Effects of ecological changes induced by various sagebrush control techniques on small mammal populations
by Ottley Paul Tschache

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE i n Fish and Wildlife Management
Montana State University

Abstract:
Small mammal populations and vegetation on each of six study plots in central Montana were studied during the summers of 1968 and 1969 to determine the effects of habitat changes following sagebrush control operations; The plots were subjected to one or the other of the following treatments: total kill,-partial kill,strip kill, defer control, or open, control., To achieve a kill of sagebrush (Artemisia tridentata), 2,4-D, was applied in June, 1968. The study plots comprised a sagebrush-grass-land habitat type and treatment with 2,4-D usually produced an increase in grass cover and a decrease in the cover of forbs and shrubs, Population indices, including home range, movement, and density, were determined for the only abundant small mammal, the deer mouse , (Peromyscuus maniculalatus osgoodi), from live trapping data; Increases or decreases, in the magnitude of these indices were approximately the same on all plots; treatment and control. There was no significant difference in the total populations of deer mice, when comparing the populations on the control plots to those on the treatment plots for the pre-treatment years, 1966-1968 (1966-67 data from Cada 1968), to the post-treatment year, 1969. Home ranges and movement indices were inversely related to the population densities. Deviations from the hypothetical 1:1 sex ratio were of the same magnitude on all plots, treatment,and control; and were correlated with population densities. The relative proportion of males was inversely related to density. Captures and observations on small mammals other than the deer mouse indicated no particular preference as to treatment or control plots. Thus it appears that habitat changes resulting from strip, partial or total kill of big sagebrush, had no measurable effects on the small mammal populations in this area 1 year after treatment.

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Date May 20, 1970

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OTTLEY PAUL TSCHACHE

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree

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Approved:

Head, Major Department

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ABSTRACT

Small mammal populations and vegetation on each of six study plots in central Montana were studied during the summers of 1968 and 1969 to determine the effects of habitat changes following sagebrush control operations. The plots were subjected to one or the other of the following treatments: total kill, partial kill, strip kill, defer control, or open control. To achieve a kill of sagebrush (*Artemisia tridentata*), 2,4-D was applied in June, 1968. The study plots comprised a sagebrush-grassland habitat type and treatment with 2,4-D usually produced an increase in grass cover and a decrease in the cover of forbs and shrubs. Population indices, including home range, movement, and density, were determined for the only abundant small mammal, the deer mouse (*Peromyscus maniculatus osgoodi*), from live trapping data. Increases or decreases in the magnitude of these indices were approximately the same on all plots, treatment and control. There was no significant difference in the total populations of deer mice, when comparing the populations on the control plots to those on the treatment plots for the pre-treatment years, 1966-1968 (1966-67 data from Cada 1968), to the post-treatment year, 1969. Home ranges and movement indices were inversely related to the population densities. Deviations from the hypothetical 1:1 sex ratio were of the same magnitude on all plots, treatment and control, and were correlated with population densities. The relative proportion of males was inversely related to density. Captures and observations on small mammals other than the deer mouse indicated no particular preference as to treatment or control plots. Thus it appears that habitat changes resulting from strip, partial or total kill of big sagebrush, had no measurable effects on the small mammal populations in this area 1 year after treatment.

INTRODUCTION

The chemical control of sagebrush to increase grass for livestock has long been practiced in Montana. Although the effects of range treatment on vegetation have received considerable study, its effects on animal life are largely unknown. Due to the continued practice of sagebrush manipulation on public as well as private lands, the Montana State Fish and Game Department, in cooperation with the Bureau of Land Management, initiated a 10-year study in 1965 to ascertain the ecological effects of this manipulation upon certain animal populations.

The effects of habitat changes following sagebrush control operations on small mammal populations is a part of that project. Population indices were measured on each of six study plots prior to planned sagebrush control operations of varying intensities according to plot by Cada (1968) during the summers of 1966 and 1967. My study, conducted during the summers of 1968 and 1969, initiated the post-treatment phase of the project. Procedures were the same as those carried out by Cada. Due to a delay in the treatment procedures, the results from the summer of 1968 are considered pre-treatment.

STUDY AREAS

The six study plots were the same as those used by Cada (1968) in the pre-treatment study. These plots are located on one or the other of two study areas in central Montana near the town of Winnett (Figure 1). Both areas are on lands administered by the Bureau of Land Management and have been used principally for livestock grazing. For the purpose of this and other studies the grazing was discontinued on all but one plot.

These study areas support a sagebrush-grassland vegetation type and consist of a moderately flat terrain adjoined by gently rolling hills and gully bottoms. The soils are clay loam and are generally exposed between sagebrush plants.

Gieseker (1938) describes the climate as semi-arid, "...characterized by a comparatively low rainfall, great temperature extremes, a large number of sunny days, and a relatively low humidity." Precipitation averages 12.57 inches annually (U. S. Department of Commerce Weather Station at Flat Willow). The total rainfall for the summers (June-September) of 1968 and 1969 were 3.21 and 0.12 inches above normal, respectively. The average summer temperatures for 1968 and 1969 were 62.3 and 64.4 degrees Fahrenheit, respectively. These were slightly below the normal average.

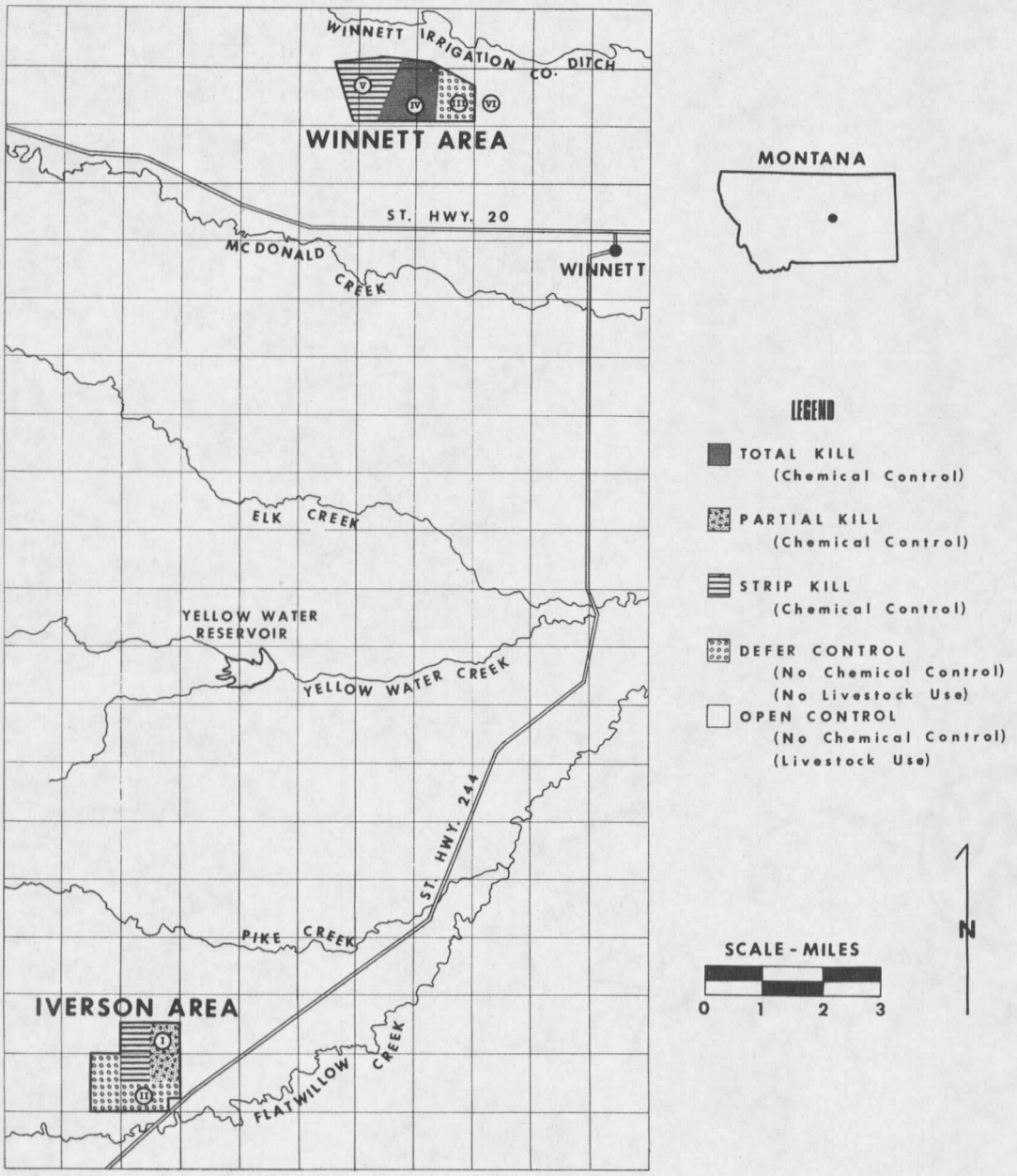

Figure 1. Map showing the two sagebrush control study areas, with special reference to the locations (I-VI) of the six small mammal study plots in relation to the various treatments.

METHODS

The study plots, with the exception of No. VI, were deferred from livestock grazing by November of 1967. Some were treated aerially with 2,4-Dichlorophenoxyacetic acid in June of 1968. Plot I was treated with 2,4-D amine at the rate of 1 pound in 6 gallons of water per acre to achieve a partial kill of sagebrush. A 2,4-D low volatile ester was used on Plot IV at the rate of 2 pounds in 6 gallons of water per acre to accomplish a total kill of sagebrush. Plot V was sprayed with the same concentration as the latter but only on alternate 100-foot strips. Plots II, III, and VI received no chemical control (Figure 1).

To make valid comparisons with the pre-treatment study, methods and materials were the same as those used by Cada (1968), but for the convenience of the reader these are described.

Trapping procedures were similar to those described by Blair (1941). Each of the six, 900-foot square study plots was gridded to 60-foot quadrates. A numbered stake at each quadrate corner marked the trapping stations. Traps were placed at alternate stations along rows and columns each day, making them operational for three nights at each station during a trapping period of 6 days. Two plots were usually trapped simultaneously.

Single-catch Sherman live traps, baited with oatmeal and provided with cotton for nesting and protection, were set in late afternoon and examined each morning. The traps were made non-operational during the day.

Animals were removed from the traps by dropping them into a small plastic bag, in which they could easily be handled. Each animal was marked according to a system of toe-clipping and ear-punching. All animals were examined at each capture for species, sex, age, and breeding condition. They were released at the point of capture. Mammal nomenclature was that of Hall and Kelson (1959) or Hoffmann and Pattie (1968).

Each plot was trapped for two, 6-day periods each summer. The consecutive trapping of Plots I through VI for 6 days each was considered a trapping series. Series I and II extended from June 22 to July 20 and from August 5 to August 27 in 1968, and from June 18 to July 20 and from August 5 to August 24 in 1969, respectively.

Population indices, including home range, movement, and density, were determined for the only abundant small mammal, the deer mouse (*Peromyscus maniculatus osgoodi*). For others, their occurrence on plots was tabulated.

Indices of home range, "...that area habitually traversed ... within a specific period of time" (Shillito 1963), were calculated from points of capture for individuals captured five or more times, and whose geometric center of capture points (Hayne 1949) were 120 feet or more within the peripheral row or column of traps. Both the "inclusive boundary strip" (Blair 1942) and the "minimum home range" (Mohr 1947) methods were used.

