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# Influence of Vegetation On The Distribution of Small Mammals On A Waterfowl Production Area

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# INFLUENCE OF VEGETATION ON THE DISTRIBUTION OF SMALL MAMMALS ON A WATERFOWL PRODUCTION AREA

BY

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INFLUENCE OF VEGETATION ON THE DISTRIBUTION OF SMALL MAMMALS ON A WATERFOWL PRODUCTION AREA

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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# INFLUENCE OF VEGETATION ON THE DISTRIBUTION OF SMALL MAMMALS ON A WATERFOWL PRODUCTION AREA

## Abstract

DOUGLAS A. SEARLS

A study was conducted on a Waterfowl Production Area in Brookings County, South Dakota in 1972-73 to determine the distribution and abundance of small mammals. Three cover types, reseeded native grasses, brome-alfalfa, and bluegrass, were studied. Meadow voles (Microtus pennsylvanicus), and deer mice (Peromyscus maniculatus) were captured most frequently. Jumping mice (Zapus hudsonius), masked shrews (Sorex cinerius), short-tailed shrews (Blarina brevicauda), grasshopper mice (Onychomys leucogaster) and house mice (Mus musculus) were also taken. The bluegrass association had the highest number of small mammal captures and the reseeded native grass association had the least. There was no significant difference ($P > 0.05$) between the number of meadow voles captured and the type of vegetation. Deer mice occurred most often in the reseeded native grass association. Four vegetative parameters; height of duff, height of vegetation, percent duff cover and percent live cover were measured in each cover type. No differences were found between these measurements and the number of meadow voles captured. Although there are more than 57,000 acres of Waterfowl Production Areas in South Dakota, little information is known about the small mammal populations on them. These small mammals form a prey base for many furbearing

carnivores which not only prey on nests of birds but are important economically. My study indicates that species of grass used for density of cover affect the number of small mammals as much as the regulation of density of cover. Habitat manipulation could be an important management tool when more information is gained on the role small mammals play in determining predation and population of carnivores.

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# INTRODUCTION

The U. S. Fish and Wildlife Service has acquired over 57,000 acres of waterfowl habitat in South Dakota under the small wetlands preservation program (U. S. Department of the Interior 1972). Much of that waterfowl habitat is upland that is managed to provide nesting cover for waterfowl and upland game. These tracts of land also provide habitat for small mammals.

Small mammals are important in the diet of many carnivorous animals. They constitute a staple food item during certain parts of the year for weasels (Mustela frenata)[1] (Errington 1936), skunks (Mephitis mephitis) (Moe 1974), and red foxes (Vulpes fulva) (Errington 1935), as well as contribute to the diet of the coyote (Canis latrans) (Murie 1945). Schwartz and Schwartz (1971) noted the importance of small mammals as a buffer against predation on game birds and stated that fluctuations in small mammal populations may influence population trends of predators.

Small mammal populations on Waterfowl Production Areas (WPA) should be managed because of their importance to carnivorous animals using the areas. Those populations should also be studied to better understand the wetland ecosystems of eastern South Dakota. The

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[1]Scientific names of mammals according to Hall and Kelson (1959).

objectives of this study were to determine the distribution and abundance of small mammals on a WPA in Brookings County.

# LITERATURE REVIEW

## Natural History

Microtus pennsylvanicus.--The meadow vole, Microtus pennsylvanicus, is distributed generally across the northern one-half of the United States and has the largest geographic range of any American species in the genus Microtus (Hall and Kelson 1959). The adult meadow vole is of medium size with a total length from 140 to 195 mm with the body two to three times as long as the tail. The fur is long and overlaid with course guard hairs. The upper parts are dull chestnut brown, bright yellowish chestnut or blackish; being darker along the middle of the back. The under parts are grayish white to grayish cinnamon (Handley and Patton 1947). Due to high mortality in the wild only a small proportion of the meadow voles live longer than sixty days (Beer and MacLeod 1961).

Meadow voles breed throughout the year under favorable weather conditions. Young females begin breeding at twenty-five days of age and young males reach sexual maturity at forty-five days of age. The normal gestation period is twenty-one days. Asdell (1964) recorded average litter size in Minnesota as 5.2 and Decoursey (1957) working in Ohio found average litters to be 4.5. In captive animals the mean litter size was found to be 6.0 (Calvin and Calvin 1970).

Females with an average body length of 110 mm, in Minnesota, produced litters at the rate of 10.7 a year (Asdell 1964). One

female in captivity produced 17 litters in a 12-month period (Asdell 1964).

Peromyscus maniculatus.--The deer mouse, Peromyscus maniculatus, is found throughout most of the United States except for the extreme southeast and consists of a long series of intergrading populations (Hall and Kelson 1959).

Total length of the deer mouse ranges from 121 to 227 mm, with a tail length of 46 to 123 mm. The upper body varies but it is generally pale grayish buff to deep reddish brown overlaid in varying degrees of dusky. The underparts and feet are white. The tail has short hairs and is dark above and light below. There are at least three pelages: juvenal, post-juvenal or sub-adult, and adult. The first pelage is distinctly gray and the color becomes progressively buffier with succeeding molts (Hall and Kelson 1959).

Deer mice may live as long as two years in the wild. However, fewer than one-fifth of those born usually reach sexual maturity (Schwartz and Schwartz 1971).

Principal mating periods of the deer mouse occur in spring and fall at which time two or more litters may be produced. Limited breeding takes place in summer and, under favorable conditions of mild temperature and abundant food, in winter (Brown and Conway 1964). Gestation is generally from 21 to 23 days. One to nine young per litter occur with three to four the most common (Schwartz and Schwartz 1971). Brown (1966) found the average number of embryos

to be 5.31.

Importance of Small Mammals as a Prey Base

Mice of the genera Microtus and Peromyscus are abundant throughout the United States. They are found in a wide variety of habitats and are important in the diets of many carnivores. Craighead and Craighead (1950) in a study of raptors on Superior Township in Wyoming found that meadow voles comprised 83 percent of the prey taken during winter, and 30 percent in spring and summer. Raptors that were present on the area during the study period included: red-tailed hawk (Buteo jamaicensis),[1] red-shouldered hawk (Buteo lineatus), rough-legged hawk (Buteo lagopus), sparrow hawk (Falco sparverius), coopers hawk (Accipiter cooperii), marsh hawk (Circus cyaneus), great horned owl (Bubo virginianus), long-eared owl (Asio otus), screech owl (Otus asio), short-eared owl (Asio flammeus), and barn owl (Tyto alba).

Small mammals are an important food for weasels. Thirty of 32 weasel fecal samples collected in Iowa contained remains of small mammals (Errington 1936). Hamilton (1933) also found that small mammals were an important food for weasels in New York.

Moe (1974) reported that mammals made up the largest volume of

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[1]Names of birds from American Ornithologists' Union Checklist (1957).

food in striped skunk stomachs collected in Brookings County, South Dakota during March, April, May, and June. The principal mammal in those samples was the meadow vole. Thirty meadow voles were found in the stomach of a striped skunk collected November 3, 1972.

Fox food habits seem to vary with availability of prey. Errington (1935) found that Microtus sp. occurred in 44 percent of 1,175 fecal samples collected in Iowa and Wisconsin throughout the year, and Peromyscus sp. in nine percent. Errington (1935) reported that foxes may prefer Microtus sp..

Both Sperry (1934) and Murie (1945) found Microtus sp. to be present in the coyote diet, especially during the winter months.

Pearson (1964) determined that 88 percent of 4,400 Microtus sp. present on his study area in California were eaten by carnivores. Microtus sp. seemed to be preferred over other small rodents and were taken even when the population was low, often until almost all were taken.

Schwartz and Schwartz (1971) contended that small mammals may reduce predation on game species and influence population trends of predators. Lack (1954) stated that during rodent declines carnivores are found weak or starving and food shortage is clearly the main cause of death. Handley and Patton (1947) observed that meadow mice apparently are cyclic, and that flesh eaters prey heavily upon birds, game and poultry when numbers of meadow mice are low.

Cyclic Phenomena

Instance of plagues and oscillations in microtine populations have been documented by Elton (1965). Hamilton (1937) concluded that there was a regular four-year cycle in the vole populations in New York with peaks in 1919-20, 1923-24, 1927-28, 1931-32, and 1935-36. Population densities were estimated to be 160-230 per acre at the peak years.

