Immediate, Landscape-scale Impacts of Even-aged and Uneven-aged Forest Management on Herpetofaunal Communities of the Missouri Ozark Forest Ecosystem Project

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Abstract.—We examined the immediate, landscape-scale impacts of even-aged and uneven-aged forest management on the species composition, species richness, and relative abundance of herpetofaunal communities and selected focal groups of species during the second and third years following initial tree harvest on Missouri Ozark Forest Ecosystem Project (MOFEP) sites in southern Missouri. We compared these measures of the pre-treatment (1992-1995) community to measures of the 1998 and 1999 post-treatment communities. We did not observe changes in species composition, species richness, and overall amphibian and reptile relative abundance in 1998 or 1999 because of the first-entry harvest within sites. Landscape-scale impacts also were not observed in the relative abundances of woodland salamanders (*Plethodon* spp.) and a group of small snakes (prairie ring-necked snake (*Diadophis punctatus arnyi*), northern red-bellied snake (*Storeria occipitomaculata occipitomaculata*), and western smooth earthsnake (*Virginia valeriae elegans*)). We did observe a landscape-scale effect on pond-breeding salamanders (*Ambystoma* spp.) and skinks (*Eumeces* spp.). Even-aged and uneven-aged forest management appeared to dampen a natural oscillation in *Ambystoma* relative abundance estimates on southwest-facing slopes and resulted in an increase in *Eumeces* relative abundance on northeast-facing slopes in 1998. Potential mechanisms for these observed impacts and future analysis plans are discussed.

Most studies of the impacts of timber harvest upon amphibians and reptiles have focused upon the effects within forest stands. Amphibian and reptile populations, however, move among stands, can be impacted by the environmental conditions within adjacent stands, and are dependent upon population dynamics that occur across many stands. The Missouri Department of Conservation manages forests with the compartment as the basic unit of management (Missouri Department of Conservation 1986). A compartment, which is typically about 415 ha in size, consists of smaller units of stands. Forest management practices, such as even-aged and uneven-aged management, are applied to compartments as a whole with stands of trees manipulated to achieve desired forest conditions (Missouri Department of Conservation 1986). Hence, an investigation of the effects of forest management at a landscape scale of the compartment is reasonable and desirable because forestry practices are applied to compartments, and because amphibian and reptile populations are likely affected by forces working at a scale greater than forest stands.

Past studies of the effects of timber harvest on amphibians and reptiles demonstrated that salamanders declined sharply in recently harvested stands (Ash 1988; Blymer and McGinnes 1977; DeGraaf and Yamasaki 1992; Dupuis *et al.* 1995; Enge and Marion 1986; Harper and Guynn 1999; Harpole and Haas 1999; Herbeck and Larsen 1999; Petranka *et al.* 1993, 1994; Pough *et al.* 1987; Sattler and Reichenback 1998), whereas some reptiles increased in abundance on recently cut stands (Goldingay *et al.* 1996, Raphael 1988). The

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estimated number of years required for salamander abundances to recover varied from about 20 years (Ash 1997) to more than 50 years (Petranka *et al.* 1993, 1994), depending on region, species, and definition of recovered population abundance (Ash 1997, Ash and Pollack 1999, Petranka 1999). Clearly, forest management has a local impact on herpetofaunal communities. On a larger geographic scale, forest fragmentation, as measured by percent forest cover, distance to forest edge, island size, and tree basal area, was associated with reduced species distribution and diversity for some amphibians in temperate (Gibbs 1998, Hager 1998) and tropical (Marsh and Pearman 1997, Pearman 1997) regions.

The goal of our study was to experimentally examine the landscape-scale effects of forest management on amphibian and reptile communities. For this report we tested the short-term (the second and third years after harvest) impacts of even-aged and uneven-aged forest management on amphibian and reptile community species composition, species richness, and relative abundance on nine compartments (which will be called sites for the remainder of this paper) in the Missouri Ozarks. With 6 years of data (4 years of pre-treatment and 2 years of post-treatment data), we evaluated the effects of management on measures of the amphibian and reptile community and the relative abundance of four taxonomic focal groups during the second and third years after timber harvest.

