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DEMOGRAPHY AND CONDITION OF POPULATIONS OF WHITE-FOOTED MICE (*PEROMYSCUS LEUCOPUS*) IN LATE AND EARLY SUCCESSIONAL HABITATS

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Populations of white-footed mice (*Peromyscus leucopus*) were monitored for 3 years (1986–1988) in late and early successional habitats. Late-successional habitats consisted of mature hardwood forests with little herbaceous vegetation. Early successional habitats were induced by treatment with either triclopyr or tebuthiuron herbicides, used with and without annual prescribed burning, and consisted of varying levels of shrubs and herbaceous vegetation. Abundance of white-footed mice was highest in 1986 and declined through 1987 and 1988, which corresponded to declines in biomass of forbs. Abundance was higher on both herbicide treatments than controls and higher on triclopyr than tebuthiuron treatments. Triclopyr-altered habitats provided a mixture of dense shrubs and forbs not found in tebuthiuron-altered sites. Litter size, but not reproductive activity, was higher on triclopyr compared to tebuthiuron treatments in spring 1986. Body condition of adult mice, but not body mass, was higher on herbicide and burned treatments than on controls and unburned treatments, respectively.

Key words: *Peromyscus leucopus*, white-footed mouse, habitat succession, triclopyr, tebuthiuron, herbicide, fire, population dynamics

Composition and structure of vegetation are two of the most important determinants of abundance and distribution of populations of small mammals (Barry and Francq, 1980; M'Closkey and Lajoie, 1975). Although much is known about the biology and ecology of populations of *Peromyscus*, questions still remain concerning the importance of specific environmental cues inducing demographic fluctuations. M'Closkey and Lajoie (1975) noted that structural attributes of vegetation, and not floristic composition, determined local abundance; similar observations have been reported by other investigators (Kaufman et al., 1983*a*; Kitchings and Levy, 1981; Seagle, 1985). Food has been proposed as an important extrinsic habitat factor influencing the dynamics of populations of *Peromyscus*. Examples include correlations of demographic attributes to myriad supplemental feeding manipulations (Hansen and Batzli, 1978; Vessey, 1987) and natural increases in food supplies (Gashwiler, 1979; Jameson, 1953).

Undoubtedly, both habitat structure and food supplies are inextricably linked in promoting fluctuations in populations of white-footed mice (*Peromyscus leucopus*). However, documentation of such a linkage through experimental manipulation of habitats is limited for this species of rodent. Alterations in quality of habitats have been used experimentally to document impacts on populations of *P. maniculatus* (Kaufman et al., 1983*a*; Santillo et al., 1989; Sullivan, 1990). Our objective was to evaluate responses of demographic, reproductive, and condition characteristics of populations of white-footed mice in habitats experimentally manipulated with herbicides and burning. Triclopyr and tebuthiuron herbicides, which differ in their effectiveness on woody vegetation, were used to alter forested habitats to early successional stages that varied in their amount of woody and herbaceous vegetation (Stritzke et al., 1991). These manipulations allowed population response of white-footed mice to be monitored in several habitat types: late-succession, forest habitats with little herbaceous understory and early succession habitats with varying proportions of shrubs and herbaceous vegetation. Our hypothesis was that abundance, reproduction, and condition indices of populations of white-footed mice would increase on herbicide-treated sites due to increased production of grasses and forbs and enhanced structural complexity; would be greater on triclopyr-treated sites, which were more structurally complex (less control of woody vegetation) than tebuthiuron treatments; and would respond positively to burned treatments due to increased nutritional quality of available forage.

MATERIALS AND METHODS

Study area.—Our study was conducted on the Cross Timbers Experimental Range, a 648-ha site located ca. 11 km SW of Stillwater, Payne Co., Oklahoma (36°02′40″–36°04′20″N, 97°09′30″–97°11′39″W). Typical cross-timbers rangeland is composed of upland forests with interspersed grassland-cedar savannas. Upland-forest habitats are dominated by post oaks (*Quercus stellata*) and black-jack oaks (*Q. marilandica*) in the overstory, and eastern red cedars (*Juniperus virginiana*), rough-leaf dogwoods (*Cornus drummondii*), redbuds (*Cercis canadensis*), American elms (*Ulmus americana*), and buckbrush (*Symphoricarpos orbiculatus*) in the understory. Understory herbaceous dominants include little bluestem (*Schizachyrium scoparium*), Indiangrass (*Sorghastrum nutans*), rosette panicgrass (*Panicum oligosanthes*), and western ragweed (*Ambrosia psilostachya*).

Experimental design.—The Cross Timbers Experimental Range was divided into 20 fenced 32.4-ha pastures that represent four replications of four experimental treatments and untreated controls in a randomized-block design. Pastures were assigned to respective blocks according to their similarity in total woody canopy cover and soil types. Experimental treatments included two herbicides applied with and without annual burning of vegetation from the previous year. Tebuthiuron (Dow Elanco, Indianapolis, IN) is a soil-applied herbicide and was applied aerially at 2.2 kg/ha in March 1983. Triclopyr (Dow Elanco) is a foliar-applied herbicide and was applied aerially at 2.2 kg/ha in June 1983. Treatment one consisted of tebuthiuron alone, treatment two was tebuthiuron with burning, treatment three was triclopyr alone, and the fourth treatment was triclopyr with burning. In the control sites, there was no herbicide treatment or burning. All 20 pastures were moderately grazed by yearling cattle at equitable stocking rates from April to September of each year (Stritzke et al., 1991).

