***This handout was developed from the March 2003 Silvicultural Handbook for British Columbia, British Columbia Ministry of Forests. The BC Ministry of Forests has a tremendous volume of information available on-line that is very applicable to the work we do on Prince of Wales Island.**

What Is a Silvicultural System?

A silvicultural system is a planned program of silvicultural treatments designed to achieve specific stand structure characteristics to meet site objectives during the whole life of a stand.

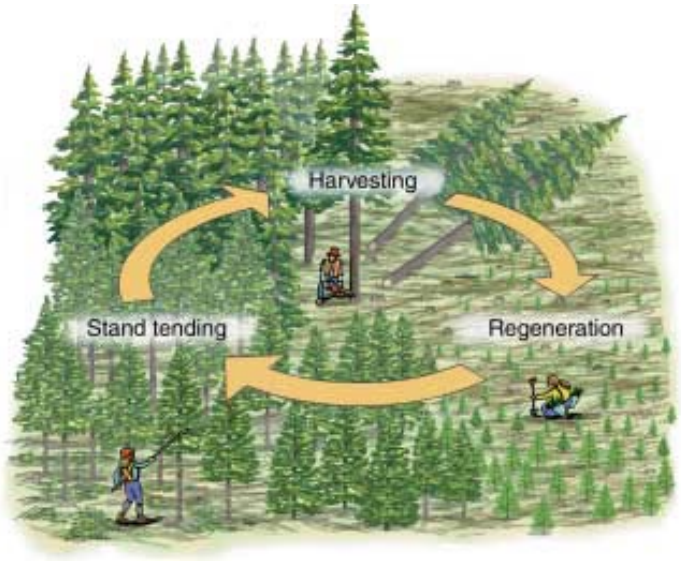

Figure 2.1-1

This program of treatments integrates specific harvesting, regeneration, and stand tending methods to achieve a predictable yield of benefits from the stand over time. Naming the silvicultural system has been based on the principal method of regeneration and desired age structure.
Silvicultural systems on most sites have been designed to maximize the production of timber crops. Non-timber objectives, such as watershed health and wildlife production, have been less common. Recently, ecological considerations and resource objectives have increased. A silvicultural system generally has the following basic goals:

- Provides for the availability of many forest resources (not just timber) through spatial and temporal distribution.
- Produces planned harvests of forest products over the long term.
- Accommodates biological/ecological and economic concerns to ensure sustainability of resources.
- Provides for regeneration and planned seral stage development.
- Effectively uses growing space and productivity to produce desired goods, services, and conditions.

- Meets the landscape- and stand-level goals and objectives of the landowner (including allowing for a variety of future management options).

- Considers and attempts to minimize risks from stand-damaging agents such as insects, disease, and windthrow.

Even-aged and Uneven-aged Stands

Even-aged stands generally have one age class, although two age classes can be found in some two-layered natural or managed stands. These stands generally have a well-developed canopy with a regular top at a uniform height.
Pure even-aged stands generally have a nearly bell-shaped diameter distribution. This means that most trees are in the average diameter class. However, diameter distributions should be viewed cautiously since diameter can be a poor criterion for age. The smallest trees in natural even-aged stands are generally spindly, with vigor suppressed by the overstory.
Uneven-aged stands have three or more well-represented and well-defined age classes, differing in height, age, and diameter. Often these classes can be broadly defined as regeneration (perhaps regeneration and sapling), pole, and sawtimber (perhaps small and large sawtimber). In the classic managed form, where diameters are a good approximation for age, distribution of diameters will approach the classic inverted-J form. The objective of such an approach is to promote sustained regular harvests, with short intervals, at the stand level.
Uneven-aged stands have an uneven and highly broken or irregular canopy (often with many gaps). This broken canopy allows for greater light penetration and encourages deeper crowns and greater vertical structure in a stand.

Integrating “Reserves” within a Silvicultural System

Reserves are intended to satisfy management objectives, requiring that the stand be maintained for a long period. Reserves are forested patches or individual trees retained during harvesting, or other forestry operations, to provide habitat, scenic, biodiversity, or other values, for at least one rotation. Reserves are areas that are to be maintained for a long time, such as more than 100 years. Any incidental seed or shelter to the regenerating stand and site that reserve trees supply is secondary to their purpose as reserve trees. Seed or shelterwood trees are not reserves, since they are removed as soon as a new crop is established. Where trees are not retained for the long term, they are not reserves.
Areas that are deferred from harvest only until the adjacent area is greened up are not reserves, simply areas of deferred harvest.
Use of reserves can be compatible with any silvicultural system, under appropriate stand and site conditions. When reserves are combined with a silvicultural system, they are incorporated into the name of the system as in *clearcut with reserves*.
To protect the structural integrity of reserve patches, there will generally not be any harvest entries. However, in limited cases, harvest entries may be required to address safety concerns or a management objective such as forest health. Treatments can be done on reserves for non-timber objectives. The treatment may involve cutting trees. Where a harvest entry occurs, predetermined stocking standards must be met.

