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INITIAL EFFECTS OF A LANDSCAPE ECOLOGY TREATMENT OF CONIFEROUS FOREST ON SMALL MAMMALS

ABSTRACT

*We present the initial response of small mammal communities and populations of deer mice (*Peromyscus maniculatus*) and yellow pine chipmunks (*Tamias amoenus*) to thinning and under-burning of mixed ponderosa pine (*Pinus ponderosa*) – Douglas fir (*Psuedotsuga menziesii*) stands in southwestern Montana. Live-trapping on six control and six treated grids from 1992 through 1996 suggested no change in the number of species of small mammals from pre-treatment to immediately post treatment. Numbers of deer mice and yellow pine chipmunks per trap grid were greater on treated grids than on a control grid although the post treatment increase of yellow pine chipmunks was not significant. A separate study in the same area showed an increase in the number of species on treated grids with a shift from boreal red-backed voles (*Clethrionomys gapperi*) on a control grid to meadow voles (*Microtus pensylvanicus*) and long-tailed voles (*M. longicaudus*) on treated grids. Post treatment populations of deer mice and yellow pine chipmunks also were greater on treated grids than on a control grid.*

Key words: Landscape Ecology, deer mouse, *Peromyscus maniculatus*, yellow pine **chipmunk, *Tamias amoenus*, thinning treatment effects, Montana.**

INTRODUCTION

We assessed the initial response of small mammal communities and populations to thinning and under-burning included in a USDA Forest Service (FS) "Landscape Ecology" treatment of a coniferous forest in western Montana. Landscape Ecology is a term used by the FS for land management over large areas to address ecological goals rather than commodity production. The management objective was to return the forest to a condition in which ecological processes believed to exist prior to 1860 could resume.

Ponderosa pine (*Pinus ponderosa*) stands are well adapted to periodic fire. In many parts of western Montana, fires have been suppressed and/or livestock grazing reduced the forest fuel load to the point that natural fires effectively ceased by 1900. A consequence of lack of fire is a decline in ponderosa pine in part due to the encroachment of Douglas fir (*Pseudotsuga menziesii*).

Mixed stands of mostly old, even-age ponderosa pine and mixed-age Douglas fir occur on the north slopes of the Flint Range south of Gold Creek, Montana. Fire scar analysis of old trees indicated that fires occurred at about 40-yr intervals prior to 1860. No significant fires have occurred in this area since

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1900. By 1992, the fuel load had increased (primarily from increasing densities of Douglas fir) to the point, that if a fire were to occur, it would probably eliminate the ponderosa pine. The FS attempted to recreate ecological conditions by thinning and under-burning that would allow fire to maintain stands of ponderosa pine.

Thinning, particularly of Douglas fir, should reduce the probability of a catastrophic fire and increase the abundance of understory vegetation that should carry the ground fire necessary to control Douglas fir encroachment and stimulate ponderosa pine generation. Naturally occurring (lightening caused) fires can then be allowed to burn, or controlled anthropogenic fires can be used to simulate a natural fire regime.

The objective of this study was to determine the side effects of thinning and under-burning (treatment) on small mammal communities and populations of common species, deer mice (*Peromyscus maniculatus)* and yellow pine chipmunks (*Tamias amoenus*).

We studied small mammals because they are a significant component of the ecosystem that can be useful indicators in ecological monitoring (Douglass 1989). They form the prey base of nearly all carnivores: coyotes (Wagner 1978, Johnson and Hansen 1979), weasels and ermine (Errington 1967, Maher 1967), and many raptorial birds (Phelan and Robertson 1978, Hamerstrom 1979). Small mammals can have significant impacts on plant communities by modifying plant species composition (Summerhays, 1941, Meuggler 1967, Frischknecht and Baker 1972) and by modifying soil-building processes and nutrient cycling (Grant and French 1979).

