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Effects of mowing and burning on small mammal populations of a restored prairie.

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EFFECTS OF MOWING AND BURNING ON SMALL MAMMAL POPULATIONS OF A RESTORED PRAIRIE

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THESIS ACCEPTANCE

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ABSTRACT

Immediate and short-term effects of mowing and burning management on populations of small mammals inhabiting a reestablished grassland were evaluated. Mowed, burned, and unburned, unmowed areas were separately live-trapped during 1975 and 1976. Ten species were observed but only four were in sufficient numbers to be used for population estimations; these were Peromyscus maniculatus, Microtus ochrogaster, Perognathus flavescens, and Reithrodontomys megalotis.

Direct mortality was only observed as a consequence of burning; young Reithrodontomys megalotis in surface nests were particularly susceptible. Immediately after both burning and mowing management R. megalotis and M. ochrogaster populations declined significantly. Perognathus flavescens populations were not diminished by either practice. Peromyscus maniculatus populations did not decline after mowing but increased significantly after burning. Although it appears that mowing and burning management select against certain other small mammal species, none of the four principal prairie species in this study were eliminated from either trapping area.

INTRODUCTION

Long-term research on the effects of burning indicates that resultant grasslands support prairie species of small mammals, particularly Peromyscus maniculatus, the prairie deer mouse (Tester, 1965; Ahlgren, 1966; Beck and Vogl, 1972; Krefting and Ahlgren, 1974). Research on the immediate and short-term effects of fire on small mammals, however, is inconclusive. Cook (1959) reported that a grass fire caused the annihilation of all species of mice, either directly or through removal of food or cover, whereas Lawrence (1966) reported that no species were eliminated although he noted an increase in populations of predatory birds and mammals. Other studies, while reporting no signs of fire-related mortality or increased predation, have found complete absence of small mammals within a few days after burning (Rice, 1932; Schramm, 1970; Springer and Schramm, 1972). Howard et al. (1959) concluded that most adult small mammals can survive the fire itself, and Moreth and Schramm (1973) noted that two species, Peromyscus leucopus (white-footed mouse) and Peromyscus maniculatus (prairie deer mouse), may actually benefit from prairie fires.

The effects of mowing on small mammal populations has received less attention. Hall (1955) emphasized that species needing cover, including Microtus ochrogaster (prairie vole) and Reithrodontomys megalotis (western harvest mouse), may abandon the area if cover is removed. LoBue and Darnell (1959) found no evidence of mortality caused directly by mowing but observed that the mowed condition favored Peromyscus maniculatus while reducing the population of Microtus pennsylvanicus (meadow vole). This observation is supported by Whitaker (1967) who found that Peromyscus maniculatus can tolerate abrupt major habitat changes being able to exist in areas with no herbaceous ground cover.

This study was an attempt to further evaluate the effects of burning and mowing management on populations of small mammals.

MATERIALS and METHODS

Study Area

This study was conducted at the Allwine Prairie Preserve, a 65-ha reestablished prairie located in Douglas County about 19 km northwest of the University of Nebraska at Omaha (Fig. 1). Originally a cultivated and terraced farm, the area was seeded to native grasses in 1970, and has been managed to favor the restoration of prairie vegetation (Bragg, 1977).

A vegetation study by Becic (1976) reported that approximately 75 percent of the coverage in 1975 was native grasses, predominately Andropogon gerardii (big bluestem), Andropogon scoparius (little bluestem), Sorghastrum avenaceum (indiangrass), Bouteloua curtipendula (side-oats grama), and Panicum virgatum (switchgrass). The waterways were dominated by Bromus inermis (smooth brome) and Phalaris arundinacea (reed canarygrass). The most abundant weedy forbs on the burn area were Lactuca canadensis (Canada lettuce) and Conyza canadensis (horseweed). The main weedy forbs in the mow area were Trifolium pratense (red clover) and Melilotus officinalis (yellow sweetclover). During the two years of my study, the coverage by Melilotus officinalis increased on the mow area. The diversity of the habitat was augmented by the agriculture terraces which favored different plant associations than between-terrace locations (Bragg, 1976).

Mowing Operation

The summer haying operations involved mowing with a windrower, allowing the vegetation to dry for several days, then baling and

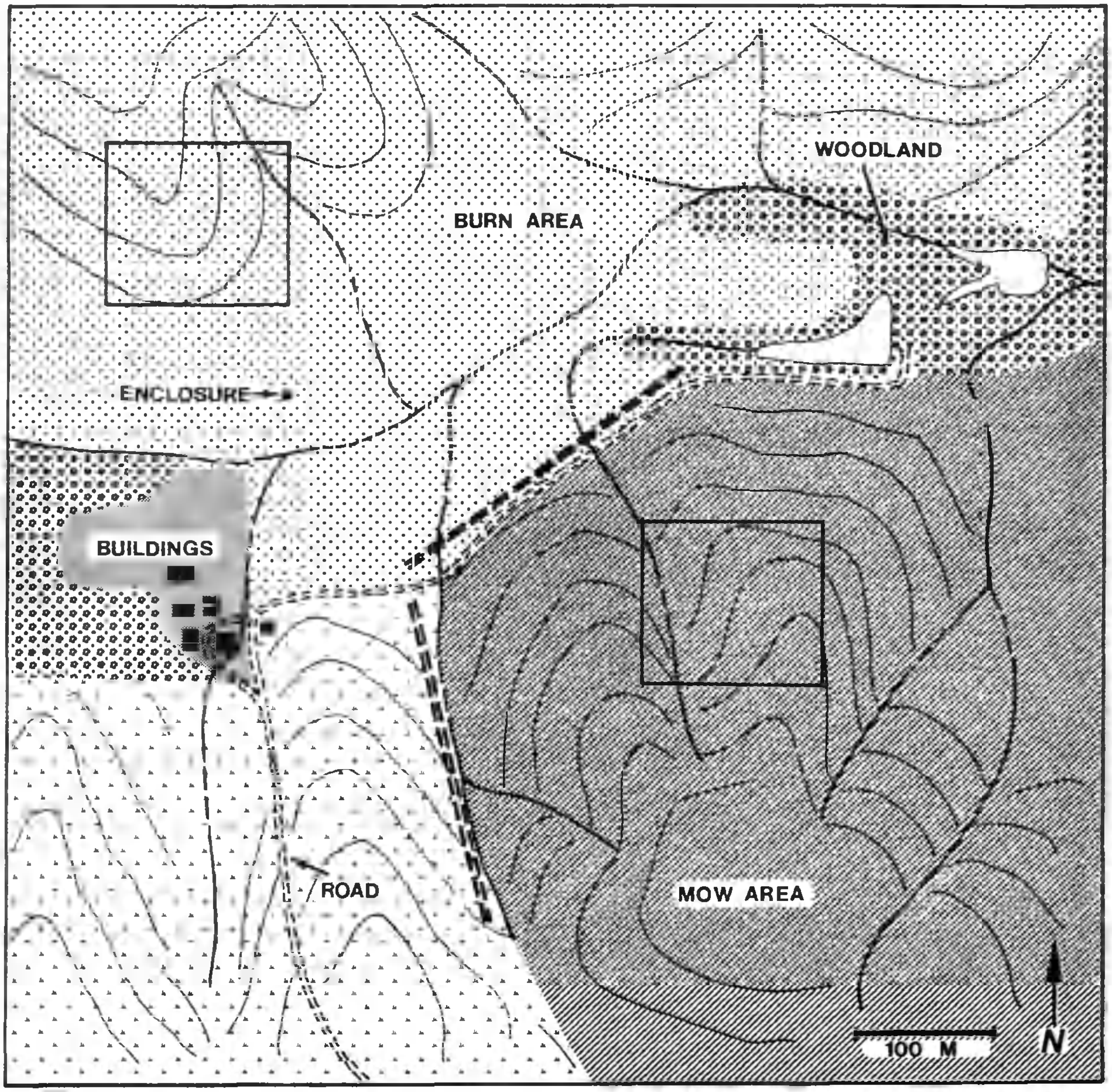

Fig. 1. Locations of trapping areas on Allwine Prairie Preserve. Large rectangles indicate trapping grids; dashed lines indicate border trap lines for examining mow-area emigration in the summer of 1976.

removing the hay. The vegetation was clipped to an average height of about 10 cm, but stubble of varied height was present. The taller stubble in low spots offered more cover to small mammals than would have been allowed if the vegetation had been clipped to a uniform shorter height by a machine more able to follow the contours of the soil surface.

