Lost Lake Found—Restoration of a Carolina Bay Wetland

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Abstract

Lost Lake is a Carolina bay wetland located on Department of Energy's Savannah River Site (SRS) near Aiken, South Carolina. Before closing access to SRS to the public, Lost Lake had been drained and planted as part of an agricultural field. In the 1950s, Lost Lake was allowed to refill and to return to its function as a wetland, but it was severely impacted by SRS operations. In 1991, Lost Lake was drained again and restored by removing and replacing contaminated sediments and through soil treatments. Studies of the amphibian populations before and after the restoration effort indicate that recovery is extensive. In addition to serving as an experiment in restoration techniques, this wetland has served as a teaching laboratory for graduate and undergraduate students in local colleges and universities.

A shimmer of light reflecting among stands of pines, dog fennel, and blackberry canes is the first glimpse one gets of Lost Lake. That glimpse comes unexpectedly considering the adjacent and surrounding area. Travelling past the closed M-Area seepage basin, numerous monitoring well heads, air strippers, injection wells, and other industrial paraphernalia and clutter associated with cleaning up a RCRA site, the last thing one would expect rounding a bend in the gravel service road would be to come upon a Carolina bay. Even more interesting is that this wetland is perched in the dry sandhill area with no obvious link to any water supply. Of course if you were an ecologist living and working in the southeastern United States, it would be exactly what you would expect and in fact, would be seeking. Actually, Lost Lake came by its name through just those circumstances. In the early 1970s, Drs. Whit Gibbons and Rebecca Sharitz of the Savannah River Ecology Laboratory (SREL) were looking for an unnamed Carolina bay near where new SREL facilities were to be built, but having forgotten the map, had no success (Gibbons 1990). Upon returning from the field, they named the elusive body of water Lost Lake. There is an irony in how that name was so historically correct and at the same time prophetic of the future of Lost Lake. Historically correct, because in 1950 when the Savannah River Site was closed to the public, Lost Lake had indeed been lost for quite some time. It did not exist except in the profiles of its rich wetland soils visible only from the air. The area where Lost Lake had previously existed, and exists today, was an agricultural field in 1950. Aerial photographs from the late 1930s and early 1940s distinctly reveal the outline of Lost Lake within the local fields and show the ditch used to drain the water from the wetland, allowing its use for agriculture. No one knows how long Lost Lake had been gone, but with closing the site and stopping maintenance on the drainage ditch, Lost Lake slowly returned to its former function. The SREL scientists' name for the bay was also prescient in that it inadvertently, but accurately, predicted the future disappearance of this Carolina bay in both the figurative and literal sense. Before we examine the known history of Lost Lake, let us examine exactly what makes a Carolina bay what it is.

Carolina bays are a unique form of wetland found on the southeastern U.S. coastal plain from Virginia to Florida. All Carolina bays are naturally occurring shallow depressions of interstream areas that share at least some of many characteristics. These characteristics include an age of at least 30,000 years, elliptical or ovoid shape with NW to SE orientation of the long axis, low sandy marginal rims with greatest development on the SE margin, substrate of either clays and silts or organic peat, and hydrology varying from seasonal to continual inundation (Schalles et al. 1989). Sizes vary greatly from one or only a few tenths of an acre to the size of Lake Waccamaw in North Carolina. The surrounding watershed determines hydrology of Carolina bays because they have no natural inflowing or outflowing streams. Anthropogenic influences, either directly by ditching, or indirectly by altering the surrounding watershed, have pronounced effects on the hydrology of Carolina bays. The fate of Lost Lake, that of being ditched and drained for agricultural use, has been the same for thousands of bays throughout their range, including many of the hundreds of bays found on SRS. Carolina bays exist as islands of water in the often xeric upland interstream areas. As such they provide important diversity of habitat and available water, forage, and breeding areas for a wide variety of organisms. Nearly all of the bays on SRS are mineral substrate, but they support a wide variety of vegetation types, depending upon their size and hydrology. Vegetation can vary from open herbaceous bays that remain wet all year to closed canopy forested bays that are wet for only a portion of the year. Some bays can remain dry for several years depending on climatic conditions. This varying hydrology has a large role in determining what type of plant community is found in any specific bay. The gradient from wet to dry from the center to the rim of bays tends to zone the vegetation communities. These zones vary, and 17 different herbaceous zones alone have been described, as many as 6 in a single bay (Schalles et al. 1989). Invertebrates, although not widely studied, can be abundant and diverse, depending upon the specific bay and its hydrology. Vertebrates have been studied extensively at several bays with amphibians being the dominant taxa. Over 30 species of amphibians and reptiles have been noted in a single bay (Gibbons 1970) and amphibian productivity can be very high because these isolated wetlands are often the only landscape feature available for amphibian reproduction in a relatively large area . Fish do not generally play a large part in the vertebrate fauna simply because the are not present in most bays. Bays that receive flooding from other sources containing fish may develop populations, but the varying hydrology and periodic drying will often eliminate any fish community. Carolina bays also serve as water sources for a large variety of terrestrial organisms and wildlife.

