

Results of a Herpetofaunal Survey of the Radford Army Ammunition Plant in Southwestern Virginia

C. Shay Garriock¹

Virginia Department of Game and Inland Fisheries
2206 South Main Street, Suite C
Blacksburg, Virginia 24060

Rick Reynolds

Virginia Department of Game and Inland Fisheries
Wildlife Diversity Division
P.O. Box 996, 127 Lee Highway
Verona, Virginia 24482

ABSTRACT

A two-year inventory of reptiles and amphibians was conducted in 1997-1998 at the Radford Army Ammunition Plant in southwestern Virginia. Eight survey techniques (time-constrained surveys, drift fences, pitfall traps, call surveys, road surveys, dip nets, cover boards, and hoop and basking traps) were used. Results included sightings or captures of 531 frogs and toads (8 species), 467 salamanders (11 species), 30 turtles (4 species), 13 lizards (1 species), and 51 snakes (9 species). A new distribution record for *Pseudacris feriarum* in Pulaski County was noted and the first occurrence of albinism in the genus *Pseudotriton* was documented. Based on relative abundance estimates from time-constrained surveys and drift fence captures, average abundance and species richness was generally greater in wetland and riparian areas, moderate to high in deciduous woods and woodlots, and low in grasslands and pine plantations. Qualitative comparison of the different survey techniques suggests that time-constrained surveys and drift fences with funnel traps were the most effective techniques used in this survey.

Key words: reptile, amphibian, relative abundance, habitat, albinism, techniques, Virginia.

INTRODUCTION

Biological inventories document spatial distributions of individuals, populations, species, guilds, communities, and ecosystems (Kremen et al., 1993). They provide valuable information and form the basis for sound wildlife management practices. Kremen et al. (1993) described four uses of inventory data: (1) to select and design reserves; (2) to assess the potential for sustainable use of natural resources; (3) to strengthen the case for habitat conservation by documenting the distribution of threatened or endangered species; and (4) to provide the basis for selecting indicator species or assemblages for

ecological monitoring. In addition, inventories can provide baseline data from which the effects of management practices may be assessed, determining species-habitat associations and species assemblages.

Many land management agencies have been developing management plans with or without baseline wildlife inventories. The U.S. Forest Service is mandated to develop forest plans that guide their management activities over a period of 10 years. State wildlife agencies manage lands often for a single species or small group of species. Often these plans are developed with little baseline inventory data to either plan management activities or assess their implications, typically because of manpower or financial constraints.

Under the Sikes Act as amended by the Sikes Act Improvement Act of 1997, the U.S. Department of Defense (USDOD) is mandated to provide for the

¹Present address: The Catena Group, 410-B Millstone Drive, Hillsborough, North Carolina 27278

conservation and rehabilitation of natural resources on lands used for military mission activities. Integrated Natural Resources Management Plans (INRMPs) are the means by which the USDOD is fulfilling its mandate. To assist with preparation of INRMPs, the U.S. Army has guidelines that identify the need for "planning level surveys" that can make a significant contribution toward the understanding and management of existing resources. These surveys should minimally include flora, fauna, plant communities, and threatened and endangered species.

This report describes the results of a reptile and amphibian survey that was part of a complete zoological inventory conducted at Radford Army Ammunition Plant (RAAP) by the Virginia Department of Game and Inland Fisheries (VDGIF) in 1997 and 1998. The inventory was conducted to provide a zoological record of species present at RAAP, particularly those that are rare or protected, and to identify their distribution and habitat associations. The inventory has provided data on which to base, in part, an INRMP developed by RAAP (Chase, 1998). The primary objectives of the herpetological survey were to obtain species presence/absence data, as well as to describe the distribution and habitat associations of species within RAAP. In addition, natural history and baseline abundance data were collected, and we provide some brief discussion concerning the efficacy of each sampling technique applied in the survey.

STUDY AREA

Physical Characteristics

RAAP is located in Montgomery and Pulaski counties in southwestern Virginia and is divided into two separate parcels, the Main and the New River facilities. The Main Facility covers an area of 1,710 ha located approximately 5 km NNE of the City of Radford, Virginia. It is intersected by the New River, which forms the boundary between Montgomery and Pulaski counties. The New River Facility covers an area of approximately 1,560 ha. It is located 8.3 km SW of the Main Facility and ca. 2 km E of Dublin, Virginia and is entirely within Pulaski County. RAAP is a USDOD industrial complex operated by a private contractor, currently Alliant Techsystems, Inc.

RAAP lies within the New River Valley region of the Ridge and Valley physiographic province of Virginia. Elevation ranges from 519 to 625 m and is generally characterized as rolling to strongly rolling; sections of the New River through the Main Facility are bordered by nearly vertical limestone bluffs reaching

heights up to 100 m above the river. The New River Valley crosses the Ridge and Valley province approximately perpendicular to the regional strike of bedrock, mainly cutting Cambrian and Ordovician limestone or dolomite. Most of RAAP is underlain by the Elbrook Formation (Cambrian) except for a small area in the easternmost section of the Main Facility that is underlain by the McCrady/Price Formation (Mississippian) bedrock (Chase, 1998). Karst features such as springs and caverns occur throughout the Elbrook Formation at RAAP.

Biotic Communities

RAAP contains six natural plant communities. Upland Forests are hardwood-dominated communities with moisture gradients ranging from dry to mesic; Limestone Barrens are grass-dominated communities underlain by dolomitic limestone with thin, weathered soils and scattered bedrock exposures; Xeric Calcareous Cliffs occur on exposed limestone cliffs with steep south- and west-facing bluffs of the New River; Calcareous Fens are permanently to semi-permanently saturated soils fed by mineral-rich waters of relatively high pH; Piedmont/Mountain Bottomland Forests are hardwood-dominated systems that occur on stream and river floodplains, particularly of the New River and Stroubles Creek; Sand/Gravel/Mud Bar and Shore is open shoreline and bar habitat along the New River, primarily of course to fine-grained alluvium with small bedrock exposures. Four artificial communities were defined at RAAP: Grasslands are a combination of old fields (still open, but abandoned agricultural fields), meadows of forbs and warm and cool season grasses (mowed annually to semi-annually), and fields cultivated for wildlife cover and forage; Successional Woodland/Forest is an artificial successional community characterized by the presence of a few colonizing woody species and weedy herbaceous species; Pine Plantations are mature pine forests planted primarily for timber harvest, and are composed of loblolly (*Pinus taeda*), white (*P. strobus*), and shortleaf (*P. echinata*) pine; Wet Meadow/Marsh and Ponds are areas of saturated soil conditions supporting an array of herbaceous and emergent hydrophytic vegetation, most of which were created by drainage ditching practices or pond creation. Complete descriptions of these communities are provided in VDGIF (1999).

The New River at the Main Facility ranges from 75 to 300 m in width and is gradually sloping. Meanders are large and depths vary from a few centimeters at cross-sectional bedrock faults to several meters in pools; vegetated, rocky bars are common. Streams at the Main Facility are relatively stable systems with

adequate forest buffers, providing good riparian and wildlife aquatic habitat, while most stream sections of the New River facility have been impacted by past and ongoing agricultural practices, and in most cases do not support woody riparian vegetation. Natural wetlands occur at both facilities in the form of hillside seepages, stream floodplain wetlands, ponded sinkholes, and springheads. A small calcareous fen occurs at the New River Facility harboring several rare plants, and a few small, isolated depression wetlands occur on the New River terrace at the southeastern corner of the Main Facility. Although indicators (e.g., seasonally saturated soils and hydrophytic plant communities) suggest the New River terrace at RAAP may have historically supported palustrine wetlands, hydrology has been effectively removed through ditching practices. Drainage ditches within the terrace direct slow-moving water and most support cattail (*Typha latifolia*) as the dominant wetland plant species. At least 12 man-made lacustrine systems occur in the form of wastewater storage lagoons, stormwater retention ponds, and wildlife impoundments. Like the drainage ditches, most of the impoundments are eutrophic and support small adjacent marshes and shorelines dominated by cattails and rushes (*Juncus* spp.).

Land Use Practices

Land use at RAAP is comprised primarily of industrial areas, maintained grasslands and agricultural fields, mixed deciduous forest and woodland patches of various stand age, and pine plantations. While the core regions of both facilities support either industrial or cleared land, RAAP has maintained a forested buffer around most of the perimeter of each facility for noise buffering and aesthetics (Chase, 1998). The buffers contain several large, mature mixed-deciduous tracts, successional woodlands, and pine plantations. Pine plantations are located on areas of low to moderate relief (covering more than half of the New River bottomland) of both facilities, while the deciduous component occurs on steeper slopes or in areas with numerous sinks and depressions.