The average distance from points of capture to an individual's calculated geometric center, "recapture radii" (Dice and Clark 1953 as cited in Cada 1968), was considered as an index of movement for that individual. Movement indices were determined for individuals captured three or more times, and whose geometric center of capture points were 120 feet or more within the peripheral row or column of traps.

To calculate population densities, the degree of residency (Hodgson 1969) was determined for all *Peromyscus* captured. Individuals captured once or twice, if only on consecutive nights, were considered "partial residents," one-sixth and two-sixths, respectively. Individuals captured three or more times, or twice, if not on consecutive nights, and those captured at least once in each of two trapping periods were considered "full residents" (six-sixths). The total of all degrees of residency during a trapping period for a plot constituted the population. Population densities per unit area for each plot were determined by adding a border strip along each side to account for individuals having only a portion of their home range covered by the trapping grid (Blair 1941). Since movement indices between plots were similar, the average movement index of all individuals of an age class for all six study plots in a trapping series was used as the width of all border strips for that series. No boundary strip was added when calculating juvenile population densities in 1969. Insufficient captures prevented the determina-

tion of a movement index.

Regular, systematic observations on and off the study plots were made to determine species composition, number, distribution and habitat preferences for larger mammals.

Vegetational surveys were taken at four sites on each plot. These sites were located as close to those used by Cada (1968) as possible. The same sites were sampled each year. The method of vegetational analysis was a modification of the method of Daubenmire (1959), whereby 20, 2 x 5 decimeter plot frames were placed at regular intervals along two, 100-foot lines at each analysis site. The percent canopy cover by cover classes and height of each species, and percentage of bare ground, rock, and plant litter were estimated within each plot frame. Frequency among plot frames and constancy among analysis sites were also determined. Sagebrush height and crown coverage were determined from intercept measurements (Canfield 1941) along one of the 100-foot lines at each of the analysis sites. Plant nomenclature was according to Booth (1950) and Booth and Wright (1959).

RESULTS

Vegetation

Each of the six study plots was characterized by an *Artemisia/Agropyron* community. The dominant shrub on all plots was big sagebrush (*Artemisia tridentata*). The principal grasses were western wheatgrass (*Agropyron smithii*), blue grama (*Bouteloua gracilis*), Junegrass (*Koeleria cristata*), green needlegrass (*Stipa viridula*), and various species of bluegrasses (*Poa* spp.). Needleleaf sedge (*Carex eleocharis*) was also abundant. The predominant forbs were Hood's phlox (*Phlox hoodii*), fringed sagewort (*Artemisia frigida*), American vetch (*Vicia americana*), and plains pricklypear (*Opuntia polycantha*).

On the bases of dominant or co-dominant grasses, each study plot was divided into vegetation sub-types similar to those described by Cada (1968). Sagebrush characteristics for each sub-type of each plot are given in Table 1. Since the effects of the herbicide were not evident in the 1968 results, these are considered pre-treatment.

Canopy coverage, frequency and constancy for taxa on Plots I-VI, with reference to vegetation sub-types, sagebrush density, and other noticeable physiographical features are given in Tables VII-XII in the appendix.

To show treatment effects, the mean canopy coverage of all grasses (including sedges), forbs (including half-shrubs), and shrubs (big sagebrush), with reference to vegetation sub-types, sagebrush density, and

other noticeable physiographical features for each plot, from the 1969 results are compared with the 1968 and 1966-67 results (Figures 2, 3, and 4).

Differences in the coverage of grasses and forbs between the pre-treatment results of 1966-67 and 1968 were probably due to variations in precipitation, differences between observers in coverage estimates and/or difference in analysis site position. Since the analysis sites used in 1969 were identical to those used in 1968, only the percent changes in canopy coverage between these 2 years will be discussed.

Grasses showed little response to treatment on the partial kill plot (Plot I). A comparison of the combined data for the plot by years, showed a mean increase in coverage of 8 percent for 1969 as compared to 1968, while on the nearby control plot (Plot II) there was a mean increase in coverage of 22 percent.

From 1968 to 1969 there was a noticeable increase in the mean coverage of grasses on the total kill plot (Plot IV) and the strip kill plot (Plot V) of 52 and 12 percent, respectively. Control plot III had a 5 percent decrease and control plot VI had a 4 percent increase in mean coverage.

When comparing control to treatment, the treatment plots had 1 percent less coverage of grasses in 1968 and 14 percent greater coverage in 1969 than the control plots. This increase can be considered treatment effect.

TABLE 1. AVERAGE NUMBER AND INTERCEPT OF BIG SAGEBRUSH PLANTS ON EACH OF THE STUDY PLOTS AS DETERMINED BY MEASUREMENTS ALONG A 100-FOOT LINE AT VARIOUS SAMPLING SITES.

Plot No.	Vegetation Sub-Type	No. Sites	SAGEBRUSH CHARACTERISTICS: Mean Intercept/Site 1968	Mean Intercept/Site 1969	Mean Number Plants/Site 1968 Live/Dead	Mean Number Plants/Site 1969 Live/Dead
I	*Atremisia tridentata/ Agropyron smithii/ Bouteloua gracilis*	3	35 (dense)[1]	15 (common)	47/4	33/28
	Artemisia tridentata/ Bouteloua gracilis	1	15 (common)	10 (common)	24/1	24/8
II	*Artemisia tridentata/ Agropyron smithii/ Bouteloua gracilis*	2	16 (common)	13 (common)	35/6	26/8
	Artemisia tridentata/ Agropyron smithii	2	33 (dense)	25 (dense)	45/6	44/10
III	*Artemisia tridentata/ Agropyron smithii*	1	55 (very dense)	43 (very dense)	63/5	63/6
		2	28 (dense)	29 (dense)	32/2	41/2
		1	15 (common)	15 (common)	19/0	37/2
IV	*Artemisia tridentata/ Agropyron smithii*	1	28 (dense)	0 (rare)	48/3	0/42
		1	31 (dense)	0 (rare)	51/1	0/42
		2	31 (dense)	1 (rare)	53/1	1/57
V	*Artemisia tridentata/ Agropyron smithii*	1	26 (dense)	3 (scattered)	40/2	13/44
		1*	16 (common)	6 (scattered	19/2	16/20
		2**	13 (common)	11 (common)	25/2	22/9
VI	*Artemisia tridentata/ Agropyron smithii*	1	35 (dense)	25 (dense)	41/1	44/4
		2	15 (common)	11 (common)	25/0	29/1
		1**	6 (scattered)	4 (scattered)	17/2	9/5

[1]Sagebrush density categories: Rare = 0-1 percent; Scattered = 1-10 percent; Common = 10-25 percent; Dense = 25-40 percent; and Very Dense = 40 percent and greater shrub intercept.
*Indicates "Gully Bottom" physiography. **Indicates "Hard Pan" physiography.

Figure 2. Mean canopy coverage of grasses, forbs and big sagebrush in each of the density categories of sagebrush (Table 1) for each of the two vegetation sub-types on Plots I and II (ARTR = *Artemisia tridentata*, AGSM = *Agropyron smithii*, and BOGR = *Bouteloua gracilis*). 1966-67 data obtained from Cada (1968).

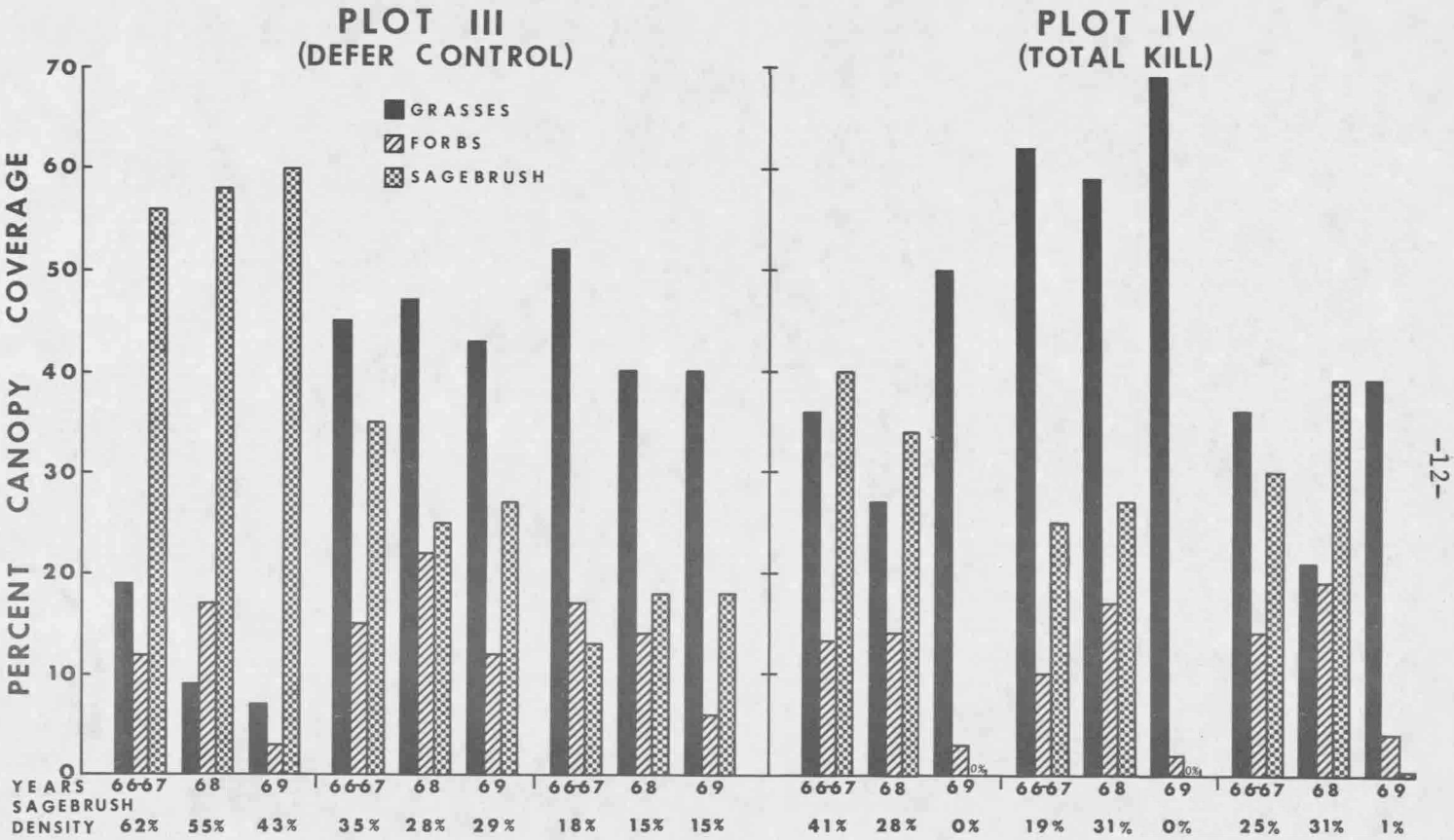

Figure 3. Mean canopy coverage for grasses, forbs and big sagebrush in each of the density categories of sagebrush (Table 1) occurring in the *Artemisia tridentata/Agropyron smithii* vegetation sub-type of Plots III and IV. 1966-67 data obtained from Cada (1968).

