Populations of small mammals in central Montana with special reference to tentative sagebrush control sites

by John David Cada

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Fish and Wildlife Management
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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 1966 and 1967. This study was prior to sagebrush control operations of varying degrees on the different study plots. Results will be available for comparison with those of a similar study following sagebrush control.

Vegetation was analyzed by determining canopy coverages and frequencies of occurrence for plant taxa. The Artemisia/Agropyron vegetation type characterized each of the plots. Sub-types represented were as follows: Artemisia tridentata/Agropyron smithii; Artemisia tridentata/Agropyron smithii/Bouteloua gracilis; Artemisia triden-tata/Bouteloua gracilis; Artemisia tridentata/Poa canbyi; Artemisia tridentata/Agropyron desertorum; and Artemisia tridentata/Agropyron smithii/Poa secunda. Canopy intercept of shrubs was determined along transect lines. Artemisia tridentata was the only abundant shrub.

Its coverage varied considerably within and between plots. The greatest variation (18 to 62 percent) occurred in one stand of the Artemisia tridentata/Agropyron smithii sub-type where the canopy coverage of Agropyron smithii was inversely related to that of Artemisia tridentata.

Data from live trapping on each of the plots during two trapping series each summer were used in determining home range, movement, and density indexes for the most abundant small mammal, Peromyscus manieu-latus osgoodi. Sixty-six home range indexes were each determined by a "minimum area" method and "boundary strip" method. The mean home' range index in acres of male adults for series I and II, 1966 and series I and II, 1967 was 2.1, 1.9, 1.0, and 1.8 for the "minimum area" method and 3.2, 3.0, 2.0, and 2.9 for the "boundary strip" method respectively. The low index for series I, 1967 corresponded with unusually heavy spring rains. Mean indexes for adult females, sub-adults, and juveniles appeared slightly smaller than those of the adult males.

One hundred one mean recapture radii were determined for Peromys-cus maniculatus. These were used as . indexes of movement. Average movement indexes in feet for male and female adults were 162 and 147 in 1966 and 190 and 184 in 1967 respectively. Movement indexes for sub-adults and juveniles were similar to those of adults.

Population density indexes for resident Peromyscus maniculatus expressed as individuals per 40 acres were determined for each plot during each trapping series. Average population indexes for all plots combined during series I and II, 1966 and series I and II, 1967 were 26.3, 18.6, 9.0, and 14.2 mice per 40 acres respectively. The relative-low population for series I, 1967 corresponded with the heavy spring rains. The relatively high population for early summer 1966 was followed by a population decline by late summer whereas the relatively low population for early summer 1967 showed a strong increase by late summer.

Other small mammals trapped or observed on the plots included: La- gurus curtatus; Lepus townsendii; Microtus sp.; Mus musculus; Onychomys leucogaster; Perognathus fasciatus; and Sylvilagus audubonii.

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by

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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 1966 and 1967. This study was prior to sagebrush control operations of varying degrees on the different study plots. Results will be available for comparison with those of a similar study following sagebrush control.

Vegetation was analyzed by determining canopy coverages and frequencies of occurrence for plant taxa. The *Artemisia/Agropyron* vegetation type characterized each of the plots. Sub-types represented were as follows: *Artemisia tridentata/Agropyron smithii; Artemisia tridentata/Agropyron smithii/Bouteloua gracilis; Artemisia tridentata/Bouteloua gracilis; Artemisia tridentata/Poa canbyi; Artemisia tridentata/Agropyron desertorum;* and *Artemisia tridentata/Agropyron smithii/Poa secunda.* Canopy intercept of shrubs was determined along transect lines. *Artemisia tridentata* was the only abundant shrub. Its coverage varied considerably within and between plots. The greatest variation (18 to 62 percent) occurred in one stand of the *Artemisia tridentata/Agropyron smithii* sub-type where the canopy coverage of *Agropyron smithii* was inversely related to that of *Artemisia tridentata.*

Data from live trapping on each of the plots during two trapping series each summer were used in determining home range, movement, and density indexes for the most abundant small mammal, *Peromyscus maniculatus osgoodi.* Sixty-six home range indexes were each determined by a "minimum area" method and "boundary strip" method. The mean home range index in acres of male adults for series I and II, 1966 and series I and II, 1967 was 2.1, 1.9, 1.0, and 1.8 for the "minimum area" method and 3.2, 3.0, 2.0, and 2.9 for the "boundary strip" method respectively. The low index for series I, 1967 corresponded with unusually heavy spring rains. Mean indexes for adult females, sub-adults, and juveniles appeared slightly smaller than those of the adult males.

One hundred one mean recapture radii were determined for *Peromyscus maniculatus.* These were used as indexes of movement. Average movement indexes in feet for male and female adults were 162 and 147 in 1966 and 190 and 184 in 1967 respectively. Movement indexes for sub-adults and juveniles were similar to those of adults.

Population density indexes for resident *Peromyscus maniculatus* expressed as individuals per 40 acres were determined for each plot during each trapping series. Average population indexes for all plots combined during series I and II, 1966 and series I and II, 1967 were 26.3, 18.6, 9.0, and 14.2 mice per 40 acres respectively. The relative-low population for series I, 1967 corresponded with the heavy spring rains. The relatively high population for early summer 1966 was followed by a population decline by late summer whereas the relatively low population for early summer 1967 showed a strong increase by late summer.

Other small mammals trapped or observed on the plots included: *Lagurus curtatus; Lepus townsendii; Microtus* sp.; *Mus musculus; Onychomys leucogaster; Perognathus fasciatus;* and *Sylvilagus audubonii.*

INTRODUCTION

The practice of sagebrush removal to afford better grass production for domestic use is well supported in the literature (Alley 1956; Hyder and Sneva 1956; Mueggler and Blaisdell 1958). The ecological effects resulting from this practice on the resident fauna are more rarely considered. Since this trend toward removal of sagebrush is increasing on public lands 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 of the effects of ecological changes resulting from eradication upon certain animal populations. The current report is part of that project.

Small mammals were studied largely by live trapping. The deer mouse (*Peromyscus maniculatus osgoodi*) made up the largest portion of all captures. Thus it is the primary concern of this paper. Relatively little quantitative work has been done with this small mammal in a sagebrush habitat.

