

Effects of Large-Scale Sediment Removal on Herpetofauna in Florida Wetlands

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ABSTRACT.—Removal of organic sediment from lakes and ponds is an established management technique that is intended to enhance sport fisheries, improve boater access, and increase stormwater capacity. Data on the effects of this management technique on lake ecosystems are limited. Our objective was to determine the effect of mechanical sediment removal on herpetofauna at five sites in northern Florida. We collected a total of 883 individuals of 31 species of herpetofauna excavated by machinery during sediment removal. Across the five sites, the average number of individuals collected was 177 per site (SD = 119, range = 71–310). The most abundant herpetofauna we encountered were aquatic turtles (*Trachemys scripta*, *Chelydra serpentina*) and large aquatic salamanders (*Amphiuma means*, *Siren* spp.). Mortality from sediment removal operations may have a detrimental effect on herpetofauna populations, especially species that depend on dried lake sediments for aestivation or with limited dispersal abilities.

Many lakes and ponds in the southeastern United States are relatively shallow and have abundant emergent, floating, and submerged aquatic vegetation (Sellards, 1910; Brenner et al., 1990; Hoyer et al., 1996). Natural substrate of these lakes usually consists of an organic layer composed of decomposing vegetation (i.e., muck) with underlying sand or clay (Sellards, 1910). Macrophytes and associated organic sediment provide a rich invertebrate resource base for littoral lake food webs (Schramm et al., 1987; Schramm and Jirka, 1989; Butler et al., 1992).

Mechanical sediment removal has become an established technique for fisheries management and enhancing stormwater function of lakes and ponds in Florida (Allen, 1999). The most commonly stated fisheries management goal of these projects is the removal of organic sediment and aquatic vegetation for enhancement to sport fisheries and boater access. Several government and agency documents report on the effect of sediment removal on sport fisheries, but peer-reviewed literature on the effects of sediment removal on other aquatic organisms is scarce. An evaluation of sediment removal on fisheries in Lake Tohopekaliga in central Florida consisted of comparisons between treated and control areas after sediment removal but did not include data before sediment removal (Moyer et al., 1995). Sport fish (largemouth bass, sunfish) were captured at higher frequencies in treated sites than control sites, but abundance of some other fish species was greater in control sites than treated sites (Moyer et al., 1995). After sediment removal at Lake Tohopekaliga, total macroinvertebrate taxa, diversity, and density were lower on treated areas than control areas (Butler et al., 1992). At Lake Kissimmee, Florida, changes in habitat after sediment removal resulted in a shift in the dominant fish from poeciliids to Seminole killifish (*Fundulus seminolis*) and other open water species (Tugend, 2001). However, the purported benefit of this change in fish community to the lake ecosystem or to sport fisheries is not clear.

The 2001 Justification Review of the Florida Fish and Wildlife Conservation Commission (FFWCC) by the State of Florida stated that data on the effectiveness of FFWCC lake restoration projects are limited (Office of Program Policy Analysis and Government Accountability, 2001). Despite the paucity of data on the long-term effects of sediment removal on lake ecosystems, large-scale sediment removal is scheduled for at least 31 lakes by the FFWCC from 2001–2020 (Allen, 1999). Sediment removal may also be conducted in ponds in suburban areas to increase the volume of stormwater such ponds can accommodate. In some cases, organic sediment removal may be performed to eliminate contaminants or high nutrient loads from lakes and ponds. However, media coverage that equates all sediment removal operations to “cleaning up” lakes may create a misconception by the public that decomposing organic sediment on lake bottoms is unnatural, and equivalent to pollution and, thus, is detrimental to wildlife, water quality, and recreation (Ritchie, 2000).

Lakes and ponds in the southeastern United States support a high diversity and abundance of reptiles and amphibians, of which some species, including *Amphiuma means*, *Chelydra serpentina*, and *Farancia abacura*, are typically associated with organic sediment (Carr, 1940; Mount, 1975; Gibbons and Semlitsch, 1991). However, no studies have evaluated the effects of sediment removal on populations of herpetofauna. The objective of this study was to determine the effect of sediment removal on herpetofauna populations in two wetland habitat types: suburban ponds and large lakes.