We expected thinning and under-burning to alter small mammal habitats that have developed since 1860. Effects of other types of forest treatments on small mammals depend on type of treatment and the species of small mammals. Effects include shifts in species composition and positive, negative, or no effect on common species such as deer mice (e.g., Cole *et al*, 1998, Sullivan *et al.* 1998, Black and Hooven 1974, Sullivan and Sullivan 1982, Ahlgren 1966, Gashwiler 1970, Kirkland 1977). We hypothesized that initially, deer mouse population densities would not change, densities of yellow pine chipmunk would increase as they have in clear cuts (Gashwiler 1970), and if herbaceous cover and litter increase, meadow voles would eventually invade (Birney *et al.* 1976).

STUDY AREA AND EXPERIMENTAL DESIGN

The study area was located on the north end of the Flint Range in Western Montana south of Gold Creek. Treated areas were small (< 20 ha), scattered, and at an average elevation of 1585 m. Within several of these prior to treatment, we constructed six 1-ha live-trapping treatment grids. Within 1 km of each treatment grid in similar forest types to be maintained under previous management regimes, we constructed six control grids. During 1992, we trapped only four control grids and four treated grids. For the remainder of the study we trapped six of each. Grids were placed to maximize distance among grids within the study area. Treated stands were previously delineated by the FS. The original plan was to sample during one pre-treatment year (1992) and then for four years following treatment. However, treatment did not occur until 1995 and 1996. Treatment involved thinning in 1995 with under-burning occurring during summer 1996 just before the study ended. Consequently the study consisted of three pre-treatment years with two years post thinning and one year post burning on previously thinned stands.

METHODS

We estimated the percent cover of lichens, mosses, grasses, forbs, shrubs, and charred vegetation to determine the effects of thinning and under-burning on understory vegetation. Contact with one of 10 vertical rods mounted in a 0.5 m long point frame was considered 10 percent cover. We collected samples within 0.5 m of each trap on all twelve grids (49 per grid) during August 1992 and again during August 1996.

During July and August from 1993 through 1996, we live-trapped bi-weekly for a period of three nights on each of 12 grids. During 1992 we trapped only eight grids. Each grid consisted of 49 traps set in a 7X7 configuration with approximately 15 m spacing. We trapped each grid for three periods each year. Traps were baited with peanut butter and rolled oats and supplied with synthetic cotton. Beginning in 1994, we reduced our exposure to Hantavirus as suggested by Mills *et al.* (1995) by replacing each trap that had captured an animal with a clean disinfected trap each day. We also wore high efficiency particulate attenuating (HEPA) filter respirators and surgical gloves while handling animals.

We ear-tagged, weighed, sexed, and determined breeding condition (Krebs *et al.* 1966) of all animals. We used body mass as an index to age. We considered deer mice weighing 18 grams or more and chipmunks weighing 30 grams or more to be adults.

We used the enumeration technique (Chitty and Phipps 1966) to determine the minimum number alive (MNA) as an index to population size. We used computer programs provided by C. J. Krebs of the University of British Columbia (Small mammal programs for mark-recapture data analysis) to make the MNA calculations as well as estimates of survival and summaries of age and breeding condition.

We used non-overlapping, 95 percent confidence intervals (Graybill and Iver 1994, Johnson 1999) to identify significant differences between control grids (*n* = 4 during 1992 and *n* = 6 for the remainder of the study) and treated grids (*n* = 4 for 1992 and *n* = 6 for the remainder of the study).

RESULTS AND DISCUSSION

Vegetation

The FS management plan required a substantial opening of the forest. Thinning and under-burning reduced the tree density as planned and significantly altered understory vegetation coverage (Fig. 1). On control grids, except for an increase in grass cover, the general vegetation was similar between pre-treatment (1992) and the immediate post-treatment period. Cover of moss, lichens and shrubs decreased on treated grids, primarily because they are perennial and their above ground structures were damaged by fire. Cover of grasses and forbs was similar between pre- and post-treatment periods probably as a result of regeneration from seed or roots that were not affected by fire.