This project was located in central Montana near the town of Winnett and was conducted on a full-time basis during the summer months of 1966 and 1967. It was a preliminary study to determine population characteristics prior to sagebrush removal operations scheduled for June, 1968. Data obtained were such that valid comparisons could be made with the results of post-eradication studies.

My objectives were to obtain density, home range, and movement indexes for resident small mammals and to determine vegetation composition of the habitat.

STUDY AREAS

Study plots were located in two study areas, both within 20 miles of Winnett (Figure 1). The terrain of these areas was moderately flat adjoined by gently rolling hills and gully bottoms. The clay loam soils were exposed and slightly depressed between sagebrush plants. Commonly these "gumbo" soils retard moisture penetration resulting in large runoff or pools during intense rains.

Much of the area had been homesteaded in the early 1900's (Gieseker 1938). By the 1920's and 30's most attempts to cultivate the land had failed forcing most operators to abandon. Since then it has been commonly used as summer rangeland for cattle and sheep.

Gieseker (*op cit.*) considered the climate semi-arid ...."characterized by a comparatively low rainfall, great temperature extremes, a large number of sunny days, and a relatively low humidity." Records for the U. S. Department of Commerce weather station at Flatwillow 4 ENE show normal mean temperatures for June, July, August, and September to be 61.9, 71.5, 69.2, and 58.9 degrees Fahrenheit respectively. The normal annual rainfall of 12.57 inches occurs mostly in the spring and summer months. The "dry" and "wet" summers experienced during this study were mainly the result of the respective June precipitations of 0.47 inches in 1966 and 4.79 inches in 1967.

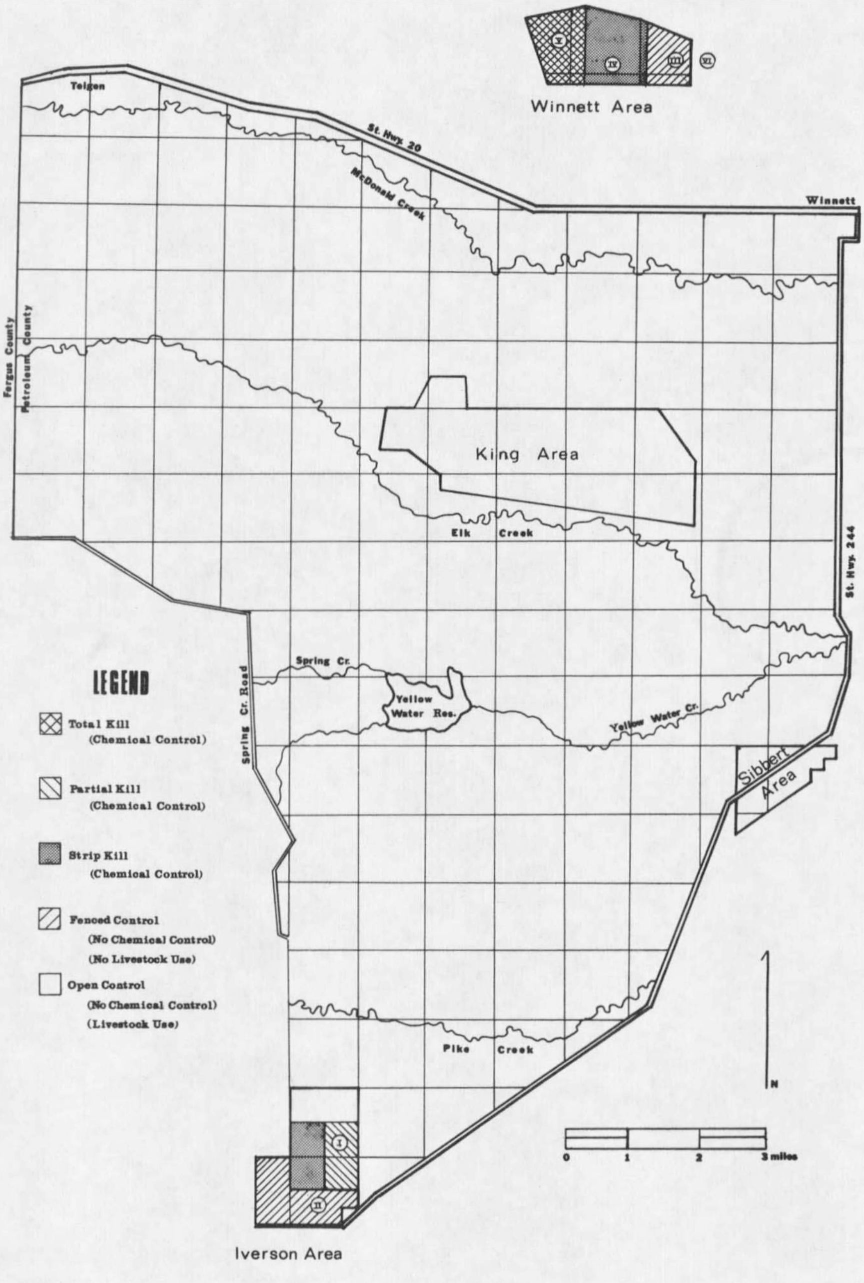


Figure 1. Map showing the four sagebrush control study areas, with special reference to the locations (I-VI) of the six small mammal study plots. The study plots were located on areas that will be subjected to varying degrees of sagebrush control as indicated.

METHODS

Six study plots were strategically positioned so as to sample certain tentative treatment and control sites (Figure 1). Trapping procedures were similar to those outlined by Blair (1941).

Trapping on an individual study plot for a certain period of time is a "trapping period." Trapping on each of the six study plots was conducted consecutively. Hence the six trapping periods represent a "trapping series." Two trapping series occurred each summer. The trapping period and plot size varied between the first and the last three trapping series. In series "I" of 1966 each study plot was 660 ft. sq. (10 acres) and the trapping period was eight days. During each of the following series each study plot was 900 ft. sq. (18.6 acres) and the trapping period was six days. Trapping was carried out during the same trapping period on each of two plots during all series except in series "II" of 1966 when each trapping period was restricted to a single plot.

Each study plot was gridded to 60-foot quadrats with numbered stakes marking trapping stations. Traps were placed at alternate stations along rows and columns each day. Thus during the six- and eight-day trapping periods a trap was in operation at each station during three and four nights respectively. During any one night the trap interval along rows and columns was 120 feet.

