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A Comparison of Lowland and Upland Forests of Fairy Stone State Park, Virginia. II. Small Terrestrial Vertebrates and Songbirds

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ABSTRACT

Small terrestrial vertebrate and songbird abundance, species richness, and species composition were studied in forests in both lowland and upland topographic positions at Fairy Stone State Park, Patrick County, Virginia. Songbird species were sampled using point counts and herpetofauna and small mammals were sampled using live traps. The species richness and abundance of songbirds did not differ markedly between upland and lowland forest plots, although there were some changes in species composition. Small mammal and reptile communities were similar in species richness, abundance, and composition between upland and lowland forests. Amphibian species were observed in higher abundance on upland sites, mostly due to a large number of captures of juvenile American Toads. These toads, however, emerged from water sources on lowland sites. Nearly all frogs were on lowland sites and we had incidental observations of four stream salamanders at lowland sites.

Key words: Blue Ridge Mountains, topography, wildlife, forest vertebrate diversity.

INTRODUCTION

In the Upper Piedmont and Blue Ridge physiographic provinces of Virginia, topographic factors play an important role in structuring forest plant communities (Johnson & Ware, 1982; Stephenson, 1982; Farrell & Ware, 1988, 1991; Harrison et al., 1989; Copenheaver et al., 2006; Brown & Fredericksen, 2008). Because plant communities influence food, cover, and nesting locations of animals, animal communities may also differ by topographic position, at least for species with relatively small home ranges. Topographic variation leads to differences in soil and air temperature, wind velocity, solar radiation, and humidity. In general, northern aspects, lower slope positions, and low slope inclinations are more mesic than southern aspects, upper slope positions, and steep slope inclinations (Rubino & McCarthy, 2003). Species dependent on sites with higher soil moisture and humidity, such as amphibians, may therefore be abundant in forests on lower slope positions compared to upper slope positions. In addition, food and cover for animals may differ between upland and lowland forests. For example, upland oak forests may provide more mast for small mammal communities (Rodewald, 2003), while lowland forests may provide more understory cover for wildlife than upland forests (Small & McCarthy, 2005).

In 2010, we conducted a study comparing the vascular plant and terrestrial vertebrate communities on lowland (toeslope and valley positions) and upland (shoulder and ridgetop positions) topographic positions in the forests of Fairy Stone State Park, Patrick County, Virginia. This paper describes the species richness, abundance, and composition of small terrestrial vertebrates and songbirds in lowland and upland locations in the forests of the park. A companion paper describes the vascular plant communities on these study sites.

STUDY SITE

Fairy Stone State Park is the largest of Virginia's six original state parks. The 1775-ha park in Patrick County is managed by the Virginia Department of Conservation and Recreation. Except for recreational

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areas that are heavily used by visitors, the park contains large areas of mature, undisturbed forest. Much of the park is highly dissected with steep slopes and deep valleys characteristic of the foothills of the Blue Ridge Mountains.

In the latest Fairy Stone State Park management plan, one of the priorities is to conduct a biological inventory of the park in order to characterize its biodiversity, identify rare and endangered species, assess conservation threats, and recommend management actions. This information can help park staff manage access to areas that have rare species or species of special concern, as well as to identify areas threatened by invasive plant species.

METHODS

Experimental Design

Lowland and upland forest types were located throughout the park using methods described in the companion paper. The first type, hereafter referred to as "lowland forests", occupied lower slopes and streamside forests. Dominant canopy species include Tuliptree (*Liriodendron tulipifera*) and American Beech *(Fagus grandifolia*). The second forest type, hereafter referred to as "upland forests", includes species of upper slopes and ridges where dominant canopy species include Scarlet Oak (*Quercus coccinea*) and Chestnut Oak (*Quercus montana*). White Pine (*Pinus strobus*), White Oak (*Quercus alba*), and Red Maple (*Acer rubrum*) are common on both upland and lowland sites. As described below, sampling methods differed according to the taxa of terrestrial vertebrate animals being studied (birds, small mammals, herpetofauna).

