Pre-harvest (1994-1995) Conditions of the Missouri Ozark Forest Ecosystem Project Small Mammal Communities

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Abstract.—We conducted a capture-recapture study on northeast-facing slopes to determine the pre-treatment landscape-scale effect of even- and uneven-aged silvicultural treatments upon the species composition, species richness, and relative abundance of small mammals on Missouri Ozark Forest Ecosystem Project (MOFEP) sites. Similarity indices of species composition between sites ranged from 0.29 to 1.00, with an overall mean index of 0.64. Species richness estimates ranged from two to six species per site per year. Overall small mammal relative abundance estimates ranged from 0.93 (s.e. = 0.35) to 6.54 (s.e. = 0.06) individuals per 100 trap nights per site. Year, treatment, block, and their interactions did not affect species richness or relative abundance estimates.

The effects of various silvicultural practices on many game species are well documented, but information on the nongame fauna is lacking. Clearcutting, for example, may alter the species composition and abundance of small mammals because of extreme habitat changes associated with the removal of the forest overstory. Natural resource management agencies are increasingly interested in examining the effects of their silvicultural practices on nongame animal communities. The Missouri Ozark Forest Ecosystem Project (MOFEP) is a comprehensive research project designed to examine the landscape-scale effects of forest management practices (even- and uneven-aged management) on selected flora, fauna (including small mammals), and abiotic components of the southern Missouri oak-hickory (*Quercus* sp. - *Carya* sp.) forest (Brookshire *et al.* 1997, Sheriff and He 1997).

In other portions of the United States, researchers have evaluated the effects of timber management on small mammal communities and have reported varied results, which emphasize the importance of site-specific and plant community differences to small mammal community changes after timber harvest. In northeastern forest ecosystems, some researchers have reported no significant changes or only minimal changes in the number and composition of small mammals following clearcutting (Brooks and Healy 1988, Healy and Brooks 1988, Krull 1970). Others have concluded that the small mammal community is generally resilient to clearcutting, but responses vary by species (Clough 1987, Healy and Brooks 1988, Kirkland 1977, Lovejoy 1975, Monthey and Soutiere 1985, Yahner 1992). Krull (1970) found lower densities of small mammals in clearcuts, and reported that there are slightly more, but not statistically significant more, mice (*Peromyscus* sp.) in forest habitat than in clearcut areas. Yahner (1992) reported that clearcutting increased populations of white-footed mice (*P. leucopus*) and southern red-backed voles (*Clethrionomys gapperi*) in an oak-aspen (*Quercus* sp. - *Poplar* sp.) forest in central Pennsylvania.

Small mammal studies in the Pacific Northwest have compared clearcuts with forested stands (Corn *et al.* 1988; Gashwiler 1959, 1970; Hooven and Black 1976; Tevis 1956). Although there is considerable treatment variation among the studies (for example: burning, herbicide use), there are some similar trends. Corn *et al.* (1988) stated that, in general, populations of deer mice (*P. maniculatus*), creeping voles (*Microtus oregoni*), and Townsend's chipmunks

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(*Tamias townsendii*) increase after logging, whereas southern red-backed voles and Trowbridge's shrews (*Sorex trowbridgii*) decline. Ream and Gruell (1980) reported that in Rocky Mountain coniferous forests, deer mice were most abundant in clearcuts about 5 years after logging. Corn *et al.* (1988) reported that deer mice were about three times more abundant in recent (<10 years old) clearcuts than in young (30 to 80 years) stands, and Hooven and Black (1976) concluded that populations of mice (*Peromyscus* sp.) and Oregon creeping voles (*M. oregoni*) increased after logging and slash burning on clearcuts.