Trapping was with Sherman live traps baited with oatmeal and provided with cotton for nesting material to provide insulation for trapped animals. Traps were made operational in late afternoon for night trapping. They were checked each morning. Traps were non-operational during the day.

When initially caught each animal was individually marked by removal of a toe(s) in accordance with a previously determined marking system. Males were examined for scrotal testes and females for prominent mammary glands before release at the trap site. Mammal nomenclature is according to Hall and Kelson (1959).

Following the thinking of Shillito (1963) who described home range as .... "that area habitually traversed .... within a specific period of time," home range indexes were calculated from points of capture obtained during one trapping period. The "inclusive boundary strip" method (Blair 1942) and the "minimum home range" method (Mohr 1947) were used to calculate indexes to home range size in acres. Points of capture considered for home range index determination were those of animals caught more than four times and whose geometric center of capture points (Hayne 1949) was 120 feet or more within the peripheral row or column of traps.

Distances from points of capture to their calculated geometric center, "recapture radii" (Dice and Clark 1953), were considered an index to the movement of an individual. Only movements of animals caught three or more times and having their geometric center of capture points 120 feet or more inside the peripheral row or column of traps were considered.

All Peromyscus captured were classified as to degree of residency (Hodgson 1968). Mammals caught only once and those caught only twice if on consecutive nights were considered "partial residents." Hence, during a six-day trapping period an individual captured once was a one-sixth resident; and an animal captured only on two consecutive nights a two-sixths resident. Captures other than the partial residents were considered as "full residents." A mammal captured at least once in each of two trapping periods was a full resident (six-sixths resident) for both periods.

In determining population density on each study plot it was necessary to add a border strip along each side to account for captures of mammals having only a portion of their normal home range covered by the trapping grid (Blair 1941). In view of the fact that there was no difference in movement indexes between plots, the width of all border strips for a trapping series was the average movement index (recapture radius) of mammals on all six study plots in that series. For each trapping period the total of all degrees of residency for a study plot was considered the number of animals occuyping the total area of the study plot and border strip.

Analysis of the vegetation was done similarly to the method described by Daubenmire (1959). During 1966 four vegetation sampling sites were systematically chosen on each of five study plots. Aerial photographs were used in 1967 to choose from three to six analysis sites on each of the six plots. All areas within each study plot having observable differences in sagebrush density and/or other vegetational features were sampled. Twenty 2 x 5 decimeter plot frames were systematically placed along two 100-foot lines at each analysis site. The height and percent canopy coverage of each plant taxon and percentage exposed soil, rock and plant litter were estimated within each plot frame. Frequency and constancy of plant occurrence among plot frames and analysis sites respectively were determined. Sagebrush height and density was determined at each analysis site by making a height and line intercept measurement of each sagebrush plant or plant part intercepting a positioned 100-foot line. Plant nomenclature was taken from Booth (1950) and Booth and Wright (1959).

RESULTS

Vegetation

The *Artemisia/Agropyron* vegetation type occurs on each of the six study plots. Included in this vegetation type are the following sub-types based on dominant or co-dominant grasses: *Artemisia tridentata/Agropyron smithii; Artemisia tridentata/Agropyron desertorum; Artemisia tridentata/Agropyron smithii/Bouteloua gracilis; Artemisia tridentata/Bouteloua gracilis; Artemisia tridentata/Poa canbyi;* and *Artemisia tridentata/Agropyron smithii/Poa secunda.* The vegetation occurring in nine hundred twenty 2 x 5 decimeter plot frames was analyzed at 46 sampling sites on the study plots. The *Artemisia tridentata/Agropyron smithii/Bouteloua gracilis* sub-type, an area of dense *Artemisia tridentata* (big sagebrush) (Table I), and the *Artemisia tridentata/Bouteloua gracilis* sub-type, an area of common sagebrush density, each occupied about one-half of Plot I (Figure 2). The dense sagebrush occurred at one corner of the plot and graded to the more sparce density at the far corner. The canopy coverage, frequency, and constancy of certain taxa occurring in each of these two sub-types are shown in Table II. *Artemisia tridentata* was the only shrub present on the plot. *Bouteloua gracilis* (blue grama) and *Agropyron smithii* (bluestem) were important grasses on both sub-types but the former was most conspicuous on the *Artemisia tridentata/Bouteloua gracilis* sub-type. Other common grasses for both sub-types were *Koeleria cristata* (junegrass), and *Poa secunda* (Sandberg bluegrass). Forbs for both sub-types included *Phlox hoodii* (Hood's phlox), *Artemisia frigida* (fringed sagewort),

TABLE I. AVERAGE NUMBER, HEIGHT, AND CROWN COVERAGE OF BIG SAGEBRUSH PLANTS ON EACH OF THE STUDY PLOTS AS DETERMINED BY MEASUREMENTS ALONG A 100-FOOT LINE AT VARIOUS SAMPLE SITES (SAMPLE SITES ARE THE SAME AS THOSE FOR TABLES II, III, AND IV).

				SAGEBRUSH CHARACTERISTICS			
				Crown Coverage			
Plot No.	Vegetation Sub-Type	Physio-graphy	No. of Sites	Mean(%)	Range(%)	Mean Ht. (inches)	Mean No. of Plants/Site
I	*Artemisia tridentata/ Agropyron smithii/ Bouteloua gracilis*	Typical	5[1]	37(Dense)[2]	29-51	11	44(2)[3]
	Artemisia tridentata/ Bouteloua gracilis	Typical	3	18(Common)	10-25	13	21(1)
II	*Artemisia tridentata/ Agropyron smithii/ Bouteloua gracilis*	Typical	2	14(Common)	12-16	8	16(1)
	Artemisia tridentata/ Agropyron smithii	Typical	5	39(Dense)	30-54	11	60(2)
III	*Artemisia tridentata/ Agropyron smithii*	Typical	1	62(Dense)	-	16	49(1)
		Typical	6	35(Dense)	26-49	11	28(2)
		Typical	1	18(Common	-	9	22(1)
IV	*Artemisia tridentata/ Agropyron smithii*	Typical	1	41(Dense)	-	11	43(1)
		Typical	5	19(Common)	13-25	12	19(1)
		Gully Bottom	1	25(Common)	-	11	25(1)
	Artemisia tridentata/ Agropyron desertorum	Typical	3	25(Common)	21-31	10	44(1)
V	*Artemisia tridentata/ Agropyron smithii*	Typical	4	15(Common)	9-20	8	31(1)
		"Hard Pan"	1	13(Common)	-	12	15(1)
		Gully Bottom	1	23(Common)	-	11	25(1)
	Artemisia tridentata/ Poa canbyi	"Hard Pan"	2	8(Common)	5-11	7	20(1)