Trapping Procedures

Grids: One trapping grid was set up on a north-facing upland slope in the area to be mowed during the summers of 1975 and 1976 and another grid was located on a south-facing upland slope in the area to be burned in the spring of 1976 (Fig. 1). Each grid was intersected by three terraces and included a portion of a drainage waterway. Previous management of both areas included mowing and burning.

General: Data on populations and home ranges were collected within the two 2-ha (approximately 5 acres) trapping grids; Sherman small live-traps were placed within the grid at 15-m intervals in nine rows, ten traps per row. Traps were set daily at dusk, checked at dawn, and left closed during the day. Bait consisted of rolled oats and "Hamster Goodies" (a product of Geisler Pet Products of Omaha, Nebraska). A cotton ball was provided as bedding.

In 1976 two changes were made in the procedure on the mowed area. One alteration to reduce trapping bias was a grid modification suggested by French (1971) in which the traps were shifted one-half the diagonal distance to the next trap halfway through each trapping period. The second change was establishment of two lines of traps in unmowed areas adjacent to the mowed area (Fig. 1). Each line consisted of a double row of 25 traps (50 traps total) spaced at 10-m intervals. The purpose of these border traps was to detect possible emigration from the mowed area.

Each captured individual was identified, examined, toe-clipped, and released. Species, sex, reproductive condition (scrotal condition for males; vaginal condition and evidence of lactation for females), age (size and pelage), general appearance, trap station, and behavior after release were recorded.

Mowed-Area Trapping Schedules: The mowing phase of this study was conducted over a two-year period. Each summer's mowing period was preceded by 15 consecutive days of trapping (1350 trap-nights) and followed by another 15 days of trapping. In both years the pre-mow period was 1 July to 15 July. The 1975 post-mow period was 25 July to 9 August; heavy rains prevented trapping on 2 August 1975. The 1976 post-mow period (29 July to 14 August) was delayed due to weather conditions. Trapping was not conducted on 1 August 1976 and 3 August 1976 because of hay-baling operations on the trapping grid. Border trap lines of the 1976 mow study provided 1900 trap-nights from 24 July to 14 August.

Burned-Area Trapping Schedules: The burn phase of the study was conducted during 1976. The area was trapped for seven days (630 trap-nights from 10 April to 26 April) prior to controlled burning on 26 April. A more extensive pre-burn trapping period of 15 days had been planned but inclement weather forced modification of the original plan. Five seven-day post-burn trapping periods during the spring and summer followed: 27 April to 4 May, 5 May to 11 May, 10 June to 17 June, 16 July to 24 July, and 23 August to 29 August.

Burn Enclosure

The immediate effects of fire on individual animals were evaluated in a 9-m^2 enclosure (Fig. 1). The enclosure was constructed with 1.27-cm hardware cloth and steel posts. The fence was buried 40 cm below ground to prevent escape by tunneling, and electric fencing was used on the above-ground portion to deter individuals from climbing. A pair of *Peromyscus maniculatus* (prairie deer mouse), a pair of *Reithrodontomys megalotis* (western harvest mouse), and one *Perognathus flavescens* (plains pocket mouse) were placed in the enclosure on 20 April. A food station was placed in the enclosure, but a shortage of traps prevented daily live-trapping to monitor the enclosed individuals. During and immediately after the fire of 26 April, the enclosure was visually checked and then trapped with a dense network of 15 snap-traps for two days. On 28 April the enclosure was raked and holes probed for burrows.

Data Analysis

Population estimates were computed by the multiple-day capture-recapture method of Schumacher and Eschmeyer (1943) and by the Leslie Method (Leslie and Davis, 1939) as described by Overton (1971). The Schumacher-Eschmeyer estimate, based on recapture of marked individuals, did not include individuals that died in traps. Because of unequal catchability among small mammals (Eberhardt, 1969), these methods often cannot accurately predict the total number of animals in an area; instead, the estimates are used as an indication of the population of trappable individuals.

Statistical differences based on the population estimates were determined using the procedure described by Davis (1965). Differences in daily capture rates were evaluated using Student t-tests, but most capture rates reflected the same trends observed in the population estimates. Changes in age or sex structure of the populations were analyzed by chi-square tests for equality of proportions.

Home ranges were examined according to observed range lengths, distances between the points of farthest capture (Brown, 1962). This method avoids making assumptions concerning home-range shape, activity, or size (Mohr and Stumpf, 1966; Sanderson, 1966; Metzgar and Sheldon, 1974). Differences in observed range lengths before and after mowing or burning were considered indications of changes in size of true home ranges; these data were also used to detect patterns in movements of individual animals.

RESULTS

Population Estimates and Home Range

During the 11,440 trap-nights of this study, ten species of small mammals were captured (Table I). Only four, all grassland species (Jones, 1964), provided enough captures to estimate populations: Peromyscus maniculatus, Microtus ochrogaster, Reithrodontomys megalotis, and Perognathus flavescens. The population estimate (N) of the Schumacher-Eschmeyer procedure was usually similar to the actual number of marked individuals in the area during each trapping period. The Leslie Method, which is not based on recapture but rather depends on the relationship between cumulative catch of individuals and the daily capture rate of new individuals, was regularly in close agreement with the actual number captured. The agreement between the estimates and the actual numbers of individuals captured suggests that nearly all catchable individuals in the area were captured during each trapping period.

In only a few instances were home ranges located entirely on the trapping grid thus preventing statistical comparison of changes as a consequence of management. One individual Peromyscus maniculatus was noted traveling over 150 m, back and forth from day to day; this distance is the length of the entire grid. Others showed travels of over 300 m, which is not uncommon for this species (Stickel, 1968). Although the grid was too small to compute mean home ranges for each species, the data were useful in determining activity patterns of individuals within the grid.

Table I. Species captured during the two-year mowing and burning study on Allwine Prairie Preserve.

Species	Individuals	Captures	Died in Traps
Peromyscus maniculatus (prairie deer mouse)	251	1791	83
Microtus ochrogaster (prairie vole)	147	563	8
Reithrodontomys megalotis (western harvest mouse)	119	441	9
Perognathus flavescens (plains pocket mouse)	99	582	7
Microtus pennsylvanicus (meadow vole)	31	155	0
Peromyscus leucopus (white-footed mouse)	12	72	1
Mus musculus (house mouse)	17	18	1
Blarina brevicauda (short-tailed shrew)	7	11	2
Sorex cinereus (masked shrew)	4	5	0
Spermophilus tridecemlineatus (thirteen-lined ground squirrel)	6	6	0
Total	693	3644	111

Mowing Effects

Mowing did not eliminate any of the four principal species from the area although it did reduce certain populations. The fates of missing individuals from these populations were unknown. Rates of predation were not determined but wandering individuals with little cover would have been easier prey. There was no evidence of direct mortality from the mowing operation itself, nor was emigration detected by the border traps.

Peromyscus maniculatus population estimates declined significantly after mowing, however the change in actual numbers of marked animals that were recaptured was small (Fig. 2). There was no indication of changes in population age structure and no immigration or emigration were detected, although six individuals appeared to travel back and forth between mowed grid and unmowed border traps thus indicating that both trap sites were part of their home ranges. Trap mortality for this species was high in comparison to other species (Table I).

