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A comparison of the herpetofauna of four different-aged wooded stands

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A COMPARISON OF THE

HERPETOFAUNA OF FOUR DIFFERENT-AGED

WOODED STANDS

APPROVAL SHEET

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ABSTRACT

The herpetofauna of four different-aged wooded stands on the peninsula between the York and James Rivers in Virginia were studied between April, 1978 and March, 1979. These stands represented dry upland forest habitat at different ages of succession: young pine, intermediate pine, older pine, and deciduous, all with hardwood seedlings and saplings. Information on range in elevation, shortest distance to body of water, amount of cover, organic content of the soil, and leaf litter depth were noted for each stand. Three methods of capture were utilized to collect specimens from the stands: quadrat sampling, searching-collecting, and trapping with drift fences. Field work was conducted with equal effort and at close intervals among the stands to allow quantitative comparisons of the herpetofauna to be made.

A total of 106 specimens distributed among 15 species were collected. The largest number of species obtained was nine for the deciduous stand, with seven from the mature pine stand, six from the intermediate pine stand, and eight from the young pine stand. In terms of total numbers of specimens, 47 were collected from the deciduous stand, 23 from the older pine stand, eight from the intermediate pine stand, and 28 from the young pine stand. The older pine stand produced the highest herpetofaunal biomass, followed by the deciduous stand, the intermediate pine stand, and the young pine stand, but when the weight of turtles is removed, the young pine stand has the highest biomass, followed by the deciduous stand, older pine stand and intermediate pine stand. Searching-collecting was found to be the most productive sampling method, followed by quadrat-sampling, with trapping being the least productive. The proportions of the species collected were found to differ significantly among the four stands.

Generally it was found that the herpetofauna of each stand was influenced by the physical conditions it it. The relatively dry, homogenous state of each stand probably led to the limited number of species inhabiting the stands, and the size of the stands was a factor in limiting the number of individuals collected. There generally appears to be a correlation between total number of individuals collected from each site and the amount of cover as expressed in mean total cross-sectional area of fallen trees per quadrat, and the general lack of cover in the intermediate pine stand may account for the unusually low numbers of individuals found there.

Also, the possible diminishing of both the grazing and detritus food web in that stand is postulated to be a factor. Physical factors also determined the species present, with the young pine stand dominated by those which prefer the open habitats with high exposure to sunlight (Sceloporus undulatus, Bufo woodhousei fowleri), and the more older stands containing higher densities of species which prefer deeper forest and subleaf litter habitat (Eumeces fasciatus, Plethodon cinereus, Carphophis amoenus).

It is postulated from the results that the dry forest herpetofauna in the Peninsula area does change as the physical characteristics change with succession. Especially important is the increase in overall density expected to occur with a buildup in amount of dead trees as the forest matures. Implications of this concerning lumbering in the area are suggested.

INTRODUCTION

There have been many studies over the years on succession of various components of ecosystems. Shelford (1913), who pioneered the placing of animal communities on an equal footing with plant communities in describing the biomes or "formations" of North America, produced a classic study of the invertebrate community on the sand dunes near Lake Michigan. Johnston and Odum (1957), in a study of succession of breeding bird populations in the southeastern United States, found that bird populations change as the life form of the plant dominants (herbs, shrubs, pine, and hardwoods) changes, and that birds influence the succession as carriers in seed dispersal. Other successional studies have been done on fishes (Shelford, 1911a, b), laboratory microcosms (Cooke, 1967), and even organic chemicals (Margalef, 1963a), as well as, of course, terrestrial vegetation.

The study of herpetofaunal succession is in its infancy; however, the results of research on herpetofaunal community structure might indicate the factors which may influence the direction of change such a community will take with time. Heyer and Berven (1973), for example, concluded that overall herpetofaunal species diversity is a function of both the number of microhabitats in a system and the species diversities within microhabitats. Rogers (1976), in a study of species density and taxonomic diversity of Texan amphibians and reptiles, suggests that higher densities are correlated with higher productivity and number of habitat types. Inger and Colwell (1977) found in Thailand that a herpetofaunal community structure is influenced by the predictability of the climate of the ecosystem--a stable climate would allow species with very similar niches to settle into "guilds" in which there would be strong interaction among the species of each guild but they would remain relatively distinct ecologically from species of other guilds, while in an unstable environment there would be more total interaction among all the members of the community and the guilds would be less distinct. The latter situation would lead to a higher extinction rate; the climatically stable community would have a higher equilibrium number of species and thus higher species richness. In a herpetofaunal successional study in a Florida sand pine scrub community, Christman, et al. (1979) found that the herpetofaunal community structure changes through time as the sand pine scrub matures. Species composition was found to be dependent upon the physical characteristics of the habitat, with the presence or absence of cover and standing water having an influence. Generally, the highest species equitability is in the intermediate seral stages, due to a temporal ecotone effect. In none of these studeis was there a suggestion that herpetofauna is influenced by the specific plant association. From these results and an assumption that the general pattern of faunal succession is a manifestation of the ecological requirements and habitat preferences of the individual species, we might expect that the course that a herpetofaunal community takes in its temporal change may be a function of the way the succession of the plant community of the same ecosystem causes a change in such physical factors as light, microclimate, moisture content, leaf litter and detritus, and substrate heterogeneity, and how these factors influence prey availability.