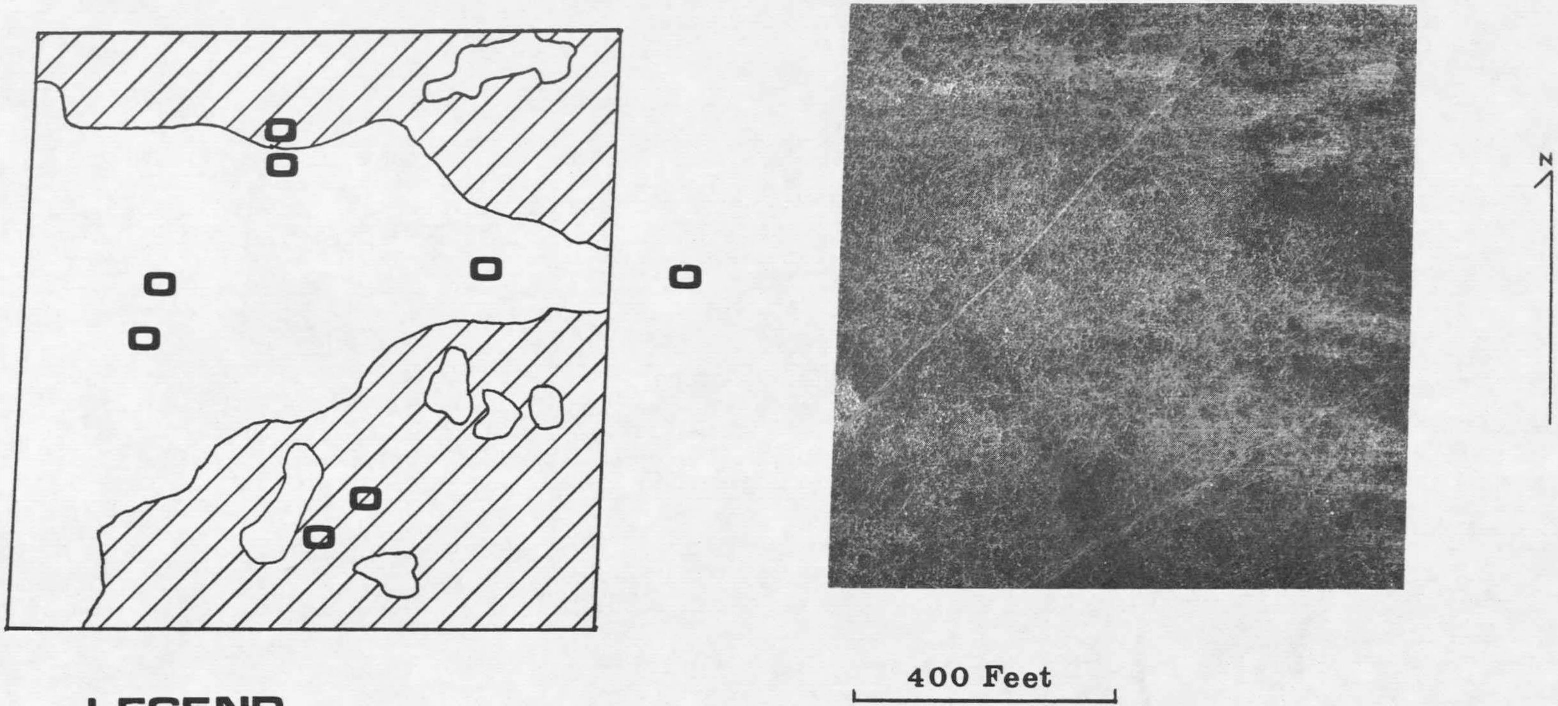
TABLE I. (CONTINUED).

Plot No.	Vegetation Sub-Type	Physio-graphy	No. of Sites	SAGEBRUSH CHARACTERISTICS: Crown Coverage Mean(%)	Crown Coverage Range(%)	Mean Ht. (inches)	Mean No. of Plants/Site
VI	*Artemisia tridentata/ Agropyron smithii*	Typical	3	40(Dense)	36-42	17	35(3)
		"Hard Pan"	1	16(Common)	-	12	15(1)
	Artemisia tridentata/ Agropyron smithii/ Poa secunda	Typical	1	8(Common)	-	14	12(1)

1/ Number of sites where crown coverage and heights were determined.

2/ Sagebrush crown coverages of 5 to 25 and of 26 and greater are categorized as common and dense sagebrush respectively (similarly to Wentland 1968).

3/ The number in parentheses refers to the number of sites at which the mean number of plants per site was determined.



LEGEND

Common Sagebrush Density (*Artemisia tridentata/Bouteloua gracilis* Sub-type).

Dense Sagebrush (*Artemisia tridentata/Agropyron smithii/Bouteloua gracilis* Sub-Type).

Sites of Vegetation Analyses.

Figure 2. Aerial Photograph and Diagram of Plot I.