Present and historically-maintained agricultural grasslands comprise roughly 75% of the total RAAP area in the form of old fields, open meadows, hay fields, and cropland. Grassland areas are maintained primarily for safety and fire suppression reasons, and approximately 195 ha are leased to area farmers for hay production. VDGIF currently manages wildlife plantings in grassland areas for White-tailed Deer (*Odocoileus virginiana*), Wild Turkey (*Meleagris gallopavo*), and Northern Bobwhite (*Colinus virginianus*). Grasslands in production areas are mowed

frequently, although grasslands in storage areas are mowed only once or twice per year; and some wildlife plots are mowed only once every three to five years. Storage areas are almost entirely managed as grasslands and cover large areas: roughly 150 and 350 ha of contiguous area at the Main and New River facilities, respectively.

To our knowledge there have been no previous, extensive herpetological surveys at RAAP, although Richard Hoffman (pers. comm.) mentioned finding *Pseudotriton ruber* and other salamanders at springheads while collecting invertebrates on the base. There are, however, a few preserved specimens at the Main Facility's Maintenance Building (dates and collector[s] unknown), which include *Agkistrodon contortrix*, *Lampropeltis triangulum*, and *Coluber constrictor*. In addition, remains of *Terrapene carolina*, *Chrysemys picta*, *Pseudemys concinna*, and *Sternotherus odoratus* were unearthed at archeological sites at the Main Facility (Barber & Tolly, 2002), and thus occurred there historically.

MATERIALS AND METHODS

Survey sites were selected based on plant community/habitat type representation and accessibility. When feasible, data gathered for each specimen collected or observed included age, sex, and snout-vent length (SVL) or carapace length (CL). Calipers were used for all measurements less than 18 cm. Individuals captured using trapping techniques were marked to avoid double counting: snakes were marked by notching ventral scales with a "V" midway along the body length each time an individual was captured, with subsequent notches placed on the next most posterior scale; turtles were marked using a numbering scheme (by filing notches in marginal scutes of the carapace) as described by Dodd (2001); and amphibians by clipping the outer-most toe of the right anterior limb, with subsequent captures clipping the next anterior-most toe. Individuals were not marked or measured during time-constrained surveys if capture was unnecessary for identification purposes. Additional data collected at each site included site designation, habitat type, date, time, and general weather conditions.

Eight sampling techniques (time-constrained surveys, drift fences, pitfall traps, call surveys, road surveys, dip nets, cover boards, and hoop and basking traps) were used to sample the herpetofauna at RAAP. Detailed information concerning sample locations is provided in VDGIF (1999). A description of each sampling technique follows.

Time-constrained Survey: Time-constrained surveys were conducted by visually searching prime

microhabitat sites ($n = 36$) within general habitat types, and documenting the time (min) spent searching each area (Bury & Raphael, 1983). Surveys were usually conducted during the day and predominantly in terrestrial habitats, although searches in aquatic/riparian zones of streams and the New River were also included in this technique. Relative abundance (Captures per Unit Effort [CPUE]) was determined for each survey site by dividing the total number of captures and/or observations by the total time spent conducting searches. To curtail repeat counting of individuals at sites that were visited more than once, only the session with the highest number observed of a given species was used in abundance estimations. Because larval amphibians tend to be concentrated in riparian areas and could bias results (Welch, 1987), aquatic larvae were excluded from abundance estimates.

Drift Fence Survey: Drift fences with pitfall and funnel traps ($n = 11$) were constructed using siltation fencing. In terrestrial habitats, Y-shaped arrays were constructed in a fashion similar to that used by Jones (1981). For ponds, three separate fence segments were evenly spaced around the pond perimeter and within 5 m of the water's edge; pitfall traps were placed at both ends of each fence segment. Fence segments were approximately 0.6 m tall and 9 m long for both array types. Nineteen-l buckets were used as pitfall traps; however, occasionally rocky substrate required the use of 9.5-l buckets. Holes were made in the bottom of each bucket to allow for drainage and funnel inserts constructed from galvanized tin were placed in pitfall openings. To prevent rainwater collection and to deter predators, bucket lids were propped with metal stakes approximately 10 cm directly above pitfall openings. Funnel traps were constructed from window screen material as described by Campbell & Christman (1982), measuring 76 cm in length and 20 cm in diameter. These were placed mid-way along both sides of each fence segment and held in place with pliable metal stakes. Generally, drift fence arrays were left open from late winter to mid-summer and then again in the Fall. Arrays were checked daily when first opened and every 2-3 days thereafter. Funnel traps were inverted and covers were placed over all pitfalls during periods of non-use. Relative abundance (CPUE) was determined for each array by dividing the total number of captures by the total number of array-nights (Heyer et al., 1994).

Pitfall Trap Survey: Pitfall traps were constructed by removing the top one-fourth of a 2-l soda bottle and burying the opening flush with the ground. These were arranged in arrays of 8, with two rows of four; spacing between pitfalls was approximately 10 m. Each pitfall was located adjacent to a log or fallen tree that could

act as a suitable drift fence. Pitfalls were filled with 10% formalin to approximately 10 cm below the opening and were checked once every 2-3 weeks.

Anuran Call Survey: Anuran call surveys were conducted at wetlands and open-water ponds during rainy nights when the ambient temperature was above 10°C. Surveys were conducted by recording the species and number of individuals calling (if possible) during a 10 min period. Incidences when many individuals of the same species were calling simultaneously were recorded as choruses. We also documented anuran calls heard incidentally throughout the field season.

Nighttime Road Survey: Road surveys were performed by driving roads within the facilities during rainy nights when the temperature was above 10°C, often in conjunction with anuran call surveys. This was accomplished by driving slowly with the headlights and a spotlight directed on the road center just ahead of the vehicle. A specific route was not established for this technique, but was directed selectively along roadways near wetlands and ponds.

Cover Board Survey: Cover boards were constructed from 5-V galvanized tin roofing and measured 60 x 100 cm. Cover boards were laid in arrays of 10 within a specific habitat type. Arrays were configured in one or two rows with cover-boards placed approximately 5 m apart. One array was placed in each of six habitat types (deciduous woods, pine plantation, grassland, limestone cliff, calcareous fen, and wetland marsh). Three arrays were relocated during the second year of the study. Arrays were checked weekly.

Dip Net Survey: Dip netting was performed in palustrine habitats by extending a D-frame dip net approximately 2 m out from the water's edge and drawing the net inward to the shoreline along the bottom. This was performed repeatedly around the entire perimeter of the wetland while documenting the number of sweeps. Larvae of each species were counted and placed in a bucket, then released after completion of sampling. Species that could not be readily identified were kept in captivity until metamorphosis.

Hoop and Basking Trap Survey: To capture aquatic turtles, unbaited hoop traps and a basking trap were used on a limited basis in the New River. Hoop traps were installed by attaching the hoop apparatus to the shoreline and extending the driftnet downstream at a 30° angle to the shoreline. A basking trap was constructed by attaching a submerged chicken wire cage (120 x 60 x 60 cm) to a known basking log with the opening flush with the water surface.

Voucher specimens obtained during this study have been deposited in the collection of the Virginia Museum of Natural History in Martinsville.

RESULTS AND DISCUSSION

Trap Success by Survey Technique

Adults and subadults of 531 frogs and toads (8 species), 467 salamanders (11 species), 30 turtles (4 species), 13 lizards (1 species), and 51 snakes (9 species) were detected at RAAP (Table 1). Two species, *Agkistrodon contortrix* and *Rana palustris*, were not detected using any of the applied survey techniques, but were found incidentally. A new distribution record for *Pseudacris feriarum* in Pulaski County was noted and the first occurrence of albinism in the genus *Pseudotriton* was documented (Garriock, 2000). No federal or state-listed reptile or amphibian species were found during the survey (Mitchell, 1991; Roble, 2001). A summary of observations and captures by survey technique is provided in Table 1.

Time-Constrained Surveys – Time-constrained surveys were conducted at 36 sites in differing habitat types described as deciduous woods and woodlots (n = 7), grasslands, old fields, and maintained fields (n = 8), pine plantations (n = 4), sun-exposed limestone talus (n = 3), vegetated wetlands (n = 3), and intermittent to perennial streams (n = 11). A total of 52 survey-hr resulted in the capture or observation of 207 individuals of 28 species (15 amphibians and 13 reptiles) (Table 1). Survey sites were visited from 1-8 times, but most often twice, during both years combined. Of the specimens collected or observed, 13% were anurans, 59% were salamanders, 8% were turtles, 14 % were snakes, and 6% were *Sceloporus undulatus*, the only lizard species detected. Time-constrained surveys were the best technique for finding each taxonomic group except anurans (specifically *Pseudacris crucifer* and *P. feriarum*). Copperheads were not found during our searches, although they were rumored to be common in some areas of the base, suggesting that other less common snakes such as *Heterodon platirhinos* and *Ophedrys aestivus* may have been missed during our searches. Detection of new species leveled off after 39 h of cumulative survey time (Fig. 1), and discovery of new species would have required a great deal of additional searching. Time-constrained surveys resulted in the highest number of species detected (82% of all amphibian and reptile species detected at RAAP), including five species that were not found using other survey techniques. Our results concur with other studies suggesting that this is the most effective survey technique for determining species richness and relative abundance of terrestrial herpetofauna (Bury & Raphael, 1983; Welch, 1987).

