Effects of chemical control of sagebrush on the occurrence of sage grouse in Southwestern Montana
by Neil Sidney Martin

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
Montana State University
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Abstract:
A study was conducted during the summers of 1962, 1963, and 1964 on a 1,900 acre allotment in Southwestern Montana. A total of 1,710 acres of the allotment had been sprayed in 1961 with 2,4-D to control sagebrush. A total of 190 acres of the allotment, consisting of three strips approximately one and one-quarter miles in length and five chains in width, as well as areas along streams, were left unsprayed. Objectives of my study were to obtain quantitative data on effects of chemical control of sagebrush on a sage grouse population® Canopy coverage measurements of vegetation in the 1,900 acre allotment revealed about 80 percent grasses and 20 percent forbs in sprayed strips and 60 percent grasses and 40 percent forbs in unsprayed strips. low shrub canopy coverage in sprayed strips was reduced as compared with unsprayed strips, and 97 percent of the Big Sage plants evaluated were recorded as dead. Only eight percent were recorded as dead in unsprayed strips.

Sprayed strips provided only four percent of the 415 sage grouse observations made" on the 1,900 acre allotment. Ninty-one percent of the 15 sage grouse observed in sprayed strips were within 95 feet of an unsprayed strip. Canopy coverage measurements of herbaceous vegetation at 137 sage grouse locations, most of which were outside the 1,900 acre allotment, consisted of approximately 60 percent grasses and 40 percent forbs, Low shrub canopy coverage was similar from year to year, and 92 percent of the Big Sage plants evaluated were recorded as living. The similarity of the vegetation composition at sage grouse locations and in the unsprayed strips led to the conclusion that the differences in numbers of sage grouse observed in sprayed and unsprayed strips were related to vegetation composition. Density, percent crown coverage, and maximum height of Big Sage plants were determined at each of 159 sage grouse locations. Broods, six weeks or less of age, were found on areas having a lesser density and lower percent crown coverage of Big Sage than were older broods and adults. Food habits were determined by analysis of the contents of 35 sage grouse crops. Sagebrush and three genera of forbs together constituted 94.6 percent of the total volume. Dandelion and sagebrush had the greatest total percent frequency of occurrence of all food items. These high frequency food plants were more abundant in unsprayed than in sprayed strips, which strengthened the conclusion that differences in numbers of sage grouse observed in unsprayed and sprayed strips were related to vegetation composition.

EFFECTS OF CHEMICAL CONTROL OF SAGEBRUSH ON THE OCCURRENCE OF SAGE GROUSE IN SOUTHWESTERN MONTANA

by

NEIL SIDNEY MARTIN

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

of

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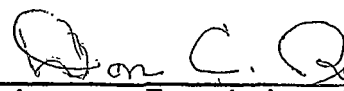
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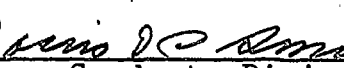
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TABLE OF CONTENTS

	Page
VITA	ii
ACKNOWLEDGEMENT	iii
TABLE OF CONTENTS	iv
LIST OF TABLES	v
LIST OF FIGURES	vii
ABSTRACT	viii
INTRODUCTION	1
DESCRIPTION OF AREA	2
METHODS	5
RESULTS	8
Vegetation of Sprayed and Unsprayed Areas	8
Observations of Sage Grouse in Sprayed and Unsprayed Strips	11
Characteristics of Vegetation at Sage Grouse Locations	16
FOOD HABITS	24
APPENDIX	27
MISCELLANEOUS OBSERVATIONS	31
Strutting Grounds	31
Nesting	31
Broods	32
Movements	33
Age Structure of Hunter Killed Birds	35
LITERATURE CITED	36

