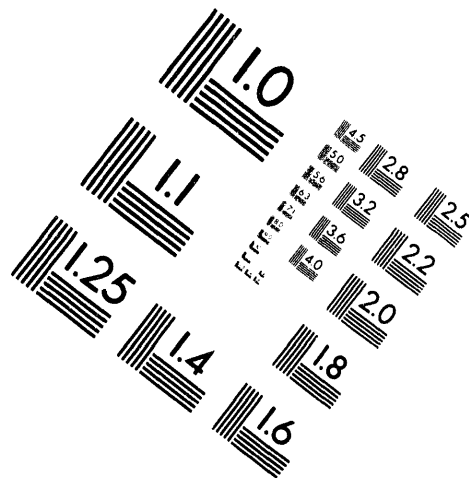
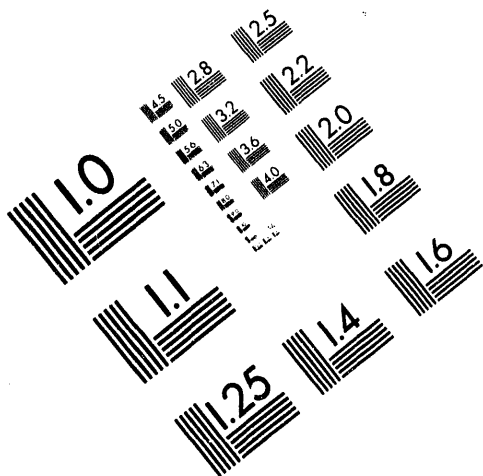




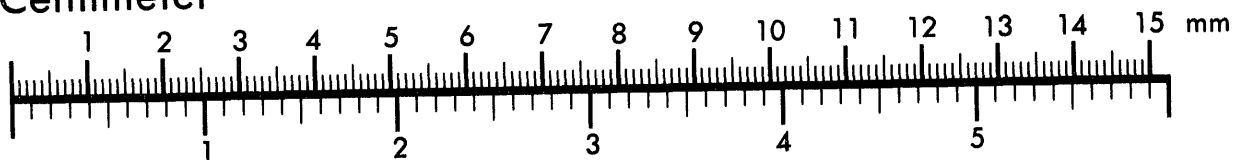
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Association for Information and Image Management

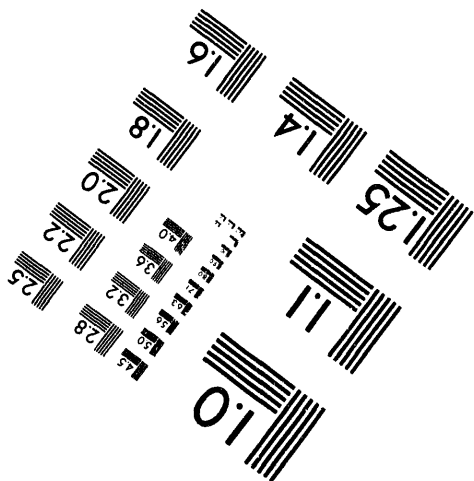
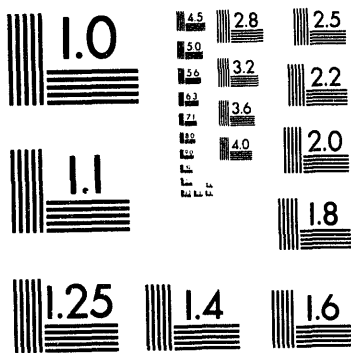
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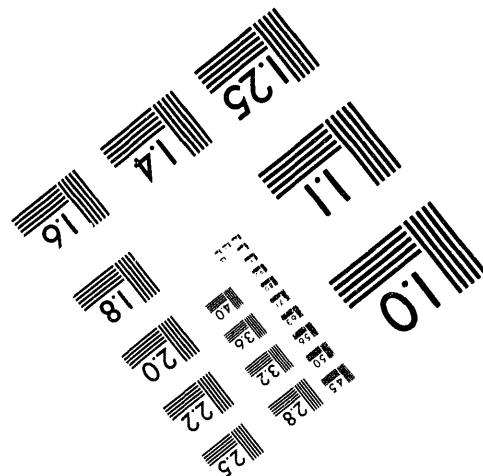
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Lost Lake—Restoration of a Carolina Bay