MATERIALS AND METHODS

We surveyed five sites in Leon County, Florida, during sediment removal operations from November 1999 to December 2000 (Table 1). McCord Pond and Harriman Pond were suburban ponds that had been converted in the past from natural wetlands to serve as stormwater retention ponds. These ponds were pumped dry prior to removal of sediment from the entire pond area. We defined suburban ponds as those less than 5 ha in surface area and situated in small parks within residential neighborhoods. The other three sites we surveyed were portions of larger sediment removal operations at two large lakes (Lake Iamonia and two

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TABLE 1. Sediment removal sites surveyed for herpetofauna in Leon County, Florida. Total area is the size of the entire wetland for each site; area treated is the amount of area treated with sediment removal (only one total area, treated area, and percent area treated are given for Lake Jackson although we sampled two separate areas of this site).

Site	Area (ha)			Percent total area treated	Survey dates	Survey Effort (h)
	Total	Treated	Surveyed			
Suburban Ponds						
McCord Pond	2	2	2	100%	12/15/99–4/28/00	246
Harriman Pond	0.5	0.5	0.5	100%	10/1/00–10/30/00	154
Lakes						
Lake Iamonia	2330	11	4	0.5%	7/18/00–8/15/00	143
Lake Jackson	1620	243		15%		
US 27			1.7		12/7/00–12/20/00	40
Megginnis Arm			1.8		11/16/99–12/21/99	140

sites at Lake Jackson: Megginnis Arm and adjacent to U.S. Highway 27).

The sediment removal procedure was similar at all sites (Fig. 1). Heavy machinery (large backhoes and bulldozers) removed organic sediment to a depth of 1–2 m at which point a sand or clay layer was reached, or much deeper in the case of the suburban ponds. In some cases, organic sediment was piled on the shore and allowed to dry for several days before being transported to off-site landfills, whereas in other cases, the sediment was immediately loaded onto trucks as it was excavated (Fig. 1).

We surveyed each site daily (mean effort = 3.7 h/day) during the sediment removal operations (Table 1). Our collection technique consisted of two methods. First, we stood near the machinery being used to remove sediment and looked for animals uncovered during excavation. Most machine operators provided assistance by signaling us when they had spotted an animal and pausing work while we collected the animal. Second, we walked transects across recently treated areas and piles of organic sediment and looked for animals that had been excavated. We recorded the numbers of individuals of each species found at each site. Frogs were difficult to detect consistently in muck and plant material and, thus, were less likely to be

detected during our surveys. Therefore, we only report presence/absence of frogs at each site. To determine whether there were differences in the frequency of taxa across habitat types, we calculated catch per unit effort (CPUE = individuals captured/hour of survey effort) for each site for the three most abundant taxa: salamanders, turtles, and snakes. We then performed a two-sample *t*-test comparing the CPUE for each of these three taxa at suburban ponds and lakes.

We feel confident that live animals we collected would have been killed during the sediment removal if we had not collected them for several reasons. First, most live animals we found were collected immediately after they had been uncovered at the site of the current machinery work. When we collected animals from sediment piles or on the surface, they were usually dead because of desiccation, suffocation, or being crushed under excavated sediment or machinery. After all sediment was removed, all sites were repeatedly graded using a bulldozer that crushed any remaining living organisms. It is possible that at the lake sites some animals may have been able to disperse away from the machinery, across large areas of exposed ground, to the remaining water, but we feel this is unlikely because it was never observed in 723 h of observations. The distance between the sediment

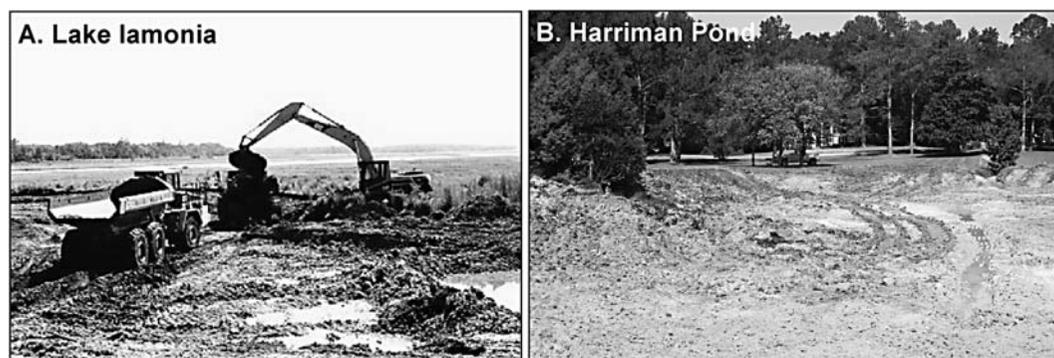


FIG. 1. (A) Lake Iamonia during sediment removal; a backhoe loads sediment directly into large dump trucks. The remaining water at this site can be seen in the distance. (B) Harriman Pond immediately after sediment removal. The site has been leveled with a bulldozer and no untreated aquatic habitat remains at this site.