In the early 1950s, after SRS had been closed to the public and Lost Lake began to function as a wetland again, two important things happened around the bay. First the entire area, except for the existing 8-acre hardwood stand south of the bay, was planted in loblolly (*Pinus taeda*) and slash (*P. elliotti*) pine. The second and more serious event was the construction of the M-Area fabrication facility and its related support facilities. One of these supporting facilities was a settling basin that received effluents containing solvents and various salts of heavy metals. Lost Lake is downslope from this settling basin, and, on those occasions where the basin overflowed, these same toxicants ended up in Lost Lake. In the 1970s, Lost Lake was so heavily impacted by these substances that emergent vegetation, such as cattails or water lilies, and submerged vegetation, such as water celery, bladderworts or coontail, were completely absent. Despite this level of contamination, amphibians continued to breed in Lost Lake, perhaps because there was no place else to go. In 1977-1978, Steven Bennett and other Savannah River Ecology Laboratory investigators conducted one of the earliest examinations of the relationship of forestry practice and amphibian community structure at this site. Their study was designed to determine terrestrial activity, relative abundance, and diversity of amphibians in the three forest types surrounding Lost Lake (Bennett et al. 1980). This study was one of the first in North America to examine the roles of forest management practices in reptile and amphibian community structure. Lost Lake, at the time of Bennett's study, was so polluted that it did not support either emergent or submerged aquatic plants but amphibians were still breeding there. Remarkably, there were 5 species of salamanders and 11 species of frogs and toads captured during that study. Bennett reported that, while the two types of pine and the hardwood forest had the same species of terrestrial amphibians, the hardwood forest yielded approximately 50% more individual amphibians than either pine forest during both study years.

The dying Lost Lake was destined to be lost again and to be reborn. In 1990, a closure plan for the M-Area settling basin near Lost Lake was developed which included, in addition to closing the basin, restoring Lost Lake to a "natural wetland system" (Gladden et al. 1992). The Department of Energy (DOE) established a task team to develop a strategy and approach for the restoration activities at Lost Lake. The team included members from DOE, Savannah River Forest Station (SRFS), Soil Conservation Service (SCS), Savannah River Ecology Laboratory (SREL), and several organizations within Westinghouse Savannah River Company (WSRC). The committee was chaired by the Savannah River Technology Center (SRTC). Lost Lake was drained, and the surrounding vegetation within a minimum radius of 50 meters was removed (see Figure 1). All vegetation from the removal action was burned, and the residual ash and contaminated sediments were dug up and moved to the settling basin and compacted. Removed sediments were replaced with "clean" soil, and the bay was divided into eight segments, each of which received one of four different soil treatments. The bay was allowed to refill and aquatic vegetation was planted. Over 150 individuals of 10 different species of woody vegetation were also planted in the cleared area around Lost Lake. Before restoration, Lost Lake had a surface area of approximately 5 acres. Based on a 1996 aerial photograph, the current surface area is approximately 16 acres. This seems like a huge change in surface area. However, in Carolina bays, fluctuation in water surface area is normal; and the range of fluctuation for any given bay may be unknown, though the sandy marginal rim probably outlines the greatest surface extent possible.

