THESE RISKS.

DuPont warrants that this product conforms to the chemical description on the label thereof and is reasonably fit for the purpose stated in the Directions for Use, subject to the inherent risks described above, when used in accordance with the Directions for Use under normal conditions.

DUPONT MAKES NO OTHER EXPRESS OR IMPLIED WARRANTY OF FITNESS OR OF MERCHANTABILITY OR ANY OTHER EXPRESS OR IMPLIED WARRANTY.

IN NO EVENT SHALL DUPONT OR SELLER BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL OR SPECIAL DAMAGES RESULTING FROM THE USE OR HANDLING OF THIS PRODUCT. BUYER'S OR USER'S BARGAINED-FOR EXPECTATION IS CROP PROTECTION. THE EXCLUSIVE REMEDY OF THE USER OR BUYER AND THE EXCLUSIVE LIABILITY OF DUPONT OR SELLER, FOR ANY AND ALL CLAIMS, LOSSES, INJURIES OR DAMAGES (INCLUDING CLAIMS BASED ON BREACH OF WARRANTY OR CONTRACT, NEGLIGENCE, TORT OR STRICT LIABILITY), WHETHER FROM FAILURE TO PERFORM OR INJURY TO CROPS OR OTHER PLANTS, AND RESULTING FROM THE USE OR HANDLING OF THIS PRODUCT, SHALL BE THE RETURN OF THE PURCHASE PRICE OF THE PRODUCT, OR AT THE ELECTION OF DUPONT OR SELLER, THE REPLACEMENT OF THE PRODUCT.

DuPont or its Ag Retailer must have prompt notice of any claim so that an immediate inspection of buyer's or user's growing crops can be made. Buyer and all users shall promptly notify DuPont or a DuPont Ag Retailer of any claims, whether based on contract, negligence, strict liability, other tort or otherwise or be barred from any remedy.

This Limitation of Warranty and Liability may not be amended by any oral or written agreement.

SL - 208-1 9038 6/30/95

For product information call 1-888-6-DUPONT

accord® HERBICIDE

by Monsanto

Complete Directions for Use in Forestry and Utility Rights-of-Way

EPA Reg. No. 524-326

AVOID CONTACT WITH FOLIAGE, GREEN STEMS, EXPOSED NON-WOODY ROOTS, OR FRUIT OF CROPS, DESIRABLE PLANTS AND TREES, SINCE SEVERE INJURY OR DESTRUCTION WILL RESULT.

1998-1 21002V6-5/CG

Read the entire label before using this product.

Use only according to label instructions.

Read "LIMIT OF WARRANTY AND LIABILITY" before buying or using. If terms are not acceptable, return at once unopened.

REFORMULATION IS PROHIBITED. SEE CONTAINER LABEL FOR REPACKAGING LIMITATIONS.

LIMIT OF WARRANTY AND LIABILITY

This Company warrants that this product conforms to the chemical description on the label and is reasonably fit for the purposes set forth in the Complete Directions for Use label booklet ("Directions") when used in accordance with those Directions under the conditions described therein. NO OTHER EXPRESS WARRANTY OR IMPLIED WARRANTY OF FITNESS FOR PARTICULAR PURPOSE OR MERCHANTABILITY IS MADE. This warranty is also subject to the conditions and limitations stated herein.

Buyer and all users shall promptly notify this Company of any claims whether based in contract, negligence, strict liability, other tort or otherwise.

Buyer and all users are responsible for all loss or damage from use or handling which results from conditions beyond the control of this Company, including, but not limited to, incompatibility with products other than those set forth in the Directions, application to or contact with desirable vegetation, unusual weather, weather conditions which are outside the range considered normal at the application site and for the time period when the product is applied, as well as weather conditions which are outside the application ranges set forth in the Directions, application in any manner not explicitly set forth in the Directions, moisture conditions outside the moisture range specified in the Directions, or the presence of products other than those set forth in the Directions in or on the soil, crop or treated vegetation.

THE EXCLUSIVE REMEDY OF THE USER OR BUYER, AND THE LIMIT OF THE LIABILITY OF THIS COMPANY OR ANY OTHER SELLER FOR ANY AND ALL LOSSES, INJURIES OR DAMAGES RESULTING FROM THE USE OR HANDLING OF THIS PRODUCT (INCLUDING CLAIMS BASED IN CONTRACT, NEGLIGENCE, STRICT LIABILITY, OTHER TORT OR OTHERWISE) SHALL BE THE PURCHASE PRICE PAID BY THE USER OR BUYER FOR THE QUANTITY OF THIS PRODUCT INVOLVED, OR, AT THE ELECTION OF THIS COMPANY OR ANY OTHER SELLER, THE REPLACEMENT OF SUCH QUANTITY, OR, IF NOT ACQUIRED BY PURCHASE, REPLACEMENT OF SUCH QUANTITY. IN NO EVENT SHALL THIS COMPANY OR ANY OTHER SELLER BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL OR SPECIAL DAMAGES.

Buyer and all users are deemed to have accepted the terms of this LIMIT OF WARRANTY AND LIABILITY which may not be varied by any verbal or written agreement.

PRECAUTIONARY STATEMENTS

Hazards to Humans and Domestic Animals

Keep out of reach of children.

CAUTION!

HARMFUL IF INHALED.

Avoid breathing spray mist.

FIRST AID: IF INHALED, remove individual to fresh air. If not breathing, give artificial respiration, preferably mouth-to-mouth. Get medical attention.

Personal Protective Equipment (PPE)

Applicators and other handlers must wear: long-sleeved shirt and long pants and shoes plus socks. Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

User Safety Recommendation

Users should:

- Wash hands before eating, drinking, chewing gum, using tobacco or using the toilet.

In case of an emergency involving this product, Call Collect, day or night, (314) 694-4000.

Environmental Hazards

Do not contaminate water when disposing of equipment washwaters. Treatment of aquatic weeds can result in oxygen depletion or loss due to decomposition of dead plants. This oxygen loss can cause fish suffocation.

In case of: **SPILL or LEAK,** soak up and remove to a landfill.

Physical or Chemical Hazards

Spray solutions of this product should be mixed, stored and applied only in stainless steel, aluminum, fiberglass, plastic and plastic-lined steel containers.

DO NOT MIX, STORE OR APPLY THIS PRODUCT OR SPRAY SOLUTIONS OF THIS PRODUCT IN GALVANIZED STEEL OR UNLINED STEEL (EXCEPT STAINLESS STEEL) CONTAINERS OR SPRAY TANKS. This product or spray solutions of this product react with such containers and tanks to produce hydrogen gas which may form a highly combustible gas mixture. This gas mixture could flash or explode, causing serious personal injury, if ignited by open flame, spark, welder's torch, lighted cigarette or other ignition source.

ACTIVE INGREDIENT:	
*Glyphosate, N-(phosphonomethyl)glycine, in the form of its isopropylamine salt	41.5%
INERT INGREDIENTS:	58.5%
	100.0%

*Contains 480 grams per litre or 4 pounds per U.S. gallon of glyphosate, N-(phosphonomethyl)glycine, in the form of its isopropylamine salt. Equivalent to 356 grams per litre or 3 pounds per U.S. gallon of the acid, glyphosate.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in any manner inconsistent with its labeling. For any requirements specific to your State or Tribe, consult the agency responsible for pesticide regulation.

Agricultural Use Requirements

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR part 170. This Standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment (PPE) and restricted-entry interval. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard.

Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application.

Do not enter or allow worker entry into treated areas during the restricted entry interval (REI) of 4 hours.

PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water, are: coveralls, waterproof gloves and shoes plus socks.

Non-Agricultural Use Requirements

The requirements in this box apply to uses of this product that are NOT within the scope of the Worker Protection Standard for agricultural pesticides (40 CFR Part 170). The WPS applies when this product is used to produce agricultural plants on farms, forests, nurseries, or greenhouses.

Uses of this product in utility rights-of-way and all other utility sites are not within the scope of the Worker Protection Standard requirements. Requirements in the Agricultural Use Requirement box do not apply to utility uses. Follow all other label requirements for applications to utility sites.

For more product information, call toll free 1-800-332-3111.

Storage and Disposal

Do not contaminate water, foodstuffs, feed or seed by storage or disposal.

STORAGE: STORE ABOVE 10°F (-12°C) TO KEEP PRODUCT FROM CRYSTALLIZING.

Crystals will settle to the bottom. If allowed to crystallize, place in a warm room 68°F (20°C) for several days to redissolve and roll or shake container or recirculate in mini-bulk containers to mix well before using. For bulk containers, see container label.

DISPOSAL: Wastes resulting from the use of this product that cannot be used or chemically reprocessed should be disposed of in a landfill approved for pesticide disposal or in accordance with applicable Federal, state or local procedures.

Emptied container retains vapor and product residue. Observe all labeled safeguards until container is cleaned, reconditioned or destroyed.

(See the individual container labels for disposal information)

GENERAL INFORMATION

This product, a water soluble liquid, mixes readily with water and surfactant to be applied as a foliar spray for the control or destruction of most herbaceous and woody plants.

This product moves through the plant from the point of foliage contact to and into the root system. Visible effects on most herbaceous weeds occur within 7 days but on most woody plants may not occur for 30 days or more.

After any site disturbance, such as logging, mechanical brush removal or mowing, allow stump sprouts, resprouts and foliar regrowth from woody brush and perennial herbaceous weeds sufficient time to regrow before treatment.

Always use the higher recommended rates of this product and surfactant when treating dense, multicanopied sites of woody vegetation or difficult-to-control woody and herbaceous plants.

Reduced control may result when woody brush, trees and herbaceous weeds are treated under poor growing conditions caused by drought, disease or insect damage. Reduced control may result if the foliage of undesirable vegetation is covered with dust at the time of treatment.

Rainfall occurring within 6 hours after application may reduce effectiveness. Heavy rainfall within 2 hours after application may wash the chemical off the foliage and a repeat treatment may be required.

When this product comes in contact with soil (on the soil surface or as suspended soil or sediment in water) it is bound to soil particles. When used in accordance with label directions, once this product is bound it is not available for plant uptake and will not harm off-site vegetation where roots grow into the treatment area or if the soil is transported off-site. When used in accordance with label directions, the strong affinity of this product to soil particles prevents this product from leaching out of the soil profile and entering ground water. The affinity between this product and soil particles remains until this product is degraded, which is primarily a biological degradation process carried out under both aerobic and anaerobic conditions by soil microflora.

Buyer and all users are responsible for all loss or damage in connection with the use or handling of mixtures of this product with herbicides or other materials that are not expressly recommended in this label. Mixing this product with herbicides or other materials not recommended in this label may result in reduced performance.

FORESTRY SITE PREPARATION AND UTILITY RIGHTS-OF-WAY

This product is recommended for the control or partial control of woody brush, trees and herbaceous weeds. This product is labeled for use in forestry and utility sites. This product is also recommended for use in preparing or establishing wildlife openings within these sites and maintaining logging roads, and for side trimming along utility rights-of-way.

In forestry, this product is recommended for use in site preparation prior to planting any tree species, including Christmas trees and silvicultural nursery sites.

In utilities, this product is recommended for use along electrical power, pipeline and telephone rights-of-way, and in other utility sites associated with these rights-of-way, such as substations.

APPLICATION RATES AND TIMING

APPLICATION	ACCORD®	SPRAY VOLUME GAL/A
BROADCAST		
Aerial	2 to 10 qts/a	5 to 30
Ground	2 to 10 qts/a	10 to 60
SPRAY-TO-WET		
Handgun, Backpack, Mistblower	3/4% to 2% by volume	spray-to-wet
LOW VOLUME DIRECTED SPRAY		
Handgun, Backpack, Mistblower	5% to 10% by volume	partial coverage*

*For low volume directed spray applications, coverage should be uniform with at least 50 percent of the foliage contacted. Coverage of the top one-half of the plant is important for best results.

In forestry site preparation and utility rights-of-way applications, this product requires use with a nonionic surfactant. Use a nonionic surfactant with greater than 80 percent active ingredient and labeled for use with herbicides. Use of this product without surfactant will result in reduced performance. See the "MIXING AND APPLICATION INSTRUCTION" section of this label for more information.

Mix 2 or more quarts of the nonionic surfactant per 100 gallons of spray solution (0.5 percent or more by spray volume). Use of surfactant concentrations greater than 1.5 percent by spray volume with handgun applications or 2.5 percent by spray volume with broadcast applications is not recommended.

Use higher rates of this product within the recommended range for control or partial control of woody brush, trees and hard-to-control perennial herbaceous weeds. For best results, apply to actively growing woody brush and trees after full leaf expansion and before fall color and leaf drop. Increase rates within the recommended range for control of perennial herbaceous weeds any time after emergence and before seedheads, flowers or berries appear.

Use the lower rates of this product within the recommended range for control of annual herbaceous weeds and actively growing perennial herbaceous weeds after seedheads, flowers or berries appear. Apply to the foliage of actively growing annual herbaceous weeds any time after emergence.

This product has no herbicidal or residual activity in the soil. Where repeat applications are necessary, do not exceed 10.6 quarts of this product per acre per year.

TANK MIXTURES

Tank mixtures of this product may be used to increase the spectrum of vegetation controlled. When tank mixing, read and carefully observe the label claims, cautionary statements and all information on the labels of both products used. Use according to the most restrictive precautionary statements for each product in the mixture. Any recommended rate of this product may be used in a tank mix.

NOTE: For forestry site preparation, make sure the tank-mix product is approved for use prior to planting the desired species. Observe planting interval restrictions. For side trimming treatments in utility rights-of-way, tank mixtures with Arsenal™ 2WSL are not recommended. For side trimming treatments, it is recommended that this product be used alone as recommended, or as a tank mixture with Garlon™ 4.

PRODUCT	BROADCAST RATE	USE SITES
Arsenal Applicators Concentrate	2 to 16 fl oz/a	Forestry site preparation
Oust™	1 to 4 oz/a	Forestry site preparation, Utility sites
Garlon 3A*, Garlon 4	1 to 4 qts/a	Forestry site preparation, Utility sites
Arsenal 2WSL	2 to 32 fl oz/a	Utility sites

PRODUCT	SPRAY-TO-WET RATES	USE SITES
Arsenal Applicators Concentrate	1/32% to 1/2% by volume	Forestry site preparation
Arsenal 2WSL	1/32% to 1/2% by volume	Utility sites

PRODUCT	LOW VOLUME DIRECTED SPRAY RATES	USE SITES
Arsenal Applicators Concentrate	1/8% to 1/2% by volume	Forestry site preparation
Arsenal 2WSL	1/8% to 1/2% by volume	Utility sites

*Ensure that Garlon 3A is thoroughly mixed with water according to label directions before adding this product. Have spray mixture agitating at the time this product is added to avoid spray compatibility problems.

For control of herbaceous weeds, use the lower recommended tank mixture rates. For control of dense stands or tough-to-control woody brush and trees, use the higher recommended rates.

Arsenal is a trademark of American Cyanamid Company.

Oust is a trademark of E. I. du Pont de Nemours and Company.

Garlon is a trademark of DowElanco Products Company.

FORESTRY CONIFER AND HARDWOOD RELEASE

DIRECTED SPRAY AND SELECTIVE EQUIPMENT

This product may be applied as a directed spray or by using selective equipment in forestry conifer and hardwood sites, including Christmas tree plantations and silvicultural nurseries. Mix 2 to 6 quarts of a nonionic surfactant per 100 gallons of spray solution (0.5 to 1.5 percent by spray volume) for all spray applications. Use a surfactant with greater than 80 percent active ingredient.

In hardwood plantations, tank mixtures with Oust may be used. In pine plantations, tank mixtures with Garlon 4 or Arsenal AC may be used. Comply with all site restrictions, forestry species limitations and precautions on the tank mix product label.

Avoid contact of spray, drift, mist or drips with foliage, green bark or non-woody surface roots of desirable species.

See all sections in the “APPLICATION EQUIPMENT AND TECHNIQUES” portion of this label for specific equipment recommendations and precautions.

For spray-to-wet applications, use a 2 percent spray solution for the control of undesirable woody brush and trees. To control herbaceous weeds, use a 1 to 2 percent solution.

For low volume directed spray applications, use a 5 to 10 percent spray solution. Coverage should be uniform with at least 50 percent of the foliage contacted. Coverage of the top one-half of the unwanted vegetation is important.

For equipment calibrated for broadcast applications, use 2 to 10 quarts of this product per acre. Apply in 10 to 60 gallons of clean water per acre. Shielded application equipment may be used to avoid contact of the spray solution with desirable plants. Shields should be adjusted to prevent spray contact with the foliage or green bark of desirable vegetation.

Wiper application equipment may be used. See the “SELECTIVE EQUIPMENT” portion of this label for equipment and rate recommendations.

BROADCAST SPRAY

Except where specifically recommended below, use only where conifers have been established for more than one year.

APPLICATION MUST BE MADE AFTER FORMATION OF FINAL CONIFER RESTING BUDS IN THE FALL OR PRIOR TO INITIAL BUD SWELLING IN THE SPRING.

Injury may occur to conifers treated for release, especially where spray patterns overlap or the higher rates are applied. Damage can be accentuated if applications are made when conifers are actively growing, or are under stress from drought, flood water, improper planting, insects, animal damage or diseases.

This product may require use with a surfactant. Unless otherwise recommended in this section of this label, use Entry™ II surfactant at 10 to 30 fluid ounces per acre. Follow the instructions under the “MIXING” portion of the “MIXING AND APPLICATION INSTRUCTIONS” section of this label.

For release of the following conifer species outside the Southeastern United States:

Douglas fir
Pseudotsuga menziesii

Fir
Abies spp.

Hemlock**
Tsuga spp.

Pines*
Pinus spp.

Redwood, California**
Sequoia spp.

Spruce
Picea spp.

*Includes all species except loblolly pine, longleaf pine, shortleaf pine or slash pine.

**Use of a surfactant is not recommended for release of hemlock species or California redwood. In mixed conifer stands, injury to these species may result if a surfactant is used.