Microtus ochrogaster populations also were significantly decreased after mowing; in this instance the actual number of recaptured animals was substantially reduced (Fig. 3). Of all individuals presumed alive just prior to the mowing, 30 percent were accounted for after the mow in 1975 and 24 percent in 1976. None of the missing animals were captured in the border trap lines, therefore no emigration from the mowed area could be verified. A shift in population age structure was evident in 1975; before the mow 85 percent of the individuals were adults compared to 38 percent after the mow (Table III). This significant change (chi-square; $P < 0.005$) reveals that the post-mow adult population

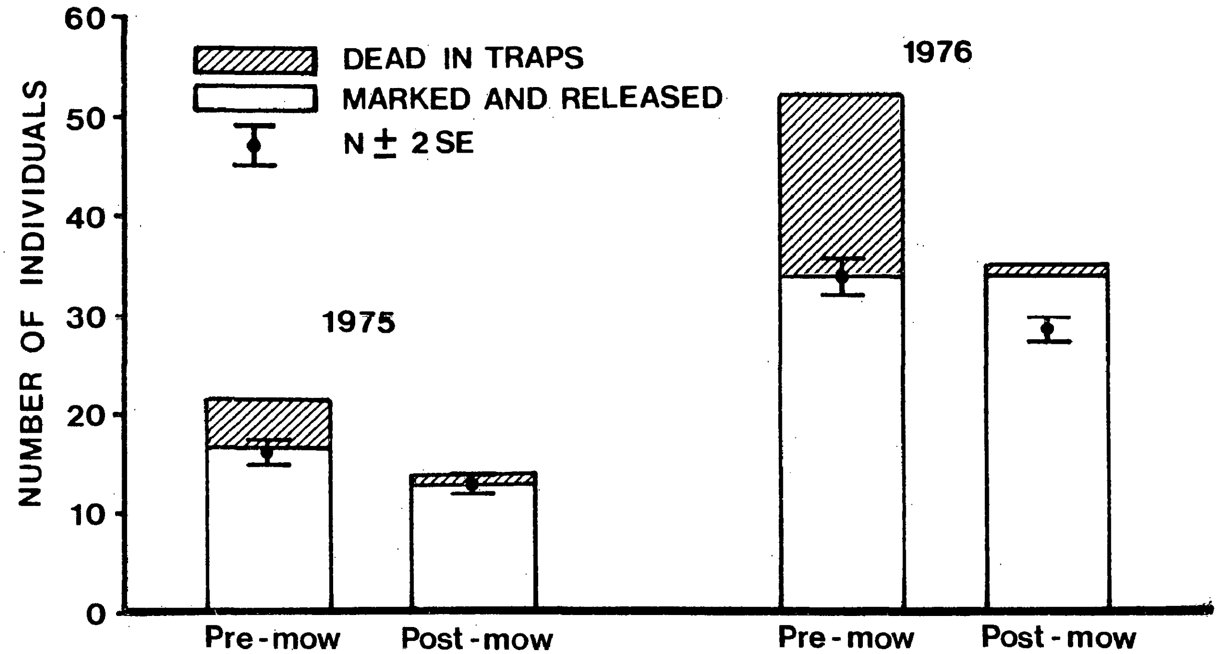

Fig. 2. Peromyscus maniculatus population estimates (N) for the mow-area trapping periods. The pre and post-mowing estimates are significantly different for both years ($P < 0.05$).

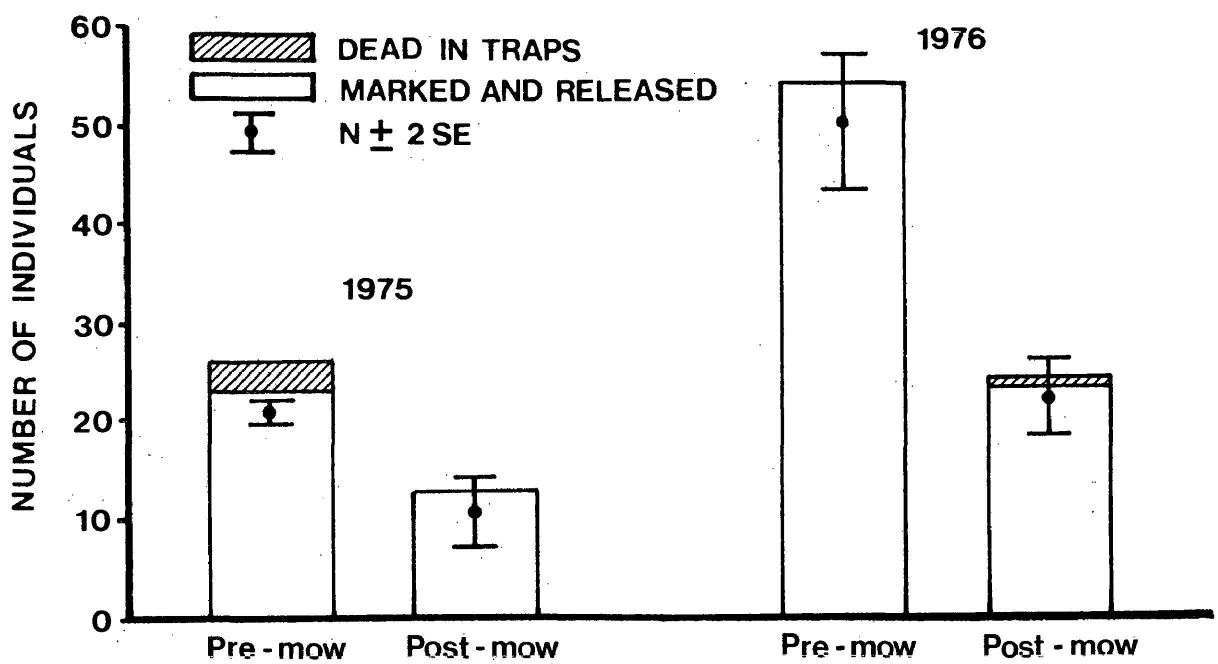

Fig. 3. Microtus ochrogaster population estimates (N) for the mow-area trapping periods. The pre and post-mowing estimates are significantly different for both years ($P < 0.05$).

was even further below the pre-mow adult population than indicated by the estimates. Activity mapping revealed that most of the Microtus captures after the mow were in close proximity to isolated patches of vegetation missed by the mower.

Perognathus flavescens were more abundant in 1975 than in 1976 (Fig. 4); sixty-seven percent of the adults captured in the first period of 1976 were individuals marked in 1975. No significant changes in population size or age structure were detected as a consequence of mowing.

The Reithrodontomys megalotis population was minimal on the mowed area during 1975, had increased by the next year, but declined after the 1976 summer mow (Fig. 5); the decline was not statistically significant. Individual trapping records revealed that 80 percent of the 1976 pre-mow individuals resided at the southeast edge of the grid, in the vicinity of a 25-m^2 area unmowed in 1975 and 1976; the only 1975 post-mow captures occurred in the same area.

Burning Effects

Peromyscus maniculatus increased significantly after burning (Fig. 6) and had the highest percentage (85 percent) of pre-fire marked animals recaptured after the burn. Inasmuch as there was not a significant drop in the percentage of adults (Table II), new mice apparently entered the burn grid after the fire. Numbers of individuals captured increased until the beginning of summer and then the population declined.