Drift Fence Surveys – Eleven arrays were established within the following habitat types:

deciduous woods and woodlots (n = 4), grasslands (n = 2), pine plantations (n = 2), and ephemeral and permanent ponds (n = 3). Arrays were opened for a total of 751 trap nights and resulted in the capture of 725 individuals of 14 amphibian and five reptile species (57.6% of all species detected at RAAP) (Table 1). Of the species captured using this technique, 57.4% were anurans, 40.4% salamanders, 0.8% turtles, and 1.4 % snakes. All species detected by drift fence arrays were also detected using other techniques. The percentage of recaptures was much lower than expected (only 1.7% of all captures in 1998). Funnel traps accounted for 10% of all array captures, and only two species, *Coluber constrictor* and *Elaphe alleghaniensis*, were captured in funnel traps but not pitfalls. Lower capture rates for funnel traps compared to pitfalls has been documented (Bury & Corn, 1987; Greenberg et al., 1994) along with their effectiveness for capturing snakes (Bury & Corn, 1987; Fitch, 1992). Effectiveness of funnel traps is also known to vary among habitat types and herpetofaunal community composition (Greenberg et al., 1994) (e.g., drift fences around a known anuran breeding pond only detected one individual each of *Hyla versicolor* and *P. feriarum*, presumably because these species were able to climb the fences). However, this was the most effective technique (compared to time-constrained surveys and dip netting) for comprehensive sampling of confined aquatic areas. Installation of each drift fence array was labor intensive and required 2-3 man-hours for proper installation, and subsequent checking and maintenance of each array required much additional time. However, drift fence arrays resulted in nearly twice the number of captures as all other techniques combined. This, coupled with very effective capture of small mammals and terrestrial invertebrates, and as a reliable means of determining relative abundance, made this technique worthwhile.

Pitfall Trap Surveys – Pitfall arrays were established within deciduous woods and woodlot (n = 3), grassland (n = 1), pine plantation (n = 1), and old field (n = 1) habitat types. This was the only survey technique applied in the bottomland hardwoods plant community due to poor accessibility of areas outside the Main Facility perimeter fence. Pitfall traps were open from early April 1998 to early November 1998 and resulted in the capture of 42 specimens of nine species (one snake, one turtle, two anurans, and five salamanders) (Table 1). Seventy-four percent of all captures were salamanders collected in deciduous woods and riparian habitats, while anurans and reptiles represented 19% and 7%, respectively. No species was detected exclusive of other techniques. Installation of the pitfall traps was rapid and simple, and the arrays required little maintenance beyond having to periodically replenish

Table 1. Number of reptiles and amphibians counted and number of species detected for each survey technique (1997 and 1998 combined).

Species	Survey Technique ¹										Total No. Individuals
	DF(PF)	DF(FT)	KT	TC ²	RC	CB	AC ³	DN ³	HT	BT	
<i>Bufo americanus</i>	71	9	2	3	56		*				141
<i>Hyla versicolor</i>	1			3	1		*				5
<i>Pseudacris crucifer</i>	80	12			15		*				107
<i>Pseudacris feriarum</i>	1	1			3		*	*			5
<i>Rana catesbeiana</i>	6	5		12			*	*			23
<i>Rana clamitans</i>				8	2		*	*			10
<i>Rana sylvatica</i>	230		6	1	3		*	*			240
<i>Ambystoma jeffersonianum</i>	56	2		2	4			*			64
<i>Ambystoma maculatum</i>	3				13			*			16
<i>Desmognathus fuscus</i>	3		2	29	1						35
<i>Desmognathus quadramaculatus</i>				11							11
<i>Eurycea cirrigera</i>	22	5	10	22		1					60
<i>Eurycea longicauda</i>	3	4		9							16
<i>Notophthalmus viridescens</i>	3			2				*			5
<i>Plethodon cinereus</i>	132	9	12	21							174
<i>Plethodon glutinosus</i>			2	7							9
<i>Plethodon wehrlei</i>	38	13	5	12		1					69
<i>Pseudotriton ruber</i>				8							8
<i>Chelydra serpentina</i>	1			3					4		8
<i>Chrysemys picta</i>				9							9
<i>Pseudemys concinna</i>				2						2	4
<i>Terrapene carolina</i>	1	4	2	2							9
<i>Sceloporus undulatus</i>				13							13
<i>Carphophis amoenus</i>			1	1							2
<i>Coluber constrictor</i>		1		2							3
<i>Diadophis punctatus</i>				2		2					4
<i>Elaphe alleghaniensis</i>		1		5							6
<i>Lampropeltis triangulum</i>				3		1					4
<i>Nerodia sipedon</i>				5		3					8
<i>Regina septemvittata</i>				4							4
<i>Thamnophis sirtalis</i>	3	5		6		6					20
Total No. Individuals	654	71	42	207	98	14	--	--	4	2	1092
Total No. Species	17	13	9	28	9	6	7	7	1	1	31
	19										

¹ DF(PF) = drift fence pitfall; DF(FT) = drift fence funnel trap; KT = formalin pitfall; TC = time-constrained survey; RC = road cruising; CB = coverboard; AC = anuran call survey; DN = dip net; HT = hoop trap; BT = basking trap

² Does not include larvae; no species were detected as larvae that were not detected as adults

³ Presence/absence provided for anuran call and dipnet surveys; presence represented by an asterisk

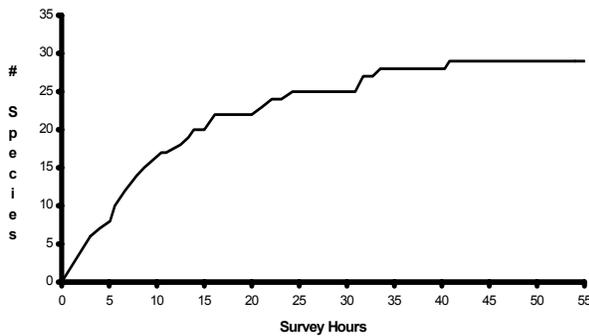


Fig. 1. Species accumulation curve for time-constrained surveys in 1997 and 1998 at RAAP.

the formalin. There are drawbacks to use of formalin worth mentioning: first, on occasion the pitfall concentration was diluted during heavy rain or flooding events and had to be replaced prematurely; secondly, the chemical can be expensive and difficult to obtain; and last, skin exposure is considered by some to be a health risk. Generally speaking, this method was relatively ineffective at sampling the herpetofauna when compared to drift fence arrays. Bury & Corn (1987) also found low capture rates in their evaluation of pitfall-only designs. Pitfall trap surveys were useful for sampling restricted areas where it would have been impractical to check live traps on a daily basis. Pitfalls were also productive at sampling small mammals and invertebrates, but less so than drift fence arrays.

Anuran Call Surveys - Anuran call surveys were conducted on nine separate nights at 11 different sites between April 1997 and September 1998. Each site was surveyed an average of two times. A total of seven anuran species was detected at both facilities combined, representing all but one of the species documented at RAAP (Table 1; *Rana palustris* was heard calling incidentally). Only three species were heard in large choruses (*P. crucifer*, *P. feriarum*, and *H. versicolor*), while the remaining species were heard in groups of less than 10 individuals. The most abundant species based on call surveys were *P. crucifer*, *P. feriarum*, and *H. versicolor*, followed by *Bufo americanus* and three ranid species. However, *B. americanus* adults were the most frequently encountered anurans during road cruising surveys and the second-most captured anurans in drift fence surveys (Table 1). Not only did anuran call surveys detect species that were missed by other sampling methods, but this was the only technique that provided wide-ranging distribution data for each species because most wetlands throughout a large area could be surveyed in one night. Notably, when coupled with incidental call observations, call surveys provided

valuable information on the time and duration of calling periods for many species (Fig. 2).

Nighttime Road Surveys - Road surveys were conducted at both facilities on six separate occasions resulting in the detection of 98 individuals representing six anuran (81.6% of captures) and three salamander species (18.4% of captures) (Table 1). No reptiles were encountered during these surveys. A total of 176 km was traveled including road sections traveled repeatedly during the same session. This was the only technique to detect *Rana sylvatica* at the New River Facility (the breeding site was later determined to be a well-hidden vernal pond). Road cruising provided valuable insight to the location of unknown amphibian breeding sites and the technique was effective at collecting large numbers of some species (notably *B. americanus* and *Ambystoma maculatum*).

