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Natural History of Amphibians, Reptiles, and Small Mammals in a Degraded Environment in Southeastern Virginia

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INTRODUCTION

It is well known that urbanization, industrialization, and other forms of land disturbance cause population declines and local extirpations of many animals and plants. Habitat loss and degradation are primary causes of decline in amphibian and reptile populations and species (Alford & Richards, 1999; Gibbons et al., 2000) and alteration and decline of some mammal populations. The amphibian, reptile, and small mammal faunas of altered landscapes have not been well studied in southeastern Virginia. Most recent studies of these vertebrates in this region have been conducted in protected jurisdictions, such as the Great Dismal Swamp National Wildlife Refuge (Breidling et al., 1983; Rose et al., 1990; Mitchell et al., 2000), Back Bay National Wildlife Refuge (Pague & Mitchell, 1991; Mitchell & Pague, 1991), and Seashore State Park (Buhlmann et al., 1994). The few more widespread studies revealed that terrestrial vertebrate communities exist in habitat fragments and have fewer numbers of species compared to the protected areas (Erdle & Pagels, 1995; Mitchell et al., 1998). Evaluation of areas that have been used heavily for agricultural, commercial, and military purposes provide information on one end of the pristine to degraded landscape spectrum.

We recently had the opportunity to evaluate a highly degraded site in southeastern Virginia that has been designated a U.S. Environmental Protection Agency Superfund Site. Our objectives in this study were to (1) inventory the major terrestrial and aquatic habitats on the site for amphibians, reptiles, and small mammals, (2) determine whether any state and federal endangered and threatened species occur there, and (3) determine which species may be targeted in later

efforts for ecotoxicological evaluations.

MATERIALS AND METHODS

Study Site

The Former Nansemond Ordnance Depot (FNOD), located at the northeastern corner of Suffolk south of the James River (Fig. 1), was used by the U.S. Army and other branches of the United States military for deployment, storage, and refurbishing of explosives from World War I through the early 1960s when it was sold to state and private interests. Most of the area (394 ha) was cleared of natural vegetation and former agricultural lands, then developed with large open areas, storage buildings, and working areas, including landfills. Tidewater Community College Suffolk Branch, General Electric Company, Dominion Properties, Hampton Road Sanitation District, and the Virginia Department of Transportation currently operate facilities on the site. Interstate 664 fragments the FNOD site into eastern and western parcels. Areas not under current use have been allowed to proceed through vegetational succession; habitat types now occurring on the site are described below. The flora and fauna that occur in this area today represent populations that have grown from the small fragments that persisted throughout occupation or have colonized the area since its use by the military.

The type and extent of plant communities observed at the site were dictated largely by past human activity, topographic setting (in areas bordering the Nansemond and James rivers), and by tidal action and salinity. As noted previously, much of the site is in a developed state or has undergone significant alteration from past human activities associated with operations at the FNOD. Nine natural habitat types defined through field surveys and aerial photography occur at the site. These include the following, as well as a category for Developed Lands. We include the number of trap days (nights) for each trapping method used to quantify inventory effort. Sites are mapped in Fig. 1.

Upland Habitats

Early successional scrub/shrub and mixed woodland (ES) - Early successional scrub/shrub and mixed woodland typify areas of the site that received heavy and protracted disturbance from operations associated with the FNOD. Many of these areas supported buildings and were likely landscaped with grass and an occasional tree or clusters of trees. Today, these areas support a mosaic of open scrub/shrub communities, interspersed with relatively mature trees or clusters of trees. Characteristic species observed within this early successional community include black locust (*Robinia pseudoacacia*), tree-of-heaven (*Ailanthus altissima*), red cedar (*Juniperus virginianus*), mimosa (*Albizia julibrissin*), hackberry (*Celtis occidentalis*), multiflora rose (*Rosa multiflora*), privet (*Ligustrum* sp.), brambles (*Rubus* sp.), honeysuckle (*Lonicera japonica*) and English ivy (*Hedera helix*). Herbaceous components of this plant community included sericea (*Lespedeza cuneata*), cinquefoil (*Potentilla* sp.), yarrow (*Achillea millifolia*), orchard grass (*Dactylus glomerata*), fireweed (*Erechtites hieraciflolia*), wild carrot (*Daucus carota*), tall goldenrod (*Solidago altissima*), asters (*Aster* spp.), yellow wood sorrel (*Oxalis stricta*), chickweed (*Stellaria* spp.) and dog fennel (*Eupatorium capillifolium*). The scattered large trees were primarily loblolly pine (*Pinus taeda*), cherrybark oak (*Quercus falcata* var. *pagodifolia*), and sweetgum (*Liquidambar styraciflua*). Effort - 190 TN snap traps, 400 TN pitfalls. Sites 7, 9, 13, 14.