Much of the forest floor was still charred when we sampled vegetation during 1996 (Fig. 1). Some slash was still smoldering but new grass and forbs were growing through the ashes.

Mammalian Species Composition

We captured 1271 individuals of five species of rodents in 23,520 trap-nights (Table 1). Deer mice and yellow pine chipmunks were most common. Bushy tailed wood rats (*Neotoma cinerea*), meadow voles (*Microtus pennsylvanicus*), and western jumping mice (*Zapus princeps*) were rarely captured. Completion of treatments in 1996 obviously did not affect the number of species of rodents captured. Deer mice were the most numerous species on both treated and control grids throughout the study. Yellow pine

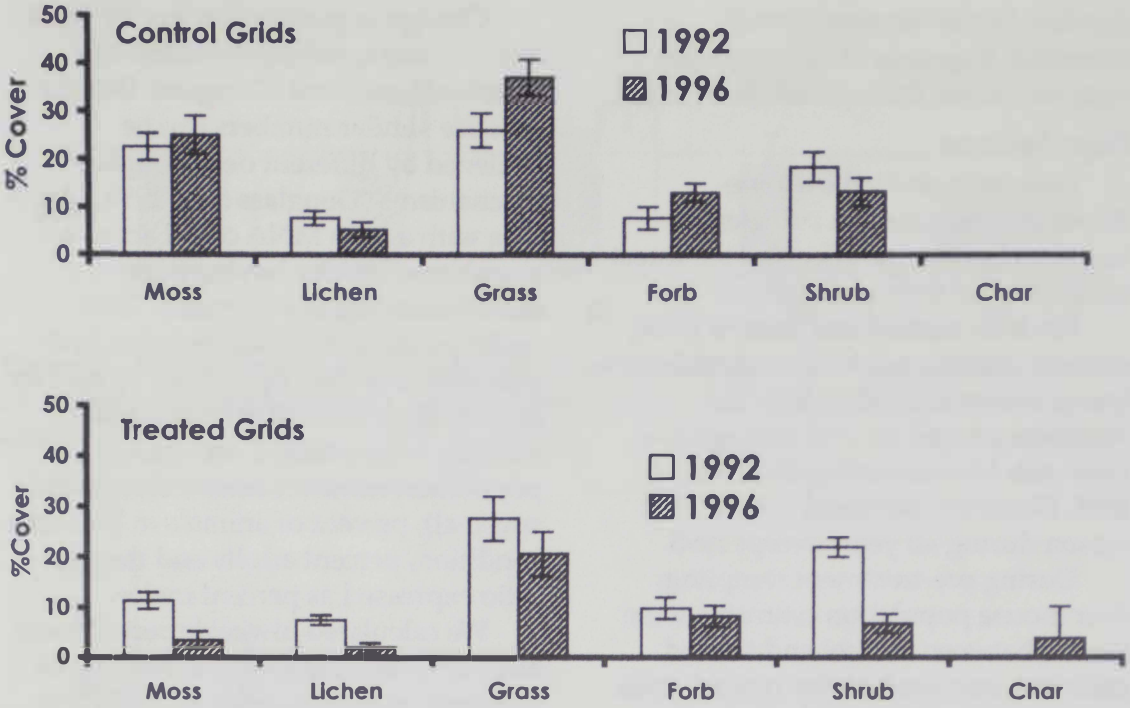

Figure 1. *Average habitat characteristics on six control grids and six treated grids before treatment (1992) and immediately after treatment (1996) near Gold Creek, Montana. Treatments included removal of small Douglas fir trees in 1995 and under-burning in 1996. Bar represents 95 percent confidence interval.*

Table 1. *Number of individuals captured on treated and control grids near Gold Creek Montana from 1992 through 1996.*