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LOST LAKE - RESTORATION OF A CAROLINA BAY

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ABSTRACT

Carolina bays are shallow wetland depressions found only on the Atlantic Coastal Plain. Although these isolated interstream wetlands support many types of communities, they share the common features of having a sandy margin, a fluctuating water level, an elliptical shape, and a northwest to southeast orientation. Lost Lake, an 11.3 hectare Carolina bay, was ditched and drained for agricultural production before establishment of the Savannah River Site in 1950. Later it received overflow from a seepage basin containing a variety of chemicals, primarily solvents and some heavy metals. In 1990 a plan was developed for the restoration of Lost Lake, and restoration activities were complete by mid-1991. Lost Lake is the first known project designed for the restoration and recovery of a Carolina bay.

The bay was divided into eight soil treatment zones, allowing four treatments in duplicate. Each of the eight zones was planted with eight species of native wetland plants. Recolonization of the bay by amphibians and

reptiles is being evaluated by using drift fences with pitfall traps and coverboard arrays in each of the treatment zones. Additional drift fences in five upland habitats were also established. Hoop turtle traps, funnel minnow traps, and dip nets were utilized for aquatic sampling. The presence of 43 species common to the region has been documented at Lost Lake. More than one-third of these species show evidence of breeding populations being established. Three species found prior to the restoration activity and a number of species common to undisturbed Carolina bays were not encountered. Colonization by additional species is anticipated as the wetland undergoes further succession.

INTRODUCTION

Carolina bays are natural, shallow depressions of upland interstream areas of the southeastern Atlantic Coastal Plain. They share the common features of a complete or beached sandy marginal rim, an elliptical or ovoid shape, and a northwest to southeast orientation of the long axis (Schalles et al., 1989). Since these depressions commonly have an impervious clay layer beneath the surface soil, their hydrologic regime depends on local precipitation patterns (Lide, 1991; Kirkman, 1992). Although individual bays may be seasonally or continually flooded, they tend to have deeper water levels in winter than in summer (Kirkman and Sharitz, 1993).

Carolina bays contain hydric or mesic communities ranging from shallow lakes to marshes, herbaceous bogs, and swamp forests (Wharton, 1978). In addition to providing forage and water for upland wildlife, bays are particularly important as sites of amphibian reproduction and larval development (Patterson, 1978; Bennett et al., 1979; Sharitz and Gibbons, 1982; Pechmann et al., 1989). Semiaquatic fauna are characteristic of Carolina bay wetlands (Sharitz and Gibbons, 1982).

Although Carolina bays are a relatively common feature of the Atlantic Coastal Plain landscape, most bays have been severely altered by human activities. The most common disturbance has been ditching and draining of bays, usually accompanied by cultivation. However, since 1950 few

Carolina bays have been actively disturbed on the Savannah River Site, a Department of Energy industrial facility in South Carolina, and most altered bays have undergone successional recovery (Schalles et al., 1989). Lost Lake is a Carolina bay on the Savannah River Site that has been negatively impacted by industrial pollutants and is the target of a wetlands restoration effort.

STUDY SITE

Lost Lake, an 11.3 hectare Carolina bay located on the Savannah River Site along the Savannah River in South Carolina, was ditched and drained for agricultural production from prior to 1943 until the early 1950s. After the Atomic Energy Commission removed the land from farming in the early 1950s, the cultivated area around the bay was planted in slash pine (*Pinus elliottii*) and loblolly pine (*Pinus taeda*), and Lost Lake began to refill and function as a wetland (Bennett et al., 1979; Gladden et al., 1992). However, impacts to the watershed continued as an industrial facility was installed nearby. Until 1984, overflow from a seepage basin contaminated the bay with a variety of chemicals, primarily cleaning fluids, solvents and heavy metals. By that time Lost Lake supported no emergent or submerged aquatic macrophytes (Bennett et al., 1979). One aspect of a closure plan for the nearby settling basin was the restoration of the degraded bay to a "natural wetland system" (Gladden et al., 1992).