LIST OF TABLES

Table		Page
I.	MEAN PERCENT CANOPY COVERAGE FOR VEGETATION, LITTER, AND BARE GROUND IN FORTY 2 x 5 DM PLOTS IN SPRAYED AND FORTY IN UNSPRAYED STRIPS, 1963 AND 1964	8
II.	AVERAGE PERCENT FREQUENCY OF OCCURRENCE OF PLANTS IN FORTY 2 x 5 DM PLOTS IN SPRAYED AND FORTY IN UNSPRAYED SAGEBRUSH STRIPS, 1963 AND 1964	10
III.	NUMBERS OF SAGE GROUSE OBSERVED IN SPRAYED AND UNSPRAYED STRIPS FROM JUNE 15 TO SEPTEMBER 14 FOR THE YEARS 1962 THROUGH 1964	14
IV.	MEAN PERCENT CANOPY COVERAGE FOR GRASSES, FORBS, AND LOW SHRUBS AT 137 SAGE GROUSE LOCATIONS DURING JUNE, JULY, AUGUST, AND SEPTEMBER OF 1962 THROUGH 1964	17
V.	AVERAGE PERCENT FREQUENCY OF OCCURRENCE OF PLANTS AT EACH OF 137 SAGE GROUSE LOCATIONS DURING JUNE, JULY, AUGUST, AND SEPTEMBER OF 1963 AND 1964	18
VI.	AVERAGE NUMBER, PERCENT CROWN COVERAGE, AND MAXIMUM HEIGHT OF BIG SAGE PLANTS WITHIN A 1/100 ACRE CIRCLE AT EACH OF 159 SAGE GROUSE LOCATIONS DURING JUNE, JULY, AUGUST, AND SEPTEMBER OF 1963 AND 1964	20
VII.	PERCENTAGE VOLUME AND FREQUENCY OF OCCURRENCE OF PLANT AND ANIMAL MATTER IN 35 ADULT SAGE GROUSE CROPS COLLECTED DURING JULY, AUGUST, AND SEPTEMBER OF 1963 AND 1964	24
VIII.	PERCENT FREQUENCY OF OCCURRENCE IN SPRAYED STRIPS, IN UNSPRAYED STRIPS, AT SAGE GROUSE LOCATIONS, AND IN SAGE GROUSE CROPS FOR THOSE PLANTS WHICH CONSTITUTED A SIGNIFICANT PORTION OF THE SAGE GROUSE DIET	25
IX.	LIST OF TAXA WHICH OCCURRED IN SPRAYED AND/OR UNSPRAYED PLOTS WITH A PERCENT FREQUENCY OF LESS THAN TEN	28

LIST OF TABLES
(continued)

Table		Page
X.	LIST OF TAXA WHICH OCCURRED AT SOME SITE(S) OF 137 SAGE GROUSE LOCATIONS WITH A PERCENT FREQUENCY OF LESS THAN TEN.	29
XI.	DATE OF LOCATION, DISTANCE TO STRUTTING GROUND, NUMBER OF EGGS AND THE ULTIMATE FATE OF EACH OF FIVE NESTS FOUND IN MAY AND JUNE OF 1964	32
XII.	AVERAGE BROOD SIZE AND PERCENT OF HENS WITH BROODS, AS DETERMINED BY OBSERVATIONS FROM JUNE 20 TO AUGUST 10, 1963 AND 1964	33
XIII.	DISTANCES FROM THE BIG SHEEP CREEK STRUTTING GROUND OF RELOCATIONS OF TEN MARKED SAGE GROUSE. .	34
XIV.	NUMBERS OF SAGE GROUSE KILLED AND YOUNG/ADULT RATIOS AS DETERMINED FROM EXAMINATION OF HUNTER KILLED BIRDS IN 1963 AND 1964.	35

LIST OF FIGURES

Figure		Page
1.	Map of the Big Sheep Creek Basin Study Area . . .	3
2.	Photographs Showing Canopy Coverage in Sprayed (top) and Unsprayed (bottom) Areas at the Approximate Midpoint of Section 3	12
3.	Photographs Showing General Aspect of Vegetation in Sprayed (top) and Unsprayed (bottom) Areas at the Approximate Midpoint of Section 3	13
4.	Locations of Observations of a Banded Hen in Relation to Sprayed and Unsprayed Strips During 1962 and 1963	16
5.	Photographs Showing the General Aspect of Big Sage Plants at Locations of Broods Six Weeks or Less of Age (top), as well as that for Older Broods and Adults (bottom).	21

