Volume 38 Number 4 December 2002

COLONIZATION OF HERPETOFAUNA TO A CREATED WETLAND

T'Shaka A. Touré[1] *and George A. Middendorf*[2]

Abstract

The colonization by amphibians and reptiles of a newly created wetland was investigated at a site along Sands Road in Davidsonville, Anne Arundel County, MD. This 52-hectare artificial wetland was constructed in a gradient design that resulted in four distinct terraced sites that temporarily retain rainwater (Fig. 1). This palustrine wetland site, surrounded by an emergent, young, shrub-scrub, forested area, is characterized by the appearance of shallow temporarily flooded areas over a clay substrate that remains wet even during the driest periods of the year with a groundwater depth less than 1.5 m. The adjacent natural forest bordering the Patuxent River served as a natural indicator of amphibian and reptile activity and a source for site colonization. The created wetland site was monitored over two field seasons (March through September 1995-96) using linear transects, frog calls, drift fence arrays, pitfall and funnel traps, and dipnets. Sampling, conducted for 54 days revealed a total of twenty-eight species (16 amphibians and 12 reptiles). The colonization of this created wetland compared favorably in diversity to adjacent, natural forest. Factors best explaining differences in herpetofaunal activity, across the different sites within the created wetland, were density of vegetation surrounding the waterbody and hydroperiod.

Introduction

Amphibians and reptiles remain abundant in the deciduous forests of the eastern United States despite their worldwide decline due to habitat destruction, introduced predators and competitors, pesticide pollution, acid precipitation, and global climate change (Wake and Morowitz 1990; Wake 1991). Previous regional herpetofaunal surveys for Maryland and the District of Columbia region provide ample historic documentation of amphibian and reptile distribution within the DC metro region (Kelly *et al.* 1936; McCauley 1945, 1949; Mansueti 1949; Stine 1953a, 1953b, Cooper 1960; Harris 1966, 1969, 1975; Conant and Collins 1998). The 63 herpetofaunal species known for this region include 29 amphibians (14 salamanders and 15 frogs; Table 3) and 34 reptiles (6 lizards, 10 turtles, and 18 snakes; Table 4). Because many species found regionally are restricted to very particular and often localized conditions that are not evenly distributed (Conant and Collins 1998; Harris 1975), local diversity is often lower than regional diversity. In the nearby 200 ha Jug Bay Wetland Sanctuary (Lothian, Anne Arundel County, MD), Smithberger and Swarth (1993) documented 39 species of amphibians and reptiles in a six-year study.

In recent years, wetland creation has been frequently employed as a mitigation technique to offset natural wetland losses, particularly for losses from highway construction and other commercial and private development (Johnston 1994). A vegetative study conducted at the Sands Road site located in Anne Arundel County, MD (Perry *et al.* 1997) indicated that this mitigation effort provided many of the ecosystem functions of a natural forested wetland and suggested that, like a number of other studies (Johnston 1994; Semlitch and Brodie 1998; Semlitch 2000a, 2000b), created wetlands may be an effective way to deal with increasing developmental pressures. Yet, few examinations have been made to determine whether these constructed sites actually reproduce conditions that create functional habits for wildlife populations (Leschisin *et al.* 1992).

Methods

Sites - The created wetland was constructed as a series of terraces that allowed water flow from the highest terrace (Site D) across three earthen levees until finally discharging through the natural forest (NF) and into the Patuxent River. Each terrace differed slightly with respect to gradient (but averaged approximately 1.5 m drop per 100 m), in distance from the probable colonization source, and in emergent vegetation (Table 1; Fig. 1). To allow comparison of species activity and colonization patterns, study sites were located in each of the four terrace levels and in the adjacent natural forest (NF) adjacent to the river.

Presence – Species' presence was determined following standardized protocols (Heyer *et al.* 1994) that involved utilization of transects, drift fences, funnel and pitfall traps, dipnets and frog call surveys to maximize the probability of documenting species colonization and activity in the study area.

Linear transects – Diurnal visual surveys along 100-m linear [diagonal across site NE-SW direction] transects were conducted at a minimum of 4 times per month within each site. Vernal pools and microhabitats were sampled along the transect path (Scott 1994).