Apparent cycles appeared to be consistent over a wide geographic area. Peaks in Illinois and Indiana were in 1923-24, 1927-28, and 1935-36 (Elton 1965). However, meadow voles in Michigan reached peaks of 14.6 per acre in 1938 and 29.8 per acre in 1942 (Blair 1948). In more recent studies Chitty et al. (1968) found meadow voles in Indiana to peak in 1960. Meadow voles peaked at 100-200 per acre in Pennsylvania in 1968 (Christian 1971). Several estimates of population peaks run as high as 1,000 per acre in the heavily cultivated valleys in the northwestern United States (Aumann 1965). During a plague in Kern County, California, Elton (1965) cited estimates of 80,000 Microtus sp. per acre.

In some cases local populations of meadow voles were found to peak out-of-phase with neighboring populations (Barbehenn 1958). The general pattern of the cycles as revealed by Hamilton (1937) in his New York studies was a slow build up over a two-year period and then a rapid decline over a few months in the spring.

Probable Causes of Cyclic Phenomena

There is no general agreement on the causes of population decline or the causes of the delay in recovery of the population after a decline. Cole (1954) felt cycles could be attributed to random fluctuations. Christian and Davis (1964) attributed the decline of high populations to endocrine exhaustion because of increased behavioral interactions. Chitty (1952) reported that young voles were smaller in populations of high density and he felt the crowding, social stress, and diminished lactation in females caused an increase in mortality. Godfrey (1955) theorized that stress caused lower reproductive rates during peak populations because of intraspecific strife in adults from the previous year. Van Gelder and Mayer (1963) stated that reproduction is depressed in female Microtus sp. by increased population density at all stages in the reproductive process.

Pearson (1966) thought that predation was a major influence delaying population recovery, but that it was insufficient to cause a decline. Lack (1954) suggested that microtine populations crashed where food supplies deteriorate and that recovery of the population is delayed until there are sufficient nutrients. However, Scheffer (1955) found body weight to be high during peak populations which indicated no food shortage. The addition of an artificial food supply during the winter by Chitty et al. (1968) did not prevent a sudden drop in the spring populations of Microtus sp..

Deer mice show marked seasonal and annual fluctuations in population size, but apparently are non-cyclic (Blair 1948). Jameson (1955) felt that the difference in population fluctuations between Peromyscus and Microtus was because Peromyscus were adaptable to a wider variety of habitat than Microtus. Peromyscus had little effect upon their environment while Microtus at high populations made a very definite effect upon their environment. A dense population of Peromyscus did not appreciably alter plant cover since they ate only small amounts of leaves and comsumption of seeds and berries had no obvious effect on the habitat. Microtus consume stems, leaves and roots and may cause herbacious ground cover to be scanty, ragged, and brown. They may literally destroy their own habitat (Jameson 1955).

Habitat Preferences

A number of studies have been conducted to determine the preferred habitat for Microtus and Peromyscus. LoBue and Darnell (1959) found that density of Microtus populations was positively correlated with vegetation height and percent cover while Peromyscus was negatively correlated. Mossman (1955), using light penetration to measure cover, stated that Microtus pennsylvanicus was most abundant in the heaviest grassy cover of an area. In a study where sample plots were cut and air dried there was an indication of direct response of Microtus to measurable differences in the amount of vegetative cover within its local habitat (Eadie 1952). Both Pearson (1959) and Zimmerman (1965)

found Microtus pennsylvanicus only in areas where grasses predominated. According to Zimmerman (1965) Microtus pennsylvanicus occurred in fields containing at least 50 percent grasses and abundant cover. They were most often associated with Poa sp. and Muhlenbergia sp..

Moisture in the air, on the surface, and in plants has been studied to some extent as a factor in habitat preference of Microtus. Blair (1940), Findley (1951), and Lewin (1968) felt that moisture was a dominant factor in vole habitat. Getz (1961) concluded moisture alone was not a dominant factor in local distribution of Microtus pennsylvanicus. He felt that biotic factors, such as the type of food and vegetation, were as important in the local distribution of voles as physical factors of the environment. Batzli (1968) contended that dispersion of Microtus californicus was related to food resources rather than cover per se. Getz (1961) stated that since voles feed on all species of grasses and sedges in an area the amount of food alone was not a factor in local distribution but that type of food may determine the area of occurrence.

Getz (1970) compared soil moisture, water content of the vegetation, soil temperature, surface temperature, air humidity, and the amount of vegetative cover in apparent similar habitats containing high and low populations of meadow voles. None of these factors was found to be significantly different between the areas and apparently did not limit meadow vole distribution.

Peromyscus maniculatus prefer woody vegetation and more sparsely vegetated areas than Microtus and because of their nocturnal habits do not require as dense a cover for protection. Where Peromyscus and Microtus occur together there is apparently interspecific interaction between the two, Microtus being dominant (Grant 1971 and Batzli 1968).

## DESCRIPTION OF THE STUDY AREA

The study area was a 360-acre WPA in northwestern Brookings County, South Dakota, within the physiographic region known as the Prairie Coteau, a plateau-like highland with elevations of about 1,600 to 1,800 feet. Soils on the area originated from the Cary drift sheet, youngest of the Wisconsin Age glacial drift. The Cary surface is typified by many closed depressions and strong local relief. Surface drainage is poorly developed. The principal soil type on the area is Poinsett silt loam ranging from nearly level areas to undulating (Westin et al. 1959).

The climate of Brookings County is continental. Spring is moist, cool, and windy, and summer is hot and sunny. Average temperature during July is 72 F and in January 14 F. Precipitation averages 21.6 inches annually, with heaviest amounts occurring as rain in May and June. Annual precipitation varies widely, however, and drought conditions occur periodically (Westin et al. 1959).

Native vegetation in the Brookings WPA area was short-mid- and tall-grasses. The dominance of any of the three kinds of grass was determined by the soil, slope, and drainage of the site. On sandy soils and on nearly level medium-textured soils tall- and mid-grasses dominated (Westin et al. 1959). Big bluestem (Andropogon gerardi Vitm.),[1] little bluestem (Andropogon scoparius Michx.), and scurfpea

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[1]Scientific names of plants according to Gleason and Cronquist (1963).

(Psoralea sp.) were present on an undisturbed area of the WPA. The poorly drained soils were sites of marsh vegetation.

The Brookings WPA was purchased in 1968 by the U. S. Bureau of Sport Fisheries and Wildlife under its small wetlands preservation program. Much of the land was under cultivation before it was purchased and areas not suitable for cropland were mowed or heavily grazed.

The predominant feature of the area is a large type IV marsh (Martin et al. 1953) of approximately 51 acres (Fig. 1). There are two type III marshes of approximately eight and 12 acres with the larger marsh supporting willows. Three other low areas on the WPA hold water through mid-summer during wet years. There are approximately 32 acres of native grasses adjacent to one of the wetlands and a woodlot of five acres exists at an old building site.

A number of land use practices exist on the Brookings WPA. One field of approximately 50 acres on the western edge of the area was reseeded to a mixture of native grasses in 1969. The predominant grasses during 1972-73 were wheatgrass (Agropyron sp.), big bluestem and little bluestem. Approximately 45 acres of bluegrass (Poa sp.) pasture surrounding the large marsh were left undisturbed. An area of approximately 50 acres in the northeast corner was seeded to a mixture of 80 percent bromegrass (Bromus sp.) and 20 percent alfalfa (Medicago sp.) in 1969. Approximately 75 acres in the southeast corner were farmed by a local farmer under a 1971 crop agreement.