Microtus ochrogaster populations significantly declined

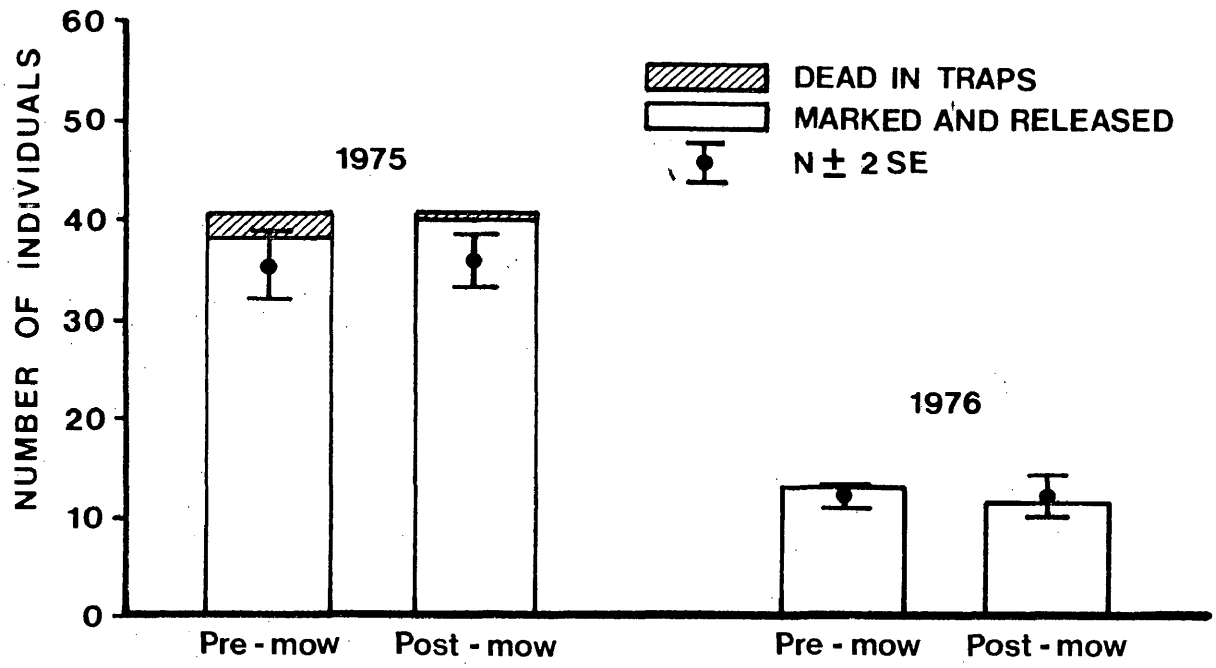

Fig. 4. Perognathus flavescens population estimates (N) for the mow-area trapping periods. No significant differences between pre and post-mowing estimates were noted.

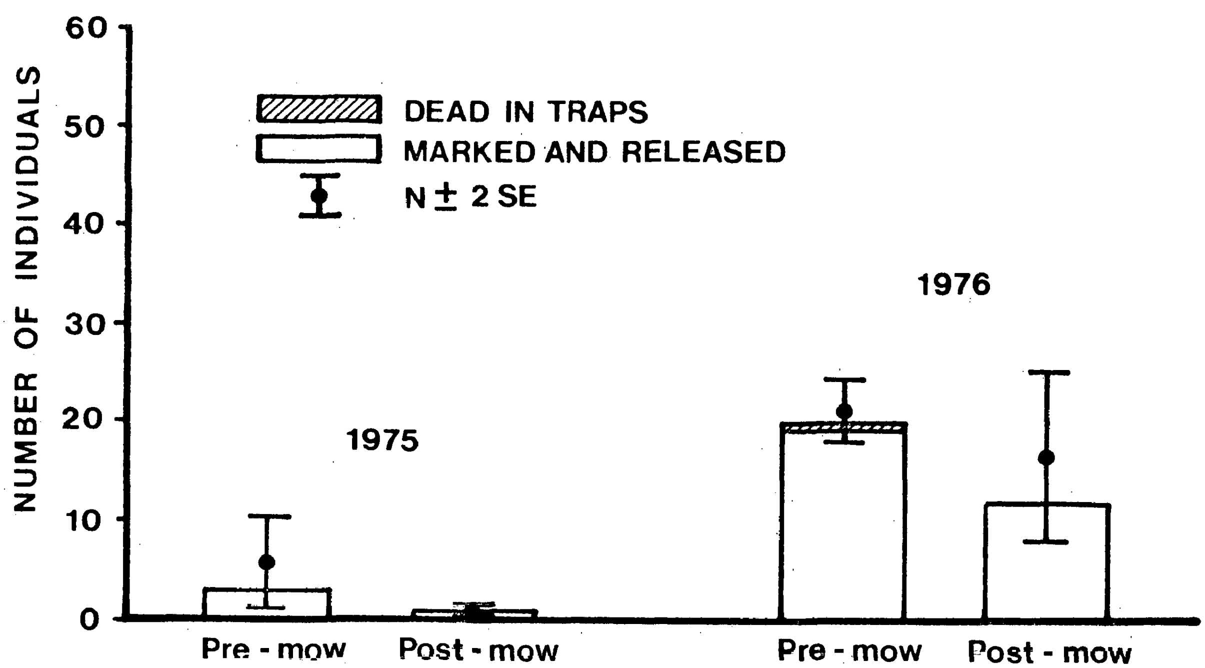

Fig. 5. Reithrodontomys megalotis population estimates (N) for the mow-area trapping periods. No significant differences between pre and post-mowing estimates were noted.

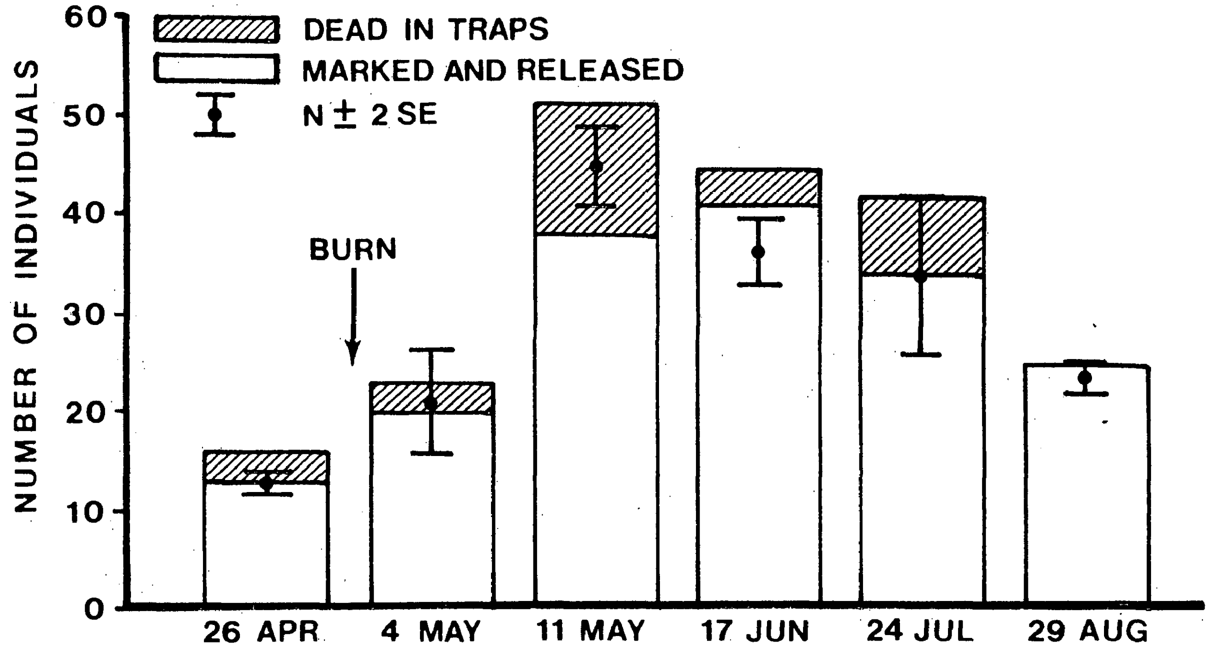

Fig. 6. Peromyscus maniculatus population estimates (N) for the final day of each burn-area trapping period. Estimates for each pair of consecutive trapping periods differed significantly ($P < 0.05$) with the exception of 17 June to 24 July.