ABSTRACT

A study was conducted during the summers of 1962, 1963, and 1964 on a 1,900 acre allotment in Southwestern Montana. A total of 1,710 acres of the allotment had been sprayed in 1961 with 2,4-D to control sagebrush. A total of 190 acres of the allotment, consisting of three strips approximately one and one-quarter miles in length and five chains in width, as well as areas along streams, were left unsprayed. Objectives of my study were to obtain quantitative data on effects of chemical control of sagebrush on a sage grouse population. Canopy coverage measurements of vegetation in the 1,900 acre allotment revealed about 80 percent grasses and 20 percent forbs in sprayed strips and 60 percent grasses and 40 percent forbs in unsprayed strips. Low shrub canopy coverage in sprayed strips was reduced as compared with unsprayed strips, and 97 percent of the Big Sage plants evaluated were recorded as dead. Only eight percent were recorded as dead in unsprayed strips. Sprayed strips provided only four percent of the 415 sage grouse observations made on the 1,900 acre allotment. Ninty-one percent of the 15 sage grouse observed in sprayed strips were within 95 feet of an unsprayed strip. Canopy coverage measurements of herbaceous vegetation at 137 sage grouse locations, most of which were outside the 1,900 acre allotment, consisted of approximately 60 percent grasses and 40 percent forbs. Low shrub canopy coverage was similar from year to year, and 92 percent of the Big Sage plants evaluated were recorded as living. The similarity of the vegetation composition at sage grouse locations and in the unsprayed strips led to the conclusion that the differences in numbers of sage grouse observed in sprayed and unsprayed strips were related to vegetation composition. Density, percent crown coverage, and maximum height of Big Sage plants were determined at each of 159 sage grouse locations. Broods, six weeks or less of age, were found on areas having a lesser density and lower percent crown coverage of Big Sage than were older broods and adults. Food habits were determined by analysis of the contents of 35 sage grouse crops. Sagebrush and three genera of forbs together constituted 94.6 percent of the total volume. Dandelion and sagebrush had the greatest total percent frequency of occurrence of all food items. These high frequency food plants were more abundant in unsprayed than in sprayed strips, which strengthened the conclusion that differences in numbers of sage grouse observed in unsprayed and sprayed strips were related to vegetation composition.

INTRODUCTION

An increasing trend toward sagebrush (*Artemisia* spp.) eradication and/or control on private and public rangelands in Montana and other parts of the western United States has become apparent in recent years. The principal objective is to release the growth of grasses and other herbaceous plants to improve grazing for domestic livestock. The dependence of sage grouse (*Centrocercus urophasianus*) on sagebrush is well known (Girard, 1937; Griner, 1939; Patterson, 1952; and others). In Montana, as elsewhere, many of these sagebrush ranges provide excellent habitat for this bird. Although various aspects of the effects of sagebrush control on wildlife populations have been studied, few references relating to sage grouse are available. Trueblood (1954) and Enyeart (1956) evaluated use of reseeded sagebrush ranges by sage grouse. Rogers (1964) determined the use of areas by sage grouse on which sagebrush had been removed by burning. Some adverse effects of chemical sagebrush removal on this species were noted by Rogers (*op cit.*).

The objective of the present study, conducted during three concurrent summers (1962 - 1964) in Southwestern Montana, was to determine effects of chemical manipulation (control) of sagebrush on a sage grouse population. Data on life history and ecology of the sage grouse were collected to aid in interpretation of the results.

DESCRIPTION OF THE AREA

The study area (Figure 1) encompassed approximately 90 square miles of an extensive mountain valley in southwestern Beaverhead County, Montana, locally known as Big Sheep Creek Basin. The area, bordered by the Continental Divide on the west and the Tendoy Mountains on the east, has numerous rolling benches ranging in elevation from 6,700 to 8,000 feet above sea level. It is drained dendritically by tributaries of Big Sheep Creek. The annual precipitation averages about 14 inches, most of which falls in winter and spring (Forest Service Report, 1961).

The vegetation was characterized by a sagebrush grassland type which occupied the major portion of the study area. Predominant shrubs included: Rubber Rabbitbrush (Chrysothamnus nauseosus), Green Rabbitbrush (C. viscidiflorus), Low Sage (Artemisia arbuscula), and Big Sage (A. tridentata), with the latter having the greater density in most situations. The principal grasses were Idaho Fescue (Festuca idahoenis), Bluebunch Wheatgrass (Agropyron spicatum), and various species of Bluegrass (Poa spp.). Pussytoes (Antennaria spp.) Phlox (Phlox spp.), Western Yarrow (Achillea millefolium), Fringed Sagewort (A. frigidia), and Sandwort (Arenaria spp.) were the dominant forbs. Various degrees of dominance and association between grass and forb species existed, particularly on areas with varying livestock grazing intensity. Stream bottoms and moist areas were characterized by a number of grasses, rushes,