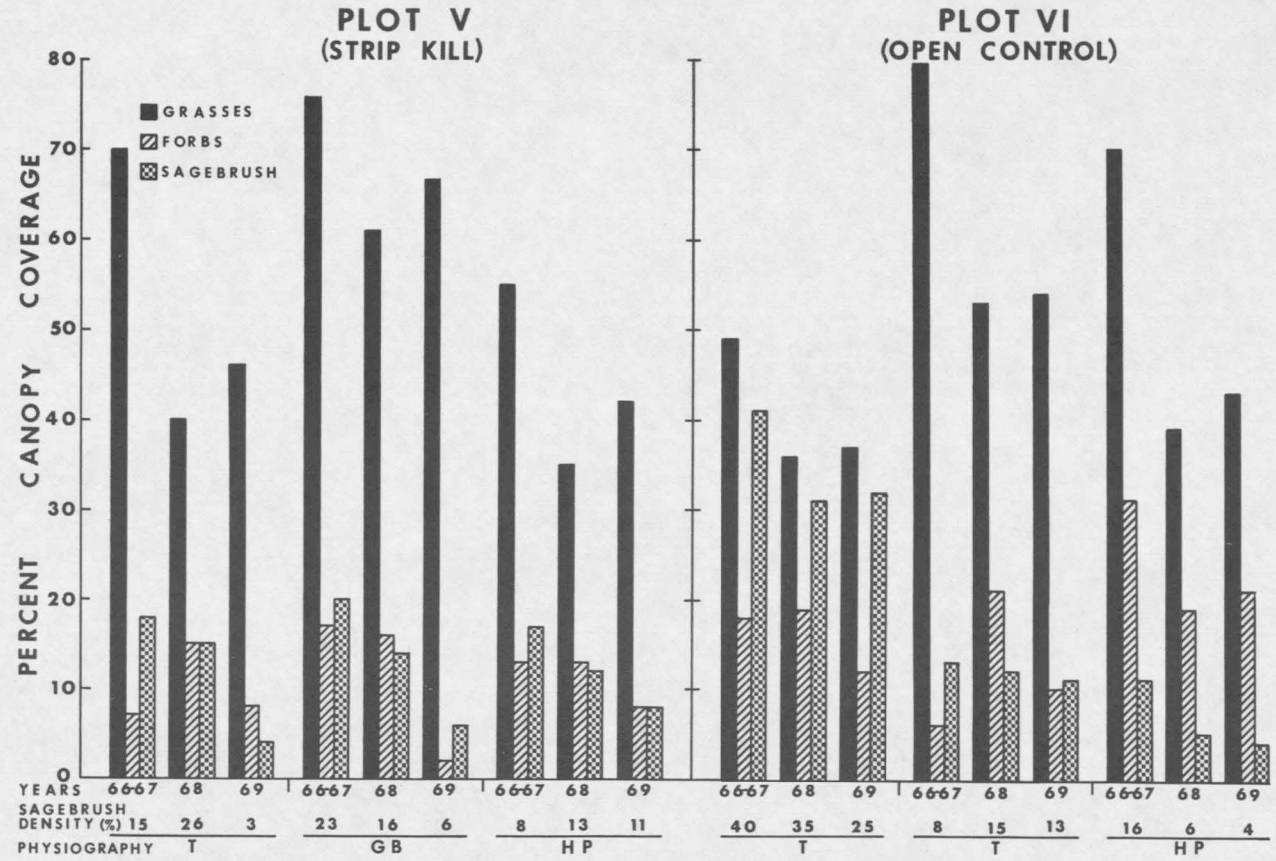

Figure 4. Mean canopy coverage for grasses, forbs, and big sagebrush occurring in the *Artemisia tridentata/Agropyron smithii* vegetation sub-type of Plots V and VI with reference to sagebrush density (Table 1) and other noticeable physiographical features (T = Typical, GB = Gully Bottom, and HP = Hard Pan). 1966-67 data obtained from Cada (1968).

There were no changes in dominance or species composition on any of the plots between 1968 and 1969 (Tables 7, 8, 9, 10, 11, 12 in the appendix). Crested wheatgrass (*Agropyron desertorum*) was a dominant species on one portion of Plot IV in the 1966-67 results, but was absent from the 1968 and 1969 results. This was probably due to a difference in analysis site position, for this species was observed on the plot.

There was a decrease in the mean coverage of forbs between 1968 and 1969 on treatment plots I, IV, and V of 27, 81, and 55 percent, respectively. Control plots II, III, and VI had a decrease in coverage of 10, 57, and 34 percent, respectively.

When comparing control to treatment, the treatment plots had 8 percent less coverage of forbs in 1968 and 41 percent less coverage in 1969 than the control plots.

There were no major changes in species composition or dominance of forbs on any of the study plots between the years.

Differences in shrub coverage for all plots between the 1966-67 and the 1968 results were mainly due to difference in analysis site position, and the slight differences in coverage on the control plots observed between 1968 and 1969 were probably due to difference in positions of the lines from which measurements were taken. Shrub coverage on treatment plots I, IV, and V decreased between 1968 and 1969, 32, 99, and 48 percent, respectively. From line intercept measurements of live plants on

the treatment plots (Table 1), one can assume a 56 percent kill of big sagebrush on the partial kill plot (this refers on the average to 56 percent of each live plant), 99 percent kill on the total kill plot, and 57 percent kill on the strip kill plot (total kill in 100-foot strips).

The light livestock grazing which was received on Plot VI seemed to have little effect on species composition or coverage of the vegetation.

There was a decrease in bare ground between 1968 and 1969 of 12 percent on the treatment plots and an average increase of 15 percent on the control plots. The mean coverage of standing litter increased on treatment and control plots 23 and 17 percent and the mean coverage of litter lying on the ground decreased 33 and 26 percent, respectively. The increase in standing litter on all plots was probably due to deferred grazing and the greater increase on the treatment plots was probably due to the presence of dead sagebrush plants. The increase in standing litter on the treatment plots probably reduced the amount of bare ground on these plots, but no explanation can be given for the increased amount of bare ground on the control plots, or for the decrease in the mean coverage of litter lying on the ground on all plots.

Peromyscus maniculatus osgoodi.

Sixty-seven home range indices were determined, each by two methods, from data involving 62 adults and sub-adults (Table 2). Only the boundary strip indices will be discussed.

The average home range for all age and sex groups ranged from 0.4 to 2.2 acres in 1968 and from 0.8 to 3.2 acres in 1969. The 1969 results were similar to the 1966-67 results (Cada 1968). The respective average home ranges for adult males and females for 1968 were 50 and 40 percent smaller than the combined averages for 1966, 1967, and 1969. The average adult male ranges of 3.0, 1.5, and 2.0 acres for 1966-67, 1968, and 1969 were consistently larger than the adult female ranges of 1.8, 0.8, and 1.4 acres, respectively. When comparing the averages for the control plots to those of the treatment plots and considering sample size, there appears to be little difference in the adult male or female home ranges in either of the 4 years of study for these study plots. The data for sub-adults and juveniles were too few for consideration.

One hundred eighty-five movement indices (average recapture radii) were calculated from data involving 166 individuals (Table 3). The 1969 movement indices were similar to those of 1966 and 1967 (Cada 1968). The respective average movement indices for adult males and females in 1968 were approximately 31 and 40 percent less than those of the combined years of 1966, 1967, and 1969. The average adult male recapture radii

TABLE 2. MEAN HOME RANGE INDICES OF *PEROMYSCUS MANICULATUS OSGOODI* CAPTURED FIVE OR MORE TIMES; CALCULATED BY TWO METHODS FOR SERIES "I" AND "II" OF 1968 AND 1969.

	MINIMUM HOME RANGE INDEX (acres)						BOUNDARY STRIP HOME RANGE INDEX (acres)					
	Series I		Series II		Series I & II		Series I		Series II		Series I & II	
Age-Sex	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
ADULT-MALE:												
ALL PLOTS:												
1968	11	0.9	8	0.7	19	0.8	11	1.7	8	1.3	19	1.5
1969	3	1.5	3	0.9	6	1.3	3	2.4	3	1.7	6	2.0
PLOTS I, IV & V:												
1968	6	0.9	5	0.7	11	0.8	6	1.7	5	1.3	11	1.5
1969	1	0.6	1	0.6	2	0.6	1	1.1	1	1.2	2	1.1
PLOTS II, III & VI:												
1968	5	0.9	3	0.6	8	0.8	5	1.7	3	1.1	8	1.5
1969	2	1.9	2	1.0	4	1.7	2	3.0	2	1.9	4	2.4
ADULT-FEMALE:												
ALL PLOTS:												
1968	9	0.3	11	0.3	20	0.3	9	0.8	11	0.8	20	0.8
1969	-	---	4	0.8	4	0.8	-	---	4	1.4	4	1.4
PLOTS I, IV & V:												
1968	7	0.3	6	0.4	13	0.3	7	0.7	6	0.9	13	0.8
1969	-	---	3	0.8	3	0.8	-	---	3	1.5	3	1.5
PLOTS II, III & VI:												
1968	2	0.5	5	0.3	7	0.4	2	1.0	5	0.8	7	0.9
1969	-	---	1	0.7	1	0.7	-	---	1	1.3	1	1.3

TABLE 2. (CONTINUED)

	MINIMUM HOME RANGE INDEX (acres)						BOUNDARY STRIP HOME RANGE INDEX (acres)					
	Series I		Series II		Series I & II		Series I		Series II		Series I & II	
Age-Sex	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
SUB-ADULTS:												
ALL PLOTS:												
1968	13	0.6	1	1.1	14	0.6	13	1.1	1	1.9	14	1.2
1969	3	0.5	1	0.3	4	0.5	3	1.1	1	0.8	4	1.0
PLOTS I, IV & V:												
1968	6	0.6	-	---	6	0.6	6	1.1	-	---	6	1.1
1969	1	0.9	-	---	1	1.9	1	1.6	-	---	1	1.6
PLOTS II, III & VI:												
1968	7	0.5	1	1.1	8	0.6	7	1.1	1	1.9	8	1.2
1969	2	0.4	1	0.3	3	0.3	2	0.9	1	0.8	3	0.8

TABLE 3. MEANS OF AVERAGE RECAPTURE RADII (FEET) OF *PEROMYSCUS MANICULATUS OSGOODI* CAPTURED THREE OR MORE TIMES DURING INDIVIDUAL TRAPPING PERIODS IN 1968 AND 1969.

			1968						1969					
			Series I		Series II		Series I&II		Series I		Series II		Series I&II	
Age	Sex	Plot	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
Adult	Male	I	6	129	6	97	12	113	2	151	1	137	3	146
		II	4	142	6	95	10	114	2	269	-	---	2	269
		III	2	101	3	106	5	104	2	149	2	170	4	160
		IV	1	170	3	146	4	152	1	99	5	179	6	164
		V	5	113	1	172	6	123	2	192	-	---	2	192
		VI	2	175	-	---	2	175	1	216	2	146	3	170
		ALL	20	131	19	110	39	121	10	184	10	165	20	174
Adult	Female	I	6	106	3	67	9	93	-	---	1	292	1	292
		II	4	47	5	69	9	59	2	98	-	---	2	98
		III	-	---	7	93	7	93	-	---	1	170	1	170
		IV	4	83	4	97	8	90	-	---	3	96	3	96
		V	2	89	4	91	6	90	-	---	1	175	1	175
		VI	1	101	2	100	3	100	-	---	1	112	1	112
		ALL	17	84	25	86	42	85	2	98	7	148	9	137
Adult	Both	I,IV & V	24	110	21	102	45	107	5	157	11	189	16	179
		II, III & VI	13	108	23	99	36	109	7	178	6	153	13	166
		ALL	37	110	44	101	81	108	12	169	17	176	29	173
Sub-Ad.	Both	ALL	30	117	16	103	46	112	12	148	6	162	18	153
Juv.	Both	ALL	6	69	5	92	11	80	-	---	-	---	-	---

of 162, 121, and 174 feet for 1966, 1968, and 1969 were consistently larger than the average adult female radii of 147, 85, and 137 feet respectively (data for 1967 were too few for consideration). The combined movement index for sub-adult males and females was intermediate between that of adult males and females within each year. The combined movement index for juvenile males and females was considerably lower than that for any other age group, averaging 114 feet in 1966 and 80 feet in 1968 (data for 1967 and 1969 were too few for consideration). There appears to be little difference in the series means for any age or sex group, or when comparing the combined indices of the control plots to those of the treatment plots for any of the 4 years.