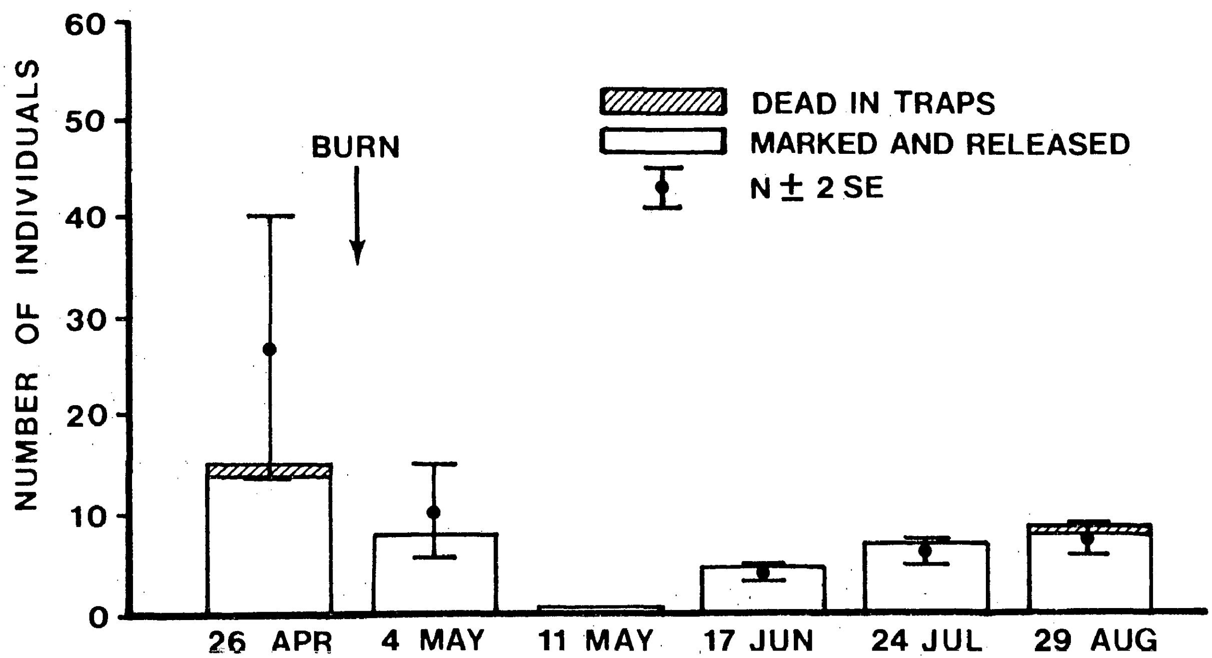

Fig. 7. Microtus ochrogaster population estimates (N) for the final day of each burn-area trapping period. Estimates for each pair of consecutive trapping periods differed significantly ($P < 0.05$) with the exception of 24 July to 29 August.

immediately after the burn and increased slowly thereafter (Fig. 7); only 43 percent of the individuals marked before the fire were accounted for after the burn. The few captures that did take place were in unburned spots along terraces and the drainage waterway where the fire skipped small patches without destroying vegetative cover.

Perognathus flavescens were infrequently captured throughout the burn study therefore changes in population size as a result of burning were undetectable (Fig. 8). The increase in July and August was caused by young animals joining the catchable population rather than by new adults.

Reithrodontomys megalotis, the most abundant small mammals on the trapping grid before the fire, significantly decreased in number by the second post-burn period and had not regained the original population size by the end of the summer (Fig. 9). Although the population decline in the first post-burn evaluation period was not statistically significant, the daily capture rate for that period showed a significant drop in the first seven days after the fire (t-test; $P < 0.01$). Charred carcasses of two young R. megalotis in two nests were observed after the fire. Data of Erwin and Stasiak (unpublished), collected concurrently with mine on the same burn area, also indicated considerable mortality to pre-weaned members of this species. Only one young animal out of a total of 30 individuals was captured between the April burning and August.

Burn Enclosure

The burn enclosure yielded no evidence of fire-related mortality.

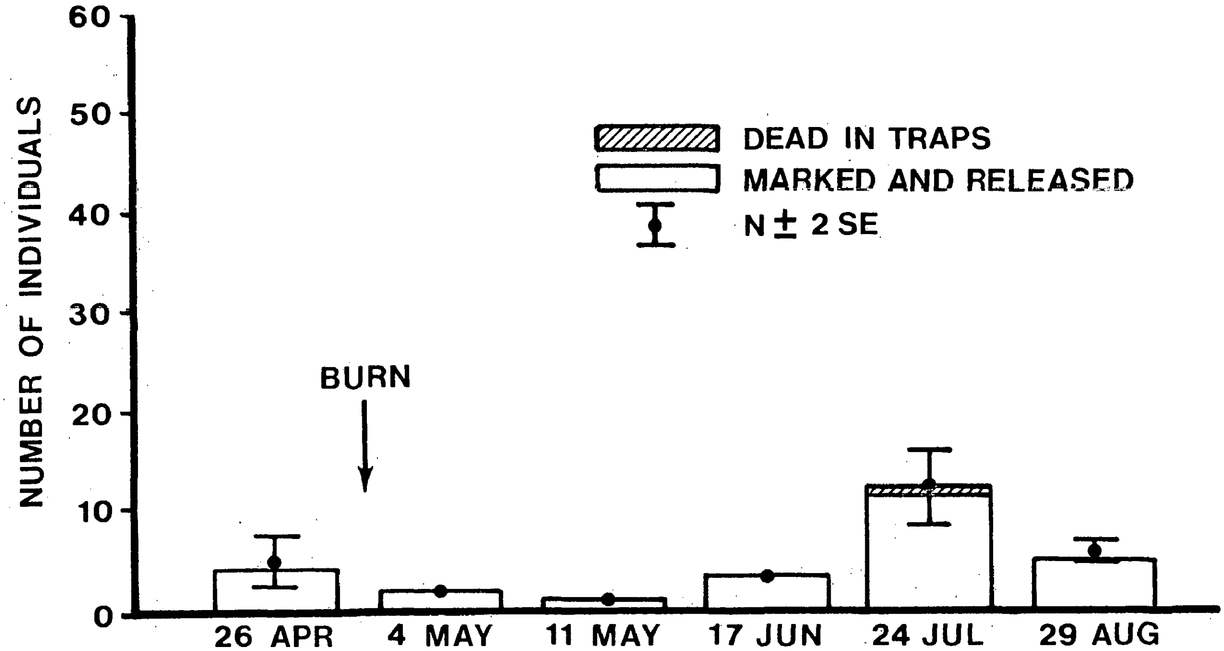

Fig. 8. Perognathus flavescens population estimates (N) for the final day of each burn-area trapping period. The estimate of 24 July differed significantly ($P < 0.05$) from both 17 June and 29 August.

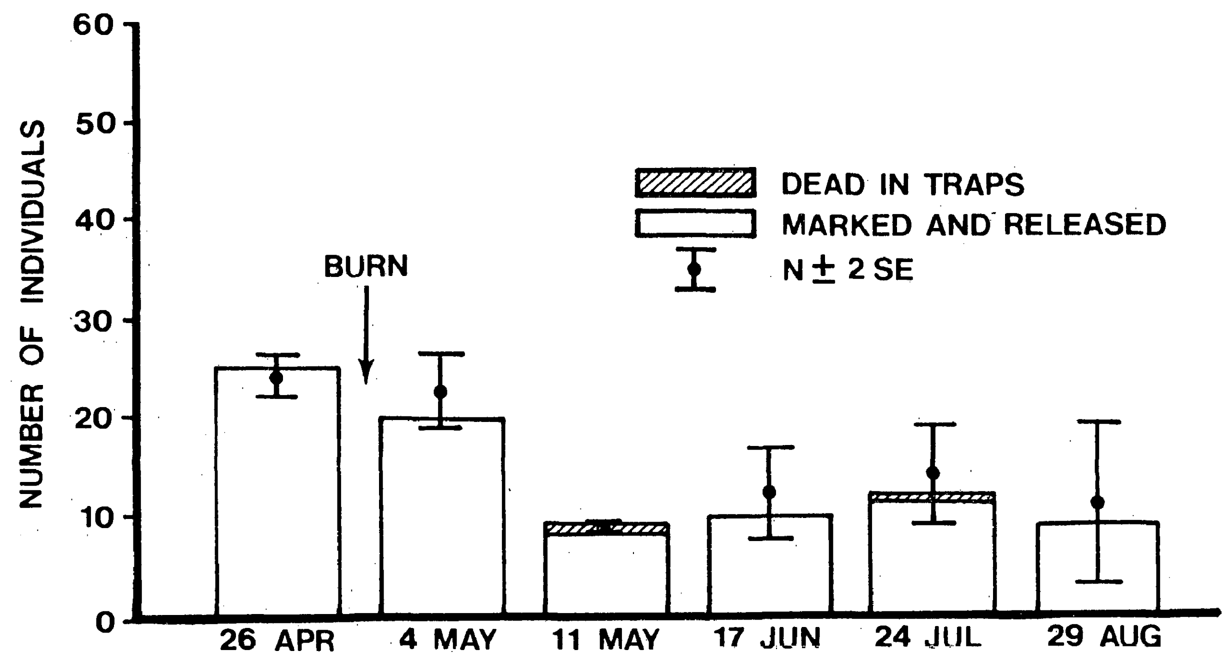

Fig. 9. Reithrodontomys megalotis population estimates (N) for the final day of each burn-area trapping period. The estimates for 4 May and 11 May were significantly different ($P < 0.05$); no other significant differences were noted.