During 1990, in cooperation with the Department of Energy Savannah River Office, a task team from Westinghouse Savannah River Company, Savannah River Forest Service, Savannah River Ecology Laboratory, and Soil Conservation Service developed a plan for the restoration of Lost Lake. Vegetation in the bay was burned, and the residual ash was removed to the settling basin and compacted. Soils from the lake basin were excavated to a depth sufficient to remove the contaminants and were then backfilled into the settling basin. The basin was then capped and closed as a hazardous waste disposal unit. Monitoring of the Lost Lake restoration project is being funded through the South Carolina Universities Research and Educational Foundation

(SCUREF), a university consortium promoting research by qualified professionals and student technicians. This is the first known project designed for the restoration and recovery of a Carolina bay.

MATERIALS AND METHODS

In January, 1991, the bay was divided into eight soil treatment zones, allowing four soil treatments in duplicate. Each of the eight zones was planted with eight species of native wetland plants, and four sizes of experimental plots were established to monitor vegetation recovery. A description of these treatments and the results of this monitoring were reported by Ornes et al., (1994).

In May, 1993, monitoring of the bay for recolonization by amphibians and reptiles was initiated. Four collecting methods were used in each of the eight treatment zones:

- (1) One 30m drift fence with pitfall traps (Gibbons and Semlitsch, 1982) was established 30 meters from and parallel to the water's edge. (Five additional drift fences were established 100 meters from the water's edge in surrounding upland habitats.) Ten-gallon buckets, which function as pitfall traps, were sunk to ground level at the ends and at 10m intervals along both sides of each fence.
- (2) Artificial cover boards (Grant et al., 1992) of sheets of plywood or galvanized roofing tin, each measuring 0.66m x 1.33m, were individually numbered. Arrays consisting of four cover boards (two each of tin and plywood) were placed at the water's edge and at intervals of 20m, 50m, and 90m along a line perpendicular to the water's edge.
- (3) Two hoop net turtle traps (Plummer, 1979) baited with sardines were placed parallel to the water's edge at a depth of 1.0 - 1.5m.
- (4) Three funnel-throat minnow traps baited with sardines were placed at depths sufficiently shallow so as not to become submerged.

Drift fence pitfall traps and coverboards were checked daily (twice daily during summer months) for a year. Turtle traps and minnow traps were set for a one-week period during each month and checked daily. Hand-collecting and the use of D-framed dipnets for aquatic sampling supplemented the primary sampling methods.

Amphibians which were collected by trap or by hand were toe-clipped, but not for individual recognition, and released. Animals captured along a drift fence were released on the opposite side of the fence. Demographic data were recorded for each captured reptile before individually marking and releasing. Lizards were marked by toe-clipping, snakes were marked by clipping ventral scales, and turtles were marked by notching marginal scutes. Data gathered for turtles were included in ongoing studies begun by SREL in the 1960s (Gibbons, 1990; Gibbons et al., 1990). Recaptured animals were noted and removed from all calculations of numbers collected.

RESULTS

A total of 43 species of amphibians and reptiles was collected or observed during this study (Table 1). The general herpetofaunal groups were represented by the following percents by species: frog and toad species - 32.6%, snake species - 30.2%, lizard species - 16.3%, salamander species - 11.6%, turtle species - 7.0%, and crocodilian species - 2.3%.

Table 1. Amphibian and reptile species collected or observed at Lost Lake, Savannah River Site, South Carolina, May 1993 - April, 1994.