Apply 1 to 2 quarts of this product per acre as a broadcast spray.

NOTE: For release of Douglas fir with this product or recommended tank mixtures of this product, Entry II or a nonionic surfactant recommended for over-the-top foliar sprays may be used. To avoid possible conifer injury, Entry II rates should not exceed 20 fluid ounces per acre at elevations above 1500 feet, or 10 fluid ounces per acre in the coastal range or at elevations below 1500 feet in Washington and Oregon. Nonionic surfactants may be used at 2 fluid ounces per acre at elevations above 1500 feet, or 1 fluid ounce per acre in the coastal range or at elevations below 1500 feet. Use of surfactant rates exceeding those listed above may result in unacceptable conifer injury and are not recommended. Ensure that the nonionic surfactant has been adequately tested for Douglas fir safety before use.

In Maine, up to 3 quarts per acre of this product may be used for the control of difficult species.

To release Douglas fir, and pine and spruce species at the end of the first growing season (except in California), apply 1 to 1.5 quarts of this product per acre. Ensure that the conifers are well hardened off.

<u>OUST TANK MIXTURES</u>—To release jack pine, white pine and white spruce, apply 1 to 2 quarts of this product with 1 to 3 ounces (1 to 1.5 for white pine) of Oust per acre. Make applications to actively growing weeds as a broadcast spray over the top of established conifers. Applications at these rates should be made after formation of conifer resting buds in the late summer or fall.

<u>ARSENAL APPLICATORS CONCENTRATE TANK MIXTURES</u>—This product may be tank mixed with Arsenal Applicators Concentrate for release of Douglas fir. Use 1 to 1 1/2 quarts of this product tank mixed with 2 to 6 fluid ounces of Arsenal per acre. For release of balsam fir and red spruce, apply a mixture of 2 quarts of this product and 1 to 2 1/2 fluid ounces of Arsenal Applicators Concentrate per acre.

For release of the following conifer species in the Southeastern United States:

Loblolly pine
Pinus taeda

Eastern white pine
Pinus strobus

Shortleaf pine
Pinus echinata

Slash pine
Pinus elliottii

Virginia pine
Pinus virginiana

Longleaf pine
Pinus palustris

Apply 1 1/2 to 2 1/2 quarts of this product per acre as a broadcast spray during late summer or early fall after the conifers have hardened off. For applications at the end of the first growing season, use 1 quart per acre of this product alone or in a recommended tank mixture.

<u>ARSENAL APPLICATORS CONCENTRATE TANK MIXTURES</u>—Apply 1 to 2 quarts of this product with 2 to 16 fluid ounces of Arsenal Applicators Concentrate per acre as a broadcast spray for conifer release. Use only on conifer species that are labeled for over-the-top sprays for both products. Use the higher recommended rates for dense, tough-to-control woody brush and trees.

Read and carefully observe the label claims, cautionary statements and all information on the labels of each product used in these tank mixtures. Use according to the most restrictive precautionary statements for each product in the mixture.

Entry is a trademark of Monsanto Company.

HERBACEOUS RELEASE

When applied as directed, this product plus listed residual herbicides provides postemergence control of the annual weeds and control or suppression of the perennial weeds listed in this label, and residual control of the weeds listed in the residual herbicide label. Make applications to actively growing weeds as a broadcast spray over the top of labeled conifers.

Oust tank mixtures—To release loblolly pines, apply 16 to 24 fluid ounces of this product, plus 2 to 4 ounces of Oust per acre.

To release slash pines, apply 12 to 16 fluid ounces of this product, plus 2 to 4 ounces of Oust per acre.

Mix up to 3.2 fluid ounces per acre of Entry II with the recommended rate of this product plus Oust. Applications can be made over newly planted pines after the emergence of herbaceous weeds in the spring or early summer. Best results are obtained from applications made in May and June.

Weed control may be reduced if water volumes exceed 25 gallons per acre for these treatments.

Atrazine tank mixtures—To release Douglas fir, apply 1 quart of this product, plus 4 pounds a.i. of atrazine per acre. Apply only over Douglas fir that has been established for at least one full growing season. Apply in the early Spring, usually mid-March through early April. Injury will occur if applications are made after bud swell in the Spring. Do not add surfactant to this mix for this use.

Always read and follow the manufacturer's label recommendations for all herbicides and surfactants used.

WETLAND SITES

This product may be used in and around water (aquatic areas) and wetlands found in forestry and in power, telephone and pipeline rights-of-way sites, including where these sites are adjacent to or surrounding domestic water supply reservoirs, supply streams, lakes and ponds. Read and observe the following before making applications in and around water.

Consult local public water control authorities before applying this product in and around public water. Permits may be required to treat in such areas.

There is no restriction on the use of treated water for irrigation, recreation or domestic purposes.

NOTE: Do not apply this product directly to water within 1/2 mile upstream of an active potable water intake in flowing water (i.e., river, stream, etc.) or within 1/2 mile of an active potable water intake in a standing body of water such as lake, pond or reservoir. To make aquatic applications around and within 1/2 mile of active potable water intakes, the water intake must be turned off for a minimum period of 48 hours after the application. These aquatic applications may be made ONLY in those cases where there are alternative water sources or holding ponds which would permit the turning off of an active potable water intake for a minimum period of 48 hours after the applications. This restriction does not apply to intermittant inadvertent overspray of water in terrestrial use sites.

Do not spray open bodies of water where woody brush, trees and herbaceous weeds do not exist. The maximum application rate of 5 quarts per acre must not be exceeded in a single over-water broadcast application except as follows, where any recommended rate may be applied:

- Stream crossings in utility rights-of-way
- Where applications will result in less than 20 percent of the total water area being treated.

MIXING AND APPLICATION INSTRUCTIONS

APPLY THESE SPRAY SOLUTIONS IN PROPERLY MAINTAINED AND CALIBRATED EQUIPMENT CAPABLE OF DELIVERING DESIRED VOLUMES. HANDGUN APPLICATIONS SHOULD BE PROPERLY DIRECTED TO AVOID SPRAYING DESIRABLE PLANTS. **NOTE:** REDUCED RESULTS MAY OCCUR IF WATER CONTAINING SOIL IS USED, SUCH AS WATER FROM PONDS AND UNLINED DITCHES.

MIXING

This product mixes readily with water. Mix spray solutions of this product as follows: Fill the mixing or spray tank with the required amount of water while adding the required amount of this product (see the "DIRECTIONS FOR USE" and "WEEDS CONTROLLED" sections of this label). For tank mixtures, add the tank-mix product before adding this product. If tank mixing with Garlon 3A, ensure that the Garlon 3A is well mixed with at least 75 percent of the total spray volume before adding this product to avoid incompatibility. Near the end of the filling process, add the required surfactant and mix well. Maintain an air break between the filling hose and the spray solution and remove the hose from the tank immediately after filling to avoid siphoning back into the water source. During mixing and application, foaming of the spray solution may occur. To prevent or minimize foam, avoid the use of mechanical agitators, terminate by-pass and return lines at the bottom of the tank and, if needed, use an approved antifoam or defoaming agent.

APPLICATION EQUIPMENT AND TECHNIQUES

ATTENTION

AVOID DRIFT. EXTREME CARE MUST BE USED WHEN APPLYING THIS PRODUCT TO PREVENT INJURY TO DESIRABLE PLANTS AND CROPS.

Do not allow the herbicide solution to mist, drip, drift or splash onto desirable vegetation since minute quantities of this product can cause severe damage or destruction to the crop, plants or other areas on which treatment was not intended. The likelihood of plant or crop injury occurring from the use of this product is greatest when winds are gusty or in excess of 5 miles per hour or when other conditions, including lesser wind velocities, will allow spray drift to occur. When spraying, avoid combinations of pressure and nozzle type that will result in splatter or fine particles (mist) which are likely to drift. AVOID APPLYING AT EXCESSIVE SPEED OR PRESSURE.

NOTE: Use of this product in any manner not consistent with this label may result in injury to persons, animals or crops, or other unintended consequences. When not in use, keep container closed to prevent spills and contamination.

■ AERIAL EQUIPMENT ■

This product is recommended for application by helicopter only in forestry sites and utility rights-of-way. Use the recommended rates of this product and surfactant in 5 to 30 gallons of spray solution per acre as a broadcast spray.

IN CALIFORNIA, AERIAL APPLICATION MAY ONLY BE MADE IN NON-RESIDENTIAL, FORESTRY SITES AND CHAPARRAL AREAS.

AVOID DRIFT—DO NOT APPLY DURING INVERSION CONDITION, WHEN WINDS ARE GUSTY, OR UNDER ANY OTHER CONDITION WHICH WILL ALLOW DRIFT; DRIFT WILL CAUSE DAMAGE TO ANY VEGETATION CONTACTED TO WHICH TREATMENT IS NOT INTENDED. TO PREVENT INJURY TO ADJACENT DESIRABLE VEGETATION, APPROPRIATE BUFFER ZONES MUST BE MAINTAINED.

Coarse sprays are less likely to drift; therefore, do not use nozzles or nozzle configurations which dispense spray as fine droplets.

Drift control additives may be used for forestry site preparation and utility rights-of-way applications. When a drift control additive is used, read and carefully observe the cautionary statements and all other information appearing on the additive label. The use of a drift control agent for conifer and herbaceous release applications may result in conifer injury and is not recommended.

PROLONGED EXPOSURE OF THIS PRODUCT TO UNCOATED STEEL SURFACES MAY RESULT IN CORROSION AND POSSIBLE FAILURE OF THE PART. The maintenance of an organic coating (paint) which meets aerospace specification MIL-C-38413 may prevent corrosion. To prevent corrosion of exposed parts, thoroughly wash aircraft after each day of spraying to remove residues of this product accumulated during spraying or from spills. Landing gear are most susceptible.

■ GROUND BROADCAST EQUIPMENT ■

This product is recommended for broadcast applications using suitable ground equipment in forestry sites, utility sites and utility rights-of-way. Use the recommended rates of this product plus surfactant in 10 to 60 gallons of clean water per acre as a broadcast spray. Check for even spray distribution throughout the spray pattern.

■ BACKPACK, HANDGUN OR MISTBLOWER EQUIPMENT ■

This product is recommended for application through backpack, handgun or hand-held mistblower* equipment. For spray-to-wet applications, coverage should be uniform and complete, but not to the point of runoff.

This product can be used for low volume directed sprays for spot treatment of trees and brush. It is most effective in areas where there is a low density of undesirable trees or brush. If a straight stream nozzle is used, start the application at the top of the targeted vegetation and spray from top to bottom in a lateral zigzag motion. For flat fan and cone nozzles and with mistblowers, mist the application over the foliage of the targeted vegetation. Small, open branched trees need only be treated from one side. If the foliage is thick or there are multiple root sprouts, applications must be made from several sides to ensure adequate spray coverage.

It is suggested that the recommended amount of this product and surfactant be mixed in a larger container and then added to the sprayer.

*This product is not registered in California or Arizona for use in mistblowers.

■ SELECTIVE EQUIPMENT ■

This product may be applied through shielded sprayers or wiper application equipment. This equipment may be used to selectively control undesirable vegetation without harming desirable vegetation.

Shielded sprayers direct the herbicide solution onto weeds while shielding desirable vegetation from the spray solution. Any recommended rate or tank mixture of this product may be used employing this equipment.

Wiper applicators physically wipe product directly onto undesirable vegetation. Care should be taken to avoid wiping desirable vegetation. Use a 33 to 100 percent solution of this product, diluted in water for wiper applications. Use a 33 percent solution for wick or gravity feed systems. Higher concentrations may be used in pressurized systems that are capable of handling thicker solutions. Addition of a nonionic surfactant at a rate of 10 percent by volume of total herbicide solution is recommended.

WEEDS CONTROLLED

When applied as recommended under the conditions described, this product CONTROLS, PARTIALLY CONTROLS or SUPPRESSES most woody brush, trees and herbaceous weeds, some of which are listed below.

WOODY BRUSH AND TREES

Alder
Alnus spp.

Ash
Fraxinus spp.

Aspen, quaking
Populus tremuloides

Bearmat (Bearclover)
Chamaebatia foliolosa

Beech
Fagus grandifolia

Birch
Betula spp.

Blackberry
Rubus spp.

Blackgum
Nyssa spp.

Bracken
Pteridium spp.

Broom:
French
Cytisus monspessulanus
Scotch
Cytisus scoparius

Buckwheat, California
Eriogonum fasciculatum

Cascara
Rhamnus purshiana

Catsclaw
Acacia greggi

Ceanothus
Ceanothus spp.

Chamise
Adenostoma fasciculatum

Cherry:
Bitter
Prunus emarginata
Black
Prunus serotina
Pin
Prunus pensylvanica

Coyote brush
Baccharis consanguinea

Creeper, Virginia
Parthenocissus quinquefolia

Dewberry
Rubus trivialis

Dogwood
Cornus spp.

Elderberry
Sambucus spp.

Elm
Ulmus spp.

Eucalyptus, bluegum
Eucalyptus globulus

Hasardia
Haplopappus squamosus

Hawthorn
Crataegus spp.

Hazel
Corylus spp.

Hickory
Carya spp.

Holly, Florida; Brazilian Peppertree
Schinus terebinthifolius

Honeysuckle
Lonicera spp.

Hornbeam, American
Carpinus caroliniana

Kudzu
Pueraria lobata

Locust, black
Robina pseudoacacia

Madrone
Arbutus menziesii

Manzanita
Arctostaphylos spp.

Maple
Acer spp.

Monkey Flower
Mimulus guttatus

Oak
Quercus spp.

Persimmon
Diospyros spp.

Pine
Pinus spp.

Poison Ivy
Rhus radicans

Poison Oak
Rhus toxicodendron

Poplar, yellow
Liriodendron tulipfera

Prunus
Prunus spp.

Raspberry
Rubus spp.

Redbud, eastern
Cercis canadensis

Rose, multiflora
Rosa multiflora

Sage, black
Salvia mellifera

Sagebrush, California
Artemisia californica

Salmonberry
Rubus spectabilis

Saltbush; Sea myrtle
Baccaharis halimifolia

Sassafras
Sassafras albidum

WOODY BRUSH AND TREES (continued)

Sourwood
Oxydendrum arboreum

Sumac
Rhus vernix

Sweetgum
Liquidambar styraciflua

Swordfern
Polystichum munitum

Tallowtree, Chinese
Sapium sebiferum

Tan Oak
Lithocarpus densiflorus

Thimbleberry
Rubus parviflorus

Tobacco, tree
Nicotiana glauca

Trumpetcreeper
Campsis radicans

Waxmyrtle, southern
Myrica cerifera

Willow
Salix spp.

HERBACEOUS WEEDS

Bahiagrass
Paspalum notatum

Balsamapple
Momordica charantia

Barnyardgrass
Echinochloa crus-galli

Bassia, fivehook
Bassia hyssopifolia

Bermudagrass
Cynodon dactylon

Bindweed, field
Convolvulus arvensis

Bluegrass, Kentucky
Poa pratensis

Brackenfern
Pteridium aquilinum

Brome
Brome spp.

Bromegrass, smooth
Bromus inermis

Broomsedge
Andropogon spp.

Buttercup
Ranunculus spp.

Cheat
Bromus secalinus

Chickweed, mouseear
Cerastium vulgatum

Clover, red
Trifolium pratense

Clover, white
Trifolium repens

Cocklebur
Xanthium strumarium

Crabgrass
Digitaria spp.

Dallasgrass
Paspalum dilatatum

Dock, curly
Rumex crispus

Dwarfdandelion
Krigia cespitosa

Falseflax, smallseed
Camelina microcarpa

Fescue
Festuca spp.

Fiddleneck
Amsinckia spp.

Flaxleaf fleabane
Conyza bonariensis

Fleabane
Erigeron spp.

Foxtail
Setaria spp.

Groundsel, common
Senecio vulgaris

Guineagrass
Panicum maximum

Horsenettle
Solanum carolinese

Horseweed/Marestail
Conyza canadensis

Johnsongrass
Sorghum halepense

Kikuyugrass
Pennisetum clandestinum

Knapweed
Centaurea repens

Kochia
Kochia scoparia

Lambsquarters, common
Chenopodium album

Lespedeza: common, sericea
Lespedeza striata
Lespedeza cuneata

Lettuce, prickly
Lactuca serriola

Morningglory
Ipomoea spp.

Muhly, wirestem
Muhlenbergia frondonsa

Mullein, common
Verbascum thapsus

Mustard, blue
Chorispora tenella

Mustard, tansy
Descurainia pinnata

Mustard, tumble
Sisymbrium altissimum

Mustard, wild
Sinapis arvensis

Napiergrass
Pennisetum purpureum

Nightshade, silverleaf
Solanum elaeagnifolium

Nutsedge: purple, yellow
Cyperus rotundus
Cyperus esculentus

Oats, wild
Avena fatua

Orchardgrass
Dactylis glomerata

Panicum
Panicum spp.

Pampasgrass
Cortaderia jubata

Pennycress, field
Thlaspi arvense

Pigweed, redroot
Amaranthus retroflexus

Pigweed, smooth
Amaranthus hybridus

HERBACEOUS WEEDS (continued)

Quackgrass
Agropyron repens

Ragweed, common
Ambrosia artemisiifolia

Ragweed, giant
Ambrosia trifida

Reed, giant
Arundo donax

Ryegrass, perennial
Lolium perenne

Saltcedar
Tamarix spp.

Sandbur, field
Cenchrus spp.

Shepherd's-purse
Capsella bursa-pastoris

Signalgrass, broadleaf
Brachiaria platyphylla

Smartweed, Pennsylvania
Polygonum pensylvanicum

Sowthistle, annual
Sonchus oleraceus

Spanishneedles
Bidens bipinnata

Spurry, umbrella
Holosteum umbellatum

Starthistle, yellow
Centaurea solstitialis

Stinkgrass
Eragrostis cilianensis

Thistle, Canada
Cirsium arvense

Thistle, Russian
Salsola kali

Vaseygrass
Paaspalum urvillei

Velvetgrass
Holcus spp.