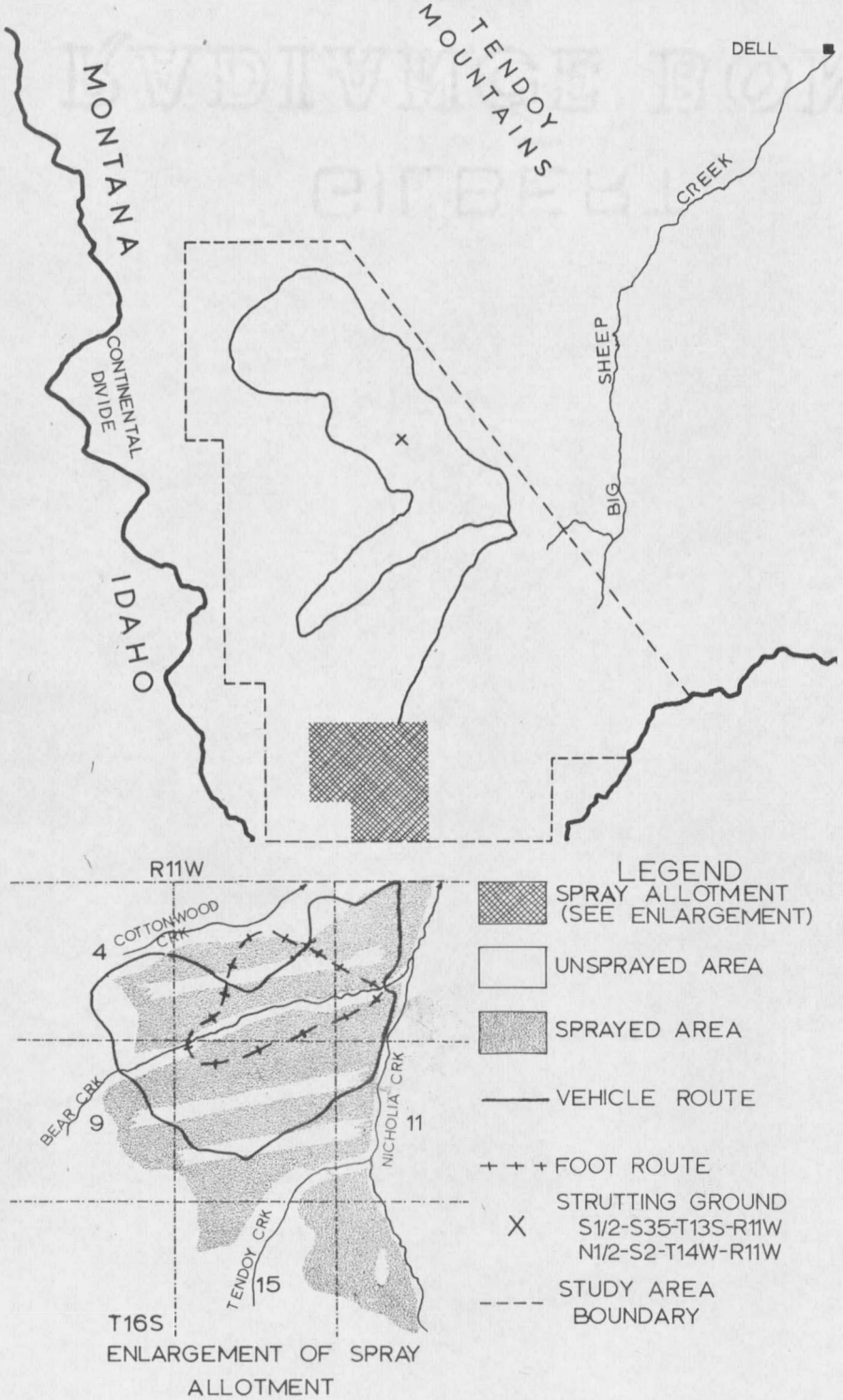


Figure 1. Map of Big Sheep Creek Basin Study Area.

willows, and succulent forbs. A more quantitative treatment of the vegetation is presented in a later section. The main economy of the area was grazing by livestock. Approximately 1,594 cattle and 3,500 sheep graze on National Forest lands in Big Sheep Creek Basin between July 1 and November 10, under a permit system.