Studies in Canada have been conducted on uncut, selectively cut, and clearcut boreal forests. Clearcutting in northern Ontario produced a dramatic change in the composition of the small mammal community, but there appeared to be little change in overall small mammal density (Martell and Radvanyi 1977). Deer mice increased on clearcuts (when compared with uncut stands) and predominated in the small mammal community by the end of the second summer after cutting. Martell (1983) reported that the small mammal community in both clearcut and strip-cut stands changed over the first 3 years after logging from one dominated by southern red-backed voles to one dominated by deer mice, and then remained relatively stable for 13 years. That shift was not apparent in selectively cut stands where the composition of the small mammal community was similar between uncut and selectively cut stands 4 to 23 years after harvest. Relatively little change occurred in total numbers of small mammals after logging. Sullivan (1979), working in British Columbian coniferous forests, concluded that densities of deer mice in forested and clearcut areas were similar, but slightly higher on clearcuts.

Many of these studies specifically addressed changes in *Peromyscus* sp. populations following logging. Most concluded that there are more deer mice on logged areas compared with adjacent forested habitat (Ahlgren 1966; Gashwiler 1959, 1970; Hooven and Black 1976; Martell and Radvanyi 1977; Tevis 1956; Verme and Ozoga 1981; Yahner 1992). Clearcut areas produce large quantities of seeds, fruits, and insects (Ahlgren 1966, Hooven 1973, Tevis 1956). Deer mice are considered a pioneering species, and these foods are a large proportion of their diet (Hamilton 1941, Whitaker 1966).

Information on the landscape-scale effects of forest management practices on the small mammal communities of Ozark oak-hickory forests is lacking. Only one known study has examined the stand-level effects of even-aged forest management on small mammal communities in Midwest oak-hickory forests. Root *et al.* (1990) noted that white-footed mice numbers were largely unaffected by even-aged cuts (up to 6 years after clearcutting) in central Missouri. They reported that clearcuts generally had greater numbers of white-footed mice, yet population trends were similar between clearcut and control areas. Clearcutting did not appear to affect overall population fluctuations of white-footed mice.

The research objectives of the MOFEP small mammal study are to determine if even- and uneven-aged silvicultural treatments have a landscape-scale, short-term (2 and 3 years after cutting) effect on species composition, species richness, and relative abundance of small mammal communities inhabiting MOFEP sites. The objective of the pre-treatment portion of the study is to document the condition of small mammal communities before any silvicultural treatments are applied. This paper reports on the pre-treatment status of small mammal communities occupying northeast-facing slopes during 1994-1995.

METHODS

Field Sampling

We randomly selected two locations on northeast-facing slopes (ecological landtype (ELT) 18) on each of the 9 MOFEP sites. At each location, a 12x12 station grid (144 stations per grid) was laid out, with 25 m between stations (7.6-ha grid, two grids per site). We sampled only on northeast-facing slopes because we believed these locations would contain more small mammals due to the moister environment on northeast-facing slopes. Only two grids were sampled per site for several reasons. First, the number of northeast-facing slopes that were large enough to contain a 7.6-ha grid was limited on several sites. Secondly, we estimated that one person could check, rebait, and reset all traps within two, 7.6-ha grids within an average workday. We selected 7.6 ha as a grid size to fit upon available northeast-facing slopes and to attempt to maximize the number of available traps within a grid. We placed one

Sherman small mammal live trap (8 x 9 x 23 cm) at each station and baited traps with a mixture of peanut butter and rolled oats. Trapping occurred during April and May of 1994 and 1995. We trapped during April and May because results from an earlier small mammal trapping effort in the south central Missouri Ozarks suggested that late March, April, and May were the most successful months for capturing small mammals (Murray 1991). We selected spring as our sampling season because small mammals may be most active or most likely to be captured during April and May, and our capture probabilities might be greatest then. Grids within each block of three sites were simultaneously sampled during a 6-night trapping period (six grids sampled per trapping period). Block 1 (sites 1, 2, and 3) was sampled on April 6-12, 1994 and April 12-18, 1995; block 2 (sites 4, 5, and 6) was sampled on May 4-10, 1994 and May 10-16, 1995; and block 3 (sites 7, 8, and 9) was sampled on May 18-24, 1994 and May 24-30, 1995. Trapping was not conducted during Missouri's annual spring firearms turkey season in late April. Traps were disinfected with a dilute bleach solution between trapping periods as a precautionary measure against possible exposure to hantavirus.