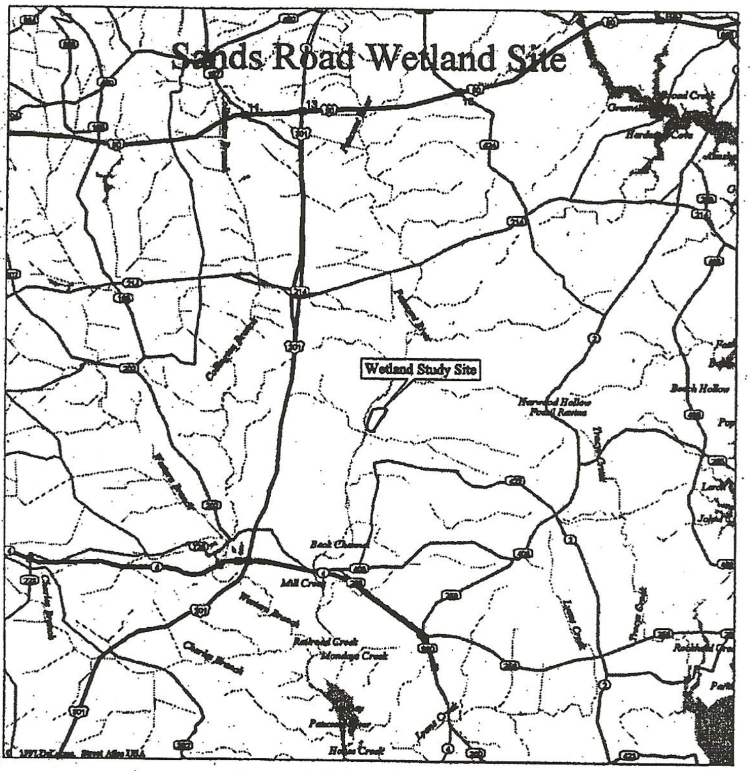

Figure 1. Sands Road Wetland Sanctuary, Anne Arundel County, Maryland

<u>Drift fences</u> – Drift fence arrays, located on berms bordering each terrace, allowed monitoring of movement. Drift fences (30 m) were constructed of aluminum flashing (Bury and Corn 1987; Corn 1994; Dodd and Scott 1994; Greenberg *et al.* 1994).

<u>Pitfall traps</u> – Twelve pitfall traps (5-gallon plastic white bucket), six on each side of the drift fence were set up in each site. There were 60 pitfall traps constructed for the overall study.

<u>Funnel traps</u> – Two double-ended funnel traps, one on each side of the drift fence, were established within each site in order to capture snakes (Fitch 1951; Clark 1966; Richter 1995).

Frog call surveys – Call surveys were conducted by recording anuran choruses for a minimum of two days per month. Surveys were taken primarily during nocturnal periods, although diurnal calls were recorded (Rand and Drewry 1994).

Dipnets – The capture of aquatic tadpoles and the observation of salamander larvae during the day were enhanced by the use of this technique. The use of dipnets allowed amphibians to be captured in waters with thick vegetation or debris (Wright and Wright 1949; Crisafulli 1997).

Each individual captured or seen was identified, and whenever possible, sexed and measured (snout to vent [SVL] to the nearest mm). Species identification was confirmed by using Green and Pauley (1987), Conant and Collins (1998) or through consultation with the curators and staff of the Smithsonian Institution's Division of Amphibians and Reptiles. For each individual, date, time, location within the site, vegetation in the immediate area, presence or absence of standing water, turbidity, air and water temperatures, other weather conditions, as well as any other unusual features were recorded (Heyer *et al.* 1994; McDiarmid 1994). Voucher specimens for each species were collected for each site. Following standard practice (Pisani 1977), most amphibian voucher specimens were immersed in a solution of chlorotone, while tadpoles were transferred directly to formalin. Other specimens were chilled, frozen, and thawed immediately after expiration. All specimens were tagged with USNM field tags, preserved in formalin (40% formaldehyde), and then transferred to ethyl alcohol (70%) (Pisani 1977), and deposited in the Smithsonian Institution, National Museum of Natural History, Division of Amphibians and Reptiles collection (USNM).

Table 1. Distance between natural forest (NF) and created wetland (A-D) sites.

Site	Distance from colonization source	Gradient
NF	0	1.5 meters
A	228	1.5 meters
B	321	1.5 meters
C	361	1.5 meters
D	373	1.5 meters

Table 2. Amphibian and reptile species richness, diversity index (Simpson's and shannon-Weiener), $H_{max,}$ and equitability by site.