Cover Boards - Cover board arrays (n = 6) were placed in nine different sites and checked from June 1997 to November 1998. A total of 14 individuals of four snake and two salamander species was detected (Table 1). Snakes comprised 90% of all captures with five individuals being recaptured one or more times. All species detected using cover boards were also detected using other survey techniques. Cover board arrays were ineffective at detecting reptiles for most of the year: 90% of all captures took place in May and June 1998. No captures were made in 1997 and, consequently, three of the arrays were relocated during the winter. Almost all of the collections were made in either pine-grassland edge (*Thamnophis sirtalis* captured exclusively) or wetland marsh, whereas no species was detected in arrays placed in deciduous woods, the calcareous fen, or pine plantation interior. Cover boards were effective for collecting snakes and increased the total number collected by roughly 40% more than that of time-constrained surveys and drift fence/funnel trap arrays combined. However, considering the cost and time involvement in constructing the cover boards, and the numerous times arrays were checked without results, this technique was somewhat unsuccessful. Contrary to our results, Fitch (1992) found the use of cover boards (corrugated metal or wood) to be more successful than funnel traps or random encounters, with cover boards accounting for 68% of total captures and five species (31%) captured exclusively. However, unlike our survey, his study employed 300 cover boards with 25 to 100 per array, and specifically targeted snakes. Based on the results obtained during our survey and observations by Fitch (1992), we suggest using this technique in the situations (1) when time-constrained surveys are limited or absent, (2) with a large number of cover boards and in large arrays, and (3) with monitoring being concentrated during the vernal period

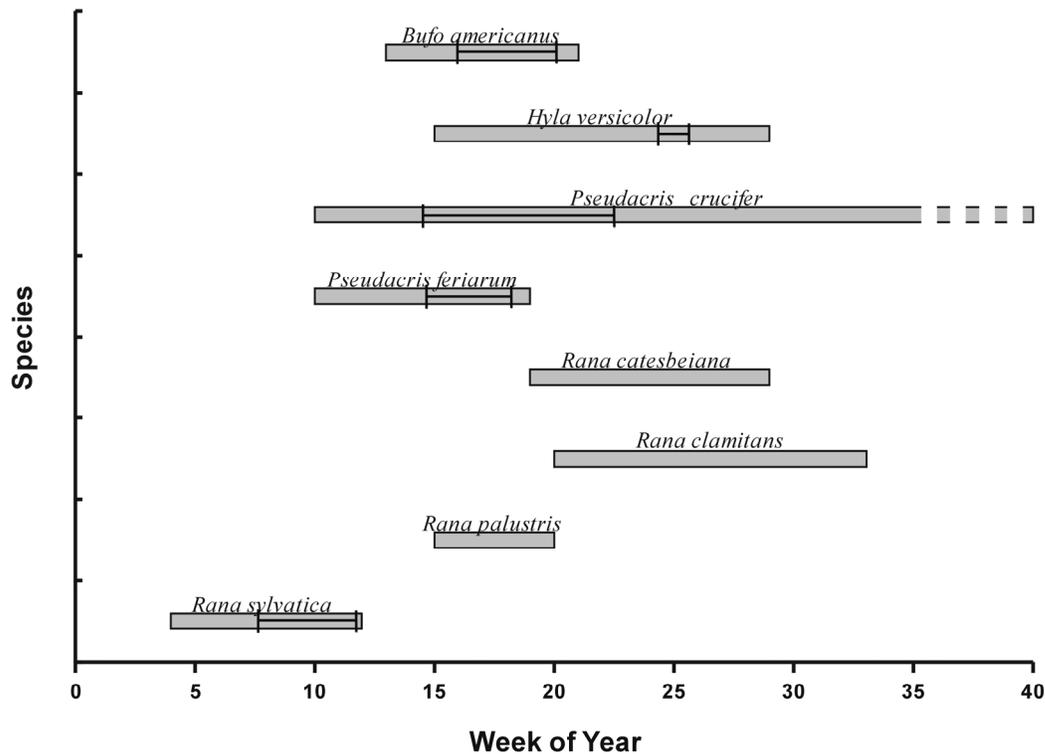


Fig. 2. Duration of incidental and survey calling periods for eight anuran species at RAAP, 1997 and 1998 combined. Brackets indicate large chorus observations; broken bars represent sporadic calling.

when reptiles and amphibians are most active and time of day when they are most likely to seek shelter.

Dip Net Surveys - Dip net surveys were conducted on a limited basis from January to July on seven occasions at four sites. A total of 170 larvae, mostly tadpoles, and two adults were collected, representing four anuran and three salamander species. It is notable that this was the first method to verify the presence of *Rana clamitans*, *R. sylvatica*, *P. feriarum*, *Ambystoma jeffersonianum*, *A. maculatum*, *P. viridescens*, although no species was exclusively detected using this technique.

Hoop and Basking Traps - Hoop traps were set overnight a total of six times and the basking trap was set in the morning and collected in the afternoon on five occasions, resulting in the capture of two species (*Chelydra serpentina* and *Pseudemys concinna*). These two methods were found to not be feasible at RAAP because of security-limited access by land to the New River. Furthermore, hoop traps required at least two persons to be installed and collected in a timely manner, further restricting their use. Thus, this technique was abandoned after a few attempts. Use of a basking trap was the only successful method for capturing *P. concinna*, although the species may have been captured

using hoop traps had they been applied more extensively. We also noted that basking turtles failed to return after repeated trap attempts at the same basking log, which would have required numerous trap relocations for effectiveness. These two techniques probably would have been much more successful if river access by boat had been a possibility, or if unlimited access to the shoreline had been available.

Species Richness and Relative Abundance

Deciduous Woods and Woodlots - Fifteen species were detected in deciduous woods during time-constrained surveys and from array captures (Table 2). Six salamander species (*Plethodon cinereus*, *P. glutinosus*, *P. wehrlei*, *Desmognathus fuscus*, *Eurycea cirrigera*, and *Notophthalmus viridescens*) accounted for 60% of all records, four anuran species (*Bufo americanus*, *Pseudacris crucifer*, *Hyla versicolor*, and *Rana sylvatica*) accounted for 28%, *Terrapene carolina* accounted for 3%, three snake species (*Elaphe alleghaniensis*, *Thamnophis sirtalis*, and *Coluber constrictor*) accounted for 3%, and *Sceloporus undulatus* (only along edges) accounted for 6%. Abundance from array captures was lower on average

Table 2. Relative abundance (CPUE) and species richness (SR) for broad category habitat types at RAAP, both years combined. CPUE is based on average number of captures per hour for time-constrained surveys and average number of captures per array night for drift fence arrays.

	Deciduous Woods		Pine Plantation			Grassland/ Old Field		Limestone Talus			Wetland		Riparian					
	n	CPUE	SR	n	CPUE	SR	n	CPUE	SR	n	CPUE	SR	n	CPUE	SR			
Time- constrained searches	7	7.68	10	4	0.17	1	8	1.99	4	3	1.96	5	3	9.18	9	11	10.28	10
Drift fence arrays	4	0.55	11	2	0.46	4	2	0.05	5	--	--	--	3	2.8	13	--	--	--

than expected because of very few captures at Drift Fence (DF) 10 (CPUE = 0.06), located in second-growth deciduous woods with a poorly developed litter layer. DF 9, located in a large area of mature calcareous forest, had the highest CPUE (1.3) of any array in uplands, and is probably more indicative of species richness and abundance in other mature deciduous stands at RAAP.

Pine Plantation – Only five species were detected in pine plantation habitat. Based on time-constrained surveys and array captures (Table 2), *P. cinereus* accounted for 90% of the total captures, two anuran species (*P. crucifer* and *B. americanus*) accounted for 8%, and *T. carolina* and *Carphophis amoenus* accounted for 1% each. Abundance in pine plantations was higher than expected because of large numbers of *P. cinereus* captured at DF 2, New River Facility, and if excluded from abundance estimations CPUE dropped from 0.46 to 0.047. Only one individual of one snake species, *C. amoenus*, was found during visual searches in pine plantations, although a great deal of suitable habitat was thought to be present for lizards and snakes. Also, *T. sirtalis* was found beneath cover boards along the edge of pine habitat and grassland.

Grassland and Old Field – Eight species were detected in grassland and old field habitat. Based on time-constrained surveys and array captures (Table 2), four snake species (*E. alleghaniensis*, *Lampropeltis triangulum*, *T. sirtalis*, and *C. constrictor*) accounted for 78% of all captures, two anuran species (*P. feriarum* and *B. americanus*) accounted for 9%, and two salamander species (*Eurycea longicauda*, *E. cirrigera*) accounted for 13%. Turtles were not represented in the survey results, but *T. carolina* was observed incidentally on occasion in grassland. Notably, three streamside amphibian species (*E. longicauda*, *E. cirrigera*, and *P. feriarum*) were captured at DF 1 (located near a perennial stream). Species of *Eurycea* are known to migrate relatively long distances from

riparian areas (MacCulloch & Bider, 1975), and based on our road cruising surveys, *P. feriarum* is possibly far-ranging from breeding sites in its foraging distribution. In the case of the New River Facility grasslands, which were historically forested and where riparian and lacustrine habitat are evenly interspersed throughout, it is fair to say that *P. feriarum* and the *Eurycea* species, along with *B. americanus* and possibly *Ambystoma jeffersonianum*, have maintained vibrant populations that disperse well away from the immediate aquatic zones and therefore should be considered grassland associates as well as wetland and/or riparian associates.