Principal study was conducted on 1,900 acres of the area's southwestern corner, of which 1,710 acres had been sprayed in 1961 with 2,4-D at the rate of one and three-fourths pounds, acid equivalent, per acre to control sagebrush (Figure 1). Three east-west strips, approximately one and one-quarter miles in length and five chains in width as well as strips of 300 feet on each side of streams, were left unsprayed. Grazing by livestock was deferred on the 1,900 acre spray allotment for two years after spraying.

METHODS

Cannon nets, similar to those described by Dill and Thornsberry (1950), were used to trap mating birds on strutting grounds in late April and early May. After hatching, broods were readily captured using hand hoop nets of a type used by Mussehl (1960). Rectangular metal-supported cotton mesh nets utilized successfully by Patterson (1952) were relatively ineffective in this area. In 1962 and 1963, captured grouse, 11 weeks and older, were marked with aniline dyes in combination with four numbered leg bands of various colors to permit individual recognition in the field. In 1964, colored naugahyde neckbands, each with a number, supplemented the aniline dyes. Numbered aluminum bands attached to the patagium of each wing of chicks less than 11 weeks old permitted later identification in the hand.

Two observation routes, one vehicle and one foot, 7.4 and 4.5 miles long, respectively, were established in the 1,900 acre spray allotment. One vehicle route, 37.5 miles long, traversed most of the basin. Vehicle routes were driven weekly at 15 mph beginning at sunrise or in the evening starting at a time necessary to complete the route just prior to darkness. Direction and time (morning or evening) of travel for each route were reversed weekly. The foot route was traveled once each week beginning at sunrise. A German Short Hair Pointer accompanied the observer. In addition to the above routes, all roads and areas passable to vehicle travel

were covered once or more a week depending upon bird concentrations. All sage grouse observations were recorded and each location marked with a numbered red plastic flag for subsequent vegetation analyses. Observations were made with the aid of a 7 x 35 binocular or 20X spotting scope. Many sightings, including most broods and all nesting hens, were initially made by the dog.

A measure of vegetation cover at sage grouse locations was obtained on the same or following day of sighting by a modification of Daubenmire's (1959) canopy coverage method. Frequency of occurrence and canopy coverage for grasses, forbs, and low shrubs in twenty 2 x 5 dm plots, five each, along 30 foot radial lines of a circle's cardinal points were evaluated at each site. Density and average height of sagebrush at bird locations were determined by counting and measuring plants in the four quadrants of a 1/100 acre circle (radius 11.7 feet). Sagebrush canopy coverage at these same locations was obtained by the line intercept method, Canfield (1941). Canopy of plants was recorded in tenths of a foot along radial lines of the circle's cardinal points. A transect, with forty 2 x 5 dm Daubenmire plots, was established in the sprayed sagebrush strips to measure plant production changes. A like transect with an equal number of plots was established in the unsprayed strips. The vegetation in the plots, located at approximately one chain intervals along the

transects, was evaluated every two weeks.

During July, August, and September of 1963 and 1964, a total of 39 sage grouse were collected to determine food habit preferences. Collections were made in late evening prior to darkness to obtain birds with full crops. Crops were examined individually and the percent by volume of identifiable material recorded. The percentage of crop contents for each month was computed by the aggregate percentage method (Martin, et al., 1946). Four crops, each of which contained less than 3 cc of material, were not considered in the evaluation.

Hunter success information and wings from hunter killed birds for determining age were collected at a checking station operated on weekends during September and October.

RESULTS

Vegetation of Sprayed and Unsprayed Areas

Mean percent canopy coverage of vegetation, litter, and bare ground for sprayed and unsprayed areas of the 1,900 acre spray allotment, as revealed by evaluations in forty 2 x 5 dm plots in each of the areas, is presented in Table 1. The vegetation in the plots was evaluated on each of the following dates for both 1963 and 1964: July 9 and 23, August 7 and 12, and September 4.

TABLE I. MEAN PERCENT CANOPY COVERAGE FOR VEGETATION, LITTER, AND BARE GROUND IN FORTY 2 x 5 DM PLOTS IN SPRAYED AND FORTY IN UNSPRAYED STRIPS, 1963 AND 1964.