The vegetation in the area in which the present study was conducted, the lower peninsula between the York and James Rivers in Virginia, undergoes a secondary successional sequence which is generally typical for the Southeastern United States (Quaterman and Keever, 1962; Ware, 1970). An old field of grasses and herbaceous dicots is invaded by shade-intolerant pines, in this area chiefly *Pinus taeda* (loblolly pine) and *Pinus virginiana* (Virginia pine). As this forest matures, an understory of shade-tolerant deciduous trees develops, mainly *Liquidamber styraciflua* (sweetgum), *Liriodendron tulipfera* (tulip poplar), *Acer* spp. (maples), *Quercus* spp. (oaks), *Carya* spp. (hickories) and *Fagus grandiflora* (beech). Eventually this canopy overtakes and shades out the pines, and replaces them with a mature deciduous climax stage. Although there has been some debate over the affinities of the hardwood forest of this area, it seems generally to be a northern extension of the Southern Mixed Hardwood Forest (SMHF), with beech, tulip poplar, *Quercus alba* (white oak), *Q. falcata* (southern red oak), *Carya tomentosa*, (mockernut hickory), *C. glabra* (pignut hickory), and *C. cordiformis* (bitternut hickory) being important species (Ware, 1970; Dewitte & Ware, in press). It differs somewhat from the SMHF in that tulip poplar, and *Acer rubrum* (red maple) to a lesser extent, are relatively important.

In this study an attempt was made to determine the herpetofauna associated with four wooded stands of different age. Three of these stands, intermediate aged pine, older pine and deciduous climax, represent seral stages in this area. The fourth, young pine, deviates from an early sere in that remnants of the previous, lumbered forest in the form of logs, dead standing oaks and brush piles, were scattered throughout the study area.

THE STUDY SITES

The four study areas representing the different seral stages were chosen for their degree of homogeneity, as determined by visual observation. All were fairly level and did not contain any standing or running water within their borders.

A. Young Pine Forest

The young pine stand is located at the southeast section at the intersection of U.S. Route 60 and County Route 647 in New Kent County, Virginia, about 32 kilometers west of Williamsburg. The stand is a cutover area approximately 0.5 x 0.5 kilometers in size and ranges from 18 to 34 meters in elevation. A mixed deciduous forest forms its southern and eastern borders, Route 60 its northern border, and Route 647 its western border. There is an intermittent stream on its southern border, and the stand is about 1 km north of the Chickahominy River, and about .8 km southeast of the nearest arm of the Diascund Reservoir. It is generally a very thick stand of 3 to 4.5 meters tall loblolly pines irregularly planted, with a scattering of Virginia pines. The understory consists of herbaceous weeds such as Solidago spp. (goldenrod), Lonicera japonica (honeysuckle) in open spaces, Andropogon virginicus (broomsedge), and tulip tree, sweet gum and red maple seedlings about 1.5 meters tall, with a few Quercus nigra (water oak) and Vaccinium spp. (blueberry) shrubs. Generally, the undergrowth seems to be arranged in a patchy mosaic of three parts: one of honeysuckle, another of herbaceous weeds, and a third of broomsedge. Also scattered within the stand are large, dead, standing and fallen hardwood and pine trees as well as large wood piles left over from the cutting of the previous forest which stood there. There is generally high exposure to sunlight.

B. Intermediate Pine Forest

The intermediate pine stand is in the southeast section at the intersection of Interstate 64 and Va. Route 155 in New Kent County, Virginia, about 40 km northwest of Williamsburg. The stand is about 0.5 x 0.5 km in size and has an elevation ranging from 30.5 to 35 meters. Interstate 64 forms its northern border, Route 155 forms its western border, with a deciduous forest on its eastern border and a deciduous forest and swamp on its southern border. Rumley Marsh lies approximately 1 km west of the stand. The stand consists mainly of loblolly pines about 7 to 7.5 meters tall planted in rows in 1965. The understory consists of sweetgums and white oaks half to three-fourths as tall as the loblollies, patches of low blueberry, Diospyros virginiana (persimmon) saplings, and a number of young, scattered, 1 to 2 meter tall Virginia pines. There are large amounts of dead Rhus copallina (dwarf sumac), throughout the stand. The canopy appears to have just recently closed, and no large die-off (self-thinning) of pines has as yet begun.