Traps were checked for captured animals and rebaited once daily. Captured animals were identified to species, individually marked by toe-clipping (except chipmunks and wood rats were individually marked with nontoxic, waterproof markers), and released at the point of capture. We recorded species, identification number, trap station number, age of individual (adult or juvenile), and whether the animal was captured for the first time or was a recapture. Dead animals were noted.

Statistical Methods

Differences in species composition of small mammal communities between sites and years were qualitatively evaluated. Coefficients of similarity (Jaccard 1901) in species composition were calculated between sites for the pre-treatment period to examine how sites differed between proposed treatment sites and blocks.

Species richness within small mammal communities was defined as the number of species caught on a site within a year. Multivariate repeated measures analysis of variance (with year as the repeated factor) (SAS 1989) was used to examine the effect of year, treatment, block, and their interactions on species richness of small mammal communities on northeast-facing slopes during the pre-treatment period. The normality of model residuals was tested (SAS 1989) after fitting the model (Z. He personal communication). We used 0.05 as the alpha level for our analysis.

We attempted to estimate densities by grid and year from the capture/recapture data using population modeling programs. However, numbers of captures and recaptures per grid were too small to produce reliable population estimates with the population models. Recapture rates were 49 percent for individuals captured in 1994 and 24 percent for 1995. Therefore, we calculated relative abundance estimates instead of density estimates. Small mammal relative abundance was defined as the number of individuals captured per grid per 100 trap nights. Relative abundance estimates for each grid were calculated by dividing the total number of individuals captured on that grid by the total number of trap nights per grid (864 trap nights). In 1994, on grid 1 of site 6, we experienced only 549 trap nights due to raccoon (*Procyon lotor*) trap raiding problems. Relative abundance estimates were averaged by site for each year. Multivariate repeated measures analysis of variance was used to detect differences in relative abundance estimates due to year, treatment, block, and their interactions. The normality of model residuals was tested (SAS 1989) after fitting the model (Z. He personal communication)

Peromyscus sp. dominated the sample in abundance and occurrence. Because relative abundance estimates for other species were so small, we combined data for *Peromyscus* sp. by grid per year and examined the effect of year, treatment, block, and their interactions on the relative abundance of only *Peromyscus* sp.

RESULTS

General

We captured, marked, and released 372 individual animals (726 total captures) of six species in 1994, and 473 individual animals (670 total captures) of eight species in 1995. The most often trapped species were white-footed mice (54 percent and 38 percent of individuals captured in 1994 and 1995, respectively) and deer mice (35 percent and 52 percent of individuals captured in 1994 and 1995, respectively).

Species Composition

Eight species of small mammals were captured on northeast-facing slopes during 1994-1995 (table 1). One species was a shrew (Elliot's short-tailed shrew, *Blarina hylophaga*), two were squirrels, (eastern chipmunk, *Tamias striatus*; southern flying squirrel, *Glaucomys volans*), and the remaining five species were members of the mice and rat family (woodland vole, *Microtus pinetorum*; eastern woodrat, *Neotoma floridana*; golden mouse, *Ochrotomys nuttalli*; white-footed mouse, *Peromyscus leucopus*; deer mouse, *Peromyscus maniculatus*). Common names follow Schwartz and Schwartz (1981).

Our sample consisted of two principal species (white-footed mouse, deer mouse) that were captured on all grids at all sites during both years (table 1). If captured within a site, eastern chipmunks tended to be consistently caught in both years. The remaining five species were sporadic, localized captures within sites and between years.

Jaccard's similarity indices of species composition among sites ranged from 0.29 for sites 3 and 5, and 3 and 7, to 1.00 for comparisons between sites 2 and 4, 5 and 7, 2 and 8, and 4 and 8 (table 2). The overall mean index between sites was 0.64. The mean index within each block of sites also was 0.64. Mean indices within treatments were not as consistent. The mean indices for control and uneven-aged treatment sites were 0.68 and 0.67, respectively. The mean index for even-aged treatment sites was 0.49. This mean was greatly influenced by the dissimilarity in communities between sites 3, 5, and 7.

