RELATIONSHIPS BETWEEN HERPETOFAUNAL COMMUNITY STRUCTURE AND VARYING LEVELS OF OVERSTORY TREE RETENTION IN NORTHERN ALABAMA: FIRST-YEAR RESULTS

Zachary I. Felix, Yong Wang, and Callie Jo Schweitzer[1]

Abstract—Forest managers are increasingly considering the effects their decisions have on the biodiversity of an area. However, there is often a lack of data upon which to evaluate these decisions. We conducted research to examine the relationship between silvicultural techniques, particularly shelterwood cuts with varying levels of basal area retention, and the community structure of amphibians and reptiles in the Cumberland Plateau of northern Alabama. We have implemented five levels of basal area retention at 15 plots (4 ha per site): 0 percent, 25 percent, 50 percent, 75 percent, and control (100 percent) with three replicates each. Drift fences with pitfall and funnel traps, and coverboards were used to quantify herpetofauna at each site. We predicted that plots with high basal area would provide better conditions for amphibians, sites with low basal area would be more favorable for reptiles, and sites with intermediate basal area would contain the most structurally and climatically complex habitats, and thus the highest species richness of herpetofauna. Our research will provide both a theoretical framework furthering our understanding of factors affecting the distribution and abundance of these organisms and applicable data that may be used to assist forest managers in sustaining these communities.

INTRODUCTION

Forest managers are increasingly asked to consider the conservation of biodiversity in their stewardship responsibilities. For this to be effective, managers must be given choices when it comes to the silvicultural techniques they use. This may include the use of alternatives to clearcuts such as shelterwoods or two-aged harvests. It is believed that these systems, because they leave some live trees standing, have a less dramatic impact on wildlife and their habitat than clearcutting. However, little is known about the benefits, if any, these alternatives provide to wildlife.

One group of wildlife that is increasingly considered in forest management decisions is herpetofauna, including all species of reptiles and amphibians. Because these organisms are ectothermic, they are very efficient at producing new tissue and, as a result, comprise a large portion of vertebrate biomass in forest ecosystems. For example, in North Carolina, terrestrial salamanders alone can reach densities of 18,000 per ha and biomass of over 16 kg per ha (Petranka and Murray 2001). Wyman (1998) demonstrated that by reducing invertebrate numbers, salamanders can reduce decomposition rates of forest litter by up to 17 percent, arguably impacting carbon dynamics of forest ecosystems. Some terrestrial turtles have been implicated as vectors of seed dispersal (Gibbons 1988). Snakes can have effects on control of rodent populations (Fitch 1949). Rodents, in turn, are capable of impacting plant community structure (Hayward and Phillipson 1979). These examples highlight the importance of herpetofauna in ecosystems, and show that it is plausible that they indirectly alter forest processes such as regeneration and nutrient cycling.

The preliminary data reported here were collected in the first of a 4-year study. This study is taking place in conjunction with research on upland oak regeneration (Schweitzer, in press) and avian response to treatments (Lesak and others, in press). The objectives of this research were (1) to compare herpetofaunal communities among treatments with a spectrum of tree retention levels and (2) to determine if differences existed in the habitats among treatments, in terms of the climate and the physical structure.

STUDY AREA

The study took place in the Cumberland Plateau region of Jackson County, which is in northeastern Alabama. Study sites are upland forests dominated by oaks (*Quercus* spp.), hickories (*Carya* spp.), yellow poplar (*Liriodendron tulipifera* L.), and sugar maple (*Acer saccharum* Marsh.). Soils are composed of gravelly and stony loams, and slopes average between 12 and 20 percent.

The study followed a randomized complete block design with three blocked replicates of five treatments involving varying levels of basal area retention of trees. Treatment categories included clearcuts, 25, 50, and 75 percent retention, and controls. The clearcuts, 25 percent, and 50 percent retention treatments were chainsaw-felled in a commercial logging operation. In 75 percent retention treatment plots, the midstory was removed by incising trees and applying the herbicide Arsenal (active ingredient imazapyr) into the cut area to achieve a shelterwood cut. Two blocks were located on a north-facing slope at Jack Gap, and the other at Miller Mountain on a southwest-facing slope. Each individual experimental unit was 4 ha in size.