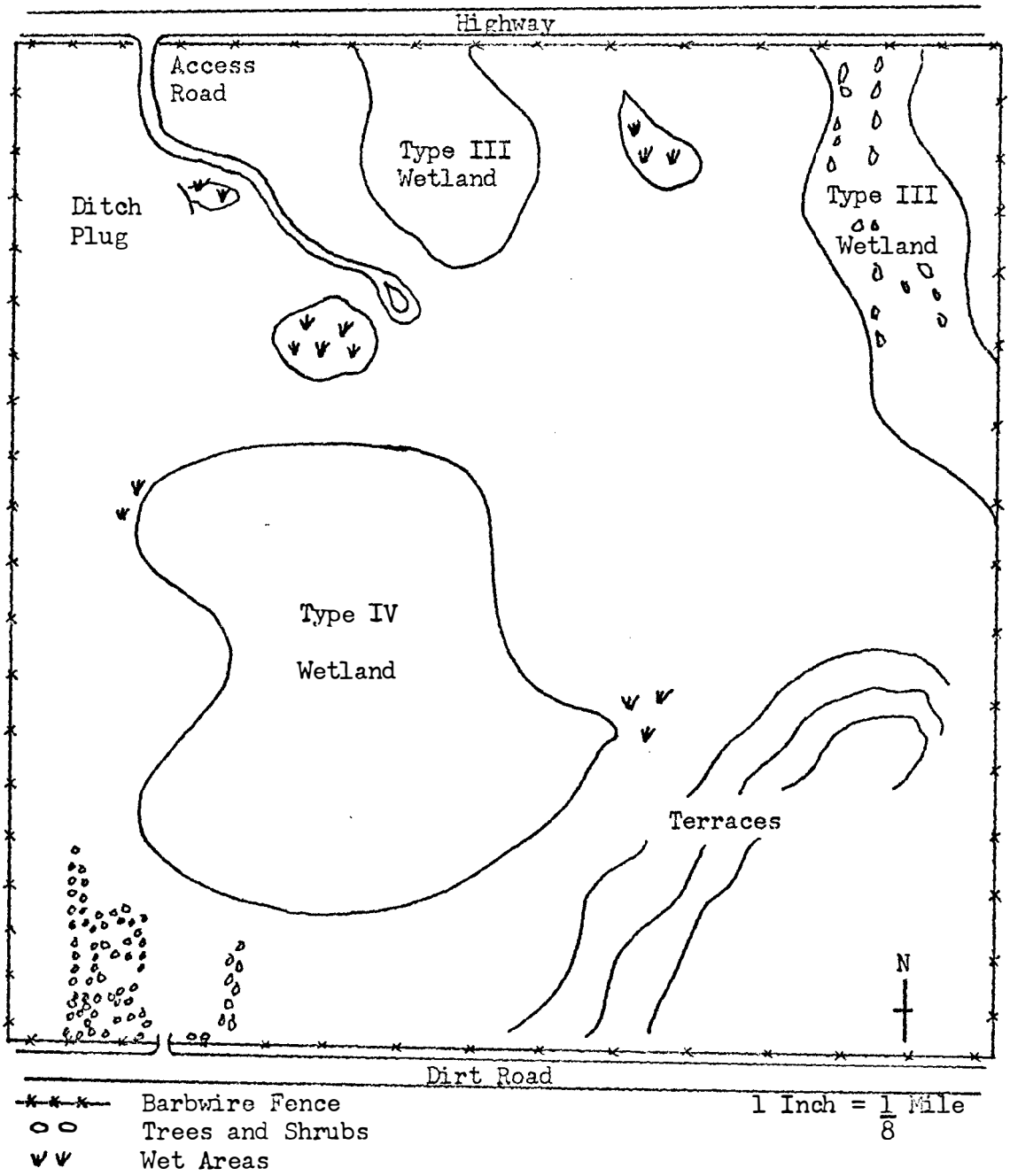


Fig. 1. There were three Type I, two Type III and one Type IV wetlands on the Brookings WPA, 1972-73.

A tract of 32 acres in the northeast corner of the WPA was burned during the last week in April, 1973. The burn included about 14 acres of reseeded native grasses and 18 acres of reclaimed pasture.

A den of red foxes with seven pups was present on the area during the spring of 1973. A weasel was trapped on the area in the fall of 1972. Two mink (Mustela vison) were seen on the area during July of 1973 and raccoons (Procyon lotor) and skunks were seen on the roads adjacent to the area. Raptors identified and recorded on the area during the study included: great horned owl, marsh hawk, and red-tailed hawk.

# METHODS

## Trapping Procedure

Three cover types resulting from different management practices were located on the Brookings WPA. These areas were identified as brome-alfalfa association, bluegrass association, and reseeded native grasses.

Each of the cover types was trapped once during August and September, 1972, using a capture-mark-recapture method. Twenty-five Havahart livetraps (number 0) and twenty-five livetraps made from oil cans were set in a 5 X 5 grid-pattern with two traps, one of each kind, per station in a 25-yard square. Stations were approximately five yards apart. Bait was a mixture of peanut butter, raisins, lard and oatmeal (Giles 1969).

The initial trapping in the bluegrass association was continued for six days. Catches the first two nights were extremely low. The number of unmarked animals captured rose sharply on the third night and remained high for the next two nights, then dropped sharply on the sixth day. Based on this information the other two cover types were sampled with the traps open and prebaited with oatmeal for two days and then set for three days. They were checked once or twice a day depending on weather conditions. All captured animals were marked with picric acid and released at the trap site. The area was left undisturbed for one day and then snap-trapped with 75 Standard

Victor mouse traps. The Lincoln Index was applied to these data to obtain indices of population densities in each plot. To compare densities between cover types with the Lincoln Index it was necessary to assume that the home ranges of the animals captured were similar in the different cover types. This assumption seemed reasonable because of the denseness of the duff and vegetation in all of the cover types. It was also necessary to assume that there was equal mortality among marked and unmarked animals and that marked animals retained their marks between marking and recapture. It was assumed that all animals were randomly mixed and that changes in the population were negligible during the sample period (Hayne 1949).

A snap-trap survey was used to obtain small-mammal population-indices for comparison between the three cover types in 1973. Homogeneous fields of approximately 45 acres were located in each of the cover types: reseeded native grasses along the west edge of the area, the reclaimed pasture area surrounding the large marsh, and the brome-alfalfa seeding on the eastern half of the area (Fig. 2). Each cover type was stratified into three sections of approximately 15 acres to insure a uniform sampling of the areas. This method is similar to procedures used by Whitaker (1963) and Zimmerman (1965). Each stratified area in the three cover types was sampled simultaneously at monthly intervals through the summer using $\frac{1}{4}$ acre quadrants.

Quadrants were chosen randomly by laying a $\frac{1}{4}$ - acre grid over an aerial photograph and numbering each square within each