From 1993 through 1996, we studied the amphibians and their recolonization of Lost Lake in an effort to assess the success of restoration. Because the amphibian populations colonizing the wetland inhabit or migrate through the three adjacent forest types, we were also able to reevaluate the relative abundance, diversity, and fluctuations of the populations in each of the three forests and to compare our results with Bennett's studies from before the restoration. Like Bennett, we found that amphibians were more abundant in the hardwood stand than in either managed pine forest. Also, of the 16 species Bennett captured, we caught 14. The gray treefrog, which Bennett captured, we did not capture, but one male was heard calling from near the shoreline during our study. The other species Bennett caught that we did not, the dwarf salamander, may not be able to recolonize Lost Lake for years, as its preferred habitat is wet leaf litter near the shoreline. Until the trees and shrubs grow back along the shoreline, there may not be suitable habitat for this species, which is otherwise common on SRS. Because Bennett only sampled in July and August, he did not capture several species that we caught in our winter and spring sampling. (For a list of all species captured, see Table 1.) Despite the good news that almost all prerestoration species are present once again, one point that may be of concern is that densities of amphibians in this area are now less than one fifth of what they were during Bennett's study. Whether this decline is the result of removing shrubs and trees near Lost Lake during restoration activities, the generalized global decline in amphibia, or due to unrelated events is unknown at this time. Although future studies may contribute to the solution of this puzzle, no research is currently being conducted, and none is budgeted for the near future.

The recovery of Lost Lake has been fertile ground for both ecological research and educa-