		Pretreatement			Thinned	Burned	
	Treatement	**1992**	**1993**	**1994**	**1995**	**1996**	**Total**
Deer Mice	**Control**	34	160	105	62	125	480
(Peromyscus maniculatus)	**Treated**	57	185	102	102	216	677
Yellow pine chipmunks	**Control**	1	8	4	3	11	23
(Tamias amoenus)	**Treated**	8	19	2	3	40	73
Bushy tailed woodrats	**Control**	0	0	0	0	10	10
(Neotoma cinerea)	**Treated**	0	0	0	0	0	0
Meadow voles	**Control**	0	0	3	0	0	3
(Microtus pennsylvanicus)	**Treated**	0	0	2	1	0	3
Jumping mice	**Control**	0	0	1	0	0	1
(Zapus princeps)	**Treated**	0	0	0	1	0	1
Total # of Individuals		100	372	219	172	402	1271
No. species	**Control**	2	2	4	2	3	5
No. species	**Treated**	2	2	3	4	2	4

chipmunks also were relatively abundant. Captures of other species were incidental throughout the study.

Populations

Deer mice and yellow pine chipmunks occurred in sufficient numbers to examine effects of the forest treatments on their populations.

For both control and treated grids, average deer mouse MNA varied from a low of five to high of 27 (Fig. 2). Numbers peaked in 1993 and again in 1996 with lows occurring in 1992 and 1995. Numbers increased through the season during all years except 1993.

During pre-treatment sampling, deer mouse population estimates were similar between control and treated grids but increased on the treated grids after treatment (Fig 2). During eight pre-treatment trapping periods, confidence intervals of populations size for control and treated grids overlapped seven times. This suggests that deer mouse population sizes were not significantly different between the control and treated grids during the pre-treatment period. During three periods of the post-treatment period, deer mouse populations were higher on treated grids than on control grids. Confidence intervals overlapped during the other three of the six post-treatment periods.

Change in population size by itself may not demonstrate the complete effects of treatment (Douglass 1989) because similar numbers can be achieved by different demographic mechanisms (Douglass *et al*. 1992). An area with a high MNA could act as a population sink by having high recruitment but low survival. This could produce high numbers but little persistence of the population. To further explore the effects of thinning and burning we examined deer mouse population turnover rates (recruitment/ survival), percent of animals in breeding condition, percent adults and the sex ratio expressed as percent males.

We calculated biweekly recruitment and survival rates for the second week of sampling each year on all grids (Fig. 3). Confidence intervals of average turnover rates overlapped between control and treated grids during all five years. This suggested that recruitment and survival rates were similar after treatment even though treated grids tended to have more deer mice

During seven trapping periods prior to treatment, the percent of deer mice breeding was nearly equal on all grids with control grids having a higher percentage breeding during one period in 1993 (Fig. 4). After the initial treatments, a smaller percent of deer

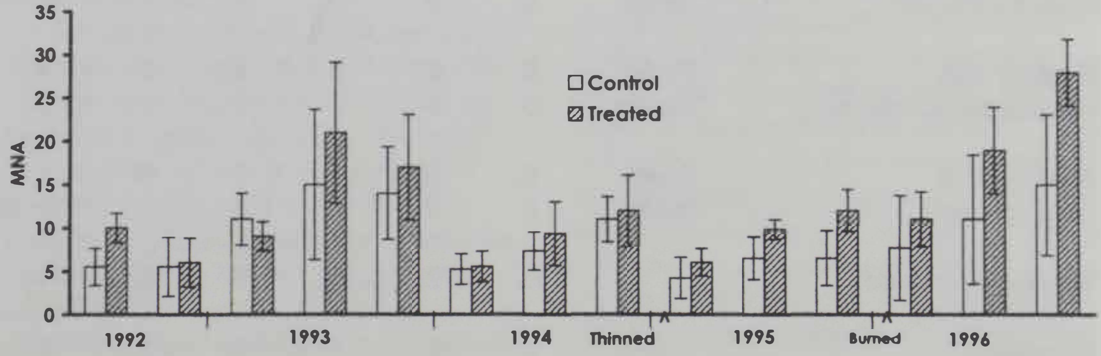

Figure 2. *Average MNA for deer mice on six treated and six control grids near Gold Creek, Montana 1992 -1996. Bars represent 95 percent confidence intervals.*