AMPHIBIANS

	Species Richness	Simpson's	Shannon-Weiner	Hmax	Equitability	Total Captures
Natural Forest	16	0.83	2.95	3.91	0.75	443
Site A	14	0.71	2.25	3.7	0.61	580
Site B	13	0.77	2.3	3.58	0.64	287
Site C	12	0.65	1.74	3.46	0.5	357
Site D	13	0.83	2.71	3.58	0.75	176
Average of wetland sites	13	0.74	2.25	3.58	0.625	350
Standard deviation of wetland sites	0.816497	0.07746	0.397576	0.09798	0.102794	170.4836
Degrees of freedom=3						
Prob.>1	***0.034897**	0.329316	0.176517	***0.043474**	0.310932	0.623349

REPTILES

	Species Richness	Simpson's	Shannon-Weiner	Hmax	Equitability	Total Captures
Natural Forest	4	0.72	1.92	2	0.96	5
Site A	6	0.79	2.42	2.58	0.94	9
Site B	6	0.54	1.64	2.58	0.64	26
Site C	2	0.22	0.54	1	0.54	8
Site D	6	0.64	1.94	2.58	0.75	20
Average of wetland sites	5	0.5475	1.635	2.185	0.7175	15.75
Standard deviation of wetland sites	2	0.07746	0.797559	0.79	0.171343	8.732125
Degrees of freedom=3						
Prob.>1	0.651448	0.526292	0.744497	0.829919	0.25193	0.306003

Activity Patterns – To determine seasonal activity patterns each site was sampled a minimum of 4 days per month between March and September (Scott 1982; Mitchell *et al.* 1993; Scott 1994; Scott and Woodward 1994) for a total of 54 days (26 in 1995 and 28 in 1996).

Residency – Amphibian breeding site and habitats in the natural forest and the constructed wetland sites were monitored to establish whether a given species' presence was temporary or permanent, i.e. whether the species was represented by colonizing individuals or by individuals representing a fully reproductive and self-sustaining population (Campbell and Christman 1982).

Analysis – Means, standard deviations, Simpson's and Shannon-Weiner Diversity Indices, H_{max}, an Equitability Index, and basic statistics were calculated in Microsoft Excel 97 to examine site variation, including diversity (Krebs 1989; Stiling 1992; Hayek 1994). An *apriori* significance probability level of 0.05 was used for all statistical comparisons.

Results

In total, twenty-eight species of amphibians and reptiles were documented in the created wetland at the Sands Road Wetland Sanctuary. These observations include almost half of the species (63) known for the Washington, DC Metro region (Conant and Collins 1998).

While many amphibian species were found in all sites (Table 2), reptile species were neither widespread nor abundant (Table 4). This is somewhat expected because amphibians are more suited for wetland environments which this was. Particularly widespread (at all sites) and abundant (10 or more observations) amphibians included American toad (*Bufo americanus*), green frog (*Rana clamitans*), and southern leopard frog (*R. sphenocephala utricularia*). Species found at all sites — but with fewer than 10 observations in some sites — included cricket frog (*Acris crepitans*), Fowler's toad (*B. fowleri*), pickerel frog (*R. palustris*), spadefoot toad (*Scaphiopus holbrookii*), marbled salamander (*Ambystoma opacum*), and northern slimy salamander (*Plethodon glutinosus*) (Table 3). While no single species of reptile was found in all sites, painted turtle (*Chrysemys picta*) and eastern mud turtle (*Kinosternon subrubrum*) were encountered in four of the five sites (Table 4).

While all amphibians observed in the created wetland were documented in the natural forest, only 4 of the 12 expected reptiles were recorded (Tables 3 and 4). The natural forest with its vernal pools and adequate vegetative

Table 3. Number of amphibians captures or observed along the Patuxent River in the natural forest and four adjacent created wetland sites (1995/1996).