Figure 2.1-2

1. **Riparian** –as described in the *Riparian Management Area Guidebook*. Typically objectives are to minimize or prevent impacts of forest and range uses on stream channel dynamics, aquatic ecosystems, and water quality of all streams, lakes, and wetlands.

2. **Wildlife** – wildlife tree management strategies can range from the retention of existing wildlife trees, as scattered individuals or in patches, to the creation of new wildlife trees.
Many approaches can be applied within a single cutblock, though reserving patches is usually recommended as the priority approach. Wildlife tree requirements apply to the use of all silvicultural systems.

3. **Other** – a catchall for reserves that provide for objectives other than the first two categories.
Each type of reserve can be further described as a patch or as dispersed. A patch is a group of trees important enough to be mapped at the scale being used. Dispersed is the appropriate description when trees are being reserved individually or in groups too small to be mapped.
Any reserve that is not a patch, is by definition dispersed.

The Clearcut System

The clearcut system manages successive even-aged stands by cutting the entire stand of trees at planned intervals (the rotation) then regenerating and tending a new stand in place of the old.
The clearcut system is the most straightforward and easiest system to use, and has been applied around the world. While it has been successful for pure timber management, especially for valuable shade-intolerant species, concern over aesthetics, habitat impacts, and watershed impacts have prompted interest in alternate systems in many areas.

A "clearcut" means a silvicultural system that removes the entire stand of trees in a single harvesting operation from an area that is about two acres or greater; and at least two tree heights in width, and is designed to manage the area as an even-aged stand.

This definition of clearcut focuses on the size and width of openings. Kimmins (1992) defines clearcutting as harvesting all trees in a single cut from an area of forest large enough so that the "forest influence" is removed from the majority of the harvested area. Forest influence occurs along the edge or ecotone of an opening adjacent to a forest and is an intermediate mircoclimate between forest openings.

A "clearcut with reserves" means a variation of clearcutting in which trees are retained either uniformly or in small groups, for purposes other than for regeneration.

Patch Cut System

The patch cut system involves removal of all the trees, from an area **less than about two acres in size**. Each patch cut is managed as a **distinct even-aged unit**. If an area has several patch cuts, each opening is still managed as a distinct opening. Regeneration is obtained either by artificial or natural regeneration, or a combination of the two.

The Basis for the Patch Cut Definition

Smith (1986) recognized the patch cut system as a type of clearcut silvicultural system promoting natural regeneration in small openings.
All definitions of patch cuts include the concept of small openings that will be managed as individual stand units, unlike the openings created in the group selection or group shelterwood systems.

Retention System

The **retention system** sustains the major ecological conditions and processes characteristic of a forest by maintaining a level of stand structure, complexity, and diversity.
The retention system is a silvicultural system that is designed to: a. retain individual trees or groups of trees to maintain structural diversity over the area of the cutblock for at least one rotation, and b. leave more than half the total area of the cutblock within one tree-height from the base of a tree or group of trees, whether or not the tree or group of trees is inside the cutblock.
A harvested area is not a clearcut if the major ecological conditions and processes characteristic of a forested environment remain more or less intact (Kimminis, 1992). Forest influence extends from residual trees into a harvested area.
One tree height is used as an administrative way to get at the concept of influence. A retention silvicultural system is where the resulting stand/area has retained trees (aggregate, edge, patch, or single) distributed throughout the cutblock, such that if a person were to conduct a random sample (of 20 samples or more) of the area actively harvested, they would find that greater than 50% of the cutblock is within one tree height of retained trees (i.e., under the influence of retained trees).
The retention system is differentiated from the clearcut with reserves system by the distribution of leave trees and the influence of edge effect. The retention system requires individual trees or groups of trees to be distributed over the block, with edge effect influence covering at least 50% of the opening. The clearcut with reserves system is not bound by a 50% edge influence requirement, nor the distribution over the block.
The retention system requires retained trees to be left in various locations across the whole cutblock, not concentrated in a few areas. The trees can be left singly, in groups of various sizes, or some combination of the two. There can also be a range in the amount and pattern of the retention. Retention objectives are unique to the individual area or landscape unit, and can include, but are not limited to, biodiversity, wildlife habitat, or aesthetic values. Regeneration can be accomplished by either natural or artificial methods.