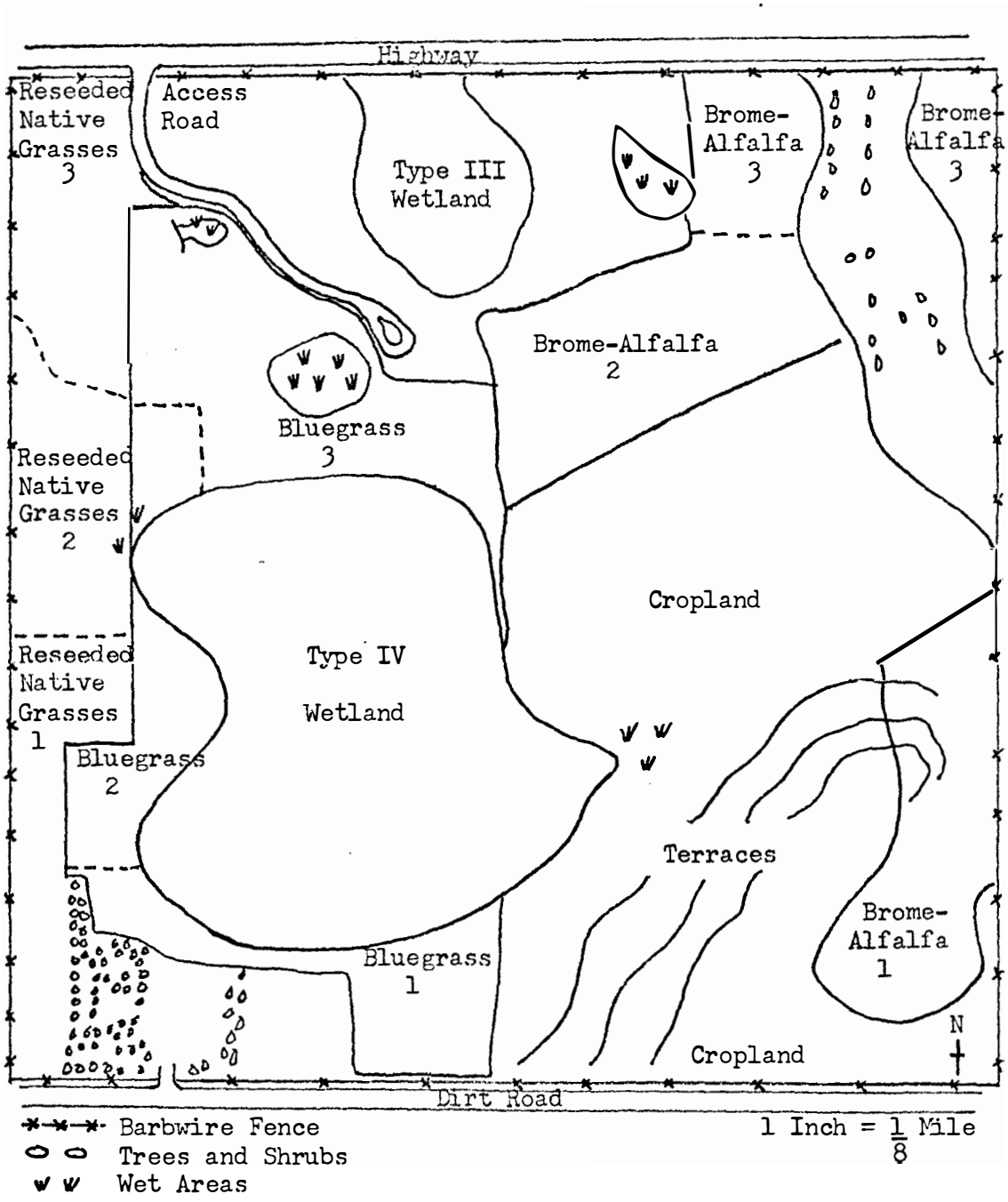


Fig. 2. Reseeded native grass, bluegrass, and brome-alfalfa associations were each stratified into three 15-acre sections (1, 2, and 3) for sampling of small mammal populations.

stratified section. Numbers were drawn to determine which quadrant would be sampled. The cruising radius of Microtus pennsylvanicus was estimated at 75 feet by Buchner (1957), therefore, any square next to a previously sampled quadrant or within 75 feet of adjoining cover types, roadways, and marshes was not used.

Ninety-eight Standard Victor mouse traps were set in a 7 X 7 grid-pattern in each square $\frac{1}{4}$ - acre quadrant with two traps per station. Quadrants were measured and traps were spaced by using a rope 34.8 yards long marked off in six equal segments of 5.8 yards. The quadrants were trapped for three or four days and all traps were checked daily. This is similar to methods employed by Batzli and Petelka (1970) and Stickle (1946).

Trapping was conducted during April 24-26, May 25-26, June 24-27, July 22-25, and August 23-26. Peanut butter was used for bait because of ease of handling and its acceptability by many different species (Beer 1964 and Patric 1970).

Data were analysed by analysis of variance (AOV) between cover types and the number of meadow voles captured. One stratified section in the bluegrass association and one in the native reseeded grasses was burned in April, 1973. Data from these areas after the April trapping were not used in the analysis.

Vegetative Analysis

Vegetation height, depth of duff, percent of duff cover, and percent of live cover were measured on each sampled quadrant during

the 1973 sample periods. A metal frame measuring one-square-foot on the inside was thrown over the left shoulder to locate plots for measurements. Nine of these samples were collected on each quadrant and averaged.

Maximum vegetative height was determined by measuring the tallest standing plant in each square-foot sample. Duff depth was taken at the deepest point by pushing a yard stick through the duff until firm soil was encountered, these measurements resulted in an average maximum depth of duff. The percent of duff and live cover was determined by visual estimates similar to methods used by Gashwiler (1970).

Linear correlation (LC) was used to determine relationships between these vegetative factors and the number of meadow voles captured.

## Population Characteristics

All animals that were not badly decomposed or eaten were sexed, weighed and measured for total length and tail length. Sex ratios were obtained from these data. Age ratios were obtained by using body length as indication of adults or juveniles (Beer and MacLeod 1961).

Embryos were counted in pregnant females, and if only one previous pregnancy had occurred placental scars were counted. All uterine observations were based on information and photographs presented by Asdell (1964).

# RESULTS

## Trapping Data

Sixty-two mammals were taken in 1972 in the reseeded native grass association, 57 in the bluegrass association, and 24 in the brome-alfalfa association during 225 trap-nights in each association on sample plots measuring 25 yards X 25 yards (Table 1). Meadow voles were most frequently captured in all cover types, but the number of captures varied. In the bluegrass association where meadow voles were taken in the greatest number they comprised 91 percent of the animals taken. Deer mice and masked shrews (Sorex cinereus) were taken in limited numbers there.

Sixty percent of the small mammals captured in the reseeded native grass association were meadow voles (Table 1). Three other species were also taken there; jumping mice (Zapus hudsonius), which made up 20 percent of the captures, deer mice and masked shrews.

The brome-alfalfa association had the fewest number of individuals captured, but the greatest number of species (Table 1). Meadow voles comprised 30 percent of the total captures but other species were taken almost as frequently. Short-tailed shrews (Blarina brevicauda), a known predator on meadow voles, were taken only in the brome-alfalfa association. The house mouse (Mus musculus) captured in this cover type was the only one taken during the two-year study.

Estimates of population densities were calculated with the use of

Table 1. Number of animals removed during 225 trap-nights from plots 25 yards square on the Brookings WPA, 1972. Totals include animals that died during live trapping and these numbers are shown in parentheses.

| | Cover Type and Date of Trapping | | |
|---|---|---|---|
| Species | Bluegrass Aug 10-12 | Reseeded Native Grasses Sept 4-6 | Brome-Alfalfa Aug 25-27 |
| Meadow Vole | 52 (15) | 37 (7) | 7 (2) |
| Deer Mouse | 4 ( 2) | 7 | 2 (1) |
| Jumping Mouse | 0 | 12 | 6 |
| Masked Shrew | 1 | 6 (1) | 5 (3) |
| Short-tailed Shrew | 0 | 0 | 3 (1) |
| House Mouse | 0 | 0 | 1 |
| Total | 57 | 62 | 24 |

Table 2. Application of the Lincoln Index to meadow vole captures in 25 yard square plots on the Brookings WPA, 1972.

| Cover Type | m | X | n | T' | D | T |
|---|---|---|---|---|---|---|
| Bluegrass | 28 | 11 | 37 | 94.3 | 15 | 109.3 |
| Reseeded Native Grass | 18 | 10 | 30 | 54.1 | 7 | 61.1 |
| Brome-Alfalfa | 9 | 4 | 5 | 11.3 | 2 | 13.3 |

m = the number of animals marked and released
X = the number of animals marked in the sample
n = sample size
T' = population index from recapture data
D = the number of animals that died during live trapping
T = population index (T') plus the number removed during live trapping (D). This gives a total plot index.

the Lincoln Index (Table 2). The estimate of 109 and 61 meadow voles per plot in the bluegrass association and reseeded native grass association indicated high populations in comparison to the 160 to 230 voles per acre estimated by Hamilton (1937) during peak years in New York. Even the 13 meadow voles estimated per plot in the brome-alfalfa would be greater than the peaks reported in Michigan by Blair (1948).

The 1972 meadow vole populations were high, and there was variation in the number of small mammals between the cover types. This information was considered preliminary as the sample size was small, cover types were not trapped at the same time, and in the bluegrass and reseeded native grass associations trapping outside but adjacent to the plots may have influenced trap results.

Four hundred ninety-eight mammals were captured on the Brookings WPA in 1973. The number and species of the animals captured were: 307 meadow voles, 109 deer mice, 29 jumping mice, 28 masked shrews, 22 short-tailed shrews, and three grasshopper mice (Onychomys leucogaster) (Tables 3, 4, and 5).

More meadow voles were caught per 100 trap-nights in the bluegrass association than any other cover type during every trapping period except April (Fig. 3). However, the differences were not significant (AOV $P > 0.05$) for each sampling period or for all periods combined (Table 6). The greatest variation in number of captures between cover types occurred in May (Table 7).