METHODS

Sampling Design and Field Sampling Methods

The overall design and location of MOFEP are described in Sheriff and He (1997) and Sheriff (this proceedings). Details about the timber harvest, or treatment, which occurred in 1996 and the sites are included elsewhere (Brookshire *et al.* 1997, Meinert *et al.* 1997). To examine the landscape-scale effect of even-aged and uneven-aged forest management on the species composition, species richness, and relative abundance of amphibian and reptile communities, we trapped amphibians and reptiles at 12 modified Jones (1981) design arrays randomly placed on southwest-facing slopes (Ecological Landtype 17) and northeast-facing slopes (Ecological Landtype 18) on each site. Of the 12 arrays, 6 were placed on southwest-facing landscapes and 6 were placed on northeast-facing landscapes (Renken 1997). Twelve arrays were used per site because we believed that two technicians could check all traps at 12 arrays within an average work day. Southwest-facing and northeast-facing slopes were sampled because they comprise 68-83 percent of the area within the sites. For further details about the arrays and reasons for selecting this technique for sampling amphibians and reptiles at MOFEP sites, see Renken (1997).

Arrays were open for trapping during 20 March - 2 July and 19 August - 28 October 1992 (165 days); 4 March - 2 July and 30 August - 30 October 1993 (174 days); 25 February - 1 July and 29 August - 2 November 1994 (183 days); 27 February - 30 June and 29 August - 2 November 1995 (184 days); 25 February - 26 June and 28 August - 30 October 1998 (188 days); and 24 February - 30 June and 25 August - 29 October 1999 (187 days). All arrays on a site were checked for captured animals approximately every 3 to 5 days. The nine sites were grouped into three blocks of three sites each (randomized block design) to account for the influence of location on observed results (Sheriff and He 1997). All arrays within a block were checked on the same day.

Captured animals were identified to species, toe clipped or ventral scale clipped with a unique mark, and released approximately 5-7 m from the traps. Turtles were marked by filing notches in marginal scutes. During 1993, 1994, 1995, 1998, 1999, and the later part of 1992, Eastern American toads (*Bufo americanus americanus*) and central newts (*Notophthalmus viridescens louisianensis*) were given a batch mark unique for the sampling year. All other species were given unique individual marks. During this research, approximately 19,600 individuals were captured during the pre-treatment period (1992-1995) and approximately 10,000 individuals were captured during the post-treatment period.

Data Analysis

Differences in species composition of amphibian and reptile communities among treatments between pre-treatment (1992 through 1995) and post-treatment (1998 and 1999) periods were quantitatively and qualitatively described. Indices of similarity (Jaccard 1901) in species composition between pre-treatment and post-treatment periods for each slope type (southwest-facing or northeast-facing) were computed for each site. An index of 1.00 meant the species composition between pre-treatment and post-treatment periods was identical. A randomized complete block analysis of variance (ANOVA; SAS 1989) using the interaction term of treatment and block as the error term was used to test the effect of treatment upon the Jaccard's indices calculated for the species composition of the sites. Similarity indices were log transformed for the analysis so that model residuals were normally distributed (Snedecor and Cochran 1980). We used an alpha of 0.1 for this test because of the low power (N=9) of the experiment (Sheriff and He 1997). In a qualitative evaluation of immediate effects of forest management on species composition, we examined species occurrences in pre-treatment and post-treatment periods to determine if species were affected by treatment. In particular, we looked for species that were not captured following treatment and for species captured only following treatment.

We defined the species richness of a site to be the number of species caught at a site within a year and slope type. To determine if treatment had an effect on species richness, we tested the numerical difference between the mean species richness observed in the pre-treatment period and the species richness observed in 1998 or 1999 for each site in a randomized complete block ANOVA. We used the treatment by block interaction term as the error term to test for differences among treatments and an alpha of 0.10 because of the low power (N=9) of the experiment.

Relative abundance estimates of animals at each array were derived by summing the number of individuals captured at each array (recaptures were not included) for each year and dividing by the total number of trap days (number of days the array was open for sampling) for that year. One trap day was defined as one array operating for one day. We defined trap days as such because all 10 traps (1 pitfall and 9 funnel traps) at an array were not independent of one another. We then standardized estimates as number of captures per 100 trap days. Mean annual relative abundance estimates for each slope type (six arrays within each slope type) within each site then were calculated. We then calculated the difference between mean pre-treatment and 1998 or 1999 overall amphibian and reptile relative abundance estimates for each site and slope type, and tested for the effect of treatment on these differences in a randomized complete block ANOVA using the treatment by block interaction term as the error term for testing the main effects among treatments. We used an alpha level of 0.1 because of the small sample size (N=9) of the experiment (Sheriff and He 1997).