C. Older Pine Forest

The older pine stand, located in Waller Mill Park, is located 3.2 km north of Williamsburg. It is also about 0.5 x 0.5 km in size, and its elevation ranges between 21 and 24 meters. It is bordered on the north by County Route 645, on the south and east by a deciduous forest, and on the west by an agricultural field. The stand, which developed on an old field, consists overwhelmingly of loblolly pines

32 to 36 centimeters in diameter, between 27 and 34 meters in height, and about 36 years in age. There are also some Virginia pine, approximately the same age, with a DBH of 20 to 25 cm and a height of about 10 to 12 meters. There is a scattered understory of sweetgum, red maple, *Oxydendrum arboreum* (sourwood), *Prunus* spp. (cherries), *Sassafras albidum* (sassafras), and tulip poplar, and a low shrub-sized layer of mostly white oak seedlings, sparse patches of persimmon, *Myrica cerifera* (wax myrtle), and low *Ilex* spp. (hollies), with dense patches of the hardwood seedlings and saplings in places. There is much free-growing *Campsis radicans* 30 cm tall, some *Vitis rotundifolia* (muscadine grape), and patches of *Rhus radicans* (poison ivy). Also found are scattered blueberry shrubs. There are many dead pine trunks on the ground, a higher percentage of these being Virginia pine than is the case in the living pines.

D. *Deciduous Forest*

The deciduous stand is also in Waller Mill Park. It is about 0.75 x 0.75 km in size, and its elevation ranges from 15-24 meters. It is bordered on the north and west by an agricultural field, and on the south and east by Waller Mill reservoir. The stand, which also developed on an old field, consists of many old beeches, 75 to 85 cm in diameter, the oldest possibly being over 100 years old, tulip poplar, and younger, smaller white oaks. The canopy is between approximately 30 and 36 meters high. The beeches have spreading crowns which suggest that they are left over from a selective cutting. Threre are many 1.5 to 3.0 meter tall hardwood saplings, mainly red maple, beech, and *Cornus florida* (dogwood). The understory is sparse and discontinuous. Dense patches of *Vinca minor* (periwinkle) cover the ground in one place. There are also scattered plants of poison ivy, *Parthenocissus quinquefolia* (Virginia creeper), muscadine grape, *Polystichum acrostichoides* (Christmas fern), and *Dryopteris* spp. (wood fern).

METHODS AND MATERIALS

Field work began in April, 1978, and continued into March, 1979, with no field work during December and February. Intensive collecting was conducted from May to September of 1978, in which field trips were made six days a week, except for a week each in June and July, when no work was attempted. During the rest of the study period, field trips were made on weekends and other available time. In general the four stands were visited on different days in sequence, and most field work was conducted from daytime to twilight. A total of 600 hours were spent in the field.

Three methods of collecting were used: trapping with drift fences, quadrat sampling, and searching-collecting. In each site a trap was constructed consisting of three, one-quarter inch, hardware cloth drift fences, each approximately 30 centimeters high and 24 meters long, set at angles of 120 degrees to each other and converging to a point where a pitfall trap was situated. The pitfall trap was a metal pail about 75 centimeters deep and 60 centimeters in diameter whose top edge was set flush with the ground. An animal which encountered the fence and was unable to cross it would walk along it and, if it chose the correct direction, would be led into the trap. The traps were checked frequently to collect animals caught and to make repairs.

In each site, transects were drawn by randomly choosing points on a compass and collecting was done from 5 x 5 meter quadrats situated along these transects. For each site 100 quadrats were examined, usually 10 per transect, with each quadrat about 50 meters apart. Each quadrat included a 5 x 5 meter inner zone in which trees were examined for arboreal species, leaf litter was raked for fossorial species, and dead trees were examined and broken apart for species which use them for shelter. If an animal was found outside the quadrat but within 5 meters of its border, it was treated as having been collected in the quadrat. If it was farther than 5 meters from the border it was taken as a sample from searching-collecting. In most of the quadrats, temperature, humidity, and leaf litter depth were measured.

The third sampling method, searching-collecting, was accomplished by searching in the sites for a period of time and collecting what was found. Searching-collecting was usually done on days when there was no quadrat-sampling, while walking transects between quadrats, and in areas outside quadrats while quadrat sampling, as mentioned above. To make comparisons as quantitative as possible, approximately equal time was devoted to searching-collecting at each stand. In both searching-collecting and quadrat sampling, care was taken not to sample close to an ecotone in order to avoid edge effect.

In January and March of 1979, 400 additional 5 x 5 meter quadrats, 100 in each stand, were chosen by the same methods as described previously, and surveyed for cover. This involved measuring length and width of dead trees, standing and fallen, which were within each quadrat. Soil samples were also taken, and the percentage of organic composition estimated by burning dried samples in an oven at about 680°C for approximately 3 hours.

Animals were collected, the microhabitat they were occupying when found was recorded (for example: resting on fallen tree), and brought back to the laboratory where they were weighed and preserved. Each specimen was given a code which indicated the date it was taken, in which stand, and by which method.

The Shannon index of general diversity was used to compare the species diversities of the four collections, and Shannon's evenness index was used to measure the differences in the way the individuals are distributed among the species in the four collections (Zar, 1974).