Forests are dynamic, and temporal change is a feature of functioning ecosystems. The element of time is a crucial consideration in planning ecosystem maintenance. The structure retained by the retention system will promote a more rapid return of ecosystem functions into the stand. Group retention has the additional advantage of providing refugia for many organisms. These areas can act as lifeboats, and allow organisms to repopulate adjacent areas once conditions become suitable again. With the retention system, the emphasis is on selecting what will be retained.

Unlike most silvicultural systems, which are named for the primary method of promoting regeneration, the name of the retention system reflects the importance placed on the structural elements of the pre-harvest stand that are retained after the area is harvested.

Variable retention is an approach to forest planning and forest harvesting in which structural elements of the existing forest are retained throughout a harvested area for at least through to the next rotation to achieve specific management objectives. The approach utilizes a wide spectrum of retention with varying amounts, types and spatial patterns of living and dead trees. Variable retention uses all silvicultural systems, from single tree selection to clearcutting, including the retention silvicultural system, to achieve variable retention over a landscape.

Seed Tree System

In a seed tree system the entire cutting unit is managed as it is with clearcut systems except that, for a designated time period, harvesting excludes those trees selected for the purpose of supplying seed. Trees are generally left just to supply seed for the next crop; therefore, the best phenotypes should be selected to try to encourage desirable genetic traits to meet specified management objectives.
In a classic seed tree system natural regeneration is used, although the seed trees may not be relied upon entirely and some planting may occur beneath seed trees, often at reduced stocking levels. It is useful to conduct a stocking survey after three years and use fill planting to fill in any gaps in stocking. Usually, the seed trees are removed in a “removal cut” once regeneration is established, although in practice this is not always the case.

Seed Tree System Variations

Group seed tree system Uniform seed tree system

Figure 2.1-3

Uniform Seed Tree System
Seed trees are left more or less uniformly distributed throughout the block.

Group Seed Tree System
Group seed trees are left in small groups. These groups may be irregular or in strips. Seedfall distance and windthrow risk play a major role for their distribution on the block.

Combination
The uniform and group seed tree systems can be used in combination. When this is done the terminology is combined, as in "*uniform and group seed tree system.*"

Seed Tree System with Reserves
Reserves can be used with any system.

Shelterwood System
In a shelterwood system the old stand is removed in a series of cuttings to promote the establishment of a new even-aged stand under the shelter of the old one.
The primary intent of this system is to protect and shelter the developing regeneration.
Generally, shelterwood systems aim at natural regeneration, although some planting may occur to diversify the species mix, bolster stocking and introduce improved seed. The central theme to shelterwoods is that the overstory leave-trees are left on site to protect the regenerating understorey until the understorey no longer requires the protection. At some point the overstory starts to inhibit development of the understorey trees through crown expansion and shading. This depends on the density of overstory trees and the species being managed.
The shelterwood trees are removed after the new trees no longer need their protection, so that the new tree can develop uninhibited.

Variations of Shelterwoods

Uniform Shelterwood
Leave trees are left for shelter, more or less uniformly distributed throughout the block.

Group Shelterwood
Patches are opened in the stand such that the surrounding edges of uncut timber shelter the new regeneration. The group size will be increased by one or more cuts until the entire block has had the overstory removed. This gradual removal of the original overstory occurs relatively quickly in successive harvesting entries within a normal regeneration period for an even-aged stand (10–25 years). The final groups to be harvested may require artificial regeneration.

Strip Shelterwood
Initial harvesting occurs in the stand as uniformly spaced linear strips. In future harvesting entries, strips are added beside the initial strips, progressively into the wind, until the entire block is harvested within a normal even-aged regeneration period (10–25 years). Harvesting in each strip may occur gradually and include a preparatory, regeneration, and removal cut, following in sequence. Strips may be oriented to use the side shade from adjacent timber, maximize sunlight penetration, or allow for visual screening from the uncut timbered matrix.

