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Furman University Lake Restoration Project

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Overview

In 2006, as part of Furman's "Year of the Environment" campaign, the university dedicated itself to improving the environmental quality of the Furman Lake and its surroundings. The lake, also known as "Swan Lake", was one of the first features constructed on the new campus in the mid-1950's, when the university moved from its downtown location. The lake was created by damming a small tributary of the Reedy River just below the confluence of two streams. The dam is at the south end of the lake, under the road to the physical plant and the Facilities Services complex. The two streams still feed the lake; one from the picnic shelter west of the Bell Tower and one from the North Village dorm complex that enters the lake near the Asian Garden.

The lake quickly became the center of student life at the university. There was a sandy beach for swimming and sunning (still marked by a low wall on the western shore), and the lake was also used for boating (there were crew and sailing clubs!), fishing, and hall competitions.

By the 1980's, however, algal blooms and high bacteria counts made the lake a less inviting place. By the end of the 1990's, most recreation was prohibited because of health concerns.

In 2006, a task force of students, faculty, and administrators was established to identify the major problems with the lake and to make recommendations for how to correct them. Since then, the university has moved swiftly to implement these recommendations and the changes to the lake environment have been dramatic. This website details the problems of the lake, the solutions that are being implemented, and the changes in habitat quality that have occurred.

The lake is being used as a living laboratory to study the effects of the restoration effort on the water quality and ecological integrity of the lake system. Long-term studies of waterfowl populations, water chemistry, and bacterial levels are overseen by faculty in the Biology and Earth and Environmental Sciences Departments. Most recently, two sections of Ecology classes studied various aspects of the lake during spring 2010. The reports of their findings are posted in the ***Progress*** section. The Lake Restoration Project exemplifies Furman's commitment to environmental stewardship, sustainability, and engaged learning, and is being used as a model for other lake restoration efforts in the region.

Problems

The environmental quality of Furman Lake and its environs has been declining for several years, so as part of the "Year of the Environment" celebration, a task force was established to study the lake, identify problems, and suggest solutions. The task force identified four major problems with the lake:

Populations of fecal-indicator bacteria were sometimes 50X higher than the upper EPA limit for recreational waters.

There were blooms of unsightly algae each summer.

There were 362 resident waterfowl on the lake, including 250 Canada geese. A lake this size should have a maximum of 50 waterfowl.

The streams were carrying lots of sediment, and the sediment was deposited in the lake. This fills the lake up, making it shallower and warmer.

The task force recommended a restoration plan that would improve the environmental quality of the watershed, in a manner sensitive to the Furman aesthetic, with a focus on student engagement and learning.
The task force identified several contributors to these problems:

1. Nutrient loading from surface runoff:

Water running over land after rainfall or watering is called "surface runoff". This carries nutrients to the lakes and streams. Until 2007 the entire lakeshore was mown to the water line, and the banks of tributary streams were mown or sprayed to remove stream-side vegetation (see photo). Water from precipitation or sprinklers carried nutrients from mown, decaying vegetation, fertilizers, and animal waste directly into the lake and tributary streams. Also, the conversion of forest to lawns during the development of the Amphitheatre and the North Village Dorm Complex, and the denuding of the North Village stream bank, probably caused a dramatic increase in nutrient and sediment loading in that stream and the lake.

2. Direct storm water discharge:

All of the parking areas and roadways in the lake's watershed have storm drains that empty directly into the lake or the two tributary streams. There are also storm drains in the lawns that surround the lake, and these empty directly into the lake, as well (photo). This storm water collected from roads, parking lots, lawns, and rooftops contributes nutrients, pollutants, and

sediments to lakes and streams. These drains have been constructed in part because using the lake as a stormwater retention facility has helped Furman earn LEED points for new building construction. Retaining stormwater on site is certainly an ecologically appropriate behavior. However, transferring it directly to the lake and stream has probably had a dramatic negative effect on these habitats. Storm drains allow water to bypass the normally slow transit through the soil to the water table. Instead, water collected over huge areas is rapidly transferred through drainpipes or channels. This huge volume of water, traveling quickly under high pressure, erodes the lakeshore or stream bank at the point of entry, and contributes nutrients and sediments to the lake and streams.

3. An overpopulation of waterfowl:

Large populations of waterfowl can contribute to the nutrient and bacterial loading of lakes. Furman lake was home to a large population of resident Canada Geese and domestic ducks. They were fed liberally by an adoring public, but they fouled the water and lawns with their feces. On 3 July 2006, there were 362 waterfowl on 28-acre Furman Lake; six times the appropriate density for a lake this size. Canada Geese harbor *E. coli* bacteria in their gut, and the fouling of the lawns and lake with their feces was undoubtedly a major source of *E. coli* contamination.