RESULTS

A total of 106 specimens representing 15 species were collected during the sampling period (Table 1). The largest number of species collected from any stand was 9 from the deciduous stand; the lowest, 6, from the intermediate pine stand. Eight species were collected in the young pine stand and 7 in the mature pine stand. In terms of total numbers of individuals, the deciduous stand had the highest with 47, the young and older pine stands produced 28 and 23 specimens, respectively, and only 8 were collected in the intermediate pine. The species found to be the most abundant (26) was the box turtle, *Terrapene carolina*, followed by the red-backed salamander *Plethodon cinereus* (18). Other species represented by five or more specimens were the iguanid lizard *Sceloporus undulatus* (14), the scincid lizard *Eumeces fasciatus* (9), the colubrid snake *Carphophis amoenus* (10), and the toads *Bufo woodhousei fowleri* (8), and *B. americanus* (6). The deciduous stand had the highest Shannon-Weaver diversity index value and the older pine stand had the lowest value (Table 1). The intermediate pine stand had the highest value for Shannon's evenness index (Table 1), although only eight specimens were found in this stand. This is followed by the value of the deciduous stand, with the older pine having the lowest value. In general, the relative abundances of the 15 species was significantly different ($.01>P>.005$) between stands as determined by a G-test of independence.

Table 1

Total reptiles and amphibians collected from four different-aged wooded stands

	YP	IP	OP	D	T
Urodela					
Plethodon cinereus	-	-	2	16	18
P. glutinosus	-	-	-	1	1
Anura					
Rana clamitans	2	-	-	2	4
Gastophryne carolinensis	1	-	-	-	1
Hyla crucifer	-	2	-	-	2
Scaphiopus holbrooki	1	-	1	-	2
Bufo woodhousei fowleri	6	1	-	1	8
B. americanus	2	1	1	2	6
Subtotal	12	4	4	22	42
Sauria					
Sceloporus undulatus	14	-	-	-	14
Eumeces fasciatus	-	-	1	8	9
Ophidia					
Coluber constrictor	1	-	-	-	1
Carphophis amoenus	-	1	2	7	10
Diadophis punctatus	-	-	2	1	3
Heterodon platyrhinos	-	1	-	-	1
Subtotal	15	2	5	16	38
Chelonia					
Terrapene carolina	1	2	14	9	26
Grand Total	28	8	23	47	106
Shannon-Weaver diversity index($-\Sigma p \log p$)	.664	.753	.586	.793	
Shannon evenness index ($\frac{H}{Hmax}$)	.736	.967	.692	.831	

The total herpetofaunal biomass for each stand is given in Table 2. The older pine produced the highest biomass with 5202.4 grams, followed by the deciduous stand with 4011.1 g, the intermediate pine with 962.6 g, and the young pine stand with 842.4 g. Most of the biomass was accounted for by the relatively large number of box turtles found, and if their weight is removed, the order of magnitude changes: 522.6 g for the young pine stand, 377.5 g for the deciduous stand, 64.4 g for the older pine stand, and 30 g for the intermediate pine stand. The box turtles have the highest total biomass in the collection with 10241.0 g, followed by an uncollected Coluber constrictor (400 g estimate, based on previously caught specimens), Bufo americanus (114.3 g), Sceloporus undulatus (53.8 g), Carphophis amoenus (45.4 g), Eumeces fasciatus and Scaphiopus holbrooki (33.9 g) each and Bufo woodhousei and Rana clamitans (26.5 g) each, with the others being lower.

The numbers of specimens and their biomass collected by each of the three capture methods are listed on Table 3. Overall, searching-collecting was the most productive method in terms of both numbers and biomass, with quadrat sampling being the second most productive in both categories. Trapping was the least productive. Generally, numbers collected by quadrat sampling increased with the age of the stand regardless of overall sample size, while trapping contributed only a relatively small percentage of the individuals collected in any stand.

The physical features of the stands are summarized in Table 4. Cover, as measured in terms of mean cross-sectional area of dead trees 15 cm in diameter and greater per quadrat, was found to be highest in the

Table 2

Total biomass of reptiles and amphibians collected from four different-aged wooded stands

	YP	IP	OP	D	T
Urodela					
Plethodon cinereus	-	-	1.9	10.1	12.0
P. glutinosus	-	-	-	1.0	1.0
Anura					
Rana clamitans	6.9	-	-	19.6	26.5
Gastophryne carolinensis	1.7	-	-	-	1.7
Hyla crucifer	-	3.2	-	-	3.2
Scaphiopus holbrooki	14.0	-	19.9	-	33.9
Bufo woodhousei fowleri	22.7	2.8	-	1.0	26.5
B. americanus	23.5	10.6	21.5	58.7	114.3
Subtotal	68.8	16.6	43.3	90.4	219.1
Sauria					
Sceloporus undulatus	53.8	-	-	-	43.8
Eumeces fasciatus	-	-	3.0	30.9	33.9
Ophidia					
Coluber constrictor	400.0(est)	-	-	-	400.0
Carphophis amoenus	-	2.0	8.8	34.6	45.4
Diadophis punctatus	-	-	9.3	4.6	13.9
Heterodon platyrhinos	-	11.4	-	-	11.4
Subtotal	453.8	13.4	21.1	70.1	558.4
Chelonia					
Terrapene carolina	319.8	932.6	5138.0	3850.6	10241.0
Grand Total	842.4	962.6	5202.4	4011.1	11018.5