Point Counts

Songbirds were sampled using point counts along established trails within the park, including a total of 30 points. Each point had a sampling area of 50 m in radius and the outer margin of the sampling area was at least 150 m from roads and at least 100 m from other sampling areas. From late-April to mid-June, each point was sampled four times, thus including sampling of breeding birds and some migrants. On sampling days, 10 points were sampled per day from 0600-0900 hours with approximately half of each in lowland forests and the remainder in upland forests. Four of the 30 points had some overlap between upland and lowland forest characteristics (e.g., steep ravines with upland tree species on either side) and were thus considered to be "transitional" between forest types. Of the remaining 26 point sampling areas, 14 were entirely in lowland topographic positions (valley and toeslope positions) and 12 were entirely in upland topographic positions (ridgetop and shoulder positions). For each point, all songbirds seen or heard within the point count area over a time interval of five minutes were tallied.

Pitfall Trapping

Three pairs of drift fence-pitfall arrays were established in the park (one each in the northwestern, central, and southeastern sections) to sample small mammals, amphibians, and reptiles. Each pair included lowland and upland topographic positions along the same slope, separated by at least 100 m. Two of three lowland pitfall arrays were located adjacent to small streams. Each array included 5 m arms of silt fencing in the form of an X with five 17-l buckets (one in the center and one at the end of each arm) buried so their tops were flush with the soil surface. The traps at each site were opened most weekdays from mid-March to mid-August for a total of 420 trap-nights (5 buckets x 84 days) per array (n=3) and 1260 trap-nights per treatment. Traps were checked in the morning of each day and captured animals were identified to species and released unmarked just outside of and facing away from the sampling area.

Live Trapping

Small mammals were sampled from June-August using Sherman live traps in four pairs of upland and lowland sites located in different areas of the park. At each site, a total of 30 traps were set with ten trapping locations separated by 50 m. At each trapping location, three traps were placed in a triangular pattern 10 m apart. Traps were baited with a mixture of peanut butter, oats, and sunflower seeds. Each of the four paired locations was trapped over an eight-day period for a total of 960 trap-nights per upland or lowland forest type (30 traps x 8 nights x 4 locations). Captured animals were ear-tagged and released, except for shrews which were not ear-tagged. We also set out two Tomahawk traps baited with sardines and marshmallows along each trap line to reduce the incidence of trap disturbance by Raccoons (*Procyon lotor*) and Virginia Opossums (*Didelphis virginiana*).

Data Analysis

Songbird abundance per point was averaged over the four sampling periods per point and a Kruskal-Wallis test examined differences in abundance among upland, lowland, and transitional areas. Paired t tests or

Wilcoxon signed rank tests were used for statistical comparisons of mammal and herpetofauna abundance between upland and lowland pitfall arrays and Sherman trap locations. Differences in species richness were not tested statistically due to relatively low species counts per replicate for point counts and trapping locations. All analyses were conducted using SYSTAT 12.2 (SYSTAT Software Inc., San Jose, CA). Due to low numbers of replicates for many species groups and individual species, differences were considered significant at $p < 0.10$.

RESULTS

The abundance of birds estimated from point counts did not differ among upland, lowland, and transitional forests ($p = 0.13$), but there was a tendency for a higher abundance of birds at lowland and transitional sites (Table 1). The species richness summed over all points only differed by three species between upland and lowland sites. Red-eyed Vireo (*Vireo olivaceus*) was the most abundant bird on all forest types and its abundance was similar between upland and lowland sites (Table 1). Ovenbird (*Seiurus aurocapillus*) was also a commonly observed species with similar abundances on upland and lowland sites. Tufted Titmouse (*Baeolophus bicolor*) was another commonly observed species in both upland and lowland forests, but it had >50% higher abundance on lowland sites. Blue-headed Vireo (*Vireo solitarius*), Yellow-throated Vireo (*Vireo flavifrons*), and Hairy Woodpecker (*Picoides villosus*) tended to occur in higher abundance on upland sites and Great-crested Flycatcher (*Myiarchus crinitus*) and Black-and-white Warbler (*Mniotilta varia*) were observed more than once during sampling on upland sites, but neither was recorded on lowland sites. On lowland sites, Acadian Flycatcher (*Empidonax virescens*) and Wood Thrush (*Hylocichla mustelina*) were relatively common, but they were absent on upland sites, as were the less common Louisiana Waterthrush (*Seiurus motacilla*) and American Redstart (*Setophaga ruticilla*).