Table 3. Small mammals captured on ¼-acre quadrants in the reseeded native grass association on the Brookings WPA, 1973. Captures resulted from 294 trap-nights per section in April and 392 trap-nights per section each other month, 1973.

| Date | Species | Number Captured: Section 1 | Section 2 | Section 3 | Total | Per 100 Trap-nights |
|---|---|---|---|---|---|---|
| April 24-26 | Meadow vole | 11 | 3 | 5 | 19 | 2.15 |
| | Deer mouse | 2 | 0 | 3 | 5 | .56 |
| | Masked shrew | 4 | 0 | 0 | 4 | |
| | Short-tailed shrew | 2 | 0 | 0 | 2 | |
| May 25-28 | Meadow vole | 9 | 2 | 0[a] | 11 | 1.40 |
| | Deer mouse | 0 | 3 | 3 | 6 | .51 |
| | Jumping mouse | 1 | 0 | 0 | 1 | |
| June 24-27 | Meadow vole | 14 | 4 | 1[a] | 18 | 2.29 |
| | Deer mouse | 7 | 11 | 4 | 22 | 1.87 |
| | Masked shrew | 1 | 0 | 0 | 1 | |
| | Jumping mouse | 1 | 0 | 0 | 1 | |
| July 22-25 | Meadow vole | 0 | 4 | 6[a] | 4 | .51 |
| | Deer mouse | 2 | 2 | 4 | 8 | .68 |
| | Masked shrew | 1 | 0 | 0 | 1 | |
| Aug 23-26 | Meadow vole | 6 | 1 | 3[a] | 7 | .89 |
| | Deer mouse | 6 | 2 | 2 | 10 | .85 |
| | Jumping mouse | 3 | 1 | 1 | 5 | |
| | Masked shrew | 2 | 0 | 0 | 2 | |
| | Short-tailed shrew | 1 | 0 | 0 | 1 | |

[a] Area burned in April and data not used in totals.

Table 4. Small mammals captured on ¼-acre quadrants in the brome-alfalfa association on the Brookings WPA, 1973. Captures resulted from 294 trap-nights per section in April and 392 trap-nights per section each other month, 1973.

| | | Number Captured | | | | |
|---|---|---|---|---|---|---|
| | | Section | | | | Per 100 |
| Date | Species | 1 | 2 | 3 | Total | Trap-nights |
| April | | | | | | |
| 24-26 | Meadow vole | 4 | 8 | 15 | 27 | 3.06 |
| May | | | | | | |
| 26-29 | Meadow vole | 35 | 17 | 1 | 53 | 4.51 |
| | Deer mouse | 2 | 3 | 1 | 6 | .51 |
| | Jumping mouse | 1 | 0 | 2 | 3 | |
| | Masked shrew | 0 | 3 | 0 | 3 | |
| | Short-tailed shrew | 0 | 0 | 1 | 1 | |
| June | | | | | | |
| 24-27 | Meadow vole | 11 | 5 | 1 | 17 | 1.45 |
| | Deer mouse | 3 | 2 | 4 | 9 | .77 |
| | Jumping mouse | 5 | 1 | 0 | 6 | |
| | Masked shrew | 0 | 2 | 0 | 2 | |
| | Short-tailed shrew | 2 | 0 | 0 | 2 | |
| July | | | | | | |
| 22-25 | Meadow vole | 3 | 1 | 2 | 6 | .51 |
| | Deer mouse | 1 | 0 | 0 | 1 | .09 |
| | Jumping mouse | 0 | 2 | 3 | 5 | |
| | Masked shrew | 2 | 3 | 0 | 5 | |
| | Short-tailed shrew | 0 | 1 | 1 | 2 | |
| Aug | | | | | | |
| 23-26 | Meadow vole | 3 | 0 | 1 | 4 | .34 |
| | Deer mouse | 2 | 2 | 1 | 5 | .43 |
| | Jumping mouse | 1 | 1 | 0 | 2 | |
| | Short-tailed shrew | 0 | 1 | 1 | 2 | |

Table 5. Small mammals captured on $\frac{1}{4}$-acre quadrants in the bluegrass association on the Brookings WPA, 1973. Captures resulted from 294 trap-nights per section in April and 392 trap-nights per section each other month, 1973.

| | | Number Captured | | | | |
|---|---|---|---|---|---|---|
| | | Section | | | | Per 100 |
| Date | Species | 1 | 2 | 3 | Total | Trap-nights |
| April | | | | | | |
| 24-26 | Meadow vole | 7 | 4 | 4 | 15 | 1.70 |
| | Deer mouse | 0 | 0 | 1 | 1 | .11 |
| May | | | | | | |
| 25-28 | Meadow vole | 24 | 30 | 1[a] | 54 | 6.89 |
| | Deer mouse | 0 | 2 | 8 | 10 | .85 |
| | Short-tailed shrew | 0 | 1 | 0 | 1 | |
| June | | | | | | |
| 24-27 | Meadow vole | 16 | 28 | 0[a] | 44 | 5.61 |
| | Deer mouse | 0 | 1 | 12 | 13 | 1.15 |
| | Short-tailed shrew | 2 | 1 | 0 | 3 | |
| | Jumping mouse | 0 | 2 | 0 | 2 | |
| | Grasshopper mouse | 0 | 0 | 2 | 2 | |
| July | | | | | | |
| 22-25 | Meadow vole | 5 | 12 | 0[a] | 17 | 2.17 |
| | Deer mouse | 0 | 1 | 5 | 6 | .51 |
| | Short-tailed shrew | 3 | 1 | 0 | 4 | |
| | Masked shrew | 1 | 1 | 0 | 2 | |
| | Jumping mouse | 0 | 1 | 1 | 2 | |
| | Grasshopper mouse | 0 | 0 | 1 | 1 | |
| Aug | | | | | | |
| 23-26 | Meadow vole | 3 | 3 | 0[a] | 6 | .77 |
| | Deer mouse | 1 | 0 | 8 | 9 | .77 |
| | Masked shrew | 3 | 5 | 0 | 8 | |
| | Short-tailed shrew | 0 | 3 | 1 | 4 | |
| | Jumping mouse | 0 | 0 | 2 | 2 | |

[a] Area burned in April and data not used in totals.