We were also interested in the effect of treatment upon the relative abundance of four taxonomic focal groups of species (*Ambystoma* spp., *Plethodon* spp., *Eumeces* spp., and a group of selected small snakes: *Diadophis punctatus arnyi*, *Storeria occipitomaculata occipitomaculata*, and *Virginia valeriae elegans*). We chose to focus on groups of species rather than individual species for several reasons. Our research goals emphasized effects of forest management on communities, but groups of species within a community may respond in opposite ways to forest management. Presumably, species within a focal group shared similar ecological habits and taxonomic characteristics that make them more or less vulnerable to forest management. Captures of individuals within focal groups also were more numerous and exhibited less within-site variability than did many individual species. Using focal groups made our analyses more robust and we were more likely to observe an effect if one existed. We calculated and analyzed the relative abundance estimates of these four focal groups in the same manner as we calculated and analyzed estimates of overall amphibian and reptile relative abundance.

RESULTS

The species composition and species richness of the amphibian and reptile community on either southwest-facing or northeast-facing slopes were not affected by even-aged or uneven-aged forest management during the second and third years following the 1996 timber harvest. We did not observe a difference in Jaccard's similarity indices (table 1) among treatments (southwest-facing slopes, $F_{2,4}$=0.14, MSE=0.0001, P=0.87; northeast-facing slopes, $F_{2,4}$=1.83, MSE=0.007, P=0.27) when comparing pre-treatment to post-treatment communities. In our qualitative analysis, we suspect the occurrence of only one species, the northern rough greensnake (*Opheodrys aestivus aestivus*), (table 2) may be related to the effects of treatment. Northern

Table 1.—*Means (and standard errors) of Jaccard's similarity indices for each treatment by slope type for MOFEP sites during 1992-1995 and 1998-1999. The indices are a measure of the similarity in species composition of pre-treatment and post-treatment amphibian and reptile communities. An index of 1.0 means the communities were identical.*

	Jaccard's similarity indices	
Treatment	Southwest-facing slopes	Northeast-facing slopes
Control	0.73 (0.02)	0.71 (0.04)
Even-aged	0.74 (0.02)	0.74 (0.01)
Uneven-aged	0.75 (0.04)	0.78 (0.0)

rough greensnakes had not been captured in even-aged sites following harvest even though they had been captured during the pre-treatment period. They also were not captured on northeast-facing slopes in uneven-aged sites in the post-treatment period. Their absence may be due to the short post-treatment period reported in this paper or it may be related to treatment. Further sampling will help us answer that question. Species richness of amphibian and reptile communities (table 3) on either slope type also was not affected by even-aged or uneven-aged forest management (southwest-facing slopes, $F_{2,4}$=1.08, MSE=3.47, P=0.42; northeast-facing slopes, $F_{2,4}$=2.45, MSE=11.44, P=0.20).

Even-aged and uneven-aged forest management did not immediately affect the overall relative abundance of amphibians and reptiles on the sites. Overall relative abundance of amphibians and reptiles was not affected by treatment on either slope type and in either post-treatment year (southwest-facing slopes, 1998, $F_{2,4}$=2.36, MSE=92.7, P=0.21; 1999, $F_{2,4}$=1.40, MSE=42.8, P=0.36; northeast-facing slopes, 1998, $F_{2,4}$=0.38, MSE=62.4, P=0.71; 1999, $F_{2,4}$=0.11, MSE=7.47, P=0.90; fig. 1). We also did not observe landscape-scale treatment effects upon *Plethodon* spp. or small snake relative abundance on either slope type (*Plethodon* spp., southwest-facing slopes, 1998, $F_{2,4}$=1.45, MSE=23.4, P=0.34; 1999, $F_{2,4}$=0.49, MSE=5.95, P=0.64; northeast-facing slopes, 1998, $F_{2,4}$=1.01, MSE=75.1, P=0.44; 1999, $F_{2,4}$=0.82, MSE=6.4, P=0.50, fig. 2; small snakes, southwest-facing slopes, 1998, $F_{2,4}$=1.46, MSE=0.88, P=0.34; 1999, $F_{2,4}$= 0.27, MSE= 0.08, P=0.78; northeast-facing slopes, 1998, $F_{2,4}$=0.78, MSE=0.74, P=0.52; 1999, $F_{2,4}$=0.50, MSE=0.41, P=0.64, fig. 3).