4. High water temperatures:

High water temperatures stimulate algal and bacterial growth (photo of algal mats, at right). At Furman Lake, the lack of vegetation along the lakeshore probably contributed to unnecessarily high water temperatures, especially because the lake is very shallow. Another potential source of heat loading is the stone retention wall that surrounds approximately 50% of the lake. Heat absorbed in the afternoon sun may transfer to the lake.

All of these factors probably contributed to the decline of the Furman Lake environment. Unfortunately, many of the past decisions that Furman made in the lake watershed increased the transport of sediment and nutrients to the lake. Furman is now taking active steps to reduce and reverse these effects.

Goals:

By 2006, the burdens of nutrient loading, sedimentation, and waterfowl were more than the lake environment could handle. The Lake Restoration Task Force envisioned a very different Furman Lake--a lake that would act more like a natural system because it was more like a natural system. In other words, we envisioned a Furman Lake with high biological diversity, high structural complexity, and high physical complexity. We envision a lake functionally integrated with the surrounding watershed. We envisioned a lake that improved water quality before sending it on to our neighbors along the Reedy River. We envisioned a lake that--because of its complexity--is functional, interesting, and beautiful.

Improving the Environmental Integrity of the Lake Watershed

To restore a more natural level of ecosystem function, the Lake Restoration Task Force recommended three major initiatives. First, appropriate vegetation should be planted in the lake and on the surrounding landscape to absorb nutrients, slow surface runoff, and deter waterfowl. Second, the inputs to the lake (streams and storm drains) should be naturalized so that water, nutrients, and sediments enter the lake in a natural, regulated manner. Lastly, waterfowl populations must be reduced to decrease nutrient and bacteria concentrations in the lake. Here is a summary of the direct and indirect benefits that these initiatives should provide:

1. Plant vegetation in the lake, on the surrounding border, and along stream channels

- Absorb nutrients and sediments entering the lake from the streams
- Create a beautiful array of flowering aquatic plants
- Create a habitat for herons and egrets
- Create a nursery area for juvenile fish
- Reduce shoreline erosion and sediment transport to water
- Cool the shallows and reduce the rate of algal and bacterial growth
- Discourage geese and ducks
- Provide habitat for a wide array of songbirds
- Plantings that provide good seed sources (e.g. sunflowers and thistles) will increase the abundance and diversity of seed-eating songbirds.

- Create a more colorful, beautiful flowering border, emphasizing native species and minimizing the use of potentially invasive exotic plants
- Create a habitat for butterflies
- Discourage children from entering (or falling into) the lake
- Focus access on particularly appropriate viewpoints
- Stabilize stream banks to prevent undercutting
- Riparian zones have a dramatic positive effect on ecosystem health and resident populations of fish and invertebrates.

2. Create smaller "rain gardens" between parking lots and the lake

- Smaller "rain gardens" can be used where ever runoff needs to be collected and added slowly to the lake.
- Absorb nutrients entering the lake from the streams
- Create a beautiful array of flowering aquatic plants
- Create a habitat for a wide array of animals and plants
- Slow the water from the storm drain and reduce sediment transport to the lake

3. Reduce waterfowl populations

- Reduce feces in surrounding lawns
- Reduce nutrient loading in the lake
- Reduce bacteria concentrations in the lake
- Potentially increase waterfowl diversity

4. Possible additional steps

- Dredging will be necessary to reduce water depth and cut channels in the wetland areas to maximize water flow
- Aerators might be necessary to reduce algal populations

Additional Design Elements to Create a Multi-Purpose Facility:

The changes that are proposed will dramatically change the look of Furman Lake. Parts of the bays on either side of the Bell Tower would be wetlands with aquatic plants. The border of the lake would be vegetated with thick rushes in some places, and flowering plants in others. There would be fields of wildflowers where the distance between the jogging trail and lake permit. These changes would limit human access to the lake. This is beneficial on one hand, because it would reduce erosion and also reduce feeding of the waterfowl. However, because people are naturally drawn to water, it would be nice to provide other design elements that would allow people to access the water in limited and appropriate ways. Likewise, the presence of more varied wildlife (butterflies, songbirds, and perhaps a wider variety of less abundant migratory ducks) might necessitate the construction of different types of viewing opportunities. Here are some design elements that we think might be exciting and useful:

1. Sites for picnickers: The picnic shelter and its environs could be upgraded. In addition, a couple of picnic tables could be positioned around the lake at particular viewpoints, or at a focal picnic area.