Table 3

Total yield by methods of capture

Stand Species	Search No.	Search Wt.(g)	Trap No.	Trap Wt.(g)	Quadrat No.	Quadrat Wt.(g)
Young Pine						
R. clamitans	-	-	2	6.9	-	-
G. carolinensis	-	-	1	1.7	-	-
S. holbrooki	-	-	1	14.0	-	-
B. woodhousei fowleri	3	5.7	2	14.5	1	2.5
B. americanus	1	11.5	-	-	1	12.0
S. undulatus	14	53.8	-	-	-	-
C. constrictor	1	400(est)	-	-	-	-
T. carolina	1	319.8	-	-	-	-
Subtotal	20	790.8	6	37.1	2	14.5
Intermediate Pine						
H. crucifer	-	-	-	-	2	3.2
B. woodhousei fowleri	-	-	-	-	1	2.8
B. americanus	1	10.6	-	-	-	-
C. amoenus	-	-	-	-	1	2.0
H. platyrhinos	1	11.4	-	-	-	-
T. carolina	-	-	2	932.6	-	-
Subtotal	2	22.0	2	932.6	4	8.0
Older Pine						
P. cinereus	-	-	-	-	2	1.9
S. holbrooki	-	-	1	19.9	-	-
B. americanus	-	-	1	21.5	-	-
E. fasciatus	1	3.0	-	-	-	-
C. amoenus	-	-	-	-	2	8.8
D. punctatus	-	-	2	9.3	-	-
T. carolina	6	2243.7	2	760.7	6	2133.6
Subtotal	7	2246.7	6	811.4	10	2144.3

Table 3 (cont'd.)

Total yield by methods of capture

Stand Species	Search No.	Search Wt.(g)	Trap No.	Trap Wt.(g)	Quadrat No.	Quadrat Wt.(g)
Deciduous						
P. cinereus	6	3.5	1	1.1	9	5.5
P. glutinosus	1	1.0	-	-	-	-
R. clamitans	1	13.3	1	6.3	-	-
B. woodhousei fowleri	1	1.0	-	-	-	-
B. americanus	1	19.9	-	-	1	38.8
E. fasciatus	4	13.0	-	-	4	17.9
C. amoenus	3	10.8	-	-	4	19.9
C. punctatus	1	4.6	-	-	-	-
T. carolina	5	2195.0	-	-	4	1655.6
Subtotal	23	2252,1	2	7.4	22	1741.6
TOTALS	52	5321.6	16	4043.2	38	3908.4

Table 4

Physical Characteristics of the Four Stands

	YP	IP	OP	D
Size (km)	.5 x .5	.5 x .5	.5 x .5	.75 x .75
Elevation (m)	18 - 34	30 - 35	21 - 24	15 - 24
Distance from nearest water (km)	.8	borders	.3	borders
Amount of cover (mean total cross-sectional area of dead trees per quadrat) cm^2	276.75	173.01	280.14	529.71
Leaf litter depth (mm)	8.8 ± 10.07	25.4 ± 4.50	26.8 ± 9.75	25.0 ± 8.53
% organic material in soil	5.7 ± .46	3.1 ± .17	2.1 ± .12	6.5 ± .67

deciduous stand, lowest in the intermediate pine stand, and nearly equal in the young and older pine stands, being somewhat intermediate between the values of the other two stands. The young pine had the lowest leaf litter depth, but it was relatively close in the other three, although the quality of the litter changes, being, of course, mainly deciduous in the deciduous stand. The soil of the deciduous stand had the highest percentage of organic content, with the young pine soil being nearly as rich, and the intermediate and older pine soils having only one-half and one-third the organic content of the deciduous soil, respectively. All four soils, however, seem to be rather sandy and porous.

One correlation that is apparent is the total number of individuals collected per stand and the amount of cover per stand (Fig. 1). Both amount of cover and individuals collected are lowest for the intermediate pine stand, highest for the deciduous stand, and roughly intermediate for the young and the older pines. Also, the ratios of amount of cover to number of individuals remains between 9.9 and 12.2 for the young and older pines and deciduous, but increases to 21.6 for the intermediate pine stand.

An account of the herpetofauna for each stand is given below:

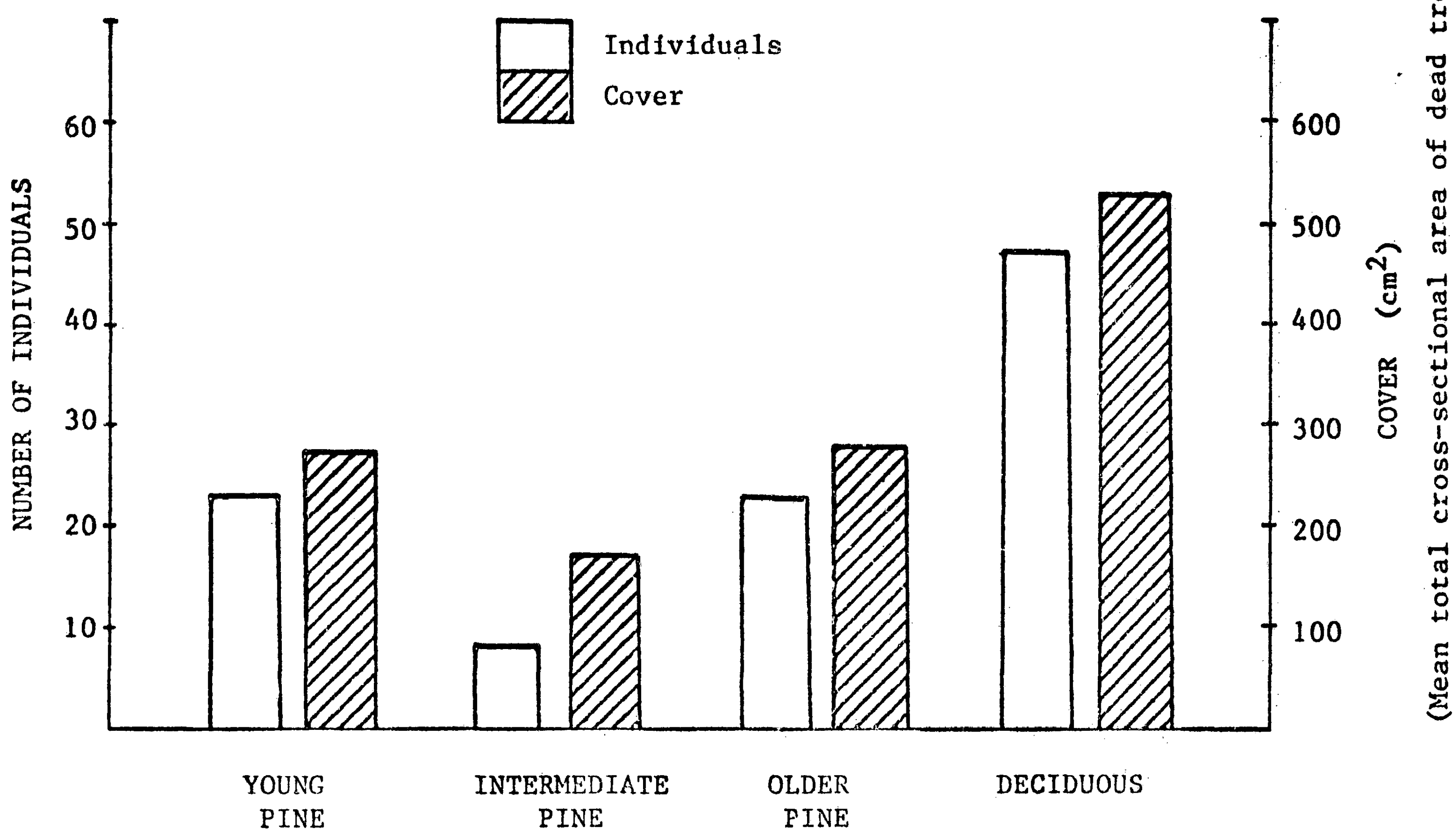
A. Young Pine Forest

The iguanid lizard Sceloporus undulatus made up the largest proportion of individuals collected from this stand. This was the only stand where this species was found, although individuals were noted on the edges of the older pine and deciduous stands. The adults (6), were

Fiqure 1

COMPARISON OF TOTAL INDIVIDUALS COLLECTED FROM STANDS

WITH AMOUNT OF COVER IN STANDS



found on large dead trees and wood piles left from the cutting of the previous forest, while immature individuals were found on the forest floor. The second most abundant species in this stand was the toad Bufo woodhousei fowleri, and most of the total individuals of this species collected were from this site. One large colubrid snake, Coluber constrictor, was found but not collected. Others found were Rana clamitans, Gastophryne carolinensis, Scaphiopus holbrooki, Bufo americanus, and Terrapene carolina.

B. Intermediate Pine Forest

This stand produced only eight individuals, spread among six species. Those species found were Hyla crucifer (2), Bufo woodhousei fowleri (10, B. americanus (1), Terrapene carolina (2), Carphophis amoenus (1), and Heterodon platyrhinos (1).

C. Older Pine Forest

The box turtle, Terrapene carolina, made up the bulk of the individuals collected from this stand, and over half the individuals of this species found were from this site. This species, as mentioned previously, is the most abundant in the collection, and is also one of only two species found in all four stands, the other being the toad Bufo americanus. The few other individuals collected from this stand are distributed evenly among six species: Plethodon cinereus, Scaphiopus holbrooki, B. americanus, Eumeces fasciatus, Carphophis amoenus, and Diadophis punctatus.

D. Deciduous Forest

This stand had the highest number of individuals (47), and the highest number of species (9). The lungless salamander Plethodon cinereus was the most abundant species in the collection. Generally, the salamanders were found under leaf litter, logs, and bark during Spring and Fall, with none being found during the summer months. Box turtles also made up a large proportion of the individuals of the scincid species, *Eumeces fasciatus*. All of these individuals were found on large dead trees, especially tulip poplars. *Carphophis amoenus*, the worm snake, was also found under leaf litter and fallen bark. Other species found in small numbers were *Plethodon glutinosus*, *Rana clamitans*, *Bufo woodhousei fowleri*, *B. americanus*, and *Diadophis punctatus*.