Evergreen (pine) dominated forest (PI) - Mature and medium-aged, evergreen dominated forests were observed on upland terraces of the FNOD. Although they have a mix of deciduous and evergreen species, these forests are characterized by a predominance of relatively even-aged loblolly pine in the overstory. Subcanopy trees include sweetgum, red cedar, black cherry (*Prunus serotina*), and American holly (*Ilex opaca*). Understory species include poison ivy (*Toxicodendron radicans*), honeysuckle, Virginia creeper (*Parthenocissus quinquefolia*), catbrier (*Smilax glauca*), yellow jasmine (*Gelsemium sempervirens*), sweet vernal grass (*Anthoxanthum odoratum*) and ebony spleenwort (*Asplenium platyneuron*). Effort - 170 TN snap traps, 400 TN pitfalls. Site 8.

Mixed hardwood and evergreen (pine) forest (HWP)– Mature and medium-aged, mixed forests were identified at the site primarily from side-slopes and ridges within the FNOD which had received the least disturbance from past human activity. These areas likely come closest to representing the original plant community composition present prior to development and operation of the FNOD. Characteristic tree species include cherrybark oak, loblolly pine, red maple (*Acer rubrum*), and sweetgum in the overstory, with southern red oak (*Quercus falcata*), sassafras (*Sassafras albidum*), black gum (*Nyssa sylvatica*), and flowering dogwood (*Cornus florida*) as understory trees. Predominant species of the shrub layer include horse sugar (*Symplocos tinctoria*), mountain laurel (*Kalmia latifolia*), red bay (*Persea borbonia*), wild muscadine (*Vitis rotundifolia*) , yellow jasmine, and Virginia