2. An observation deck extending into the lake, and boardwalks across or near the wetlands: These will provide excellent viewing opportunities for watching wading birds, songbirds, butterflies, and dragonflies. It could also provide an ideal site for photographing the Bell Tower. A permanent blind for birdwatching could also be constructed.

3. A jogging/walking/biking trail: The existing jogging trail should be kept, but the paved surface could be replaced by a graded trail, or a pavement with a porous surface to reduce erosion from runoff.

4. A nature trail: A nature trail along the back of the lake might meander through the wildflowers, cross the wetlands on boardwalks, and connect to the observation deck. The nature trail could also have a tree map for the trees already identified in the arboretum. In addition, there could be observation stations positioned around the lake, with the permanent 'binocular stations'. Bat boxes, bluebird boxes, birdfeeders, and hummingbird feeders would attract wildlife.

5. Educational signage: This can point out particular species, describe ecological principles (succession, nutrient cycling, water cycle, etc.), and also describe how particular elements of the lake restoration project are designed to achieve particular objectives.

6. Furman's "Rails to Trails" Station: A tramline is likely to link Travelers Rest to Greenville in the future, using the railroad line that runs right along the western boundary of Furman Lake. There will certainly be a "stop" or "station" on the FU campus. If this is near the lake, we will need to consider how to manage foot and bike traffic and minimize impact on the lake itself.

7. A microturbine in the lake outflow: There are very small hydroelectric generators that can generate power from a head as shallow as five feet. The head on the lake is approximately 30 feet, and it is a very constant flow. The turbine could be used to power footlights along the jogging trail, or streetlights to the tram station.

8. Canoe/kayak rental: When water quality improves, it might be appropriate to allow limited access to the lake surface. A canoe/kayak rental could be orchestrated from facilities services or the bookstore.

9. Fishing: When water quality improves, we could also allow fishing on the lake. A limited number of day permits could be issued, and fishing could be limited to particular areas to limit trash and trampling.

The Lake as Pedagogy:

The restoration of Furman Lake will provide extraordinary educational opportunities in ecology, botany, zoology, natural resource management, ornithology, entomology, microbiology, hydrology, biogeochemistry, sediment transport and deposition, GIS, and environmental science. First, students and faculty can become involved in implementing parts of the plan. Second, students and faculty will be involved in measuring the effects that the restoration efforts have on the water quality and health of the environment.

The naturalized lake will become a destination for field trips by local schools and nature groups. The constructed wetlands would be particularly interesting to some in our community. The nature trail would have an accompanying pamphlet, highlighting particular sites at stations along the way. In addition, a nature guide could be written that would be more complete than a pamphlet, and might form the foundation for curricular ideas for teachers. It could also suggest some projects or comparisons that could be performed at the lake.

The lake will become a living example of restoration ecology. Businesses, colleges, or municipalities with similar shallow impoundments will be interested in visiting Furman and studying the progress we have made. This restoration will become a model for other universities interested in environmental sustainability.

Progress:

The university has made significant and visible progress on the Lake Restoration Project. In spring 2007, the landscaping and grounds crew stopped mowing within the perimeter of the walking trail on the north and western shores. This resulted in a flush of shoreline vegetation that acted as an important buffer to runoff and as a deterrent to waterfowl. In Spring 2008, EarthDesign began "Phase I" of the Restoration Project along the north shore. This was completed with the opening of the Southern Living Home, now the Shi Center for Sustainability at Cliffs Cottage.

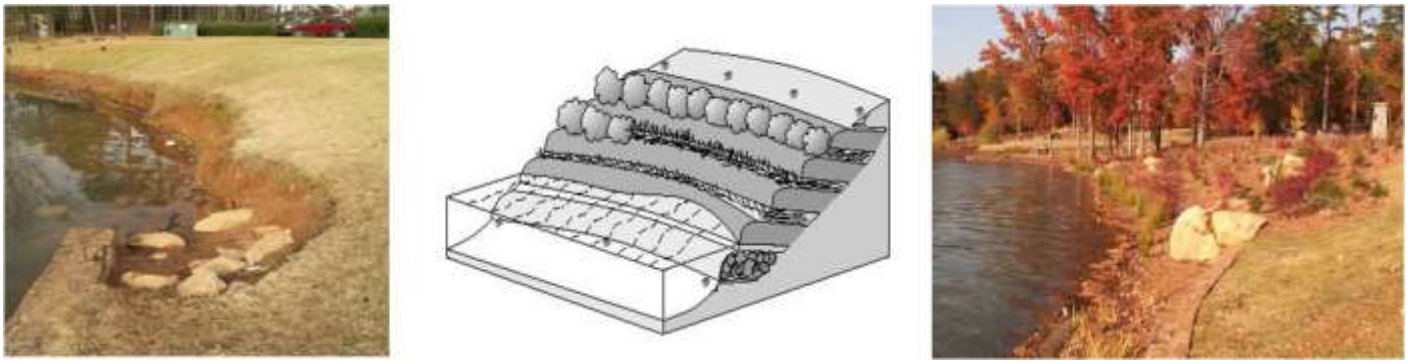
In addition, the lake continues to be the focus of research on wetlands restoration. In spring 2010, two Ecology classes conducted projects to measure the response of the lake system to the restoration effort. For an overview of the progress in these areas and to see the most recent reports by our Ecology students, visit the subsites on the menu.