DISCUSSION

There are two results which are apparent in the frequency distribution of total reptiles and amphibians collected. One is the relatively small numbers of species collected. There is estimated to be about 70 species in the Williamsburg area of Virginia (Conant, 1975), so that 15 species would be a small representation. A possible explanation for this is that relatively homogenous dry forest habitats with no standing or running water were surveyed. The lack of aquatic environments in the study automatically excludes about nine species of pond and streamside salamanders such as Notophthalmus viridescens, Ambystoma spp. and Pseudotriton spp.; 12 species of anurans including ranids, hylids, and microhylids; about nine species of turtles belonging to the families Emydidae and Kinosternidae as well as the chelydrid Chelydra serpentina; and many snakes which frequent moist areas, such as those of the genera Natrix and Thamnophis. The exclusion of moist habitats is also reflected in the results by the fact that 60 percent of the individuals collected were reptiles, and that the bulk of the amphibians collected, such as Plethodon cinereus, bufo woodhousei fowleri, and B. americanus, are known to inhabit relatively drier areas. Another factor which may have had an influence on the number of species found is that the sites, all being fairly level, homogenous stands, in a sense were only four microhabitats, possibly allowing for only a few relatively wide niches, and thus leading to competitive exclusion from the community of many species. Jaeger (pers. comm.) suggests that the dry forest habitat on the Peninsula is a stochastic, or fluctuating, environment (May and MacArthur, 1972), at least for the salamanders of the area. Amphibians are dependent on moisture to avoid dessication. In the dry forests such as the ones surveyed, water appears only occasionally in the form of rain, while in aquatic habitats moisture is constant. Thus for amphibians the dry forest habitat is a stochastic environment while the aquatic habitat is deterministic or stable. For *Plethodon cinereus*, the stochastic environment causes it to become opportunistic, thus widening its niche and leading to competitive exclusion of *P. glutinosus* (Jaeger, pers. comm.).

A second result that is apparent is the small sample size. One possible reason for this is the small sizes of the study sites. The vegetation on the Peninsula has undergone a tremendous amount of disturbance and thus homogenous stands are relatively small. Since all terrestrial vertebrates have limits on their densities, the size of a habitat will influence overall abundances. Another reason is probably the limited man hours devoted to collecting, since usually only one person was able to go out into the field. A third reason is that a greater percentage of the field time(about 455 out of 600 hours), was devoted to searching-collecting, which was a less efficient method per man hour than examining quadrats, the latter being more efficient for collecting sub-leaf litter species (*Plethodon cinereus*, *Carphophis amoenus*), which are relatively important in the collection, especially in the older stands. This also accounts for the increase in quadrat yield with age of stand.

One aspect of the results mentioned previously is the apparent correlation between number of individuals and the amount of cover in the form of dead trees (Fig. 1). This may partially explain the relatively low numbers found in the intermediate pine stand. The young pine had an unexpectedly high amount of cover due to the dead trees left from the cutting of the previous forest. However, the intermediate pine stand is, of course, older, and most of the cover left from the previous forest on that site has broken down and disappeared, and it probably will not reappear in a substantial amount until the pines start reaching maturity. After the deciduous forest matures, cover should increase substantially, due to the higher cross-sectional areas of the older hardwoods. The way these dead trees are utilized depends on the species. For amphibians in general they provide areas where moisture is retained during dry periods. For lizards they provide a place for thermoregulation and territorial lookout. For many species they provide shelter and food in the form of the invertebrate detritivores upon which they prey. In general, there is a positive relationship, and a strong correlation should not be surprising. Also, the correlation on the Peninsula may be especially strong due to the fact that it lies on the Coastal Plain, where rock outcroppings which could also serve as cover are nonexistent; thus the herpetofauna is totally dependent on the dead trees in natural areas. Since, as suggested above, amount of cover changes with the age of the forest, it might be expected that the density of the herpetofauna associated with the forest changes along with it.

Associated with this is the change in energy flow as an ecosystem matures, with the general decrease in the productivity to biomass ratio and the change from a grazing to a detritus food web(See Odum, 1971; and Horn, 1973, for reviews). This is reflected in the increase in leaf litter depth and organic content of soil in the most mature stage, with a concomitant increase in the subleaf-litter species (Plethodon cinereus, Carphophis amoenus) which feed on invertebrate detritivores. It is possible to speculate that the unusually low numbers of individuals collected from the intermediate pine may also be partially caused by the shading-out of the flowering herbaceous dicots, which may indirectly provide food for resident herpetofauna in the form of nectar and pollen-feeding insects, while at the same time no substantial die-off of pines has as yet begun. Thus for the intermediate pine herpetofauna there may be neither a very substantial grazing or detritus food web.