The two Peromyscus maniculatus were captured immediately after the fire, confirming their survival. One of the Reithrodontomys megalotis was discovered at the far northwest corner of the trapping grid several days later, indicating escape from the enclosure. Because the other Reithrodontomys megalotis and the Perognathus flavescens were never found, no conclusions could be made. A careful search of the enclosure produced a nest with four newborn mice 10 cm below the ground surface. This litter presumably was born before the fire and belonged to the lactating Peromyscus maniculatus female which was removed several hours after the fire.

DISCUSSION

Mowing Effects

Microtus ochrogaster populations showed the greatest post-mow reductions of any species present. Meserve (1971) reported this species as having peaks of activity in dawn and twilight hours under adequate vegetative protection. Baker (1971) proposed that the normal eating habits and daylight activity patterns of some grass-eaters, such as *Microtus*, make them less likely to risk leaving vegetative cover than nocturnal seed-eaters, such as *Peromyscus*. These habits suggest that mowing would force *M. ochrogaster* from a field, although Hall (1955) proposed that they may retreat to extensive subsurface runways and stores of food when cover is removed. The apparent drop in the *M. ochrogaster* population in this study may have been at least partially the consequence of decreased trappability because of reduced surface activity when mowing removed the cover.

Reithrodontomys megalotis populations were also reduced in mowed areas. Jones (1964) described the optimum habitat for this species as lush, lowland swales, but he mentioned that this species also lives on upland areas where ground cover is abundant. Other authors also emphasized that *R. megalotis* inhabit dense grassy vegetation (Hall, 1955; Hall and Kelson, 1959; Burt and Grossenheider, 1964; Shump, 1974). It appears that it is the cover that makes some upland habitats favorable for this species. The individuals must seek refuge if the cover is removed by mowing. This consequence was emphasized by the home ranges of individuals which were restricted to the vicinity of adjacent unmowed portions of the study area.

Perognathus flavescens populations did not appear to be affected by mowing. Jones (1964) described this species as being more common in the short-grass areas of western Nebraska, thus they appear to be more adapted to low cover than either Reithrodontomys megalotis or Microtus ochrogaster. The upland area of this study was predominately covered by tallgrasses, but individuals of P. flavescens seemed to concentrate their home ranges on portions where the vegetation was shorter and more sparse; home ranges were thus more affected by excessive vegetative growth than by reduced cover. In 1976 when the vegetation was higher due to an abundance of Melilotus officinalis, the P. flavescens population was less than in the preceding year. The individuals captured in 1975, however, still occupied the same general home ranges in 1976.

Peromyscus maniculatus population estimates showed a statistically significant decline after mowing although the actual numbers of marked animals before and after mowing were similar. A decline in population size at this time of year was noted in the burned area suggesting that this decline may be a normal population trend rather than an effect of management. Clear interpretation of the data is further hindered by the extensive trapping mortality; 23 percent of the pre-mow individuals in 1975 and 35 percent of the pre-mow individuals in 1976 died in traps. Trapping mortality alone, thus, may have altered the population structure of P. maniculatus in the mow area. Previous studies indicate that populations of this species are not reduced by mowing; in the unmowed, unburned border area of this study, where much litter had accumulated, the absence of P. maniculatus further supported the concept that this species favors areas of reduced cover (LoBue and Darnell, 1959; Whitaker, 1967).

Microtus pennsylvanicus (meadow vole), infrequently captured in pre-mow trapping and never in post-mow trapping, were found primarily in the unburned, unmowed area. This lowland species prefers dense vegetation and accumulation of litter; the results of this study suggested that mowing and burning management select against Microtus pennsylvanicus which are not adapted to upland prairie conditions.

Burning Effects

The immediate effects of fire on small mammal populations in this study were not as drastic as noted by previous studies. All species of mice were not eliminated (Cook, 1959; Schramm, 1970; Springer and Schramm, 1972), nor was there an obvious increase in predation, as reported by Baker (1940) and Lawrence (1966). In agreement with Howard et al. (1959) and Lawrence (1966), most individuals seemed to survive the fire itself. Fifty-five percent of all marked animals presumed alive before the fire were confirmed alive after the fire by trapping records. Eighty-five percent of pre-burn Peromyscus maniculatus were recaptured after the fire, 75 percent of Perognathus flavescens, 60 percent of Reithrodontomys megalotis, and 43 percent of Microtus ochrogaster. The fates of the missing individuals cannot be ascertained; some may have been driven from the area by the fire itself, others may have emigrated because of insufficient vegetative cover, as suspected in the mowed areas for R. megalotis and M. ochrogaster, or increased predation may have been a factor (Beck and Vogl, 1972).

Direct mortality due to fire, however, was recorded. Young Reithrodontomys megalotis in surface nests were found to be most susceptible. Bancroft (1969) reported that Peromyscus maniculatus and Reithrodontomys megalotis both exhibit peak reproductive periods in April which coincided with the timing of the spring burn. Surface nests, such as those established by R. megalotis (Shump, 1974; Erwin and Stasiak, unpublished), are highly vulnerable to destruction in a prairie fire. Burrow nests, such as that containing living newborn mice found in the burn enclosure, are less susceptible to destruction by fire; high numbers of young P. maniculatus, a burrow-nesting species, captured in the month after the burn verify nest survival during the fire.

The presence of Microtus ochrogaster and Reithrodontomys megalotis in near-normal numbers immediately after the burn indicates adult survival of the fire, but subsequent reduction in captures suggests loss to predation or emigration. A significant increase in percentage of females (chi-square; $P < 0.05$) for R. megalotis in the first post-burn period indicates greater movement of females than before the burn (Table V). The destruction of nests and removal of vegetative cover most likely precipitated population movements for this species. As discussed regarding mowing results, adequate cover seems to be a limiting factor for both R. megalotis and M. ochrogaster. All individuals of these two species in the burned area were captured near or within patches of unburned vegetation, indicating that unburned islands may account for the maintenance of minimal populations of certain small mammals in burned areas.

Peromyscus maniculatus are expected to benefit when wooded areas are replaced by prairie vegetation after burning management (Beck and Vogl, 1972). In my study the number of captures of this species increased steadily after the fire but the increase occurred before the regrowth of vegetation, indicating that this species can inhabit an area lacking any herbaceous cover (Whitaker, 1967). Post-fire trapping records show a large number of new adults captured in the outer rows of the trapping grid thus suggesting that the baited traps became feeding stations for animals of the surrounding burned area as well as those initially within the grid. On several occasions I observed individuals traveling distances over 50 m away from the grid when released from the outer row of traps, although the majority took shelter in nearby burrows indicating residence in the immediate area. These data thus make post-fire population estimates of the grid area difficult to assess.

Concerning the adaptations of these four prairie species to prairie fires, this study demonstrated that burrows of *Peromyscus maniculatus* and *Perognathus flavescens* protect them from fire and the sudden removal of cover. *Reithrodontomys megalotis* were never observed to enter burrows, but Cook (1959) reported an ability for this genus to irrupt after vegetation requirements have been met. *Microtus ochrogaster* also have a reproductive potential that can allow their population to rapidly increase in previously burned areas once cover is sufficient. The effects of fire on small mammals may vary with the duration and intensity of the fire and type of shelter available (Tester, 1965) or with other factors. Such variation may result in other population responses than observed in this study.