The western shore of the lake: mown to the eroded shoreline in summer 2006 (left), regrown with natural vegetation in summer 2008 after mowing was stopped (center), and a rendition by EarthDesign of the area after restoration, showing a zone of semi-aquatic plants that will help restore the eroded bank (right).

1. Landscaping

The primary aspect of the Lake Restoration Project is landscaping the shoreline in a way that controls runoff, absorbs nutrients before they can enter the lake, discourages waterfowl, and increases the beauty and biodiversity of the area. Furman University hired the services of EarthDesign Environmental Arts & Landscape Design to create and implement a master plan for the lake. To this point, EarthDesign has implemented and completed "Phase I" along the north shore of the lake: from the front of the Shi Center for Sustainability at Cliffs Cottage, past the Amphitheatre, to the burm at the inlet of the feeder creek.

There are several important features of the new landscaping. Directly down from the Shi Center, the shoreline had eroded badly, requiring a complete reconstruction of the bank. A series of tiers was used to create a stable bank, and boulders were used to anchor the bank and add a visual feature. The front was planted in rushes, and a series of biologs were placed to help maintain the new bank.



Another major element was the large rain garden just down the trail. Uphill from the lake, the bank was contoured to funnel runoff from the landscape to a small rain garden to the right of the

trail. Water seeps through a pipe beneath the walkway to the rain garden on the lake shore. Rain gardens are deep depressions filled with layers of sand and gravel. Plants tolerant of drought and flooding are used to filter the water contained in the garden. After a storm event, water is held in the garden and percolates more slowly and naturally into the lake.

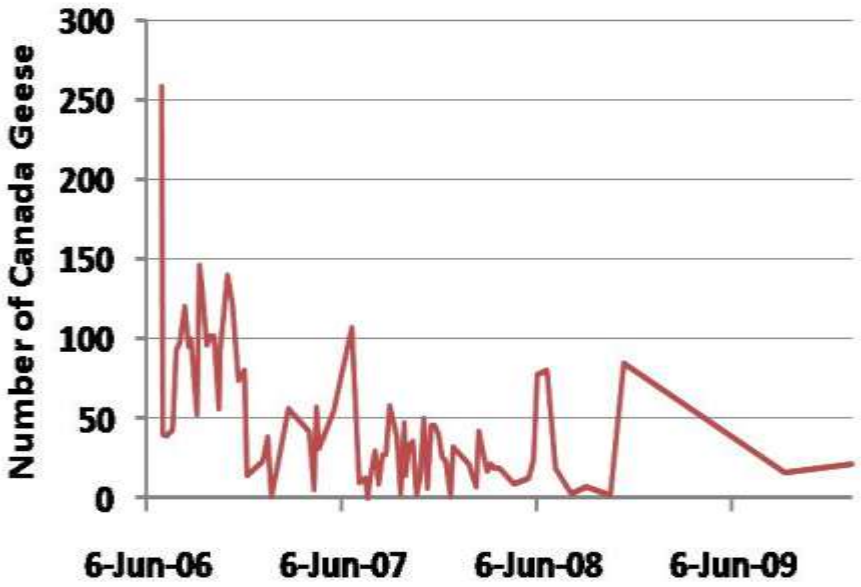
Runoff and erosion are also addressed by planting native wildflower meadows on the shore. They intercept and absorb more surface runoff than turfgrass, and also add more color, structure, and diversity. Bank erosion can be slowed and reversed with the use of biologs. These are rolled mats that are staked offshore. As waves move over them, sediment is deposited behind the log, regrowing the shoreline from the bank. During this process, this shallow area is home to a group of semi-aquatic plants like rushes and cattails that absorb and store large amounts of

nutrient runoff.



In spring 2010, Ecology students measured the concentration of various ions entering and leaving three rain gardens to determine whether the rain gardens were filtering ions effectively.