Witchgrass
Panicum capillare

INJECTION AND CUT STUMP APPLICATIONS

Woody brush and trees may be controlled using injection or cut stump applications of this product in forestry and utility right-of-way sites.

INJECTION APPLICATIONS

Apply the equivalent of 1 ml of this product per each 2 inches of trunk diameter. This is best achieved by applying a 25 to 100 percent concentration of this material either to a continuous frill around the tree or as cuts evenly spaced around the tree below all branches. As tree diameter increases in size, better results are achieved by applying diluted material to a continuous frill or more closely spaced cuttings. Avoid application techniques that allow runoff to occur from frill or cut areas in species that exude sap freely after frills or cutting. In these species, make frill or cut at an oblique angle so as to produce a cupping effect and use undiluted material. For best results, avoid applications during peak sap flow in the Spring.

CUT STUMP TREATMENTS

Woody vegetation may be controlled by treating freshly cut stumps of trees and resprouts with this product. Apply this product using suitable equipment to ensure coverage of the entire cambium. Cut vegetation close to the soil surface. **Apply a 50 to 100 percent solution of this product to the freshly cut surface immediately after cutting.** Delays in application may result in reduced performance. For best results, avoid applications during peak sap flow in the Spring.

When used according to directions for cut stump application, this product will CONTROL, PARTIALLY CONTROL or SUPPRESS most woody brush and tree species, some of which are listed below:

Alder
Alnus spp.

Coyotebrush
Baccharis consanguinea

Dogwood
Cornus spp.

Eucalyptus
Eucalyptus spp.

Hickory
Carya spp.

Madrone
Arbutus menziesii

Maple
Acer spp.

Oak
Quercus spp.

Poplar
Populus spp.

Saltcedar
Tamarisk spp.

Sweetgum
Liquidambar styraciflua

Sycamore
Platanus occidentalis

Tan Oak
Lithocarpus densiflorus

Willow
Salix spp.

Product protected by U.S. Patent No. 4,405,531.
Other patents pending. No license granted
under any non-U.S. patent(s).

MONSANTO COMPANY
ST. LOUIS, MISSOURI 63167 U.S.A.

ENTRY™ II

SURFACTANT

by Monsanto

SURFACTANT FOR USE WITH ACCORD® HERBICIDE AND TANK MIXTURES OF ACCORD IN FORESTRY AND UTILITY RIGHTS-OF-WAY. THIS PRODUCT ENHANCES BRUSH AND WEED CONTROL AND CAN BE USED FOR CONIFER RELEASE APPLICATIONS.

Read the entire label before using this product.

Use only according to label instructions.

Read "LIMIT OF WARRANTY AND LIABILITY" before buying and using. If terms are not acceptable, return at once unopened.

REFORMULATION OR REPACKAGING IS PROHIBITED.

PRECAUTIONARY STATEMENTS

Keep out of reach of children.

DANGER!

CAUSES EYE BURNS.

CAUSES SKIN IRRITATION.

HARMFUL IF SWALLOWED.

MAY CAUSE ALLERGIC SKIN REACTION.

Do not get in eyes, on skin or on clothing.

Wear goggles or face shield and rubber gloves when transferring and mixing.

Wash thoroughly with soap and water after handling.

FIRST AID: IF IN EYES, immediately flush with plenty of water for at least 15 minutes. Get medical attention.

IF ON SKIN, immediately flush with plenty of water while removing contaminated clothing. As soon as soap is available, wash thoroughly with soap and water. Wash clothing before reuse. Sensitized persons should avoid further contact and reuse of contaminated clothing. Get medical attention.

IF SWALLOWED, this product will cause gastrointestinal tract irritation. Immediately dilute by swallowing water or milk. Get medical attention.

In case of an emergency involving this product, Call Collect, day or night, (314) 694-4000.

DIRECTIONS FOR USE

Entry™ II is recommended for use only with Accord® herbicide and tank mixtures of Accord for forestry conifer release (woody and herbaceous), forestry site preparation and utility rights-of-way applications.

For conifer release, use up to 10 fluid ounces of this product per quart of Accord applied per acre.* Do not exceed 30 fluid ounces per acre of this product for conifer release.

For herbaceous release treatments in newly planted pines in the Southeastern United States, use up to 6 fluid ounces of this product per acre.

For site preparation, utility rights-of-way, and post-directed sprays in established conifer sites, apply a minimum of 1 percent (4 quarts per 100 gallons of spray solution) by spray volume. Use of concentrations of this product greater than 3 percent by spray volume with handheld applicators or 3 percent by spray volume with broadcast applications is not recommended.

This product should not be used in excess of 32 fluid ounces per acre when making broadcast applications in and around water.

*In the Southeastern United States, up to 20 fluid ounces per acre of this product may be used with any recommended rate of Accord.

MIXING INSTRUCTIONS

Before using this product, read the entire label for Accord. All instructions on that label must be followed.

Fill the spray tank two-thirds (2/3) full with clean water. Add the recommended rate of Accord or tank mixture of Accord, followed by the recommended amount of this product. Fill spray tank to desired level. Ensure that the spray solution is thoroughly mixed. If needed, use an approved antifoam or defoaming agent.

Storage and Disposal

Do not contaminate water, food or feed by storage or disposal.

STORAGE: Store in original container. In case of leak or spill, use absorbent materials to contain liquids and dispose of wastes.

DISPOSAL: Wastes of this product may cause eye burns. If these wastes cannot be disposed of by use according to the label instructions, dispose of in a hazardous waste facility.

Emptied container retains vapor and product residue. Observe all labeled safeguards until container is destroyed.

Do not reuse container. Return emptied container per the Monsanto container return program. If not returned, triple rinse container, then puncture and dispose of in a sanitary landfill, or by incineration, or, if allowed by state and local authorities, by burning. If burned, stay out of smoke.

LIMIT OF WARRANTY AND LIABILITY

This Company warrants that this product conforms to the chemical description on the label and is reasonably fit for the purposes set forth in the Complete Directions for Use ("Directions") when used in accordance with those Directions under the conditions described therein. NO OTHER EXPRESS WARRANTY OR IMPLIED WARRANTY OF FITNESS FOR PARTICULAR PURPOSE OR MERCHANTABILITY IS MADE. This warranty is also subject to the conditions and limitations stated herein.

Buyer and all users shall promptly notify this Company of any claims whether based in contract, negligence, strict liability, other tort or otherwise.

Buyer and all users are responsible for all loss or damage from use or handling which results from conditions beyond the control of this Company, including, but not limited to, incompatibility with products other than those set forth in the Directions, application to or contact with desirable vegetation, unusual weather, weather conditions which are outside the range considered normal at the application site and for the time period when the product is applied, as well as weather conditions which are outside the application ranges set forth in the Directions, application in any manner not explicitly set forth in the Directions, moisture conditions outside the moisture range specified in the Directions, or the presence of products other than those set forth in the Directions in or on the soil, crop or treated vegetation.

THE EXCLUSIVE REMEDY OF THE USER OR BUYER, AND THE LIMIT OF THE LIABILITY OF THIS COMPANY OR ANY OTHER SELLER FOR ANY AND ALL LOSSES, INJURIES OR DAMAGES RESULTING FROM THE USE OR HANDLING OF THIS PRODUCT (INCLUDING CLAIMS BASED IN CONTRACT, NEGLIGENCE, STRICT LIABILITY, OTHER TORT OR OTHERWISE) SHALL BE THE PURCHASE PRICE PAID BY THE USER OR BUYER FOR THE QUANTITY OF THIS PRODUCT INVOLVED, OR, AT THE ELECTION OF THIS COMPANY OR ANY OTHER SELLER, THE REPLACEMENT OF SUCH QUANTITY, OR, IF NOT ACQUIRED BY PURCHASE, REPLACEMENT OF SUCH QUANTITY. IN NO EVENT SHALL THIS COMPANY OR ANY OTHER SELLER BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL OR SPECIAL DAMAGES.

Buyer and all users are deemed to have accepted the terms of this LIMIT OF WARRANTY AND LIABILITY which may not be varied by any verbal or written agreement.

In case of an emergency involving this product, Call Collect, day or night, (314) 694-4000.

PRINCIPAL FUNCTIONING AGENT:

Ethoxylated tallow amine	35.0%
INERT INGREDIENTS	65.0%
	100.0%

The substance listed below is identified as a hazardous chemical under the criteria of the OSHA Hazard Communications Standard (29 CFR 1910.1200):

Ethoxylated tallow amine,
CAS Reg. No. 61791-26-2

MONSANTO COMPANY
ST. LOUIS, MISSOURI 63167 U.S.A.

CA Reg. No. 524-50021

43011V2-2/CG

RODEO®

EMERGED AQUATIC WEED AND BRUSH HERBICIDE

BY Monsanto

Complete Directions for Use in Aquatic and Other Noncrop Sites.

EPA Reg. No. 524-343

AVOID CONTACT WITH FOLIAGE, GREEN STEMS, EXPOSED NON-WOODY ROOTS, OR FRUIT OF CROPS, DESIRABLE PLANTS AND TREES, SINCE SEVERE INJURY OR DESTRUCTION MAY RESULT.

1998-1 21061W3-1/CG

Read each of these sections of this label for essential product performance information.

Read the entire label before using this product.

Use only according to label instructions.

Read "LIMIT OF WARRANTY AND LIABILITY" before buying or using. If terms are not acceptable, return at once unopened.

REFORMULATION IS PROHIBITED. SEE INDIVIDUAL CONTAINER LABEL FOR REPACKAGING LIMITATIONS.

LIMIT OF WARRANTY AND LIABILITY

This Company warrants that this product conforms to the chemical description on the label and is reasonably fit for the purposes set forth in the Complete Directions for Use label booklet ("Directions") when used in accordance with those Directions under the conditions described therein. NO OTHER EXPRESS WARRANTY OR IMPLIED WARRANTY OF FITNESS FOR PARTICULAR PURPOSE OR MERCHANTABILITY OR ANY OTHER EXPRESS OR IMPLIED WARRANTY IS MADE. This warranty is also subject to the conditions and limitations stated herein.

Buyer and all users shall promptly notify this Company of any claims whether based in contract, negligence, strict liability, other tort or otherwise.

Buyer and all users are responsible for all loss or damage from use or handling which results from conditions beyond the control of this Company, including, but not limited to, incompatibility with products other than those set forth in the Directions, application to or contact with desirable vegetation, unusual weather, weather conditions which are outside the range considered normal at the application site and for the time period when the product is applied, as well as weather conditions which are outside the application ranges set forth in the Directions, application in any manner not explicitly set forth in the Directions, moisture conditions outside the moisture range specified in the Directions, or the presence of products other than those set forth in the Directions in or on the soil or treated vegetation.

THE EXCLUSIVE REMEDY OF THE USER OR BUYER, AND THE LIMIT OF THE LIABILITY OF THIS COMPANY OR ANY OTHER SELLER FOR ANY AND ALL LOSSES, INJURIES OR DAMAGES RESULTING FROM THE USE OR HANDLING OF THIS PRODUCT (INCLUDING CLAIMS BASED IN CONTRACT, NEGLIGENCE, STRICT LIABILITY, OTHER TORT OR OTHERWISE) SHALL BE THE PURCHASE PRICE PAID BY THE USER OR BUYER FOR THE QUANTITY OF THIS PRODUCT INVOLVED, OR, AT THE ELECTION OF THIS COMPANY OR ANY OTHER SELLER, THE REPLACEMENT OF SUCH QUANTITY, OR, IF NOT ACQUIRED BY PURCHASE, REPLACEMENT OF SUCH QUANTITY. IN NO EVENT SHALL THIS COMPANY OR ANY OTHER SELLER BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL, OR SPECIAL DAMAGES.

Buyer and all users are deemed to have accepted the terms of this LIMIT OF WARRANTY AND LIABILITY which may not be varied by any verbal or written agreement.

PRECAUTIONARY STATEMENTS

Hazards to Humans and Domestic Animals

Keep out of reach of children.

CAUTION!

HARMFUL IF INHALED.

Avoid breathing spray mist.

Remove contaminated clothing and wash clothing before reuse.

Wash thoroughly with soap and water after handling.

FIRST AID: IF INHALED, remove individual to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. Get medical attention.

In case of an emergency involving this product, Call Collect, day or night, (314) 694-4000.

Environmental Hazards

Do not contaminate water when disposing of equipment washwaters. Treatment of aquatic weeds can result in oxygen depletion or loss due to decomposition of dead plants. This oxygen loss can cause fish suffocation.

In case of: SPILL or LEAK, soak up and remove to a landfill.

Physical or Chemical Hazards

Spray solutions of this product should be mixed, stored and applied using only stainless steel, aluminum, fiberglass, plastic and plastic-lined steel containers.

DO NOT MIX, STORE OR APPLY THIS PRODUCT OR SPRAY SOLUTIONS OF THIS PRODUCT IN GALVANIZED STEEL OR UNLINED STEEL (EXCEPT STAINLESS STEEL) CONTAINERS OR SPRAY TANKS. This product or spray solutions of this product react with such containers and tanks to produce hydrogen gas which may form a highly combustible gas mixture. This gas mixture could flash or explode, causing serious personal injury, if ignited by open flame, spark, welder's torch, lighted cigarette or other ignition source.

ACTIVE INGREDIENT:
*Glyphosate, N-(phosphonomethyl)glycine,
in the form of its isopropylamine salt 53.8%
INERT INGREDIENTS: 46.2%
100.0%

*Contains 648 grams per litre or 5.4 pounds per U.S. gallon of the active ingredient, glyphosate, in the form of its isopropylamine salt. Equivalent to 480 grams per litre or 4 pounds per U.S. gallon of the acid, glyphosate.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in any manner inconsistent with its labeling.

For more product information, call toll-free 1-800-332-3111.

Storage and Disposal

Do not contaminate water, foodstuffs, feed or seed by storage or disposal.

See container label for STORAGE AND DISPOSAL instructions.

GENERAL INFORMATION

This product, a water-soluble liquid, mixes readily with water and nonionic surfactant to be applied as a foliar spray for the control or destruction of many herbaceous and woody plants.

This product moves through the plant from the point of foliage contact to and into the root system. Visible effects on most annual weeds occur within 2 to 4 days but on most perennial brush species may not occur for 7 days or more. Extremely cool or cloudy weather following treatment may slow the activity of this product and delay visual effects of control. Visible effects are a gradual wilting and yellowing of the plant which advances to complete browning of above-ground growth and deterioration of underground plant parts.

Unless otherwise directed on this label, delay application until vegetation has emerged and reached the stages described for control of such vegetation under the "WEEDS CONTROLLED" section of this label.

Unemerged plants arising from unattached underground rhizomes or root stocks of perennials or brush will not be affected by the spray and will continue to grow. For this reason best control of most perennial weeds or brush is obtained when treatment is made at late growth stages approaching maturity.

Always use the higher rate of this product per acre within the recommended range when vegetation is heavy or dense.

Do not treat weeds or brush under poor growing conditions such as drought stress, disease or insect damage, as reduced control may result. Reduced results may also occur when treating weeds or brush heavily covered with dust.

Reduced control may result when applications are made to any weed or brush species that have been mowed, grazed or cut, and have not been allowed to regrow to the recommended stage for treatment.

Rainfall or irrigation occurring within 6 hours after application may reduce effectiveness. Heavy rainfall or irrigation within 2 hours after application may wash the product off the foliage and a repeat treatment may be required.

When this product comes in contact with soil (on the soil surface or as suspended soil or sediment in water) it is bound to soil particles. Under recommended use situations, once this product is bound to soil particles, it is not available for plant uptake and will not harm off-site vegetation where roots grow into the treatment area or if the soil is transported off-site. Under recommended use conditions, the strong affinity of this product to soil particles prevents this product from leaching out of the soil profile and entering ground water. The affinity between this product and soil particles remains until this product is degraded, which is primarily a biological degradation process carried out under both aerobic and anaerobic conditions by soil microflora.

This product does not provide residual weed control. For subsequent residual weed control, follow a label-approved herbicide program. Read and carefully observe the cautionary statements and all other information appearing on the labels of all herbicides used.

Buyer and all users are responsible for all loss or damage in connection with the use or handling of mixtures of this product or other materials that are not expressly recommended in this label. Mixing this product with herbicides or other materials not recommended in this label may result in reduced performance.

ATTENTION

AVOID DRIFT. EXTREME CARE MUST BE USED WHEN APPLYING THIS PRODUCT TO PREVENT INJURY TO DESIRABLE PLANTS AND CROPS.

Do not allow the herbicide solution to mist, drip, drift or splash onto desirable vegetation since minute quantities of this product can cause severe damage or destruction to the crop, plants or other areas on which treatment was not intended. The likelihood of plant or crop injury occurring from the use of this product is greatest when winds are gusty or in excess of 5 miles per hour or when other conditions, including lesser wind velocities, will allow spray drift to occur. When spraying, avoid combinations of pressure and nozzle type that will result in splatter or fine particles (mist) which are likely to drift. AVOID APPLYING AT EXCESSIVE SPEED OR PRESSURE.

NOTE: Use of this product in any manner not consistent with this label may result in injury to persons, animals or crops, or other unintended consequences. When not in use, keep container closed to prevent spills and contamination.

MIXING AND APPLICATION INSTRUCTIONS

APPLY THESE SPRAY SOLUTIONS IN PROPERLY MAINTAINED AND CALIBRATED EQUIPMENT CAPABLE OF DELIVERING DESIRED VOLUMES. HAND-GUN APPLICATIONS SHOULD BE PROPERLY DIRECTED TO AVOID SPRAYING DESIRABLE PLANTS. NOTE: REDUCED RESULTS MAY OCCUR IF WATER CONTAINING SOIL IS USED, SUCH AS WATER FROM PONDS AND UNLINED DITCHES.