CONCLUSIONS

Peromyscus maniculatus and Perognathus flavescens have burrowing habits and nocturnal activity that make them well-adapted to abrupt changes in habitat and sudden removal of cover. Mowing and burning management appear to have no detrimental effects on their populations. Reithrodontomys megalotis depend on dense vegetative cover for nesting and normal activity thus they suffer short-term population declines after mowing and burning. Microtus ochrogaster also need vegetation to shelter their typical crepuscular activities and when the cover is removed their populations apparently decline; high reproductive potential permits rapid recovery of this species when the vegetative cover is reinstated. While Microtus pennsylvanicus appear to be limited to unburned, unmowed areas, none of the four principal prairie species of small mammals in this short-term study were eliminated by mowing or burning management.

REFERENCES CITED

Ahlgren, C. E. 1966. Small mammals and reforestation following prescribed burning. J. Forestry, 64:614-618.

Baker, R. H. 1940. Effect of burning and grazing on rodent populations. J. Mammal., 21:223.

Baker, R. H. 1971. Nutritional strategies of myomorph rodents in North American grasslands. J. Mammal., 52:800-805.

Bancroft, W. L. 1969. Notes on reproduction of three rodents of Douglas County, Kansas. Trans. Kansas Acad. Sci., 72:67-69.

Becic, J. N. 1976. Grassland reestablishment under burning and mowing management in eastern Nebraska. M.A. Thesis, University of Nebraska at Omaha. 25 pp.

Beck, A. M., and R. J. Vogl. 1972. The effects of spring burning on rodent populations in a brush prairie savanna. J. Mammal., 53:336-346.

Bragg, T. B. 1976. The effects of terraces on reestablishing native grasslands in eastern Nebraska. Page 39 in Abstracts of Papers Presented at the 29th Annual Meeting of the Society for Range Management. Omaha, Nebraska. (Abstract)

Bragg, T. B. 1977. Allwine Prairie Preserve: a reestablished bluestem grassland research area. In D. C. Glenn-Lewin and R. W. Landers, eds. Proc. Fifth Midwest Prairie Conf. Ames, Iowa. (In press)

Brown, L. E. 1962. Home range in small mammal communities. Pages 131-179 in Bentley Glass, ed. Survey of biological progress, Vol. IV. Academic Press, New York.

Burt, W. H., and R. P. Grossenheider. 1964. A field guide to the mammals. Houghton Mifflin Company, Boston. 284 pp.

Cook, S. F., Jr. 1959. The effects of fire on a population of small rodents. Ecology, 40:102-108.

Davis, D. E. 1965. Estimating the numbers of game populations. Pages 89-118 in H. S. Mosby, ed. Wildlife investigational techniques. The Wildlife Society, Washington, D.C.

Eberhardt, L. L. 1969. Population estimates from recapture frequency. J. Wildlife Manage., 33:28-39.

Erwin, W. J., and R. H. Stasiak. Unpublished. Vertebrate mortality during the burning of a reestablished prairie in Nebraska. Biology Department, University of Nebraska at Omaha. (Submitted for publication)

French, N. R. 1971. Small mammal studies in the U.S.-IBP Grassland Biome. Ann. Zool. Fennici, 8:48-53.

Hall, E. R. 1955. Handbook of mammals of Kansas. Museum of Natural History, University of Kansas, Lawrence. 303 pp.

Hall, E. R., and K. R. Kelson. 1959. The mammals of North America. Vol. 2. The Ronald Press Company, New York. 1083 pp.

Howard, W. E., R. L. Fenner, and H. E. Childs, Jr. 1959. Wildlife survival in brush burns. J. Range Manage., 12:230-234.

Jones, J. K., Jr. 1964. Distribution and taxonomy of mammals of Nebraska. University of Kansas Publications, Museum of Natural History, Lawrence. 356 pp.

Krefting, L. W., and C. E. Ahlgren. 1974. Small mammals and vegetation changes after fire in a mixed conifer-hardwood forest. Ecology, 55:1391-1398.

Lawrence, G. E. 1966. Ecology of vertebrate animals in relation to chaparral fire in the Sierra Nevada foothills. Ecology, 47:278-291.

Leslie, P. H., and D. H. S. Davis. 1939. An attempt to determine the absolute number of rats on a given area. J. Animal Ecol., 8:94-113.

LoBue, J., and R. M. Darnell. 1959. Effect of habitat disturbance on a small mammal population. J. Mammal., 40:425-437.

Meserve, P. L. 1971. Population ecology of the prairie vole, <u>Microtus ochrogaster</u>, in the western mixed prairie of Nebraska. Amer. Midland Nat., 86:417-433.

Metzgar, L. H., and A. L. Sheldon. 1974. An index of home range size. J. Wildlife Manage., 38:547-551.

Mohr, C. O., and W. A. Stumpf. 1966. Comparison of methods for calculating areas of animal activity. J. Wildlife Manage., 30:293-304.

Moreth, L. H., and P. Schramm. 1973. A comparative survey of small mammal populations in various grassland habitats with emphasis on restored prairie. Pages 79-83 <u>in</u> L. C. Hulbert, ed. Proc. Third Midwest Prairie Conf. Manhattan, Kansas.

Overton, W. S. 1971. Estimating the number of animals in wildlife populations. Pages 403-456 in R. H. Giles, Jr., ed. Wildlife management techniques. The Wildlife Society, Washington, D.C.

Rice, L. A. 1932. The effect of fire on the prairie animal communities. Ecology, 13:392-401.

Sanderson, G. C. 1966. The study of mammal movements -- a review. J. Wildlife Manage., 30:216-235.

Schramm, P. 1970. Effects of fire on small mammal populations in a restored tall-grass prairie. Pages 39-41 in P. Schramm, ed. Proceedings of a Symposium on Prairie and Prairie Restoration, Knox College Biological Field Station Special Publ. No. 3. Galesburg, Illinois.

Schumacher, F. X., and R. W. Eschmeyer. 1943. The estimate of fish population in lakes or ponds. J. Tennessee Acad. Sci., 18:228-249.

Shump, K. A., Jr. 1974. Nest construction by the western harvest mouse. Trans. Kansas Acad. Sci., 77:87-92.

Springer, J. T., and P. Schramm. 1972. Effects of fire on small mammal populations in a restored prairie. Pages 91-96 in J. H. Zimmerman, ed. Proc. Second Midwest Prairie Conf. Madison, Wisc.

Stickel, L. F. 1968. Home range and travels. Pages 373-411 in J. A. King, ed. Biology of Peromyscus (Rodentia). The American Society of Mammalogists, Special Publication No. 2. Stillwater, Oklahoma.

Tester, J. R. 1965. Effects of a controlled burn on small mammals in a Minnesota oak-savanna. Amer. Midland Nat., 74:240-243.

Whitaker, J. O. 1967. Habitat relationships of four species of mice in Vigo County, Indiana. Ecology, 48:867-872.

APPENDIX

Table II. *Peromyscus maniculatus*: summary of capture data for each trapping period during the two-year study.

	Mow 1975		Mow 1976		West Border	North Border	Burn 1976					
	15 Jul	9 Aug	15 Jul	14 Aug	14 Aug	14 Aug	26 Apr	4 May	11 May	17 Jun	24 Jul	29 Aug
Number of Individuals	22	14	52	35	17	40	16	23	51	45	42	25
Number of Captures	115	99	253	181	119	186	55	74	175	184	149	96
Number of Dead in Traps	5	1	18	1	2	21	3	3	13	4	8	0
Number of Adults	16	12	35	28	12	31	13	15	28	33	29	18
Number of Males (Adult)	10	8	24	15	9	18	7	8	13	21	16	13
Number Marked in a Previous Period	0	11	1	21	2	11	0	11	21	17	25	18
Schumacher-Eschmeyer Population Estimate	16	13	34	28	13	18	13	21	45	36	34	24
Leslie Population Estimate	22	15	50	35	17	39	15	50	52	43	40	25

Table III. *Microtus ochrogaster*: summary of capture data for each trapping period during the two-year study.