Limestone Talus – Five species were detected in sun-exposed limestone talus associated with road cuts and the quarry at the New River Facility (Table 2). These areas were dominated by reptiles with the exception of *B. americanus* and *P. wehrlei*, both found in slightly moist soil beneath talus. Based on time-constrained surveys, *T. sirtalis* and *Diadophis punctatus* accounted for 26% of total captures, *S. undulatus* 16%, *B. americanus* 5%, and *P. wehrlei* 53%. The two amphibians were only found in the talus areas of the TNT area, Main Facility.

Riparian – Nine species were detected in riparian areas and the New River (Table 2). Based on time-constrained surveys, five salamander species (*D. fuscus*, *D. quadramaculatus*, *E. cirrigera*, *E. longicauda*, and *Pseudotriton ruber*) accounted for 86% of all captures, *B. americanus* 2%, *Pseudemys concinna* 2%, and *Nerodia sipedon* and *Regina septemvittata* 10%. *Chelydra serpentina* also occurs in riparian areas but was only observed incidentally or captured in hoop traps.

Wetlands - Sixteen species were detected in perennial and ephemeral wetlands during time-constrained surveys and array captures (Table 2). Six salamander species (*A. jeffersonianum*, *A. maculatum*, *P. cinereus*, *E. cirrigera*, *E. longicauda*, and *N.*

viridescens) accounted for 23% of the total captures, seven anuran species (*B. americanus*, *P. feriarum*, *P. crucifer*, *H. versicolor*, *Rana catesbeiana*, *R. clamitans*, and *R. sylvatica*) 74%, *C. serpentina* and *Chrysemys picta* 2%, and *R. septemvittata* <1%. *Pseudacris feriarum* was abundant in wetlands of the New River Facility but was not collected in any of the wetland drift fence arrays, and *N. sipedon* was observed incidentally and beneath coverboards. Array captures of metamorphs and postmetamorphs accounted for 71% of anurans, but only 13% of salamanders.

The combined results of time-constrained searches and drift fence arrays (Table 2) suggest that average abundance and species richness is generally greater in wetland and riparian areas, moderate to high in deciduous woods and woodlots, and low in grasslands and pine plantations. However, these results should be viewed with caution because of noteworthy sample biases. For instance, Heyer et al. (1994) discouraged making relative abundance comparisons between habitat types when using time-constrained searches, since not all habitat types can be sampled with equal success. Furthermore, our search efforts were unequal among habitat types, as in the case of pine plantation where surveys were abandoned after several search sessions resulted in only one observation. Instead, most of our efforts were directed towards habitat types with the greatest likelihood of yielding additional species, and this likely has biased species richness estimates in favor of these areas. Yet another bias associated with time-constrained surveys was the inclusion of aquatic areas where species tend to be concentrated and were found with ease, resulting in the potential overestimation of abundance and species richness in wetlands and streams when compared to terrestrial environments. Finally, drift fence arrays constructed around ponds were configured to intercept animals moving toward/away from centralized breeding sites, in contrast to arrays in other habitat types that were configured to detect more randomized movement. Thus, our abundance and diversity estimates using these techniques are not wholly comparable between habitat types and should only be applied as baseline data in support of land management decisions and subsequent inventories.

Species Accounts

Reptile and amphibian species inventoried at RAAP in 1997 and 1998 are listed and described below. Taxonomic nomenclature, common names, and order of reference are based on species listings by Mitchell & Reay (1999). Detailed locality information for each species at RAAP is provided in VDGIF (1999).

Frogs and Toads

Bufo americanus Holbrook - American Toad

American Toads were detected at both facilities in both counties. This species occurred throughout the study area in almost all habitat types encountered including permanent and vernal ponds, drainage ditches, stream and river margins, upland and bottomland deciduous woods, and pine plantations. Calling (Fig. 2), mating, and oviposition were observed at permanent and vernal ponds from late March to late May. Our earliest records for first-year individuals captured in pitfalls was early July for both years. Many adults possessed morphological characteristics of *B. fowleri*, namely the presence of more than three warts within dark patches of the dorsum. This may suggest some degree of hybridization between the two species; however, this was the only identification characteristic of *B. fowleri* observed on collected individuals (Collins & Conant, 1998; Martof et al., 1980). *Bufo fowleri* was not heard calling at breeding sites in 1997 or 1998, and we could not detect any variation of *B. americanus* calls that would suggest hybridization between the two species (Zweifel, 1968). Mitchell & Reay (1999) and Tobey (1985) plotted records in Montgomery and Pulaski counties for *B. fowleri* in the vicinity of RAAP. However, based on audio surveys and absence of strong morphological characters, *B. fowleri* does not occur at RAAP, and we suggest caution should be taken when identifying this species in the New River Valley area based on dorsal markings alone.

Hyla versicolor LeConte - Gray Treefrog

Gray Treefrogs were detected at both facilities in both counties. Breeding sites were drainage ditches and ponds in pine-dominated woods. Calling by males was sporadic, occurring between mid-May through late July (Fig. 2), and often at forest edges far from water. A large chorus was heard on 10 June 1998 at a vernal pond surrounded by pine plantations at the New River Facility. The most notable characteristic of this species at RAAP is its apparent affinity for pine.

Pseudacris crucifer (Wied-Neuwied) - Spring Peeper

Spring Peepers occur at both facilities in both counties. Habitat associations included deciduous woods and grasslands near streams, pine plantations near ponds or wetlands, margins of permanent ponds, vernal pools, marshes, and drainage ditches. In both years, large breeding choruses began in mid-March and continued through mid- to late May; smaller choruses

of fewer than 10 individuals continued through mid-September (Fig. 2). Following choruses, sporadic calling was heard until early November, often far from water. In 1998, metamorphs and postmetamorphs were captured in pitfalls from early June to early July.

Pseudacris feriarum (Baird)- Southeastern Chorus Frog

This species is abundant at the New River Facility and tends to be concentrated in the northern portion of the plant, but it does not occur at the Main Facility. Habitat associations included grasslands near streams, vegetated drainage ditches and pond shallows, vernal ponds in grassland and pine plantation, and a ponded sinkhole in deciduous woods. In 1998, calling by males was from early March to early May, with the largest choruses occurring in mid- to late March (Fig. 2). According to Mitchell & Reay (1999), this represents a distribution record for this species in Pulaski County, although Tobey (1985) reported several records throughout the county.

Rana catesbeiana Shaw - American Bullfrog

Bullfrogs occur at both facilities in both counties. Habitat associations of adults and tadpoles were along margins of permanent and temporary ponds, wastewater lagoons, drainage ditches, and stream pools. Observations occurred from March to September; calling by males was recorded from mid-May to mid-June (Fig. 2).

Rana clamitans Rafinesque - Green Frog

Green Frogs occur at both facilities in both counties. Calling males were heard from mid-May to early July (Fig. 2). Habitat associations of adults and tadpoles were similar to those of bullfrogs. Both of these species tend to be most abundant in eutrophic aquatic environments at RAAP.

Rana palustris LeConte - Pickerel Frog

Pickerel Frogs were not observed at RAAP, but were detected by calling males heard incidentally during the day. One male was calling on 21 May 1997 along the shore of the New River at the Main Facility in Pulaski County. Three calling males were heard in mid- and late April at a fish pond at the Main Facility in Montgomery County. This is perhaps the least abundant and distributed anuran species at RAAP.

Rana sylvatica LeConte - Wood Frog

Wood Frogs occur at both facilities in both counties, although only one population was found at the New River Facility. Breeding habitats were vernal ponds in deciduous woods, pine plantation, old fields, and pastureland. However, the species is not obligated to breeding in temporary waters: a permanently inundated drainage ditch was used as a breeding site and one egg mass was found in a shallow region of a permanent fish pond. Adult males called from late January through late March (Fig. 2). Egg masses and mating were observed as early as 20 February in 1998. Metamorphs and postmetamorphs were collected at drift fences beginning in late June and tapering off in early July.

Salamanders

Ambystoma jeffersonianum (Green) - Jefferson Salamander

This species occurs at both facilities in both counties. Habitat associations are vernal ponds in pine plantation, pastureland, and deciduous woods, but breeding was not restricted to temporary ponds or forested habitat: adults were collected in pitfalls at a permanent pond in grassland approximately 150 m from the nearest wooded area. Egg masses and larvae were also collected along the margins of a permanent fish pond, a drainage ditch, and a concrete spring basin vegetated by cattail (*Typha latifolia*). In 1998, migration to breeding sites began in mid-February and recently transformed juveniles began dispersing by mid-June. Adults were collected at breeding sites no later than June 23 with the exception of three individuals captured in pitfalls in October 1998. Larvae collected at the New River Facility and raised in captivity were observed to feed on the larvae of *B. americanus*, *R. sylvatica*, *A. maculatum*, and other *A. jeffersonianum*. CSG has observed larval cannibalism in this species at a breeding pond less than 3.5 km from the Main Facility in Whitethorne, Montgomery County, and similar behavior has been reported by Petranka (1998).