Table 1. Mean number of birds detected per point in upland, lowland, and transitional topographic positions in forests of Fairy Stone State Park, Patrick County, Virginia. The number of points is given as the sample size. Each point was sampled four times between late April and mid-June, 2010. Summed over all species, the number of birds per point did not differ by topographic position ($p = 0.13$, Kruskal-Wallis test).

Lowland (n=14)	**#**	**Upland (n=12)**	**#**	**Transitional (n=4)**	**#**
Vireo olivaceus	0.39	*Vireo olivaceus*	0.38	*Vireo olivaceus*	0.56
Baeolophus bicolor	0.32	*Seiurus aurocapillus*	0.21	*Empidonax virescens*	0.38
Empidonax virescens	0.27	*Baeolophus bicolor*	0.19	*Piranga olivacea*	0.31
Seiurus aurocapillus	0.25	*Vireo solitarius*	0.17	*Vireo flavifrons*	0.25
Piranga olivacea	0.14	*Vireo flavifrons*	0.10	*Vireo solitarius*	0.19
Hylocichla mustelina	0.13	*Picoides villosus*	0.10	*Seiurus aurocapillus*	0.13
Vireo solitarius	0.05	*Piranga olivacea*	0.08	*Helmitheros vermivorus*	0.06
Sitta carolinensis	0.05	*Myiarchus crinitus*	0.06	*Cyanocitta cristata*	0.06
Thryothorus ludovicianus	0.05	*Melanerpes carolinus*	0.04	*Wilsonia citrina*	0.06
Melanerpes carolinus	0.04	*Mniotilta varia*	0.04	*Seiurus noveboracensis*	0.06
Seiurus motacilla	0.04	*Wilsonia citrina*	0.02	*Picoides villosus*	0.06
Vireo flavifrons	0.04	*Empidonax virescens*	0.02	*Cardinalis cardinalis*	0.06
Setophaga ruticilla	0.04	*Sitta carolinensis*	0.02	*Baeolophus bicolor*	0.06
Picoides villosus	0.04	*Archilochus colubris*	0.02	Unidentified	0.06
Poecile carolinensis	0.02	*Catharus ustulatus*	0.02		
Cardinalis cardinalis	0.02	*Dendroica virens*	0.02		
Cyanocitta cristata	0.02	*Poecile carolinensis*	0.02		
Unidentified	0.17	*Cardinalis cardinalis*	0.02		
		Coccyzus americanus	0.02		
		Dendroica pinus	0.02		
		Contopus virens	0.02		
		Unidentified	0.08		
TOTAL	**2.08**	**TOTAL**	**1.67**	**TOTAL**	**2.30**

Table 2. Number of small mammals captured in pitfall arrays in lowland and upland forests of Fairy Stone State Park, Patrick County, Virginia.

Species	Lowland	Upland
Peromyscus leucopus	7	9
Myodes gapperi	5	4
Ochrotomys nuttalli	0	1
Napaeozapus insignis	1	1
Blarina brevicauda	9	4
Sorex cinereus	3	10
Sorex fumeus	8	12
TOTAL	**33**	**41**

There was no difference in the number of small mammal captures in Sherman traps (not including recaptures) between lowland and upland plots ($p = 0.72$). White-footed Mouse (*Peromyscus leucopus*) comprised the majority of captures (33 in upland and 37 in lowland forests). Two Short-tailed Shrews (*Blarina brevicauda*) were captured in lowland plots and one was captured in an upland plot. One Eastern Chipmunk (*Tamias striatus*) was captured in each forest type.

Small mammal captures in pitfall traps also were similar between upland and lowland sites ($p = 0.65$; Table 2). White-footed Mouse, Southern Red-backed Vole (*Myodes gapperi*), and Smoky Shrew (*Sorex fumeus*) were captured in similar numbers in upland and lowland pitfall traps. Captures of Masked Shrew (*Sorex cinereus*) tended to be higher on upland sites, whereas those of Short-tailed Shrew tended to be higher on lowland sites.