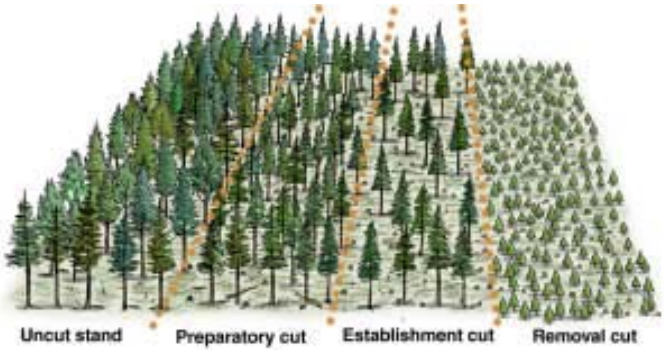

Figure 2.1-4

Irregular Shelterwood

Irregular shelterwoods differ from others based on timing of harvesting entries. There are longer periods between the initial establishment cut and the removal cut than for a traditional shelterwood (removal period generally exceeds 20% of the projected rotation).

Uniform, group, and strip shelterwoods can all be used in an irregular variant (e.g., *irregular group shelterwood*). This system may be the same as a *shelterwood with reserves* if the overstory is retained for the entire rotation. The difference is that with an *irregular shelterwood* the seedbed is receptive to regeneration for a very long time. The intent is to continue to procure regeneration for much longer than the normal regeneration period.

"*Irregular*" refers to the subsequent variation in tree heights in the new stand, which provides an age-class structure that is neither even- or uneven-aged. This variant is difficult to administer and approaches single tree and group selection.

Natural Shelterwood

The *natural shelterwood* often referred to as overstory removal or release cutting, is a form of shelterwood where the overstory is removed to create open growing conditions for a fully stocked suppressed understorey. This form of shelterwood has only a removal cut as a harvesting entry.

Nurse-tree Shelterwood

This form of shelterwood is similar to a natural shelterwood except the overstory trees are of a different species from those in the understory. The establishment cut would leave the overstory nurse-trees, while the removal cut removes the overstory nurse-trees.

This shelterwood approach follows natural successional patterns in stands such as those that include aspen and spruce, larch and redcedar (or hemlock), pine and spruce (and subalpine fir), alder and redcedar, and cottonwood and Sitka spruce (or redcedar). Often these stands are originally established after large disturbances that open the entire stand. Both species may establish at approximately the same time. The understorey species may build its presence more slowly under the established overstory.

Nurse-tree shelterwoods may be started in cleared areas by planting. For example, at the Malcom Knapp UBC Research Forest, alder and western redcedar have been planted together for this purpose. Nurse-tree shelterwoods have been established through underplanting where the pioneer species is already established as a continuous canopy. In such cases, gaps in the canopy may be created by cutting or girdling to increase early survival and growth in the understorey. When long-lived species are managed as the pioneer overstory, careful retention of a pioneer component through the rotation will ensure a regeneration potential for that component, helping to sustain the system, if that is desired.

Combinations

The following combinations of shelterwoods may commonly be applied:

- Group and strip – different combinations of group and strip are commonly used in Europe and elsewhere.
- Uniform and group – may be used when sheltering leave-trees are clumpy in distribution.
- Irregular with uniform, group, strip, or nurse-tree – as described previously.

Shelterwood System with Reserves

Reserves can be used with any variant of the shelterwood system (e.g., *strip shelterwood with reserves*). These may be a form of irregular shelterwood.

Selection System

Selection systems remove mature timber either as single scattered individuals or in small groups at relatively short intervals, repeated indefinitely, where an uneven-aged stand is maintained. Regeneration should occur throughout the life of the stand with pulses following harvest entries.
These systems depend on recruitment of trees into successive age classes over time and the predictable yield from merchantable age classes. Yield will be obtained by thinning clumps, by harvesting individual trees, or by harvesting whole groups of the oldest age class to create small openings scattered throughout the stand.
The selection system can be complex. Three variations of selection systems are used.

Variations of the Selection System

Single Tree Selection

Single tree selection removes individual trees and small clumps of trees of all size classes, more or less uniformly throughout the stand, to achieve or maintain a balanced, regulated, uneven-aged stand structure. It is easier to apply such a system to a stand that is naturally close to the uneven-aged condition. However, an even-aged stand can be converted to an uneven-aged stand for management under a single tree selection system, although numerous establishment cuttings must be made to bring the stand into a structure where the system can truly be applied.
Once the uneven-aged structure approximates the balanced condition, the single tree selection system generally manages a complex mixture of small even-aged clumps that are thinned over time. In theory these clumps should be able to yield at least one mature tree of the specified maximum diameter; however, in practice these clumps are often larger.