MIXING

This product mixes readily with water. Mix spray solutions of this product as follows: fill the mixing or spray tank with the required amount of water while adding the required amount of this product (see “DIRECTIONS FOR USE” and “WEEDS CONTROLLED” sections of this label). Near the end of the filling process, add the required surfactant and mix well. Remove hose from tank immediately after filling to avoid siphoning back into the water source. During mixing and application, foaming of the spray solution may occur. To prevent or minimize foam, avoid the use of mechanical agitators, place the filling hose below the surface of the spray solution, terminate by-pass and return lines at the bottom of the tank and if needed use an approved anti-foam or defoaming agent.

Keep by-pass line on or near bottom of tank to minimize foaming. Screen size in nozzle or line strainers should be no finer than 50 mesh. Carefully select correct nozzle to avoid spraying a fine mist. For best results with conventional ground application equipment, use flat fan nozzles. Check for even distribution of spray droplets.

When using this product, mix 2 or more quarts of a nonionic surfactant per 100 gallons of spray solution. Use a nonionic surfactant labeled for use with herbicides. The surfactant must contain 50 percent or more active ingredient.

Always read and follow the manufacturer’s surfactant label recommendations for best results.

These surfactants should not be used in excess of 1 quart per acre when making **broadcast** applications.

Colorants or marking dyes approved for use with herbicides may be added to spray mixtures of this product. Colorants or dyes used in spray solutions of this product may reduce performance, especially at lower rates or dilutions. Use colorants or dyes according to the manufacturer’s label recommendations.

Clean sprayer and parts immediately after using this product by thoroughly flushing with water and dispose of rinsate according to labeled use or disposal instructions.

Carefully observe all cautionary statements and other information appearing in the surfactant label.

APPLICATION EQUIPMENT AND TECHNIQUES

■ AERIAL EQUIPMENT ■

See the supplemental label for use of this product by air in California.

Use the recommended rates of this product and surfactant in 3 to 20 gallons of water per acre as a broadcast spray, unless otherwise specified. See the “WEEDS CONTROLLED” section of this label for specific rates. Aerial applications of this product may only be made as specifically recommended in this label.

AVOID DRIFT — DO NOT APPLY DURING INVERSION CONDITIONS, WHEN WINDS ARE GUSTY OR UNDER ANY OTHER CONDITION WHICH WILL ALLOW DRIFT. DRIFT MAY CAUSE DAMAGE TO ANY VEGETATION CONTACTED TO WHICH TREATMENT IS NOT INTENDED. TO PREVENT INJURY TO ADJACENT DESIRABLE VEGETATION, APPROPRIATE BUFFER ZONES MUST BE MAINTAINED.

Coarse sprays are less likely to drift; therefore, do not use nozzles or nozzle configurations which dispense spray as fine spray droplets. Do not angle nozzles forward into the airstream and do not increase spray volume by increasing nozzle pressure.

Drift control additives may be used. When a drift control additive is used, read and carefully observe the cautionary statements and all other information appearing in the additive label.

Ensure uniform application—To avoid streaked, uneven or overlapped application, use appropriate marking devices.

Thoroughly wash aircraft, especially landing gear, after each day of spraying to remove residues of this product accumulated during spraying or from spills. PROLONGED EXPOSURE OF THIS PRODUCT TO UNCOATED STEEL SURFACES MAY RESULT IN CORROSION AND POSSIBLE FAILURE OF THE PART. LANDING GEAR ARE MOST SUSCEPTIBLE. The maintenance of an organic coating (paint) which meets aerospace specification MIL-C-38413 may prevent corrosion.

■ BOOM EQUIPMENT ■

For control of weed or brush species listed in this label using conventional boom equipment—Use the recommended rates of this product and surfactant in 3 to 30 gallons of water per acre as a broadcast spray, unless otherwise specified. See the “WEEDS CONTROLLED” section of this label for specific rates. As density of vegetation increases, spray volume should be increased within the recommended range to ensure complete coverage. Carefully select correct nozzle to avoid spraying a fine mist. For best results with ground application equipment, use flat fan nozzles. Check for even distribution of spray droplets.

■ HAND-HELD and HIGH-VOLUME EQUIPMENT ■

Use Coarse Sprays Only

For control of weeds listed in this label using knapsack sprayers or high-volume spraying equipment utilizing handguns or other suitable nozzle arrangements—Prepare a 3/4 to 2 percent solution of this product in water, add a nonionic surfactant and apply to foliage of vegetation to be controlled. For specific rates of application and instructions for control of various annual and perennial weeds, see the “WEEDS CONTROLLED” section in this label.

Applications should be made on a spray-to-wet basis. Spray coverage should be uniform and complete. Do not spray to point of runoff.

This product may be used as a 5 to 8 percent solution for low-volume directed sprays for spot treatment of trees and brush. It is most effective in areas where there is a low density of undesirable trees or brush. If a straight stream nozzle is used, start the application at the top of the targeted vegetation and spray from top to bottom in a lateral zig-zag motion.

Ensure that at least 50 percent of the leaves are contacted by the spray solution. For flat fan and cone nozzles and with hand-directed mist blowers, mist the application over the foliage of the targeted vegetation. Small, open-branched trees need only be treated from one side. If the foliage is thick or there are multiple root sprouts, applications must be made from several sides to ensure adequate spray coverage.

Prepare the desired volume of spray solution by mixing the amount of this product in water, shown in the following table:

Spray Solution

Desired Volume	Amount of Rodeo®					
	3/4%	1%	1¼%	1½%	5%	8%
1 Gal	1 oz.	1⅓ oz.	1⅔ oz.	2 oz.	6 oz.	10¼ oz.
25 Gal	1½ pt.	1 qt.	1¼ qt.	1½ qt.	5 qt.	2 gal.
100 Gal	3 qt.	1 gal.	1¼ gal.	1½ gal.	5 gal.	8 gal.

2 tablespoons = 1 fluid ounce

For use in knapsack sprayers, it is suggested that the recommended amount of this product be mixed with water in a larger container. Fill sprayer with the mixed solution and add the correct amount of surfactant.

WEEDS CONTROLLED

ANNUAL WEEDS

Apply to actively growing annual grasses and broadleaf weeds.

Allow at least 3 days after application before disturbing treated vegetation. After this period the weeds may be mowed, tilled or burned. See “DIRECTIONS FOR USE”, “GENERAL INFORMATION” and “MIXING AND APPLICATION INSTRUCTIONS” for labeled uses and specific application instructions.

Broadcast Application—Use 1 1/2 pints of this product per acre plus 2 or more quarts of a nonionic surfactant per 100 gallons of spray solution if weeds are less than 6 inches tall. If weeds are greater than 6 inches tall, use 2 1/2 pints of this product per acre plus 2 or more quarts of an approved nonionic surfactant per 100 gallons of spray solution.

Hand-Held, High-Volume Application—Use a 3/4 percent solution of this product in water plus 2 or more quarts of a nonionic surfactant per 100 gallons of spray solution and apply to foliage of vegetation to be controlled.

When applied as directed under the conditions described in this label, this product plus nonionic surfactant WILL CONTROL the following ANNUAL WEEDS:

Balsamapple** — _Momordica charantia_
Barley — _Hordeum vulgare_
Barnyardgrass — _Echinochloa crus-galli_
Bassia, fivehook — _Bassia hyssopifolia_
Bluegrass, annual — _Poa annua_
Bluegrass, bulbous — _Poa bulbosa_
Brome — _Bromus spp._
Buttercup — _Ranunculus spp._
Cheat — _Bromus secalinus_
Chickweed, mouseear — _Cerastium vulgatum_
Cocklebur — _Xanthium strumarium_
Corn, volunteer — _Zea mays_
Crabgrass — _Digitaria spp._
Dwarfdandelion — _Krigia cespitosa_
Falseflax, smallseed — _Camelina microcarpa_
Fiddleneck — _Amsinckia spp._
Flaxleaf fleabane — _Conyza bonariensis_
Fleabane — _Erigeron spp._
Foxtail — _Setaria spp._
Foxtail, Carolina — _Alopecurus carolinianus_
Groundsel, common — _Senecio vulgaris_
Horseweed/Marestail — _Conyza canadensis_
Kochia — _Kochia scoparia_
Lambsquarters, common — _Chenopodium album_
Lettuce, prickly — _Lactuca serriola_
Morningglory — _Ipomoea spp._
Mustard, blue — _Chorispora tenella_
Mustard, tansy — _Descurainia pinnata_
Mustard, tumble — _Sisymbrium altissimum_
Mustard, wild — _Sinapis arvensis_
Oats, wild — _Avena fatua_
Panicum — _Panicum spp._
Pennycress, field — _Thlaspi arvense_
Pigweed, redroot — _Amaranthus retroflexus_
Pigweed, smooth — _Amaranthus hybridus_
Ragweed, common — _Ambrosia artemisiifolia_
Ragweed, giant — _Ambrosia trifida_
Rocket, London — _Sisymbrium irio_
Rye — _Secale cereale_
Ryegrass, Italian* — _Lolium multiflorum_
Sandbur, field — _Cenchrus spp._
Shattercane — _Sorghum bicolor_
Shepherd’s-purse — _Capsella bursa-pastoris_
Signalgrass, broadleaf — _Brachiaria platyphylla_
Smartweed, Pennsylvania — _Polygonum pensylvanicum_
Sowthistle, annual — _Sonchus oleraceus_
Spanishneedles* — _Bidens bipinnata_
Stinkgrass — _Eragrostis cilianensis_
Sunflower — _Helianthus annuus_
Thistle, Russian — _Salsola kali_
Spurry, umbrella — _Holosteum umbellatum_
Velvetleaf — _Abutilon theophrasti_
Wheat — _Triticum aestivum_
Witchgrass — _Panicum capillare_

*Apply 3 pints of this product per acre.

**Apply with hand-held equipment only.

Annual weeds will generally continue to germinate from seed throughout the growing season. Repeat treatments will be necessary to control later germinating weeds.

PERENNIAL WEEDS

Apply this product as follows to control or destroy most vigorously growing perennial weeds. Unless otherwise directed, allow at least 7 days after application before disturbing vegetation.

Add 2 or more quarts of a nonionic surfactant per 100 gallons of spray solution to the rates of this product given in this list. See the “GENERAL INFORMATION”, “DIRECTIONS FOR USE” and “MIXING AND APPLICATION” sections in this label for specific uses and application instructions.

NOTE: If weeds have been mowed or tilled, do not treat until regrowth has reached the recommended stages. Fall treatments must be applied before a killing frost.

Repeat treatments may be necessary to control weeds regenerating from underground parts or seed.

When applied as recommended under the conditions described, this product plus surfactant WILL CONTROL the following PERENNIAL WEEDS:

Alfalfa — _Medicago sativa_
Alligatorweed* — _Alternanthera philoxeroides_
Anise/Fennel — _Foeniculum vulgare_
Artichoke, Jerusalem — _Helianthus tuberosus_
Bahiagrass — _Paspalum notatum_
Bermudagrass — _Cynodon dactylon_
Bindweed, field — _Convolvulus arvensis_
Bluegrass, Kentucky — _Poa pratensis_
Blueweed, Texas — _Helianthus ciliaris_
Brackenfern — _Pteridium spp._
Bromegrass, smooth — _Bromus inermis_
Canarygrass, reed — _Phalaris arundinacea_
Cattail — _Typha spp._
Clover, red — _Trifolium pratense_
Clover, white — _Trifolium repens_
Cogongrass — _Imperata cylindrica_
Cordgrass — _Spartina spp._
Cutgrass, giant* — _Zizaniopsis miliacea_
Dallisgrass — _Paspalum dilatatum_
Dandelion — _Taraxacum officinale_
Dock, curly — _Rumex crispus_
Dogbane, hemp — _Apocynum cannabinum_
Fescue — _Festuca spp._
Fescue, tall — _Festuca arundinacea_

Guineagrass
Panicum maximum

Hemlock, poison
Conium maculatum

Horsenettle
Solanum carolinense

Horseradish
Armoracia rusticana

Ice Plant
Mesembryanthemum crystallinum

Johnsongrass
Sorghum halepense

Kikuyugrass
Pennisetum clandestinum

Knapweed
Centaurea repens

Lantana
Lantana camara

Lespedeza: common, serices
Lespedeza striata
Lespedeza cuneata

Loosestrife, purple
Lythrum salicaria

Lotus, American
Nelumbo lutea

Maidencane
Panicum hematomon

Milkweed
Asclepias spp.

Muhly, wirestem
Muhlenbergia frondosa

Mullein, common
Verbascum thapsus

Napiergrass
Pennisetum purpureum

Nightshade, silverleaf
Solanum elaeagnifolium

Nutsedge: purple, yellow
Cyperus rotundus
Cyperus esculentus

Orchardgrass
Dactylis glomerata

Pampasgrass
Cortaderia jubata

Paragrass
Brachiaria mutica

Phragmites**
Phragmites spp.

Quackgrass
Agropyron repens

Reed, giant
Arundo donax

Ryegrass, perennial
Lolium perenne

Smartweed, swamp
Polygonum coccineum

Spatterdock
Nuphar luteum

Starthistle, yellow
Centaurea solstitialis

Sweet potato, wild*
Ipomoea pandurata

Thistle, artichoke
Cynara cardunculus

Thistle, Canada
Cirsium arvense

Timothy
Phleum pratense

Torpedograss*
Panicum repens

Tules, common
Scirpus acutus

Vaseygrass
Paspalum urvillei

Velvetgrass
Holcus spp.

Waterhyacinth
Eichornia crassipes

Waterlettuce
Pistia stratiotes

Waterprimrose
Ludwigia spp.

Wheatgrass, western
Agropyron smithii

*Partial control.

**Partial control in southeastern states. See specific recommendations below.

Alligatorweed—Apply 6 pints of this product per acre as a broadcast spray or as a 1 1/4 percent solution with hand-held equipment to provide partial control of alligatorweed. Apply when most of the target plants are in bloom. Repeat applications will be required to maintain such control.

Bermudagrass—Apply 7 1/2 pints of this product per acre as a broadcast spray or as a 1 1/2 percent solution with hand-held equipment. Apply when target plants are actively growing and when seedheads appear.

Bindweed, field / Silverleaf Nightshade / Texas Blueweed—Apply 6 to 7 1/2 pints of this product per acre as a broadcast spray west of the Mississippi River and 4 1/2 to 6 pints of this product per acre east of the Mississippi River. With hand-held equipment, use a 1 1/2 percent solution. Apply when target plants are actively growing and are at or beyond full bloom. For silverleaf nightshade, best results can be obtained when application is made after berries are formed. Do not treat when weeds are under drought stress. New leaf development indicates active growth. For best results apply in late summer or fall.

Brackenfern—Apply 4 1/2 to 6 pints of this product per acre as a broadcast spray or as a 3/4 to 1 percent solution with hand-held equipment. Apply to fully expanded fronds which are at least 18 inches long.

Cattail—Apply 4 1/2 to 6 pints of this product per acre as a broadcast spray or as a 3/4 percent solution with hand-held equipment. Apply when target plants are actively growing and are at or beyond the early-to-full bloom stage of growth. Best results are achieved when application is made during the summer or fall months.

Cogongrass—Apply 4 1/2 to 7 1/2 pints of this product per acre as a broadcast spray. Apply when cogongrass is at least 18 inches tall and actively growing in late summer or fall. Allow 7 or more days after application before tillage or mowing. Due to uneven stages of growth and the dense nature of vegetation preventing good spray coverage, repeat treatments may be necessary to maintain control.

Cordgrass–Apply 4 1/2 to 7 1/2 pints of this product per acre as a broadcast spray or as a 1 to 2 percent solution with hand-held equipment. Schedule applications in order to allow 6 hours before treated plants are covered by tidewater. The presence of debris and silt on the cordgrass plants will reduce performance. It may be necessary to wash targeted plants prior to application to improve uptake of this product into the plant.

Cutgrass, giant—Apply 6 pints of this product per acre as a broadcast spray or as a 1 percent solution with hand-held equipment to provide partial control of giant cutgrass. Repeat applications will be required to maintain such control, especially where vegetation is partially submerged in water. Allow for substantial regrowth to the 7 to 10-leaf stage prior to retreatment.

Dogbane, hemp / Knapweed / Horseradish—Apply 6 pints of this product per acre as a broadcast spray or as a 1 1/2 percent solution with hand-held equipment. Apply when target plants are actively growing and most have reached the late bud-to-flower stage of growth. For best results, apply in late summer or fall.

Fescue, tall—Apply 4 1/2 pints of this product per acre as a broadcast spray or as a 1 percent solution with hand-held equipment. Apply when target plants are actively growing and most have reached the boot-to-head stage of growth. When applied prior to the boot stage, less desirable control may be obtained.

Guineagrass—Apply 4 1/2 pints of this product per acre as a broadcast spray or as a 3/4 percent solution with hand-held equipment. Apply when target plants are actively growing and when most have reached at least the 7-leaf stage of growth.

Johnsongrass / Bluegrass, Kentucky / Bromegrass, smooth / Canarygrass, reed / Orchardgrass / Ryegrass, perennial / Timothy / Wheatgrass, western — Apply 3 to 4 1/2 pints of this product per acre as a broadcast spray or as a 3/4 percent solution with hand-held equipment. Apply when target plants are actively growing and most have reached the boot-to-head stage of growth. When applied prior to the boot stage, less desirable control may be obtained. In the fall, apply before plants have turned brown.

Lantana—Apply this product as a 3/4 to 1 percent solution with hand-held equipment. Apply to actively growing lantana at or beyond the bloom stage of growth. Use the higher application rate for plants that have reached the woody stage of growth.

Loosestrife, purple—Apply 4 pints of this product per acre as a broadcast spray or as a 1 to 1 1/2 percent solution using hand-held equipment. Treat when plants are actively growing at or beyond the bloom stage of growth. Best results are achieved when application is made during summer or fall months. Fall treatments must be applied before a killing frost.

