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Conservation of Biological Diversity:

A Key to the Restoration of the Chesapeake Bay Ecosystem and Beyond

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BIOLOGICAL DIVERSITY OF CREATED FORESTED WETLANDS IN COMPARISON TO REFERENCE FORESTED WETLANDS IN THE BAY WATERSHED

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Abstract: Amphibians, reptiles, birds, and mammals were surveyed at six created forested wetlands in central Maryland and at six adjacent reference forested wetlands during 1993-1996 to determine comparative biological diversity of these habitats. Amphibians and reptiles were caught in pitfall and funnel traps associated with 15.4-m (50-ft) drift fences. Birds were surveyed with a complete count while walking through each area. Mammals were surveyed by capture in live traps. More species and total individuals of amphibians were caught on the reference wetlands than on the created wetlands. The red-backed salamander (*Plethodon cinereus*), the four-toed salamander (*Hemidactylium scutatum*), the eastern spadefoot (*Scaphiopus holbrooki*), and the wood frog (*Rana sylvatica*) were captured on the reference wetlands, but not on the created sites. The wood frog was captured at all reference sites and may represent the best amphibian species to characterize a forested wetland. Reptiles were not caught in sufficient numbers to warrant comparisons. Ninety-two bird species were recorded on created sites and 55 bird species on the reference sites. Bird species on the created sites represented those typically found in nonforested habitats. Mammal species were similar on both sites, but overall the reference sites had three times the number caught on created sites. The meadow vole (*Microtus pennsylvanicus*) was the dominant species captured on created sites, and the white-footed mouse (*Peromyscus leucopus*) was the dominant species on reference sites, with little habitat overlap for these two species. Although species richness and total number of animals were high for created forested wetlands, these survey results show major differences from species expected for a forested wetland. The created forested wetlands appear to provide good habitat for wildlife, but are probably not providing the full functions and values of the forested wetlands that they were constructed to replace.

INTRODUCTION

Wetlands in the mid-Atlantic region were reduced in area by 25% from 1956 to 1979 (Tiner and Finn 1986). In the Chesapeake Bay watershed, the loss of wetlands from 1982 to 1989 was at a rate of 3 ha (8 acres) per day (Tiner et al. 1994). Forested wetlands have sustained the greatest loss of any type of wetland, with over 5,668 ha (14,000 acres) destroyed when they were converted to open water, urban areas, and agricultural land (Tiner et al. 1994; Tiner and Burke 1995). The importance and functions of forested wetlands are well documented (Fredrickson 1980; Conner and Day 1982).

Wetland creation is frequently used to mitigate loss of natural wetlands (Hey 1987; Kusler and Kentula 1989; Mitsch 1992). There is a critical need for information to guide regulatory agencies (especially the U.S. Fish and Wildlife Service and U.S. Army Corps of Engineers) in recommending mitigation practices and wetland design that can reliably produce benefits to living resources. Companies constructing wetlands also could benefit from more information. Current wetland creation efforts may be failing to produce habitats that function like natural wetlands in terms of supporting wildlife (Leschinsin et al. 1992). Therefore, planning, construction, and man-

agement practices associated with these sites need to be evaluated to understand better the effects on migratory birds and other wildlife.

Although emergent vegetation wetlands have predominated in mitigation projects, an increased emphasis has been placed on creating forested wetlands (Allen 1990, 1997; Perry et al. 1996). Forested wetlands have been created with the anticipation that they will become productive wetland areas; however, few have been studied to determine whether they are truly functioning wetlands (Hickman and Mosca 1991; Weller et al. 1991; Leschinsin et al. 1992). Created forested wetlands represent early successional stages that managers presume will become functional wetlands in time. To assess achievement of wildlife functions of a created wetland, the composition and relative abundance of wildlife using the site must be monitored.

Live trapping of wildlife has been used as a technique to determine the species composition of an area (Perry et al. 1997). Although numerous hours of trapping are usually necessary to obtain a full complement of species that occur on and use an area, common species can be easily captured and can be used to evaluate use of the area by wildlife (Buhlmann et al. 1992). However, lists of species and the number caught do not represent the complete wildlife component (Nichols and Conroy 1996) or an estimate of population size (Conroy 1996). The objective of this study was to compare the wildlife (i.e., amphibians, reptiles, birds, and mammals) using created forested wetlands with wildlife using reference forested wetlands in the Chesapeake Bay watershed.