	1963		1964		1963-1964	
	S	US	S	US	S	US
Grasses	47	34	54	38	51	36
Forbs	12	23	13	29	13	26
Total herbaceous	59	57	67	67	64	62
Low shrubs[1]	9	13	9	18	9	16
Litter	19	18	25	28	22	23
Bare ground	17	17	17	19	17	18

S = Sprayed strip; US = Unsprayed strip

[1] includes both dead and living plants

Although the mean percent canopy coverage for total herbaceous vegetation in 1963 and 1964 was similar in sprayed and unsprayed strips, there was a greater canopy coverage of grasses and a lesser canopy coverage of forbs in the sprayed strips. The two year average canopy coverage for forbs in the

sprayed plots was only about one half that of the unsprayed plots. Forb reduction or destruction following application of the chemical 2,4-D to control sagebrush has been reported by Blaisdell, 1956; Hyder, 1954; and others. The average percent canopy coverage for total herbaceous vegetation increased from 1963 to 1964 in both sprayed and unsprayed plots. The increase in unsprayed plots resulted mostly from forbs, while the increase in sprayed plots was due mainly to grasses.

The somewhat constant percent of shrub canopy coverage in sprayed strips, as compared with the increase in unsprayed strips for the two year period, was possibly due to impaired growth and/or dead sagebrush plants. The latter is suggested by the percent frequency of Big Sage (Artemisia tridentata) in sprayed strips (Table II).

Relatively small difference in the average percent canopy coverage of litter was noted for sprayed and unsprayed strips. Litter increased from 1963 to 1964 for both the sprayed and unsprayed strips.

The average percent frequency of occurrence of plants in the plots for 1963 and 1964 is presented in Table II.

The average percent frequency of occurrence of all grasses recorded except Idaho Fescue (F. idahoensis) was greater in sprayed than in unsprayed plots. Four of the eight forbs recorded were most common in the unsprayed strips, while three were most common in the sprayed strips.

TABLE II. AVERAGE PERCENT FREQUENCY OF OCCURRENCE OF PLANTS IN FORTY 2 x 5 DM PLOTS IN SPRAYED AND FORTY IN UNSPRAYED SAGEBRUSH STRIPS, 1963 AND 1964.

Plant taxa[1]	1963		1964		1963-1964	
	S	US	S	US	S	US
GRASSES						
Agropyron spicatum	65	42	68	58	66	51
Festuca idahoensis	93	100	93	100	93	100
Koeleria cristata	32	29	33	15	32	23
Poa spp.	45	29	50	49	49	39
FORBS						
Achillea millefolium	17	12	18	10	17	11
Antennaria spp.	41	59	41	60	41	59
Arenaria congesta	29	29	24	18	26	25
Astragalus miser	26	32	28	35	27	34
Lupinus sericeus	7	23	9	25	8	24
Phlox caespitosa	26	21	22	19	24	21
Phlox longifolia	18	14	11	10	13	13
Sedum stenopetalum	3	16	4	16	3	16
LOW SHRUBS						
Artemisia tridentata[2]	4	45	4	56	4	50

[1] All taxa in both sprayed and unsprayed strips with less than ten percent frequency of occurrence were excluded (See Table IX, Appendix).

[2] Dead plants were not included

Frequency of occurrence of grasses, except June Grass (Koeleria cristata), increased or remained about constant in both sprayed and unsprayed areas from 1963 to 1964. June Grass decreased substantially in unsprayed plots. No general pattern was indicated for increase or decrease of the forbs from 1963 to 1964 in either the sprayed or unsprayed plots. Some increased others decreased.

The only low shrub that occurred in either the sprayed or unsprayed strips with a greater percent frequency than ten for living plants was Big Sage. The frequency of this plant in unsprayed plots was several times that in sprayed plots. It increased significantly in unsprayed plots from 1963 to 1964, but not in sprayed plots. Big Sage plants were recorded as 100 percent dead in 8 and 97 percent of the unsprayed and sprayed plots, respectively.

Figures 2 and 3 depict the vegetation characteristics in sprayed and unsprayed strips.

Observations of Sage Grouse in Sprayed and Unsprayed Strips

Numbers of sage grouse in sprayed and unsprayed strips, as determined by observations made from a vehicle or while on foot in the 1,900 acre spray allotment, are presented in Table III. Observations were made from June 15 to September 14, during each of the years 1962 through 1964.