Lotus, American—Apply 4 pints of this product per acre as a broadcast spray or as a 3/4 percent solution with hand-held equipment. Treat when plants are actively growing at or beyond the bloom stage of growth. Best results are achieved when application is made during summer or fall months. Fall treatments must be applied before a killing frost. Repeat treatment may be necessary to control regrowth from underground parts and seeds.

Maidencane / Paragrass—Apply 6 pints of this product per acre as a broadcast spray or as a 3/4 percent solution with hand-held equipment. Repeat treatments will be required, especially to vegetation partially submerged in water. Under these conditions, allow for regrowth to the 7 to 10-leaf stage prior to retreatment.

Milkweed, common—Apply 4 1/2 pints of this product per acre as a broadcast spray or as a 1 1/2 percent solution with hand-held equipment. Apply when target plants are actively growing and most have reached the late bud-to-flower stage of growth.

Nutsedge: purple, yellow—Apply 4 1/2 pints of this product per acre as a broadcast spray, or as a 3/4 percent solution with hand-held equipment to control existing nutsedge plants and immature nutlets attached to treated plants. Apply when target plants are in flower or when new nutlets can be found at rhizome tips. Nutlets which have not germinated will not be controlled and may germinate following treatment. Repeat treatments will be required for long-term control.

Pampasgrass—Apply a 1 1/2 percent solution of this product with hand-held equipment when plants are actively growing.

Phragmites—For partial control of phragmites in Florida and the counties of other states bordering the Gulf of Mexico, apply 7 1/2 pints per acre as a broadcast spray or apply a 1 1/2 percent solution with hand-held equipment. In other areas of the U.S., apply 4 to 6 pints per acre as a broadcast spray or apply a 3/4 percent solution with hand-held equipment for partial control. For best results, treat during late summer or fall months when plants are actively growing and in full bloom. Due to the dense nature of the vegetation, which may prevent good spray coverage and uneven stages of growth, repeat treatments may be necessary to maintain control. Visual control symptoms will be slow to develop.

Quackgrass / Kikuyugrass / Muhly, wirestem—Apply 3 to 4 1/2 pints of this product per acre as a broadcast spray or as a 3/4 percent solution with hand-held equipment when most quackgrass or wirestem muhly is at least 8 inches in height (3 to 4-leaf stage of growth) and actively growing. Allow 3 or more days after application before tillage.

Reed, giant / ice plant—For control of giant reed and ice plant, apply a 1 1/2 percent solution of this product with hand-held equipment when plants are actively growing. For giant reed, best results are obtained when applications are made in late summer to fall.

Spatterdock—Apply 6 pints of this product per acre as a broadcast spray or as a 3/4 percent solution with hand-held equipment. Apply when most plants are in full bloom. For best results, apply during the summer or fall months.

Sweet potato, wild—Apply this product as a 1 1/2 percent solution using hand-held equipment. Apply to actively growing weeds that are at or beyond the bloom stage of growth. Repeat applications will be required. Allow the plant to reach the recommended stage of growth before retreatment.

Thistle: Canada, artichoke—Apply 3 to 4 1/2 pints of this product per acre as a broadcast spray or as a 1 1/2 percent solution with hand-held equipment for Canada thistle. To control artichoke thistle, apply a 2 percent solution as a spray-to-wet application. Apply when target plants are actively growing and are at or beyond the bud stage of growth.

Torpedograss—Apply 6 to 7 1/2 pints of this product per acre as a broadcast spray or as a 3/4 to 1 1/2 percent solution with hand-held equipment to provide partial control of torpedograss. Use the lower rates under terrestrial conditions, and the higher rates under partially submerged or a floating mat condition. Repeat treatments will be required to maintain such control.

Tules, common—Apply this product as a 1 1/2 percent solution with hand-held equipment. Apply to actively growing plants at or beyond the seedhead stage of growth. After application, visual symptoms will be slow to appear and may not occur for 3 or more weeks.

Waterhyacinth—Apply 5 to 6 pints of this product per acre as a broadcast spray or apply a 3/4 to 1 percent solution with hand-held equipment. Apply when target plants are actively growing and at or beyond the early bloom stage of growth. After application, visual symptoms may require 3 or more weeks to appear with complete necrosis and decomposition usually occurring within 60 to 90 days. Use the higher rates when more rapid visual effects are desired.

Waterlettuce—For control, apply a 3/4 to 1 percent solution of this product with hand-held equipment to actively growing plants. Use higher rates where infestations are heavy. Best results are obtained from mid-summer through winter applications. Spring applications may require retreatment.

Waterprimrose—Apply this product as a 3/4 percent solution using hand-held equipment. Apply to plants that are actively growing at or beyond the bloom stage of growth, but before fall color changes occur. Thorough coverage is necessary for best control.

Other perennials listed on this label—Apply 4 1/2 to 7 1/2 pints of this product per acre as a broadcast spray or as a 3/4 to 1 1/2 percent solution with hand-held equipment. Apply when target plants are actively growing and most have reached early head or early bud stage of growth.

WOODY BRUSH AND TREES

When applied as recommended under the conditions described, this product plus surfactant CONTROLS or PARTIALLY CONTROLS the following woody brush plants and trees:

Alder
Alnus spp.

Ash*
Fraxinus spp.

Aspen, quaking
Populus tremuloides

Bearclover, Bearmat
Chamaebatia foliolosa

Birch
Betula spp.

Blackberry
Rubus spp.

Broom:
French
Cytisus monspessulanus
Scotch
Cytisus scoparius

Buckwheat, California*
Eriogonum fasciculatum

Cascara*
Rhamnus purshiana

Catsclaw*
Acacia greggi

Ceanothus
Ceanothus spp.

Chamise
Adenostoma fasciculatum

Cherry:
Bitter
Prunus emarginata
Black
Prunus serotina
Pin
Prunus pensylvanica

Coyote brush
Baccharis consanguinea

Creeper, Virginia*
Parthenocissus quinquefolia

Dewberry
Rubus trivialis

Dogwood
Cornus spp.

Elderberry
Sambucus spp.

Elm*
Ulmus spp.

Eucalyptus, bluegum
Eucalyptus globulus

Hasardia*
Haplopappus squamosus

Hawthorn
Crataegus spp.

Hazel
Corylus spp.

Hickory
Carya spp.

Holly, Florida;
Brazilian Peppertree
Schinus terebinthifolius

Honeysuckle
Lonicera spp.

Hornbeam, American
Carpinus caroliniana

Kudzu
Pueraria lobata

Locust, black*
Robinia pseudoacacia

Manzanita
Arctostaphylos spp.

Maple:
Red**
Acer rubrum
Sugar
Acer saccharum
Vine*
Acer circinatum

Monkey Flower*
Mimulus guttatus

Oak:
Black*
Quercus velutina
Northern pine
Quercus palustris
Post
Quercus stellata
Red
Quercus rubra
Southern red
Quercus falcata
White*
Quercus alba

Persimmon*
Diospyros spp.

Poison Ivy
Rhus radicans

Poison Oak
Rhus toxicodendron

Poplar, yellow*
Liriodendron tulipifera

Prunus
Prunus spp.

Raspberry
Rubus spp.

Redbud, eastern
Cercis canadensis

Rose, multiflora
Rosa multiflora

Russian-olive
Elaeagnus angustifolia

Sage: black, white
Salvia spp.

Sagebrush, California
Artemisia californica

Salmonberry
Rubus spectabilis

Salt cedar*
Tamarix spp.

Saltbush, Sea myrtle
Baccharis halimifolia

Sassafras
Sassafras aibidum

Sourwood*
Oxydendrum arboreum

Sumac:
Poison*
Rhus vernix
Smooth*
Rhus glabra
Winged*
Rhus copallina

Sweet gum
Liquidambar styraciflua

Swordfern*
Polystichum munitum

Tallowtree, Chinese
Sapium sebiferum

Thimbleberry
Rubus parviflorus

Tobacco, tree*
Nicotiana glauca

Trumpetcreeper
Campsis radicans

Waxmyrtle, southern*
Myrica cerifera

Willow
Salix spp.

*Partial control

**See below for control or partial control instruction.

NOTE: If brush has been mowed or tilled or trees have been cut, do not treat until regrowth has reached the recommended stage of growth.

Apply the recommended rate of this product plus 2 or more quarts of a nonionic surfactant per 100 gallons of spray solution when plants are actively growing and, unless otherwise directed, after full-leaf expansion. Use the higher rate for larger plants and/or dense areas of growth. On vines, use the higher rate for plants that have reached the woody stage of growth. Best results are obtained when application is made in late summer or fall after fruit formation.

In arid areas, best results are obtained when application is made in the spring or early summer when brush species are at high moisture content and are flowering. Ensure thorough coverage when using hand-held equipment. Symptoms may not appear prior to frost or senescence with fall treatments.

Allow 7 or more days after application before tillage, mowing or removal. Repeat treatments may be necessary to control plants regenerating from underground parts or seed. Some autumn colors on undesirable deciduous species are acceptable provided no major leaf drop has occurred. Reduced performance may result if fall treatments are made following a frost.

See the "DIRECTIONS FOR USE" and "MIXING AND APPLICATION INSTRUCTIONS" sections in this label for labeled use and specific application instructions.

Applied as a 5 to 8 percent solution as a directed application as described in the "HAND-HELD AND HIGH-VOLUME EQUIPMENT" section, this product will control or partially control all species listed in this section of this label. Use the higher rate of application for dense stands and larger woody brush and trees.

Apply the product as follows to control or partially control the following woody brush and trees.

Alder / Blackberry / Dewberry / Honeysuckle / Oak, Post / Raspberry—For control, apply 4 1/2 to 6 pints per acre as a broadcast spray or as a 3/4 to 1 1/4 percent solution with hand-held equipment.

Aspen, Quaking / Hawthorn / Trumpetcreeper—For control, apply 3 to 4 1/4 pints of this product per acre as a broadcast spray or as a 3/4 to 1 1/4 percent solution with hand-held equipment.

Birch / Elderberry / Hazel / Salmonberry / Thimbleberry—For control, apply 3 pints per acre of this product as a broadcast spray or as a 3/4 percent solution with hand-held equipment.

Broom: French, Scotch—For control, apply a 1 1/4 to 1 1/2 percent solution with hand-held equipment.

Buckwheat, California / Hasardia / Monkey Flower / Tobacco, Tree—For partial control of these species, apply a 3/4 to 1 1/2 percent solution of this product as a foliar spray with hand-held equipment. Thorough coverage of foliage is necessary for best results.

Catsclaw—For partial control, apply a 1 1/4 to 1 1/2 percent solution with hand-held equipment when at least 50 percent of the new leaves are fully developed.

Cherry: Bitter, Black, Pin / Oak, Southern Red / Sweet Gum / Prunus—For control, apply 3 to 7 1/2 pints of this product per acre as a broadcast spray or as a 1 to 1 1/2 percent solution with hand-held equipment.

Coyote brush—For control, apply a 1 1/4 to 1 1/2 percent solution with hand-held equipment when at least 50 percent of the new leaves are fully developed.

Dogwood / Hickory / Salt cedar—For partial control, apply a 1 to 2 percent solution of this product with hand-held equipment or 6 to 7 1/2 pints per acre as a broadcast spray.

Eucalyptus, bluegum—For control of eucalyptus resprouts, apply a 1 1/2 percent solution of this product with hand-held equipment when resprouts are 6 to 12-feet tall. Ensure complete coverage. Apply when plants are actively growing. Avoid application to drought-stressed plants.

Holly, Florida / Waxmyrtle, southern—For partial control, apply this product as a 1 1/2 percent solution with hand-held equipment.

Kudzu—For control, apply 6 pints of this product per acre as a broadcast spray or as a 1 1/2 percent solution with hand-held equipment. Repeat applications will be required to maintain control.

Maple, Red—For control, apply as a 3/4 to 1 1/4 percent solution with hand-held equipment when leaves are fully developed. For partial control, apply 2 to 7 1/2 pints of this product per acre as a broadcast spray.

Maple, Sugar / Oak: Northern Pin, Red—For control, apply as a 3/4 to 1 1/4 percent solution with hand-held equipment when at least 50 percent of the new leaves are fully developed.

Poison Ivy / Poison Oak—For control, apply 6 to 7 1/2 pints of this product per acre as a broadcast spray or as a 1 1/2 percent solution with hand-held equipment. Repeat applications may be required to maintain control. Fall treatments must be applied before leaves lose green color.

Rose, multiflora—For control, apply 3 pints of this product per acre as a broadcast spray or as a 3/4 percent solution with hand-held equipment. Treatments should be made prior to leaf deterioration by leaf-feeding insects.

Sage, black / Sagebrush, California / Chamise / Tallowtree, Chinese—For control of these species, apply a 3/4 percent solution of this product as a foliar spray with hand-held equipment. Thorough coverage of foliage is necessary for best results.

Saltbush, Sea myrtle—For control, apply this product as a 1 percent solution with hand-held equipment.

Willow—For control, apply 4 1/2 pints of this product per acre as a broadcast spray or as a 3/4 percent solution with hand-held equipment.

Other woody brush and trees listed in this label—For partial control, apply 3 to 7 1/2 pints of this product per acre as a broadcast spray or as a 3/4 to 1 1/2 percent solution with hand-held equipment.

AQUATIC AND OTHER NONCROP SITES

When applied as directed and under the conditions described in the "WEEDS CONTROLLED" section in this label, this product will control or partially control the labeled weeds growing in the following industrial, recreational and public areas or other similar aquatic and terrestrial sites.

Aquatic Sites—This product may be applied to emerged weeds in all bodies of fresh and brackish water which may be flowing, nonflowing or transient. This includes lakes, rivers, streams, ponds, estuaries, rice levees, seeps, irrigation and drainage ditches, canals, reservoirs, wastewater treatment facilities, wildlife habitat restoration and management areas, and similar sites.

If aquatic sites are present in the noncrop area and are part of the intended treatment, read and observe the following directions:

This product does not control plants which are completely submerged or have a majority of their foliage under water.

There is no restriction on the use of treated water for irrigation, recreation or domestic purposes.

Consult local state fish and game agency and water control authorities before applying this product to public water. Permits may be required to treat such water.

NOTE: Do not apply this product directly to water within 1/2 mile upstream of an active potable water intake in flowing water (i.e., river, stream, etc.) or within 1/2 mile of an active potable water intake in a standing body of water such as lake, pond or reservoir. To make aquatic applications around and within 1/2 mile of active potable water intakes, the water intake must be turned off for a minimum period of 48 hours after the application. The water intake may be turned on prior to 48 hours if the glyphosate level in the intake water is below 0.7 parts per million as determined by laboratory analysis. These aquatic applications may be made ONLY in those cases where there are alternative water sources or holding ponds which would permit the turning off of an active potable water intake for a minimum period of 48 hours after the applications. This restriction does not apply to intermittent inadvertant overspray of water in terrestrial use sites.

For treatments after drawdown of water or in dry ditches, allow 7 or more days after treatment before reintroduction of water to achieve maximum weed control. Apply this product within 1 day after drawdown to ensure application to actively growing weeds.

Floating mats of vegetation may require retreatment. Avoid wash-off of sprayed foliage by spray boat or recreational boat backwash or by rainfall within 6 hours of application. Do not re-treat within 24 hours following the initial treatment.

Applications made to moving bodies of water must be made while traveling upstream to prevent concentration of this herbicide in water. When making any bankside applications, do not overlap more than 1 foot into open water. Do not spray in bodies of water where weeds do not exist. The maximum application rate of 7 1/2 pints per acre must not be exceeded in any single broadcast application that is being made over water.

When emerged infestations require treatment of the total surface area of impounded water, treating the area in strips may avoid oxygen depletion due to decaying vegetation. Oxygen depletion may result in fish kill.

Other Noncrop-Type Sites—This product may be used to control the listed weeds in terrestrial noncrop sites and/or in aquatic sites within these areas.

Airports

Golf Courses

Habitat Restoration & Management Areas

Highways & Roadsides

Industrial Plant Sites

Lumberyards

Parking Areas

Parks

Petroleum Tank Farms

Pipeline, Power, Telephone & Utility Rights-of-Way

Pumping Installations

Railroads

Schools

Storage Areas

Similar Sites

WILDLIFE HABITAT RESTORATION AND MANAGEMENT AREAS

This product is recommended for the restoration and/or maintenance of native habitat and in wildlife management areas.

Habitat Restoration and Maintenance—When applied as directed, exotic and other undesirable vegetation may be controlled in habitat management areas. Applications may be made to allow recovery of native plant species, to open up water to attract waterfowl, and for similar broad-spectrum vegetation control requirements in habitat management areas. Spot treatments may be made to selectively remove unwanted plants for habitat enhancement. For spot treatments, care should be exercised to keep spray off of desirable plants.

Wildlife Food Plots—This product may be used as a site preparation treatment prior to planting wildlife food plots. Apply as directed to control vegetation in the plot area. Any wildlife food species may be planted after applying this product, or native species may be allowed to reinfest the area. If tillage is needed to prepare a seedbed, wait 7 days after applying this product before tilling to allow for maximum effectiveness.

WIPER APPLICATIONS

For wick or wiper applications, mix 1 gallon of this product with 2 gallons of clean water to make a 33 percent solution. Addition of a nonionic surfactant at a rate of 10 percent by volume of total herbicide solution is recommended.

Wiper applications can be used to control or suppress annual and perennial weeds listed on this label. In heavy weed stands, a double application in opposite directions may improve results. See the "WEEDS CONTROLLED" section in this label for recommended timing, growth stage and other instructions for achieving optimum results.

CUT STUMP APPLICATION

Woody vegetation may be controlled by treating freshly cut stumps of trees and resprouts with this product. Apply this product using suitable equipment to ensure coverage of the entire cambium. Cut vegetation close to the soil surface. **Apply a 50 to 100 percent solution of this product to freshly cut surface immediately after cutting.** Delay in applying this product may result in reduced performance. For best results, trees should be cut during periods of active growth and full leaf expansion.