We did observe an effect of treatment on *Ambystoma* spp. relative abundance on southwest-facing slopes in 1998 and 1999 (fig. 4a) and on *Eumeces* spp. relative abundance on northeast-facing slopes in 1998 (fig. 5b). Both even-aged and uneven-aged management appeared to dampen a natural *Ambystoma* spp. oscillation in relative abundance estimates that occurred on control sites in the post-treatment period (southwest-facing slopes, 1998, $F_{2,4}$=4.64, MSE=0.57, P=0.09; 1999, $F_{2,4}$=5.20, MSE=1.52, P=0.08). *Eumeces* spp. relative abundance appeared to be greater on northeast-facing slopes on even-aged and uneven-aged management sites than on control sites in the second year after harvest ($F_{2,4}$=4.05, MSE=1.33, P=0.11). This effect, however, was not observed in 1999 ($F_{2,4}$=1.23, MSE=0.68, P=0.38). There was no effect of treatment on *Ambystoma* spp. relative abundance on northeast-facing slopes (1998, $F_{2,4}$=0.12, MSE=0.06, P=0.89; 1999, $F_{2,4}$=2.19, MSE=3.54, P=0.23; fig. 4b) or on *Eumeces* spp. relative abundance on southwest-facing slopes (1998, $F_{2,4}$=2.34, MSE=0.67, P=0.21; 1999, $F_{2,4}$=0.70, MSE=1.66, P=0.55; fig. 5a).

DISCUSSION

The lack of an immediate, landscape-scale treatment effect upon the species composition, species richness, and overall amphibian and reptile relative abundance of the MOFEP sites was not unexpected. Because a relatively small proportion of the forest (approximately 10 percent of a site) was harvested and disturbed during this first timber harvest, we did not expect to observe landscape-scale impacts to such general measures, such as species composition and overall relative abundance, of the

Table 2.—*The species composition of MOFEP amphibian and reptile communities within control, even-aged, and uneven-aged management sites on southwest-facing and northeast-facing slopes during the pre-treatment (1992-1995) and immediate post-treatment (1998-1999) years. An X denotes the capture of at least one individual of that species during the pre-treatment period. An O denotes the capture of a species during the post-treatment period.*

	Species presence within treatment types and by slope types											
	Southwest-facing slopes						Northeast-facing slopes					
	Control		Even-aged		Uneven-aged		Control		Even-aged		Uneven-aged	
Species	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
Spotted salamander *Ambystoma maculatum* (Shaw)	X	O	X	O	X	O	X	O	X	O	X	O
Marbled salamander *Ambystoma opacum* (Gravenhorst)	X	O	X	O	X	O	X	O	X	O	X	O
Eastern tiger salamander *Ambystoma tigrinum tigrinum* (Green)							X					
Central newt *Notophtalmus viridescens louisianensis* Wolterstorff	X	O	X	O	X	O	X	O	X	O	X	O
Dark-sided salamander *Eurycea longicauda melanopleura* (Cope)	X	O	X	O	X	O	X	O	X	O	X	O
Cave salamander *Eurycea lucifuga* Rafinesque	X	O	X	O	X	O	X	O	X	O	X	O
Four-toed salamander *Hemidactylium scutatum* (Schlegel)	X	O	X	O	X	O	X	O	X		X	O
Western slimy salamander *Plethodon albagula* Grobman	X	O	X	O	X	O	X	O	X	O	X	O
Southern red-backed salamander *Plethodon serratus* Grobman	X	O	X	O	X	O	X	O	X	O	X	O
Eastern American toad *Bufo americanus americanus* Holbrook	X	O	X	O	X	O	X	O	X	O	X	O
Fowler's toad *Bufo fowleri* Hinckley	X	O	X	O	X	O	X	O	X	O	X	O
Blanchard's cricket frog *Acris crepitans blanchardi* Harper	X						X					
Gray treefrogs *Hyla chrysoscelis - Hyla versicolor* complex	X	O	X	O	X	O	X		X	O	X	O
Northern spring peeper *Pseudacris crucifer crucifer* (Wied - Neuwied)	X	O	X	O	X	O	X	O	X	O	X	O
Eastern narrow-mouthed toad *Gastrophryne carolinensis* (Holbrook)	X	O	X		X		X	O				O
American bullfrog *Rana catesbeiana* Shaw							X					
Northern green frog *Rana clamitans melanota* Rafinesque	X	O	X	O	X	O	X	O	X	O	X	O
Pickerel frog *Rana palustris* LeConte	X	O	X	O	X	O	X	O	X	O	X	O
Southern leopard frog *Rana sphenocephala* Cope	X	O	X	O	X	O	X	O	X	O	X	O
Three-toed box turtle *Terrapene carolina triunguis* (Agassiz)	X	O	X	O	X	O	X	O	X	O	X	O
Northern fence lizard *Sceloporus undulatus hyacinthinus* (Green)	X	O	X	O	X	O	X	O	X	O	X	O

(Table 2 continued on next page)

(Table 2 continued)