As Christman, et al.(1979) found, the youngest and oldest pine had the lowest species equitability, while the intermediate stage had the highest. They attributed this to a temporal ecotone effect, with the intermediate stands having representatives of species which prefer the younger stages and of species which prefer the older stages in fairly substantial numbers. In this study the intermediate pine was also found to have the highest species equitability, but it was probably caused by the poor conditions in the intermediate pine affecting all species equally. As was also found in the Florida study, the presence of different species in different sites reflects the individual ecologies of of each species as well as physical conditions of the stand. For instance, the young pine stand is relatively open and the floor is exposed to a high amount of sunlight. The young pine as a result should have greater extremes in moisture and temperature than the deciduous stand, which would be expected to have a more buffered micro-climate. This limits the species which can inhabit this stand to the ones which can withstand these relatively harsher conditions.

One species which was found in the young pine stand was Sceloporus undulatus. This lizard is generally known to prefer open areas with high exposure to sunlight and much dead wood (Mansuetti, 1943), which are conditions found in the young pine stand. As mentioned previously, all adults were found on large dead trees left from the previous forest. Iguanid lizards, including S. undulatus, are known to be territorial and to center their territories around a high point such as a fallen tree (Carpenter, 1967). The fallen tree fulfills certain needs for the lizard, such as a lookout, a point for making aggressive and mating displays, a surface on which to thermoregulate, a shelter, and a source of food (invertebrate detritivores). The lizards found seem to most prefer a situation where a large log was lying next to a tall standing tree, the standing tree allowing for an escape from enemies. Bufo woodhousei fowleri, which was found mainly in the young pine stand, is also noted for preferring more open, clearing-type habitats (Cory and Manion, 1955); however, it is also noted for preferring such habitats with ponds in them, and the lack of one in the young pine stand may account for the small numbers of this species found. The few specimens of its congener, B. americanus, collected were spread evenly among the four stands. This species is known to prefer deeper forest-type habitat, and is thus separated ecologically from B. woodhousei.

Box turtles, Terrapene carolina, seem to prefer the more mature stands, which may be explained by its more omnivorous diet, and also its preference for resting under logs and rotting vegetation. They may also feed on the fungi growing around rotting logs.

The second most abundant species in the collection was Plethodon cinereus, which was found primarily in the deciduous stand. Generally they were found under leaf litter and fallen trees, and under the fallen bark at the bases of standing dead trees. P. cinereus are mainly active during cooler times of the year (Highton, 1971). Therefore, no individuals were found during the summer months, probably having retreated underground. Since about 250 of the 400 quadrats were surveyed during these months, the abundance of P. cinereus may have been underestimated.

Another species which was fairly abundant, especially in the deciduous stand, is the worm snake, Carphophis amoenus. They were found in conditions similar to P. cinereus, such as under leaf litter and fallen bark, and like P. cinereus, they feed on soil invertebrates. Another small colubrid snake, Diadophis punctatus, was also found in the mature pine and deciduous stands, but in very small numbers. However, this may be an underestimation. These snakes prefer living in dead trees, and many of the dead trees were difficult to tear apart completely. It is probable that there is a small population of this species in both the mature pine and deciduous stands.

It appears that the deciduous stand supports a population of scincid lizards, Eumeces fasciatus. This species has been shown previously to prefer deeper forest-type habitat, as opposed to the more open-type habitat favored by S. undulatus (Fitch and von Achen, 1977). All individuals of this species were found on large fallen trees, except an adult and immature, which were found under the bark of a dead standing pine. Generally they also seem to prefer a situation similar to that which S. undulatus preferred - a large fallen deciduous tree next to a standing dead tree to which it would escape. It is probable that E. fasciatus uses the fallen tree for the same reasons as S. undulatus - as a lookout, a thermoregulatory surface, a food source, and possibly a high point for mating displays. Although it has been noted that E. fasciatus lacks territoriality (Fitch, 1967), it is possible that it has some form of home range with a large fallen tree as a center.

One individual each of the large colubrid snakes Coluber constrictor and Heterodon platyrhinos were found, the former in the young pine stand, the latter in the intermediate pine. C. constrictor individuals were observed on the edges of the mature pine and deciduous stands, and this preference for forest edges has been noted previously (Wright and Wright, 1957).

Rana clamitans, Gastophryne carolinensis, Hyla crucifer, and Scaphiopus holbrooki appear to be waifs from wetter habitats, although S. holbrooki, the spadefoot toad, may inhabit the mature pine stand due to the sandy soil in which the toad may burrow. Rana clamitans seems abundant locally around standing water, but ventures into the forests after rains when temporary pools form.

In conclusion, it is apparent that there are a number of factors which can influence the herpetofauna in any one stand, and these factors change with the age of the stand. Light intensity, microclimate, moisture, and detritus seem to be important in creating conditions which influence the kind and relative abundances of species. Especially important, at least in the case of the herpetofauna of the dry upland forests on the Peninsula, is the amount of cover in the form of logs and dead trees, which seem to have a positive effect on overall herpetofaunal abundance. This can be understood in light of the ecology of the individual species, many of which depend on the dead trees for one reason or another. Since lumbering is a relatively important industry in this part of Virginia, one must consider the negative effect on herpetofaunal density of clearing forests instead of allowing them to mature and building up a layer of cover.

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