Vegetative analysis.—Standing crop of current annual production of understory vegetation was estimated in densely wooded, shallow savanna and sandy savanna range sites in late July and early August of each year (1985–1988). Range sites with >80% woody overstory canopy cover were considered densely wooded. Vegetation was sampled in randomly placed portable wire-mesh cages (50- by 50-cm surface area on the ground) that excluded grazing. Current year's growth, in 14 wire cages (seven per range site), was clipped and separated into grasses, forbs, and woody vegetation. Woody vegetation included leaves and current annual growth of stems from 0 to 1.5 m height. Samples were dried at 70°C to a constant weight to determine total dry mass.

Collection of animals.—Populations of white-footed mice were sampled in March, June, September, and December, 1986 and 1987, and in June and December 1988, for a total of 10 sampling periods. In the 1st sampling period, two of the four replications were randomly selected and each treatment site was sampled using an 8 by 8 grid (15-m spacing; 1.1 ha) randomly placed in upland forest habitats. To avoid effects of removal trapping, sites were trapped at a minimum interval of 3 months and grids were relocated before each sampling period so that no area was trapped more than once. The alternate two replicates were sampled after every 2 successive sampling periods. Two Museum Special snap traps per station and one Victor rat trap at every second station were placed within a 1-m radius of each grid point. A mixture of peanut butter and rolled oats was used as bait for all Victor rat traps and one Museum Special trap per station; slices of apples were used as bait for the second Museum Special. These baits were used to increase the potential for capturing a variety of species in the event some species had a specific preference for bait. Each grid was trapped for 3 consecutive nights with daily removal of captured animals and counting of all sprung traps. Abundance was calculated as a relative index of catch per unit effort and expressed as the number of animals caught per 100 trap-nights (corrected for sprung traps; Nelson and Clark 1973).

Collected animals were taken to the laboratory to record body mass (±0.1 g) and total length of body, length of tail, and length of hind foot (±1.0 mm). Body mass of females was corrected for pregnancy by subtracting uterine mass from body mass. There was a natural break at body mass of 19 g, which separated reproductive from nonreproductive female mice; thus, both males and females $\geq$19.0 g were classified as adults, while those $\leq$18.9 g were considered non-adults. Reproductive status of each male was assessed by weights of the testes and seminal vesicles and by scoring smears of epididymal sperm. Presence of spermatozoa in the epididymis was ascertained by cutting the caudal pole, extruding its contents, and smearing across a glass slide. Slides were examined microscopically, and the relative abundance of sperm was assessed by assigning a numerical rank of 0 (none), 1 (trace), 2 (moderate), and 3 (abundant). Females were classified as pregnant only when embryos were grossly visible upon necropsy. Embryos were counted when present, and females were recorded as lactating if mammary tissue was conspicuous with hair-free areas surrounding the nipples. Females were considered reproductively active if pregnant or lactating. Condition of animals was assessed only in 1986 by examining mass (±1.0 mg) of liver, spleen, and adrenal glands. An index of general condition was calculated for each animal as the proportion of body weight to length of body, expressed as a percentage.

Statistical analyses.—We analyzed differences in frequency distributions among treatments and seasons for age and sex ratios, sperm-abundance scores, and reproductive status of females by chi-square analysis based on a null hypothesis of equal frequencies (Koopmans, 1981). Estimates of relative abundance were arcsine transformed (Sokal and Rohlf, 1981) and differences among treatments and seasons were tested by analysis of variance using the general linear-model procedure (PROC GLM; SAS, Institute, Inc., 1985). Condition indices (body mass, condition score, organ and gland masses) were rank transformed before data analysis as a method to analyze non-normally distributed data (Conover and Iman, 1981). Main and interaction effects of treatment, season, and sex were examined by analysis of variance for the rank-transformed data. Specific contrasts and Duncan's multiple-range tests were used in all analysis-of-variance procedures to compare differences between major treatment components (tebuthiuron versus triclopyr, burned versus unburned, all treatments versus controls). Statistical significance was $P \leq 0.05$ for all tests. Values are given as mean ± 1 *SE.*

RESULTS

Characteristics of habitats.—Herbicide treatments resulted in early successional habitats with increased production of grasses and forbs in all years (Fig. 1). Production of woody dicots was higher on triclopyr-treated than tebuthiuron-treated sites; however, relative abundance of woody dicots was consistently highest on untreated control habitats. Fluctuations in grasses, forbs, and woody vegetation were observed from 1985 through 1988 in manipulated habitats. Forbs became less important components of manipulated habitats after 1985 (52% in 1985 versus 19% in 1988) with a concomitant increase in grasses and, to a lesser degree, woody vegetation.