Ambystoma maculatum (Shaw) - Spotted Salamander

Spotted Salamanders were detected only at the Main Facility in Montgomery County in March and April 1998. Habitat associations were a vernal pond and a permanent fish pond in deciduous woods, and a

perennial drainage ditch. Three adults were collected at a breeding pond on 9 March 1998; 13 adults were captured on 18 March 1998 while dispersing from their breeding site towards uplands. In 1998, egg masses were observed as late as 21 April, and a newly hatched larva (20 mm TL) was collected as late as 25 April. Larvae kept in captivity were eaten by *A. jeffersonianum*, but did not exhibit cannibalism.

Desmognathus fuscus (Green) - Northern Dusky Salamander

Dusky salamanders occur throughout both facilities where they were found beneath flat rocks in perennial and intermittent streams (usually in areas moist to saturated but not inundated) and beneath logs on sand and mud bars of small streams. Specimens were also found in crevices of steep stream banks at headcuts and beneath cover objects in vegetated wetlands. Some specimens were collected in pitfalls up to 5 m from an active stream. Larvae were found beneath rocks along stream margins and in leaf packs. Dorsal patterns were highly variable, and some individuals lacked pigmentation on the venter. Of 12 individuals sampled, half had a tail length \geq 50% total length (TL) and showed sparse or no mottling on the venter. These characters made it difficult to differentiate between *D. fuscus* and *D. monticola* (Conant & Collins, 1998). Two adults similar in appearance to *D. monticola* were observed and determined to be *D. fuscus* based on head shape and dorsal markings (J.C. Mitchell, pers. comm.). No *D. monticola* were found at RAAP during the study.

Desmognathus quadramaculatus (Holbrook) - Black-bellied Salamander

Black-bellied Salamanders occur at the Main Facility in Montgomery County. Distribution is limited to one unnamed tributary to the New River at the easternmost portion of the facility and the three tributaries feeding Stroubles Creek. Black-bellied salamanders were found beneath flat rocks in rocky, shaded streams with moderate to fast moving water, usually in inundated regions or in the immediate streamside splash zone. Adults were seen foraging on large rocks at night and larvae were found during the day beneath rocks along stream margins.

Eurycea cirrigera (Green) - Southern Two-lined Salamander

Two-lined salamanders are abundant throughout both facilities. This species was found beneath cover objects in perennial streams (including New River),

intermittent streams, springheads, pond margins, bottomland hardwood forest, and wetland marshes. Several adults were collected in pitfall traps located 25 m from the New River. Larvae were found beneath rocks during day or fully exposed at night in pools and shallows of streams and springs, often in association with larval *E. longicauda* and *Pseudotriton ruber*. Some larvae inhabiting karst springheads within grasslands of the New River Facility reach sizes prior to metamorphosis that potentially suggest a three-year larval period. For instance, one larva collected from a springhead on 30 March 1997 measured 33 mm SVL and 74 mm TL, which is at the upper size range of 13 metamorphosed specimens collected; transformation occurred after two weeks in captivity. Length of larval period is generally longer in northern than in southern populations of the closely related northern two-lined salamander, *E. bislineata* (Petranka, 1998). Hudson (1955) reported the maximum SVL of second-year larvae in Pennsylvania as 27.0 mm; SVL of third-year larvae averaged 29.6 mm. Larvae in Canada may reach a TL of >70 mm with some individuals overwintering into a third year (Petranka, 1998). Studies by Bruce (1986, 1988) on age of metamorphosis in North Carolina populations identified a one- or two-year larval period and maximum SVL of ca. 25 mm. However, Bruce (1982b) also reported SVL of second year larvae at Santeetlah Creek, North Carolina to average 31.8 mm, and Wood (1951) encountered three "year-old" individuals with SVL's of 32 mm in the Virginia Coastal Plain. Bruce (1982a) also noted that premetamorphs in a seepage-fed pond were significantly larger than those in a mountain stream. CSG has observed *E. cirrigera* larvae in streams in several counties in the New River Valley but has not encountered any comparable in size to this specimen. The larger larvae of the New River Facility are most likely at the upper extent of the size distribution for second-year individuals, but it is also possible that some individuals overwinter twice and metamorphose in the third year. To our knowledge, length of larval period or size at metamorphosis has not been closely studied for this species in the Virginia mountains.

Eurycea longicauda (Green) - Long-tailed Salamander

Long-tailed Salamanders occur at both facilities and were found in streams beneath rocks and cover objects along pond, spring, and stream margins. This species appears to be closely associated with the karst spring and pond system at the New River Facility, where all but one of the observations were in close proximity to active springs. Larvae were found at the New River Facility exposed at night in spring boxes and a spring

spillway. Larvae, but no adults, were found at the Main Facility in one of the unnamed tributaries to Stroubles Creek.

Notophthalmus viridescens (Rafinesque) - Red-spotted Newt

Newts were only found at the Main Facility in Montgomery County. Aquatic adults and larvae were collected in a perennial drainage ditch, and adults were also observed along the edge of a man-made fishing pond. Efts were found beneath rotting logs in deciduous woods and in pitfalls around a vernal pond in deciduous woods. Apparently, this species has not colonized the wildlife impoundments of the New River Facility.

Plethodon cinereus (Green) - Red-backed Salamander

Red-backed Salamanders (both color phases) occur at both facilities where they inhabit uplands of mature deciduous woods, mixed deciduous-pine woods, or pine plantations, with 72% of the total individuals counted occurring in mature pine plantations of the New River Facility. Observations occurred from February to December. Interestingly, pine plantations at the Main Facility do not support a population of *P. cinereus*, and this may be due to differences in previous land use and/or moisture regime.

Plethodon glutinosus (Green) - Northern Slimy Salamander

Slimy salamanders occur at both facilities and were found beneath large rocks or logs in mature deciduous woods of upland slopes and in association with *P. cinereus* and *P. wehrlei*. However, this species is much less abundant than its congeners.

Plethodon wehrlei Fowler and Dunn - Wehrle's Salamander

Wehrle's Salamanders were found from March to November at the Main Facility, Montgomery County. Habitat requirements were closely tied to the presence of limestone talus and regions of forested limestone sinks. Most individuals were collected in upland slopes of mature deciduous woods where talus is abundant. However, nine subadults and one adult were found on slightly moist soil beneath sun-exposed talus up to 30 m from deciduous woods; another adult was found in talus beneath a sun-exposed cover board located approximately 50 m from woods. None was found at these same locations when soils became entirely dry. Although it is unusual for *Plethodon* species to inhabit

relatively dry microhabitats, this species seems to be considerably more tolerant of such conditions than are other *Plethodon* species at RAAP. Pauley (1978) found *P. wehrlei* more abundant than *P. cinereus* in drier microhabitats exhibiting higher temperature and greater wind exposure.

Pseudotriton ruber (Latreille) - Red Salamander

Red Salamanders were observed only at the New River Facility. Adults and larvae were found beneath rocks at springheads and in stream riffles. Most 1-2 year larvae were observed foraging in pools at night, and a few were collected incidentally with dip nets during aquatic invertebrate surveys. Larger larvae (>70 mm TL) that appeared to be nearing metamorphosis were found beneath rocks submerged in shallow water. Adults were also observed foraging on humid nights in the vicinity of springheads, where as many as nine individuals were seen at one time in an area approximately 4 m². On 19 March, 1998, a leucistic adult *P. ruber* was found foraging near a springhead at the New River Facility (KU CT 11720-21). This was the first documented occurrence of albinism in the genus *Pseudotriton* (Garriock, 2000). Red Salamanders were not detected at the Main Facility although suitable habitat exists there, especially in the more shaded tributaries of Stroubles Creek.

Turtles

Chelydra serpentina (Linnaeus) - Snapping Turtle

Snapping Turtles occur in wastewater lagoons, ponds, perennial streams, vegetated wetland ditches, and the New River. Although most individuals were observed basking in ponds at the water surface, on 7 July 1997 one adult was observed basking on a log along the New River shoreline, and on 17 April 1998 two adults were observed simultaneously basking above the water surface in a red cedar (*Juniperus virginiana*) snag in the center of a man-made pond (Roble & Garriock, 1998). Aerial basking is unusual in southern populations (Palmer & Braswell, 1995), and rarely does more than one Snapping Turtle utilize the same basking site (Ernst et al., 1994).

Chrysemys picta (Schneider) - Painted Turtle

Painted Turtles were observed at both facilities while swimming or basking in drainage ditches, permanent and temporary ponds, wastewater lagoons, and the New River. Observations occurred from April to September. On 13 May 1997, two farm ponds used

for cattle watering at the New River Facility were found to contain Painted Turtle hatchlings. Both ponds were approximately 15 m in diameter and shallow with a mud substrate. The number of hatchlings basking (with heads emerged) was counted to be 25 in one pond and 45 in the other. Two of the hatchlings were collected, both with a CL of 27 mm and plastron length of 31 mm. The ponds were completely dry two weeks later, and presumably the juveniles had burrowed into the pond bottom and/or dispersed through pastureland in search of other water sources.