METHODS

Habitat Sampling

Climate—Climatic regimes were sampled with H8 Hobo dataloggers (Onset Corp., Bourne, MA). One datalogger was placed adjacent to each drift fence during trapping

[1]Graduate Student and Associate Professor, Center for Forestry and Ecology, Alabama A&M University, Normal, AL; and Research Forester, USDA Forest Service, Southern Research Station, Alabama A&M University, Normal, AL, respectively.

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periods and recorded hourly air temperature (°C), soil temperature (°C) at 7 cm below the surface, and relative humidity (percent).

Physical—Two 10-m line transects were utilized at each drift fence to sample physical attributes of habitat. The point-intersect method was used to calculate percent cover of the following variables along each transect: leaf litter, bare soil, herbaceous vegetation, woody vegetation, slash, rocks, and coarse woody debris. Every 2 m along transects, percent canopy closure was measured with a hand-held spherical densiometer, and leaf litter depth was measured with a ruler.

Herpetofaunal Sampling

The main method used to sample reptiles and amphibians was drift fence trapping. Drift fences were 15 m in length, constructed of silt fencing, and included one 19-L pitfall bucket at each end and two double-sided funnel traps placed on either side of fences at the midpoint. Three drift fences were placed on each plot (9 per treatment, 45 total). Drift fences were opened for a total of 300 trap nights in August and September 2002, and February 2003. A trap night was defined as one drift fence open for 24 hours. Artificial cover objects, or coverboards, were also used for animal sampling (Fellers and Drost 1994). Small coverboards (30 x 20 cm) were used to target salamanders (90 per plot), while larger (120 x 60 cm) boards were used for both reptiles and amphibians (9 per plot). Community comparisons were made in terms of relative abundance and species richness.

Statistical Analyses

Randomized complete block ANOVA tests were used for comparisons among treatments. Tests on both temperature and relative humidity measurements were performed on means of 18 days of hourly measures taken in August and September of 2002. Mean separations were performed using Tukey's HSD test. Significance is reported at a level of $p < 0.05$. Data transformations included arcsine transformation of percentage data associated with relative humidity and ground cover measures.

RESULTS

Climate—Both air ($F_{4,8} = 28.26$, $P = 0.002$) and soil ($F_{4,8} = 31.23$, $P < 0.005$) temperatures were different among treatments (table 1). Temperatures were higher on clearcuts and 25 percent retention plots, and lower on 50 percent, 75 percent, and control plots. Relative humidity was also different among treatments ($F_{4,8} = 20.9$, $P < 0.005$), with higher values on control and 75 percent treatments and lower values on 50 and 25 percent, and clearcuts.

Physical—Canopy cover differed among treatments ($F_{4,8} = 105.3$, $P < 0.005$, table 1). Canopy cover was higher on control and 75 percent treatments, intermediate on 25 and 50 percent, and lower on clearcuts. Mean litter depth also differed among treatments ($F_{4,8} = 11.27$, $P < 0.005$), with greater depths on controls and lower depths on 50 percent, 25 percent, and clearcut treatments. Four of the seven categories of ground cover measured differed among treatments (figs. 1 and 2). Leaf litter cover was higher on controls and lower on clearcuts ($F_{4,8} = 11.27$, $P < 0.005$). Residual slash cover showed the opposite trend, with higher values on clearcuts and lower values on 75 percent and controls ($F_{4,8} = 35.21$, $P < 0.005$). Coarse woody debris cover was higher on clearcuts and lower in controls ($F_{4,8} = 6.54$, $P = 0.012$), and bare soil cover showed a similar pattern ($F_{4,8} = 11.22$, $P < 0.005$).