Characteristics of populations.—A total of 1,516 white-footed mice was captured over the 3-year study. Abundance differed significantly among seasons ($P < 0.001$)

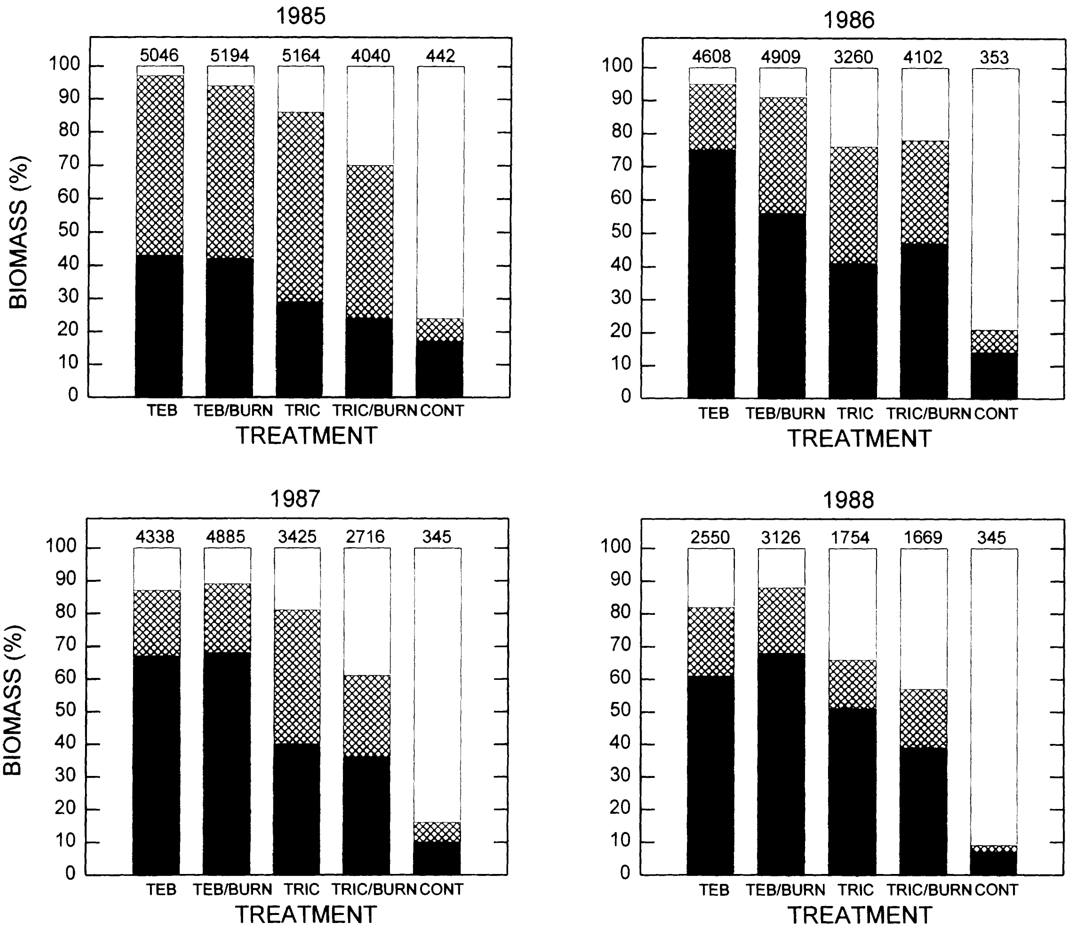

FIG. 1.—Relative composition of current annual standing crop of grasses (black), forbs (hatched), and woody vegetation (open) from four treatments and controls, 1985–1988. Treatments are tebuthiuron only (TEB) and with prescribed burn (TEB/BURN), triclopyr only (TRIC) and with prescribed burn (TRIC/BURN), and control (CONT). Values above bars represent biomass of current annual growth in kg/ha.

and treatments ($P < 0.001$), decreasing from a high in 1986 to a low in 1988. Although population trends during the study were similar, the amplitude of fluctuations differed greatly among the five treatments (Fig. 2). Differences in abundance among seasons were most pronounced in 1986, with greatest abundances occurring in spring and winter (Fig. 2).

Overall, abundance of white-footed mice was greater in unburned triclopyr-treated pastures than in the other four treatments during all 3 years of our study. Specific contrasts revealed that abundance was significantly greater ($P < 0.001$) in herbicide-treated than control pastures and in triclopyr-treated than tebuthiuron-treated pastures ($P < 0.05$). Abundance approached significantly greater levels on unburned than on burned pastures ($P < 0.06$).

Sex ratios of non-adults did not differ ($P > 0.100$) among treatments or seasons. During the study, 707 non-adult mice were collected (53% males, 47% females). The percentage of males in the adult population, which was similar in all treatments, differed among seasons in 1986 ($\chi^2 = 16.7$, 3 *d.f.*, $P < 0.001$) and in 1987 ($\chi^2 = 7.8$, 3 *d.f.*,