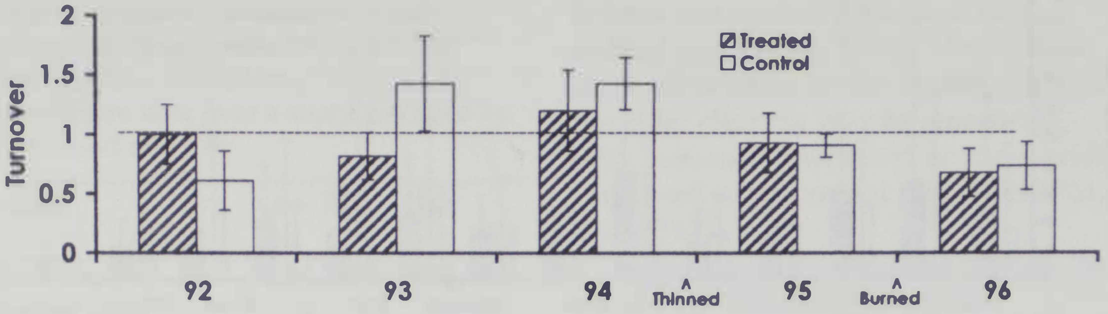

Figure 3. *Population turnover rates (survival/recruitment) for deer mice on six control and six treated grids near Gold Creek, Montana 1992 - 1996. Bars represent 95% confidence intervals.*

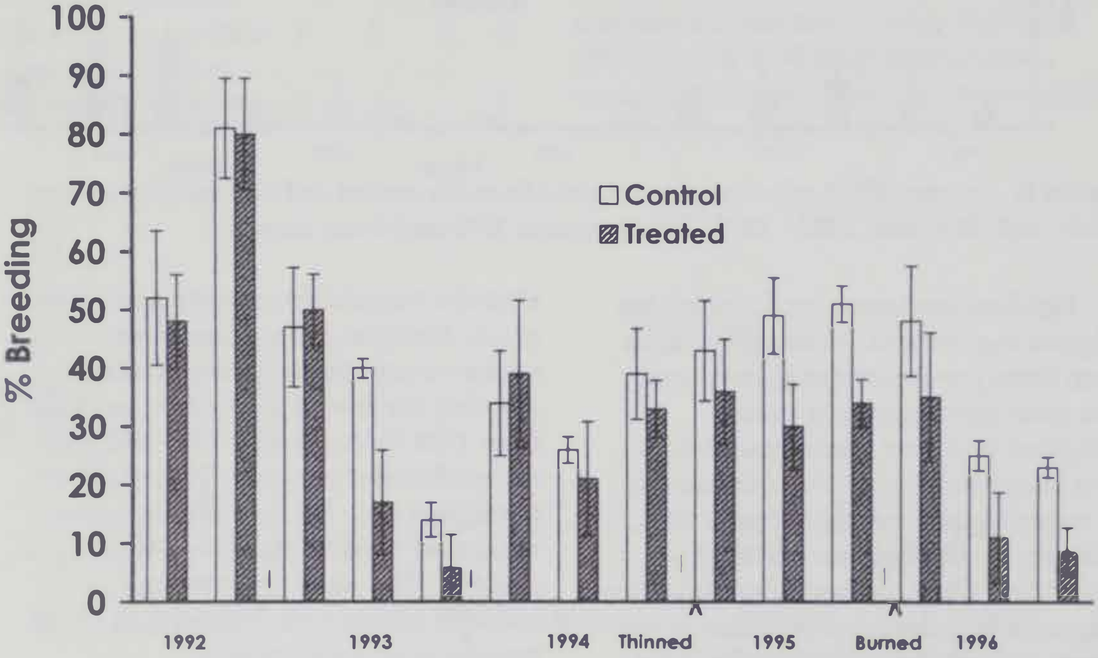

Figure 4. *Percentage of deer mice in breeding condition on six control and six treated grids near Gold Creek, Montana 1992 - 1996. Bars represent 95% confidence intervals.*