Species	Species presence within treatment types and by slope types											
	Southwest-facing slopes						Northeast-facing slopes					
	Control		Even-aged		Uneven-aged		Control		Even-aged		Uneven-aged	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Southern coal skink *Eumeces anthracinus pluvialis* Cope	X	O	X	O	X	O	X	O	X	O	X	O
Common five-lined skink *Eumeces fasciatus* (Linnaeus)	X	O	X	O	X	O	X	O	X	O	X	O
Broad-headed skink *Eumeces laticeps* (Schneider)	X	O	X	O	X	O	X	O	X	O	X	O
Little brown skink *Scincella lateralis* (Say)	X	O	X	O	X	O	X	O	X	O	X	O
Eastern six-lined racerunner *Cnemidophorus sexlineatus sexlineatus* (Linnaeus)							X					
Western wormsnake *Carphophis vermis* (Kennicott)	X	O	X	O	X	O	X	O	X	O	X	O
Eastern yellow-bellied racer *Coluber constrictor flaviventris* Say	X	O	X	O	X	O	X	O	X	O	X	O
Prairie ring-necked snake *Diadophis punctatus arnyi* Kennicott	X	O	X	O	X	O	X	O	X	O	X	O
Black ratsnake *Elaphe obsoleta obsoleta* (Say)	X	O	X	O	X	O	X		X	O	X	O
Eastern hog-nosed snake *Heterodon platirhinos* Latreille	X	O	X	O	X	O	X	O	X	O	X	O
Speckled kingsnake *Lampropeltis getula holbrooki* Stejneger			X		X		X				X	
Red milksnake *Lampropeltis triangulum syspila* (Cope)	X	O	X	O	X	O	X		X		X	O
Common watersnake *Nerodia sipedon sipedon* (Linnaeus)	X		X		X						X	O
Northern rough greensnake *Opheodrys aestivus aestivus* (Linnaeus)	X	O	X		X	O			X		X	
Midland brownsnake *Storeria dekayi wrightorum* Trapido	X	O	X	O	X	O	X	O	X	O	X	O
Northern red-bellied snake *Storeria occipitomaculata occipitomaculata* (Storer)	X	O	X	O	X	O	X	O	X	O	X	O
Orange-striped ribbonsnake *Thamnophis proximus proximus* (Say)	X	O		O	X	O	X	O	X	O	X	O
Eastern gartersnake *Thamnophis sirtalis sirtalis* (Linnaeus)	X	O	X	O	X	O	X	O	X	O	X	O
Rough earthsnake *Virginia striatula* (Linnaeus)	X		X		X	O	X		X		X	
Western smooth earthsnake *Virginia valeriae elegans* Kennicott	X	O	X	O	X	O	X	O	X	O	X	O
Osage copperhead *Agkistrodon contortrix phaeogaster* Gloyd	X	O	X	O	X	O	X	O	X	O	X	O
Timber rattlesnake *Crotalus horridus* Linnaeus	X		X	O				O	X	O	X	
Western pygmy rattlesnake *Sistrurus miliarius streckeri* Gloyd						O						

Table 3.—*Means and standard errors for species richness estimates by treatment type and slope type on MOFEP sites during pre-treatment (1992-1995) and post-treatment (1998, 1999) periods. Species richness is the number of species captured within a slope type within a site.*

	Species richness estimates					
	Southwest-facing slopes			Northeast-facing slopes		
Treatment	Pre-treatment	1998	1999	Pre-treatment	1998	1999
Control	24.1 (0.8)	23.7 (1.3)	22.3 (0.9)	24.0 (1.4)	23.3 (0.9)	19.3 (0.7)
Even-aged	22.8 (0.3)	24.7 (2.0)	23.0 (2.0)	23.0 (0.4)	24.7 (1.7)	23.0 (0.6)
Uneven-aged	22.8 (0.9)	24.3 (0.3)	22.0 (1.7)	22.1 (1.7)	22.7 (1.2)	22.7 (0.3)