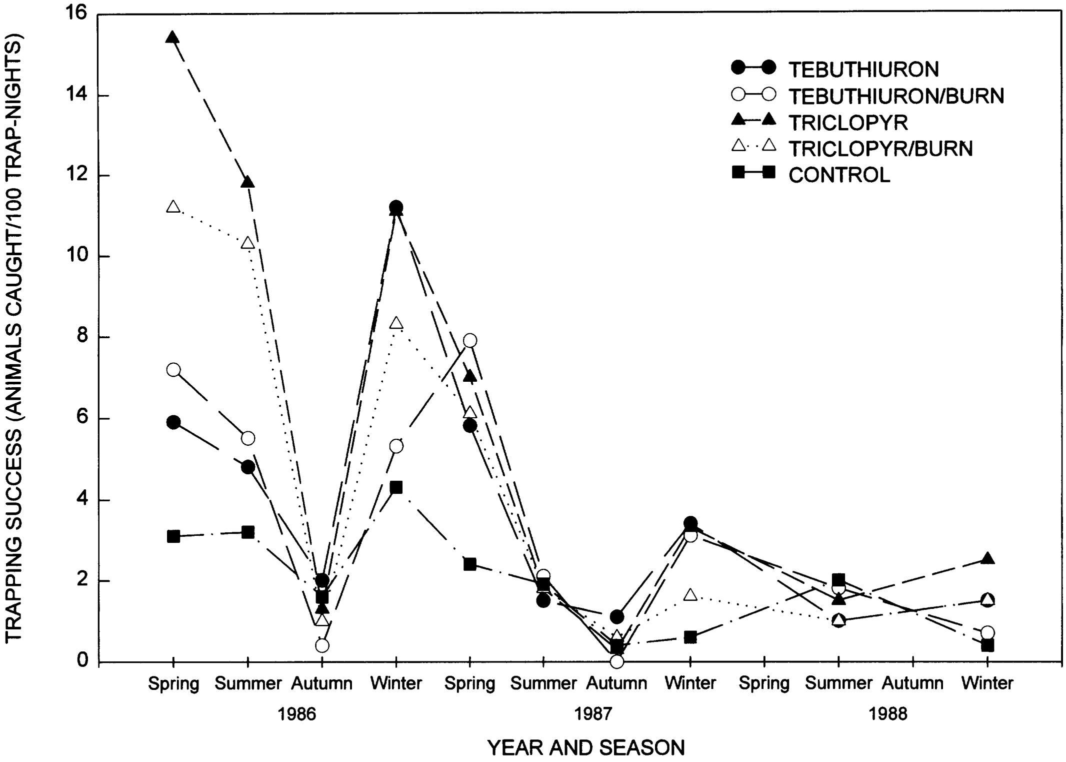

FIG. 2.—Trapping success of white-footed mice throughout the study on four treatments and the control plots.

$P = 0.051$). In 1986, percentage of adult males was lowest in autumn (28%) and highest in winter (60%). Similarly, percentage of adult males in 1987 was lowest in autumn (35%) and highest in spring and winter (63%).

Non-adult mice occurred in all 10 sampling periods and represented >30% of mice in each season except autumn 1986 and autumn 1987 (<10%). Percentage of non-adults in populations of white-footed mice differed among seasons ($\chi^2 = 64.9$, 3 *d.f.*, $P < 0.001$) with percentages typically lowest in autumn and highest in summer (30–76%). Differences among herbicide treatments were apparent in March 1986 ($\chi^2 = 10.3$, 1 *d.f.*, $P < 0.01$), when percentage of non-adults was greater in triclopyr than in tebuthiuron pastures (Fig. 3). Also, there was a trend toward a higher percentage of non-adult mice on unburned than on burned pastures ($\chi^2 = 3.7$, 1 *d.f.*, $P < 0.058$). Frequency of occurrence of non-adults (all seasons and years pooled) in populations inhabiting herbicide-treated pastures was greater than untreated controls ($\chi^2 = 3.97$, 1 *d.f.*, $P < 0.05$).

Reproductive activity.—Distinct seasonal peaks of reproductive activity were evident with the highest peak occurring in spring 1986; other peaks occurred in autumn 1986 and 1987 (Fig. 4). Experimental treatments did not influence the percentage of reproductively active adult females in any season sampled ($P > 0.10$).

Litter size ranged from two to eight with an overall mean (± 1 *SE*) of 4 ± 0.1. Litter size differed among seasons ($P < 0.001$) and treatments ($P < 0.05$) in 1986, but not in 1987 or 1988 (Table 1). Litter size was greatest in autumn (5 ± 0.2) and least in spring (3 ± 0.1). Further, specific contrasts for spring 1986, when sample size was large, indicated that litter size was greater

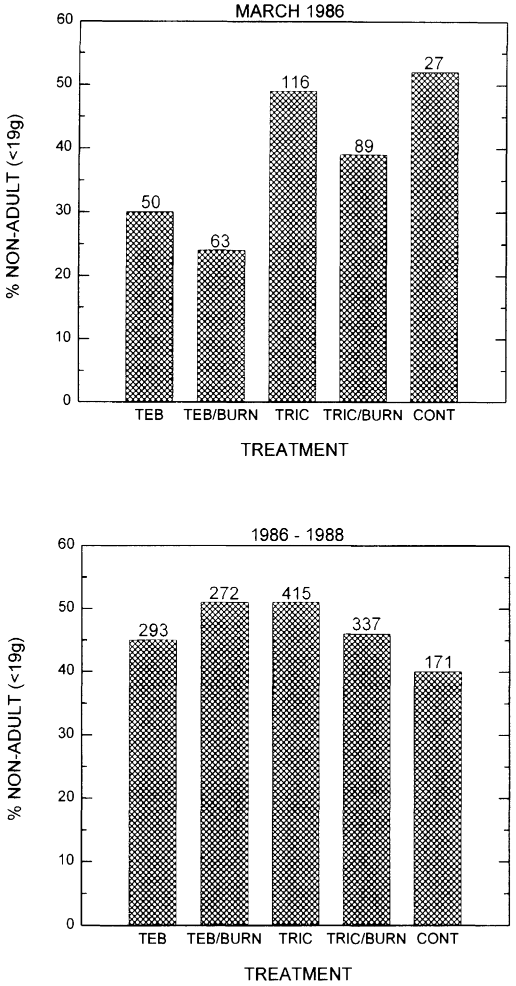

FIG. 3.—Percentage of the mouse population composed of non-adults in March 1986 (above) and throughout the 3-year study (below) on four treatments and the control plots. Non-adults were defined as mice weighing <19 g. Values above bars represent sample size (*n*).

on triclopyr (4 ± 0.1, $n = 34$) than tebuthiuron sites (3 ± 0.1, $n = 22$; $P < 0.01$). Differences in in-utero litter mass among treatments, as measured by the total weight of gravid uteri, approached significance in spring 1986 ($P < 0.051$). Contrasts showed that mean mass of gravid uteri was significantly ($P < 0.05$) greater on control sites (4.02 ± 1.85 g, $n = 3$) than on herbicide-treated sites (1.54 ± 0.25 g, $n = 56$).