mice were in breeding condition on treated than control grids during all trapping periods with confidence intervals overlapping on only two occasions. Because the MNA tended to be higher on treated grids after treatment, this difference could reflect a higher proportion of juvenile non-breeding animals on treated grids. Although deer mouse populations on treated grids had consistently lower average percentages of adults after treatment, differences were small and insignificant (Fig. 5).

Yellow pine chipmunks occurred on all grids during most trapping periods (Fig. 6). Average MNA varied from zero to three per grid over five years (Fig. 6) with highs occurring during 1993 and 1996 on both treated and control grids. Chipmunk MNA was not significantly greater on treated grids than on control grids during these two years (Fig. 6). Also, average chipmunk numbers were higher on treated grids after treatment than anytime during the study but the difference was not statistically significant.

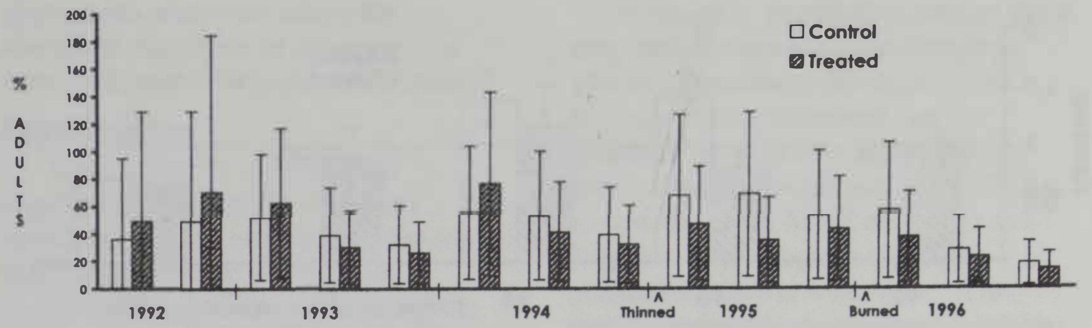

Figure 5. *Average percent of adult deer mice captured on control and treated grids near Gold Creek, Montana, 1992 - 1996. Bars indicate 95% confidence intervals.*

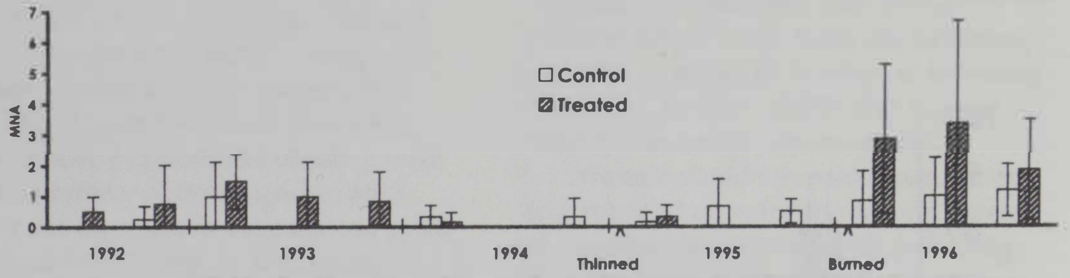

Figure 6. *Average MNA of yellow pine chipmunks on six control and six treated grids near Gold Creek, Montana, 1992 - 1996. Bars represent 95% confidence intervals.*

Delayed treatment confounded the original experiment. However, results from three pre-treatment seasons and two semi-post-treatment years, indicated that deer mouse and yellow pine chipmunk populations increased on treated grids, but the increase in yellow pine chipmunks was not significant. Only continuation under the original study design would clarify the effects of thinning and under-burning on rodent populations.