Pseudemys concinna (LeConte) - River Cooter

River Cooters were observed along the entire stretch of the New River through RAAP, but were most abundant in 1997 in a rocky section of the river (approximately 1.1 km east of the New River Bridge). River Cooters were observed basking on emerged rocks and logs throughout the warm season. On 21 August 1997, as many as 11 adults were counted basking in an approximately 50 m stretch of the river (river width = 180 to 215 m). On multiple occasions as many as seven turtles were observed basking on one log at the same time, and on several occasions two were observed basking on the same rock. Notably, upon release of water from the Claytor Lake Dam, rising water levels would force turtles basking on rocks to relocate to logs along the shoreline, suggesting the preferred basking sites occur on rocks some distance from the shoreline. On at least two occasions cooters were displaced from rocks by conspecifics, suggesting competition for basking sites. However, Mitchell (1994) reported that aggressive behavior has not been observed in this species. Unfortunately, installation of a wastewater effluent diffuser beneath the riverbed during the winter of 1997 resulted in the removal of nearly all emergent basking rocks at the bridge site. Consequently, river cooters were not observed in this area in 1998. This is a disjunct population in the New River of Virginia and was discovered only recently. In 1987, Buhlmann (1989) documented the Radford population as being the first to occur in the New River in Virginia, although several years earlier Seidel (1982) reported a New River population in Virginia, most likely in the vicinity of the Bluestone Reservoir dam. Based on bone fragments of *P. concinna* excavated at archaeological sites within the Main Facility, the species likely occurred there prior to the 13th century (Barber & Tolley, 2002).

Terrapene carolina (Linnaeus) - Eastern Box Turtle

Box turtles occur at both facilities and were found

in deciduous forests and woodlots, pine plantations, grasslands, old fields, rocky slopes, near streams, and in shallow, ephemeral pools. Observations of active adults occurred from April to October. A millipede (Polydesmida) and a caterpillar (Lepidoptera) were observed being eaten by adult females in June 1997. On 19 November 1997, while clearing leaf litter for pitfall installation in a deciduous woodlot, an adult box turtle (sex undetermined) was found in a hibernaculum. A downward angled ditch had been excavated until the top of the carapace was even with the soil surface and approximately 8 cm of leaf litter covered the partially exposed carapace. The turtle was left undisturbed and the location marked and monitored during the spring; the burrow was vacated during the second week of April 1998.

Lizards

Sceloporus undulatus (Green) - Fence Lizard

Fence Lizards occur at the Main Facility in Montgomery County and are restricted to sun-exposed, xeric, rocky cliffs and buildings adjacent to upland deciduous woods. Two separate populations were identified: one inhabits limestone talus cliffs adjacent to calcareous woods in the southwestern portion of the facility, and the other occurs in rocky areas of the sandstone/shale – oak association of the southeastern portion of the facility. We cannot readily explain the apparent absence of this species from the remainder of RAAP, especially the New River Facility, where sun-exposed talus, rock piles, log piles, and old buildings are abundant. One explanation for this may be the lack of suitable microhabitat adjacent to mature deciduous forest, an association that seems to be correlated with the two populations at the Main Facility. Also, based on distribution records in Virginia (Mitchell & Reay, 1999), Fence Lizards are not well documented in the New River Valley. Records are lacking for several nearby counties, including Floyd, Giles, Pulaski, and Grayson, whereas Carroll and Wythe counties contain only one record each (but see Gibson & White, 2003).

Snakes

Agkistrodon contortrix Palisot de Beauvois – Copperhead

One specimen was found at RAAP in Montgomery County (29 October 1997), the result of a road kill at the Main Facility. Based on personal accounts and photographs provided by RAAP and security personnel, Copperheads occur at both facilities, especially in the

forested, sandstone/shale areas in the westernmost portion of the Main Facility where our specimen was found. Time-constrained surveys in this region were unsuccessful in finding the species, although they are apparently common there.

Carphophis amoenus (Say) - Eastern Wormsnake

The only wormsnares observed were two found at the Main Facility in Pulaski County. One was encountered during a time-constrained survey in a rotting log at the edge of a pine plantation, and the other was collected in a pitfall array in an old field. This is one of only two snake species detected in pine plantations of the Main Facility (the other species being *Thamnophis sirtalis*).

Coluber constrictor Linnaeus - Northern Black Racer

Black racers were found only at the New River Facility along the edges of deciduous woods and in open areas beneath limestone talus. One juvenile (TL = 355.6 mm) was collected in a drift fence funnel trap on 8 October 1997 at the edge of deciduous woods.

Diadophis punctatus (Linnaeus) - Ring-necked Snake

Ring-necked Snakes were found at both facilities. Two specimens were found during time-constrained surveys beneath thin limestone talus in sun-exposed areas; a third individual was found beneath a cover board over muddy substrate in a cattail marsh.

Elaphe alleghaniensis (Holbrook) - Eastern Ratsnake

Ratsnakes were found throughout both facilities. Adults were found basking or hidden beneath cover objects in deciduous woods and woodlots, woodland edges, wetland margins, grasslands, debris piles, and buildings. Ratsnakes occur abundantly in the walls and rafters of wood frame storage buildings at both facilities.

Lampropeltis triangulum (Lacépède) - Eastern Milksnake

Milksnakes were observed at both facilities beneath cover objects near storage buildings or in grasslands. Two juveniles were found incidentally crossing roads within grasslands and deciduous woods. Patterns were of the blotched type of red or brown coloration (Mitchell, 1994).

Nerodia sipedon (Linnaeus) - Northern Watersnake

Watersnakes occur at both facilities where adults and juveniles were found either basking in trees or on large rocks of riparian areas, or beneath large flat rocks of rocky stream bars. Several individuals were found beneath cover boards in a cattail marsh, and one adult was collected from a small perennial stream after being electro-shocked during a fish survey. This species is abundant at RAAP and likely occurs near all permanent water sources at either facility.

Regina septemvittata (Say) - Queen Snake

Queen Snakes were detected only at the Main Facility in Montgomery County within riparian areas of Stroubles Creek and at a drainage ditch. Adults were found either beneath rocks at stream edges or basking in streamside shrubs. This species undoubtedly occurs in riparian areas of the New River as well, and although it was not detected there, may occur within stream or wetland habitat at the New River Facility.

Thamnophis sirtalis (Linnaeus) - Eastern Gartersnake

Gartersnakes occur throughout both facilities. This species was found as early as February basking or beneath cover objects in practically all habitat types at RAAP, including limestone talus, pine plantation edges, and wetlands. This species and the Eastern Ratsnake are likely the most abundant and widely distributed snakes at RAAP.

Undetected Species

Several species were expected or thought likely to occur at RAAP based on documented distribution, local sightings, and habitat types on the base. These are briefly discussed below.

Bufo fowleri Hinckley - Fowler's Toad

There are seven confirmed records for this species in Pulaski and Montgomery counties (Tobey, 1985; Mitchell & Reay, 1999), including several in the vicinity of RAAP. However, based on two consecutive years of anuran call data and the lack of strong *B. fowleri* morphological characteristics (lack of dark markings on the chest and enlarged warts on the tibia) on any of the *Bufo* individuals observed, we do not believe this species occurs at the base, or if it does is extremely rare. According to Mitchell & Reay (1999),

B. fowleri prefers sandy soils in Virginia, limiting its distribution west of the Coastal Plain. At RAAP this type of habitat would be confined to alluvial areas along Stroubles Creek and the New River. More information concerning anuran call data is needed to properly assess the distribution of *B. fowleri* and the complexity of *Bufo* hybridization in the New River Valley.

Scaphiopus holbrookii (Harlan) – Eastern Spadefoot

Very few mountain records exist for this species in Virginia (Tobey, 1985; Mitchell & Buhlmann, 1999; Mitchell & Reay, 1999; Gibson, 2002), but two are within a few miles of RAAP. If the Eastern Spadefoot occurs at RAAP, it should have been detected during our nighttime road surveys or anuran call surveys because it is considered to have a very loud call (Green & Pauley, 1987) and to be an explosive breeder during heavy rains (Tobey, 1985). At RAAP, the species would most likely occur within the New River floodplain of the Main Facility where sandy, alluvial soils occur naturally, but soil disturbances in the way of pine plantations and industrial development have depleted much of this substrate type within the facility.

Ambystoma opacum (Gravenhorst) - Marbled Salamander

This species occurs primarily east of the Blue Ridge except for isolated records in Page, Rockbridge, Botetourt, Augusta (Mitchell & Reay, 1999), and Alleghany counties (Hoffman, 1985). It was also documented in Craig County about 64 km northeast of RAAP (Hayslett, 1994), and Tobey (1985) published a sight record (unconfirmed) near RAAP in Montgomery County. Recently, larvae identified as *A. opacum* were found in Wythe County (Gibson & White, 2003) and a subadult was reported from Scott County (Hobson & Roble, 2003). However, based on lack of documented evidence that *A. opacum* occurs in the New River Valley, and since most of the known vernal breeding sites at RAAP were intensively surveyed during the breeding and/or larval periods, we do not believe the species is likely to occur on the base.