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

	PLOT I		PLOT II	
	Vegetation Sub-Type		Vegetation Sub-Type	
	Artemisia tridentata/Agropyron smithii/Bouteloua gracilis	*Artemisia tridentata/Bouteloua gracilis*	*Artemisia tridentata/Agropyron smithii*	*Artemisia tridentata/Agropyron smithii/Bouteloua gracilis*
	SAGEBRUSH DENSITY[2]		SAGEBRUSH DENSITY	
	Dense (37%) 5 Sites 100 Plots	Common (18%) 3 Sites 60 Plots	Dense (39%) 5 Sites 100 Plots	Common (14%) 2 Sites 40 Plots
Taxa[1]	Cv/Fr/Cy[3]	Cv/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy
GRASSES				
Bouteloua gracilis	11/41/100	41/97/100	t/ 8/60	20/77/100
Agropyron smithii	10/91/100	14/93/100	27/92/100	26/90/100
Koeleria cristata	3/73/100	2/35/100	2/16/100	t/12/100
Poa secunda	3/45/100	1/30/100	t/26/60	4/70/100
Stipa viridula	3/20/60	--/--/---	2/ 9/60	t/ 3/50
Stipa comata	2/38/100	3/37/100	t/ 1/20	--/--/---
Poa sp.	t/11/40 [4]	--/--/---	t/10/80	2/27/100
Agropyron sp.	1/ 4/60	--/--/---	--/--/---	--/--/---
Bromus tectorum	t/ 3/40	--/--/---	6/58/100	--/--/---
ALL GRASSES	39/99/100	63/100/100	42/99/100	57/100/100
FORBS				
Phlox hoodii	2/33/100	1/26/100	t/ 3/40	2/22/100
Artemisia frigida	1/29/100	2/30/100	t/ 6/60	1/12/100
Opuntia polycantha	t/ 5/60	1/10/100	--/--/---	t/ 5/100
Plantago spinulosa	t/15/60	1/33/66	t/32/80	1/50/100
Achillea millefolium	1/12/80	t/ 8/33	t/ 1/20	--/--/---
ALL FORBS	8/76/100	5/78/100	3/56/100	5/32/100
SHRUB				
Artemisia tridentata	37/88/100	15/60/100	39/90/100	9/45/100

TABLE II. (CONTINUED).

	PLOT I		PLOT II	
	Vegetation Sub-Type		Vegetation Sub-Type	
	Artemisia tridentata/Agropyron smithii/Bouteloua gracilis	*Artemisia tridentata/Bouteloua gracilis*	*Artemisia tridentata/Agropyron smithii*	*Artemisia tridentata/Agropyron smithii/Bouteloua gracilis*
	SAGEBRUSH DENSITY		SAGEBRUSH DENSITY	
	Dense (37%) 5 Sites 100 Plots	Common (18%) 3 Sites 60 Plots	Dense (39%) 5 Sites 100 Plots	Common (14%) 2 Sites 40 Plots
Taxa	Cv/Fr/Cy	C/Fr/Cy	Cv/Fr/Cy	Cv/Fr/Cy
OTHERS				
Carex sp.	5/41/80	2/40/100	--/--/---	1/15/50
Lichen	2/69/100	2/50/100	t/ 2/20	4/80/100
Selaginella densa	1/ 9/60	3/13/66	--/--/--	--/--/---
Bare Ground	34/97/100	28/100/100	57/98/100	39/100/100
Litter	24/80/100	18/45/100	11/50/100	12/90/100

1/ Taxa having canopy coverages of less than 1 percent in all categories of sagebrush density were not included (these are listed in Appendix, Table XI).

2/ Density was obtained from line intercept measurements of sagebrush at each analysis site (Table I).

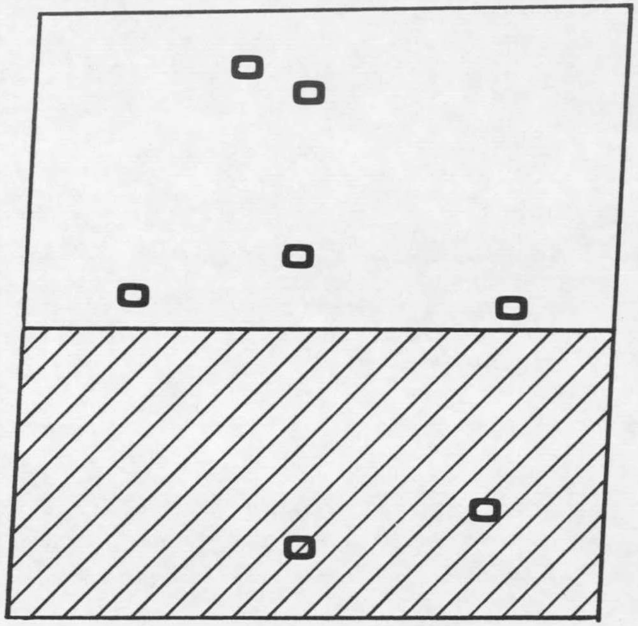
3/ Canopy coverage/Frequency/Constancy.

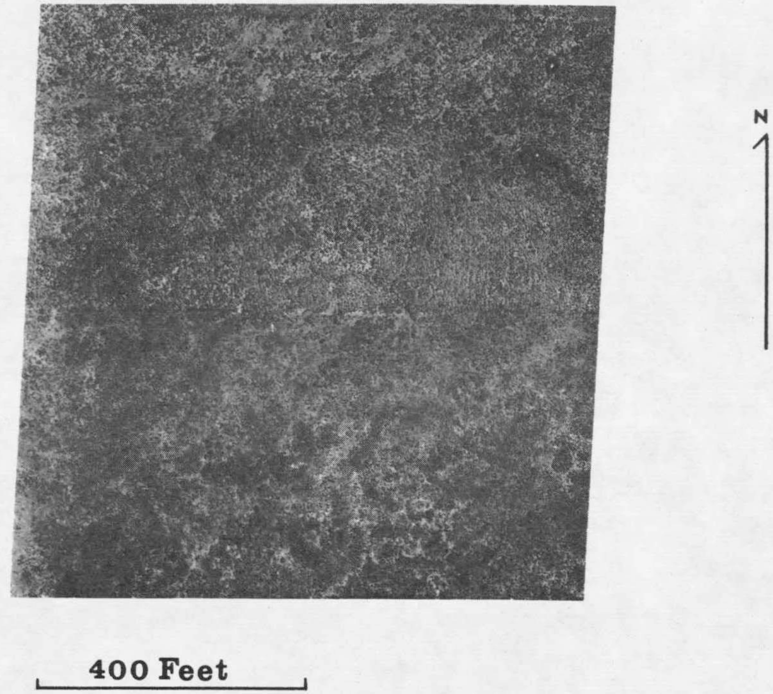
4/ t indicates taxon having less than 1 percent canopy coverage.

Opuntia polycantha (plains pricklypear), *Plantago spinulosa* (spindle plantain) and *Achillea millefolium* (yarrow).