Animal captures—The most numerous group of reptile or amphibian captured was frogs and toads, with highest abundance in the 75 percent treatment (fig. 3). Captures of one species, the American toad (*Bufo americanus* Holbrook) made up a large percentage of this group. Lizard numbers were highest in 25 percent treatments, and snake captures peaked in clearcuts. Coverboard captures of salamanders were relatively low in numbers but showed the beginnings

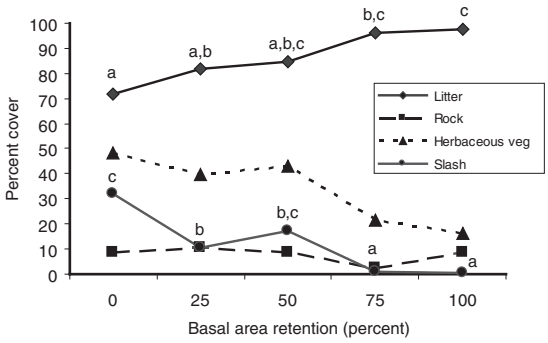

Figure 1—Percent ground cover of four variables across treatments in northern Alabama, August and September 2002.

Table 1—Mean environmental measures among various basal area retention treatments in northern Alabama, August and September 2002[a]

		Treatment (*percent BA retention*)			
Environmental variable	Clearcut	5	50	75	Control
Air temperature (°*C*)	26.7a	26.2a	25.8b	24.4b	24.2b
Soil temperature (°*C*)	25.9a	26.2a	25.8b	24.4b	24.2b
Relative humidity (*%*)	74.6a	76.1a	77.2a	80.8b	82.3b
Canopy cover (*%*)	14.1a	39.6b	48.7b	83.6c	89.6c
Litter depth (*cm*)	2.1a	2.7a	2.4a	3.4a,b	4.8c

BA = basal area.

[a] Means within rows with different superscripts are significantly different.

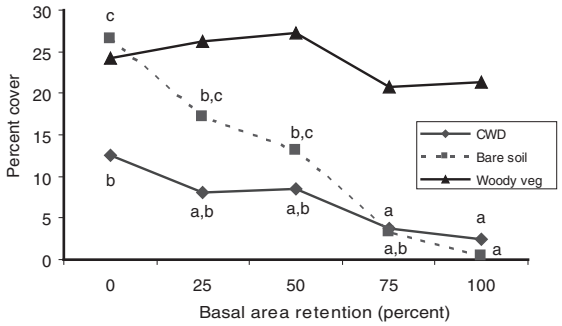

Figure 2—Percent ground cover of three variables across treatments in northern Alabama, August and September 2002.

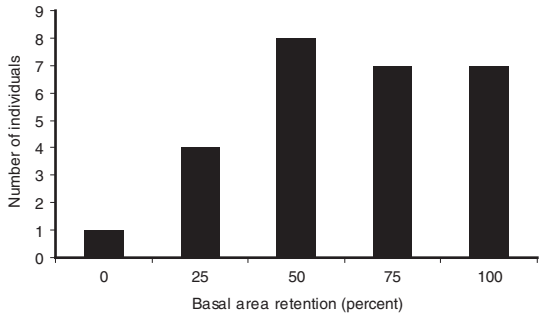

Figure 4—Captures of salamanders using artificial coverboards (1,485 boards) across treatments in northern Alabama, January 2003.

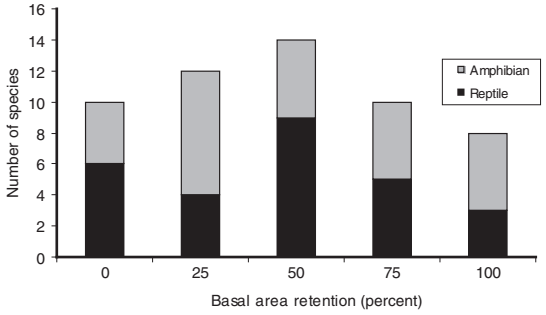

Figure 5—Species richness of reptiles and amphibians combined across treatments in northern Alabama, August and September 2002, and February 2003. Each bar represents the additive number of species of amphibians (hatched) and reptiles (solid) combined.

of a pattern with numbers maintained on the control, 75, and 50 percent treatments and dropping to a low on clearcuts (fig 4). Total species richness of reptiles and amphibians combined was highest on 50 percent treatments and tailed off towards clearcuts and controls (fig. 5).