When used according to directions for cut stump application, this product will CONTROL, PARTIALLY CONTROL or SUPPRESS most woody brush and tree species, some of which are listed below:

Alder
Alnus spp.

Coyote brush*
Baccharis consanguinea

Dogwood*
Cornus spp.

Eucalyptus
Eucalyptus spp.

Hickory*
Carya spp.

Madrone
Arbutus menziesii

Maple*
Acer spp.

Oak
Quercus spp.

Poplar*
Populus spp.

Reed, giant
Arundo donax

Salt cedar
Tamarix spp.

Sweet gum*
Liquidambar styraciflua

Sycamore*
Platanus occidentalis

Tan oak
Lithocarpus densiflorus

Willow
Salix spp.

*This product is not approved for this use on these species in the state of California.

INJECTION AND FRILL APPLICATIONS

Woody vegetation may be controlled by injection or frill application of this product. Apply this product using suitable equipment which must penetrate into living tissue. Apply the equivalent of 1 ml of this product per 2 to 3 inches of trunk diameter. This is best achieved by applying 25 to 100 percent concentration of this product either to a continuous frill around the tree or as cuts evenly spaced around the tree below all branches. As tree diameter increases in size, better results are achieved by applying dilute material to a continuous frill or more closely spaced cuttings. Avoid application techniques that allow runoff to occur from frill or cut areas in species that exude sap freely after frills or cutting. In species such as these, make frill or cut at an oblique angle so as to produce a cupping effect and use undiluted material. For best results, applications should be made during periods of active growth and full leaf expansion.

This treatment WILL CONTROL the following woody species:

Oak
Quercus spp.

Poplar
Populus spp.

Sweet gum
Liquidambar styraciflua

Sycamore
Platanus occidentalis

This treatment WILL SUPPRESS the following woody species:

Black gum*
Nyssa sylvatica

Dogwood
Cornus spp.

Hickory
Carya spp.

Maple, red
Acer rubrum

*This product is not approved for this use on this species in the state of California.

RELEASE OF BERMUDAGRASS OR BAHIAGRASS ON NONCROP SITES

RELEASE OF DORMANT BERMUDAGRASS AND BAHIAGRASS

When applied as directed, this product will provide control or suppression of many winter annual weeds and tall fescue for effective release of dormant bermudagrass or bahiagrass. Make applications to dormant bermudagrass or bahiagrass.

For best results on winter annuals, treat when weeds are in an early growth stage (below 6 inches in height) after most have germinated. For best results on tall fescue, treat when fescue is in or beyond the 4 to 6-leaf stage.

WEEDS CONTROLLED

Rate recommendations for control or suppression of winter annuals and tall fescue are listed below.

Apply the recommended rates of this product in 10 to 25 gallons of water per acre plus 2 quarts nonionic surfactant per 100 gallons of total spray volume.

WEEDS CONTROLLED OR SUPPRESSED*

NOTE: C = Control
S = Suppression

	RODEO® FLUID OZ/ACRE					
WEED SPECIES	6	9	12	18	24	48
Barley, little *Hordeum pusillum*	S	C	C	C	C	C
Bedstraw, catchweed *Galium aparine*	S	C	C	C	C	C
Bluegrass, annual *Poa annua*	S	C	C	C	C	C

WEEDS CONTROLLED OR SUPPRESSED* (continued)

NOTE: C = Control
S = Suppression

WEED SPECIES	RODEO® FLUID OZ/ACRE 6	9	12	18	24	48
Chervil *Chaerophyllum tainturieri*	S	C	C	C	C	C
Chickweed, common *Stellaria media*	S	C	C	C	C	C
Clover, crimson *Trifolium incarnatum*	•	S	S	C	C	C
Clover, large hop *Trifolium campestre*	•	S	S	C	C	C
Speedwell, corn *Veronica arvensis*	S	C	C	C	C	C
Fescue, tall *Festuca arundinacea*	•	•	•	•	S	S
Geranium, Carolina *Geranium carolinianum*	•	•	S	S	C	C
Henbit *Lamium amplexicaule*	•	S	C	C	C	C
Ryegrass, Italian *Lolium multiflorum*	•	•	S	C	C	C
Vetch, common *Vicia sativa*	•	•	S	C	C	C

*These rates apply only to sites where an established competitive turf is present.

RELEASE OF ACTIVELY GROWING BERMUDAGRASS

NOTE: USE ONLY ON SITES WHERE BAHIAGRASS OR BERMUDAGRASS ARE DESIRED FOR GROUND COVER AND SOME TEMPORARY INJURY OR YELLOWING OF THE GRASSES CAN BE TOLERATED.

When applied as directed, this product will aid in the release of bermudagrass by providing control of annual species listed in the "WEEDS CONTROLLED" section in this label, and suppression or partial control of certain perennial weeds.

For control or suppression of those annual species listed in this label, use 3/4 to 2 1/4 pints of this product as a broadcast spray in 10 to 25 gallons of spray solution per acre, plus 2 quarts of a nonionic surfactant per 100 gallons of total spray volume. Use the lower rate when treating annual weeds below 6 inches in height (or length of runner in annual vines). Use the higher rate as size of plants increases or as they approach flower or seedhead formation.

Use the higher rate for partial control or longer-term suppression of the following perennial species. Use lower rates for shorter-term suppression of growth.

Bahiagrass	Johnsongrass**
Dallisgrass	Trumpetcreeper*
Fescue (tall)	Vaseygrass

*Suppression at the higher rate only.
**Johnsongrass is controlled at the higher rate.

Use only on well-established bermudagrass. Bermudagrass injury may result from the treatment but regrowth will occur under moist conditions. Repeat applications in the same season are not recommended, since severe injury may result.

BAHIAGRASS SEEDHEAD AND VEGETATIVE SUPPRESSION

When applied as directed in the "NONCROP SITES" section in this label, this product will provide significant inhibition of seedhead emergence and will suppress vegetative growth for a period of approximately 45 days with single applications and approximately 120 days with sequential applications.

Apply this product 1 to 2 weeks after full green-up of bahiagrass or after the bahiagrass has been mowed to a uniform height of 3 to 4 inches. Applications must be made prior to seedhead emergence. Apply 5 fluid ounces per acre of this product, plus 2 quarts of an approved nonionic surfactant per 100 gallons of total spray volume in 10 to 25 gallons of water per acre.

Sequential applications of this product plus nonionic surfactant may be made at approximately 45-day intervals to extend the period of seedhead and vegetative growth suppression. For continued vegetative growth suppression, sequential applications must be made prior to seedhead emergence.

Apply no more than 2 sequential applications per year. As a first sequential application, apply 3 fluid ounces of this product per acre plus nonionic surfactant. A second sequential application of 2 to 3 fluid ounces per acre plus nonionic surfactant may be made approximately 45 days after the last application.

ANNUAL GRASS GROWTH SUPPRESSION

For growth suppression of some annual grasses, such as annual ryegrass, wild barley and wild oats growing in coarse turf on roadsides or other industrial areas, apply 3 to 4 ounces of this product in 10 to 40 gallons of spray solution per acre. Mix 2 quarts of a nonionic surfactant per 100 gallons of spray solution. Applications should be made when annual grasses are actively growing and before the seedheads are in the boot stage of development. Treatments made after seedhead emergence may cause injury to the desired grasses.

Product is protected by U.S. Patent No. 4,405,531. Other patents are pending. No license granted under any non-U.S. patent(s).

EPA Reg. No. 524-343

In case of an emergency involving this product,
Call Collect, day or night, (314) 694-4000.

MONSANTO COMPANY
ST. LOUIS, MISSOURI, 63167 U.S.A. 21061W3-1/CG

Roundup® PRO

Herbicide by Monsanto

The complete broad spectrum postemergence professional herbicide for industrial, turf and ornamental weed control.

Complete Directions for Use

EPA Reg. No. 524-475

AVOID CONTACT OF HERBICIDE WITH FOLIAGE, GREEN STEMS, EXPOSED NON-WOODY ROOTS OR FRUIT OF CROPS, DESIRABLE PLANTS AND TREES, BECAUSE SEVERE INJURY OR DESTRUCTION IS LIKELY TO RESULT.

1998-1 21136W4-1/CG

Read the entire label before using this product.

Use only according to label instructions.

It is a violation of Federal law to use this product in any manner inconsistent with its labeling.

Not all products recommended on this label are registered for use in California. Check the registration status of each product in California before using.

Read the "LIMIT OF WARRANTY AND LIABILITY" statement at the end of the label before buying or using. If terms are not acceptable, return at once unopened.

REFORMULATION IS PROHIBITED. SEE INDIVIDUAL CONTAINER LABEL FOR REPACKAGING LIMITATIONS.

1.0 INGREDIENTS

ACTIVE INGREDIENT:	
*Glyphosate, N-(phosphonomethyl)glycine, in the form of its isopropylamine salt	41.0%
INERT INGREDIENTS (including surfactant):	59.0%
	100.0%

*Contains 480 grams per litre or 4 pounds per U.S. gallon of the active ingredient glyphosate, in the form of its isopropylamine salt. Equivalent to 356 grams per litre or 3 pounds per U.S. gallon of the acid, glyphosate.

This product is protected by U.S. Patent No. 4,405,531. Other patents pending. No license granted under any non-U.S. patent(s).

2.0 IMPORTANT PHONE NUMBERS

1. FOR PRODUCT INFORMATION OR ASSISTANCE IN USING THIS PRODUCT, CALL TOLL-FREE,

   1-800-332-3111

2. IN CASE OF AN EMERGENCY INVOLVING THIS PRODUCT, OR FOR MEDICAL ASSISTANCE, CALL COLLECT, DAY OR NIGHT,

   (314)-694-4000

3.0 PRECAUTIONARY STATEMENTS

3.1 Hazards to Humans and Domestic Animals

Keep out of reach of children.

CAUTION!

CAUSES EYE IRRITATION.

Avoid contact with eyes or clothing.

FIRST AID: IF IN EYES, flush with plenty of water. Get medical attention if irritation persists.

DOMESTIC ANIMALS: This product is considered to be relatively nontoxic to dogs and other domestic animals; however, ingestion of this product or large amounts of freshly sprayed vegetation may result in temporary gastrointestinal irritation (vomiting, diarrhea, colic, etc.). If such symptoms are observed, provide the animal with plenty of fluids to prevent dehydration. Call a veterinarian if symptoms persist for more than 24 hours.

Personal Protective Equipment (PPE)

Applicators and other handlers must wear: long-sleeved shirt and long pants, shoes plus socks. Follow manufacturer's instructions for cleaning/maintaining Personal Protective Equipment (PPE). If there are no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

When handlers use closed systems, enclosed cabs or aircraft in a manner that meets the requirements listed in Worker Protection Standard (WPS) for agricultural pesticides [40 CFR 170.240 (d) (4-6)], the handler PPE requirements may be reduced or modified as specified in the WPS.

User Safety Recommendations:

Users should:

- Wash hands before eating, drinking, chewing gum, using tobacco or using the toilet.
- Remove clothing immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.

3.2 Environmental Hazards

Do not apply directly to water, to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment washwaters.

3.3 Physical or Chemical Hazards

Spray solutions of this product should be mixed, stored and applied using only stainless steel, aluminum, fiberglass, plastic or plastic-lined steel containers.

DO NOT MIX, STORE OR APPLY THIS PRODUCT OR SPRAY SOLUTIONS OF THIS PRODUCT IN GALVANIZED STEEL OR UNLINED STEEL (EXCEPT STAINLESS STEEL) CONTAINERS OR SPRAY TANKS. This product or spray solutions of this product react with such containers and tanks to produce hydrogen gas which may form a highly combustible gas mixture. This gas mixture could flash or explode, causing serious personal injury, if ignited by open flame, spark, welder's torch, lighted cigarette or other ignition source.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in any manner inconsistent with its labeling. For any requirements specific to your State or Tribe, consult the agency responsible for pesticide regulations.

Agricultural Use Requirements

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR part 170. This Standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about Personal Protective Equipment (PPE) and restricted entry interval. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard.

Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application.

Do not enter or allow worker entry into treated areas during the restricted entry interval (REI) of 4 hours.

PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil or water, is: coveralls, waterproof gloves, shoes plus socks.

Non-Agricultural Use Requirements

The requirements in this box apply to uses of this product that are NOT within the scope of the Worker Protection Standard (40 CFR Part 170) for agricultural pesticides. The WPS applies when this product is used to produce agricultural plants on farms, forests, nurseries or greenhouses.

Keep people and pets off treated areas until spray solution has dried to prevent transfer of this product onto desirable vegetation.

4.0 STORAGE AND DISPOSAL

Do not contaminate water, foodstuffs, feed or seed by storage or disposal.

See container label for STORAGE AND DISPOSAL instructions.

5.0 GENERAL INFORMATION

Product Description: This product is a postemergent, systemic herbicide with no soil residual activity. It gives broad spectrum control of many annual weeds, perennial weeds, woody brush and trees. It is formulated as a water-soluble liquid containing surfactant and no additional surfactant is needed or recommended.

Environmental Fate: When this product comes in contact with the soil it is bound to soil particles. When used in accordance with label directions, once this product is bound it is not available for plant uptake and will not harm off-site vegetation where roots grow into the treatment area or if the soil is transported off-site. The strong affinity of this product to soil particles prevents this product from leaching out of the soil profile and entering ground water. The affinity between this product and soil particles remains until this product is degraded, which is primarily a biological degradation process carried out under both aerobic and anaerobic conditions by soil microflora.

Time to Symptoms: This product moves through the plant from the point of foliage contact to and into the root system. Visible effects on most annual weeds occur within 2 to 4 days, but on most perennial weeds may not occur for 7 days or more. Extremely cool or cloudy weather following treatment may slow activity of this product and delay development of visual symptoms. Visible effects are a gradual wilting and yellowing of the plant which advances to complete browning of above-ground growth and deterioration of underground plant parts.

Mode of Action in Plants: The active ingredient in this product inhibits an enzyme found only in plants that is essential to formation of specific amino acids.

Cultural Considerations: Reduced control may result when applications are made to annual or perennial weeds that have been mowed, grazed or cut, and have not been allowed to regrow to the recommended stage for treatment.

Rainfastness: Heavy rainfall soon after application may wash this product off of the foliage and a repeat application may be required for adequate control.

No Soil Activity: Weeds must be emerged at the time of application to be controlled by this product. Weeds germinating from seed after application will not be controlled. Unemerged plants arising from unattached underground rhizomes or root stocks of perennials will not be affected by the herbicide.

Volatility: Roundup Pro is non-volatile. Therefore, it cannot move as a vapor after application to affect nearby vegetation.

Toxicology: Exposure to workers and other applicators generally is expected to pose minimal risks based on results of short-term toxicity studies. Glyphosate has been thoroughly tested and determined not to cause cancer or other adverse long-term health effects.

Tank Mixing: This product does not provide residual weed control. For subsequent residual weed control, follow a label-approved herbicide program. Read and carefully observe the cautionary statements and all other information appearing on the labels of all herbicides used. Use according to the most restrictive label directions for each product in the mixture.

Buyer and all users are responsible for all loss or damage in connection with the use or handling of mixtures of this product with herbicides or other materials that are not expressly recommended in this label. Mixing this product with herbicides or other materials not recommended on this label may result in reduced performance.

Annual Maximum Use Rate: The combined total of all treatments must not exceed 10.6 quarts of this product per acre per year.

ATTENTION

AVOID CONTACT OF HERBICIDE WITH FOLIAGE, GREEN STEMS, EXPOSED NON-WOODY ROOTS OR FRUIT OF CROPS, DESIRABLE PLANTS AND TREES, BECAUSE SEVERE INJURY OR DESTRUCTION IS LIKELY TO RESULT.

AVOID DRIFT. EXTREME CARE MUST BE USED WHEN APPLYING THIS PRODUCT TO PREVENT INJURY TO DESIRABLE PLANTS AND CROPS.

Do not allow the herbicide solution to mist, drip, drift or splash onto desirable vegetation since minute quantities of this product can cause severe damage or destruction to the crop, plants or other areas on which treatment was not intended. The likelihood of injury occurring from the use of this product increases when winds are gusty, as wind velocity increases, when wind direction is constantly changing or when there are other meteorological conditions that favor spray drift. When spraying, avoid combinations of pressure and nozzle type that will result in splatter or fine particles (mist) which are likely to drift. AVOID APPLYING AT EXCESSIVE SPEED OR PRESSURE.

NOTE: Use of this product in any manner not consistent with this label may result in injury to persons, animals or crops, or other unintended consequences. Keep container closed to prevent spills and contamination.

6.0 MIXING

Clean sprayer parts immediately after using this product by thoroughly flushing with water.

NOTE: REDUCED RESULTS MAY OCCUR IF WATER CONTAINING SOIL IS USED, SUCH AS VISIBLY MUDDY WATER OR WATER FROM PONDS AND DITCHES THAT IS NOT CLEAR.

6.1 Mixing with Water

This product mixes readily with water. Mix spray solutions of this product as follows: Fill the mixing or spray tank with the required amount of water. Add the recommended amount of this product near the end of the filling process and mix well. Use caution to avoid siphoning back into the carrier source. Use approved anti-back-siphoning devices where required by state or local regulations. During mixing and application, foaming of the spray solution may occur. To prevent or minimize foam, avoid the use of mechanical agitators, terminate by-pass and return lines at the bottom of the tank and, if needed, use an approved anti-foam or defoaming agent.

6.2 Tank Mixing Procedure

When tank mixing, read and carefully observe label directions, cautionary statements and all information on the labels of all products used. Add the tank-mix product to the tank as directed by the label. Maintain agitation and add the recommended amount of this product.

Maintain good agitation at all times until the contents of the tank are sprayed. If the spray mixture is allowed to settle, thorough agitation may be required to resuspend the mixture before spraying is resumed.

Keep by-pass line on or near the bottom of the tank to minimize foaming. Screen size in nozzle or line strainers should be no finer than 50 mesh.