AMPHIBIANS

	Natural Forest	Site A	Site B	Site C	Site D	Wetland Average	Wetland std	P>t
Hyliidae								
Acris crepitans	12/0	10/2	27/8	0/2	9/0	14.5	14.29452	0.872301
Hyla chrysoscelis	1/7	0/0	0/0	0/2	1/0	0.75	0.957427	***0.004777**
Hyla cinerea	0/3	0/2	0/0	0/2	0/0	1	1.154701	0.181690
Pseudacris crucifer	3/0	7/0	7/0	0/0	5/0	4.75	3.304038	0.633044
Pseudacris triseriata	P	P	P	P	P	–	–	–
Bufonidae								
Bufo americanus	76/54	56/225	21/23	34/18	19/7	100.75	120.6576	0.824081
Bufo fowleri	6/2	0/83	0/10	3/63	0/10	42/25	37/88029	0.432556
Ranidae								
Rana catesbeiana	5/0	1/0	3/2	0/0	0/8	3/5	2/696846	0.712130
Rana clamitans	61/2	24/9	18/20	18/5	10/6	27.5	9.882645	***0.036966**
Rana palustris	2/3	3/2	5/2	1/1	8/0	5.5	2.645751	0.86216
Rana sphenocephala	57/24	15/82	33/85	6/101	8/43	93.25	29.44345	0.705343
Pelobatidae								
Scaphious holbrookii	0/57	0/28	1/2	0/77	2/35	36.25	30.7395	0.548027
Ambystomatidae								
Ambystoma opacum	43/2	17/6	3/7	18/4	3/1	14.75	9.287088	***0.047231**
Ambystoma maculatum	0/1	0/0	0/0	0/0	0/0	0	0	–
Plethodontidae								
Plethodon glutinosus	0/19	0/6	0/7	0/2	0/1	4	2.94392	***0.014615**
Salamandridae								
Notophthalamus viridescens	3/0	1/1	2/1	0/0	0/0	1.25	1.5	0.327652

P= species identified as present based on calling observations, but individuals were neither seen nor captured.

coverage provided particularly good habitat for amphibians and thus, probably served as the "source" site for amphibian colonization of the created wetland sites. Abundant species in the Natural Forest Site, e.g. American toad, green frog, southern leopard frog, spadefoot toad, marbled salamander, and northern slimy salamander, were also seen in all four created wetland sites. We note that the only spotted salamander (*Ambystoma maculatum)* captured during the two-year study was found only in the natural forest.

In Site A, which at 228 m was the closest created wetland site to the natural forest, we found 14 species of amphibians and 6 species of reptiles (Tables 3 and 4). With an abundance of amphibian species—only 2 from the natural forest site were absent — this site exhibited high amphibian richness and diversity (Table 1). In fact, the capture rate for amphibians in this site was greater than that for all other sites — including the natural forest. Three species, American toad, Fowler's toad, and southern leopard frog, were especially abundant. The numbers of reptile species were similarly high and are mirrored in both high richness and diversity values (Table 1). These high faunal diversities probably resulted from the fact that species could easily move the short distance from the adjacent natural forest, the source of colonization, and that the site retained water throughout the spring season, making it attractive for both breeding and feeding.

Site B, located 321 m from the natural forest, revealed 13 amphibians and 6 reptiles (Tables 3 and 4). A small pond located in this site provided a source of water during dry periods and was a focus of much herpetofauna activity (Table 3). This pond and its environs served as refugia for a number of species, e.g. painted turtle laid eggs in adjacent sandy areas, green frog and bullfrog (*Rana catesbeiana)* tadpoles were observed in the waters, and during the early spring, a southern leopard frog was observed emerging from hibernacula. Because it retained water longer than others during the summer season and provided adequate vegetative coverage, activity on this site was high and overall diversity was similar to that for Site A (Tables 1 and 2).

Site C, was 361 meters from the natural forest, and only 12 amphibian species and 2 reptile species were observed (Tables 3 and 4), resulting in the lowest richness and diversity among all sites (Tables 1). None-the-less, Site C must have contained some features not abundant in other sites as more spadefoot toads were observed here than for the other sites (Table 3). It is possible that the presence of breeding congregations of spadefoot toads resulted after heavy rains and by habitat features associated with the proximity of an old sand quarry.

Site D, the furthest of the sites, at 373 m, from the natural forest with 13 amphibian species and 6 reptile species (Tables 3 and 4), displayed moderate richness and diversity for amphibians and high richness and diversity for reptiles (Table 1). Although documented in all study sites, pickerel frog, which uses a variety of aquatic habitats (including bogs, seeps, grassy meadows, and the margins and banks of marshes, swamps, brooks, and streams), was more common here than in other sites. The diversity here may be the result of a small patchy shrub-scrub area that provided shade for reptiles during the

Table 4. Number of reptiles captures or observed along the Patuxent River in the natural forest and four adjacent created wetland sites (1995/1996).