Population density is expressed as the number of individuals per 40 acres. Six hundred forty-six residency determinations were made from 488 individuals in 1968 and 223 from 182 individuals in 1969 (Table 4). When comparing the adult male-female means for both series of all plots, the respective populations in 1966 and 1967 of 7.3 and 4.8 individuals per 40 acres were quite similar to that of 1969, which was 5.6 individuals per 40 acres. The greatest density was observed in 1968 when the average population for all plots was 19.8 individuals per 40 acres. When comparing the combined means of 1966, 1967, and 1969 to the mean for 1968, this is a 236 percent increase. The combined density indices for the sub-adult males and females were consistently lower than those for adults, but followed the same general trend,

TABLE 4. RESIDENT DEER MOUSE POPULATION INDICES (INDIVIDUALS PER 40 ACRES) DETERMINED FROM CAPTURES DURING EACH TRAPPING SERIES AND PERIOD.

Age	Plot Number	1968 Series I Male	1968 Series I Female	1968 Series II Male	1968 Series II Female	1969 Series I Male	1969 Series I Female	1969 Series II Male	1969 Series II Female
Adult	I	14.7	28.5	25.5	26.3	5.6	5.8	7.0	3.4
	II	14.9	20.5	25.5	25.0	10.0	7.5	8.5	2.3
	III	7.0	5.6	41.9	23.4	3.8	3.5	10.4	6.8
	IV	12.1	20.1	24.1	19.0	7.9	5.8	10.4	10.7
	V	14.0	14.2	23.4	24.8	3.5	1.4	5.3	2.3
	VI	11.7	11.7	21.7	19.0	2.9	0.0	7.7	1.1
	ALL	12.4	16.8	27.0	22.9	5.6	4.0	8.2	4.4
Sub-Ad.	ALL	15.8	6.7	10.0	5.1	4.2	2.3	2.8	1.8
Juv.	ALL	2.8	3.0	2.5	3.0	0.0	0.2	0.1	0.6
TOTAL		31.0	26.5	39.5	31.0	9.8	6.5	11.1	6.8

low numbers in 1966, 1967, and 1969 and high numbers in 1968. The capture of juveniles was too inconsistant for consideration.

There was a natural but only slight variation in the average total population density between each plot for each year (Figure 5), but there was no significant difference when comparing the combined density indices of the control plots to the treatment plots for the pre-treatment years and the post-treatment year. A test was made to determine whether the difference in the combined density indices between the treatment plots and the control plots varied between the pre-treatment years and the post-treatment year (Figure 6).

The error variance used in the test was based on the remaining sum-of-squares after removing a year effect, a plot effect, and the one degree of freedom sum-of-squares for the above treatment by year interaction, giving 14 degrees of freedom. This was done by analysis of variance procedures using years as one factor having four levels and plots as another factor having six levels. The error sum-of-squares was then based on the calculation for interaction between plots and years, assuming such did not in fact exist, except for the one degree of freedom component above.

The F test was not significant; in fact the F value was less than 1.0 (0.15). The probability of getting an F larger than 0.15 when there would be no treatment effect is 0.70.

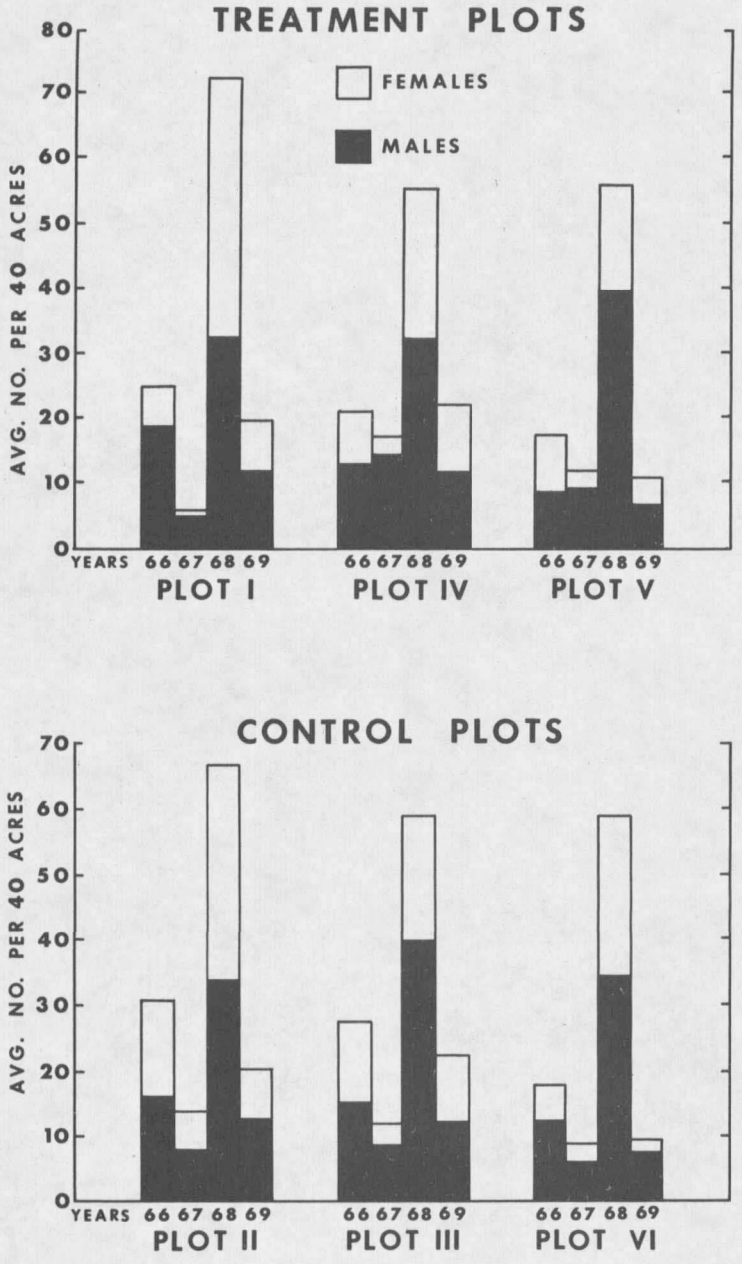

Figure 5. Average number of individuals per 40 acres, by plot, for each year of study, 1966-1969. 1966-67 data obtained from Cada (1968).

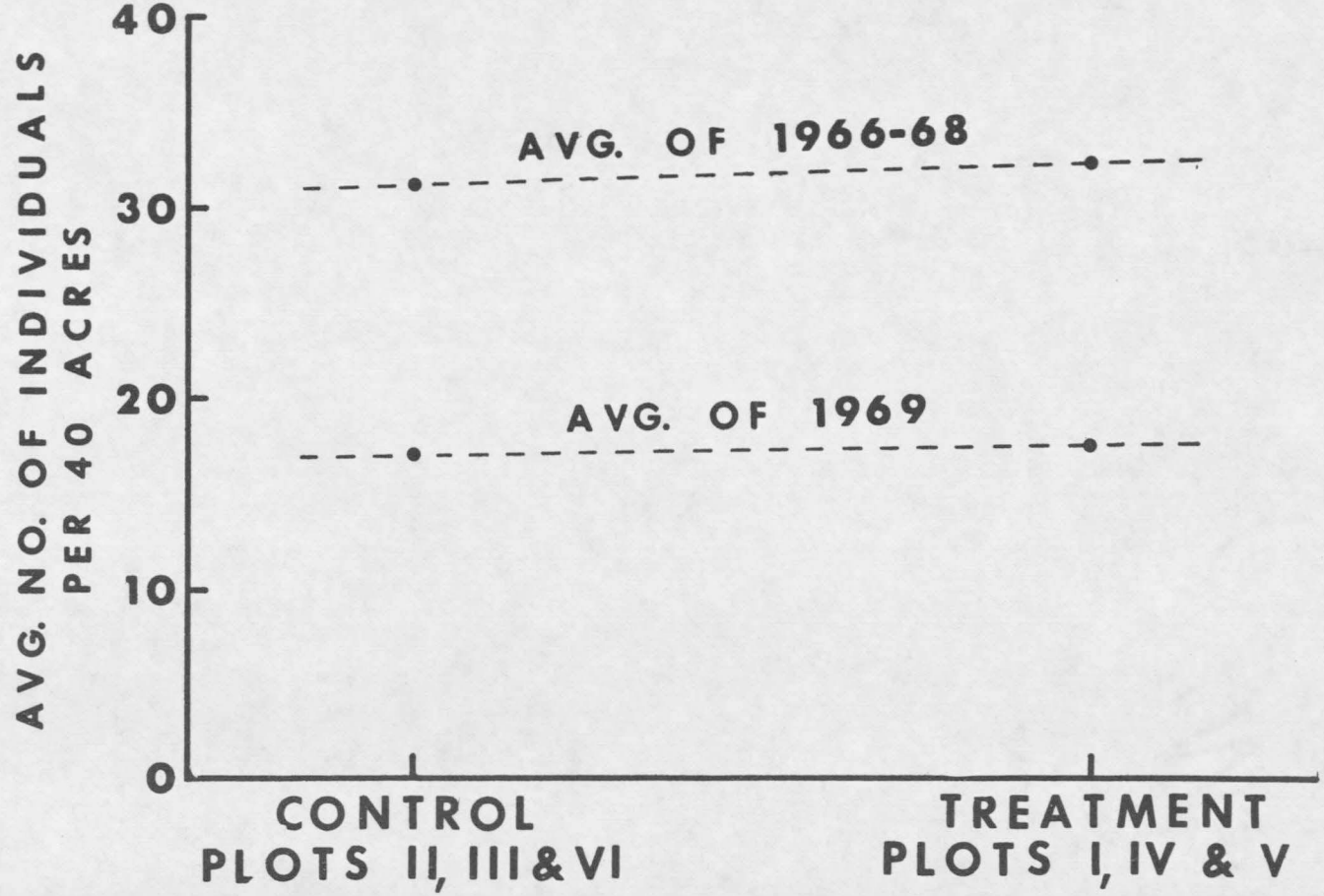

Figure 6. Test to determine whether the population varied between pre- and post-treatment years on control and treatment plots. 1966-67 data obtained from Cada (1968).

A preponderance of males over females is indicated. The respective mean percent of males for Series I and II in 1966, 1967, 1968, and 1969 were 61 and 62, 68 and 78, 54 and 56, and 60 and 61, respectively. The number of males was consistently higher in late summer (Series II). An inverse relation between the proportion of males and the total population density can be detected. When comparing the mean percent of males on the control plots to that on the treatment plots, no differences were noted for any of the 4 years.

As was found by Cada (1968), delineating aggregates of points of capture within plots did not reveal distinct relations between vegetation sub-types and the occurrence of deer mice within the *Artemisia/Agropyron* vegetation type, but some habitat preferences were indicated. Few captures were made in areas of dense sagebrush on either of the six study plots and mice were seldom caught in traps set in areas of dense grass cover. No changes in points of capture were noted in the post-treatment year other than the fact that the points were less widely dispersed.