DISCUSSION

Climate—Climatic conditions on clearcuts were warmer and drier than on the control area, with a gradient between the two extremes. Climate on clearcuts is characterized by warmer and more variable air temperatures and more variable relative humidity than forested sites (Chazal and Niewiarowski 1998, Gieger 1971). Another study found no difference in surface soil temperatures between clearcut and control areas (Phelps and Lancia 1995). It is interesting to note that air and soil temperatures and relative humidity were not different between the clearcuts and 25 percent treatments or between the control and 75 percent treatments. This suggests the amount of overstory canopy present may play an important role in regulating climate of a forest. For example, there was little difference between the 75 percent retention and control. The goal of the 75 percent treatment was to reduce the basal area by 25 percent without creating large canopy gaps using herbicide. Harpole and Haas (1999) found soil temperatures exhibited an increasing trend from control and herbicide treatments to two different shelterwood cuts, and peaked in clearcuts. The control and herbicide treatments were also the most similar in their study in terms of canopy cover and soil temperatures. These differences in climatic regimes will likely play an important role in determining the distribution and abundance of reptiles and amphibians on study plots.

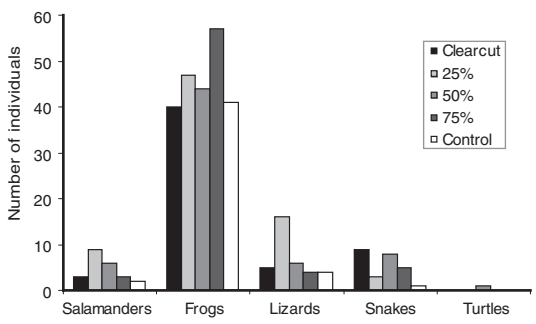

Figure 3—Captures of herpetofauna using drift fences for 300 trap nights across treatments in northern Alabama, August and September 2002, and February 2003.

Physical—The measured differences in percent canopy cover across treatments were as expected. It is notable that there was little difference in percent canopy cover measured between the 75 percent retention and controls. As discussed above, this was the goal of the treatment and the result is encouraging. Harpole and Haas (1999) also found similar canopy cover percentages between control stands and stands with understory removal via a herbicide treatment. Important components of herpetofaunal habitat, as indicated by measured ground cover categories, differed. These differing components included leaf litter, bare soil, coarse woody debris, and slash. Leaf litter coverage and depth are positively related to abundance of amphibians, especially salamanders (DeMaynadier and Hunter 1998, Pough and others 1987). Ash (1995) argued that decreases in litter depth and coverage after clearcutting may contribute to observed disappearances of salamanders. Greenberg and others (1994) found that certain species of lizards primarily use open-scrub habitat with a high proportion of bare soil. In Maine, high amounts of bare soil were negatively associated with capture rates of amphibians (DeMaynadier and Hunter 1998). Terrestrial amphibian abundance is positively associated with amount of coarse woody debris in the form of downed logs (Brooks 1999, Petranka and

others 1994, Ross and others 2000), especially logs in older states of decay (Butts and McComb 2000).

Animal captures—Trapping in the first year was limited due to equipment implementation efforts. Preliminary results suggested that most groups may be more abundant in intermediate treatments, but sample sizes are too low for any conclusions at this time. Salamander captures in drift fences were inconclusive. Drift fences were opened at the end of the summer, which is not the ideal time for targeting this group. Coverboard captures of salamanders were also low but suggested the beginnings of an interesting pattern. Abundance of salamanders seemed to be maintained in control, 75 percent, and 50 percent treatments but declined at the 25 percent level and were lowest in clearcuts. Some debate exists as to whether salamander abundances can be maintained in stands with intermediate harvest. Results of Harpole and Haas (1999) indicated populations of salamanders declined after even partial removal of canopy. Other research has found no difference in abundance between control stands and those stands with residual stocking ranging from 40 to 70 percent (Brooks 1999, Sattler and Reichenbach 1998). Observed patterns in species richness of reptiles and amphibians suggested that more species of herpetofuana were able to exist in plots with intermediate cuts. We predict this pattern will continue with additional trapping, and that it will be related to patterns of habitat complexity and heterogeneity.

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