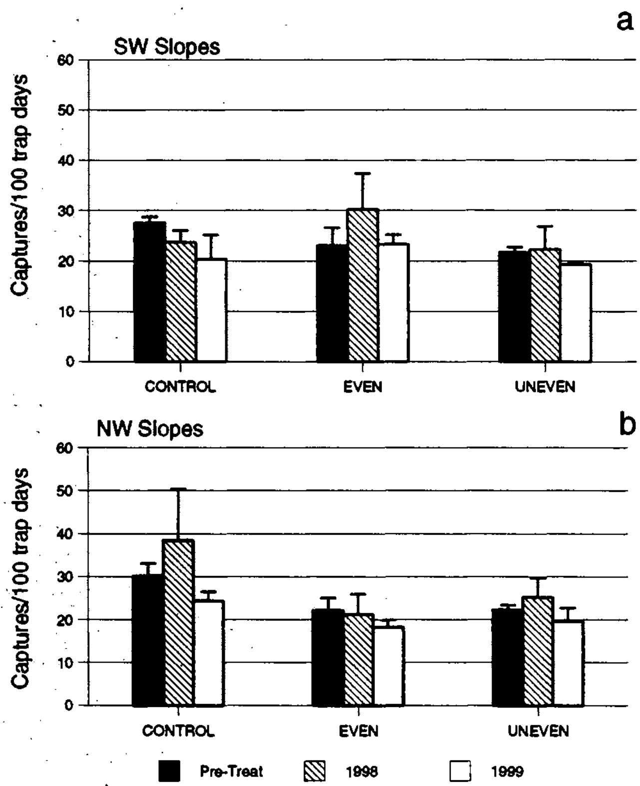

Figure 1.—*Means and standard errors for overall amphibian and reptile relative abundance on southwest-facing (a) and northeast-facing (b) slopes during pre-treatment, 1998, and 1999.*

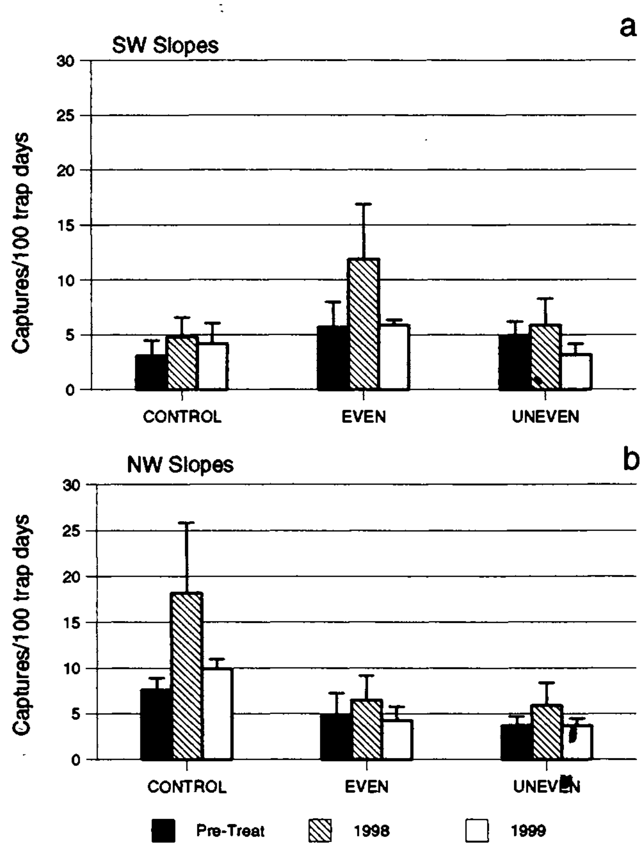

Figure 2.—*Means and standard errors for* Plethodon *spp. relative abundance on southwest-facing (a) and northeast-facing (b) slopes during pre-treatment, 1998, and 1999.*

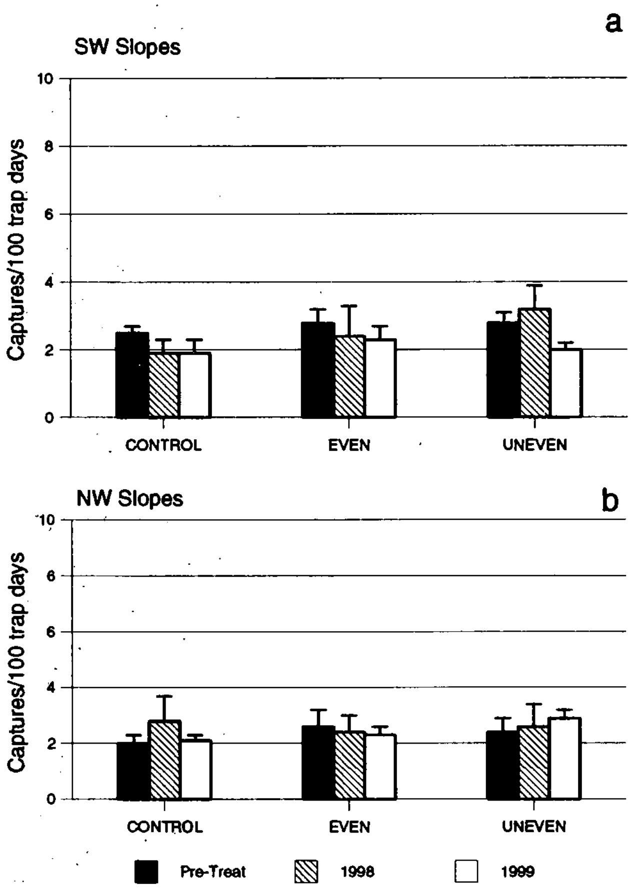

Figure 3.—*Means and standard errors for small snake relative abundance on southwest-facing (a) and northeast-facing (b) slopes during pre-treatment, 1998, and 1999.*