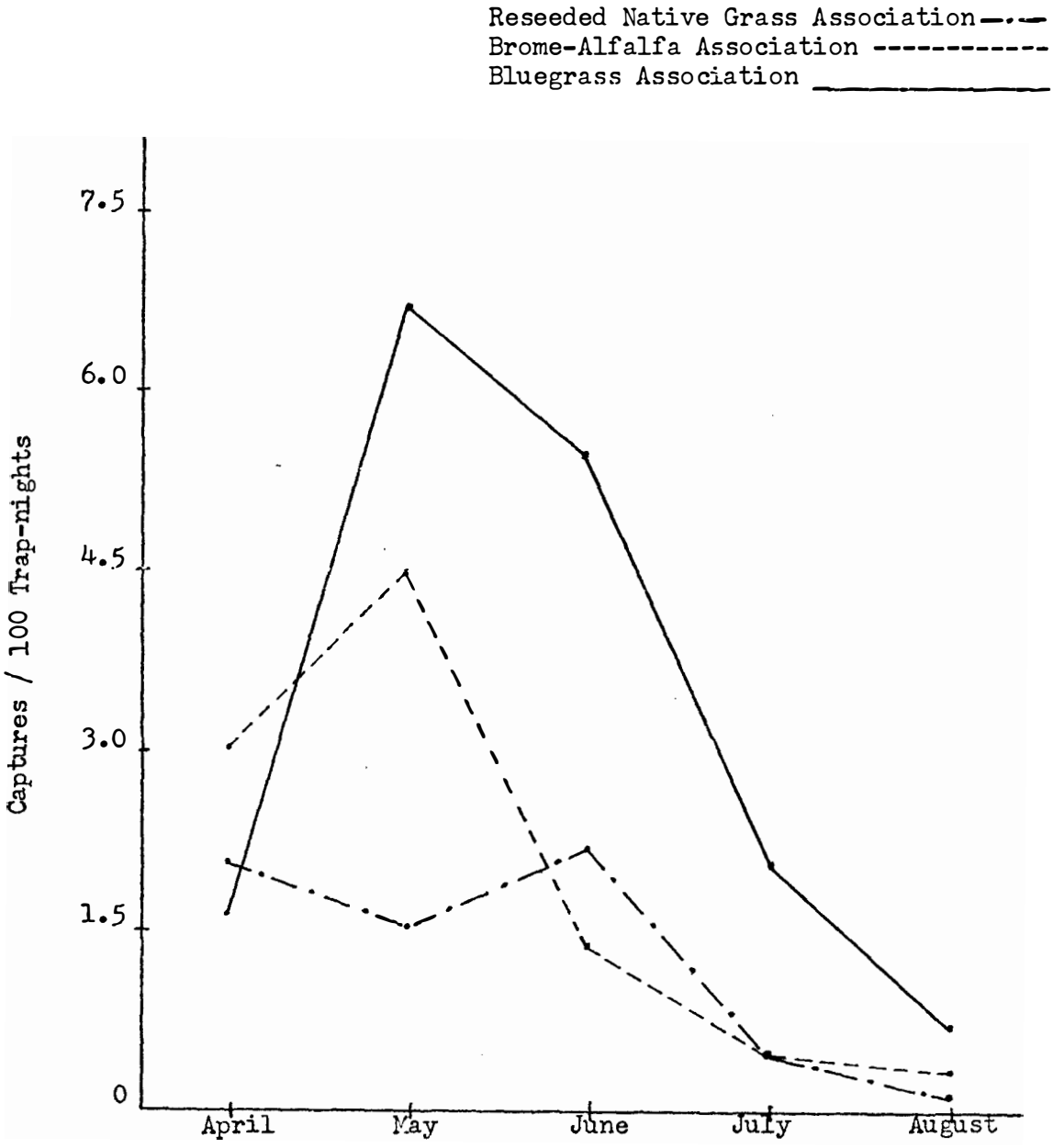


Fig. 3. Meadow voles captured per 100 trap-nights in each of three cover types on the Brookings WPA, 1973.

Table 6. Analysis of variance for snap-trap data obtained throughout the summer on the Brookings WPA, 1973.

| Source of Variation | Degrees of Freedom | Sum of Squares | Mean Square | F Value |
|---|---|---|---|---|
| Among cover types | 2 | 330.27 | 165.14 | 2.21 |
| Within cover types | 34 | 2,545.73 | 74.81 | |
| Total | 36 | 2,876.00 | | |

Table 7. Analysis of variance for snap-trap data obtained during May trapping on the Brookings WPA, 1973.

| Source of Variation | Degrees of Freedom | Sum of Squares | Mean Square | F Value |
|---|---|---|---|---|
| Among cover types | 2 | 465.69 | 232.845 | 1.50 |
| Within cover types | 4 | 621.17 | 155.293 | |
| Total | 6 | 1,086.86 | | |

The number of meadow voles captured per 100 trap-nights during 1973 ranged from 6.9 during May in the bluegrass association to 0.1 in the reseeded native grass association during August (Tables 3 and 4). This indicated a lower population than the previous year when 23.1 meadow voles were caught per 100 trap-nights in the bluegrass association in August and 16.4 meadow voles were trapped per 100 trap-nights during September in the reseeded native grass association.

Sixty-one meadow voles were taken in all cover types combined in April, 1973. The number taken in May almost doubled, rising to 119 animals. However, the June and July samples showed a steady decline and reached a low in August when only 14 animals were captured in 3,528 trap nights (Fig. 4).

The number of deer mice caught in each association fluctuated in a similar manner throughout the summer, however, there were more caught each month in the reseeded native grasses than in either of the other associations except during May (Fig. 5). Populations were low in April and rose steadily to a peak in June. July captures showed a decline but numbers rose again in August. The number of captures in all cover types combined revealed a similar pattern (Fig. 4).

The number of deer mice captured per 100 trap-nights during 1973 ranged from 1.9 during June in reseeded native grass association to a low of 0.0 during April in brome-alfalfa association. The pattern was similar in 1972 with captures per 100 trap-nights ranging from

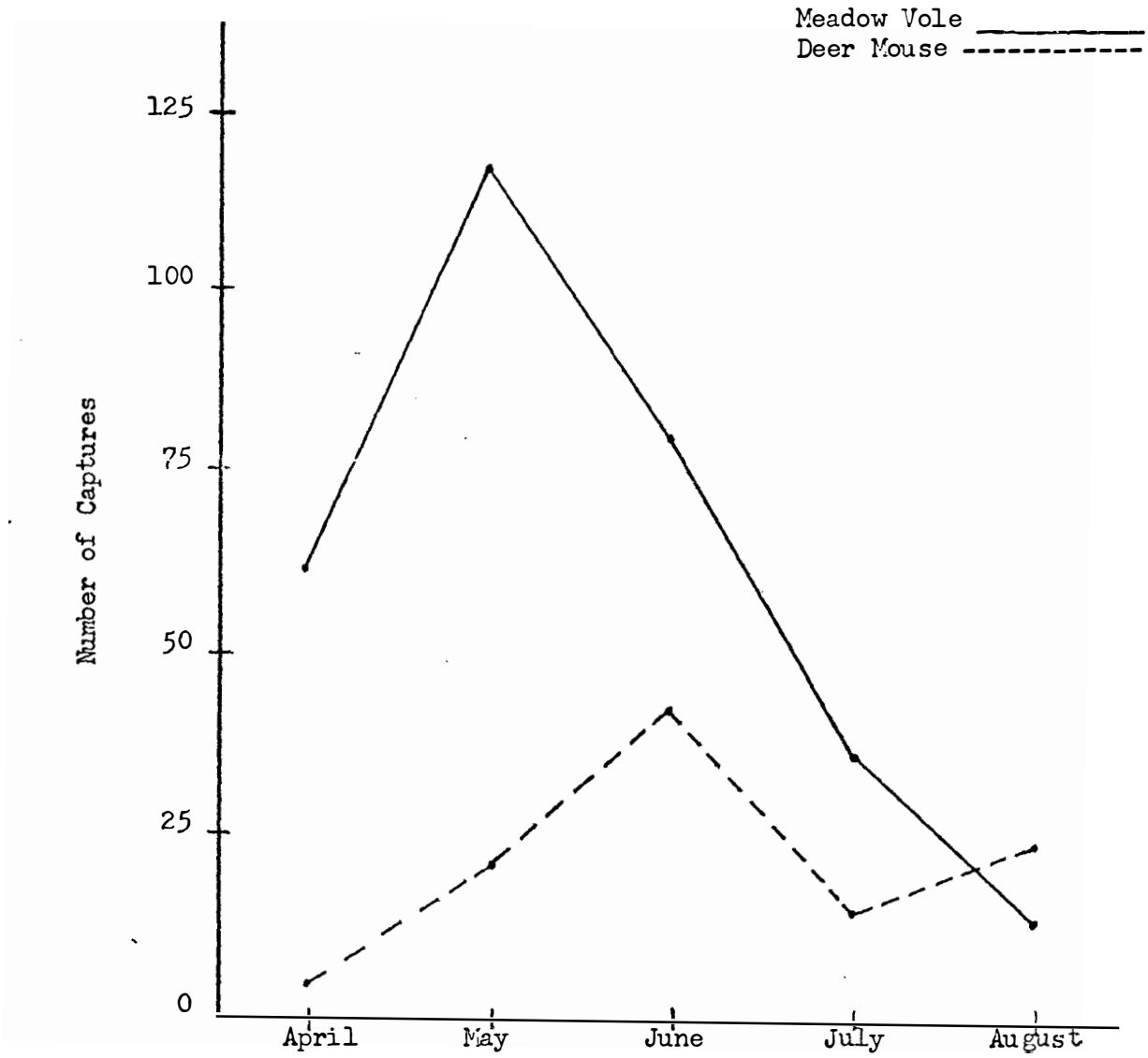


Fig. 4. Number of meadow voles and deer mice captured in 2,646 trap-nights in April and 3,528 trap-nights in May, June, July, and August on the Brookings WPA, 1973.