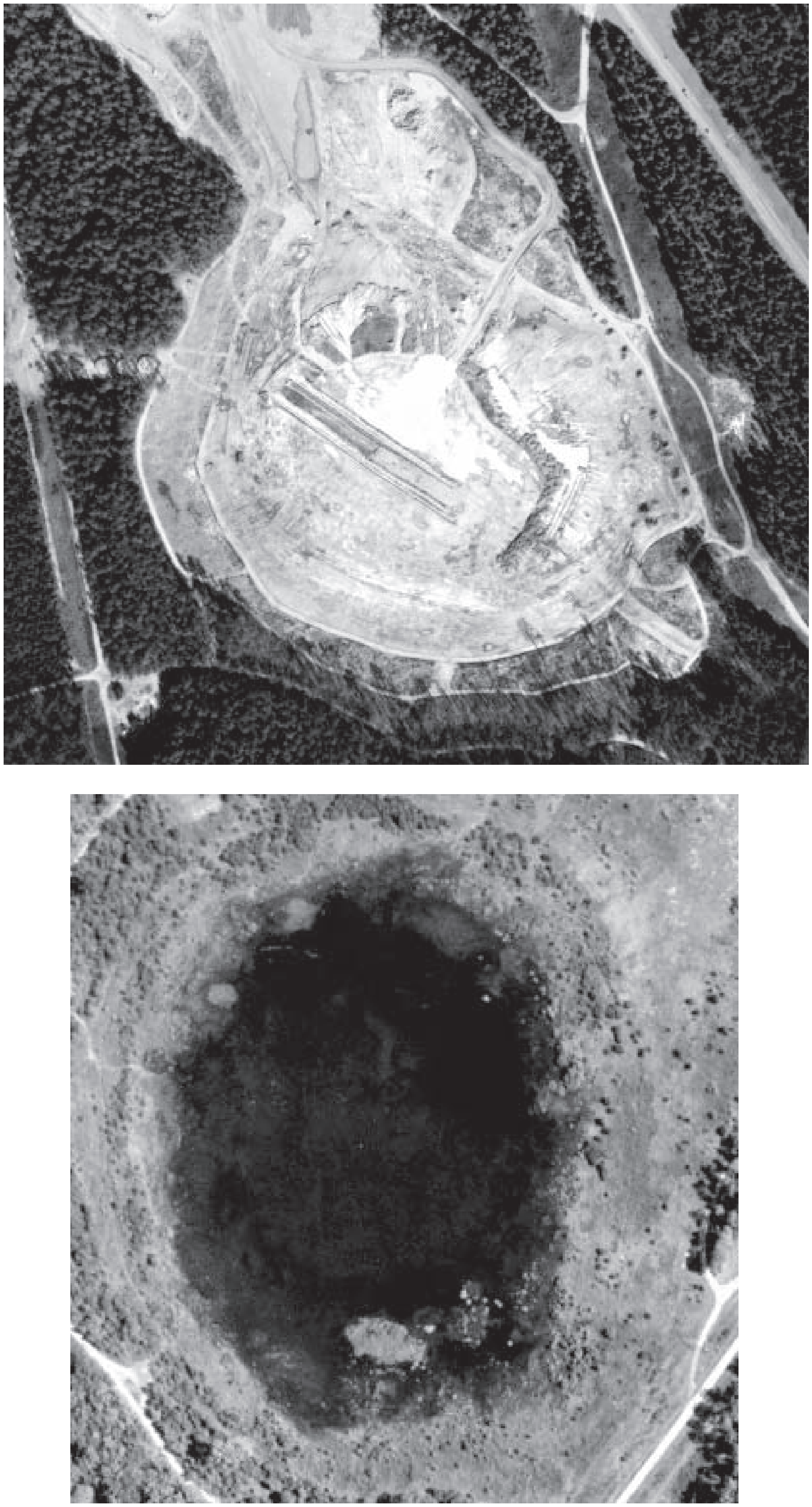

Figure 1. Lost Lake during and after restoration

Table 1. Amphibian species captured after restoration and during the 1977-1978 study by Bennett.

Species	Before Restoration	After Restoration
Salamanders		
Ambystoma opacum, Marbled salamander	X	X
Ambystoma talpoideum, Mole salamander	X	X
Ambystoma tigrinum, Tiger salamander		X
Eurycea quadridigitata, Dwarf salamander	X	
Notophthalmus viridescens, Eastern newt	X	X
Plethodon glutinosus, Slimy salamander	X	X
Frogs and Toads		
Acris gryllus, Southern cricket frog		X
Bufo quercicus, Oak toad	X	X
Bufo terrestris, Southern toad	X	X
Gastrophryne carolinensis, Eastern narrowmouth toad	X	X
Hyla cinerea, Green treefrog	X	X
Hyla gratiosa, Barking treefrog	X	X
Hyla squirella, Squirrel treefrog	X	X
Hyla versicolor, Common gray treefrog	X	
Pseudacris crucifer, Spring peeper		X
Pseudacris nigrita, Southern chorus frog		X
Pseudacris ornata, Ornate chorus frog		X
Rana catesbeiana, Bullfrog	X	X
Rana clamitans, Green frog	X	X
Rana utricularia, Southern leopard frog	X	X
Scaphiopus holbrooki, Eastern spadefoot toad	X	X