Species Richness

Species richness estimates ranged from two species for site 7 during 1994, to six species for site 8 during 1995 (table 1). The number of species on each site typically did not vary more than by one species between years. This small difference is not surprising because so few species were captured on the sites. Only eight species were captured in all. We believe that the difference in species richness will never be great because of the small number of species we could possibly capture. We determined that year, treatment, block, and the interactions of year x treatment and year x block had no significant influence on species richness during the pre-treatment period (table 3).

Relative Abundance

Overall small mammal relative abundance estimates ranged from 0.93 individuals per 100 trap nights (s.e. = 0.35) for site 5 in 1994 to 6.64 individuals per 100 trap nights (s.e. = 0.06) for site 1 in 1994 (table 1). Year, treatment, block, and the interactions of year x treatment and year x block had no significant effect upon relative abundance estimates (table 4). The difference between 1994 and 1995 estimates within sites ranged from 0.23 individuals per 100 trap nights for site 4, to 4.34 individuals per 100 trap nights for site 7 (table 1). Generally, relative abundance estimates increased slightly from 1994 to 1995.

Most relative abundance estimates of individual species on the sites were small and had large standard errors (table 1). The only somewhat reasonable estimates were those for white-footed and deer mice, although for some sites, estimates had extremely high standard errors (sites 1, 2, 5, and 9). Estimates of relative abundance for all other species were small and may not be valuable for examining the effects of forest management practices on an individual species basis.

If we examine the relative abundance estimates of just *Peromyscus* sp., and lump white-footed and deer mice captures, then year, treatment, and the interaction of year x treatment still had no significant effect on relative abundance estimates (table 5). However, the year x block interaction was significant and block nearly significant. While block 2 relative abundance estimates of *Peromyscus* sp. remained about the same from 1994 to 1995, block 1 estimates decreased and block 3 estimates increased. This interaction was probably influenced by the high relative abundance estimates for sites 1 in 1994 and 7 in 1995. The localized annual variation in *Peromyscus* sp. numbers may make interpretation of treatment effects challenging after treatment.

Table 1.—*Mean small mammal relative abundance estimates (s.e.) on northeast-facing slopes for MOFEP sites during 1994 and 1995. Relative abundance was defined as the number of individuals captured per 100 trap nights. N = 2 for each estimate.*