Table 3. Number of amphibians captured in pitfall arrays in lowland and upland forests of Fairy Stone State Park, Patrick County, Virginia.

Species	Lowland	Upland
Anaxyrus americanus	45	80
Lithobates sylvaticus	6	0
Lithobates clamitans	9	1
Lithobates palustris	6	0
Notophthalmus viridescens	3	3
Ambystoma maculatum	0	1
Plethodon cylindraceus	2	0
Plethodon cinereus	3	5
Pseudotriton ruber	3	1
TOTAL	**77**	**91**

Table 4. Number of reptiles captured in pitfall arrays in lowland and upland forests of Fairy Stone State Park, Patrick County, Virginia.

Species	Lowland	Upland
Terrapene carolina	1	0
Plestiodon fasciatus	3	5
Scincella lateralis	0	2
Carphophis amoenus	1	2
Storeria occipitomaculata	1	0
Diadophis punctatus	0	2
Pantherophis alleghaniensis	1	0
TOTAL	**7**	**11**

Amphibians in pitfall traps were dominated by the American Toad (*Anaxyrus americanus*), most of which were juveniles (Table 3). Overall, amphibian captures were significantly higher on upland sites ($p = 0.08$). This result was mostly due to higher captures of juvenile American Toads on one upland site compared to its paired lowland site, but there was not an overall difference in American Toads between forest types ($p = 0.32$). Frogs (all in the genus *Lithobates*) were much more numerous on lowland sites (Table 3), but mostly due to one site and not significantly different between lowland and upland sites ($p = 0.30$). Pitfall captures of salamanders were similar between upland and lowland sites and identical for Red-Spotted Newts (*Notophthalmus viridescens*). This was surprising given the high number of incidental observations of terrestrial juveniles (efts) of this species in many areas of the park. Incidental captures of salamanders in streams on lowland sites included Seal Salamander (*Desmognathus monticola*), Northern Dusky Salamander (*Desmognathus fuscus*), Southern Two-lined Salamander (*Eurycea cirrigera*), and Three-lined Salamander (*Eurycea guttolineata*).

Captures of reptiles in pitfall traps were low and not significantly different between treatments ($p = 0.27$; Table 4). The most commonly captured reptile was the Common Five-lined Skink (*Plestiodon fasciatus*). Only small snakes or juveniles of larger snakes were captured in pitfall traps. Two incidental observations of Northern Water Snakes (*Nerodia sipedon*) were made in lowland forests near Fairy Stone Lake. Other incidental observations of snakes during the study period included a Black Racer (*Coluber constrictor*) found within the lower slope forest and Northern Copperhead (*Agkistrodon contortrix*) and Timber Rattlesnake (*Crotalus horridus*); the latter two species were found on roads.

DISCUSSION

Lowland and upland communities of birds, and terrestrial small mammals, amphibians, and reptiles differed little in abundance and species richness. Most differences were in species composition, and mainly among amphibians and birds.

Unexpectedly, one of the few significant differences was a higher abundance of amphibians on upland sites compared to lowland sites. Some of this difference was attributable to numerous juvenile toads at a sampling site near a water retention pond in the center of the park. The retention pond is the presumed natal habitat of these toads due to calling activity observed there earlier in the year. While the pond is equidistant from the upland and lowland pitfall trapping arrays, toads that happened to disperse from the south side of this pond could take a direct travel path uphill to the upland site. To reach the lowland site, however, toads would need to leave from the south side of the pond, travel approximately 100 m, and then move along the base of a hill to the lowland site. American Toads represented 73% of all amphibian captures and 59% of all American Toads were captured near the site closest to the pond. The upland site had 92% of all captures of toads within this upland-lowland pair. The pond is also the presumed source of Green Frogs and Pickerel Frogs, due to observations of calling activity earlier in the year, but frogs are less tolerant of dry conditions and of dehydration than toads (Schmid, 1965; Bentley & Yorio, 1976; Gatten, 1987) and likely stayed in the damper lowland areas, perhaps resulting in more captures at lowland sites. Nearly 80% of all frog captures occurred on the lowland trapping array near this pond. If toads are removed from the totals, there were nearly three times the captures of amphibians in lowland plots (32) compared to upland plots (11). Although not captured in traps, Spring Peeper (*Pseudacris crucifer*) and Upland Chorus Frog (*Pseudacris feriarum*) were observed in the park in the spring of 2010.