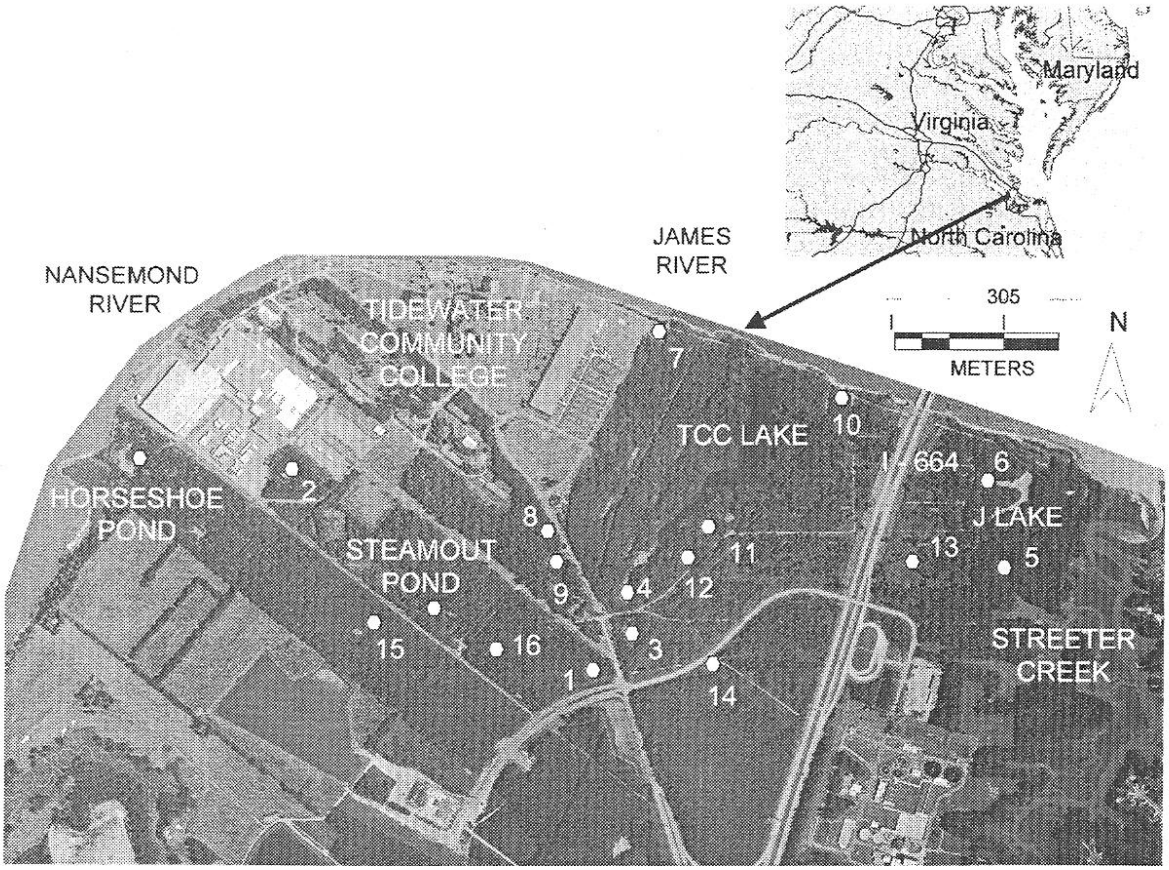

Fig. 1. Location of the FNOD study site in Suffolk, Virginia. Specific study sites are numbered or named.

creeper. Spotted wintergreen (*Chimaphila maculata*), Virginia grapefern (*Botrychium virginianum*), and Nepal microstegium (*Microstegium vimineum*) were noted species in the herbaceous layer. Effort – 517 TN snap traps, 400 TN pitfalls. Sites 5, 6, 10, 11, 12, 15, 16, Steamout Area.

Hardwood forest (HW) - The primary hardwood forest habitats on the FNOD site are along the TCC Lake and near the Horseshoe Pond. Characteristic tree species along the lake include cherrybark oak, red maple, southern red oak, and sweetgum in the overstory, with sassafras, black gum, loblolly pine, and flowering dogwood (*Cornus florida*) as understory trees. Hackberry and mulberry (*Morus* sp.) were the major tree species at the Horseshoe Pond with black walnut (*Juglans nigra*) and loblolly pine as minor components. Understory trees consisted of these four species. Vines were abundant and consisted of muscadine grape, slender woody vine (*Smilax rotundifolia*), honeysuckle, and trumpet creeper (*Campsis radicans*). The thick herbaceous cover was comprised of pokeweed (*Phytolacca americana*) and smartweed (*Polygonum pennsylvanicum*). Effort - 266 TN snap traps. Horseshoe Pond site.

Developed Lands (DEV) - This habitat type consisted mostly of occupied buildings, lawns, and parking lots associated with TCC, the commercial and state businesses on the site, and abandoned and now overgrown areas of the former depot. Effort - haphazard observations. Sites 7, 10, 11.

Wetland Habitats

Nontidal, palustrine forested, seasonally to semi-permanently saturated wetlands (FW) - Nontidal, palustrine forested wetlands were observed at scattered locations, generally associated with small, unnamed drainageways feeding one of the man-made ponds found within the FNOD. A relatively large area of palustrine forested wetlands occurs at the upper reaches

of the primary drainageway feeding TCC Lake. Characteristic tree species included cherrybark oak, American elm (*Ulmus americana*), red maple, and bald cypress (*Taxodium distichum*) in the overstory, with sweet bay (*Magnolia virginica*), green ash (*Fraxinus pennsylvanica*), alder (*Alnus serrulata*), high-bush blueberry (*Vaccinium corymbosum*), and water loosestrife (*Decodon verticillatus*) as understory trees and shrubs. Predominant species noted in the herbaceous layer included jewelweed (*Impatiens capensis*), lizard tail (*Saururus cernuus*), false nettle (*Boehmeria cylindrica*), shallow sedge (*Carex lurida*), royal fern (*Osmunda regalis*), New York fern (*Thelypteris novaboracensis*) and chain fern (*Woodwardia aereolata*). Effort - 67 minnow trap days. Sites 1 and 7.

Nontidal, seasonally to permanently flooded, freshwater ponds (PO) - A number of freshwater ponds occur throughout the site. The majority of these appear to be man-made (either through excavation or impoundment), although several near the southwestern boundary of the study area may occur in natural depressions. The largest is TCC Lake, which by historical accounts, was a tidally influenced tributary of the James River prior to construction of a causeway at its mouth. In general, the ponds are not vegetated, except for floating aquatic duckweeds (*Spirodella oligorhiza* and *Lemna* sp.) and eastern mosquito fern (*Azolla caroliniana*). Many of the ponds were observed to support small areas of wetlands. Predominant species noted from these wetlands included willow (*Salix* sp.), buttonbush (*Cephalanthus occidentalis*), smartweeds (*Polygonum hydropiperoides*, *P. pensylvanicum* and *P. lapathifolium*), rice cutgrass (*Leersia oryzoides*), soft rush (*Juncus effusus*), Virginia button-weed (*Diodia virginiana*), and blunt spikerush (*Eleocharis obtusa*). Effort - 319 minnow trap days. Sites 2, 3, 4, 5, 6, Horseshoe, Steamout.