Always predetermine the compatibility of labeled tank mixtures of this product with water carrier by mixing small proportional quantities in advance.

Refer to the "Tank Mixing" section of "GENERAL INFORMATION" for additional precautions.

6.3 Mixing for Hand-held Sprayers

Prepare the desired volume of spray solution by mixing the amount of this product in water as shown in the following table:

Spray Solution

Desired	Amount of Roundup PRO					
Volume	1/2%	1%	1 1/2%	2%	5%	10%
1 Gal	2/3 oz	1 1/3 oz	2 oz	2 2/3 oz	6 1/2 oz	13 oz
25 Gal	1 pt	1 qt	1 1/2 qt	2 qt	5 qt	10 qt
100 Gal	2 qt	1 gal	1 1/2 gal	2 gal	5 gal	10 gal
2 tablespoons = 1 fluid ounce						

For use in knapsack sprayers, it is suggested that the recommended amount of this product be mixed with water in a larger container. Fill sprayer with the mixed solution.

6.4 Colorants or Dyes

Agriculturally-approved colorants or marking dyes may be added to this product. Colorants or dyes used in spray solutions of this product may reduce performance, especially at lower rates or dilution. Use colorants or dyes according to the manufacturer's recommendations.

7.0 APPLICATION EQUIPMENT AND TECHNIQUES

Do not apply this product through any type of irrigation system.

APPLY THESE SPRAY SOLUTIONS IN PROPERLY MAINTAINED AND CALIBRATED EQUIPMENT CAPABLE OF DELIVERING DESIRED VOLUMES.

7.1 Aerial Equipment

DO NOT APPLY THIS PRODUCT USING AERIAL SPRAY EQUIPMENT EXCEPT UNDER CONDITIONS AS SPECIFIED WITHIN THIS LABEL.

FOR AERIAL APPLICATION IN CALIFORNIA, REFER TO THE FEDERAL SUPPLEMENTAL LABEL FOR AERIAL APPLICATIONS IN THAT STATE FOR SPECIFIC INSTRUCTIONS, RESTRICTIONS AND REQUIREMENTS. This product plus Oust™, Banvel™ or 2,4-D tank mixtures may not be applied by air in California.

AVOID DRIFT—DO NOT APPLY DURING LOW-LEVEL INVERSION CONDITIONS, WHEN WINDS ARE GUSTY OR UNDER ANY OTHER CONDITION WHICH FAVORS DRIFT. DRIFT IS LIKELY TO CAUSE DAMAGE TO ANY VEGETATION CONTACTED TO WHICH TREATMENT IS NOT INTENDED. TO PREVENT INJURY TO ADJACENT DESIRABLE VEGETATION, APPROPRIATE BUFFER ZONES MUST BE MAINTAINED.

Avoid direct application to any body of water.

Use the recommended rates of this herbicide in 3 to 25 gallons of water per acre.

Coarse sprays are less likely to drift; therefore, do not use nozzles or nozzle configurations which dispense spray as fine spray droplets. Do not angle nozzles forward into the airstream and do not increase spray volume by increasing nozzle pressure.

Drift control additives may be used. When a drift control additive is used, read and carefully observe the cautionary statements and all other information appearing on the additive label.

Ensure uniform application—To avoid streaked, uneven or overlapped application, use appropriate marking devices.

PROLONGED EXPOSURE OF THIS PRODUCT TO UNCOATED STEEL SURFACES MAY RESULT IN CORROSION AND POSSIBLE FAILURE OF THE PART. The maintenance of an organic coating (paint) which meets aerospace specification MIL-C-38413 may prevent corrosion. To prevent corrosion of exposed parts, thoroughly wash aircraft after each day of spraying to remove residues of this product accumulated during spraying or from spills. Landing gear are most susceptible.

7.2 Ground Broadcast Equipment

Use the recommended rates of this product in 3 to 40 gallons of water per acre as a broadcast spray unless otherwise specified. As density of weeds increases, spray volume should be increased within the recommended range to ensure complete coverage. Carefully select proper nozzles to avoid spraying a fine mist. For best results with ground application equipment, use flat fan nozzles. Check for even distribution of spray droplets.

7.3 Hand-Held and High-Volume Equipment

Apply to foliage of vegetation to be controlled. For applications made on a spray-to-wet basis, spray coverage should be uniform and complete. Do not spray to the point of runoff. Use coarse sprays only.

For control of weeds listed in the "Annual Weeds" section of "WEEDS CONTROLLED," apply a 0.5 percent solution of this product to weeds less than 6 inches in height or runner length. For annual weeds over 6 inches tall, or unless otherwise specified, use a 1 percent solution. Apply prior to seedhead formation in grass or bud formation in broadleaf weeds.

For best results, use a 2 percent solution on harder-to-control perennials, such as bermudagrass, dock, field bindweed, hemp dogbane, milkweed and Canada thistle.

For low volume directed spray applications, use a 5 to 10 percent solution of this product for control or partial control of annual weeds, perennial weeds, or woody brush and trees. Spray coverage should be uniform with at least 50 percent of the foliage contacted. Coverage of the top one half of the plant is important for best results. To ensure adequate spray coverage, spray both sides of large or tall woody brush and trees, when foliage is thick and dense, or where there are multiple sprouts.

7.4 Selective Equipment

This product may be applied through recirculating spray systems, shielded applicators, hooded sprayers, wiper applicators or sponge bars after dilution and thorough mixing with water to listed weeds growing in any noncrop site specified on this label.

A recirculating spray system directs the spray solution onto weeds growing above desirable vegetation, while spray solution not intercepted by weeds is collected and returned to the spray tank for reuse.

A shielded or hooded applicator directs the herbicide solution onto weeds, while shielding desirable vegetation from the herbicide.

A wiper or sponge applicator applies the herbicide solution onto weeds by rubbing the weed with an absorbent material containing the herbicide solution.

AVOID CONTACT OF HERBICIDE WITH DESIRABLE VEGETATION AS SERIOUS INJURY OR DEATH IS LIKELY TO OCCUR.

Applicators used above desired vegetation should be adjusted so that the lowest spray stream or wiper contact point is at least 2 inches above the desirable vegetation. Droplets, mist, foam or splatter of the herbicide solution settling on desirable vegetation is likely to result in discoloration, stunting or destruction.

Better results may be obtained when more of the weed is exposed to the herbicide solution. Weeds not contacted by the herbicide solution will not be affected. This may occur in dense clumps, severe infestations or when the height of the weeds varies so that not all weeds are contacted. In these instances, repeat treatment may be necessary.

Shielded and hooded applicators

Use nozzles that provide uniform coverage within the treated area. Keep shields on these sprayers adjusted to protect desirable vegetation. EXTREME CARE MUST BE EXERCISED TO AVOID CONTACT OF HERBICIDE WITH DESIRABLE VEGETATION.

Wiper applicators and sponge bars

Equipment must be designed, maintained and operated to prevent the herbicide solution from contacting desirable vegetation. Operate this equipment at ground speeds no greater than 5 mph. Performance may be improved by reducing speed in areas of heavy weed infestations to ensure adequate wiper saturation. Better results may be obtained if 2 applications are made in opposite directions.

Avoid leakage or dripping onto desirable vegetation. Adjust height of applicator to ensure adequate contact with weeds. Keep wiping surfaces clean. Be aware that, on sloping ground, the herbicide solution may migrate, causing dripping on the lower end and drying of the wicks on the upper end of a wiper applicator.

Do not use wiper equipment when weeds are wet.

Mix only the amount of solution to be used during a 1-day period, as reduced activity may result from use of leftover solutions. Clean wiper parts immediately after using this product by thoroughly flushing with water.

For Rope or Sponge Wick Applicators—Solutions ranging from 33 to 75 percent of this product in water may be used.

For Porous-Plastic Applicators and pressure-feed systems—Solutions ranging from 33 to 100 percent of this product in water may be used.

When applied as recommended, this product CONTROLS the following weeds:

Corn, volunteer	Sicklepod
Panicum, Texas	Spanishneedles
Rye, common	Starbur, bristly
Shattercane	

When applied as recommended, this product SUPPRESSES the following weeds:

Beggarweed, Florida	Ragweed, common
Bermudagrass	Ragweed, giant
Dogbane, hemp	Smutgrass
Dogfennel	Sunflower
Guineagrass	Thistle, Canada
Johnsongrass	Thistle, musk
Milkweed	Vaseygrass
Nightshade, silverleaf	Velvetleaf
Pigweed, redroot	

7.5 Injection Systems

This product may be used in aerial or ground injection spray systems. It may be used as a liquid concentrate or diluted prior to injecting into the spray stream. Do not mix this product with the undiluted concentrate of other products when using injection systems unless specifically recommended.

7.6 CDA Equipment

The rate of this product applied per acre by controlled droplet application (CDA) equipment must not be less than the amount recommended in this label when applied by conventional broadcast equipment. For vehicle-mounted CDA equipment, apply 3 to 15 gallons of water per acre.

CDA equipment produces a spray pattern which is not easily visible. Extreme care must be exercised to avoid spray or drift contacting the foliage or any other green tissue of desirable vegetation, as damage or destruction is likely to result.

8.0 SITE AND USE RECOMMENDATIONS

Detailed instructions follow alphabetically, by site.

Unless otherwise specified, applications may be made to control any weeds listed in the annual, perennial and woody brush tables. Refer also to the "SELECTIVE EQUIPMENT" section.

8.1 Cut Stumps

Cut stump treatments may be made on any site listed on this label. This product will control many types of woody brush and tree species, some of which are listed below. Apply this product using suitable equipment to ensure coverage of the entire cambium. Cut trees or resprouts close to the soil surface. Apply a 50 to 100 percent solution of this product to the freshly-cut surface **immediately** after cutting. Delays in application may result in reduced performance. For best results, applications should be made during periods of active growth and full leaf expansion.

Alder	Saltcedar
Eucalyptus	Sweetgum
Madrone	Tan oak
Oak	Willow
Reed, giant	

DO NOT MAKE CUT STUMP APPLICATIONS WHEN THE ROOTS OF DESIRABLE WOODY BRUSH OR TREES MAY BE GRAFTED TO THE ROOTS OF THE CUT STUMP. INJURY RESULTING FROM ROOT GRAFTING IS LIKELY TO OCCUR IN ADJACENT WOODY BRUSH OR TREES.

8.2 General Noncrop Areas and Industrial Sites

Use in areas such as airports, apartment complexes, Christmas tree farms, ditch banks, dry ditches, dry canals, fencerows, golf courses, industrial sites, lumberyards, manufacturing sites, office complexes, ornamental nurseries, parks, parking areas, petroleum tank farms and pumping installations, railroads, recreational areas, residential areas, roadsides, sod or turf seed farms, schools, storage areas, utility substations, warehouse areas, other public areas, and similar industrial and noncrop sites.

General weed control, Trim-and-edge and Bare ground

This product may be used in general noncrop areas. It may be applied with any application equipment described in this label. This product may be used to trim-and-edge around objects in noncrop sites, for spot treatment of unwanted vegetation and to eliminate unwanted weeds growing in established shrub beds or ornamental plantings. This product may be used prior to planting an area to ornamentals, flowers, turfgrass (sod or seed), or prior to laying asphalt or beginning construction projects.

Repeated applications of this product may be used, as weeds emerge, to maintain bare ground.

This product may be tank mixed with the following products. Refer to these products' labels for approved noncrop sites and application rates.

ARSENAL™	PLATEAU™
BANVEL	PRINCEP™ DF
BARRICADE™ 65WG	PRINCEP LIQUID
DIURON	RONSTAR™ 50 WP
ENDURANCE™	SAHARA™
ESCORT™	SIMAZINE
KARMEX™ DF	SURFLAN™
KROVAR™ I DF	TELAR™
OUST	VANQUISH™
PENDULUM™ 3.3 EC	2,4-D
PENDULUM WDG	

Oust, Banvel and 2,4-D tank mixtures may not be applied by air in California.

When applied as a tank mixture for bare ground, this product provides control of the emerged annual weeds and control or partial control of emerged perennial weeds, woody brush and trees.

For control or partial control of the following perennial weeds, apply 1 to 2 quarts of this product plus 2 to 4 ounces of Oust per acre.

Bahiagrass	Fescue, tall
Bermudagrass	Johnsongrass
Broomsedge	Poorjoe
Dallisgrass	Quackgrass
Dock, curly	Vaseygrass
Dogfennel	Vervain, blue

Chemical mowing—Perennials

This product will suppress perennial grasses listed in this section to serve as a substitute for mowing. Use 8 fluid ounces of this product per acre when treating tall fescue, fine fescue, orchardgrass or quackgrass covers. Use 6 fluid ounces of this product per acre when treating Kentucky bluegrass. Apply treatments in 10 to 40 gallons of spray solution per acre.

Use only in areas where some temporary injury or discoloration of perennial grasses can be tolerated.

Chemical mowing—Annuals

For growth suppression of some annual grasses, such as annual ryegrass, wild barley and wild oats growing in coarse turf on roadsides or other industrial areas, apply 4 to 5 fluid ounces of this product in 10 to 40 gallons of spray solution per acre. Applications should be made when annual grasses are actively growing and before the seedheads are in the boot stage of development. Treatments may cause injury to the desired grasses.

Dormant turfgrass

This product may be used to control or suppress many winter annual weeds and tall fescue for effective release of dormant bermudagrass and bahiagrass turf. Treat only when turf is dormant and prior to spring greenup.

Apply 8 to 64 fluid ounces of this product per acre. Apply the recommended rates in 10 to 40 gallons of water per acre. Use only in areas where bermudagrass or bahiagrass are desirable ground covers and where some temporary injury or discoloration can be tolerated.

Treatments in excess of 16 fluid ounces per acre may result in injury or delayed greenup in highly maintained areas, such as golf courses and lawns. DO NOT apply tank mixtures of this product plus Oust in highly maintained turfgrass areas. For further uses, refer to the "ROADSIDES" section of this label, which gives rates for dormant bermudagrass and bahiagrass treatments.

Actively growing bermudagrass

This product may be used to control or partially control many annual and perennial weeds for effective release of actively growing bermudagrass. DO NOT apply more than 16 fluid ounces of this product per acre in highly maintained turfgrass areas. DO NOT apply tank mixtures of this product plus OUST in highly maintained turfgrass areas. For further uses, refer to the "ROADSIDES" section of this label, which gives rates for actively growing bermudagrass treatments. Use only in areas where some temporary injury or discoloration can be tolerated.

Turfgrass renovation, seed, or sod production

This product controls most existing vegetation prior to renovating turfgrass areas or establishing turfgrass grown for seed or sod. For maximum control of existing vegetation, delay planting or sodding to determine if any regrowth from escaped underground plant parts occurs. Where repeat treatments are necessary, sufficient regrowth must be attained prior to application. For warm-season grasses such as bermudagrass, summer or fall applications provide the best control. Where existing vegetation is growing under mowed turfgrass management, apply this product after omitting at least one regular mowing to allow sufficient growth for good interception of the spray.

Do not disturb soil or underground plant parts before treatment. Tillage or renovation techniques such as vertical mowing, coring or slicing should be delayed for 7 days after application to allow translocation into underground plant parts.

Desirable turfgrasses may be planted following the above procedures.

Hand-held equipment may be used for spot treatment of unwanted vegetation growing in existing turfgrass. Broadcast or hand-held equipment may be used to control sod remnants or other unwanted vegetation after sod is harvested.

Do not feed or graze turfgrass grown for seed or sod production for 8 weeks following application.

8.3 Habitat Management

Habitat restoration and management

This product may be used to control exotic and other undesirable vegetation in habitat management and natural areas, including rangeland and wildlife refuges. Applications can be made to allow recovery of native plant species, prior to planting desirable native species, and for similar broad spectrum vegetation control requirements. Spot treatments can be made to selectively remove unwanted plants for habitat management and enhancement.

Wildlife food plots

This product may be used as a site preparation treatment prior to planting wildlife food plots. Any wildlife food species may be planted after applying this product, or native species may be allowed to repopulate the area. If tillage is needed to prepare a seedbed, wait 7 days after application before tillage to allow translocation into underground plant parts.

8.4 Injection and Frill (Woody Brush and Trees)

This product may be used to control woody brush and trees by injection or frill applications. Apply this product using suitable equipment which must penetrate into the living tissue. Apply the equivalent of 1 ml of this product per each 2 to 3 inches of trunk diameter at breast height (DBH). This is best achieved by applying a 50 to 100 percent concentration of this product either to a continuous frill around the tree or as cuts evenly spaced around the tree below all branches. As tree diameter increases in size, better results are achieved by applying diluted material to a continuous frill or more closely spaced cuttings. Avoid application techniques that allow runoff to occur from frilled or cut areas in species that exude sap freely. In species such as this, make the frill or cuts at an oblique angle to produce a cupping effect and use a 100 percent concentration of this product. For best results, application should be made during periods of active growth and after full leaf expansion. This product will control many species, some of which are listed below:

Control	Partial Control
Oak	Black gum
Poplar	Dogwood
Sweetgum	Hickory
Sycamore	Maple, red

8.5 Ornamentals and Plant Nurseries, Christmas Trees

Post-directed, Trim-and-edge

This product may be used as a post-directed spray around established woody ornamental species such as arborvitae, azalea, boxwood, crabapple, euonymus, fir, douglas fir, jojoba, hollies, lilac, magnolia, maple, oak, privet, pine, spruce and yew. This product may also be used to trim and edge around trees, buildings, sidewalks and roads, potted plants and other objects in a nursery setting.

Desirable plants may be protected from the spray solution by using shields or coverings made of cardboard or other impermeable material. THIS PRODUCT IS NOT RECOMMENDED FOR USE AS AN OVER-THE-TOP BROADCAST SPRAY IN ORNAMENTALS AND CHRISTMAS TREES. Care must be exercised to avoid contact of spray, drift or mist with foliage or green bark of established ornamental species.

Site preparation

This product may be used prior to planting any ornamental, nursery or Christmas tree species.