Results From A Concurrent Study

Some indication of effects for a longer period after treatment than available for this study was gained from another study in the same area that began in 1994, continued over two years post-treatment (Douglass *et al.* 1996), and was designed to monitor Hantavirus in rodents. Three grids similar to those in the current study were live-trapped. One of these grids was placed in a treated area another in a control and a third in an old clear-cut (all trees removed) dominated by aspen (*Populus tremuloides*), shrubs and thick grass. Sampling procedures were similar excep that trapping occurred monthly for five to six months per year from 1994 through May 1999 and there were 100 traps per grid. This study (Douglass *et al.* 1996) provided a non-replicated view of three post-treatment seasons. The clear-cut provides an example of what the treated grid could become over a longer time.

More species were captured from 1994 through spring 1999 (Table 2) than in the current study. A six-month trapping regime probably allowed more opportunity to capture rare species. Potentially significant differences in species composition occurred among control, treated, and clear-cut grids. Boreal red-backed voles (*Clethrionomys gapperi*) were the second most abundant species on the control grid and meadow voles were second most abundant species on the other grids. The apparent decrease in red-backed voles and increase in meadow voles on treated grids has been described for other treatments that reduced tree cover,

Table 2. *Numbers of small mammals captured on three grids near Gold Creek Montana from 1994 through May 1999. Unpublished data from a study described by Douglass et al. 1996.*

Species	Con-trol	Treat-ted	Clear cut	Total
Deer mice	214	379	260	853
Meadow voles	0	79	81	160
Yellow Pine chipmunks	6	65	45	116
Boreal red-backed vole *(Cletrionomys gapperi)*	22	3	4	29
Western jumping mice	0	1	6	7
Long-tailed voles *(Microtus longicaudus)*	0	2	1	3
Northern flying squirrels *(Gloucomys sabrinus)*	2	0	0	2
Northern pocket gopher	0	0	1	1

lichens and mosses (Douglass 1977, Pollard and Relton, 1973). The increase in meadow voles on the treated grid and the older clear cut may be associated with increased litter cover on these grids compared to the control grid (Getz 1961, Grant 1971).

Changes in deer mouse MNA on the control and treated grids of the Hantavirus study were similar to those of the current study for the three years the studies coincided (Figs. 2 and 7). However, the divergence between MNA on control and treated grids seen during 1995 in the current study did not occur and was inconsistent during 1996 and 1997. During 1998 (two years post-treatment), the MNA on the treated grid increased to nearly three times

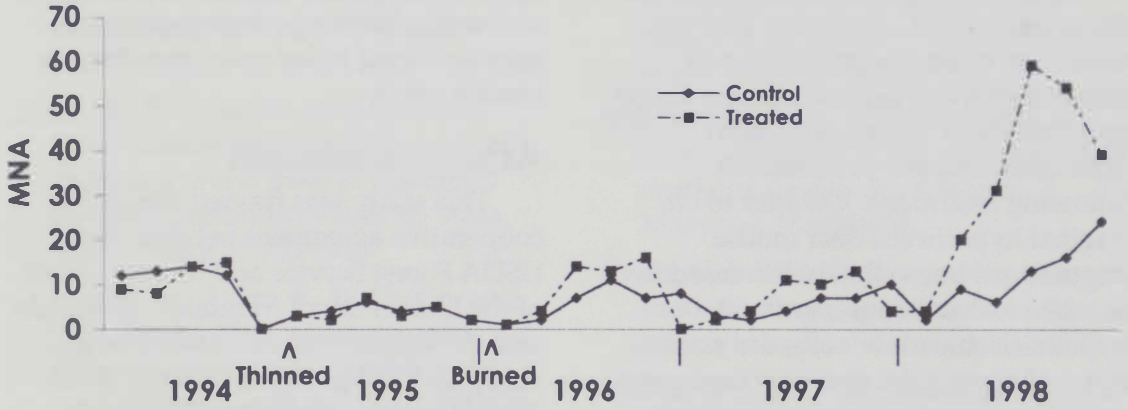

Figure 7. *Deer mouse MNA on one control and one treated grid near Gold Creek, Montana,1994 - 1998. These grids were trapped during a separate study conducted in the study area (unpublished data, Douglass et al. 1996).*