STUDY AREA AND METHODS

Study Sites

Wildlife trapping and surveys were conducted on six study sites located in central Maryland (Fig. 1). All sites were constructed by contractors as mitigation projects for past wetland losses due to activities of the Maryland State Highway Administration (SHA), Baltimore Gas and Electric Company (BGE), and Prince George's County government. Sites constructed by SHA included BWI (near Baltimore Washington International Airport), R-1 (on Patuxent Research Refuge), Glazier (near Patuxent River and Maryland Route 214), and Sands Road (between Patuxent River and Sands Road). One site at Patuxent Research Refuge was constructed by BGE and also was called BGE in this study. Prince George's County government constructed the site at the National Wildlife Visitor Center (NWVC) located at Patuxent Research Refuge. All sites are within the Patuxent River watershed except BWI, which is within the Severn River watershed.

The study sites differed in size and in past vegetational cover. The NWVC and R-1 sites are the smallest, at 0.4 ha (1.0 acre) and 0.5 ha (1.3 acres), respectively, and both were originally grass meadows. Glazier is 3.1 ha (7.8 acres) and was originally a second-growth forest. BWI and Sands Road are 4.9 ha (12.2 acres) and 6.0 ha (15 acres), respectively, and were originally old gravel pits. BGE is 4.4 ha (11 acres) and was a previous military firing range used by the U.S. Army.

Two-year-old, balled-root, nursery stock woody transplants were planted at BWI, R-1, and Glazier in 1992 and at BGE and the NWVC in 1993. One-year-old, bare-root, nursery stock woody transplants were planted at Sands Road in the fall of 1993 and spring of 1994. Half of the transplants at Sands Road were planted within tree tubes.

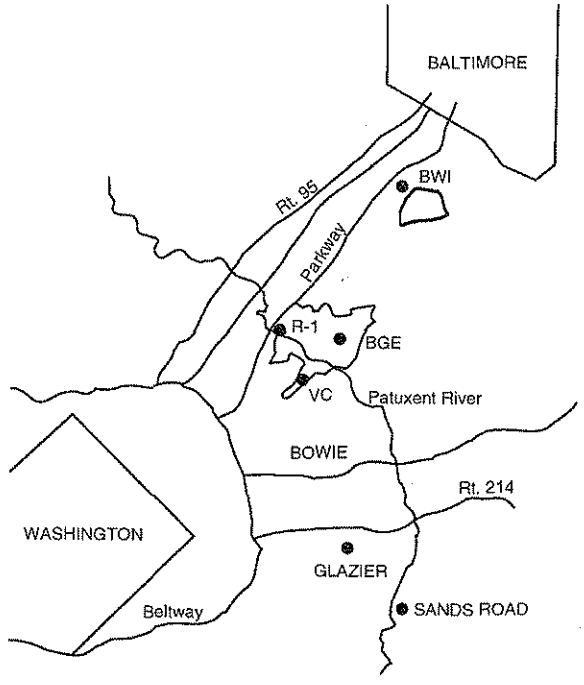

Figure 1. Location in central Maryland of six study sites.

Reference sites were established adjacent to each of the six wetlands to compare species richness for amphibians, reptiles, and mammals. The size of the area studied in the reference wetland was similar to that of the study area of the adjacent created site. Because of the more mobile nature of birds, only one reference area was established to survey birds. This site was located at Patuxent Research Refuge, which is approximately in the middle of the overall study area.

Techniques

Drift fences with pitfalls and funnel traps were monitored in 1995 and 1996 to determine species richness and relative abundance of amphibians and reptiles using the sites. A 15.4-m (50-ft) drift fence was established at each created site and in a forested wetland adjacent to the created sites. Four 18.9-l (5-gal) pitfall traps were established at each drift fence, one on each side at each end of the fence. One funnel trap was placed on each side and in the middle of each fence. Drift fences were located near existing open water on the created and reference sites to maximize the possibility of capturing amphibians. Traps were checked daily in the morning. All amphibians and reptiles captured in pitfall and funnel traps were identified and then released on site approximately 15.4-30.8 m (50-100 ft) from the drift fence. The entire array of four pitfall and two funnel traps was considered one "trap day" for amphibians and reptiles.