TABLE 2. Number of individuals of 30 species found during daily surveys of five sediment removal sites in Leon County, Florida. Locality abbreviations are McC = McCord Pond, Har = Harriman Pond, Iam = Lake Iamonia, Meg = Lake Jackson, Megginis Arm, US27 = Lake Jackson, U.S. 27. A (–) indicates a species was absent from that site. Frogs are recorded as present (+) or absent (–) and were not included in the total number of individuals at each site.

Species	Suburban Ponds		Lakes		
	McC	Har	Iam	Meg	US27
Salamanders					
<i>Amphiuma means</i>	62	–	63	30	11
<i>Siren</i> spp. ¹	43	189	8	66	49
Frogs					
<i>Acris gryllus</i>	–	–	–	+	–
<i>Bufo terrestris</i>	+	+	+	+	+
<i>Gastrophryne carolinensis</i>	–	–	+	+	–
<i>Hyla chrysoscelis</i>	+	–	–	–	–
<i>Hyla cinerea</i>	+	+	+	+	–
<i>Rana catesbeiana</i>	+	+	–	+	–
<i>Rana grylio</i>	–	–	–	+	–
<i>Rana sphenoccephala</i>	+	+	+	+	–
Turtles					
<i>Apalone ferox</i>	9	–	–	1	–
<i>Chelydra serpentina</i>	31	11	–	1	–
<i>Kinosternon subrubrum</i>	2	4	–	1	2
<i>Pseudemys floridana</i>	27	19	1	–	–
<i>Sternotherus minor</i>	1	–	–	–	–
<i>Sternotherus odoratus</i>	41	4	3	4	5
<i>Terrapene carolina</i>	2	–	–	–	–
<i>Trachemys scripta</i>	88	69	–	3	–
Lizards					
<i>Ophisaurus ventralis</i>	–	2	1	–	1
<i>Scincella lateralis</i>	–	–	–	–	1
Snakes					
<i>Agkistrodon piscivorus</i>	–	–	–	1	–
<i>Cemophora coccinea</i>	–	–	1	–	–
<i>Coluber constrictor</i>	–	–	1	–	2
<i>Diadophis punctatus</i>	1	–	–	–	–
<i>Elaphe obsoleta</i>	1	–	–	–	–
<i>Farancia abacura</i>	–	–	–	3	–
<i>Lampropeltis getula</i>	–	–	–	1	–
<i>Nerodia fasciata</i>	2	1	–	1	–
<i>Nerodia floridana</i>	–	–	–	6	–
<i>Seminatrix pygaea</i>	–	–	–	6	–
Crocodilians					
<i>Alligator mississippiensis</i>	–	–	–	1	–
Total	310	299	78	125	71

¹ Sirens are listed as *Siren* spp. because we could not always distinguish between *S. lacertina* and *S. intermedia*.

removal sites and the sediment disposal areas ranged from 3 to 30 km, thus it is unlikely that herpetofauna transported to these disposal sites could disperse back to their site of capture. At the suburban ponds, there was no remaining aquatic habitat to disperse to as the entire pond was drained and treated with sediment removal. In addition, for the sites that were treated with sediment removal during cold weather (Megginis Arm, US 27, and McCord Pond) many organisms were inactive after being excavated by machinery and incapable of moving. Also, at most sediment removal

sites, we observed predators (cattle egrets, *Bubulcus ibis*; hawks, *Buteo* spp.; and raccoons, *Procyon lotor*) consuming dead and live animals excavated by machinery. Thus, our observations suggest that very few, if any, organisms we found alive during sediment removal could have survived.

RESULTS

We found 883 individuals of 31 species of reptiles and amphibians at five sediment removal sites (Table 2). Average number of animals collected at each site was

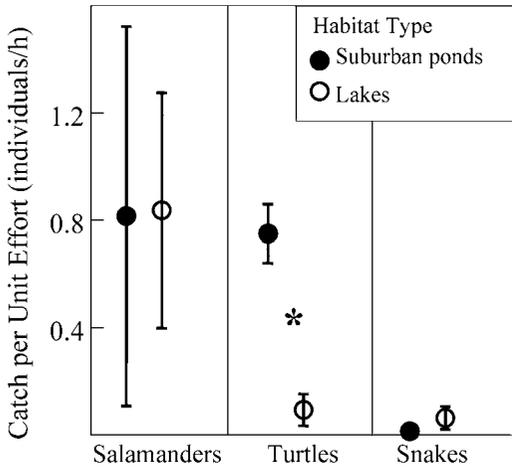


FIG. 2. Catch per unit effort (CPUE, mean and standard error) of salamanders, turtles, and snakes collected from suburban ponds ($N = 2$) and lakes ($N = 3$) during sediment removal operations. An * indicates a significant difference in CPUE for a taxa across habitat types with a two-sample t -test.

