EFFECTS OF PRESCRIBED FIRE ON HERPETOFAUNA WITHIN HARDWOOD FORESTS OF THE UPPER PIEDMONT OF SOUTH CAROLINA: A PRELIMINARY ANALYSIS

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Abstract—Despite a large body of knowledge concerning the use of prescribed burning for wildlife management, amphibians and reptiles (collectively, herpetofauna) have received relatively little attention regarding their responses to fire. With few exceptions, previous studies of herpetofauna and prescribed burning have been confined to fire-maintained, pine-dominated ecosystems in the Coastal Plain of the southeastern United States. We initiated a study to examine effects of prescribed burning on herpetofauna in Piedmont upland hardwood stands. Linear drift fence arrays with pitfall traps were installed within control and treatment plots to assess effects of burn treatments through analysis of species captures. Treatment plots were subjected to low intensity winter and growing season fire. The initial prescribed burn treatments were implemented in February and March (1999) while the second prescribed burn treatments were implemented in April (2000). All treatment plots were burned with strip head fires set 10-20 feet apart resulting in flame lengths averaging less than 1 foot. Direct searching and drift fence sampling immediately after each prescribed burn revealed 1) no evidence of direct herpetofaunal mortality, and 2) no evidence of emigration from burn plots. Statistical analysis of data through the installation of the second burn (May 1999 through April 2000) revealed no significant difference between burned and unburned treatments for abundance, richness (S), diversity (H'), or evenness (J')($P > 0.1$) of the herpetofaunal community.

INTRODUCTION

Prescribed burning is used to achieve a variety of silvicultural objectives including controlling heavy fuel accumulation, exposing mineral soil, releasing available nutrients for seedbed preparation, and controlling certain diseases, insects, and competing vegetation (Hunter 1990, Pyne and others 1996). Prescribed burning is also an important tool for wildlife management because it influences the amount and type of food and cover by modifying habitat structure. Despite a large body of knowledge concerning the use of prescribed burning for wildlife management, amphibians and reptiles (collectively, herpetofauna) have received relatively little attention regarding their responses to fire (deMaynadier and Hunter 1995, Harlow and Van Lear 1981, 1987, NCASI 1999, NCASI 1993, Russell and others 1999, Smith 2000). With few exceptions (i.e., Ford and others 1999, Kirkland and others 1996), previous studies of herpetofauna and prescribed burning have been confined to fire-maintained, pine-dominated ecosystems in the southeastern Coastal Plain (e.g., Lyon and others 1978, Means 1978, Means and Campbell 1981, McLeod and Gates 1998). Because little data are available concerning responses of herpetofauna to fire in other regions and forest types, we initiated a study to examine the effects of prescribed burning on herpetofauna in Piedmont upland hardwood stands.

Increased demands on southeastern forests, both public and private, are expected to continue (Sharitz and others 1992, USDA Forest Service 1988). As demands on timber resources increase, the use of prescribed fire as a forest management tool will continue to expand. If herpetofauna are to be considered in future forest management decisions, the effects of forestry practices such as prescribed burning on herpetofauna must be better understood. Objectives of this research effort included the determination of both the direct and indirect effects of prescribed fire on the diversity and abundance of herpetofaunal species within pine-hardwood forests in the Piedmont of the Southeast. Questions addressed within this research are of particular relevance in light of the utilization of prescribed fire in hardwood-dominated forest habitats within recent research to regenerate oak species (e.g., Barnes and Van Lear 1998, Brose and others 1999a, Brose and others 1999b, Van Lear 1991).

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Citation for proceedings: Outcalt, Kenneth W., ed. 2002. Proceedings of the eleventh biennial southern silvicultural research conference. Gen. Tech. Rep. SRS–48. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 622 p.