	Species								
Site/Year	**Elliot's short-tailed shrew**	**Southern flying squirrel**	**Woodland vole**	**Eastern wood rat**	**Golden mouse**	**Deer mouse**	**White-footed mouse**	**Eastern chipmunk**	**All species**
1 - 1994	0.06 (0.06)	—	—	—	0.17 (0.17)	2.20 (0.58)	4.05 (0.69)	0.06 (0.06)	6.64 (0.06)
1 - 1995	—	—	0.06 (0.06)	—	0.17 (0.06)	1.33 (0.64)	0.87 (0.17)	—	2.43 (0.81)
2 - 1994	0.12 (0.00)	—	—	0.23 (0.23)	—	1.22 (0.87)	1.27 (0.23)	0.06 (0.06)	2.89 (0.81)
2 - 1995	—	—	—	—	0.06 (0.06)	1.33 (0.87)	0.98 (0.52)	0.12 (0.12)	2.49 (1.56)
3 - 1994	0.06 (0.06)	—	—	—	—	1.45 (0.06)	1.50 (0.35)	—	3.01 (0.35)
3 - 1995	—	0.06 (0.06)	—	0.12 (0.00)	0.06 (0.06)	2.26 (0.64)	1.50 (0.58)	—	3.99 (1.22)
4 - 1994	0.23 (0.12)	—	—	—	—	0.35 (0.00)	0.75 (0.17)	0.12 (0.00)	1.45 (0.06)
4 - 1995	—	—	—	0.12 (0.12)	0.06 (0.06)	0.98 (0.41)	0.41 (0.06)	0.12 (0.12)	1.68 (0.64)
5 - 1994	—	—	—	—	—	0.23 (0.00)	0.64 (0.29)	0.06 (0.06)	0.93 (0.35)
5 - 1995	—	—	—	—	—	0.98 (0.41)	0.52 (0.17)	0.06 (0.06)	1.56 (0.64)
6 - 1994	0.06 (0.06)	—	—	—	—	0.98 (0.29)	1.67 (0.51)	0.42 (0.31)	3.14 (1.05)
6 - 1995	—	—	—	—	—	1.68 (0.17)	1.68 (0.64)	0.46 (0.23)	3.82 (1.04)
7 - 1994	—	—	—	—	—	0.35 (0.12)	0.87 (0.41)	—	1.22 (0.29)
7 - 1995	—	—	—	—	—	2.95 (0.75)	2.43 (0.93)	0.17 (0.06)	5.56 (1.62)
8 - 1994	0.06 (0.06)	—	—	—	—	0.69 (0.12)	0.81 (0.12)	0.35 (0.00)	1.91 (0.17)
8 - 1995	0.06 (0.06)	—	—	0.12 (0.12)	0.06 (0.06)	1.97 (0.93)	1.22 (0.17)	0.35 (0.12)	3.76 (1.33)
9 - 1994	—	—	—	—	—	0.41 (0.17)	0.46 (0.23)	0.17 (0.06)	1.04 (0.00)
9 - 1995	—	—	—	0.06 (0.06)	—	0.87 (0.29)	0.93 (0.58)	0.12 (0.12)	1.97 (1.04)

Table 2.—*Jaccard's indices of similarity* in species composition of small mammal communities observed on northeast-facing slopes on MOFEP sites during 1994-1995. Pairs of sites with indices near 1.00 are most similar.*

Site	1	2	3	4	5	6	7	8	9
1		0.71	0.50	0.71	0.50	0.67	0.50	0.71	0.43
2			0.71	1.00	0.50	0.67	0.50	1.00	0.67
3				0.71	0.29	0.43	0.29	0.71	0.43
4					0.50	0.67	0.50	1.00	0.67
5						0.75	1.00	0.50	0.75
6							0.75	0.67	0.60
7								0.50	0.75
8									0.67
9									

* Similarity index = $\frac{a}{a + b + c}$

where:

a = the number of species present on Site A that are also present on Site B
b = the number of species absent on Site A that are present on Site B
c = the number of species present on Site A that are absent on Site B

Table 3.—*Results of repeated measures analysis of variance of species richness values for small mammal communities on northeast-facing slopes of MOFEP sites during 1994-1995.*

Between Subject Effects

Source	df	Mean square	F-value	P
Treatment	2	1.06	0.61	0.51
Block	2	0.89	0.52	0.63
Error (Blk x Trt)	4	1.72		

Within Subject Effects

Source	Pillai's trace	F-value	Numerator df	Denominator df	P
Year	0.20	1.00	1	4	0.37
Yr x Trt	0.18	0.44	2	4	0.67
Yr x Blk	0.33	1.00	2	4	0.44

Table 4.—*Results of repeated measures analysis of variance of relative abundance estimates of small mammals on northeast-facing slopes of MOFEP sites during 1994-1995.*

Between Subject Effects

Source	df	Mean square	F-value	P
Treatment	2	3.62	2.60	0.19
Block	2	3.34	2.40	0.21
Error (Blk x Trt)	4	1.39		

Within Subject Effects

Source	Pillai's trace	F-value	Numerator df	Denominator df	P
Year	0.17	0.82	1	4	0.42
Yr x Trt	0.29	0.81	2	4	0.51
Yr x Blk	0.57	2.63	2	4	0.19

Table 5.—*Results of repeated measures analysis of variance of relative abundance estimates of Peromyscus sp. on northeast-facing slopes of MOFEP sites during 1994-1995.*