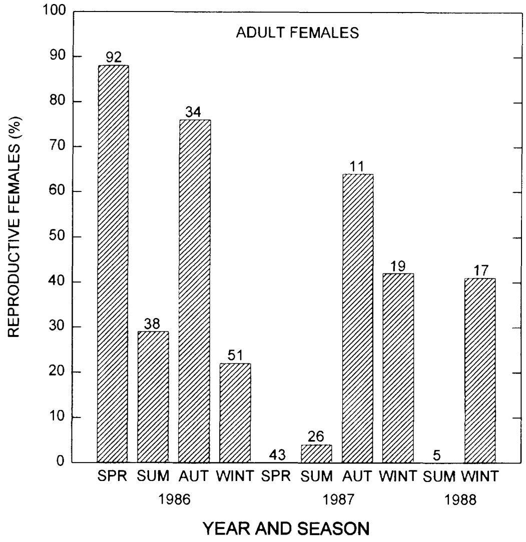

FIG. 4.—Seasonal trends in percentage of adult female mice that were reproductively active (pregnant or lactating) throughout the study. Values above bars represent sample size (*n*).

Data pooled across the two spring seasons showed the percentage of males with relative sperm-abundance scores >2 were higher in unburned (90%) than burned (77%) treatments ($\chi^2 = 5.8$, 1 *d.f.*, $P < 0.025$; Fig. 5). Mean masses of testes and seminal vesicles of adult males were significantly different among pooled seasons and complemented patterns of reproductive activity based on the relative degree of spermatogenesis ($P < 0.001$; Table 2). Mean mass of testes and of seminal vesicles for each season differed from all other seasons and were heaviest in autumn and lightest in summer. Treatments had no influence on mean mass of seminal vesicles or testes ($P > 0.10$).

Condition.—Body mass and scores of relative condition for adult white-footed mice were not different between males and females ($P > 0.050$), and thus were combined and used as gross indices of body condition. There were no significant differences in adult body mass among treatments ($P > 0.05$), although there was a significant treatment-by-season interaction ($P < 0.05$). This was due primarily to the heavy mice

TABLE 1.—*Litter size in white-footed mice collected from the Cross Timbers Experimental Range from spring 1986 to winter 1988. Pregnant mice were not captured in summer 1986, spring and summer 1987, or spring, summer, and autumn 1988.*

	Year and season																	
	1986									1987						1988		
	Spring			Autumn			Winter			Autumn			Winter			Winter		
Treatment	*n*	$\bar{X}$	*SE*	*n*	$\bar{X}$	*SE*	*n*	$\bar{X}$	*SE*	*n*	$\bar{X}$	*SE*	*n*	$\bar{X}$	*SE*	*n*	$\bar{X}$	*SE*
Tebuthiuron	8	3	0.1	4	5	0.5	0			4	4	0.4	1	4		1	3	
Tebuthiuron and burning	15	3	0.2	0			0			0			0			0		
Triclopyr	20	4	0.2	3	4	0.3	1	8		0			3	4	0.3	1	3	
Triclopyr and burning	15	4	0.2	3	4	0.3	0			1	6		1	4		1	5	
Control	3	3	0.3	3	5	0.6	0			1	4		1	4		1	3	

collected in autumn on burned tebuthiuron treatments. Relative condition scores for adult mice were significantly influenced by treatment ($P < 0.05$) and, as with body mass, there was a significant treatment-by-season interaction ($P < 0.001$). Specific contrasts indicated that condition-score means for adult mice inhabiting herbicide-treated pastures (24.4 ± 0.1 g) and burned pastures (24.5 ± 0.1 g) were greater than those from untreated controls (23.5 ± 0.2 g; $P < 0.01$) and unburned treatments (24.3 ± 0.1 g; $P < 0.05$), respectively.

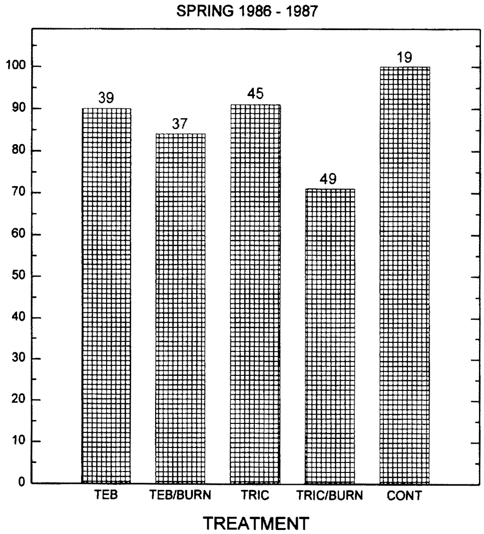

FIG. 5.—Percentage of adult male mice with sperm-abundance scores ≥2 on four treatments and the control plots in spring 1986 and 1987, combined. Values above bars represent sample size (*n*).