Intertidal, estuarine emergent wetlands (brackish marsh) (EW) - Tidal wetlands were observed along the shores of the Nansemond and James rivers and in association with Streeter Creek. Although scattered throughout the shoreline of the FNOD, tidal wetlands were best developed along Streeter Creek and on an accreting bar at the western corner of the study area. These wetlands are strongly controlled by the tides and ocean-derived salts. They are dominated by emergents with a scattering of shrub species. Plant species noted from these brackish marshes included groundsel tree (*Baccharis halmifolia*), marsh elder (*Iva frutescens*), big cordgrass (*Spartina cynosuroides*), smooth cordgrass (*Spartina alternifolia*), saltmeadow hay (*Spartina patens*), salt grass (*Distichlis spicata*), glasswort (*Salicornia* sp.), seashore mallow (*Kosteletzkya virginica*), seaside goldenrod (*Solidago sempervirens*), sea lavender (*Limonium carolinianum*), saltmarsh bulrush (*Scirpus robustus*), and sea oxeye (*Borrichia frutescens*). Effort - haphazard observations.

Ephemeral pools (EP) - Shallow depressions, such as woodland vernal pools and road ruts, often hold water long enough for amphibians to breed, pass through the larval period, and reach metamorphosis. There were two vernal pools in the section south of the Steamout Pond Area that contained a diversity of amphibians and reptiles. The larger of these pools contained small sweetgum trees. No duckweed or emergent vegetation was observed in the vernal pools. Effort - 8 minnow trap days. Site 15.

Open water (OW) - Open water pertains primarily to the James River adjacent to the FNOD site on its north side and the Nansemond River on its west. These river areas were not surveyed, however, the species expected would be similar to those occupying Streeter Creek, a tidally influenced tributary of the James River. Effort - haphazard observations. The only site for this habitat was the river adjacent to site 10.

METHODS

We inventoried the FNOD site for amphibians, reptiles, and small mammals on five 2-3 day field trips during the period of 3 May through 16 August 2000. Trip dates were 3-4 and 18-19 May, 8-9 and 28-29 June, and 14-16 August. The site was also visited on 3 April 2001.

We used multiple inventory techniques to survey for these taxa in different aquatic and terrestrial habitat types on FNOD. To capture terrestrial vertebrates we installed 40 pitfall traps (1 gallon, 3.8 L, plastic pails) in early successional, pine plantation, and mixed pine and hardwood habitats. Pitfalls were arranged in a 40 x 100 meter grid with traps set 10 m apart from each other. These traps contained 3-5 inches (7.5-12.5 cm) of water and were covered with a section of roofing shingle when not in use. They were opened the day before we arrived on site and left open for two nights. Total number of pitfall trap nights during the course of the study was 400 for each habitat type (total = 1600). We also set standard small mammal (museum special) snap traps baited with peanut butter and oatmeal in several sites each visit, including the three sites containing pitfall traps. These were set for one trap night each on all but the last site visit when they were set the day before we arrived (2 nights). Total number

of snap trap nights was 1,252.

For aquatic vertebrates we set standard minnow traps in shallow portions of 11 wetland sites on FNOD. Each trap was set with the upper portion above water to avoid drowning air-breathing vertebrates such as frogs, snakes, and turtles. Each trap was checked and pulled the following day. Total number of trap days was 394. We also noted all species observed visually and frogs heard calling in and around each site during day and night visits to the wetlands. We recorded species observed with binoculars (turtles) and those we heard or saw while walking through various habitats and areas.

We surveyed for bats with mist nets on May 8 and August 15. Four mist nets (two=12x3 m, one=6x3 m, and one=9x3 m) were set near the upper end of the large Tidewater Community College pond on the first date and five (two=12x3 m, two=6x3 m, and one 3x6 m) were set in the western end of the Steamout Pond area on the edge of a field on the second date.

We recorded developmental stage of many tadpoles captured using the following stages, modified after Gosner (1960): tadpole with no limb buds to Gosner stage 25 (Stage I), limb buds present to Gosner stage 34 (Stage II), small rear legs present to Gosner stage 39 (Stage III), large rear legs to Gosner stage 41 (Stage IV), near metamorph with forelegs and most of tail present (Stage V), metamorph with short tail bud (Stage VI), and full metamorph without tail bud and with fully formed mouth (Stage VII). All measurements of snout-to-vent length were taken in mm with a plastic ruler. Turtles were measured with calipers. We obtained body masses with Pesola® scales. We also recorded abnormalities and injuries when present.