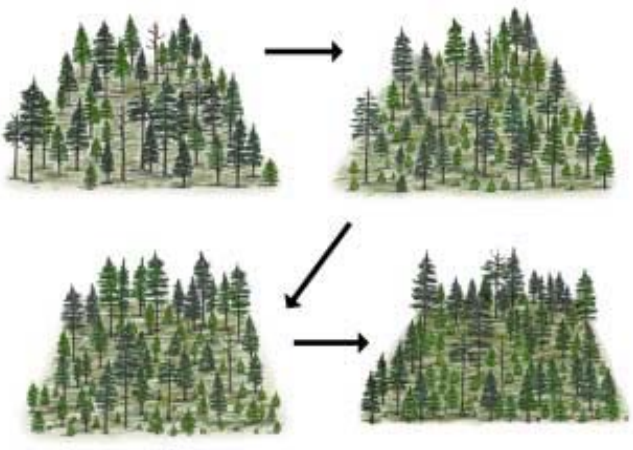

Figure 2.1-5

New regeneration develops in small, scattered openings created in small gaps. Since regeneration is always being recruited and larger mature trees are scattered, or in very small groups, these stands appear quite open, with many gaps. Since regeneration is always being recruited and immature age classes are intermixed in a balanced uneven-aged structure, the total stand basal area may be somewhat less than that of a fully stocked, mature, even-aged stand on a similar site.

Issue: *Single tree harvesting is not necessarily single tree selection.*

Single tree selection is a term that has been misunderstood and therefore abused. It has been incorrectly applied to many stands where single trees were only harvested for salvage, highgrading, or general thinning. This has created considerable confusion around the term. Single tree selection manages a stand using regular, predictable sustained harvesting entries in perpetuity by managing towards a balanced (or close to balanced) uneven-aged structure, as described previously. Single tree selection is much more complex than removing a few large trees from a stand.

Group Selection

Group selection systems also promote uneven-aged stands with clumps of even-aged trees well distributed throughout the cutting unit. Unlike single tree selection, however, these small even-aged groups are large enough that they can be tracked within the stand (see Figure 2.1-6).

Figure 2.1-6

The small gaps or openings are created on short intervals to develop a mosaic of at least three or more age classes throughout the stand (see Figure 2.1-7). The harvesting entries are light enough so that an uneven-aged structure develops, unlike a group shelterwood.

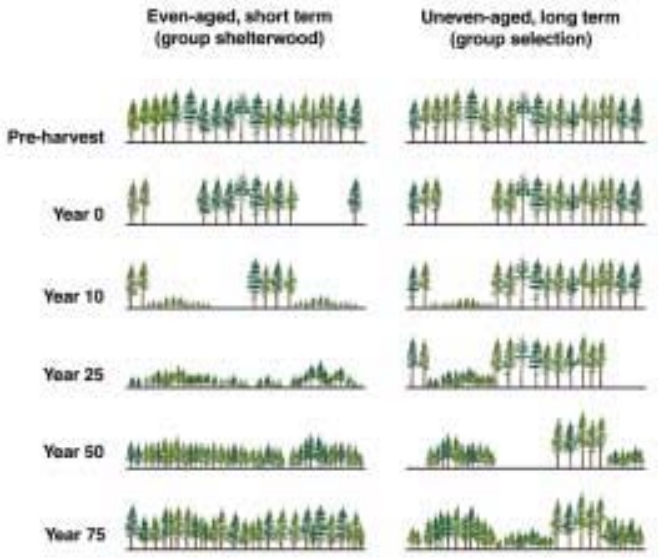

Figure 2.1-7

Groups may be uniformly staggered narrow linear strips (usually 15–50 m wide). Future harvesting strips are added at short regular intervals beside the initial strips, progressively into the wind (see Figure 2.1-8). Such an approach minimizes windthrow risk.
Harvesting intensity and timing between entries are planned to create an uneven-aged stand with linear clumps of age classes, thus meeting the definition of selection. This differs from its shelterwood counterpart by harvesting the entire area much more slowly over time through harvest entries that remove much less volume.

Figure 2.1-8
First entry strips in a four-pass strip selection system.

Future strips will progress down the ridge (to the right) into the wind.

Selection System with Reserves

Reserves can be used with any variant of the selection system (e.g., *group selection with reserves*).

Additional Reading

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