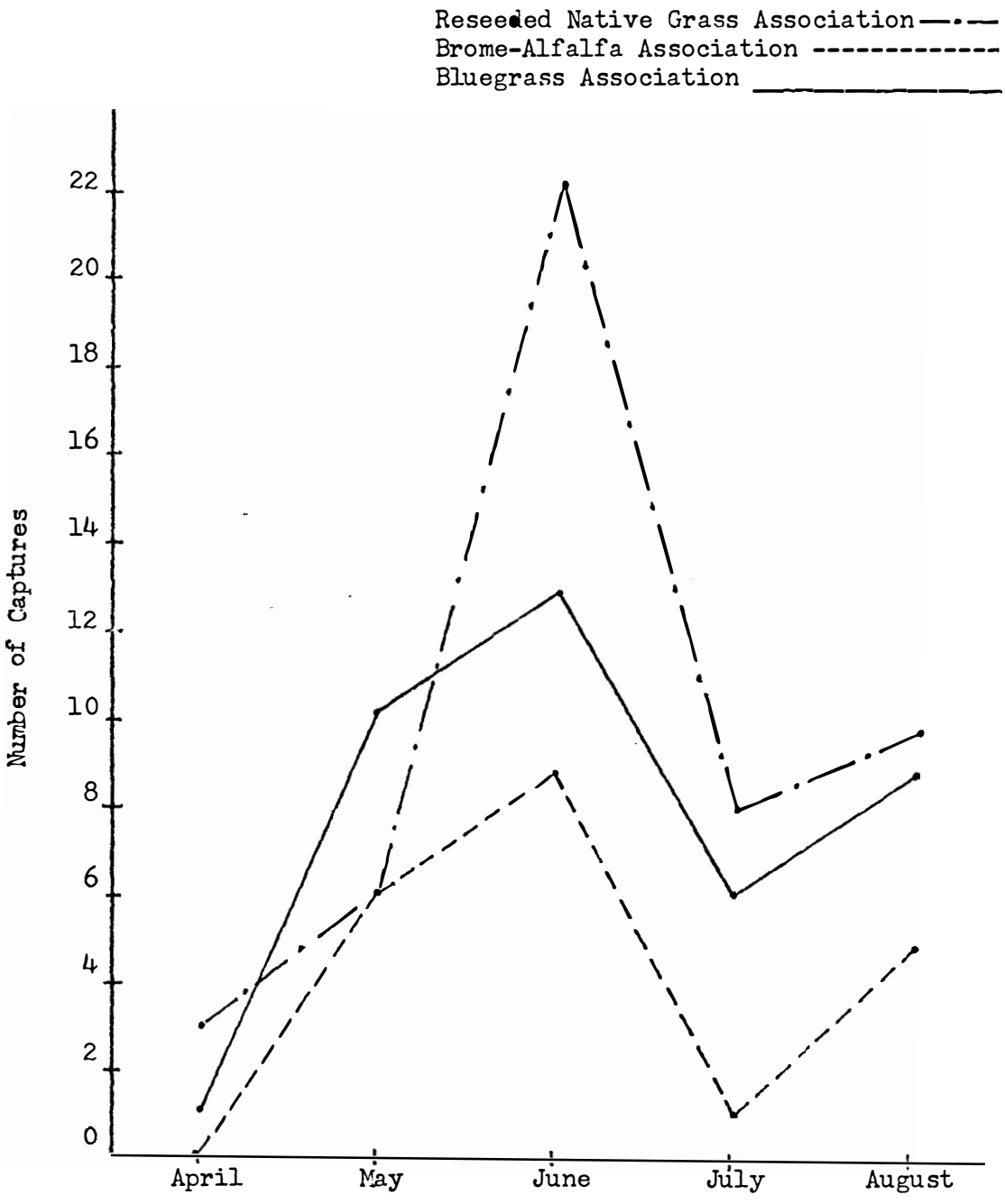


Fig. 5. Number of deer mice captured in each of three cover types in 882 trap-nights in April and 1,176 trap-nights in May, June, July, and August on the Brookings WPA, 1973.

3.1 in reseeded native grasses to 0.9 in brome-alfalfa.

Twenty-nine jumping mice were taken on the Brookings WPA in 1973; 16 in the brome-alfalfa association, six in the bluegrass association and seven in the reseeded native grass association (Tables 3, 4, and 5). More than twice as many jumping mice were captured in brome-alfalfa than in either of the other two cover types. The highest number of jumping mice captured in brome-alfalfa was in June and July.

The two species of shrews were captured in all three cover types. The masked shrew occurred in about equal numbers in all areas. The short-tailed shrew was more prevalent in the bluegrass than in the brome-alfalfa and occurred least in the reseeded native grasses. This follows the same trend as the meadow vole population.

Burning of reseeded native grasses and bluegrass associations had a definite effect on the small mammal populations. In 294 trap-nights on quadrants in the area before it was burned four meadow voles and one deer mouse were taken in the bluegrass association and five meadow voles and three deer mice were taken in the reseeded native grass association (Table 3 and 4). Approximately four weeks after the burn one meadow vole and eight deer mice were captured on the burned bluegrass area and no meadow voles and three deer mice were captured on the reseeded native grass area in 392 trap-nights. The burned area in the bluegrass association did not have a dense vegetative cover and all duff cover was destroyed. No

other meadow voles were captured on the burned bluegrass area during the remainder of the summer; however, deer mice captures ranged from five to 12. The grasshopper mice were taken only on this burned bluegrass area. The burned area in the reseeded native grass association came back to a dense stand of wheatgrass which provided 100 percent ground cover. One meadow vole was captured on this area in June, six in July, and three in August. Deer mice were captured on the reseeded native grass area in numbers varying from two to four throughout the summer.

## Vegetative Analysis

Correlation was not significant (LC $P > 0.05$) between average maximum height of duff and number of meadow voles captured in each quadrant except during July ($r = 0.79$, 5 d.f.) (Table 8). Percent cover of duff fell below 90 percent on only three occasions and then only as low as 77 percent (Table 9). This variation was not sufficient to warrant statistical analysis.

Vegetation height was not a significant factor (LC $P > 0.05$) influencing meadow vole distribution on the Brookings WPA. Areas of tall vegetation often had lower populations than areas with short vegetation (Table 10). From my observations it appeared that matted vegetation that provided protection for runways was more important than height of the vegetation.

Relationship between percent of live cover and number of meadow voles taken was not analysed statistically because of difficulty in

Table 8. Average maximum height of duff in inches based on nine samples per quadrant and number of meadow voles captured per 100 trap-nights on each quadrant on the Brookings WPA, 1973.

| Cover Type | April | | May | | June | | July* | | August | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Height of duff | Number of voles | Height of duff | Number of voles | Height of duff | Number of voles | Height of duff | Number of voles | Height of duff | Number of voles |
| Reseeded Native Grasses | | | | | | | | | | |
| 1 | 2.4 | 3.7 | 2.2 | 2.3 | .7 | 3.6 | .6 | 0 | .7 | 0 |
| 2 | 1.1 | 1.0 | .8 | .5 | 1.2 | 1.0 | 1.3 | 1.0 | .3 | 0.3 |
| 3[a] | 1.5 | 1.7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Brome-Alfalfa | | | | | | | | | | |
| 1 | 2.2 | 1.4 | 2.4 | 8.9 | 1.6 | 2.8 | 1.6 | 0.8 | .8 | 0.8 |
| 2 | 2.1 | 2.7 | 3.9 | 4.3 | 2.7 | 1.3 | 2.2 | 0.3 | 2.3 | 0 |
| 3 | 2.3 | 5.1 | 1.9 | 0.3 | 1.9 | 0.3 | 1.8 | 0.5 | 1.5 | 0.3 |
| Bluegrass | | | | | | | | | | |
| 1 | 3.3 | 2.4 | 4.0 | 6.1 | 3.3 | 4.0 | 3.9 | 1.3 | 2.4 | 0.8 |
| 2 | 3.4 | 1.4 | 3.7 | 7.7 | 3.2 | 7.0 | 4.1 | 3.0 | 3.1 | 0.8 |
| 3[a] | 3.8 | 1.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

* Significant correlation ($P<0.05$).

[a] Area was burned in April and data from this area not used in data analysis.