Species	Number Collected
CLASS AMPHIBIA	
Order Caudata - Salamanders	
Family: Ambystomatidae	
¹ <i>Ambystoma opacum</i> (marbled salamander)	15
^{1,2} <i>Ambystoma talpoideum</i> (mole salamander)	452
^{1,2} <i>Ambystoma tigrinum</i> (tiger salamander)	71
Family: Salamandridae	
^{1,2} <i>Notophthalmus viridescens</i> (eastern newt)	1,392
Family: Plethodontidae	
² <i>Plethodon glutinosus</i> (slimy salamander)	20

Order Anura - Frogs and Toads

Family: Pelobatidae

^{1,2}*Scaphiopus holbrooki* (eastern spadefoot toad) 13

Family: Bufonidae

¹*Bufo quercicus* (oak toad) 1

^{1,2}*Bufo terrestris* (southern toad) 12,432

Family: Hylidae

¹*Acris gryllus* (southern cricket frog) 497

¹*Hyla chrysoscelis* (Cope's gray treefrog) 0
(observation only)

^{1,2}*Hyla cinerea* (green treefrog) 155

^{1,2}*Hyla gratiosa* (barking treefrog) 1,842

¹*Hyla squirella* (squirrel treefrog) 43

¹*Pseudacris crucifer* (spring peeper) 4

Pseudacris nigrita (southern chorus frog) 2

¹*Pseudacris ornata* (ornate chorus frog) 13

Family: Microhylidae

¹*Gastrophryne carolinensis*
(narrow-mouthed toad) 559

Family: Ranidae

^{1,2}*Rana catesbeiana* (bullfrog) 1,000

¹*Rana clamitans* (green frog) 2

^{1,2}*Rana utricularia* (southern leopard frog) 330

CLASS REPTILIA

Order Crocodilia - Crocodilians

Family: Alligatoridae

Alligator mississippiensis
(American alligator) 2

Order Chelonia - Turtles

Family: Kinosternidae

Kinosternon subrubrum (eastern mud turtle) 4

Family: Emydidae

¹*Trachemys scripta* (slider turtle) 40

¹*Deirochelys reticularia* (chicken turtle) 8

Order Squamata - Lizards and Snakes

Suborder Lacertilia - Lizards

Family: Iguanidae

¹*Anolis carolinensis* (green anole) 29

Sceloporus undulatus (eastern fence lizard) 0
(observation only)

Family: Teiidae

Cnemidophorus sexlineatus
(six-lined racerunner) 3

Family: Scincidae		
<i>Eumeces fasciata</i>	(five-lined skink)	1
<i>Eumeces inexpectatus</i>	(southeastern five-lined skink)	1
<i>Eumeces laticeps</i>	(broadheaded skink)	3
<i>Scincella lateralis</i>	(ground skink)	30
Suborder Serpentes - Snakes		
Family: Colubridae		
<i>Cemophora coccinea</i>	(scarlet snake)	1
<i>Coluber constrictor</i>	(racer/black racer)	34
<i>Diadophis punctatus</i>	(ringneck snake)	1
<i>Elaphe obsoleta</i>	(rat snake)	1
<i>Heterodon platirhinos</i>	(eastern hognose snake)	10
<i>Nerodia fasciata</i>	(banded water snake)	134
<i>Storeria dekayi</i>	(brown snake)	1
<i>Storeria occipitomaculata</i>	(red-bellied snake)	6
<i>Tantilla coronata</i>	(southeastern crowned snake)	7
<i>Thamnophis sirtalis</i>	(common garter snake)	10
Family Viperidae (=Crotalidae)		
<i>Crotalus horridus</i>	(canebrake rattlesnake)	4
<i>Sistrurus miliarius</i>	(pygmy rattlesnake)	3

¹Successful reproduction documented by presence of larvae, recent metamorphs, hatchlings or newborns.

²Species reported by Bennett (draft ms)

³Species is normally terrestrial in periphery of bays and other aquatic habitats.

Successful reproduction was documented for fifteen species (Table 1). Evidence of successful reproduction included the presence of larvae or recent metamorphs (for amphibians) and hatchlings or newborns (for reptiles). Males of four additional species of frogs were heard calling from the bay and gravid females of one lizard species were collected. However, these observations indicate only breeding activity and not successful reproduction.

DISCUSSION

Our results indicate significant recolonization of Lost Lake by amphibians and reptiles. Successful reproduction was documented for more than one-third of the species encountered. However, many of the species, particularly those most abundant, inhabit a wide variety of wetland habitats, including ones that have been heavily disturbed.