177 (SD = 119, range 71–310). The most abundant taxa overall at both suburban ponds and lakes were large aquatic salamanders (*Siren* spp. and *Amphiuma means*). Catch per unit effort for salamanders, snakes, and turtles varied from a low of 0.014 individuals/h for snakes at suburban ponds to a high of 0.84 for salamanders at lakes (Fig. 2). Catch per unit effort of salamanders ($t = 0.042$, $df = 3$, $P = 0.97$) and snakes ($t = 1.17$, $df = 3$, $P = 0.33$) did not differ between lakes and suburban ponds, whereas turtles were captured more frequently at suburban ponds ($t = -8.98$, $df = 3$, $P = 0.003$; Fig. 2). Species that could not easily disperse from drying lakes, and species that normally aestivate in organic sediment such as *A. means*, *Siren* spp., *Chelydra serpentina*, and *Sternotherus odoratus* (Aresco, 2000, 2002) were collected at greater frequencies than species such as snakes that may have greater dispersal ability. In addition, we collected several species typical of upland habitats, including *Coluber constrictor*, *Cemophora coccinea*, and *Ophisaurus ventralis*, that colonized the dry lakebeds of some sites during drought (Table 2).

DISCUSSION

We documented that sediment removal projects at lakes and ponds negatively affect herpetofauna by removal of large numbers of individuals of many species, both through direct mortality and transport to off-site sediment disposal areas. We collected large aquatic salamanders and snakes at similar frequencies in large lakes and smaller suburban ponds, and collected significantly more turtles at suburban ponds than lakes. Mortality caused by sediment removal may especially affect those species that have inherently slow population growth rates due to demographic constraints (e.g. turtles and large-bodied snakes). Long-lived vertebrates have a suite of unique life-history traits (delayed sexual maturity, high juvenile mortality, and low adult mortality) that make it difficult for them

to recover from a sudden and dramatic increase in adult mortality (Congdon et al., 1994). Large-scale sediment removal projects of large lakes (e.g., 6.7 million cubic yards at Lake Tohopekaliga) may reduce populations of some species below levels necessary for recovery. For example, at Lake Jackson, 243 ha (2 million cubic yards) of lake bottom was removed in 1999–2001. Based on our count of sirens and amphiumas from the sediment removal operation at Megginis Arm of Lake Jackson, and assuming that these species are distributed homogeneously throughout this shallow, heavily vegetated lake, we extrapolated that approximately 8900 sirens and 4100 amphiumas were removed from Lake Jackson during this sediment removal operation. Lakes that are repeatedly subjected to muck removal operations over time may have a decreased probability of population recovery of species such as sirens and amphiumas.

In cases where entire wetlands are drained and dredged, local extinctions of populations of some species are possible. For example, in this study, because Harriman Pond was completely drained and the entire pond was treated with sediment removal, the siren population was probably extirpated. Landscape features such as distance to nearest unaltered wetland, habitat fragmentation, aquatic connections, roads, and topography may result in differential colonization rates among species (Gibbs and Shriver, 2002). Thus, species such as large aquatic salamanders with limited dispersal ability may be incapable of recolonizing isolated wetlands, especially in fragmented suburban landscapes (Snodgrass et al., 1999; Aresco, 2002).

Habitat alteration resulting from sediment removal operations probably reduces the likelihood of recovery for some species. Large-scale sediment removal operations leave the littoral zone with a hard, graded sand substrate devoid of any organic material and macrophytes (Hulon et al., 1992). Many species of herpetofauna in the southeastern United States, including *A. means*, *Siren* spp., *C. serpentina*, *F. abacura*, *Seminatrix pygaea*, and *Nerodia floridana*, are primarily associated with habitats of thick organic sediment and dense stands of macrophytes for foraging, reproduction, or aestivation (Carr, 1940; Aresco, 2000).

We conclude that the negative effects of sediment removal on herpetofauna should be carefully considered prior to the permitting of such projects by regulatory agencies. Surveys of population structure and abundance of reptiles and amphibians both before and after sediment removal operations should be conducted to understand the full range of effects of this management method. Because millions of dollars are spent annually in Florida for sediment removal projects for the purpose of "habitat enhancement," the positive and negative effects of this management technique on wetland ecosystems must be fully understood.

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