Greenhouse/Shadehouse

This product may be used to control weeds growing in and around greenhouses and shadehouses. Desirable vegetation must not be present during application and air circulation fans must be turned off.

8.6 Parks, Recreational and Residential Areas

This product may be used in parks, recreational and residential areas. It may be applied with any application equipment described in this label. This product may be used to trim-and-edge around trees, fences, paths, around buildings, sidewalks, and other objects in these areas. This product may be used for spot treatment of unwanted vegetation. This product may be used to eliminate unwanted weeds growing in established shrub beds or ornamental plantings. This product may be used prior to planting an area to ornamentals, flowers, turfgrass (sod or seed), or prior to laying asphalt or beginning construction projects.

All of the instructions in the "GENERAL NONCROP AREAS AND INDUSTRIAL SITES" section apply to park and recreational areas.

8.7 Railroads

All of the instructions in the "GENERAL NONCROP AREAS AND INDUSTRIAL SITES" section apply to railroads.

Bare ground, Ballast and Shoulders, Crossings, and Spot treatment

This product may be used to maintain bare ground on railroad ballast and shoulders. Repeat applications of this product may be used, as weeds emerge, to maintain bare ground. This product may be used to control tall-growing weeds to improve line-of-sight at railroad crossings and reduce the need for mowing along rights-of-way. For crossing applications, up to 80 gallons of spray solution per acre may be used. This product may be tank mixed with the following products for ballast, shoulder, spot, bare ground and crossing treatments:

ARSENAL	KROVAR I DF
BANVEL	OUST
DIURON	SAHARA
ESCORT	SPIKE™
GARLON™ 3A	TELAR
GARLON 4	VANQUISH
HYVAR™ X	2,4-D

Brush control

This product may be used to control woody brush and trees on railroad rights-of-way. Apply 4 to 10 quarts of this product per acre as a broadcast spray, using boom-type or boomless nozzles. Up to 80 gallons of spray solution per acre may be used. Apply a 3/4 to 2 percent solution of this product when using high-volume spray-to-wet applications. Apply a 5 to 10 percent solution of this product when using low volume directed sprays for spot treatment. This product may be mixed with the following products for enhanced control of woody brush and trees:

ARSENAL	GARLON 4
ESCORT	TORDON™ K
GARLON 3A	

Bermudagrass release

This product may be used to control or partially control many annual and perennial weeds for effective release of actively growing bermudagrass. Apply 1 to 3 pints of this product in up to 80 gallons of spray solution per acre. Use the lower rate when treating annual weeds below 6 inches in height (or runner length). Use the higher rate as weeds increase in size or as they approach flower or seedhead formation. These rates will also provide partial control of the following perennial species:

Bahiagrass	Johnsongrass
Bluestem, silver	Trumpetcreeper
Fescue, tall	Vaseygrass

This product may be tank-mixed with Oust. If tank-mixed, use no more than 1 to 3 pints of this product with 1 to 2 ounces of Oust per acre. Use the lower rates of each product to control annual weeds less than 6 inches in height (or runner length) that are listed in this label and the Oust label. Use the higher rates as annual weeds increase in size and approach the flower or seedhead stages. These rates will also provide partial control of the following perennial weeds:

Bahiagrass	Fescue, tall
Blackberry	Johnsongrass
Bluestem, silver	Poorjoe
Broomsedge	Raspberry
Dallisgrass	Trumpetcreeper
Dewberry	Vaseygrass
Dock, curly	Vervain, blue
Dogfennel	

Use only on well-established bermudagrass. Bermudagrass injury may result from the treatment, but regrowth will occur under moist conditions. Repeat applications in the same season are not recommended, since severe injury may occur.

8.8 Roadsides

All of the instructions in the "GENERAL NONCROP AREAS AND INDUSTRIAL SITES" section apply to roadsides.

Shoulder treatments

This product may be used on road shoulders. It may be applied with boom sprayers, shielded boom sprayers, high-volume off-center nozzles, hand-held equipment, and similar equipment.

Guardrails and other obstacles to mowing

This product may be used to control weeds growing under guardrails and around signposts and other objects along the roadside.

Spot treatment

This product may be used as a spot treatment to control unwanted vegetation growing along roadsides.

Tank mixtures

This product may be tank-mixed with the following products for shoulder, guardrail, spot and bare ground treatments:

BANVEL	PRINCEP LIQUID
DIURON	RONSTAR 50WP
ENDURANCE	SAHARA
ESCORT	SIMAZINE
KROVAR I DF	SURFLAN
OUST	TELAR
PENDULUM 3.3 EC	VANQUISH
PENDULUM WDG	2,4-D
PRINCEP DF	

See the "GENERAL NONCROP AREAS AND INDUSTRIAL SITES" section of this label for general instructions for tank mixing.

Release of Bermudagrass or Bahiagrass

Dormant applications

This product may be used to control or partially control many winter annual weeds and tall fescue for effective release of dormant bermudagrass or bahiagrass. Treat only when turf is dormant and prior to spring greenup. This product may also be tank-mixed with Oust for residual control. Tank mixtures of this product with Oust may delay greenup.

For best results on winter annuals, treat when plants are in an early growth stage (below 6 inches in height) after most have germinated. For best results on tall fescue, treat when fescue is at or beyond the 4- to 6-leaf stage.

Apply 8 to 64 fluid ounces of this product per acre alone or in a tank mixture with 1/4 to 1 ounce per acre of Oust. Apply the recommended rates in 10 to 40 gallons of water per acre. Use only in areas where bermudagrass or bahiagrass are desirable ground covers and where some temporary injury or discoloration can be tolerated. To avoid delays in greenup and minimize injury, add no more than 1 ounce of Oust per acre on bermudagrass and no more than 0.5 ounce of Oust per acre on bahiagrass and avoid treatments when these grasses are in a semi-dormant condition.

Actively growing bermudagrass

This product may be used to control or partially control many annual and perennial weeds for effective release of actively growing bermudagrass. Apply 1 to 3 pints of this product in 10 to 40 gallons of spray solution per acre. Use the lower rate when treating annual weeds below 6 inches in height (or runner length). Use the higher rate as weeds increase in size or as they approach flower or seedhead formation. These rates will also provide partial control of the following perennial species:

Bahiagrass	Johnsongrass
Bluestem, silver	Trumpetcreeper
Fescue, tall	Vaseygrass

This product may be tank-mixed with Oust. If tank-mixed, use no more than 1 to 2 pints of this product with 1 to 2 ounces of Oust per acre. Use the lower rates of each product to control annual weeds less than 6 inches in height (or runner length) that are listed in this label and the Oust label. Use the higher rates as annual weeds increase in size and approach the flower or seedhead stages. These rates will also provide partial control of the following perennial weeds:

Bahiagrass	Fescue, tall
Bluestem, silver	Johnsongrass
Broomsedge	Poorjoe
Dallisgrass	Trumpetcreeper
Dock, curly	Vaseygrass
Dogfennel	Vervain, blue

Use only on well-established bermudagrass. Bermudagrass injury may result from the treatment, but regrowth will occur under moist conditions. Repeat applications of the tank mix in the same season are not recommended, since severe injury may occur.

Actively growing bahiagrass

For suppression of vegetative growth and seedhead inhibition of bahiagrass for approximately 45 days, apply 6 fluid ounces of this product in 10 to 40 gallons of water per acre. Apply 1 to 2 weeks after full greenup or after mowing to a uniform height of 3 to 4 inches. This application must be made prior to seedhead emergence.

For suppression up to 120 days, apply 4 fluid ounces of this product per acre, followed by an application of 2 to 4 fluid ounces per acre about 45 days later. Make no more than 2 applications per year.

A tank mixture of this product plus Oust may be used. Apply 6 fluid ounces of this product plus 0.25 ounce of Oust per acre 1 to 2 weeks following an initial spring mowing. Make only one application per year.

9.0 WEEDS CONTROLLED

Always use the higher rate of this product per acre within the recommended range when weed growth is heavy or dense or weeds are growing in an undisturbed (noncultivated) area.

Reduced results may occur when treating weeds heavily covered with dust. For weeds that have been mowed, grazed or cut, allow regrowth to occur prior to treatment.

Refer to the following label sections for recommended rates for the control of annual and perennial weeds and woody brush and trees. For difficult to control perennial weeds and woody brush and trees, where plants are growing under stressed conditions, or where infestations are dense, this product may be used at 5 to 10 quarts per acre for enhanced results.

9.1 Annual Weeds

Use 1 quart per acre if weeds are less than 6 inches in height or runner length and 1.5 quarts to 4 quarts per acre if weeds are over 6 inches in height or runner length or when weeds are growing under stressed conditions.

For spray-to-wet applications, apply a 0.5 percent solution of this product to weeds less than 6 inches in height or runner length. Apply prior to seedhead formation in grass or bud formation in broadleaf weeds. For annual weeds over 6 inches tall, or for smaller weeds growing under stressed conditions, use a 1 to 2 percent solution. Use the higher rate for tough-to-control species or for weeds over 24 inches tall.

WEED SPECIES

Annoda, spurred	Horseweed/Marestail *(Conyza canadensis)*
Barley*	Itchgrass*
Barnyardgrass*	Johnsongrass, seedling
Bittercress*	Junglerice
Black nightshade*	Knotweed
Bluegrass, annual*	Kochia
Bluegrass, bulbous*	Lambsquarters*
Bassia, fivehook	Little barley*
Brome, downy*	London rocket*
Brome, Japanese*	Mayweed
Browntop panicum*	Medusahead*
Buttercup*	Morningglory *(Ipomoea spp.)*
Carolina foxtail*	Mustard, blue*
Carolina geranium	Mustard, tansy*
Cheatgrass*	Mustard, tumble*
Chervil*	Mustard, wild*
Chickweed*	Oats
Cocklebur*	Pigweed*
Copperleaf, hophornbeam	Plains/Tickseed coreopsis*
Corn*	Prickly lettuce*
Corn speedwell*	Purslane, common
Crabgrass*	Ragweed, common*
Dwarfdandelion*	Ragweed, giant
Eastern mannagrass*	Red rice
Eclipta*	Russian thistle
Fall panicum*	Rye*
Falsedandelion*	Ryegrass*
Falseflax, smallseed*	Sandbur, field*
Fiddleneck	Shattercane*
Field pennycress*	Shepherd's-purse*
Filaree	Sicklepod
Fleabane, annual*	Signalgrass, broadleaf*
Fleabane, hairy *(Conyza bonariensis)**	Smartweed, ladysthumb*
Fleabane, rough*	Smartweed, Pennsylvania*
Florida pusley	Sowthistle, annual
Foxtail*	Spanishneedles
Goatgrass, jointed*	Speedwell, purslane*
Goosegrass	Sprangletop*
Grain sorghum (milo)*	Spurge, annual
Groundsel, common*	Spurge, prostrate*
Hemp sesbania	Spurge, spotted*
Henbit	Spurry, umbrella*
Starthistle, yellow	Virginia copperleaf
Stinkgrass*	Virginia pepperweed*
Sunflower*	Wheat*
Teaweed/Prickly sida	Wild oats*
Texas panicum*	Witchgrass*
Velvetleaf	Woolly cupgrass*
	Yellow rocket

*When using field broadcast equipment (aerial applications or boom sprayers using flat fan nozzles) these species will be controlled or partially controlled using 1 pint of this product per acre. Applications must be made using 3 to 10 gallons of carrier volume per acre. Use nozzles that ensure thorough coverage of foliage and treat when weeds are in an early growth stage.

9.2 Perennial Weeds

Best results are obtained when perennial weeds are treated after they reach the reproductive stage of growth (seedhead initiation in grasses and bud formation in broadleaves). For non-flowering plants, best results are obtained when the plants reach a mature stage of growth. In many situations, treatments are required prior to these growth stages. Under these conditions, use the higher application rate within the recommended range.

Ensure thorough coverage when using spray-to-wet treatments using hand-held equipment. When using hand-held equipment for low volume directed spot treatments, apply a 5 to 10 percent solution of this product.

Allow 7 or more days after application before tillage.

Weed Species	Rate (QT/A)	Hand-Held % Solution
Alfalfa*	1	2
Alligatorweed*	4	1.5
Anise (fennel)	2-4	1-2
Bahiagrass	3-5	2
Bentgrass*	1.5	2
Bermudagrass	5	2
Bermudagrass, water (knotgrass)	1.5	2
Bindweed, field	4-5	2
Bluegrass, Kentucky	2	2
Blueweed, Texas	4-5	2
Brackenfern	3-4	1-1.5
Bromegrass, smooth	2	2
Bursage, woolly-leaf	—	2
Canarygrass, reed	2-3	2
Cattail	3-5	2
Clover; red, white	3-5	2
Cogongrass	3-5	2
Dallisgrass	3-5	2
Dandelion	3-5	2
Dock, curly	3-5	2
Dogbane, hemp	4	2
Fescue (except tall)	3-5	2
Fescue, tall	1-3	2
German ivy	2-4	1-2
Guineagrass	3	1
Horsenettle	3-5	2
Horseradish	4	2
Iceplant	2	1.5-2
Jerusalem artichoke	3-5	2
Johnsongrass	2-3	1
Kikuyugrass	2-3	2
Knapweed	4	2
Lantana	—	1-1.25
Lespedeza	3-5	2
Milkweed, common	3	2
Muhly, wirestem	2	2
Mullein, common	3-5	2
Napiergrass	3-5	2
Nightshade, silverleaf	2	2
Nutsedge; purple, yellow	3	1-2
Orchardgrass	2	2
Pampasgrass	3-5	1.5-2
Paragrass	3-5	2
Pepperweed, perennial	4	2
Phragmites*	3-5	1-2
Poison hemlock	2-4	1-2
Quackgrass	2-3	2
Redvine*	2	2
Reed, giant	4-5	2
Ryegrass, perennial	2-3	1
Smartweed, swamp	3-5	2

Weed Species	Rate (QT/A)	Hand-Held % Solution
Spurge, leafy*	—	2
Sweet potato, wild*	—	2
Thistle, artichoke	2-3	1-2
Thistle, Canada	2-3	2
Timothy	2-3	2
Torpedograss*	4-5	2
Trumpetcreeper*	2-3	2
Vaseygrass	3-5	2
Velvetgrass	3-5	2
Wheatgrass, western	2-3	2

*Partial control

9.3 Woody Brush and Trees

Apply this product after full leaf expansion, unless otherwise directed. Use the higher rate for larger plants and/or dense areas of growth. On vines, use the higher rate for plants that have reached the woody stage of growth. Best results are obtained when application is made in late summer or fall after fruit formation.

In arid areas, best results are obtained when applications are made in the spring to early summer when brush species are at high moisture content and are flowering.

Ensure thorough coverage when using spray-to-wet treatments using hand-held equipment. When using hand-held equipment for low volume directed-spray spot treatments, apply a 5 to 10 percent solution of this product.

Symptoms may not appear prior to frost or senescence with fall treatments.

Allow 7 or more days after application before tillage, mowing or removal. Repeat treatments may be necessary to control plants regenerating from underground parts or seed. Some autumn colors on undesirable deciduous species are acceptable provided no major leaf drop has occurred. Reduced performance may result if fall treatments are made following a frost.

Weed Species	Broadcast Rate (QT/A)	Hand-Held Spray-to-Wet % Solution
Alder	3-4	1-1.5
Ash*	2-5	1-2
Aspen, quaking	2-3	1-1.5
Bearmat (Bearclover)*	2-5	1-2
Beech*	2-5	1-2
Birch	2	1
Blackberry	3-4	1-1.5
Blackgum	2-5	1-2
Bracken	2-5	1-2
Broom; French, Scotch	2-5	1.5-2
Buckwheat, California*	2-4	1-2
Cascara*	2-5	1-2
Catsclaw*	—	1-1.5
Ceanothus*	2-5	1-2
Chamise*	2-5	1
Cherry; bitter, black, pin	2-3	1-1.5
Coyote brush	3-4	1.5-2
Dogwood*	2-5	1-2
Elderberry	2	1
Elm*	2-5	1-2
Eucalyptus	—	2
Florida holly (Brazilian Peppertree)*	2-5	1-2
Gorse*	2-5	1-2
Hasardia*	2-4	1-2
Hawthorn	2-3	1-1.5
Hazel	2	1
Hickory*	2-5	1-2
Honeysuckle	3-4	1-1.5
Hornbeam, American*	2-5	1-2
Kudzu	4	2
Locust, black*	2-4	1-2
Madrone resprouts*	—	2
Manzanita*	2-5	1-2
Maple, red	2-4	1-1.5
Maple, sugar	—	1-1.5
Monkey flower*	2-4	1-2
Oak; black, white*	2-4	1-2
Oak, post	3-4	1-1.5
Oak; northern, pin	2-4	1-1.5
Oak, Scrub*	2-4	1-1.5
Oak; southern red	2-3	1-1.5
Persimmon*	2-5	1-2
Pine	2-5	1-2
Poison ivy	4-5	2
Poison oak	4-5	2
Poplar, yellow*	2-5	1-2
Redbud, eastern	2-5	1-2
Rose, multiflora	2	1
Russian olive*	2-5	1-2
Sage, black	2-4	1
Sage, white*	2-4	1-2
Sage brush, California	2-4	1
Salmonberry	2	1
Saltcedar*	2-5	1-2
Sassafras*	2-5	1-2
Sourwood*	2-5	1-2
Sumac; poison, smooth, winged*	2-4	1-2
Sweetgum	2-3	1-1.5
Swordfern*	2-5	1-2
Tallowtree, Chinese	—	1
Tan oak resprouts*	—	2
Thimbleberry	2	1
Tobacco, tree*	2-4	1-2
Trumpetcreeper	2-3	1-1.5
Vine maple*	2-5	1-2
Virginia creeper	2-5	1-2
Waxmyrtle, southern*	2-5	1-2
Willow	3	1

*Partial control

10.0 LIMIT OF WARRANTY AND LIABILITY

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