Other Species

Ten species of small mammals other than *Peromyscus maniculatus* were captured (Table 5). Total numbers for eight of these species comprised 14 percent of all mammals captured in 1968 and total numbers for six comprised 9 percent of all captures in 1969. The sagebrush vole (*Lagurus curtatus pallidus*) was the most abundant, making up 75 and 57 percent of the captures for these species in 1968 and 1969, respectively. Only one sagebrush vole was taken in 1966, and none in 1967. Similar to the deer mouse, there was a decrease in the number of sagebrush vole captures of 80 percent from 1968 to 1969. Decreases on control and treatment plots were of about the same magnitude. No noticeable changes in species composition or relative abundance was noted when comparing the control plots to the treatment plots for any of the 4 years. The other species which were captured at least once during the 1968 or 1969 trapping periods in order of decreasing abundance were: the northern grasshopper mouse (*Onycomys leucogaster missouriensis*), the meadow vole (*Microtus pennsylvanicus* subsp.), the desert cottontail (*Sylvilagus audubonii baileyi*), the Wyoming pocket mouse (*Perognathus fasciatus olivaceogriseus*), the house mouse (*Mus musculus domesticus*), the least weasel (*Mustela nivalis* subsp.), the long-tailed weasel (*Mustela frenata* subsp.), the whitetail jackrabbit (*Lepus townsendii townsendii*), and the northern pocket gopher (*Thomomys talpoides talpoides*).

TABLE 5. NUMBER, SEX, AND AGE OF ALL SMALL MAMMALS, OTHER THAN DEER MICE, CAPTURED AT LEAST ONCE DURING THE 1968 AND 1969 TRAPPING SERIES.

Species	PLOT NUMBER I	II	III	IV	V	VI	Total
1968							
Lagurus curtatus	I 1 M Su II 2 M Ad II 1 M Su II 1 F Ad	I 2 M Ad II 1 M Ad II 1 M Su II 2 F Su	I 1 M Su I 6 M Ju I 1 F Ad I 3 F Ju II 7 M Ad II 1 M Su II 4 F Ad II 2 F Su	I 3 M Ad I 1 M Ju I 3 F Ad II 3 M Ad II 5 F Ad II 1 F Su II 1 F Ju	I 2 M Ad I 3 F Ad II 4 M Ad II 1 M Su II 4 M Ju II 4 F Ad II 1 F Su II 2 F Su	I 1 M Ad I 1 M Ju I 1 F Ad I 1 F Su II 1 M Ad II 4 F Ad II 3 F Su	77(83)[2]
Onychomys leucogaster		I 2 M Ad I 1 F Ad I 2 F Su II 2 M Ad II 1 F Ad	I 1 M Ad I 1 M Su I 1 F Ad II 1 M Ad				10(12)
Microtus pennsylvanicus			II 1 M Ad II 2 F Ad		I 1 M Ad	II 2 M Ad II 2 F Ad II 1 F Su	9
Mus musculus			I 1 F Ad	I 1 M Ad			2
Perognathus fasciatus					I 1 F Ad II 1 F Ad		1(2)
Sylvilagus audubonii		II 1 U Ju					1
Lepus townsendii					I 1 U Ju		1
Thomomys talpoides				I 1 M Ad			1
TOTAL							102
1969							
Lagurus curtatus	I 1 M Ju II 1 F Ad		I 1 M Ad II 1 M Ad II 1 M Ju	I 1 F Ad	I 1 M Su I 1 F Ad I 1 F Su II 1 M Ad II 2 F Ad		12
Sylvilagus audubonii			I 1 U Ju II 1 U Ju		II 1 U Ju		3
Perognathus fasciatus			II 1 M Ad	II 1 M Ad			2
Mustela nivalis		I 1 U Ad		I 1 U Ad			2
Mustela frenata					II 1 F Ad		1
Onychomys leucogaster					II 1 M Ad		1
TOTAL							21

[1] Symbols: Ser. = Series; N = Number; A = Age; S = Sex; M = Male; F = Female; U = Unsexed; Ad = Adult; Su = Sub-adult; and Ju = Juvenile.
[2] Number of individuals with total captures in parenthesis.

Desert cottontail and whitetail jackrabbit observations are listed in Table 6. The dates of each individual observation are given in the Appendix, Table 14. The number of whitetail jackrabbit observations made in 1966, 1967, and 1968 were similar, but there was an increase of 250 percent in the number of observations made between 1968 and 1969. This may indicate an increase in the jackrabbit population in 1969 over each of the other 3 years. No noticeable preferences were noted as to treatment or control plots. The number of desert cottontail observations increased slightly each year from 1966 to 1969, but numbers were too small for consideration. The only other small mammals observed were one coyote (*Canis latrans* subsp.) on the Iverson Study Area (Figure 1), and one striped skunk (*Mephitis mephitis hudsonica*) on Plot III. Three and two separate groups of northern pocket gopher mounds were observed on the total kill plot (Plot IV), and three and two separate groups on the strip kill plot (Plot V) in 1968 and 1969, respectively. No preference as to treated or untreated strips on the strip kill plot was noted.

TABLE 6. NUMBER AND LOCATION BY PLOT OF INDIVIDUAL OBSERVATIONS MADE ON TWO SPECIES OF LEPORIDAE.

PLOT NUMBER		I		II		III		IV		V		VI		
		SERIES												
Species	Year	1	2	1	2	1	2	1	2	1	2	1	2	Total
Lepus townsendii	1966[1]	–	–	2	–	–	1	–	–	–	–	–	–	3
	1967	–	–	2	–	–	2	–	1	–	1	–	–	6
	1968	1	1	1	–	–	1	–	–	1	3	–	–	8
	1969	2	4	1	5	1	–	3	1	5	3	–	3	28
Sylvilagus audubonii														
	1966	–	–	–	–	1	2	–	–	–	–	–	–	3
	1967	–	–	–	–	2	2	–	–	–	–	–	–	4
	1968	1	–	–	3	–	1	–	–	1	–	–	–	6
	1969	–	–	–	–	1	5	–	–	–	1	–	1	8

[1] The 1966 and 1967 observations are from Cada (1968).

DISCUSSION

In general, range treatment with 2,4-D decreased the shrub and forb coverage, permitting grasses to increase in production and consequently coverage. This has been reported by numerous authors including Best (1970), whose study was in the same area as that of the present study, and in Colorado by Johnson and Hansen (1969).

These habitat changes, resulting from strip, partial, or total kill of big sagebrush, had no measurable effects on the small mammal populations in this area 1 year after treatment. The deer mice showed only slight variation between early and late summer and marked annual fluctuations in the average total population densities. There was a decrease from 1966 to 1967 of 51 percent in the average total population density, an increase of 439 percent from 1967 to 1968, and a 72 percent decrease from 1968 to 1969 (Figure 5). Other small mammals including the sagebrush vole generally showed similar trends, being quite abundant in 1968 and dropping to low numbers in 1969. These yearly fluctuations in populations occurred on both control and treatment plots. They apparently were related to "natural phenomena" rather than to sagebrush manipulation.

In the deer mouse population the departures from the hypothetical 1:1 sex ratio seemed to be related to the annual population fluctuations. There was a preponderance of males in the sample trapped for each of the 4 years of study. There was also a direct relation between the proportion of females and an inverse relation between the proportion of males

and the total population density. Similar results have been reported by Terman and Sassaman (1967). The explanation most often given for the preponderance of males is that males tend to wander more than females and thus have greater trap exposure than females (Burt 1940). The fact that in this study the adult male movement and home range indices were consistently larger than those for females more or less backs this explanation.

It is also interesting to note that there was an inverse relation between the population density and the movement and home range indices, the latter two decreasing as the population increased (Figure 7). These findings correlate with Stickel's (1960) findings that movements for *Peromyscus* were more extensive on an area of low population than on an area of high population. The reasons for the fluctuations in populations are not the objective of this paper, but various workers have interested themselves in the problem for many years (Chapman 1925, Nicholson 1933, Elton 1942, Errington 1945 and others). The population, movement, and home range increases or decreases in size were of the same magnitude on all plots, treatment and control, for all 4 years of this study, and thus can only be considered natural. There was no significant difference in the total population of deer mice when comparing the total population on the control plots to those on the treatment plots for the pre-treatment years to the post-treatment year.

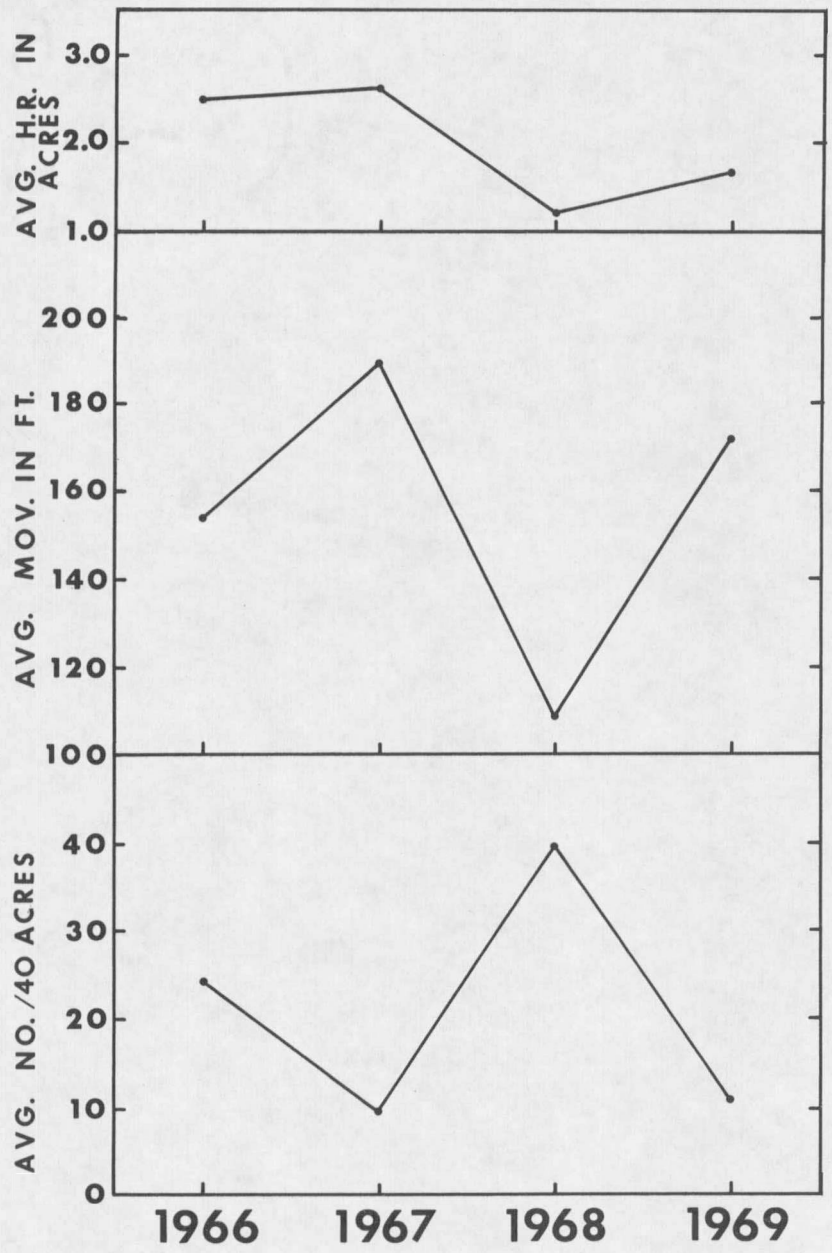

Figure 7. Relationship between population densities, movements, and home range sizes for adult deer mice. 1966-67 data obtained from Cada (1968).