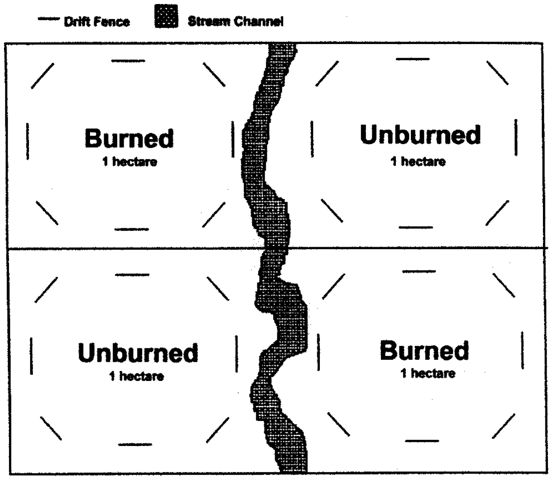

Figure 1—Experimental design of treatment and control plots of each of the three research sites, Clemson University Experimental Forest, Clemson, South Carolina, May 1999-April 2000.

METHODS AND STUDY AREA

Study Design and Site Selection

Study sites were located within the northern portion of the 17,356 acre Clemson University Experimental Forest (CUEF) in Pickens County in the Upper Piedmont of northwestern South Carolina. The CUEF is characterized by slightly to moderately rolling hills with elevations to 1,000 feet above sea level. Soil associations are Pacolet-Madison-Wilkes and Cecil-Hiawassee-Catuala (Typic Kanhapludults and Typic Hapludalfs). Soils are strongly acidic, firm and clayey being derived from gneiss, mica schist, hornblende schist and schist (Smith and Hallbeck 1979).

We evaluated the effects of prescribed burning on herpetofauna species found within three sites located along separate stream drainages within hardwood forest stands. These sites were selected based on similarity of species composition (dominant vegetation), vegetative structure, and aspect. The upland hardwood stands adjacent to each stream were divided into approximately 2.5 acre (1 hectare) control (unburned) and burn treatments (figure 1), for a total of six burn and control plots, respectively.

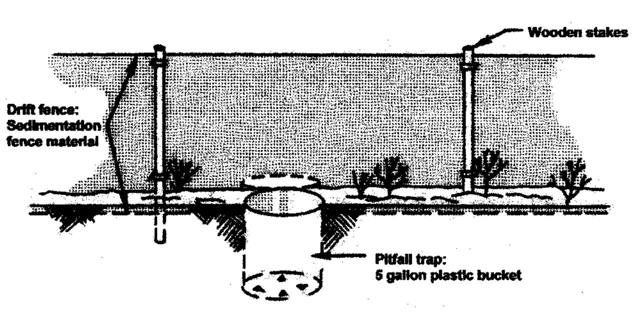

Figure 2—Schematic of pitfall-drift fence array construction, Clemson University Experimental Forest, Clemson, South Carolina, May 1999-April 2000 (diagram adapted from: Gibbons and Semlitsch 1982).

Herpetofaunal Sampling

Herpetofaunal species composition of the study sites were determined through the capture of individuals within pitfall-drift fence arrays. Linear drift fence arrays with pitfall traps (Gibbons and Semlitsch 1982) were installed along the perimeter of each plot to sample small terrestrial herpetofauna. Each drift fence array consisted of a 30 foot section of silt cloth with 2 pitfall traps (each a 5 gallon bucket, buried flush with the soil surface) at each end of the fence for a total of 4 pitfalls/fence (figure 2). Each plot had eight drift fences for a total of 96 drift fences and 384 pitfall traps among the three sites. All herpetofauna captured were identified to species, sex (when possible), age class, measured to the nearest mm in snout-vent length (SVL) and total length (TL), and marked. After all information was recorded and a mark assigned, herpetofauna were released on the opposite side of the fence from which they were captured.

Prescribed Fire Treatments

The initial prescribed burn treatments were implemented in February 1999 (sites 1, 2) and March 1999 (site 3) with strip head fires set 15-30 feet apart resulting in flame lengths averaging slightly over 1 foot. The second prescribed burn treatments (intended to be “growing season” burns) were implemented in April 2000 for all three sites with strip head fires set 10-20 feet apart. Flame lengths averaged less than 1 foot because of light fuel loading.