Between Subject Effects

Source	df	Mean square	F-value	P
Treatment	2	4.84	2.27	0.14
Block	2	7.13	3.34	0.07
Error (Blk x Trt)	13	2.13		

Within Subject Effects

Source	Pillai's trace	F-value	Numerator df	Denominator df	P
Year	0.11	1.56	1	13	0.23
Yr x Trt	0.21	1.75	2	13	0.21
Yr x Blk	0.43	4.90	2	13	0.03

DISCUSSION

Small mammal communities on the MOFEP sites were similar in species composition and species richness during the 2-year pre-treatment period. Although similarity indices in species composition ranged as low as 0.29, the communities only differed by one to four species. The small number of possible species to capture on the sites greatly influenced the magnitude of the similarity indices. All sites were occupied by white-footed and deer mice, and eastern chipmunks occurred on most sites. The remaining five species were sporadic, localized captures, and therefore would not be good indicator species for determining the landscape-scale effects of forest management.

Small mammal communities were also similar in overall relative abundance during 1994-1995. Sites did not significantly differ in overall small mammal relative abundance between years or between treatment and block assignments. The nearly significant block effect on *Peromyscus* sp. only supports the use of the randomized block design for the MOFEP experiment by attributing some of the variation in results to local geographic variation. We did observe a significant year by block interaction in lumped *Peromyscus* sp. relative abundance. This interaction principally was the result of the nearly significant block effect and the yet unexplained annual variation in relative abundance on two sites. This type of annual variation in small mammal numbers is not unusual. Small mammal numbers may fluctuate annually in response to a variety of density-dependent and density-independent factors. Other researchers have determined that annual population fluctuations were not dependent on treatment type (Krull 1970, Root *et al.* 1990, Yahner 1992). Yahner (1992) reported significantly lower numbers of individuals during a drought year that presumably reduced the availability of terrestrial arthropods as a food resource. Krull (1970) found irregular yearly fluctuations of white-footed mice densities that occurred despite the effects of earlier habitat manipulation of northern hardwood stands. Petticrew and Sadleir (1974) found that deer mice densities in coniferous stands in British Columbia varied more between years than between habitat types. Root *et al.* (1990) stated that white-footed mice numbers will fluctuate regardless of whether a site has been cut or not. Unless we observe huge sustained changes in animal numbers following treatment, these natural population variations will make determining the influence of treatments on small mammal numbers challenging. Collaboration with other MOFEP researchers, especially those working on the hard mast study, may provide insight into the variation we observed.

Logging affects the vegetative structure and species composition of forests, and can have a major influence on microclimates available to resident small mammals. Physical barriers are created or removed, more sunlight reaches the ground, the range of ground surface temperatures increases, and moisture regimes are altered. Eventually, the increase in light and moisture results in abundant growth of forbs, grasses, and shrubs, which provide more favorable habitat for some small mammal species (Ream and Gruell 1980).

Researchers have reported a successional sequence of small mammal species in response to the availability of food and cover following logging (Ream and Gruell 1980). Most species were adversely affected immediately following logging, but over the long term, populations of most small mammals increased (some species decreased). In general, habitat change associated with an even-aged cut was more dramatic than change associated with a selective cut. Extreme habitat modification associated with clearcuts resulted in the decline of some small mammal species and increases in others. Less pronounced changes were associated with uneven-aged cuts because selective cutting resulted in an insufficient change in the environment to significantly alter the composition of the small mammal community or total numbers of small mammals (Martell 1983).

The MOFEP experiment provides a unique opportunity to examine the effects of forest management on small mammal communities because it is concerned with the landscape-scale effects of management, rather than the smaller forest stand-scale other researchers have studied. The experiment also provides the opportunity to examine conditions of small mammal communities before treatment, rather than solely after treatment. Unlike many other studies, MOFEP gives us the opportunity to examine responses of small mammal communities for many decades. It is hoped that the results of this pre-treatment research will provide a good springboard for the comparison of post-treatment conditions, and ultimately, help us discern the long-term, landscape-scale effects of forest management on small mammal communities.

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