Mass of adrenal glands, spleen, and liver of adult white-footed mice were used as relative indicators of stress (Christian et al., 1965) and condition. Mass of adrenal glands and of spleens were not significantly different between males and females ($P > 0.05$), so sexes were combined for analysis. However, because mass of liver was significantly greater for adult females than for males ($P < 0.001$), sexes were analyzed separately. Mass of spleens, but not mass of adrenals, of adult male and female mice were significantly influenced by treatment ($P < 0.01$), and there was a significant treatment-by-season interaction ($P < 0.05$). Specific contrasts showed that mass of spleens was heaviest on treated (56.4 ± 1.9 mg) and burned (60.7 ± 3.5 mg) sites compared to untreated control (47.4 ± 3.3 mg; $P < 0.05$) and unburned sites (52.9 ± 1.8 mg; $P < 0.05$), respectively. Mass of livers of adult males also was significantly influenced by treatment ($P < 0.05$), with mass of livers on treated sites (1,046 ± 12 mg) being heavier than on untreated controls (905 ± 30 mg). Mass of livers of adult females was not influenced by treatment ($P > 0.05$), but there was a significant treatment-by-season interaction ($P < 0.01$). Specific contrasts showed that mass of livers of adult females was heavier on treated

TABLE 2.—*Mass of testes and seminal vesicles of adult males of white-footed mice collected from the Cross Timbers Experimental Range from spring 1986 to winter 1988.*

		Year and season											
		Spring			Summer			Autumn			Winter		
Reproductive parameter	Year	*n*	$\bar{X}$	*SE*	*n*	$\bar{X}$	*SE*	*n*	$\bar{X}$	*SE*	*n*	$\bar{X}$	*SE*
Weight of testes (mg)	1986	117	565	18	56	113	11	13	601	49	83	111	13
	1987	75	191	12	24	69	9	6	509	36	33	385	28
	1988				12	85	26				21	346	23
Weight of seminal vesicle (mg)	1986	117	417	19	56	35	3	13	415	35	83	30	4
	1987	75	50	6	24	22	2	6	396	35	33	187	23
	1988				12	27	4				21	179	27

(1,277 ± 24 mg) than on untreated sites (1,075 ± 67 mg; $P < 0.05$).

DISCUSSION

Herbicides and prescribed burning were used at the Cross Timbers Experimental Range to induce retrogression of the dominant post oak and black-jack oak upland forests toward tallgrass prairie. These treatments provided an opportunity to explore the simultaneous effects of structural complexity and forage composition on demography of resident populations of white-footed mice. Stritzke et al. (1991) demonstrated that treatment with triclopyr is less effective than tebuthiuron in providing complete kill of overstory hardwoods. Additionally, triclopyr is less efficient than tebuthiuron at controlling resprouting of understory species such as American elm, hackberry (*Celtis occidentalis*), roughleaf dogwood, and buckbrush, which resulted in a dense, structurally complex, understory. Biomass of forbs was essentially equal between tebuthiuron and triclopyr sites, whereas the more efficient control of woody vegetation by tebuthiuron allowed for increased production of grass in tebuthiuron sites.

Small mammals respond to habitat alterations according to individual habitat and forage requirements (Borrecco et al., 1979; Kirkland, 1978; Santillo et al., 1989). Studies on populations of white-footed mice have demonstrated their affinity for woody vegetation (Kaufman et al., 1983*b*; Kitchings and Levy, 1981; M'Closkey and Lajoie, 1975). Likewise, studies of supplemental feeding have shown the importance of nutrition in facilitating population growth of wild white-footed mice (for review see Vessey, 1987).

As expected, white-footed mice responded to successional changes in habitat composition and structure. Removal of canopy on treated sites promoted dramatic changes in structure and composition of vegetation as total biomass of forbs, grasses, and woody vegetation ranged from six to 11 times greater on treated sites than on control sites during the study. Peak abundance of white-footed mice was greater on treated than on control sites, especially in 1986 and spring 1987. Abundance of mice on treated sites declined after spring 1987 and remained similar to control sites through the end of the study, coinciding with the decline of forbs in treated sites. Populations of cotton rats (*Sigmodon hispidus*) on the Cross Timbers Experimental Range followed a similar pattern (McMurry et al., 1994).

Although white-footed mice probably consume mast of trees and shrubs as a primary food source (Baker, 1968), their feeding strategy is known to be flexible (Drickamer, 1976). Therefore, increased production of forbs on treated sites may have provided an important forage base for the mice. Reproduction and survival are known to increase in wild populations of *Peromys-*

cus receiving supplemental food (Bendell, 1959; Briggs, 1986; Taitt, 1985; Vessey, 1987). Populations of mice in manipulated habitats had a higher proportion of juveniles in the trappable population.

If food resources of herbicide-treated pastures were improved over untreated controls, then the lack of any significant differences in reproductive parameters of adult females is difficult to explain. Although forage biomass increased on treated sites, changes in quantity of food per individual may have been minimal. Merson (1979) found female white-footed mice to be sensitive to diet, with a reduction of food intake as low as 10% causing a significant decline in incidence of vaginal estrus. However, the greater scores for relative body condition, spleen, and liver mass of white-footed mice from herbicide-treated pastures compared to untreated controls support the possibility that treatments improved the overall nutritional quality of habitats. Merson (1979) reported significant reductions in weight of livers in white-footed mice subjected to moderate dietary restrictions, although body mass apparently was not a sensitive indicator of nutritional status.