The *Artemisia tridentata/Agropyron smithii* and the *Artemisia tridentata/Agropyron smithii/Bouteloua gracilis* sub-types occupied equal halves of Plot II (Figure 3). Except for *Bouteloua gracilis* and *Bromus tectorum* (downy chess brome) the vegetation was similar on the two sub-types on Plot II as well as on the two sub-types on Plot I (Table II). *Bouteloua gracilis* was rare in the *Artemisia tridentata/Agropyron smithii* sub-type, an area of dense sagebrush. In the *Artemisia tridentata/Agropyron smithii/Bouteloua gracilis* sub-type of Plot II, an area of common sagebrush density, the coverage of *Bouteloua gracilis* was less than on areas of similar sagebrush density for this sub-type on Plot I but greater than on the *Artemisia tridentata/Agropyron smithii* sub-type. *Bromus tectorum* was conspicuous only on the *Artemisia tridentata/Agropyron smithii* sub-type.

The *Artemisia tridentata/Agropyron smithii* sub-type was completely dominant on Plot III and occupied more than one-half of Plot IV (Figures 4 and 5). The sagebrush density in this sub-type graded from areas of low density to areas of high density (Table I). Occurrence of taxa for this sub-type is shown for each of three categories of sagebrush density on each plot (Table III). *Artemisia tridentata* and *Atriplex nuttallii* (Nuttall saltbush) were the only conspicuous shrubs present. On both plots the common grasses of this sub-type were *Agropyron smithii*, *Koeleria cristata*, *Agropyron* spp., and *Poa secunda*.

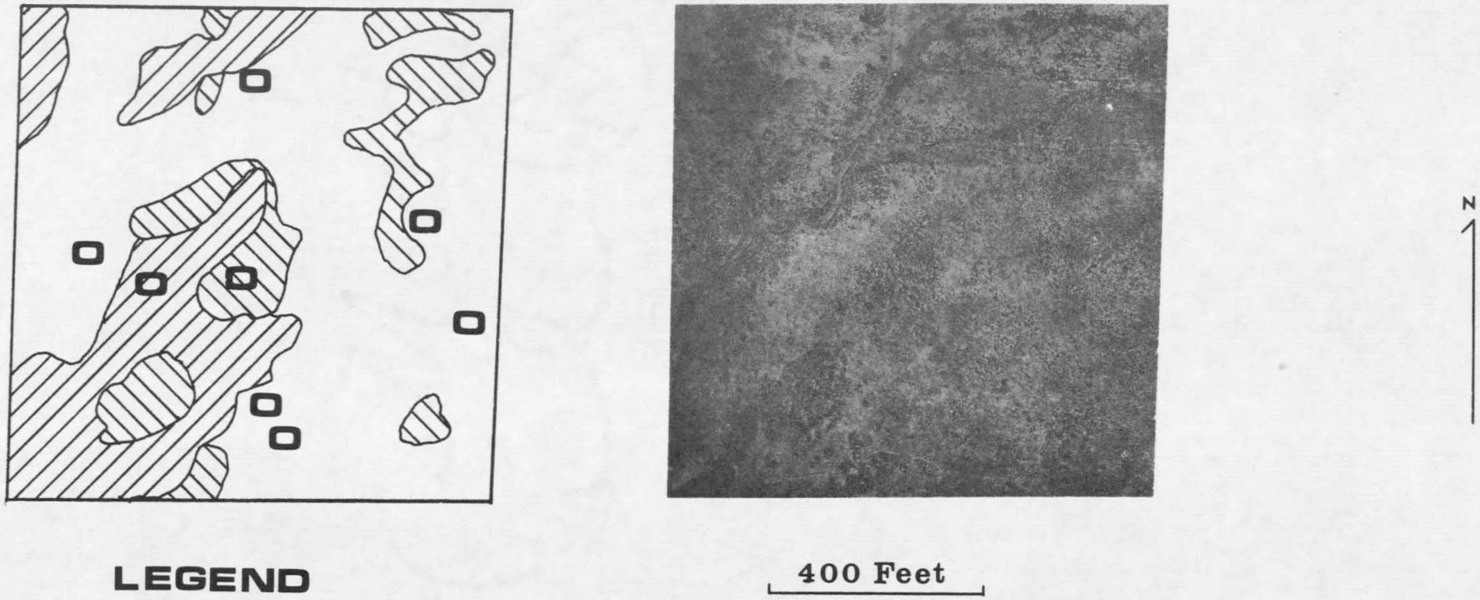




LEGEND

- ☐ Dense Sagebrush (*Artemisia tridentata/Agropyron smithii* Sub-type).
- ▨ Common Sagebrush Density (*Artemisia tridentata/Agropyron smithii/Bouteloua gracilis* Sub-type).
- ▢ Sites of Vegetation Analyses.

Figure 3. Aerial Photograph and Diagram of Plot II.



LEGEND

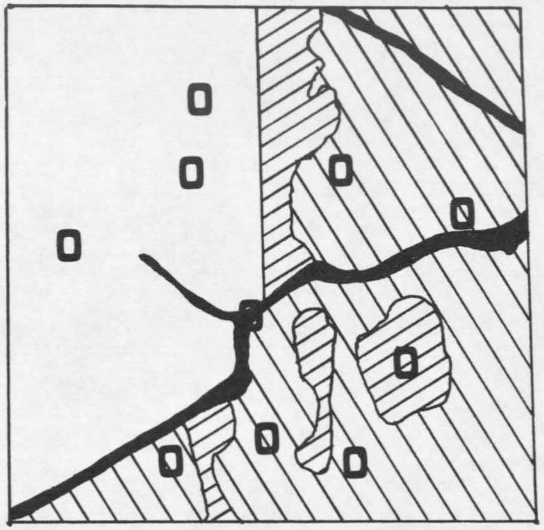
Dense Sagebrush (62%).

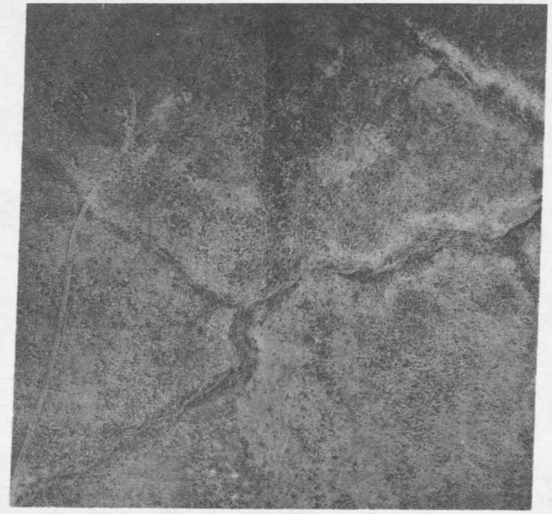
Dense Sagebrush (35%).