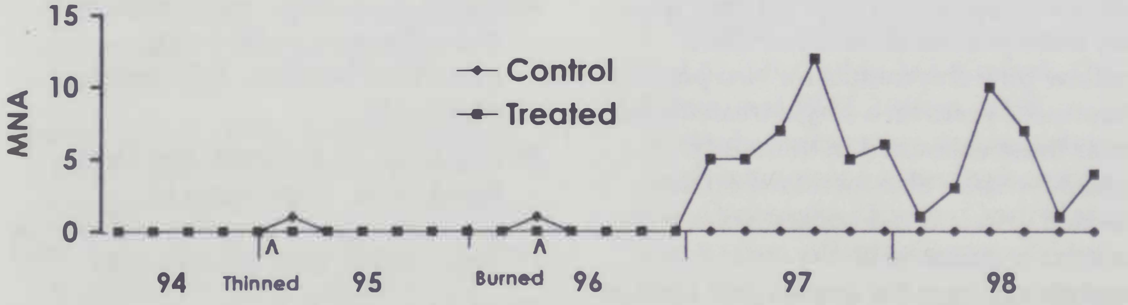

Figure 8. *Yellow pine chipmunk MNA on one control and one treated grid near Gold Creek, Montana 1994 - 1998. These grids were trapped during a separate study conducted in the study area (unpublished data Douglass et al. 1996).*

pretreatment levels and only two times the previous high on control grids. This non-replicated post-treatment increase in deer mouse densities is consistent with the results of the current study.

Except for an occasional capture, Yellow pine chipmunks were absent from both treated and control grids until after treatment (Fig. 8). One year after treatment, yellow pine chipmunks were present only on the treated grid during all trapping periods with numbers reaching maxima of 10 or more animals each year. This type of response of chipmunks was consistent with that described by Gashwiler (1970) and may be a continuation of the initial, though non-significant, response demonstrated in the current study.

CONCLUSION

Although we were unable to assess the impact of the Landscape Ecology project on rodent populations and communities during more than a single post treatment season, we found significant changes immediately following treatment. Counter to our original hypothesis, deer mouse populations immediately increased in numbers. Also inconsistent with our hypothesis, meadow voles did not respond during the first post treatment year. Consistent with our hypothesis, yellow pine chipmunk populations increased on treated grids but the increase was not significant. Non-replicated data from an ongoing study (Douglass *et al.*1996), also showed increase population sizes for deer mice for three post-treatment years and yellow pine chipmunks for two post-treatment years on a single treated grid near those examined in this study. Meadow voles also increased on the treated grid and red-backed voles were relatively common on the control grid and absent from the treated grid after treatment.

Although we were unable to complete the study as planed, we found considerable evidence that thinning and under-burning affected rodent communities as well as population sizes of some species. Habitat modifications created by treatment allowed deer mouse and probably yellow pine chipmunk population sizes to increase. From a concurrent study we conclude that treatment may eliminate red-backed voles when present and allow the invasion and increase of meadow voles.

The management ramifications are that this type of treatment should increase ecological factors dependent on small mammal numbers (prey base, nutrient cycling). The effect on the biodiversity of small mammals could be that a few locally rare species are replaced by other rare species. For example, red-backed voles and flying squirrels may be eliminated by thinning and under-burning whereas jumping mice and long tailed voles may invade treated areas.

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