Surveys of birds in study sites were conducted approximately every 2 weeks during spring and fall migration and every 4 weeks during the remainder of the year. The observer walked through the entire area and recorded all birds seen or heard on the site. Birds seen or heard in surrounding habitat were also recorded to give a better representation of the birds using the whole area. Data were recorded separately as "on" or "off" the site. It is recognized, however, that this ecotone represents neither a mature nor an incipient forested wetland. In addition, one reference site in a forested wetland established at Patuxent Research Refuge was surveyed for birds approximately every 2-4 weeks.

Live trapping of mammals was conducted on created and reference sites to determine species composition and relative numbers. The same general area used for the drift fence trapping was used for the mammal trapping. Five Sherman live traps baited with peanut butter were used at each site to capture small mammals, and three box-type live traps (HAV-A-HART and Tomahawk) baited with canned cat food were used to capture medium-sized mammals. Cotton balls were placed in Sherman traps for insulation when ambient temperatures were near freezing. The pitfall traps used to capture amphibians were also useful to capture small mammals that are difficult to trap in Sherman traps, such as shrews (Buhlmann et al. 1992).

All traps were set on Monday and closed on Friday to obtain 4 days of trapping per month on each site. The traps were checked each day in the morning and mammals released on site after identification. Dead mammals (<5%) were removed from each site. A trap day for mammals represented one open trap for one day. Sprung or rolled traps were recorded as zero trap day. Trapping began in 1993 and continued irregularly until November 1996. Track counts (Perry and Giles 1970) were conducted to determine use of habitats by species difficult to capture.

RESULTS

Drift fence trapping for amphibians and reptiles was conducted for 390 trap days for both the created and reference sites. A total of 1,313 (336.7/100 trap days) amphibians were captured on the created sites and 1,912 (490.3/100 trap days) amphibians were captured on the reference sites during 1995-1996.

Thirteen species of amphibians were captured on the created sites and 17 species of amphibians on the reference sites (Table 1). The southern leopard frog was the most commonly captured amphibian on the created site, whereas the American toad was the most frequently captured amphibian on the reference wetlands. The red-backed salamander, four-toed salamander, eastern spadefoot, and wood frog were captured on the reference wetlands, but not on the created sites.

Seven species of reptiles were captured on the created forested wetlands and five species on the reference forested wetlands (Table 2). No species were caught in sufficient numbers to warrant comparisons between the two habitats.

A total of 440 bird surveys were conducted for the six created wetlands and 36 surveys for one reference wetland. Ninety-two species of birds were recorded on the created sites and 55 species on one reference wetland. Most species were recorded during the spring and fall (Table 3). As expected, there was a positive relationship

Table 1. Amphibians captured (number per 100 trap days) in pitfall and funnel traps at six created forested wetlands and six reference forested wetlands during 1995-1996 (390 trap days).

Species	Scientific name	Sites	
		Created	Reference
Salamanders			
marbled salamander	*Ambystoma opacum*	1.8	14.9
spotted salamander	*Ambystoma maculatum*	1.3	5.4
eastern newt	*Notophthalmus viridescens*	0.5	3.8
red-backed salamander	*Plethodon cinereus*	0.0	1.5
four-toed salamander	*Hemidactylium scutatum*	0.0	1.0
Total		3.6	26.6
Toads and Frogs			
eastern spadefoot	*Scaphiopus holbrooki*	0.0	7.9
American toad	*Bufo americanus*	73.3	230.3
Fowler's toad	*Bufo woodhousei*	14.6	19.0
northern cricket frog	*Acris crepitans*	19.7	11.5
spring peeper	*Hyla crucifer*	38.5	48.5
green treefrog	*Hyla cinerea*	0.3	0.3
gray treefrog	*Hyla versicolor*	12.8	4.9
bullfrog	*Rana catesbeiana*	10.3	4.6
green frog	*Rana clamitans*	73.1	69.7
wood frog	*Rana sylvatica*	0.0	7.4
southern leopard frog	*Rana sphenocephala*	81.3	54.4
pickerel frog	*Rana palustris*	9.2	5.1
Total		333.1	463.6

between the number of species and the size of the wetland. Sands Road, which was the largest area, had the highest number of species.

Eight species of birds were recorded on the created sites and 17 species of birds were recorded from the reference wetland at an average rate of at least one bird per survey day during at least one season between 1993 and 1996 (Table 4). There was no overlap of these species between the two sites. Red-winged blackbird was the most abundant species in the created sites and was recorded for every season. The American robin was the most abundant in the reference sites, but was only observed in spring and fall. Carolina chickadee and the tufted titmouse were the only species recorded in every season in the reference site at an average of one bird per visit per season.