Johnson and Hansen (1969) found that the density of the deer mouse was little affected by the 2,4-D treatment in Colorado. Johnson (1964) showed that due to availability, grass seeds made up a greater proportion of the deer mouse diet than forbs and shrubs on the treatment areas than on the untreated areas. Apparently the deer mouse was able to adjust to the habitat changes.

Keith *et al.* (1959), Tietjen *et al.* (1967) and Johnson and Hansen (1969) all found that treatment with 2,4-D reduced the density of northern pocket gophers (*Thomomys talpoides*). Tietjen *et al.* (1967) related this to the elimination on forbs, their preferred food. The occurrence of northern pocket gophers on two of the treatment plots in my study suggests an increase when compared to the pre-treatment observations of Cada (1968), but data were too few for conclusions. Rabbit observations showed no particular preference as to treatment or control plots.

Thus it can be concluded that no measurable effects on small mammal populations were found 1 year after treatment with 2,4-D for sagebrush control.

APPENDIX

TABLE 7. CANOPY COVERAGE, FREQUENCY, AND CONSTANCY FOR TAXA IN EACH OF THE TWO SAGEBRUSH DENSITY CATEGORIES FOR EACH OF THE TWO VEGETATION SUB-TYPES ON PLOT I, BEFORE AND AFTER TREATMENT.

Vegetation Sub-Type	*Artemisia tridentata/ Agropyron smithii/ Bouteloua gracilis*		*Artemisia tridentata/ Bouteloua gracilis*	
	Before	After	Before	After
Sagebrush Density[1]	Dense (35%) 3 Sites 60 Plots	Common (15%) 3 Sites 60 Plots	Common (15%) 1 Site 20 Plots	Common (10%) 1 Site 20 Plots
Taxa	Cv/Fr/Cy[2]	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy
GRASSES:				
Agropyron smithii	9/93/100	8/87/100	15/90	13/100
Bouteloua gracilis	11/68/100	8/58/100	46/95	39/100
Carex eleocharis	8/77/100	5/82/100	3/50	2/75
Koeleria cristata	4/62/100	7/70/100	7/55	3/45
Poa spp.	1/43/100	tr/47/100[3]	3/65	tr/45
Schedonnardus paniculatus	tr/2/33	tr/ 5/33	-	-
Stipa comata	4/37/100	6/53/100	3/50	4/65
Stipa viridula	3/17/100	4/25/100	-	-
ALL GRASSES	32/100/100	39/98/100	60/100	56/100
FORBS:				
Achillea millefolium	2/12/100	1/10/11	-	-
Androsace septentrionalis	tr/ 2/33	-	-	-
Artemisia frigida	2/30/100	3/42/100	3/30	2/30
Gutierrezia sarothrae	tr/ 5/67	tr/ 5/67	-	-
Lepidium densiflorum	tr/ 3/33	-	tr/25	-
Linum rigidum	-	tr/ 2/33	tr/15	tr/10
Opuntia polycantha	1/18/67	2/13/100	tr/ 5	tr/15
Phlox hoodii	3/48/100	tr/40/100	2/25	tr/10
Plantago purshii	tr/28/100	tr/20/100	3/90	-

TABLE 7. (CONTINUED).

Vegetation Sub-Type	*Artemisia tridentata/ Agropyron smithii/ Bouteloua gracilis*		*Artemisia tridentata/ Bouteloua gracilis*	
	Before	After	Before	After
Sagebrush Density	Dense (35%) 3 Sites 60 Plots	Common (15%) 3 Sites 60 Plots	Common (15%) 1 Site 20 Plots	Common (10%) 1 Site 20 Plots
Taxa	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy
Potentilla pennsylvanica	tr/ 5/67	-	-	-
Psoralea tenuiflora	tr/ 3/33	tr/ 7/67	-	-
Sphaeralcea coccinea	tr/ 5/67	-	-	-
Taraxacum officinale	-	-	-	-
Tragopogon dubius	tr/ 2/33	-	tr/5	-
Vicia americana	1/23/100	tr/10/100	tr/10	-
ALL FORBS	8/90/100	7/80/100	8/95	2/85
SHRUBS:				
Artemisia tridentata	31/82/100	20/75/100	15/35	12/40
OTHERS:				
Selaginella densa	1/18/100	tr/ 8/100	5/15	tr/10
Lichen	1/85/100	1/97/100	6/95	3/95
Bare Ground	31/92/100	28/97/100	16/100	18/95
Litter I[4]				
Litter II				
Rock	1/18/67	tr/ 8/67	1/20	2/15

[1] Density was obtained from line intercept measurements of sagebrush at each analysis site (Table 1).

[2] Canopy coverage/Frequency/Constancy.

[3] Tr indicates taxon having less than 1 percent canopy coverage.

[4] Litter I includes dead vegetative material lying on the ground. Litter II includes dead vegetative material still standing.

TABLE 8. CANOPY COVERAGE, FREQUENCY, AND CONSTANCY FOR TAXA IN EACH OF THE TWO SAGEBRUSH DENSITY CATEGORIES FOR EACH OF THE TWO SUB-TYPES ON PLOT II, 1968 AND 1969.

Vegetation Sub-Type	*Artemisia tridentata/ Agropyron smithii*		*Artemisia tridentata/ Agropyron smithii/ Bouteloua gracilis*	
	1968	1969	1968	1969
Sagebrush Density[1]	Dense (33%) 2 Sites 40 Plots	Dense (25%) 2 Sites 40 Plots	Common (16%) 2 Sites 40 Plots	Common (13%) 2 Sites 40 Plots
Taxa	Cv/Fr/Cy[2]	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy
GRASSES:				
Agropyron smithii	14/90/100	14/83/100	26/98/100	30/100/100
Bouteloua gracilis	-	-	18/60/100	20/73/100
Bromus japonicus	tr/60/100[3]	tr/38/100	3/30/50	tr/ 8/50
Carex eleocharis	-	-	3/43/100	3/43/100
Festuca octoflora	-	-	tr/ 2/50	-
Koeleria cristata	2/20/100	tr/10/100	2/30/100	6/40/100
Poa spp.	1/45/100	1/28/100	13/98/100	9/100/100
Schedonnardus paniculatus	-	tr/40/100	tr/15/100	2/33/100
Stipa comata	-	-	tr/ 3/50	tr/ 5/50
Stipa viridula	4/25/100	8/38/100	1/ 3/50	tr/ 3/50
ALL GRASSES	17/98/100	24/1000/100	54/100/100	62/100/100
FORBS:				
Achillea millefolium	2/15/100	1/15/100	tr/ 3/50	-
Artemisia frigida	-	1/10/100	tr/ 8/50	1/10/50
Bahia oppositifolia	tr/ 3/50	tr/ 3/50	-	-
Camelina microcarpa	-	-	tr/10/50	-
Draba brachycarpa	tr/10/50	-	tr/ 8/50	-
Erigeron pumilis	tr/ 3/50	-	-	-
Grindelia squarrosa	-	tr/ 3/50	-	-
Gutierrezia sarothrae	2/25/100	3/33/100	tr/ 3/50	tr/ 3/50
Hedeoma hispida	-	-	tr/ 3/50	-
Lepidium densiflorum	tr/ 5/50	tr/ 3/50	tr/18/50	tr/ 5/50

TABLE 8. (CONTINUED).

Vegetation Sub-Type	*Artemisia tridentata/ Agropyron smithii*		*Artemisia tridentata/ Agropyron smithii/ Bouteloua gracilis*	
	1968	1969	1968	1969
Sagebrush Density	Dense (33%)	Dense (25%)	Common (16%)	Common (13%)
	2 Sites	2 Sites	2 Sites	2 Sites
	40 Plots	40 Plots	40 Plots	40 Plots
Taxa	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy
Opuntia polycantha	-	-	1/10/100	tr/ 8/100
Phlox hoodii	-	-	1/28/100	2/33/100
Plantago purshii	tr/15/100	-	tr/58/100	-
Sphaeralcea coccinea	tr/ 8/50	tr/ 3/50	tr/ 5/50	tr/ 5/50
Taraxacum officinale	tr/ 5/50	tr/10/100	tr/ 5/50	tr/20/100
Tragopogon dubius	tr/ 3/50	tr/10/100	tr/ 3/50	tr/10/100
Vicia americana	1/18/100	tr/10/100	tr/ 5/100	tr/ 5/100
ALL FORBS:	6/60/100	6/68/100	5/78/100	4/63/100
SHRUBS:				
Artemisia tridentata	36/95/100	29/93/100	16/60/100	17/75/100
OTHERS:				
Selaginella densa	tr/ 5/100	tr/ 5/50	2/33/50	1/33/100
Lichen	tr/ 5/100	tr/ 3/50	4/58/100	1/70/100
Bare Ground	43/93/100	42/98/100	25/98/100	18/100/100
Litter I[4]				
Litter II				
Rock	tr/15/100	18/45/50	tr/ 8/50	-

[1]Density was obtained from line intercept measurements of sagebrush at each analysis site (Table 1).

[2]Canopy coverage/Frequency/Constancy.

[3]Tr indicates taxon having less than 1 percent canopy coverage.

[4]Litter I includes dead vegetative material lying on the ground. Litter II includes dead vegetative material still standing.

TABLE 9. CANOPY COVERAGE, FREQUENCY, AND CONSTANCY FOR TAXA IN EACH OF THE DENSITY CATEGORIES OF SAGEBRUSH OCCURRING IN THE *ARTEMISIA TRIDENTATA/AGROPYRON SMITHII* SUB-TYPE OF PLOT III, 1968 AND 1969.

Sagebrush Density[1]	1968 Very Dense 55% 1 Site 20 Plots	1969 Very Dense 43% 1 Site 20 Plots	1968 Dense 28% 2 Sites 40 Plots	1969 Dense 29% 2 Sites 40 Plots	1968 Common 15% 1 Site 20 Plots	1969 Common 15% 1 Site 20 Plots
Taxa	Cv/Fr/Cy[2]	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy
GRASSES:						
Agropyron smithii	6/55	6/55	38/100/100	37/95/100	38/100	39/100
Bromus japonicus	2/25	tr/15[3]	7/35/ 100	tr/18/50	tr/10	-
Carex filifolia	-	-	tr/ 3/50	-	-	-
Koeleria cristata	-	tr/10	tr/20/50	tr/ 5/100	-	-
Poa spp.	tr/15	2/25	4/43/100	3/33/100	-	-
Schedonnardus paniculatus	-	-	-	-	-	tr/5
Stipa viridula	-	-	7/25/50	4/18/50	-	-
ALL GRASSES	9/75	7/80	47/100/100	43/98/100	40/100	40/100
FORBS:						
Arenaria hookeri	-	-	tr/ 5/50	-	-	-
Artemisia frigida	2/5	tr/5	1/15/50	2/13/100	-	-
Aster canescens	-	-	tr/ 5/50	tr/13/100	3/35	tr/25
Atriplex nuttallii	-	1/5	-	2/3/50	tr/5	-
Bahia oppositifolia	-	-	3/35/100	2/38/100	tr/30	tr/30
Draba brachycarpa	1/60	tr/15	tr/33/100	-	tr/30	-
Erigeron pumilus	-	-	-	tr/5/50	-	-
Grindelia squarrosa	-	-	2/13/50	tr/3/50	-	-
Gutierrezia sarothrae	2/5	-	2/18/100	tr/8/100	tr/5	tr/20
Hymenopappus filifolius	-	-	tr/5/50	-	-	-
Iva axillaris	-	-	tr/3/50	tr/5/100	3/35	tr/30
Lepidium densiflorum	2/30	tr/15	1/50/100	-	1/60	-
Lesquerella alpina	tr/5	-	tr/8/50	-	-	-
Lomatium spp.	-	-	tr/5/100	tr/5/50	-	-

TABLE 9. (CONTINUED).