tional opportunities. Under the direction of Dr. John Williams, 28 undergraduate and graduate students at South Carolina State University have performed research projects supported by the DOE program for Historically Black Colleges and Universities. At University of South Carolina-Aiken, in addition to the 9 students participating in our research and a post doctoral sabbatical for Dr. Hugh Hanlin, more than 12 undergraduate independent study projects have been performed involving the recovery of Lost Lake. Currently, Dr. J. Hayes of Paine College is studying the insect populations of the hardwood area near Lost Lake to help develop baselines for terrestrial rapid bioassessment techniques. Additionally, two high school students participating in the NSF Young Scholars Program at the Ruth Patrick Science Education Center and the South Carolina Governor's School for Science and Mathematics have done research projects involving Lost Lake. These undergraduate studies have varied in subject matter. A few examples are a study of the mosquitoes of Lost Lake; a survey of small mammals in the Lost Lake wetlands; water quality of Lost Lake; habitat preferences and movements of amphibians such as bullfrogs, mole salamanders and tiger salamanders; bird communities in the Lost Lake wetlands; and comparisons of algae communities between Lost Lake and undisturbed Carolina bays. In addition, over a dozen tours have been conducted by the senior author for groups from area colleges, schools, clubs, and service groups. The recovery of Lost Lake has been the subject of several newspaper articles and will be part of an upcoming CNBC piece on environmental restoration activities at SRS.

To date there have been more than 6 publications in refereed scientific journals and more than 10 papers presented at symposia or meetings of professional societies. These papers and presentations dealt with either changes in amphibians and reptiles following restoration, changes in vegetation, and using wetlands as ecological laboratories for educating students.

Conclusion

The return of Lost Lake has been an example of promises fulfilled. A project that started as almost an afterthought to a waste site clean-up has become an example of how cooperation and initiative can produce effective results in a timely and cost effective manner. Lost Lake was the first Carolina bay to be restored at SRS, possibly the first anywhere. Lost Lake has exceeded its expectations in that it has provided remarkable educational opportunities throughout the local area for high school and college students as well as professors and research scientists. Lost Lake also provided to the science of wetland restoration and resource management a wealth of information on recovery and conservation of these unique wetland systems and environmental restoration in general. In spite of the fact that there are no current on-going research programs at Lost Lake, this aquatic jewel in the sandhills still offers abundant information about how restored wetlands recover and function over time. It is our sincere hope that we can find the resources in the near future to begin again and further investigate the mysteries of how finding Lost Lake has progressed and to enumerate the benefits it offers to the surrounding landscape and beyond to the entire SRS.

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Biographies

Lynn D. Wike

Lynn D. Wike received a BA in biology from Millersville University in 1973, an MS in Environmental Biology from Eastern Illinois University in 1981, and a Ph.D. in aquatic ecology from the University of Illinois in 1987. His training and experience varies widely from ecology to herpetology, fisheries, small mammal ecology, and wetland ecology. He has taught at the university level and continues as an adjunct at the University of South Carolina-Aiken, teaching general biology, zoology, and ecology. He has worked as a biologist at Three Mile Island, the Illinois Natural History Survey, and as a private consultant. He has been the author or co-author of over 30 publications and presentations and has been at Savannah Rive Site since 1989.

F. Douglas Martin

F. Douglas Martin received a BS in zoology in 1964 from Louisiana State University, an MA in 1967, and a Ph.D. in 1968 in zoology from the University of Texas at Austin and an MS in information science from the University of North Texas in 1991. His primary training is in ecology and vertebrate taxonomy. He has taught at university level, worked as a research biologist, resource manager for state and federal agencies, and has worked as a scientist in private industry. He has more than 30 refereed publications including three books or volumes. He has been at Savannah River Site since 1992.

John Gladden

John Gladden received his Bachelors Degree in biology from the University of Pennsylvania in 1970 and his Ph.D. in biology from Emory University in 1979. His dissertation research addressed the movement of radiocesium in a stream-wetland ecosystem on the Savannah River Site. Following completion of his Ph.D. he worked for Texas Instruments, Inc. developing mathematical models for fisheries and carbon cycling in the Hudson River. Subsequently, he had research and research management positions at SUNY-Stony Brook and the University of Georgia's Savannah River Ecology Laboratory. In 1984 he moved to Du Pont's Savannah River Laboratory conducting limnological and wetlands research and impact assessments. In 1989, he became manager of that unit and is currently manager of the Environmental Analysis Section in the Savannah River Technology Center.

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