Eighteen species of forest breeding birds were recorded in the reference site during the summer that were not recorded in the created sites. Eleven species were Neotropical migrants and included yellow-billed cuckoo (*Coccyzus americanus*), Acadian flycatcher, wood thrush (*Hylocichla mustelina*), red-eyed vireo, yellow-throated vireo (*Vireo flavifrons*), northern parula (*Parula americana*), American redstart (*Setophaga ruticilla*), ovenbird (*Seiurus aurocapillus*), hooded warbler (*Wilsonia citrina*), Kentucky warbler, and scarlet tanager (*Piranga olivacea*). Seven species of residents recorded in reference sites, but not in created sites included Carolina chickadee, tufted titmouse, white-breasted nuthatch (*Sitta carolinensis*), red-bellied woodpecker, pileated woodpecker (*Dryocopus pileatus*), downy woodpecker (*Picoides pubescens*), and hairy woodpecker (*Picoides villosus*). The sharp-shined hawk (*Accipiter striatus*) was the only species of forest-breeding birds recorded using the created wetlands during the summer.

The number of trap days used to capture small mammals with Sherman live traps was 1,543 on the created wetlands and 1,137 on the reference wetlands during 1993-1996. The meadow vole was the most fre-

Table 2. Reptiles captured (number per 100 trap days) in pitfall and funnel traps at six created forested wetlands and six adjacent reference forested wetlands during 1995-1996 (390 trap days).

Species	Scientific name	Sites	
		Created	Reference
stinkpot	*Sternotherus odoratus*	0.3	0.0
eastern mud turtle	*Kinosternon subrubrum*	0.5	0.3
eastern box turtle	*Terrapene carolina*	0.3	0.3
painted turtle	*Chrysemys picta*	0.3	0.0
five-lined skink	*Eumeces fasciatus*	0.0	0.3
black racer	*Coluber constrictor*	0.3	0.0
northern water snake	*Nerodia sipedon*	0.5	0.3
common garter snake	*Thamnophis sirtalis*	0.3	0.0
smooth earth snake	*Virginia valeriae*	0.0	0.5
Total		2.5	1.7

quently captured small mammal in the created sites, with an overall capture rate of 8.9 animals/100 trap days during the entire trapping period (Table 5). However, during November and December 1994, the trap rate was 61.4/100 trap days, which was the highest trapping rate for any mammal during the study. High numbers of voles were captured on all sites, but this species was most numerous on BWI, where the combination of dense redtop (*Agrostis alba*) vegetation and abundant seeds of Japanese millet (*Echinochloa crusgalli*) provided excellent cover and food.

The high vole populations were responsible for wildlife damage to tree transplants on several of the sites and may have been a major factor in the mortality of the woody plants. At BWI the population of meadow voles girdled 37% of the trees. Voles girdled all species except pond pines, the only conifer. Dense grass, which provided excellent cover and food, has been implicated in other studies as a factor leading to increased girdling (Tobin and Richmond 1993). Other wildlife damage on the created wetlands included browsing and antler rubbing by white-tailed deer (*Odocoileus virginianus*).

The white-footed mouse was the most frequently caught mammal in the reference forested wetland, whereas this species was captured only four times in the created forested wetland (Table 5). Trapping of medium-sized mammals indicated that there was much greater use of the natural forested sites by raccoons and opossums than on the created sites. As expected, the gray squirrel and eastern chipmunk were restricted to the

Table 3. Number of species of birds recorded on six created forested wetland sites and one reference forested wetland during different seasons, 1993-1996.

Site	Spring	Summer	Fall	Winter	Total
Created					
BGE	20	14	16	10	38
BWI	32	19	17	12	45
Glazier	27	12	13	5	36
R-1	11	4	11	7	22
Sands Road	59	33	56	24	82
Visitor Center	21	12	12	1	31
Total	71	41	65	31	92
Reference	43	26	35	23	55

Table 4. Results of avian surveys (average number of birds per visit) of six created forested wetland sites (data combined) and one reference natural forested wetland site, March 1994-February 1995.