Bennett (draft ms) conducted a similar study of Lost Lake herpetofauna in the summers of 1978 and 1979 prior to restoration in which he utilized drift fences with pitfall traps and coverboards on a smaller scale and did not use turtle or minnow traps. He documented only 27 species (Table 1), but those included three species not encountered in the present study. The eastern coral snake (*Micrurus fulvius*) is a secretive animal associated with turkey oak-pine habitats, and few have been collected on the Savannah River Site (Gibbons and Semlitsch, 1991). One specimen was collected in a pitfall trap in 1978-1979. Two specimens of the smooth earth snake (*Virginia valeriae*) were collected in 1978-1979. This secretive animal inhabits forested areas in the periphery of some Carolina bays and may be captured in pitfall traps. Further sampling may verify the presence of these species since upland forests, though now at some distance, still surround Lost Lake. The dwarf salamander (*Eurycea quadridigitata*), which is commonly found in leaf litter in the margins of undisturbed bays, was present in 1978-1979 but not encountered in the present study in spite of intensive sampling. It is possible that this species was extirpated from Lost Lake during the excavation activity or that the sparse vegetation now surrounding the bay does not provide adequate cover or shade for these animals.

Schalles et al. (1989) and Gibbons and Semlitsch (1991) list amphibian and reptile species collected or observed in other Carolina bays on the Savannah River Site. A comparison with our results reveals numerous common species not encountered at Lost Lake (Table 2). The absence of many of these species is not surprising since the bay is in a very early successional stage. There is little emergent or submerged vegetation, and the area surrounding the bay is dominated by "old field" successional plant species rather than trees.

Table 2. Amphibian and reptile species collected or observed in Carolina bays on the Savannah River Site, South Carolina (Schalles et al., 1989; Gibbons and Semlitsch, 1991) but not collected or observed at Lost Lake in this study.

CLASS AMPHIBIA

Order Caudata - Salamanders

Family: Amphiumidae

Amphiuma means (two-toed amphiuma)

Family: Sirenidae

Siren intermedia (lesser siren)

Siren lacertina (greater siren)

Family: Plethodontidae

Eurycea cirrigera (two-lined salamander)

Eurycea longicauda (long-tailed salamander)

Eurycea quadridigitata (dwarf salamander)

Order Anura - Frogs and Toads

Family: Hylidae

Hyla avivoca (bird-voiced treefrog)

Hyla femoralis (pine woods treefrog)

Family: Ranidae

Rana areolata (crawfish frog)

Rana grylio (pig frog)

Rana palustris (pickerel frog)

Rana virgatipes (carpenter frog)

CLASS REPTILIA

Order Chelonia Turtles

Family: Chelydridae

Chelydra serpentina (common snapping turtle)

Family: Kinosternidae

Kinosternon bauri (striped mud turtle)

Sternotherus odoratus (stinkpot)

Family: Emydidae

Pseudemys floridana (Florida cooter)

Chrysemys picta (painted turtle)

Clemmys guttata (spotted turtle)

Order Squamata - Lizards and Snakes

Suborder Serpentes - Snakes

Family: Colubridae

**Elaphe guttata* (corn snake)

Farancia abacura (mud snake)

Farancia erythrogramma (rainbow snake)
**Lampropeltis getulus* (common kingsnake)
Nerodia floridana (Florida green water snake)
Nerodia erythrogaster (red-bellied water snake)
Regina rigida (glossy crayfish snake)
**Rhadinaea flavilata* (yellow-lipped snake)
Seminatrix pygaea (black swamp snake)
**Thamnophis sauritus* (eastern ribbon snake)
**Virginia valeriae* (smooth earth snake)
Family: Viperidae (=Crotalidae)
Agkistrodon piscivorus (cottonmouth)

*Species is normally terrestrial in periphery of bays and other aquatic habitats.

We predict that as the wetland undergoes further succession, suitable habitats will allow recolonization by additional species. Our sampling design will allow us to test the correlation of relative abundances of amphibian and reptile species with any vegetational differences that may occur between the eight soil treatment zones. Continued monitoring of the herpetofauna of Lost Lake will significantly enhance our understanding of the recovery of this unique Coastal Plain ecosystem.

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