2. Waterfowl



On July 3, 2006, there were 362 waterfowl on the 28 acres of Furman Lake, including 250 Canada geese. By most wildlife estimates, a density of 2 geese/acre is appropriate, 6-times less than our resident population. Through a combination of direct removals by the South Carolina Department of Natural Resources, publicity campaigns to discourage public feeding of the waterfowl, and habitat change, the Canada geese population is now near appropriate levels (See figure). In order to evaluate the impact of the restoration project on Canada geese behavior, Ecology students monitored the patterns of habitat use in areas with different vegetation types around the lake.

3. Algae

Furman Lake is an ideal place for algal growth. Over 90% of the lake is less than 6 ft deep, so light penetrates through the entire water column. The shallow water warms quickly in spring, and nutrients running off the landscape stimulate the growth of large blooms of algae. When these algal mats die, they feed decomposing bacteria and create an unpleasant odor. Several elements of the Lake Restoration Project should reduce nutrient runoff and decrease algal growth. First, we have changed the topography of the landscape so that surface water drains to lakeside depressions called rain gardens. These raingardens are deep depressions, filled with layers of sand and gravel that hold and filter water after a storm event so that it can percolate slowly into the lake in a more natural way. In addition, plants that can tolerate drought and flooding are planted to intercept water and nutrients before they reach the lake. We would prefer to grow pretty plants on the shoreline, rather than algae in the water.

One might expect that the restored shoreline areas would support less algal growth than mown areas where runoff should be higher. One group of Ecology students measured the amount of algae in mown, regrown, and restored areas to test this hypothesis.

4. Biodiversity

One hope of the Lake Restoration Project is that the diversity of charismatic animal groups (like songbirds, butterflies, and dragonflies) will increase in response to the greater plant and habitat diversity in the lake environment. In changing the habitat from a monoculture of turfgrass to a mixture of wildflower meadows, rain gardens, and aquatic plants, we hope to attract a greater variety of animals to our campus habitat.

This year, one group of Ecology students began a survey of "songbirds" in the three vegetation zones that now occur around the lake: mown lawns, regrown vegetation, and the restored wildflower meadows.

5. Water Chemistry

The chemical characteristics of Furman Lake, its feeder streams, and the outlet stream that runs to the Reedy River have been studied for several years as part of the River Basins Research

Initiative (RBRI) - the largest and longest-running interdisciplinary research program in the university's history. Spearheaded by the Earth and Environmental Sciences Department, the RBRI has sampled water from watersheds throughout the upstate since the late 1990's in an effort to determine the effects of suburban growth on water quality. Studies have examined the effects of wastewater treatment plants on nitrogen levels in streams, the effects of differences in land cover and vegetation type on water quality, and the effects of changes in water quality on the fish and invertebrate communities that inhabit the streams.

In this context, one group of Ecology students decide to study how water chemistry varied between the two feeder creeks to the lake, as one drains a forested area and the other drains the major dorm complex. In addition, they sampled upstream from the dorm complex to determine whether the chemistry of this steam changed as it passed this developed area.

6. Bacteria

One of the major problems in the lake are the periodically high concentrations of bacteria, including two taxa used as indicators of fecal contamination (*E. coli* and *Enterococcus*). Obviously, a high concentration of these bacteria presents a health risk, and is the major reason why Furman Lake has been closed to recreation. Since the creation of the Lake Restoration Task Force, faculty and students have been sampling and quantifying the levels of bacteria for research projects and laboratory activities.

When the sampling began, the levels of *E. coli* bacteria occasionally spiked at levels more than 50-times higher than the upper limit set by the Environmental Protection Agency as safe for "recreational waters". For the last few years, however, perhaps because of the reduction in the waterfowl populations and the presence of a vegetational buffer zone that reduces runoff, levels have spiked at only 30% above EPA levels.

Bacterial populations fluctuate dramatically and can respond to favorable conditions very quickly. They are often in high concentration in the sediment, and only become suspended in the water column at high concentrations after storm events when the lake is mixed. So, there are no plans to open the lake to recreation soon - we need to be sure that the bacterial concentrations will remain low, even under conditions that are favorable to their growth.

Two groups of Ecology students examined the abundance of bacteria in the lake in spring 2010. One group focused on the abundance of fecal indicator bacteria, and the other group focused on the concentrations of anti-biotic resistant bacteria in the lake. Antibiotics that we use in our households and feed to animals gets into our enviuronment, where it can act as a selective pressure for environmental bacteria. These bacteria, exposed to these antibiotics, evolve resistance.