REPTILES

	Natural Forest	Site A	Site B	Site C	Site D
Colubridae					
Carphophis amoenus	0/0	2/1	0/0	0/0	1/2
Nerodia sipedon	0/0	0/0	1/0	0/0	0/0
Virginia valeriae	0/0	2/0	0/0	0/0	0/0
Thamnophis sirtalis	0/0	1/0	1/0	0/0	1/0
Heterodon platirhinos	0/0	0/0	1/0	0/0	0/0
Scincidae					
Eumeces fasciatus	2/0	0/0	0/0	0/0	0/0
Teiidae					
Cnemidophorus sexlineatus	0/0	0/0	0/0	0/0	1/0
Chelydridae					
Chelydra serpentina	1/0	0/0	1/1	0/1	0/1
Chrysemys picta	0/0	0/1	14/6	0/7	4/7
Emydidae					
Terrepene carolina	0/0	1/0	0/0	0/0	0/0
Kinosternidae					
Kinosternon subrubrum	1/0	0/1	1/3	0/0	2/1
Sternotherus odoratus	1/0	0/0	0/0	0/0	0/0

day and was used by anurans for calling at all hours of the day and evening. As in Site B, nests and egg hatchlings of painted turtles were found. Despite the presence of shade and water, the lower richness and diversity, compared to Site B, may be due to the distance from the colonizing source.

While it might generally appear that the number of species captured and the species richness for each site was correlated with the distance from the colonization source, specific trends are confounded by variation in vegetation and the duration of standing water. Species richness and diversity were significantly different among the sites (t-test; *df* = 3; p = 0.03). Species richness of assemblages (H_{max}) was significantly more diverse in the natural forest than the created sites (t-test; *df* = 3; p = 0.04). For amphibians, Cope's gray tree frog (*Hyla chrysoscelis*), green frog, marbled salamander (*Ambystoma opacum*), and northern slimy salamander (*Plethodon glutinosus*) assemblages were significantly greater in the natural forest (t-test; *df* = 3; p = 0.004, 0.03, 0.04, 0.01). For reptiles, no significant differences were detected in richness or diversity between the natural forests and created wetland. During the two-year study average of total captures for reptiles (15.75) was much smaller than that seen for amphibians (350) (Table 2).

Conclusions

The creation of wetlands as a mitigation tool is increasingly important as wetlands have been shown to play a major role in reducing the likelihood of local extinction (Gibbs 1993) and may offset local extinction effects due to wetland loss, as well as increasing levels of fragmentation (Gibbs 1998). Examination and determination of critical features associated with successful mitigation via wetland creation is, thus, of great usefulness.

We note that one of the major goals in using created wetlands for mitigation purposes is the establishment of successfully reproducing populations. It is not enough that species migrate to and occupy a created site, they must also successfully reproduce. Herpetofaunal activity occurs within a variety of habitats and microhabitats that provide features essential for foraging, predator escape, thermoregulation, and reproduction. Successful reproduction may require features quite different than those associated with foraging, escape and thermoregulation, particularly for those species dependent upon vernal pools, ponds, and vegetative coverage. For instance, created wetlands that retain water in the spring but not into and through the summer and fall, may provide features adequate for breeding but not, ultimately, for successful reproduction. Clearly, wetlands able to provide features critical for reproduction are better suited for colonization and successful establishment of amphibian and reptile populations.

With its greater habitat diversity, vegetative coverage, and biomass, the natural forest provided source populations of amphibians and reptiles to the newly created and previously unoccupied areas. The high levels of amphibian diversity within a year following site creation is testament to the nearby location of a colonization source, the ability of these organisms to move distances, and to the attractiveness of the created habitat, particularly for the amphibians. The lower diversity of reptiles in both the natural forest and created wetlands may simply be due to their generally more secretive nature coupled with the difficulties of detecting them in mature forests (Gibbons and Coker 1978; Bennett *et al.* 1980).