Stream-dwelling salamanders were not captured in any pitfall traps because they rarely travel far from the stream channel (T. Fredericksen, pers. obs.), but we found them to be very abundant in streams in the park and found four species during stream searches. Among terrestrial salamanders, it was interesting to note that White-Spotted Slimy Salamanders (*Plethodon cylindraceus*) and Red Salamanders (*Pseudotriton ruber*) were captured more frequently on lowland sites, but the Red-backed Salamander (*Plethodon cinereus*) was captured more commonly on upland sites, but this could be an artifact of small sample size. In a study in Pennsylvania, Ross et al. (2000) found a higher abundance of Red-backed Salamanders, and terrestrial salamanders in general, in more mesic northern hardwood stands compared to drier oak-hickory stands. Requiring moist soils, leaf litter, or cover objects to breathe and for reproduction (Beane et al., 2010), it was expected that they would have been more abundant in lowland forests.

Captures of some species were lower than expected, particularly Red-Spotted Newts, given their observed abundance in the park, as well as some common frog species, such as Green Frogs and Pickerel Frogs. Using the same pitfall trapping strategy, Fredericksen et al. (2010) recorded large numbers of these species in the forests of Ferrum College, approximately 20 km north of the park. Gibson & Sattler (2007) recorded Marbled Salamanders (*Ambystoma opacum*) in the park, but we did not observe that species in this study.

Interior forest bird species, such as Red-eyed Vireo and Ovenbird, were equally dominant in upland and lowland forests. Tufted Titmouse, among the most abundant species, is considered a mature forest generalist (Murray & Stauffer, 1995), but it had a higher abundance in lowland forests. As expected from their preference for streamside habitats (Murray & Stauffer, 1995), Acadian Flycatcher and Louisiana Waterthrush were present only on lowland or transitional sites. In a study conducted in nearby counties, Fredericksen (2008) also observed that American Redstarts were more common in mesic, lowland forests. The Wood Thrush was only detected on lowland sites. This species is more common in mesic forests (Murray & Stauffer, 1995). Other bird species had higher abundances on upland sites. Some species, such as the Great-Crested Flycatcher and Blue-headed Vireo, have been associated with upland oak forests (Murray & Stauffer, 1995). Rodewald (2003) noted an expected preference of bark-foraging bird species for oak forests due to their furrowed bark, which provides more opportunities for insect foraging and for caching food in furrowed or loose bark. The higher abundance of bark-foraging birds on upland sites, such as Hairy Woodpecker and Black-and-White Warbler, supports this hypothesis, but other bark-foraging and seed-caching species, such as Tufted Titmouse, Carolina Chickadee (*Poecile carolinensis*), and White-breasted Nuthatch (*Sitta carolinensis*), did not show preferences for upland forests.

Small mammal captures in Sherman traps consisted predominantly of the White-Footed Mouse. This species was also the most commonly captured mammal in pitfall traps. The number of captures was similar in upland and lowland forests, which was expected because this species is considered to be a habitat generalist (Adler & Wilson, 1987; Menzel et al., 1999).

Some studies, however, have reported a relationship between population levels of this and other species, such as Eastern Chipmunk, to acorn yield (Ostfeld et al., 1996; McShea, 2000; Schnurr et al., 2002), which suggests that upland oak forests may support higher levels of these populations during mast-producing years. Shrew species were commonly captured in pitfall traps. The Smoky Shrew was captured in similar numbers in upland and lowland forests. The Masked Shrew was captured more often in upland forests and the Short-tailed Shrew was captured more commonly in lowland forest sites, although both of these species are considered to be habitat generalists (Mitchell et al., 1997; Menzel et al., 1999). Again, captures of small mammal species were relatively low compared to captures in a study of forests at Ferrum College (Fredericksen et al. 2010) using the same trapping methods.

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