Cryptobranchus alleganiensis (Daudin) – Hellbender

There are several documented occurrences of this species in the New River in the Radford area (Mitchell & Reay, 1999) and it was once considered to be abundant above the Little River dam just south of Radford (R. L. Hoffman, pers. comm.). This species

most likely occurs in the New River within the confines of RAAP given that areas of suitable habitat are common, but because of its secretive and nocturnal nature, little emphasis was placed on detecting it during our surveys. We have heard of several undocumented Hellbender sightings in the Little and New rivers in Pulaski, Montgomery, and Floyd counties, and based on discussions with area fishermen, Hellbenders are still killed (when accidentally caught) because of misconceptions that they are poisonous or predators of game fish.

Necturus maculosus (Rafinesque) – Mudpuppy

Mudpuppies are not documented to occur in the New River drainage (Mitchell & Reay, 1999) except for one unconfirmed record in Pulaski County (Hoffman, 1984; Tobey, 1985) in a section of the New River that is now part of Claytor Lake. Unfortunately, the specimen was lost before Hoffman (1984) could confirm it as being *N. maculosus*. Although there is a remote chance the species occurs in the New River at RAAP, we did not attempt to find it during our surveys.

Desmognathus monticola Dunn – Seal Salamander

The Seal Salamander should occur at RAAP and may still be documented with additional surveys. It is unusual that this species was not found given the broad range of riparian habitat surveyed throughout much of the base. Based on distributional records (Tobey, 1985; Mitchell & Reay, 1999), *D. monticola* is abundant in the New River Valley, and is reported by Petranka (1998) to be most abundant at elevations below 1219 to 1372 m. The most likely place for this species to occur on the base is the easternmost tributary of Stroubles Creek (Geese Branch). However, *D. quadramaculatus* is abundant there and could have possibly excluded *D. monticola* from the stream channel (Petranka, 1998).

Eurycea lucifuga Rafinesque – Cave Salamander

Given that much of RAAP is underlain by limestone bedrock and with sinkholes being common, it seems very likely that the Cave Salamander would occur at RAAP. We explored on two occasions the only accessible (without excavation) cave opening found, but did not find the species. The Cave Salamander in Virginia occurs primarily in the Ridge and Valley region bordering West Virginia and in the extreme western counties of the state (Tobey, 1985; Mitchell & Reay, 1999); the nearest records occur only 8 km to the north of the Main Facility in bordering Giles County.

Gyrinophilus porphyriticus (Green) – Spring Salamander

Although this species occurs throughout southwestern Virginia, we were unsuccessful at finding adults or larvae. This is surprising given the suitability of the rocky, shaded streams feeding Stroubles Creek and the numerous springheads at the New River Facility. Further surveys in these two areas could yield the species, especially in Geese Branch and the unnamed perennial stream in the northeast quadrant of the Main Facility that drains directly into the New River.

Hemidactylium scutatum (Schlegel) – Four-toed Salamander

The Four-toed Salamander occurs in Montgomery County and neighboring Giles, Floyd, and Wythe counties (Tobey, 1985; Mitchell & Reay, 1999), but was not found at RAAP. Wet areas supporting sphagnum mats or bogs, the preferred breeding habitat for the species (Green & Pauley, 1987), were searched when encountered incidentally, but such areas were not significant in their occurrence at either facility.

Sternotherus odoratus (Latreille) – Eastern Musk Turtle

Confirmed records for this species occur along the New River up and downstream of RAAP (Mitchell & Reay, 1999) and they have been observed by S. Garriock and M. Pinder (VDGIF) in the New River approximately 8 km north of RAAP. We attempted on three separate occasions to find this species by snorkeling vegetated shallows of the New River, and no observations were made during a mussel survey of the New River in 1998. Based on nearby records it is reasonable to assume *S. odoratus* occurs at the Main Facility within the New River and possibly Stroubles Creek. Bone fragments have been found on the New River floodplain at the Main Facility (Barber & Tolly, 2002).

Eumeces fasciatus (Linnaeus) – Five-lined Skink

Skinks were not observed at RAAP even though excellent habitat (e.g., sun-exposed, rocky areas, concrete structures, open pine woods) is ubiquitous at both facilities. Mitchell & Reay (1999) reported sparse records in the mountain provinces with only one documented record in the New River Valley (Blacksburg area). This species has also been observed in the McCoy area (unconfirmed record) approximately 5 km north of RAAP, and in Giles and Floyd counties

(Tobey, 1985; Garriock et al., 1996). This suggests that the species is more widespread in the New River Valley than indicated by Mitchell & Reay (1999), although populations appear to be fragmented in their distribution. We believe it is unlikely that *E. fasciatus* was missed at RAAP because the species tends to be easily found where it occurs.

Heterodon platirhinos Latreille – Eastern Hognose Snake

Records for this species are scattered and widespread in the mountains of Virginia including three confirmed records in Montgomery and Pulaski counties (Mitchell & Reay, 1999). We specifically sought this species on the dry sandstone/shale areas in the southeastern portion of the Main Facility without success. There was an undocumented account of this species in 1998 in the McCoy area and discussion with a maintenance worker revealed that “blowin vipers” were abundant in the agricultural areas of the New River Facility more than 20 years ago, but were often killed during mowing operations.

Opheodrys aestivus (Linnaeus) – Rough Greensnake

Based on documented localities, this species seems to be very uncommon in the New River Valley in Virginia, with only one record in central Wythe County (Mitchell & Reay, 1999) and two records in southern Carroll County (Tobey, 1985). It is documented to occur in Raleigh County, West Virginia (Green & Pauley, 1987), but the locality may not be within the New River Drainage Basin. An eastern Montgomery County record (Mitchell & Reay, 1999) occurs within the North Fork Roanoke River Drainage, and CSG has seen the species in Montgomery County crossing a road adjacent to the North Fork Roanoke River. We made specific attempts, without success, to find Rough Greensnakes during a few nighttime time-constrained surveys. This was done by shining a bright light upward into overhanging stream and pond margin vegetation and searching for ventral scale reflections.

Thamnophis sauritus (Linnaeus) – Eastern Ribbonsnake

This is another species that is poorly represented in the New River Valley and westward, although two vouchered (Mitchell & Reay, 1999) and three unvouchered (Tobey, 1985) records occur in the Valley surrounding RAAP (Carroll, Giles, Grayson, Montgomery, and Pulaski counties), and CSG has observed and photographed this species on a few occasions in or adjacent to wetlands in Floyd County

(Garriock et al., 1996). Nonetheless, given only a few confirmed records, the Eastern Ribbonsnake is likely uncommon and spotty in distribution in the New River Valley. Because of its affinity for wet areas, which are common at RAAP, we had hoped to find the species beneath cover boards placed in marshes and fens or in our pond-perimeter funnel traps.

CONCLUSION AND MANAGEMENT CONCERNS

Several areas harboring notable reptile and amphibian diversity occur within the confines of RAAP. These areas should be considered when making natural resource management decisions. Notable localities within the Main Facility are 1) the calcareous forest region west of the main entrance; 2) the calcareous and oak forest (including the pond and associated riparian areas of Stroubles Creek and its tributaries) in the southeast portion of the plant; 3) vernal ponds within the Stroubles Creek floodplain; and 4) drainage ditches within the New River floodplain. Bottomland hardwoods along the New River were not adequately sampled and require further surveys. The most notable areas within the New River Facility are 1) wildlife impoundments along with associated springheads and marshes; 2) the vernal pond located just northeast of the main entrance; 3) deciduous woodlots within the grassland-pine matrix; and 4) the calcareous forest of the Hazel Hollow area.

Potential threats to reptiles and amphibians of RAAP are primarily improper storage and disposal of toxic chemicals, draining or maintenance of existing wetlands, impacts to streams, clearcutting, and herbicide application in grasslands. There are few natural wetland systems remaining at the base; however, man-made systems such as the wildlife impoundments have created a considerable amount of good habitat, and should be kept active. There also exists potential for wetland restoration or creation within the New River floodplain at the Main Facility that, if undertaken, would significantly benefit biodiversity at the facility. Equally important are the isolated vernal pond systems that may not receive protection under current state and federal laws (Sections 401/404 of the 1997 Clean Water Act). These systems tend to be small and may seem insignificant, but they harbor a specialized, yet diminishing ecosystem still unknown to most people. Care should be taken in the management of the existing upland and bottomland hardwood systems that are currently in climax stages and contiguous over large areas, because these areas harbor much of plant and wildlife diversity

on the base. Although we realize the importance of the hardwood component as a renewable natural resource commodity, deforestation of these areas would severely impact the facility's biological diversity. With regard to riparian buffers, much effort should go into protecting existing stream and vernal pond forest buffers, and addition of new hardwood buffers should be considered in mitigation opportunities if they arise. An especially worthy undertaking would be replacement of the New River pine buffer, when all or portions are harvested, with mesic bottomland hardwood species. Finally, creative management of grasslands that regulates and oversees mowing operations, cattle grazing, and herbicide application, yet still provides benefits to local game hunters and farmers, would likely have substantial positive effects on grassland floral and faunal biodiversity.

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