The created wetland at Sands Road appears to have great potential as a suitable habitat for amphibians. The presence of amphibians and reptiles in all sites suggests that all sites provided microhabitats essential for successful foraging and predator escape. However, the results of the present study suggest that amphibians responded most positively, e.g. bred successfully, in sites where the hydroperiod was longest and where vegetative cover present. Resident species and reproductive success was documented during the second field season in sites B and D, the sites exhibiting the highest levels of diversity. The longer hydroperiods in both sites provided adequate habitat and sufficient time for successful breeding and reproduction to occur. The observation and capture of large bullfrog tadpoles in site B indicates year-round presence of water as the species can take two years to metamorph. Although not documented as successfully reproducing, the emergence of a southern leopard frog from its winter hibernacula during the second field season is a positive indication of features associated with habitat necessary for permanent residency.

Physical habitat characteristics important to colonization should be expected to change over time, leading to differential colonization and occupation patterns. Examples include distance from the source, amount and depth of standing water, water turbidity, and vegetation. As these change, so too will the herpetofaunal community (Burke and Gibbons 1995; Thomas and Barron 1995; Mitchell 1996; Gibbons *et al.* 1997). The appearance of northern slimy salamanders in the second year in all five sites is suggestive of habitat change as it was not seen in any of the sites in the first year. Another salamander, spotted salamander, may be of particular interest in designing and determining long-term habitat suitability of mitigated sites. Colonization by this salamander is constrained by particular habitat requirements such as mature forest, vernal pools and ponds and is probably not at all affected by an inability to travel long distances (Semlitch 1998).

A five-year survey at the nearby (8 km S of the Sands Road site), 200 ha Jug Bay Sanctuary (Smithberger and Swarth. 1993) revealed 39 species of amphibians and reptiles: 18 amphibians (11 anurans, 7 salamanders) and 21 reptiles (7 turtles, 3 lizards, 11 snakes). These numbers are only slightly greater than those documented during the two-year Sands Road study: 16 amphibians (12 anurans, 4 salamanders) and 12 reptiles (5 turtles, 2 lizards, 5 snakes). The higher richness in the Jug Bay Sanctuary is likely due to greater variation in habitat types that include freshwater tidal and non-tidal wetlands, upland hardwood forest and agricultural fields. The majority of amphibians and reptiles recorded at Jug Bay were found within both upland and non-tidal wetland areas, while all species recorded in Sands Road where in a palustrine habitat within a young forest.

By monitoring the seasonal activity and utilization of the created wetland, knowledge was gained on the essential factors to be considered when constructing suitable habitats for successful colonization and reproduction of amphibians, reptiles, and other wetland dependent species. Amphibians warn us about our environment and by studying their colonization to created habitats more information can be attained which may allow us to make intelligent recommendations on how to better preserve our natural environment and wildlife.

It will be interesting to observe changes in herpetofaunal diversity as the sites mature and the results of this study will provide baseline data for future studies within the Sands Road Wetland Sanctuary.

Acknowdlegments

We would like to give special thanks to Matthew Perry for project support, supplies, and encouragement. Steve Pugh's tireless efforts and assistance in putting in those drift fences. Steve Gotte and George Zug for their expertise and assistance in the field. Robert Hoffman, R. McDiarmid, and J. Mitchell for the never-ending support and encouragement. Robert Reynolds for review of the manuscript. We also thank the Washington Biologists' Field Club for its financial support.

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[1]*U. S. Geological Survey/Biological Resource Discipline, Western Ecological Research Center San Diego Station - Irvine Office, 2883 Irvine Blvd, Irvine, CA 92602*
[2] *Department of Biology, Howard University, Washington, DC 20059*

Received: 5 September 2002
Accepted: 28 October 2002

BULLETIN OF THE

US ISSN: 0025-4231

Maryland Herpetological Society

DEPARTMENT OF HERPETOLOGY

THE NATURAL HISTORY SOCIETY OF MARYLAND, INC.

MDHS....... A FOUNDER MEMBER OF THE EASTERN SEABOARD HERPETOLOGICAL LEAGUE

31 DECEMBER 2002

VOLUME 38 NUMBER 4

BULLETIN OF THE MARYLAND HERPETOLOGICAL SOCIETY

Volume 38 Number 4 December 2002

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BULLETIN OF THE

mdhs

Volume 38 Number 4 December 2002

The Maryland Herpetological Society
Department of Herpetology, Natural History Society of Maryland, Inc.

Library of Congress Catalog Card Number: 76-93458

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