Table 9. Average percent of duff cover based on visual estimates of nine samples within each $\frac{1}{4}$-acre quadrant on the Brookings WPA, 1973.

| Cover Type | April | May | June | July | August |
|---|---|---|---|---|---|
| Reseeded Native Grasses | | | | | |
| 1 | 83.4 | 99.4 | 93.3 | 83.3 | 92.2 |
| 2 | 98.3 | 98.9 | 100.0 | 77.8 | 95.6 |
| 3[a] | 0 | 0 | 0 | 0 | 0 |
| Bluegrass | | | | | |
| 1 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 2 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 3[a] | 0 | 0 | 0 | 0 | 0 |
| Brome-alfalfa | | | | | |
| 1 | 93.3 | 95.6 | 91.1 | 96.0 | 93.3 |
| 2 | 94.4 | 100.0 | 100.0 | 100.0 | 100.0 |
| 3 | 98.9 | 91.1 | 100.0 | 100.0 | 100.0 |

[a] Area was burned in April and data from this area not used in data analysis.

Table 10. Average maximum height of vegetation in inches based on nine samples per quadrant, and number of meadow voles captured per 100 trap-nights on each quadrant on the Brookings WPA, 1973.

| Cover Type | May | | June | | July | | August | |
|---|---|---|---|---|---|---|---|---|
| | Height of vegetation | Number of voles | Height of vegetation | Number of voles | Height of vegetation | Number of voles | Height of vegetation | Number of voles |
| Reseeded Native Grasses | | | | | | | | |
| 1 | 17.6 | 2.3 | 16.7 | 3.6 | 11.9 | 0 | 18.3 | 0 |
| 2 | 17.0 | 0.5 | 24.3 | 1.0 | 24.1 | 1.0 | 26.8 | 0.3 |
| 3[a] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Brome-Alfalfa | | | | | | | | |
| 1 | 25.0 | 8.9 | 38.2 | 2.8 | 28.0 | 0.8 | 26.4 | 0.8 |
| 2 | 29.3 | 4.3 | 32.9 | 1.3 | 36.9 | 0.3 | 41.6 | 0 |
| 3 | 26.1 | 0.3 | 27.2 | 0.3 | 36.8 | 0.5 | 23.9 | 0.3 |
| Bluegrass | | | | | | | | |
| 1 | 22.3 | 6.1 | 25.8 | 4.0 | 26.0 | 1.3 | 16.4 | 0.8 |
| 2 | 20.3 | 7.7 | 19.3 | 7.0 | 23.1 | 3.0 | 24.7 | 0.8 |
| 3[a] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[a] Measurements of vegetation were not made on the burned area.

obtaining reliable estimates. However, it did not appear that percent live cover influenced the number of voles captured on an area.

Population Characteristics

Age ratios of meadow voles captured in 1973 indicated a declining population (Table 11). Of 56 voles captured in April only one was young, indicating little reproduction through the winter. In May 54 adults and 39 young were captured while in June 14 adults and 15 young were taken, resulting in an age ratio of about 1:1. Although captures in July indicated an age ratio of three young per adult these data were based on only 17 animals. Only eight animals were aged in August and the majority of these were adults.

Age ratios for the animals captured in August 1972 were 2.6 young per adult in the bluegrass association and 3.3 young per adult in the reseeded native grass association. Age ratio was not determined in the brome-alfalfa association. Although the 1972 data were based on only one sample, they indicated that the number of young voles was greater than the number of adults in the fall of 1972. During 1973 the number of adults was generally equal to or greater than the number of young. Such age ratio changes indicated a declining population (Giles 1969).

Percent pregnancy of capured females in 1973 also indicated a declining population. Of thirty-five females examined in April,

Table 11. Sex-ratios and age ratios of meadow voles captured on the Brookings WPA, 1973.

| Sex | April | | May | | June | | July | | August | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Adult | Young | Adult | Young | Adult | Young | Adult | Young | Adult | Young | Adult | Young |
| **Reseeded Native Grasses** | | | | | | | | | | | | |
| male | 5 | 0 | 1 | 5 | 2 | 1 | 1 | 0 | 1 | 0 | 10 | 6 |
| female | 13 | 0 | 2 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 17 | 2 |
| combined | 18 | 0 | 3 | 7 | 3 | 1 | 2 | 0 | 1 | 0 | 27 | 8 |
| **Brome-Alfalfa** | | | | | | | | | | | | |
| male | 10 | 0 | 10 | 12 | 1 | 0 | 0 | 1 | 0 | 0 | 21 | 13 |
| female | 13 | 1 | 8 | 3 | 2 | 2 | 1 | 0 | 1 | 1 | 25 | 7 |
| combined | 23 | 1 | 18 | 15 | 3 | 2 | 1 | 1 | 1 | 1 | 46 | 20 |
| **Bluegrass** | | | | | | | | | | | | |
| male | 4 | 0 | 11 | 13 | 1 | 8 | 1 | 8 | 1 | 1 | 18 | 30 |
| female | 10 | 0 | 12 | 4 | 7 | 4 | 2 | 3 | 2 | 1 | 33 | 12 |
| combined | 14 | 0 | 23 | 17 | 8 | 12 | 3 | 11 | 3 | 2 | 51 | 42 |

82 percent were pregnant while only 63 percent of 35 females captured during the May through August period were pregnant. Litter sizes based on embryo and placental scar counts showed little variation between cover types (Table 12).

A preponderance of males was captured during the 1972 trapping period. Beer and MacLeod (1961) also found a distorted sex ratio and they noted that the sex ratio of trapped animals changed throughout the year. They cited the larger home range of males, the seclusion of breeding females, and small sample size as reasons for trap data not revealing a true sex ratio. In 1973 there was very little variation from an even sex ratio of captured animals in any of the cover types on the Brookings WPA. Of 190 meadow voles sexed on the study area, 96 were males and 94 were females (Table 12). The nearly equal sex ratio of captured animals in 1973 may have resulted from more extensive trapping and a high number of nonproductive females during May through August that year.

Table 12. Embryo and placental scar counts for April captures of meadow voles on the Brookings WPA for all cover type sections combined, 1973.

| Cover Type | Number Observed | Number with Embryos | Average Number of Embryos | Number with recent Placental Scars | Percent Pregnant | Average of Number of Embryos and Placental Scar Counts |
|---|---|---|---|---|---|---|
| Reseeded Native Grasses | 13 | 10 | 5.10 | 1 | 85 | 5.09 |
| Brome-Alfalfa | 12 | 7 | 5.00 | 3 | 83 | 4.80 |
| Bluegrass | 10 | 7 | 4.57 | 1 | 80 | 4.63 |

# DISCUSSION AND CONCLUSIONS

Of the three cover types sampled on the Brookings WPA, the bluegrass association had the highest level of small mammal populations. The brome-alfalfa association had intermediate population levels and the reseeded native association had the lowest levels. Meadow voles and deer mice were captured most frequently; however, jumping mice, masked shrews, short-tailed shrews, three grasshopper mice, and one house mouse were also taken.

The number of meadow voles captured was not significantly different among the three vegetative cover types sampled. There were also no differences in the number of voles captured and four vegetative parameters measured: height of duff, height of vegetation, percent duff cover, and percent live cover. The WPA had been left undisturbed for a number of years, and adequate cover had accumulated for protection of meadow voles in all of the cover types. The type of vegetation did not seem to be as important as the type of protection the vegetation offered. Bluegrass that was leaning and covered the ground offered more protection for meadow voles from above than did the taller brome-alfalfa association. It appeared that the bluegrass association was the favored habitat for meadow voles on the Brookings WPA.

Deer mice occurred most often in the reseeded native grass association. The plants in that cover type were clumped and the deer mice may have preferred the open cover. However, meadow voles, that

are antagonistic and dominant over deer mice, were taken in fewer numbers in the reseeded native grass association. The influence of meadow voles on deer mice could not be ascertained in this study, but it may have been an important factor in their distribution.

Although more than 57,000 acres in Waterfowl Production Areas are managed for wildlife in South Dakota, a search of the literature did not reveal information on managing small mammals on these areas. Apparently small mammals were not deemed important for management, yet they form a principal prey for many furbearing carnivores, which not only prey on nests of birds but are important economically. My study indicates that species of grass used for cover does not affect the number of small mammals as much as the density of the cover. If a high number of meadow voles are desired for a prey base, plantings that permit a substantial build-up of duff material appears to be most satisfactory. Meadow vole numbers could be controlled by periodic burning of the duff and reducing density of the vegetation. Additional information is needed on the role small mammals play in determining populations of carnivores.

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