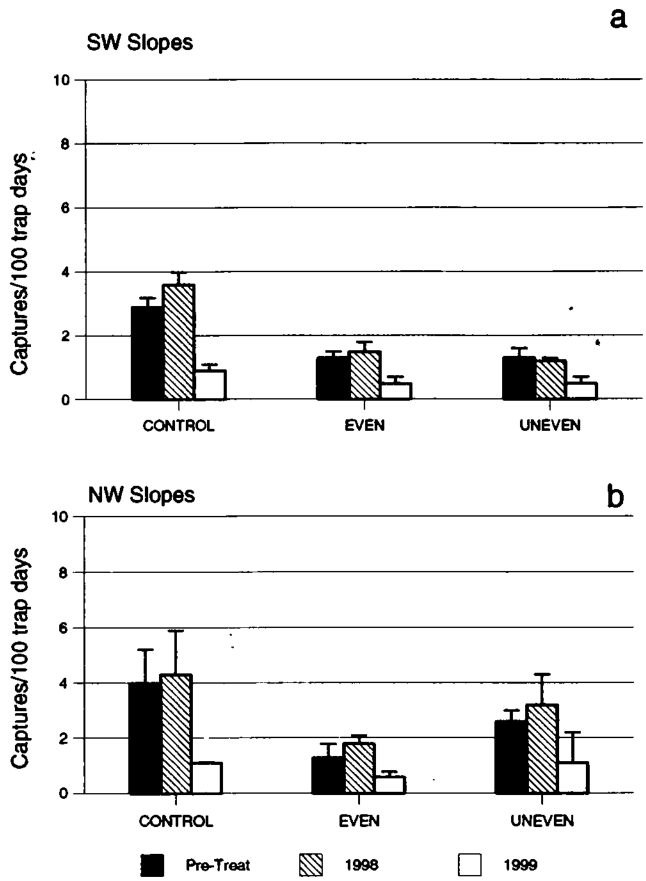

Figure 4.—*Means and standard errors for* Ambystoma *spp. relative abundance on southwest-facing (a) and northeast-facing (b) slopes during pre-treatment, 1998, and 1999.*

herpetofaunal community. We suspect that if impacts are detected to such general measures, they will be observed when a greater proportion of the forest area has been cut. Landscape-scale impacts, however, may still not be detected in those future surveys because even-aged and uneven-aged sites are likely to provide a mix of old trees (100+ year old trees) in undisturbed habitat, intermediate-aged trees (30 to 50 years old) in recovering habitat, and a small proportion of young trees (20 years old or less) in recently disturbed habitat. This mix may still support the diversity of species and result in overall amphibian and reptile capture rates similar to those observed in herpetofaunal communities prior to the initial 1996 timber harvest and in control sites.

The effect of landscape-scale forest management was probably better evaluated when impacts upon focal groups of species were examined. A general measure such as overall amphibian and reptile relative abundance may change if the impact was dramatic and more widespread on the landscape, but might not change with smaller, more subtle changes following the first tree harvest. Subtle changes are more likely to affect specific species groups, which respond in different ways to habitat alterations. It appeared even-aged and uneven-aged forest management on southwest-facing slopes dampened a natural oscillation in *Ambystoma* spp. relative abundance estimates observed on southwest-facing slopes of the control sites. In 1998, *Ambystoma* spp. relative