Population responses of white-footed mice to the habitat alterations induced by triclopyr and tebuthiuron also were different, with greater abundances on those pastures treated with triclopyr. We found that woodrats (*Neotoma floridana*), a woodland species, also responded favorably to triclopyr-treated sites (McMurry et al., 1993). In 1985 and 1986, biomass of woody vegetation on triclopyr-treated sites was 4.0 and 2.5 times greater, respectively, than on tebuthiuron treatments, a difference that became less evident in 1987 and 1988. Increased woody vegetation on triclopyr-treated sites may have promoted habitat conditions, which promote increases in abundance of white-footed mice (Borrecco et al., 1979; Kirkland, 1978). Litter size and recruitment were higher on triclopyr than on other sites in March 1986.

Abundance of populations of white-footed mice tended to be lower on burned than unburned sites. White-footed mice typically avoid burned habitat (Beck and Vogl, 1972), whereas *P. maniculatus* often responds favorably to burning due to increased availability of seeds (Ahlgren, 1966; Beck and Vogl, 1972; Tester, 1965). Because burning of rangeland in spring increases nutritive quality of several species of plants (Allen et al., 1976), we expected mice to show a positive response on burned plots. Although condition scores and mass of spleens were greater on burned sites, the percentage of adult males with a sperm-abundance score ≥2 was lower. Stritzke et al. (1991) noted that penetration of fire into brushy upland sites was relatively inefficient due to a lack of fine fuel. Therefore, prescribed burning may have been of little consequence in areas that we sampled. If burning did improve the nutritional quality of the vegetation, benefits may have been offset by adverse impacts on habitat structure.

Factors unrelated to herbicide treatment may have influenced the observed responses in populations of *Peromyscus*. A general decline in numbers of mice in the region of the Cross Timbers Experimental Range could explain the similarity in abundances in 1987 and 1988. However, results of this study suggest that populations of white-footed mice responded to alterations of forage components and structural attributes of their habitat. Peak abundance of populations of *P. leucopus* occurred on unburned triclopyr treatments, which may have provided the best combination of vegetative cover and food resources. Declines in abundance of mice accompanied a decrease in biomass of forbs, while total biomass of woody vegetation remained relatively constant, suggesting that structure may have been of secondary importance to available forage. Modifications such as those described in this study are not permanent, as succession of the plant community proceeds rapidly following treatment with herbicides. Although animals were not collected in 1985, we suspect that the high abundances in spring 1986 were attributable to high overwinter survival following the flush in production of forbs in 1985, coupled with the favorable structural aspects of triclopyr-treated sites. Increased overwinter survival and earlier initiation of the breeding season have been attributed to increased food supply (Bendell, 1959; Flowerdew, 1973).

The complete absence of reproduction among females in spring 1987, although difficult to explain, may have been partially due to the decline in production of forbs in 1986, and probably led to the decline and sustained low in abundances observed throughout 1987 and 1988. Average production of forbs in 1986 declined ca. 50% from 1985 levels on tebuthiuron- and triclopyr-treated pastures and may have represented a major decline in a heavily used food resource. The lower condition scores of adult white-footed mice in spring 1987, compared to spring 1986, also suggests a decline in quality of forage in this period. Quality of forage is known to have positive effects on the reproductive potential of female mice (Bomford and Redhead, 1987; Merson, 1979; Merson and Kirkpatrick, 1982).

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LITERATURE CITED

AHLGREN, C. E. 1966. Small mammals and reforestation following prescribed burning. Journal of Forestry, 64:614–618.

ALLEN, L. J., L. H. HARBERS, R. R. SCHALLES, C. E. OWENSBY, AND E. F. SMITH. 1976. Range burning and fertilizing related to nutritive value of grass. Journal of Range Management, 29:306–308.

BAKER, R. H. 1968. Habitats and distribution. Pp. 98–126, *in* Biology of *Peromyscus* (Rodentia) (J. A. King, ed.). Special Publication, The American Society of Mammalogists, 2:1–593.

BARRY, R. E., JR., AND E. N. FRANCQ. 1980. Orientation to landmarks within the preferred habitat by *Peromyscus leucopus*. Journal of Mammalogy, 61: 292–303.

BECK, A. M., AND R. J. VOGL. 1972. The effects of spring burning on rodent populations in a brush prairie savanna. Journal of Mammalogy, 53:336–346.

BENDELL, J. F. 1959. Food as a control of a population of white-footed mice, *Peromyscus leucopus noveboracensis* (Fischer). Canadian Journal of Zoology, 37:173–209.

BORRECCO, J. E., H. C. BLACK, AND E. F. HOOVEN. 1979. Response of small mammals to herbicide-induced habitat changes. Northwest Science, 53:97–106.

BOMFORD, M., AND T. REDHEAD. 1987. A field experiment to examine the effects of food quality and population density on reproduction of wild house mice. Oikos, 48:304–311.

BRIGGS, J. M. 1986. Supplemental food and two island populations of *Peromyscus leucopus*. Journal of Mammalogy, 67:474–480.

CHRISTIAN, J. J., J. A. LLOYD, AND D. E. DAVIS. 1965. The role of endocrines in the self-regulation of mammalian populations. Recent Progress in Hormone Research, 21:501–578.