RESULTS

The number of species observed or captured on the FNOD site was a subset of those expected for the area based on distribution patterns and habitat availability. Of the 16 species of frogs expected for the site, eight were confirmed. No salamanders were found on the site despite the fact that as many as nine could have occurred there. Two of seven species of lizards were confirmed, as were four species of 19 possible snake species. We documented six of eleven species of turtles that were expected on the site or along the James River and its tributaries. We found no evidence of federally protected sea turtles in the area but they may occasionally become stranded on the beach along the James River. The diamond-backed terrapin (*Malaclemys terrapin*) is considered a Federal Species of Concern (U.S. Fish and Wildlife Service), although it has no legal protection. One shell was found on the beach at the beachfront landfill site. One subspecies of freshwater turtle, the red-eared slider (*Trachemys scripta elegans*), has been introduced into the region via the pet trade and is genetically swamping local populations of the yellow-bellied slider (*Trachemys scripta scripta*) in southeastern Virginia (Mitchell, 1994). However, no sliders were observed in any of the ponds.

Nineteen species of rodents and insectivores were expected for the area but only nine were confirmed. None is listed as endangered or threatened. One of the rodents was the introduced house mouse (*Mus musculus*). The white-footed mouse (*Peromyscus leucopus*) was the most abundant small mammal on the FNOD site. We captured one adult male and one female red bat (*Lasiurus borealis*) on May 8; no bats were captured in the Steamout Pond field, however, two bat calls were detected acoustically there using an ANABAT™ ultrasonic detector. The species were not determined.

Evaluation of the number of species by terrestrial habitat type (Table 1) reveals that the mixed hardwood and pine community supports the largest number of amphibian and reptile species on the FNOD site, whereas the early successional habitat supports the highest diversity of small mammals. The mixed forest is the most common vegetated habitat on the site and would be expected to support terrestrial stages of most frogs and nearly all of the terrestrial reptiles. Early successional habitats support the highest diversity of small mammals in the region due to the extensive grass cover and food supply for these grass and seed consumers.

Comparison of the amphibians and reptiles of the aquatic habitats on the FNOD site reveals that all these habitats support relatively high diversities of these animals (Table 1). This makes intuitive sense, as all the frogs breed in these habitats and most turtles inhabit them most of the time. These wetlands are obviously critical habitats for these vertebrates on the FNOD site. It should be noted, however, that all of the species that inhabit the wetlands also use terrestrial habitats extensively. This includes upland use during the non-breeding periods (frogs), dispersal from breeding sites (frogs, turtles), and egg laying in terrestrial sites by the aquatic turtles.

Annotated Species Accounts

Frogs

Bufo terrestris (2, 4, 7, 8, 12, 13, 14, 15, 16, Horseshoe, Steamout)

This species was encountered on each trip to the site.

Table 1. Relative abundance of amphibians, reptiles, and small mammals on the FNOD Superfund site, Suffolk, Virginia by habitat type. Habitat abbreviations: ES = early successional, PI = pine, HWP = mixed hardwoods and pine, HW = hardwoods, DEV = developed lands, FW = palustrine fresh water, PO = freshwater ponds, EW = estuarine emergent wetlands, EP = ephemeral pools, and OW = open water tidal. Abundance codes: U = uncommon (1-3 occurrences), C = common (4-9 occurrences), A = abundant (>9 occurrences).

Species	ES	PI	HWP	HW	DEV	FW	PO	EW	EP	OW
Frogs										
Bufo terrestris	U	U	U	U	C	A	C		A	
Gastrophryne carolinensis	U	U					C			
Hyla cinerea						A	A		A	
Pseudacris crucifer			C		U	C	A		A	
Rana catesbeiana		U	U	U		U	A		C	
Rana clamitans					U	U	A		C	
Rana sphenocephala	U	U	U		C	A	A		A	
Scaphiopus holbrookii		C								
Lizards										
Eumeces fasciatus		U	U							
Scincella lateralis			U							
Snakes										
Coluber constrictor			U							
Diadophis punctatus			U							
Nerodia sipedon					U	U	C			
Thamnophis sauritus							U			
Turtles										
Chrysemys picta						U	U		U	
Chelydra serpentina							C	U	U	U
Kinosternon subrubrum	U						U	U		
Malaclemys terrapin										U
Pseudemys rubriventris							C			
Terrapene carolina	U			C	U					
Small Mammals										
Blarina brevicauda	U	C		U						
Cryptotis parva	U									
Glaucomys volans			U							
Mus musculus	U									
Ochrotomys nuttalli	U									
Peromyscus leucopus	U		C	A	U					
Reithrodontomys humulis	U									
Sigmodon hispidus	U									

We found tadpoles on 4 and 18 May and 9 June (Table 2). The sample from site 7 collected on 4 May contained developmental stages II-V. Full metamorphs (stage VII, 9-13 mm SVL, 0.06-0.19 g, N = 39) were abundant around site 7 on 18 May. One was missing its left rear leg. The largest adult male measured 55 mm SVL and weighed 16 g and the largest adult female was 81 mm and 46 g. Four adults (1 female, 3 males) were found dead on 3 April 2001 at site 7. Each had been eviscerated by an unknown predator, who ate only the lower jaw, arms, and pectoral regions. The dorsum was avoided. Fresh egg masses were observed on this date at Site 7.