Statistical Analysis

We calculated species richness (S; Margalef 1958), evenness (J’; Pielou 1969), and diversity (H’; Shannon 1948) for amphibian and reptile communities at each site. Student’s t-tests (Brower and others 1990) were calculated to compare mean values of abundance, richness, evenness, and diversity between burned and unburned (control) treatments. We also determined abundance for each order or suborder (or family), (i.e., frogs, toads, salamanders, newts, turtles, lizards, and snakes). We then compared the mean values of abundance, richness, evenness, and diversity for each of these taxonomic groups between burned and unburned site treatments using t-tests.

RESULTS

Direct searching and drift fence sampling immediately after prescribed burns revealed 1) no evidence of direct herpetofaunal mortality, and 2) no evidence of emigration from burn plots. Within the data analyzed (May 1999 through April 2000), 29 species of amphibians and reptiles were captured from the three drainages combined. Four species of the 29 were captured only in burned plots, while 5 species were captured only in unburned plots (table 1). Preliminary analysis of data following the first prescribed fire treatment using indices of species overlap (i.e., a measure of the number of shared species) indicated greater differences between sites (e.g., site 1 vs. site 2: 0.615) than between burn and control treatments (0.800). Statistical analysis of data through the installation of the second burn (May 1999 through April 2000) revealed no significant difference between burned and unburned

Table 1–Herpetofaunal taxa captured from burned and control plots in the Clemson University Experimental Forest, South Carolina, May 1999-April 2000

Taxonomic group	Common name	Treatment	
		Burn	Control
AMPHIBIA (amphibians)			
Caudata (salamanders)			
Desmognathus fuscus	(northern dusky salamander)	*	*
Desmognathus monticola	(seal salamander)		*
Desmognathus ocoee	(Ocoee salamander)	*	*
Desmognathus quadramaculatus	(black-bellied salamander)		*
Eurycea cirrigera	(southern two-lined salamander)	*	*
Eurycea guttolineata	(three-lined salamander)		*
Gyrinophilus porphyriticus dunni	(Carolina spring salamander)	*	*
Notophthalmus v. viridescens	(red-spotted newt)	*	*
Plethodon chlorobryonis	(Atlantic Coast slimy salamander)	*	*
Pseudotriton ruber schencki	(black-chinned red salamander)	*	*
Total salamanders		**51**	**77**
Anura (frogs and toads)			
Acris c. crepitans	(eastern cricket frog)	*	*
Bufo a. americanus	(eastern American toad)	*	*
Bufo terrestris	(southern toad)	*	
Bufo fowleri	(Fowler's toad)	*	*
Hyla chrysoscelis/versicolor	(gray treefrog)		*
Rana clamitans melanota	(northern green frog)	*	
Total anurans		**57**	**48**
Total amphibians		**108**	**125**
REPTILIA (reptiles)			
Serpentes (snakes)			
Carphophis a. amoenus	(eastern worm snake)	*	*
Diadophis punctatus edwardsii	(northern ring-necked snake)	*	*
Elaphe o. obsoleta	(black ratsnake)	*	*
Heterodon platirhinos	(eastern hog-nosed snake)		
*			
Nerodia s. sipedon	(common watersnake)	*	
Storeria o. occipitomaculata	(northern red-bellied snake)		*
Tantilla coronata	(southeastern crowned snake)	*	
Total snakes		**16**	**20**
Lacertilia (lizards)			
Anolis c. carolinesis	(northern green anole)	*	*
Eumeces fasciatus	(common five-lined skink)	*	*
Eumeces inexpectatus	(southeastern five-lined skink)	*	*
Sceloporus undulatus hyacinthinus	(northern fence lizard)	*	*
Scincella laterallis	(little brown skink)		*
*			
Total lizards		**69**	**54**
Testudines (turtles)			
Terrapene c. carolina	(eastern box turtle)	*	*
Total turtles		**2**	**3**
Total reptiles		**87**	**77**
Total captures		**195**	**203**

treatments for abundance, richness (S), diversity (H'), or evenness (J')(P > 0.1). Analysis of abundance, richness, diversity, and evenness for taxonomic groups (frogs, toads, salamanders, newts, turtles, lizards, and snakes) revealed no significant difference with respect to treatment (P > 0.1). However, captures of individuals tended to be greater within unburned (control) plots for salamanders and snake species (figure 3) and may prove significant as more data becomes available with continued sampling.