CONOVER, W. J., AND R. IMAN. 1981. Rank transformations as a bridge between parametric and nonparametric statistics. The American Statistician, 35: 124–129.

DRICKAMER, L. C. 1976. Hypothesis linking food habits and habitat selection in *Peromyscus*. Journal of Mammalogy, 57:763–766.

FLOWERDEW, J. R. 1973. The effect of natural and artificial changes in food supply on breeding in woodland mice and voles. Journal of Reproduction and Fertility, 19:259–269.

GASHWILER, J. S. 1979. Deer mouse reproduction and its relationship to the tree seed crop. The American Midland Naturalist, 102:95–104.

HANSEN, L., AND G. O. BATZLI. 1978. The influence of food availability on the white-footed mouse: populations in isolated woodlots. Canadian Journal of Zoology, 56:2530–2541.

JAMESON, E. W., JR. 1953. Reproduction of deer mice (*Peromyscus maniculatus* and *P. boylei*) in the Sierra Nevada, California. Journal of Mammalogy, 34: 44–58.

KAUFMAN, D. W., AND E. D. FLEHARTY. 1974. Habitat selection by nine species of rodents in north-central Kansas. The Southwestern Naturalist, 18:443–452.

KAUFMAN, D. W., G. A. KAUFMAN, AND E. J. FINCK.

1983*a*. Effects of fire on rodents in tallgrass prairie of the Flint Hills region of eastern Kansas. The Prairie Naturalist, 15:49–56.

KAUFMAN, D. W., S. K. PETERSON, R. FRISTIK, AND G. A. KAUFMAN. 1983*b*. Effect of microhabitat features on habitat use by Peromyscus leucopus. The American Midland Naturalist, 110:177–185.

KIRKLAND, G. L. 1978. Population and community responses of small mammals to 2,4,5-T. United States Forest Service Research Note, PNW-314:1–6.

KITCHINGS, J. T., AND D. J. LEVY. 1981. Habitat patterns in a small mammal community. Journal of Mammalogy, 62:814–820.

KOOPMANS, L. H. 1981. An introduction to contemporary statistics. Duxbury Press, Boston, Massachusetts, 599 pp.

M'CLOSKEY, R. T., AND D. T. LAJOIE. 1975. Determinants of local distribution and abundance in white-footed mice. Ecology, 56:467–472.

McMURRY, S. T., R. L. LOCHMILLER, J. F. BOGGS, D. M. LESLIE, JR., AND D. M. ENGLE. 1993. Woodrat population dynamics following modification of resource availability. The American Midland Naturalist, 129:248–256.

———. 1994. Demographic profiles of populations of cotton rats in a continuum of habitat types. Journal of Mammalogy, 75:50–59.

MERSON, M. H. 1979. Influence of restricted feed intake on the reproductive characteristics, energetics, and body composition of two species of rodents. Ph.D. dissert., Virginia Polytechnic Institute and State University, Blacksburg, 228 pp.

MERSON, M. H., AND R. C. KIRKPATRICK. 1982. Relative sensitivity of reproduction activity and body-fat level to food restriction in white-footed mice. The American Midland Naturalist, 106:305–312.

NELSON, L., JR., AND F. W. CLARK. 1973. Correction for sprung traps in catch/effort calculations of trapping results. Journal of Mammalogy, 54:295–298.

SANTILLO, D. J., D. M. LESLIE, JR., AND P. W. BROWN. 1989. Responses of small mammals and habitat to glyphosate application on clearcuts. The Journal of Wildlife Management, 53:164–171.

SAS INSTITUTE, INC. 1985. SAS user's guide: statistics, fifth ed. SAS Institute, Inc., Cary, North Carolina, 956 pp.

SEAGLE, S. W. 1985. Patterns of small mammal microhabitat utilization in cedar glade and deciduous forest habitats. Journal of Mammalogy, 66:22–35.

SOKAL, R. R., AND F. J. ROHLF. 1981. Biometry: the principles and practice of statistics in biological research. Second ed. W. H. Freeman and Company, San Francisco, California, 776 pp.

STRITZKE, J. F., D. M. ENGLE, AND F. T. McCOLLUM. 1991. Vegetation management in the Cross Timbers: response of woody species to herbicides and burning. Weed Technology, 5:400–405.

SULLIVAN, T. P. 1990. Demographic responses of small mammal populations to a herbicide application in coastal coniferous forest: population density and resiliency. Canadian Journal of Zoology, 68:874–883.

TAITT, M. J. 1985. Cycles and annual fluctuations: *Microtus townsendii* and *Peromyscus maniculatus*. Acta Zoologica Fennica, 173:41–42.

TESTER, J. R. 1965. Effects of a controlled burn on small mammals in a Minnesota oak-savanna. The American Midland Naturalist, 74:240–243.

VESSEY, S. H. 1987. Long-term population trends in white-footed mice and the impact of supplemental food and shelter. American Zoologist, 27:879–890.

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LINKED CITATIONS

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Literature Cited

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LINKED CITATIONS

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Stable URL:
http://links.jstor.org/sici?sici=0022-2372%28198111%2962%3A4%3C814%3AHPIASM%3E2.0.CO%3B2-6

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John R. Tester
American Midland Naturalist, Vol. 74, No. 1. (Jul., 1965), pp. 240-243.
Stable URL:
http://links.jstor.org/sici?sici=0003-0031%28196507%2974%3A1%3C240%3AEOACBO%3E2.0.CO%3B2-I