	Mow 1975		Mow 1976		West Border	North Border	Burn 1976					
	15 Jul	9 Aug	15 Jul	14 Aug	14 Aug	14 Aug	26 Apr	4 May	11 May	17 Jun	24 Jul	29 Aug
Number of Individuals	26	13	54	24	8	2	15	8	1	5	7	9
Number of Captures	103	40	192	72	25	2	20	13	1	14	21	23
Number of Dead in Traps	3	0	0	1	0	1	1	0	0	0	0	1
Number of Adults	22	5	37	15	6	1	11	5	0	5	6	7
Number of Males (Adult)	15	3	15	7	2	1	0	1	0	1	1	4
Number Marked in a Previous Period	0	7	0	13	0	0	0	5	1	1	3	3
Schumacher-Eschmeyer Population Estimate	21	11	50	22	8	--	27	11	--	5	6	7
Leslie Population Estimate	40	--	102	31	14	2	--	14	1	5	42	13

Table IV. *Perognathus flavescens*: summary of capture data for each trapping period during the two-year study.

	Mow 1975		Mow 1976		West Border	North Border	Burn 1976					
	15 Jul	9 Aug	15 Jul	14 Aug	14 Aug	14 Aug	26 Apr	4 May	11 May	17 Jun	24 Jul	29 Aug
Number of Individuals	41	41	13	11	1	11	4	2	1	3	12	5
Number of Captures	159	247	49	28	1	30	9	5	4	5	23	9
Number of Dead in Traps	3	1	0	0	0	1	0	0	0	0	1	0
Number of Adults	24	30	12	8	1	9	4	2	1	3	7	4
Number of Males (Adult)	11	20	4	3	1	5	4	2	1	2	5	3
Number Marked in a Previous Period	0	23	8	6	0	0	1	2	1	1	3	4
Schumacher-Eschmeyer Population Estimate	35	36	12	12	—	10	5	2	1	3	12	6
Leslie Population Estimate	46	41	15	13	1	11	4	2	1	3	17	5

Table V. *Reithrodontomys megalotis*: summary of capture data for each trapping period during the two-year study.

	Mow 1975		Mow 1976		West Border	North Border	Burn 1976					
	15 Jul	9 Aug	15 Jul	14 Aug	14 Aug	14 Aug	26 Apr	4 May	11 May	17 Jun	24 Jul	29 Aug
Number of Individuals	3	1	20	12	25	20	25	20	9	10	12	9
Number of Captures	4	3	46	20	100	46	86	43	24	18	20	15
Number of Dead in Traps	0	0	1	0	1	5	0	0	1	0	1	0
Number of Adults	3	1	11	10	21	16	25	20	9	9	12	7
Number of Males (Adult)	3	1	9	7	15	9	20	10	5	7	11	5
Number Marked in a Previous Period	0	0	0	5	0	0	0	12	8	6	9	6
Schumacher-Eschmeyer Population Estimate	6	1	21	17	24	17	24	22	9	12	14	11
Leslie Population Estimate	4	1	22	17	29	--	25	22	11	--	13	11

Table VI. *Microtus ochrogaster*: summary of capture data for each trapping period during the two-year study.

	Mow 1975		Mow 1976		West Border	North Border	Burn 1976					
	15 Jul	9 Aug	15 Jul	14 Aug	14 Aug	14 Aug	26 Apr	4 May	11 May	17 Jun	24 Jul	29 Aug
Number of Individuals	1	0	3	0	24	0	1	3	1	0	0	0
Number of Captures	2		8		136		3	4	1			
Number of Dead in Traps	0		0		0		0	0	0			
Number of Adults	1		3		23		1	2	1			
Number of Males (Adult)	1		2		15		0	0	0			
Number Marked in a Previous Period	0		0		0		0	1	1			
Schumacher-Eschmeyer Population Estimate	1		3		22		1	4	--			
Leslie Population Estimate	1		3		23		1	2	1			

Table VII. <u>Peromyscus leucopus</u>: summary of capture data for each trapping period during the two-year study.

	Mow 1975		Mow 1976		West Border	North Border	Burn 1976					
	15 Jul	9 Aug	15 Jul	14 Aug	14 Aug	14 Aug	26 Apr	4 May	11 May	17 Jun	24 Jul	29 Aug
Number of Individuals	3	2	3	2	0	2	0	0	0	0	2	0
Number of Captures	16	4	22	17		5					2	
Number of Dead in Traps	0	1	0	0		0					0	
Number of Adults	3	2	2	2		2					2	
Number of Males (Adult)	2	1	1	1		1					1	
Number Marked in a Previous Period	0	1	0	2		0					0	
Schumacher-Eschmeyer Population Estimate	2	2	3	2		4					--	
Leslie Population Estimate	3	2	3	2		--					--	

Table VIII. Mus musculus: summary of capture data for each trapping period during the two-year study.

	Mow 1975		Mow 1976		West Border	North Border	Burn 1976					
	15 Jul	9 Aug	15 Jul	14 Aug	14 Aug	14 Aug	26 Apr	4 May	11 May	17 Jun	24 Jul	29 Aug
Number of Individuals	1	1	0	0	1	9	0	0	0	0	3	2
Number of Captures	1	1			1	10					3	2
Number of Dead in Traps	0	0			0	1					0	0
Number of Adults	1	1			1	8					3	1
Number of Males (Adult)	1	1			1	8					3	1
Number Marked in a Previous Period	0	0			0	0					0	0
Schumacher-Eschmeyer Population Estimate	--	--			--	70					--	--
Leslie Population Estimate	1	1			1	19					--	--

Table IX. *Blarina brevicauda*: summary of capture data for each trapping period during the two-year study.

	Mow 1975		Mow 1976		West Border	North Border	Burn 1976					
	15 Jul	9 Aug	15 Jul	14 Aug	14 Aug	14 Aug	26 Apr	4 May	11 May	17 Jun	24 Jul	29 Aug
Number of Individuals	2	0	0	0	3	1	0	0	0	0	1	0
Number of Captures	2				7	1					1	
Number of Dead in Traps	0				1	0					1	
Number of Adults	2				3	1					1	
Number of Males (Adult)	2				0	0					0	
Number Marked in a Previous Period	0				0	0					0	
Schumacher-Eschmeyer Population Estimate	—				2	—					—	
Leslie Population Estimate	2				3	1					1	

Table X. *Sorex cinereus*: summary of capture data for each trapping period during the two-year study.

	Mow 1975		Mow 1976		West Border	North Border	Burn 1976					
	15 Jul	9 Aug	15 Jul	14 Aug	14 Aug	14 Aug	26 Apr	4 May	11 May	17 Jun	24 Jul	29 Aug
Number of Individuals	0	0	0	0	2	1	1	0	0	0	0	0
Number of Captures					3	1	1					
Number of Dead in Traps					0	0	0					
Number of Adults					2	1	1					
Number of Males (Adult)					--	--	--					
Number Marked in a Previous Period					0	0	0					
Schumacher-Eschmeyer Population Estimate					3	--	--					
Leslie Population Estimate					2	1	--					

Table XI. <u>Spermophilus tridecemlineatus</u>: summary of capture data for each trapping period during the two-year study.

	Mow 1975		Mow 1976		West Border	North Border	Burn 1976					
	15 Jul	9 Aug	15 Jul	14 Aug	14 Aug	14 Aug	26 Apr	4 May	11 May	17 Jun	24 Jul	29 Aug
Number of Individuals	0	5	0	0	0	0	0	0	0	1	0	0
Number of Captures		5								1		
Number of Dead in Traps		0								0		
Number of Adults		5								0		
Number of Males (Adult)		--								--		
Number Marked in a Previous Period		0								0		
Schumacher-Eschmeyer Population Estimate		--								--		
Leslie Population Estimate		--								--		