DISCUSSION

The lack of statistically significant differences in data between treatments may be attributed to the limited subset of project data available for this preliminary data analysis. Significant differences between burned and control treatments may be found in future analyses of data collected over a greater temporal scale. We believe that the differences (although not statistically significant) observed in salamander species capture between burned and unburned plots are an indirect result of the low intensity prescribed fire treatments. Surface fires introduced to the treatment plots substantially reduced or completely eliminated the litter mass, but not the duff mass, on the forest floor until leaf fall the following autumn.

Ash (1995) postulated that reductions in litter mass, depth, and moisture may contribute to the disappearance of terrestrial salamander species as they depend on a moist environment for dermal respiration and on litter as their primary foraging substrate. Furthermore, low intensity surface fire in mature upland mixed hardwood stands may reduce moisture content of the soil surface through the elimination of leaf litter and by increasing the amount of solar radiation reaching the soil surface (Barnes and Van Lear 1998).

Plethodontid salamanders (the lungless family of salamanders with an entirely terrestrial life cycle) spend roughly 70 - 80 percent of their lives in underground burrows, emerging at night to forage within the leaf litter under favorable conditions (Ash 1995, Taub 1961). The combined effect of decreased surface soil moisture and repeated reduction or elimination of leaf litter mass by prescribed fire treatments could result in a decrease in the relative humidity in these burrows, resulting in the gradual decline of salamander populations within burned plots, especially in more xeric sites (e.g., ridge tops).

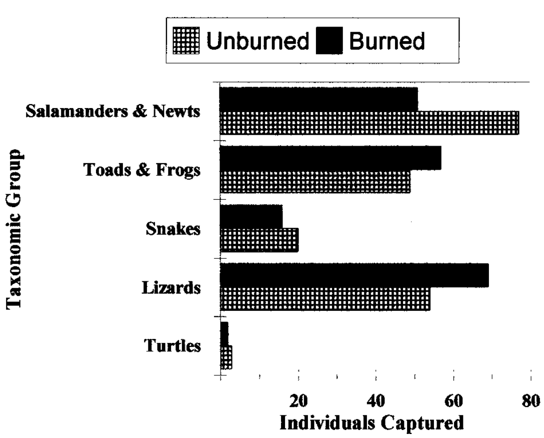

Figure 3—Total number of individuals captured by taxonomic group following burning in the Clemson University Experimental Forest, Clemson, South Carolina, May 1999-April 2000.

SUMMARY AND CONCLUSIONS

Preliminary analysis of a subset of project capture data (May 1999 through April 2000) revealed no significant difference between burned and unburned treatments with respect to abundance, richness (S), diversity (H'), or evenness (J')(P > 0.1). Analysis of abundance, richness, diversity, and evenness for taxonomic groups (frogs, toads, salamanders, newts, turtles, lizards, and snakes) revealed no significant difference with respect to treatment (P > 0.1). Based on these preliminary analyses, the use of prescribed fire in hardwood forests of the Upper Piedmont of South Carolina does not appear to have a measurable negative effect on herpetofaunal communities associated with these upland hardwood habitats. However, we believe that the differences (although not statistically significant) observed in salamander species capture between burned and unburned plots are an indirect result of the low intensity prescribed fire treatments. We therefore suggest continued monitoring of the research sites and analysis of additional data, as data collected over a greater span of time may reveal differences among species such as Plethodontid salamanders. Analysis of additional data will be conducted in the near future.

ACKNOWLEDGMENTS

Funding for this project was provided by the McIntire-Stennis Cooperative Forestry Research Program and the Clemson University Department of Forest Resources. We thank J. Williams for his considerable contribution to the statistical analyses.

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