Sagebrush Density	1968 Very Dense 55% 1 Site 20 Plots	1969 Very Dense 43% 1 Site 20 Plots	1968 Dense 28% 2 Sites 40 Plots	1969 Dense 29% 2 Sites 40 Plots	1968 Common 15% 1 Site 20 Plots	1969 Common 15% 1 Site 20 Plots
Taxa	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy
Musineon divaricatum	-	-	-	tr/3/50	-	-
Orobanche fasciculata	tr/5	-	-	-	-	-
Penstemon nitidus	-	-	-	tr/13/50	-	tr/25
Phlox hoodii	2/20	tr/15	1/30/50	1/18/50	-	-
Plantago purshii	-	-	tr/8/50	-	tr/5	-
Rorippa islandica	tr/5	-	tr/5/50	-	-	-
Sphaeralcea coccinea	1/10	tr/10	tr/20/100	tr/13/100	2/20	1/60
Taraxacum officinale	1/25	tr/20	8/43/100	5/43/100	tr/15	tr/25
Tragopogon dubius	-	tr/10	tr/10/50	tr/3/50	-	-
Vicia americana	9/55	1/30	6/53/100	tr/18/100	5/30	tr/20
Viola nuttallii	-	-	tr/8/50	-	tr/15	-
ALL FORBS	17/95	3/75	22/98/100	12/93/100	14/95	6/95
SHRUBS:						
Artemisia tridentata	58/100	60/95	25/78/100	27/68/100	18/60	18/60
OTHERS:						
Selaginella densa	tr/5	tr/5	-	tr/3/50	-	-
Lichen	tr/5	-	-	tr/3/50	tr/5	-
Bare Ground	15/60	25/70	14/80/100	22/80/100	22/95	40/100
Litter I[4]	56/100	58/100	37/100/100	40/100/100	31/100	26/100
Litter II	21/100	17/100	27/100/100	34/100/100	17/100	26/100
Rock	3/10	1/5	tr/ 8/50	tr/ 8/100	2/5	tr/5

[1] Density was obtained from line intercept measurements of sagebrush at each analysis site (Table 1).
[2] Canopy coverage/Frequency/Constancy.
[3] Tr indicates taxon having less than 1 percent canopy coverage.
[4] Litter I = dead vegetative material lying on the ground; Litter II = that still standing.

TABLE 10. CANOPY COVERAGE, FREQUENCY, AND CONSTANCY FOR TAXA IN EACH OF THE DENSITY CATEGORIES OF SAGEBRUSH OCCURRING IN THE *ARTEMISIA TRIDENTATA/AGROPYRON SMITHII* SUB-TYPE OF PLOT IV, BEFORE AND AFTER TREATMENT.

Sagebrush Density[1]	Before Dense 28% 1 Site 20 Plots	After Rare 0% 1 Site 20 Plots	Before Dense 31% 1 Site 20 Plots	After Rare 0% 1 Site 20 Plots	Before Dense 31% 2 Sites 40 Plots	After Rare 1% 2 Sites 40 Plots
Taxa	Cv/Fr/Cy[2]	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy
GRASSES:						
Agropyron smithii	18/100	36/100	54/100	62/100	15/78/100	29/93/100
Bouteloua gracilis	tr/5	-	-	-	-	tr/3/50
Bromus japonicus	-	-	1/25	-	-	tr/5/50[3]
Bromus tectorum	-	-	tr/5	-	-	-
Koeleria cristata	6/55	8/65	-	tr/5	tr/3/50	tr/5/50
Poa spp.	1/20	tr/15	12/95	7/90	7/65/100	9/83/100
Stipa viridula	6/30	7/50	5/20	2/10	1/8/50	2/8/50
ALL GRASSES	27/100	50/100	59/100	69/100	21/93/100	39/100/100
FORBS:						
Arenaria hookeri	tr/10	tr/5	-	-	tr/3/50	tr/3/50
Artemisia frigida	1/10	-	-	-	-	-
Astragalus dasyglottis	tr/5	tr/5	-	-	-	-
Astragalus gilviflorus	1/20	tr/15	-	-	-	-
Astragalus missouriensis	tr/10	tr/15	-	-	tr/3/50	-
Atriplex nuttallii	-	-	-	tr/5	2/8/50	tr/3/50
Bahia oppositifolia	tr/10	-	-	-	tr/5/100	tr/3/50
Camelina microcarpa	-	-	tr/20	-	tr/10/100	tr/8/50
Crepis acuminata	tr/5	-	-	-	-	-
Draba brachycarpa	tr/45	-	tr/35	-	tr/28/100	tr/3/50
Grindelia squarrosa	tr/5	tr/5	-	-	-	-
Gutierrezia sarothrae	2/15	tr/10	-	-	-	tr/5/50
Hedeoma hispida	tr/5	-	-	-	-	-
Iva axillaris	tr/15	-	-	-	-	tr/13/50

TABLE 10. (CONTINUED).

Sagebrush Density	Before Dense 28% 1 Site 20 Plots	After Rare 0% 1 Site 20 Plots	Before Dense 31% 1 Site 20 Plots	After Rare 0% 1 Site 20 Plots	Before Dense 31% 2 Sites 40 Plots	After Rare 1% 2 Sites 40 Plots
Taxa	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy
Lappula redowskii	-[1]	-	-	-	-	tr/3/50
Lepidium densiflorum	tr/5	-	-	-	-	-
Lesquerella alpina	-	-	-	-	tr/3/50	-
Lomatium spp.	tr/15	-	tr/30	-	tr/25/50	tr/5/50
Opuntia polycantha	-	tr/5	-	-	-	-
Orobanche fasciculata	tr/10	-	-	-	-	-
Phlox hoodii	6/90	1/30	4/45	1/15	6/38/100	tr/20/100
Plantago purshii	-	-	tr/20	-	tr/8/50	tr/3/50
Rorippa islandica	tr/20	-	tr/10	-	tr/5/100	-
Sphaeralcea coccinea	tr/20	-	tr/5	-	tr/8/50	-
Taraxacum officinale	-	tr/5	3/25	-	tr/5/50	tr/13/100
Thelasperma marginatum	tr/5	-	-	-	-	-
Tragopogon dubius	2/15	-	tr/5	-	tr/5/100	-
Vicia americana	6/80	tr/5	11/95	1/35	7/83/100	tr/18/100
Viola nuttallii	tr/30	-	-	-	tr/5/50	-
ALL FORBS	14/100	3/60	17/100	2/45	19/95/100	4/63/100
SHRUBS:						
Artemisia tridentata	34/85	-	27/85	-	39/93/100	tr/5/50
OTHERS:						
Selaginella densa	4/50	tr/15	4/25	tr/5	-	tr/3/50
Lichen	tr/30	tr/25	tr/20	tr/5	tr/5/100	-
Bare Ground	38/90	16/90	17/100	10/95	33/90/100	35/100/100
Litter I[4]	46/100	38/100	32/100	30/100	47/100/100	25/100/100
Litter II	37/100	43/100	15/100	51/100	39/100/100	41/100/100
Rock	tr/20	tr/15	-	-	-	tr/5/100

[1] Density was obtained from line intercept measurements at each analysis site (Table 1).
[2] Canopy coverage/Frequency/Constancy.
[3] Tr indicates taxon having less than 1 percent canopy coverage.
[4] Litter I = dead vegetative material lying on the ground; Litter II = that still standing.

TABLE 11. CANOPY COVERAGE, FREQUENCY, AND CONSTANCY FOR TAXA IN THE *ARTEMISIA TRIDENTATA/AGROPYRON SMITHII* VEGETATION SUB-TYPE OF PLOT V WITH REFERENCE TO SAGEBRUSH DENSITY AND OTHER NOTICEABLE PHYSIOGRAPHICAL FEATURES, BEFORE AND AFTER TREATMENT.

Physiography	Typical		Gully Bottom		Hard Pan	
	Before	After	Before	After	Before	After
Sagebrush Density[1]	Dense	Scattered	Common	Scattered	Common	Common
	26%	3%	16%	6%	13%	11%
	1 Site	1 Site	1 Site	1 Site	2 Sites	2 Sites
	20 Plots	20 Plots	20 Plots	20 Plots	40 Plots	40 Plots
Taxa	Cv/Fr/Cy[2]	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy
GRASSES:						
Agropyron smithii	19/85	28/100	45/100	46/100	19/98/100	25/98/100
Bouteloua gracilis	4/20	3/15	10/50	9/55	6/30/100	5/33/100
Bromus japonicus	-	-	1/5	tr/10[3]	-	-
Bromus tectorum	tr/5	-	-	-	-	-
Carex eleocharis	-	tr/15	tr/20	3/70	tr/3/50	1/30/100
Festuca octoflora	-	-	2/35	-	-	-
Koeleria cristata	17/85	13/80	6/65	8/75	10/75/100	8/70/100
Poa spp.	1/55	2/55	1/80	6/95	4/60/100	4/70/100
Schedonnardus paniculatus	-	tr/5	tr/5	2/40	tr/8/50	tr/23/100
Stipa viridula	2/20	2/20	-	tr/5	-	tr/3/50
ALL GRASSES	40/100	46/100	61/100	66/100	35/100/100	42/100/100
FORBS:						
Achillea millefolium	-	-	-	tr/5	-	-
Arenaria hookeri	tr/5	-	-	-	-	-
Artemisia frigida	2/50	2/25	3/15	1/15	1/25/100	1/33/100
Aster canescens	-	tr/5	-	-	tr/3/50	tr/3/50
Astragalus gilviflorus	-	tr/5	-	-	-	-
Atriplex nuttallii	1/10	1/10	-	-	tr/3/50	1/8/100
Eriogonum ovalifolium	tr/15	-	-	-	-	-
Grindelia squarrosa	tr/5	-	-	-	tr/3/50	-
Gutierrezia sarothrae	2/15	tr/10	-	-	tr/5/50	1/8/50
Hedeoma hispida	-	-	1/40	tr/30	-	-

TABLE 11. (CONTINUED).