Gastrophryne carolinensis (2, 8, 13, Steamout)

Most of the individuals captured were found in pitfall traps in early successional and pine habitats. No males were heard calling. Tadpoles in stages III and IV were found in the Steamout Pond on 16 August. The largest female was 32 mm SVL and the largest male was 34 mm SVL.

Hyla cinerea (4, 7, 15, Horseshoe, Steamout)

Males were heard calling on 18 May and 8 June. Females with eggs were captured on 8 June. Adult males were 36-48 mm SVL and weighed 2.9-6.3 g (N = 29) and adult females were 39-50 mm SVL and weighed 3.8-7.6 g (N = 6). Tadpoles in modified Gosner stages III and IV were found on 29 June and 16 August in site 7. Tadpoles in stage I were found in the Steamout Pond on August 16.

Pseudacris crucifer crucifer (2, 3, 4, 7, 15, 16, Steamout)

A single tadpole was found in site 7 on 3 May. No males were heard calling in May but large choruses were heard in all of the noted wetlands on 3 April 2001.

Rana catesbeiana (1, 2, 3, 4, 6, 8, 12, 15, Horseshoe, Steamout)

Adults, juveniles, and tadpoles of this frog was observed commonly in several sites. Calls were heard on 3 May and 8 June. Tadpoles were found on all site visits. Series obtained from the J-pond on five occasions show changes in developmental stages over a 3.5 month period (Table 2). The sample from 16 August shows that tadpoles from a previous year's cohort (1998 or 1999) were proceeding through metamorphosis and that most tadpoles from the 2000 cohort had already developed limb buds. Tadpoles that were in stage V (metamorphs with tail present) were captured on 9 and 29 June and 16 August, indicating that metamorphosis of the putative 1998 or 1999 cohort largely occurred during July and August. The largest male measured 111 mm SVL and 119 g and the largest female was 142 mm SVL and 310 g.

Rana clamitans melanota (1, 2, 4, 6, 7, 15, Steamout)

This frog was heard calling on 18 May. Most observations were of juveniles. Only one adult was captured, a 68 mm SVL and 27 g male in the Steamout Pond.

Rana sphenocephala utricularia (2, 4, 6, 7, 8, 12, 13, 14, 15, Horseshoe, Steamout)

One male was heard calling on 8 June. Most

Table 2. Developmental chronology for tadpoles of three species of frogs at the FNOD site in Suffolk, Virginia. Stages I-VII are described in the text. N is sample size and numbers are percent of sample size. Site numbers refer to those in Fig. 1. H is the Horseshoe Pond site.

Species/ Date	Site	N	I	II	III	IV	V	VI	VII
Bufo terrestris									
4 May	7	37		18.9	81.8				
18 May	7	61		11.5	24.5			9.8	54.1
9 June	7	2			100.0				
Rana catesbeiana									
4 May	6	142		84.5	15.5				
19 May	6	64		67.2	29.7	3.1			
9 June	6	33		12.1	51.5	36.4			
29 June	6	65		12.3	26.2	41.5	20.0		
16 Aug.	6	98	3.1	39.8	3.1	35.7	18.4		
Rana sphenocephala									
4 May	7	338	0.5	55.3	42.9	1.2			
9 June	7	53		24.5	56.6	18.9			
19 June	7	10		60.0	20.0	10.0	10.0		
19 May	H	15		46.7	53.3				
9 June	H	70		37.1	40.0	22.9			
29 June	H	3		33.3	67.7				
9 June	2	33		33.3	48.4	18.2			
9 June	15	74		13.5	36.4	45.9	4.1		

observations were of tadpoles captured in minnow traps and juveniles captured in pitfall traps. Three juveniles were captured in small mammal snap traps, presumably when they tried to eat insects on the bait. Series of tadpoles from three ponds illustrate changes in development over a period of several weeks (Table 2). Juveniles were captured in pitfall traps in early successional, pine, and mixed hardwood and pine habitats. Metamorphs with tails (stage V) were found on 29 June. The largest individual measured was a female at 72 mm SVL and 31 g.