Common Sagebrush Density.

Sites of Vegetation Analyses.

Figure 4. Aerial Photograph and Diagram of Plot III (*Artemisia tridentata/Agropyron smithii* Sub-type).





400 Feet

LEGEND

Dense Sagebrush (*Artemisia tridentata/Agropyron smithii* Sub-type).

Common Sagebrush Density (*Artemisia tridentata/Agropyron smithii* Sub-type).

Common Sagebrush Density-Gully Bottom (*Artemisia tridentata/Agropyron smithii* Sub-type).

Common Sagebrush Density (*Artemisia/tridentata/Agropyron desertorum* Sub-type).

Sites of Vegetation Analyses.

Figure 5. Aerial Photograph and Diagram of Plot IV.

TABLE III. CANOPY COVERAGE, FREQUENCY, AND CONSTANCY FOR TAXA IN EACH OF THE DENSITY CATEGORIES[1] OF SAGEBRUSH OCCURRING IN THE *ARTEMISIA TRIDENTATA/AGROPYRON SMITHII* SUB-TYPE OF PLOTS III AND IV AND IN THE *ARTEMISIA TRIDENTATA/AGROPYRON DESERTORUM* SUB-TYPE OF PLOT IV.

	PLOT III			PLOT IV			
Vegetation Sub-Type	*Artemisia tridentata/ Agropyron smithii*			*Artemisia tridentata/ Agropyron smithii*			*Artemisia tridentata/Agropyron desertorum*
Sagebrush Density	Dense (62%)[3]	Dense (35%)	Common (18%)	Dense (41%)	Common (19%)	Common (25%)[4]	Common (25%)
Taxa[2]	1 Site 20 Plots Cv/Fr/Cy[5]	6 Sites 120 Plots Cv/Fr/Cy	1 Site 20 Plots Cv/Fr/Cy	1 Site 20 Plots Cv/Fr/Cy	5 Sites 100 Plots Cv/Fr/Cy	1 Site 20 Plots Cv/Fr/Cy	3 Sites 60 Plots Cv/Fr/Cy
GRASSES							
Agropyron smithii	12/65	28/94/100	42/100	19/80	33/89/100	32/100	6/42/100
Agropyron spp.	3/30	4/30/66	7/30	1/35	13/39/60	10/45	--/--/---
Agropyron desertorum	--/--	--/--/---	--/---	--/--	--/--/---	--/---	31/75/100
Koeleria cristata	4/20	4/42/100	t/5	7/50	3/32/80	10/55	--/--/---
Bouteloua gracilis	--/--	t[6]/1/17	--/---	--/--	3/22/40	--/---	--/--/---
Stipa viridula	--/--	t/ 6/66	--/---	5/35	2/13/80	--/---	--/--/---
Poa secunda	4/30	t/ 1/17	1/10	--/--	2/19/40	8/45	5/34/66
Poa canbyi	--/--	--/--/---	--/---	2/40	2/26/40	13/75	--/--/---
ALL GRASSES	19/70	45/98/100	52/100	36/95	62/100/100	68/100	36/98/100
FORBS							
Vicia americana	6/50	t/13/83	7/65	7/85	3/25/100	6/80	4/20/100
Phlox hoodii	5/65	6/63/83	--/--	6/85	3/40/100	t/20	8/44/100
Taraxacum officinale	t/5	--/--/--	--/--	t/10	--/--/---	16/60	--/--/---

TABLE III. (CONTINUED).

Vegetation Sub-Type	PLOT III			PLOT IV			
	Artemisia tridentata/ Agropyron smithii			*Artemisia tridentata/ Agropyron smithii*			*Artemisia tridentata/Agropyron desertorum*
Sagebrush Density	Dense (62%)	Dense (35%)	Common (18%)	Dense (41%)	Common (19%)	Common (25%)	Common (25%)
Taxa	1 Site 20 Plots Cv/Fr/Cy	6 Sites 120 Plots Cv/Fr/Cy	1 Site 20 Plots Cv/Fr/Cy	1 Site 20 Plots Cv/Fr/Cy	5 Sites 100 Plots Cv/Fr/Cy	1 Site 20 Plots Cv/Fr/Cy	3 Sites 60 Plots Cv/Fr/Cy
Gutierrezia sarothrae	t/ 5	4/39/83	t/15	3/10	1/12/60	4/25	--/--/---
Artemisia frigida	t/ 3	3/33/100	--/--	t/15	1/15/60	1/15	--/--/---
Sphaeralcea coccinea	t/10	1/28/83	4/40	t/15	t/ 5/40	t/ 5	t/ 7/66
Iva axillaris	--/--	t/ 5/17	3/45	2/35	t/ 2/20	t/20	--/--/---
Achillea millefolium	--/--	--/--/---	--/--	--/--	t/ 1/20	3/25	--/--/---
Allium textile	t/5	t/ 1/17	--/--	t/ 5	t/ 1/20	2/40	t/ 3/33
Androsace septentrionalis	--/--	1/ 9/33	--/--	--/--	--/--/---	--/--	--/--/---
Arenaria hookeri	--/--	1/14/66	--/--	t/ 5	t/ 1/20	--/--	--/--/---
ALL FORBS	12/95	15/95/100	17/95	15/90	10/93/100	34/100	14/80/100
SHRUBS							
Artemisia tridentata	56/100	35/92/100	13/50	40/95	25/81/100	22/70	30/70/100
Atriplex nuttallii	--/---	1/14/66	2/ 5	--/--	t/ 2/20	--/--	t/13/66

TABLE III. (CONTINUED).