Species[a]	Scientific name	Spring	Summer	Fall	Winter
Created Wetlands					
Canada goose	*Branta canadensis*	2.2	1.0		1.7
common grackle	*Quiscalus quiscula*	1.2		1.6	
European starling	*Sturnus vulgaris*			1.5	2.2
mallard	*Anas platyrhynchos*	2.6			1.6
red-winged blackbird	*Agelaius phoeniceus*	4.2	7.9	6.7	1.1
rock dove	*Columba livia*			1.0	
song sparrow	*Melospiza melodia*	1.4		1.7	2.7
swamp sparrow	*Melospiza georgiana*			1.5	
Reference Wetland					
Acadian flycatcher	*Empidonax virescens*		1.5		
American goldfinch	*Carduelis tristis*	2.4			
American robin	*Turdus migratorius*	2.7		30.4	
blue jay	*Cyanocitta cristata*	1.5			2.6
Carolina chickadee	*Poecile carolinensis*	1.5	1.7	1.6	1.9
Carolina wren	*Thryothorus ludovicianus*				1.4
cedar waxwing	*Bombycilla cedrorum*				4.2
common grackle	*Quiscalus quiscula*				1.4
Kentucky warbler	*Oporornis formosus*		1.0		
northern cardinal	*Cardinalis cardinalis*				1.0
northern flicker	*Colaptes auratus*	1.2			
red-bellied woodpecker	*Melanerpes carolinus*	1.0		1.3	
red-eyed vireo	*Vireo olivaceus*		1.5		
rusty blackbird	*Euphagus carolinus*	2.3			
tufted titmouse	*Baeolophus bicolor*	2.1	2.3	1.0	3.4
wood duck	*Aix sponsa*	1.4			
yellow-rumped warbler	*Dendrocia coronata*	1.6			

[a] Species represent those that were recorded an average of at least one bird per visit for at least one season.

natural forested sites.

Mammal species seen on the created sites but not captured included eastern cottontail (*Sylvilagus floridanus*), red fox (*Vulpes vulpes*), and white-tailed deer. Tracks of these species were also recorded with the sand plots established for track surveys.

CONCLUSIONS

The trapping and surveys conducted to document the species richness of vertebrates on created forested wetlands and reference forested wetlands indicated that the created sites were providing habitat for a large number of amphibians, reptiles, birds, and mammals. Overall, there were 121 wildlife species recorded on the created sites and 91 on the reference sites. There appeared to be major differences among some of the species of amphibians, birds, and mammals between the created and reference forested wetlands. The created forested wetlands are providing wildlife habitat based on the number of species recorded and the abundance of these species. Many of the species (especially birds), however, do not represent the species expected in a forested wetland. Data indicate that these sites are new habitats and do not represent the wildlife functions that were lost when the original wetlands were destroyed. It might take many years for these created wetlands to provide the more natural component of wildlife.

Species captured during this study that probably

Table 5. Mammals captured (animals per 100 trap days) on six created forested wetlands and six reference forested wetlands, 1993-1996 (n=total trap days).

Species	Scientific name	Sites: Created	Sites: Reference
Small mammals		n=1543	n=1137
masked shrew[a]	*Sorex cinereus*	3.0	3.0
short-tailed shrew	*Blarina brevicauda*	0.2	0.4
white-footed mouse	*Peromyscus leucopus*	0.3	22.3
meadow vole	*Microtus pennsylvanicus*	8.9	0.0
woodland vole	*Microtus pinetorum*	0.0	0.1
house mouse	*Mus musculus*	2.5	0.1
meadow jumping mouse[a]	*Zapus hudsonius*	0.3	0.3
Medium-sized mammals		n=1052	n=972
opossum	*Didelphis virginiana*	0.2	7.5
gray squirrel	*Sciurus carolinensis*	0.0	0.5
eastern chipmunk	*Tamias striatus*	0.0	0.1
woodchuck	*Marmota monax*	0.1	0.1
raccoon	*Procyon lotor*	1.1	8.0
striped skunk	*Mephitis mephitis*	0.0	0.1
gray fox	*Urocyon cinereoargenteus*	0.0	0.4
domestic dog	*Canis familiaris*	0.0	0.2
domestic cat	*Felis domesticus*	0.6	0.1

[a] Data based on pitfall trapping, 390 trap days for both created and reference wetlands.

should be used as an index of biological integrity are wood frogs, among the amphibians; any of the 18 species of forest-breeding birds; and the white-footed mouse, among the mammals. No reptiles were captured in sufficient numbers to determine which species could be used as an index of biological integrity.

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