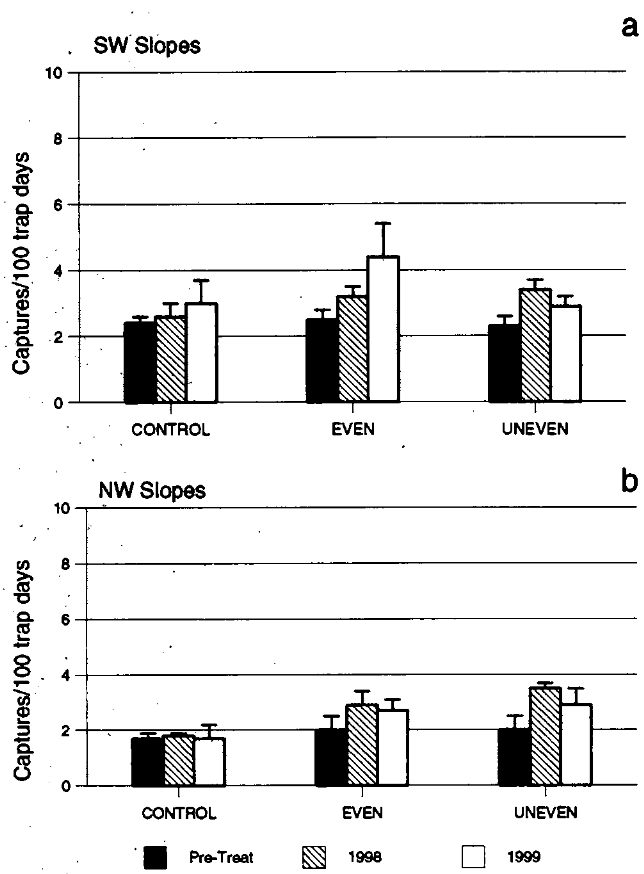

Figure 5.—*Means and standard errors for* Eumeces *spp. relative abundance on southwest-facing (a) and northeast-facing (b) slopes during pre-treatment, 1998, and 1999.*

abundance on control sites increased while this group's relative abundance remained the same on even-aged and uneven-aged sites. In 1999, all treatment types showed a decline in salamander relative abundance, yet on control sites the decline was dramatic compared to the decline observed on even-aged and uneven-aged sites, which displayed relative abundances already smaller than relative abundances on control sites. We suspect the dampened oscillations of *Ambystoma* spp. on southwest-facing slopes of even-aged and uneven-aged management sites were the result of salamanders electing not to move in, near, or through the drier, more hostile conditions of recently cut forest on southwest-facing slopes, even when it appeared conditions were conducive (in 1998) for much salamander movement as evidenced by the increased relative abundance observed on the control sites. Although salamanders are typically thought to move no more than a few hundred meters from breeding ponds (Kleeberger and Werner 1983, Madison 1997, Williams 1973), we have learned from the pre-treatment period capture data that these salamanders are more widespread in distribution in the upland forest and were moving farther (up to 1,500 m) from the few breeding ponds (Renken 1997) than what has been reported (also see Gordon 1968). There is evidence to suggest pond-breeding salamanders either move out of or avoid entering recently harvested forest areas (deMaynadier and Hunter 1998, 1999; Raymond and Hardy 1991). Other researchers have noted that salamanders retreat underground when soil surface conditions are dry and harsh for these moisture-dependent animals (Semlitsch 1983). We suspect salamanders that occupy southwest-facing slopes of even-aged and uneven-aged management sites restricted their movements upon and through those slopes after harvest to avoid desiccation.

An increase in *Eumeces* spp. relative abundance following timber harvest was a more expected result of forest management. Although reptile responses to forest management have been studied less than amphibian responses, other workers have noted that lizards are more abundant in recently harvested moist forests (Goldingay *et al.* 1996). We suspect the warmer (Zheng *et al.* 2000), drier soil surface conditions and change in vegetation structure caused by the opening of the forest canopy and increased sunlight to the forest floor following harvest were conducive to these lizards and possibly the prey they feed upon. The significant increase in relative abundance on northeast-facing slopes within even-aged and uneven-aged sites, but not on southwest-facing slopes, is likely due to the smaller variation around relative abundance estimates for all treatment types on the northeast-facing slopes and to the more dramatic changes in soil temperature (Zheng *et al.* 2000) and likely in soil moisture that resulted from the harvest on northeast-facing slopes.

SUMMARY

In summary, we did not observe any landscape-scale impacts of treatment upon the species composition and richness, and overall amphibian and reptile relative abundance within the sites. We also did not observe any treatment impacts on *Plethodon* spp. and small snake relative abundance. Treatment impacts were observed on pond-breeding salamanders (*Ambystoma* spp.) and skinks (*Eumeces* spp.), but depended upon slope type and length of time following harvest.

We plan to continue sampling amphibian and reptile communities through 2001 and then sporadically sample, perhaps 3 years out of 5, through the rest of the MOFEP experiment. Less sporadic sampling may also be conducted several years immediately before and after succeeding tree harvest entries, which at this time are scheduled to occur every 15 years.

We emphasize that the results presented in this paper are an initial look at the impacts of even-aged and uneven-aged forest management on amphibian and reptile communities. We plan to further analyze data to examine amphibian and reptile response in the spring and fall seasons separately and focus on specific species that are sufficiently abundant in the data to allow analysis. We also plan to soon report updated findings to managers and the scientific community. An important task for us and every investigator succeeding us will be to continually analyze and examine data, and report results so the information is communicated to managers, administrators, and the general public. We think we have only begun to learn how the herpetofaunal community is responding to forest management in this immediate, post-treatment period.

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