Scaphiopus holbrookii (8)

One adult and 7 juveniles were captured on 18 May and 9 and 28 June in the pine plantation.

Lizards

Eumeces inexpectatus (8, 15)

One juvenile was captured in the pine plantation and one was observed under a board in a grassy area under a power line.

Scincella lateralis (12, 16)

All three adult skinks were observed in the mixed hardwood and pine habitat.

Snakes

Coluber constrictor constrictor (11)

One adult female (930 mm, 295 g) was found crawling over a debris pile next to an abandoned building in mixed hardwood and pine habitat on 3 May. This snake was in the process of ecdysis.

Diadophis punctatus punctatus (10)

One adult non-gravid female (210 mm SVL, 3.4 g) with normal pattern was found under a piece of shingle next to an abandoned building in mixed hardwood and pine habitat on 3 May.

Nerodia sipedon sipedon (2, 7, Horseshoe)

Several adults were caught in minnow traps, all in May. The largest snake measured was a male at 835 mm SVL and 598 g.

Thamnophis sauritus sauritus (2)

One adult female (511 mm SVL, 59 g) was found along the grassy margin of a small, shallow pond on 18 May.

Turtles

Chrysemys picta picta (2, 15)

One juvenile was captured in a minnow trap in a small, isolated pond. An adult female (140 mm CL) was caught on 8 June about 20 m from a vernal pool, apparently returning from nesting as the posterior portion of her shell was covered with mud.

Chelydra serpentina serpentina (2, 6, 15, Horseshoe, James River)

An adult was observed basking on a log in a shallow pond on 3 May. Another was observed as it crawled from the beach into the James River on 18 May.

Kinosternon subrubrum subrubrum (2, 5, 7, 13)

Two juveniles were captured in minnow traps in a small pond on 19 May and 16 August. One emaciated adult male (102 mm CL, 158 g) was found in the floodplain of a small tributary leading to a small pond, and one adult was found in a pitfall trap in an early successional habitat.

Malaclemys terrapin terrapin (10)

The shell of a dead male (116 mm CL) was found on the bank of the James River on 18 May.

Pseudemys rubriventris (6)

Several adults were observed basking in a pond on 3 May. One road-killed adult male (239 mm PL) was found about 0.8 km south of the site on State Rt. 135.

Terrapene carolina carolina (6, 14, 15, 16, Horseshoe, Steamout)

Juveniles and adults were found in mixed hardwood and pine and hardwood forest habitats, all in June and August. Three individuals were found at the edges of ponds in August. One of these was found dead floating in the water. The largest was a male measuring 137 mm CL, 134 mm PL, and 476 g.

Mammals

Blarina brevicauda (8, 13, Horseshoe)

Most adults were captured on 19 May and 9 June in the pine plantation, one was caught on 9 June in mixed hardwoods, and one was in a pitfall trap in an early successional habitat on 15 August.

Cryptotis parva (14)

One least shrew was caught in a pitfall trap in an old-field habitat on 19 May.

Glaucomys volans (12)

One adult male was caught in a snap trap (later released unharmed) in the mixed hardwood and pine pitfall trap habitat on 4 May.

Lasiurus borealis (12)

One male (105 mm total length, 309 mm wingspan, 38 mm forearm length, 10 g) and one female (119 mm total length, 336 mm wingspan, 41 mm forearm length, 13 g) were captured on 18 May in mixed hardwood and pine habitat.

Mus musculus (7, 13)

One male was caught in a snap trap in the grass field around site 7 on 4 May. Another (male?) was caught in an old field on 19 May.

Peromyscus leucopus (3, 6, 13, 14, Horseshoe, Steamout)

This common species was captured in early successional, mixed hardwood and pine, and hardwood habitats.

Ochrotomys nuttalli (14)

One male was captured in a snap trap in an early successional site on 4 May.

Reithrodontomys humulis (14)

One female was captured in a snap trap in an early successional site on 4 May.

Sigmodon hispidus (13)

One individual was captured in a snap trap in an early successional on 19 May.