	PLOT III			PLOT IV			
Vegetation Sub-Type	*Artemisia tridentata/ Agropyron smithii*			*Artemisia tridentata/ Agropyron smithii*			*Artemisia tridentata/Agropyron desertorum*
Sagebrush Density	Dense (62%)	Dense (35%)	Common (18%)	Dense (41%)	Common (19%)	Common (25%)	Common (25%)
Taxa	1 Site 20 Plots Cv/Fr/Cy	6 Sites 120 Plots Cv/Fr/Cy	1 Site 20 Plots Cv/Fr/Cy	1 Site 20 Plots Cv/Fr/Cy	5 Sites 100 Plots Cv/Fr/Cy	1 Site 20 Plots Cv/Fr/Cy	3 Sites 60 Plots Cv/Fr/Cy
OTHERS							
Litter	38/95	46/100/100	17/90	22/60	23/87/100	25/95	10/95/100
Rock	1/25	4/35/83	2/45	t/20	2/18/60	--/--	t/15/100
Lichen	--/--	t/ 9/33	--/--	t/20	1/21/80	t/ 5	--/--/---
Bare Ground	26/90	45/98/100	42/100	45/100	33/100/100	28/100	57/97/100
Selaginella densa	t/ 5	t/ 1/33	--/---	t/ 5	--/---/---	--/---	t/35/66

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

2/ Taxa having canopy coverages of less than 1 percent in all categories of sagebrush density were not included (these are listed in Appendix, Table XII).

3/ One of several stands of highly dense sagebrush (Figure 4).

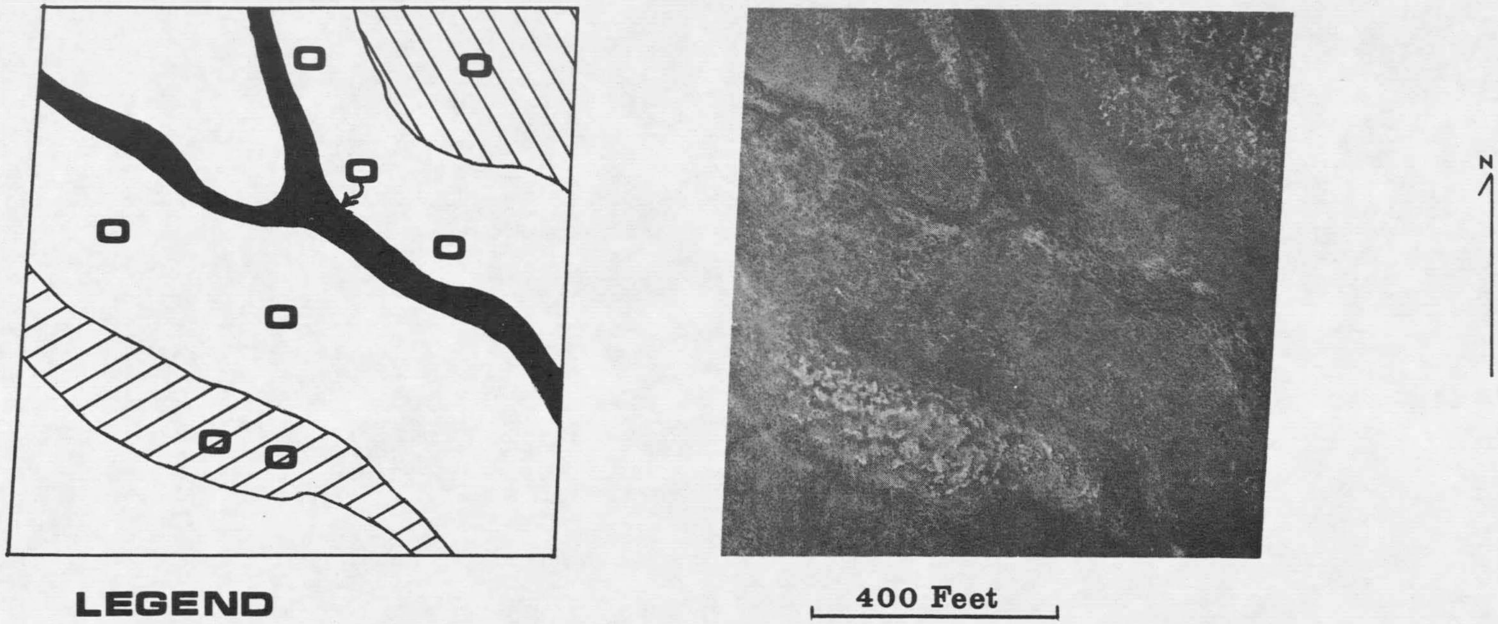
4/ Vegetation characteristic of the gully bottom (Figure 5).

5/ Canopy coverage/Frequency/Constancy.

6/ t indicates taxon having less than 1 percent canopy coverage.

Poa canbyi (Canby bluegrass), although not present on Plot III, was common on this sub-type of Plot IV. Canopy coverages and frequencies of *Agropyron smithii* varied inversely with those of *Artemisia tridentata*. *Vicia americana* (American vetch), *Phlox hoodii*, *Artemisia frigida*, *Gutierrezia sarothrae* (broom snakeweed), and *Sphaeralcea coccinea* (scarlet globemallow) were common forbs. Canopy coverage for *Taraxacum officinale* (common dandelion) was conspicuous only for a gully bottom, an area of common (25 percent) sagebrush density, on Plot IV. The *Artemisia tridentata/Agropyron desertorum* sub-type occupied that portion of Plot IV not occupied by the *Artemisia tridentata/Agropyron smithii* sub-type. Common grasses were *Agropyron desertorum* (crested wheatgrass), *Agropyron smithii*, and *Poa secunda*. *Vicia americana* and *Phlox hoodii* were the only forbs having a canopy coverage greater than nine-tenths of one percent.

The vegetation of study Plots V and VI was analyzed with respect to certain physiographic features as well as sub-types and sagebrush density. The *Artemisia tridentata/Agropyron smithii* sub-type occupied the greatest portions of both Plots V and VI but the respective *Artemisia tridentata/Poa canbyi* and *Artemisia tridentata/Agropyron smithii/Poa secunda* sub-types were also represented (Figures 6 and 7). Common sagebrush density was the only category present on each sub-type of Plot V (Table I). Plot VI had both common and dense categories for the *Artemisia tridentata/Agropyron smithii* sub-type and only common for the other sub-type. Both plots possessed a "hard pan"



LEGEND

- "Hard Pan" (*Artemisia tridentata/Poa canbyi* Sub-type).
- "Hard Pan" (*Artemisia tridentata/Agropyron smithii* Sub-type).
- Typical (*Artemisia tridentata/Agropyron smithii* Sub-type).
- Gully Bottom (*Artemisia tridentata/Agropyron smithii* Sub-type).
- Sites of Vegetation Analyses.

Figure 6. Aerial Photograph and Diagram of Plot V (Common Sagebrush Density).