Physiography	Typical		Gully Bottom		Hard Pan	
	Before	After	Before	After	Before	After
Sagebrush Density	Dense 26% 1 Site 20 Plots	Scattered 3% 1 Site 20 Plots	Common 16% 1 Site 20 Plots	Scattered 6% 1 Site 20 Plots	Common 13% 2 Sites 40 Plots	Common 11% 2 Sites 40 Plots
Taxa	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy
Hymenoxys richardsonii	1/15	tr/15	-	-	tr/5/50	tr/8/50
Iva axillaris	tr/5	-	-	-	1/13/50	1/8/50
Lepidium densiflorum	tr/10	-	-	-	tr/15/50	-
Linum rigidum	tr/10	-	-	-	tr/3/50	-
Lomatium spp.	tr/5	-	tr/5	-	tr/5/50	-
Mamillaria vivipara	-	-	-	-	-	tr/3/50
Opuntia polycantha	tr/15	2/20	-	tr/5	1/8/100	tr/8/50
Phlox hoodii	7/70	2/55	1/10	tr/15	5/45/100	2/43/100
Plantago purshii	2/40	-	7/95	-	1/45/100	-
Sphaeralcea coccinea	tr/5	tr/10	-	tr/5	-	tr/10/100
Taraxacum officinale	-	tr/10	-	tr/20	-	tr/3/50
Vicia americana	3/50	-	tr/10	tr/5	3/45/100	1/28/100
Viola nuttallii	tr/5	-	-	-	-	-
ALL FORBS	15/100	8/85	16/100	2/60	13/88/100	8/75/100
SHRUBS:						
Artemisia tridentata	15/90	4/35	14/60	6/40	12/65/100	8/53/100
OTHERS:						
Selaginella densa	2/25	-	2/15	3/80	2/13/100	2/13/100
Lichen	6/80	3/65	6/95	6/100	9/75/100	7/83/100
Bare Ground	30/100	23/100	11/95	5/85	29/100/100	29/100/100
Litter I[4]	29/100	26/100	43/100	41/100	22/100/100	27/100/100
Litter II	26/100	38/100	31/100	56/100	18/98/100	33/100/100
Rock	tr/15	tr/5	-	-	4/35/100	3/28/50

[1]Density was obtained from line intercept measurements at each analysis site (Table 1).
[2]Canopy coverage/Frequency/Constancy.
[3]Tr indicates taxon having less than 1 percent canopy coverage.
[4]Litter I = dead vegetative material lying on the ground; Litter II = that still standing.

TABLE 12. CANOPY COVERAGE, FREQUENCY, AND CONSTANCY FOR TAXA IN THE *ARTEMISIA TRIDENTATA/AGROPYRON SMITHII* VEGETATION SUB-TYPE ON PLOT VI WITH REFERENCE TO SAGEBRUSH DENSITY AND OTHER NOTICEABLE PHYSIOGRAPHICAL FEATURES, 1968 AND 1969.

Physiography	Typical		Typical		Hard Pan	
	1968	1969	1968	1969	1968	1969
Sagebrush Density[1]	Dense		Common		Scattered	
	35%	25%	15%	13%	6%	4%
	1 Site 20 Plots	1 Site 20 Plots	2 Sites 40 Plots	2 Sites 40 Plots	1 Site 20 Plots	1 Site 20 Plots
Taxa	Cv/Fr/Cy[2]	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy
GRASSES:						
Agropyron smithii	22/95	27/100	45/100/100	50/100/100	35/100	38/100
Boutéloua gracilis	-	-	-	-	2/20	2/10
Bromus japonicus	2/5	tr/5[3]	2/20/50	-	tr/5	-
Carex eleocharis	tr/5	2/10	tr/18/100	1/20/100	tr/5	2/20
Festuca octoflora	-	-	-	-	1/15	-
Koeleria cristata	7/65	7/65	3/43/100	3/35/100	2/25	2/20
Poa spp.	2/80	2/80	14/90/100	9/93/100	5/85	6/75
Schedonnardus paniculatus	-	-	-	-	-	1/15
Stipa viridula	5/15	3/15	-	-	-	-
ALL GRASSES	36/100	37/100	53/100/100	54/100/100	39/100	43/100
FORBS:						
Achillea millefolium	4/15	tr/10	tr/3/50	tr/3/50	1/5	2/10
Artemisia frigida	1/10	1/20	4/30/100	3/25/100	9/65	13/65
Aster canescens	-	-	-	-	tr/5	-
Atriplex nuttallii	tr/10	tr/5	1/10/50	1/13/50	1/5	2/15
Bahia oppositifolia	tr/5	2/15	tr/13/50	1/18/50	-	1/5
Draba brachycarpa	tr/55	-	tr/73/100	tr/5/50	tr/15	-
Erigeron pumilis	-	-	-	-	-	tr/5
Eriogonum multiceps	-	-	-	-	-	tr/5
Eriogonum ovalifolium	tr/5	tr/10	-	-	-	-
Gutierrezia sarothrae	1/10	2/15	tr/8/50	tr/5/50	1/5	-
Hedeoma hispida	-	-	-	-	tr/10	tr/5

TABLE 12. (CONTINUED).

Physiography	Typical		Typical		Hard Pan	
	1968	1969	1968	1969	1968	1969
Sagebrush	Dense		Common		Scattered	
Density	35%	25%	15%	13%	6%	4%
	1 Site 20 Plots	1 Site 20 Plots	2 Site 40 Plots	2 Sites 40 Plots	1 Site 20 Plots	1 Site 20 Plots
Taxa	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy
Iva axillaris	-	-	tr/23/50	1/15/50	-	-
Lepidium densiflorum	tr/15	-	tr/33/100	-	tr/75	-
Linum rigidum	-	-	-	-	tr/5	-
Mamillaria vivipara	-	-	-	tr/3/50	-	-
Musineon divaricatum	-	-	-	-	-	tr/5
Opuntia polycantha	-	-	-	tr/3/50	-	-
Penstemon nitidus	-	-	-	tr/3/50	-	-
Phlox hoodii	9/80	6/65	2/30/100	3/35/100	2/20	2/20
Plantago purshii	tr/5	tr/5	5/68/100	tr/13/50	4/75	tr/15
Sphaeralcea coccinea	tr/22	tr/25	1/25/100	tr/33/100	-	-
Taraxacum officinale	tr/5	tr/20	-	tr/15/100	tr/10	tr/20
Tragopogon dubius	tr/5	-	-	tr/3/50	tr/5	2/10
Vicia americana	7/75	tr/35	4/50/100	tr/10/50	2/20	1/20
Viola nuttallii	tr/5	-	tr/15/100	-	-	-
ALL FORBS	19/100	12/95	21/100/100	10/88/100	19/100	21/85
SHRUBS:						
Artemisia tridentata	31/90	32/75	12/50/100	11/65/100	5/30	4/10
OTHERS:						
Selaginella densa	-	-	-	1/45/50	11/50	6/65
Lichen	1/10	tr/10	2/45/100	1/75/100	7/85	7/100
Bare Ground	14/75	12/85	12/98/100	16/100/100	12/65	14/95
Litter I[4]	56/100	42/95	42/100/100	21/100/100	25/100	16/100
Litter II	24/100	28/100	21/100/100	29/100/100	18/100	26/100
Rock	-	tr/5	1/8/50	2/8/50	2/20	3/15

[1]Density was obtained from line intercept measurements at each analysis site (Table 1).
[2]Canopy coverage/Frequency/Constancy.
[3]Tr indicates taxon having less than 1 percent canopy coverage.
[4]Litter I = dead vegetative material lying on the ground; Litter II = that still standing.

TABLE 13. NUMBER OF INDIVIDUALS AND DEGREES OF RESIDENCY FOR DEER MICE CAPTURED ON EACH STUDY PLOT, 1968 AND 1969.

Plot Number	SERIES I						SERIES II					
	Male			Female			Male			Female		
	Ad.[1]	Su.	Ju.	Ad.	Su.	Ju.	Ad.	Su.	Ju.	Ad.	Su.	Ju.
1968:												
I												
No. Caught	12	7	1	22	7	0	20	14	1	19	12	5
Residents	10 1/2	7	1/6	20 1/3	5 1/3	0	17 2/3	10	1/6	18 1/6	8 2/3	4 1/6
II												
No. Caught	14	12	3	17	10	1	21	5	2	19	2	6
Residents	10 2/3	11 1/6	2 1/6	14 2/3	8 1/2	1	17 2/3	3 1/2	2	17 1/3	2	2 2/3
III												
No. Caught	5	16	1	4	3	0	33	5	3	20	6	2
Residents	5	16	1	4	3	0	29	3 1/3	1 1/3	16 1/6	3 5/6	1/3
IV												
No. Caught	10	10	3	16	2	0	20	11	4	14	3	3
Residents	8 2/3	8 1/2	2 1/6	14 1/3	1 1/6	0	16 2/3	7 1/6	1 2/3	13 1/6	2 1/6	1 2/3
V												
No. Caught	10	17	5	11	4	8	17	12	6	18	4	7
Residents	10	14 1/2	2 1/2	10 1/6	4	7 1/6	16 1/6	10	2 1/6	17 1/6	2 2/3	3 1/6
VI												
No. Caught	9	15	3	9	8	3	19	11	6	14	3	1
Residents	8 1/3	12	2 1/6	8 1/3	7 1/6	3	15	7 5/6	2 2/3	13 1/6	2 1/6	1/6
1969:												
I												
No. Caught	7	8	0	5	2	0	9	3	0	3	3	0
Residents	4 5/6	7 1/3	0	5	2	0	6 1/6	3	0	3	2 1/6	0
II												
No. Caught	10	4	0	8	2	0	11	3	0	2	1	1
Residents	8 2/3	3 1/6	0	6 1/2	2	0	7 1/2	2 1/3	0	2	1/6	1

TABLE 13. (CONTINUED).

Plot Number	SERIES I						SERIES II					
	Male			Female			Male			Female		
	Ad.	Su.	Ju.	Ad.	Su.	Ju.	Ad.	Su.	Ju.	Ad.	Su.	Ju.
III												
No. Caught	4	6	0	3	4	1	10	6	0	6	3	2
Residents	3 1/3	4 1/3	0	3	4	1/6	9 1/6	2 5/6	0	6	3	1 1/6
IV												
No. Caught	9	3	0	5	3	0	10	3	0	11	3	0
Residents	6 5/6	3	0	5	2 1/6	0	9 1/6	1 1/2	0	9 1/2	1 1/2	0
V												
No. Caught	3	1	0	2	2	0	7	5	2	2	1	1
Residents	3	1/6	0	1 1/6	1 1/6	0	4 2/3	3 1/2	1/3	2	1	1/6
VI												
No. Caught	4	4	0	0	0	2	9	1	0	1	1	1
Residents	2 1/2	2 1/3	0	0	0	1/3	6 5/6	1	0	1	1	1/6

[1] Ad. = Adult, Su. = Sub-adult, Ju. = Juvenile.

TABLE 14. LOCATION BY PLOT AND DATES OF INDIVIDUAL OBSERVATIONS MADE ON TWO SPECIES OF LEPORIDAE.

Species	PLOT NUMBER					
	I	II	III	IV	V	VI
Lepus townsendii townsendii	6/25/68	7/28/66[1]	8/08/66	8/19/67	8/23/67	8/11/69
	8/06/68	7/30/66	8/09/67	7/17/69	7/02/68	8/14/69
	6/20/69	6/08/67	8/11/67	7/18/69	8/15/68	8/16/69
	6/23/69	6/11/67	8/23/68	7/19/69	8/16/68	
	8/04/69	7/02/68	7/14/69	8/24/69	8/18/68	
	8/05/69	6/17/69			6/23/69	
	8/07/69	8/05/69			6/30/69	
	8/08/69	8/06/69			7/03/69	
		8/07/69			7/05/69	
		8/09/69			7/06/69	
		8/10/69			8/11/69	
					8/13/69	
					8/14/69	
Sylvilagus audubonii baileyii	6/22/68	8/07/68	7/01/66		7/07/68	8/12/69
		8/08/68	8/09/66		8/18/69	
		8/10/68	8/11/66			
			6/14/67			
			6/16/67			
			8/16/67			
			8/18/67			
			8/25/68			
			7/14/69			
			8/19/69			
			8/20/69			
			8/21/69			
			8/22/69			
			8/23/69			

[1]1966 and 1967 observations are from Cada (1968).

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