DISCUSSION AND CONCLUSIONS

The absence of herbaceous plants on the forest floor in the majority of sites we sampled suggests that the vegetation community on the FNOD site is substantially altered from that expected for natural communities in this area. Robust communities of understory herbs occur in natural habitats in surrounding areas. However, the lack of herbs on the FNOD site was pronounced and may have a negative impact on terrestrial vertebrates, especially small mammals that depend on herbaceous plant matter as a supplement to seasonally produced seeds and mast. Some invasive vines (e.g., Japanese honeysuckle) commonly use disturbed (open) areas, but are able to prosper in the low-light environment of the forest infrastructure (Carter et al., 1989). They were common on the forest floor of many of our study sites. Colonization of understory herbs in this area was hindered by the historical use of the FNOD site, the unusually high incidence of vines, and perhaps some other factor, such as contamination or the widespread presence of the human-derived gravel layer under the recently deposited topsoil. Other species that do well in disturbed habitats (e.g., mimosa, hackberry, poison ivy, multiflora rose) were commonly encountered on the FNOD site. Thus, our study encompassed habitats in a heavily disturbed landscape.

The amphibian and reptile faunas in the FNOD site consisted of common and widely distributed species that would be expected in ecologically altered landscapes. All of them are widespread in Virginia and eastern North America (Conant & Collins, 1998; Mitchell & Reay, 1999). American bullfrogs, northern green frogs, southern leopard frogs, and southern toads are well-known inhabitants of disturbed habitats in urban and suburban areas (Wright & Wright, 1949; JCM, pers. obs.). The presence of sandy soils in the pine plantation allowed the uncommonly discovered eastern spadefoots to persist in this area. Treefrogs are closely tied to ephemeral wetlands and require surrounding forested habitat to persist. They disperse widely (Dodd, 1996; Semlitsch, 1998) and may have colonized some areas of the FNOD site since military operations ceased. No terrestrial or aquatic salamanders

were found on this site, suggesting that they were extirpated and have not colonized the area since it was occupied by the military. The terrestrial lizards and snakes documented on the FNOD site are known to occur in urban and altered areas as long as there is food and shelter and have not been extirpated locally. The southern ring-necked snake is the only species we discovered that is closely tied to forested habitats (Mitchell, 1994), suggesting that some natural habitat remained on the FNOD site through is occupation. With the exception of the estuarine diamond-backed terrapin, all of the turtle species we encountered are found in other urban and disturbed habitats in Virginia (Mitchell, 1994). Thus, the herpetofauna of the FNOD site is similar to those in urbanized and other disturbed areas in southeastern Virginia.

The small mammal community also consists of widespread species known to use fragmented habitats in degraded landscapes. Small mammal species richness and diversity in early successional habitats were higher in the FNOD site compared to other habitats sampled because of microhabitat preferences. Species (excluding bats) fell into two categories, (1) early successional habitat specialists (least shrew, eastern harvest mouse, hispid cotton rat) (Dunaway, 1968; Pagels, 1977; Pagels et al., 1992), and (2) habitat generalists (white-footed mouse, northern short-tailed shrew, house mouse) (Miller & Getz, 1977; Dueser & Shugart, 1979; Adler, 1985; Pagels et al., 1992; Linzey, 1998). Two species, the golden mouse and southern flying squirrel, are nearly always encountered in forested habitats (Golley et al., 1965; Cothran et al., 1991; Linzey, 1998). All of the generalist species occur in early successional habitats, as well as in habitats dominated by hardwood forests.

No listed (state or federal) species were found during our inventory. Only the diamond-backed terrapin, considered a Federal Species of Concern (U.S. Fish and Wildlife Service), was discovered during this study.

Two food webs can be identified on the FNOD site, one in wetlands and one in terrestrial habitats. Interactions between the food webs and between food webs in different terrestrial habitats occur through movements of individuals and by eggs deposited on land by largely aquatic species (e.g., turtles). Identification of the components of these food webs would allow us to target those species most useful for ecotoxicological evaluations. The terrestrial vertebrate food web consists of adult and juvenile frogs, watersnake and black racer predators, and a variety of mammals and birds which prey upon the frogs and snakes. Several of these species would make excellent models for the uptake and movement of environmental contaminants in the FNOD site. The tadpole life history stage of frogs in this region are primary consumers in freshwater wetlands and may carry contaminants into terrestrial food webs following metamorphosis and dispersal. The only common to abundant mammal at this site that may be useful for evaluation of environmental contamination is the white-footed mouse. These mice eat vegetation and seeds that could transfer contaminants from contaminated soil.

Interstate 664 may fragment populations of these wetland and terrestrial vertebrates into two different communities. Few amphibians, reptiles, or small mammals are likely to move successfully across this heavily traveled road. Contaminated animals in these three vertebrate classes, if there are any, are not very likely to move from one side to the other. Thus, with the exception of birds of prey, crows, vultures, or some mid-sized mammals that feed on these smaller animals, the terrestrial vertebrate community food webs east and west of I-664 should be viewed as separate entities. Rates of movement of predatory or carrion-feeding species across the interstate should be taken into consideration in risk assessment models.

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