Despite the fact that more than proportionately equal time was spent in the sprayed strips, which were approximately nine times the unsprayed in area, they provided only four percent of the sage grouse observed. Rogers (op cit.) reported that spraying of 1,300 acres surrounding a 1,700 acre sagebrush range, sprayed two years previously, caused sage grouse to emigrate the area. During any month or year, the greatest numbers of sage grouse observed on my study area

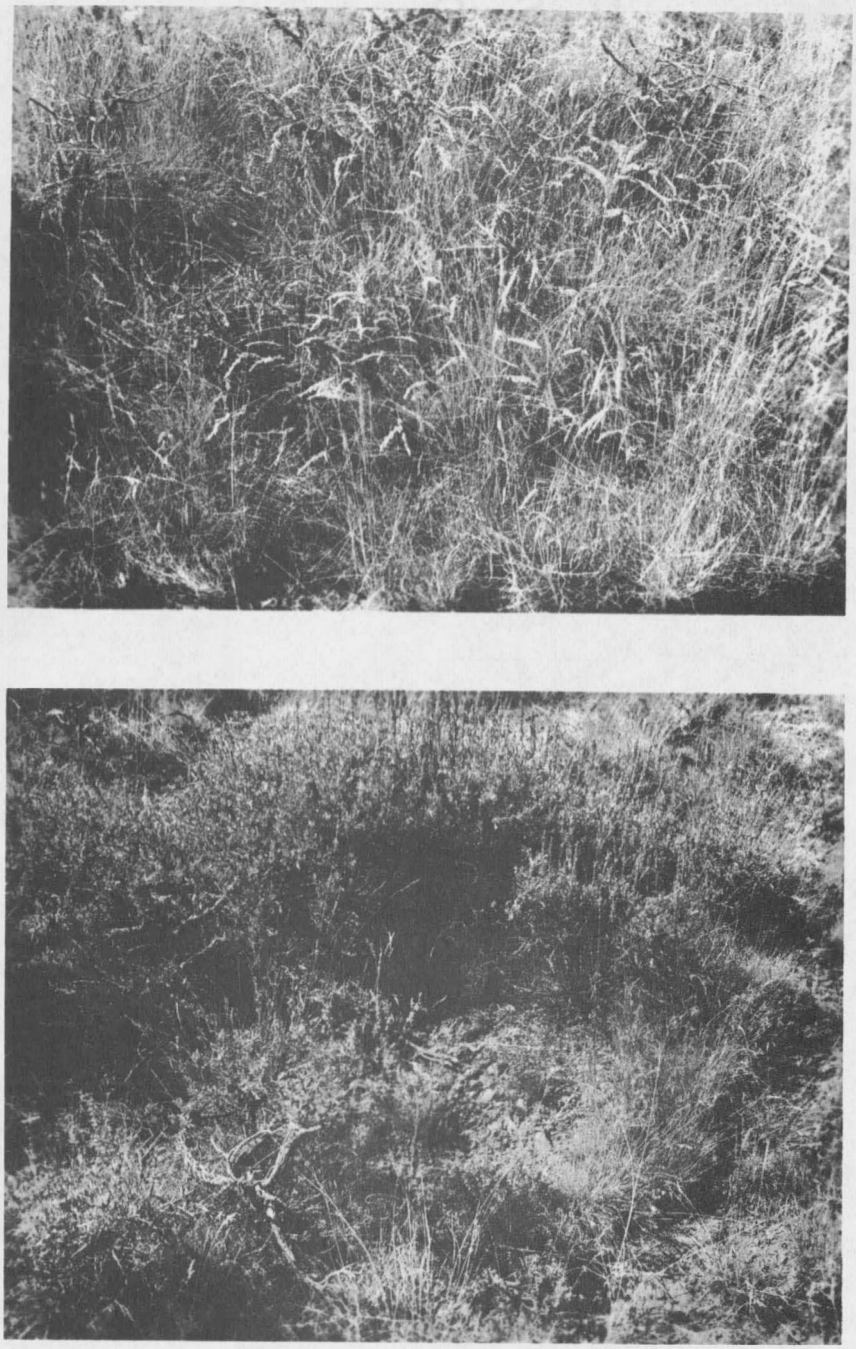


Figure 2. Photographs Showing Canopy Coverage in Sprayed (top) and Unsprayed (bottom) Areas at the Approximate Midpoint of Section 3 (see enlargement of spray allotment, Figure 1).

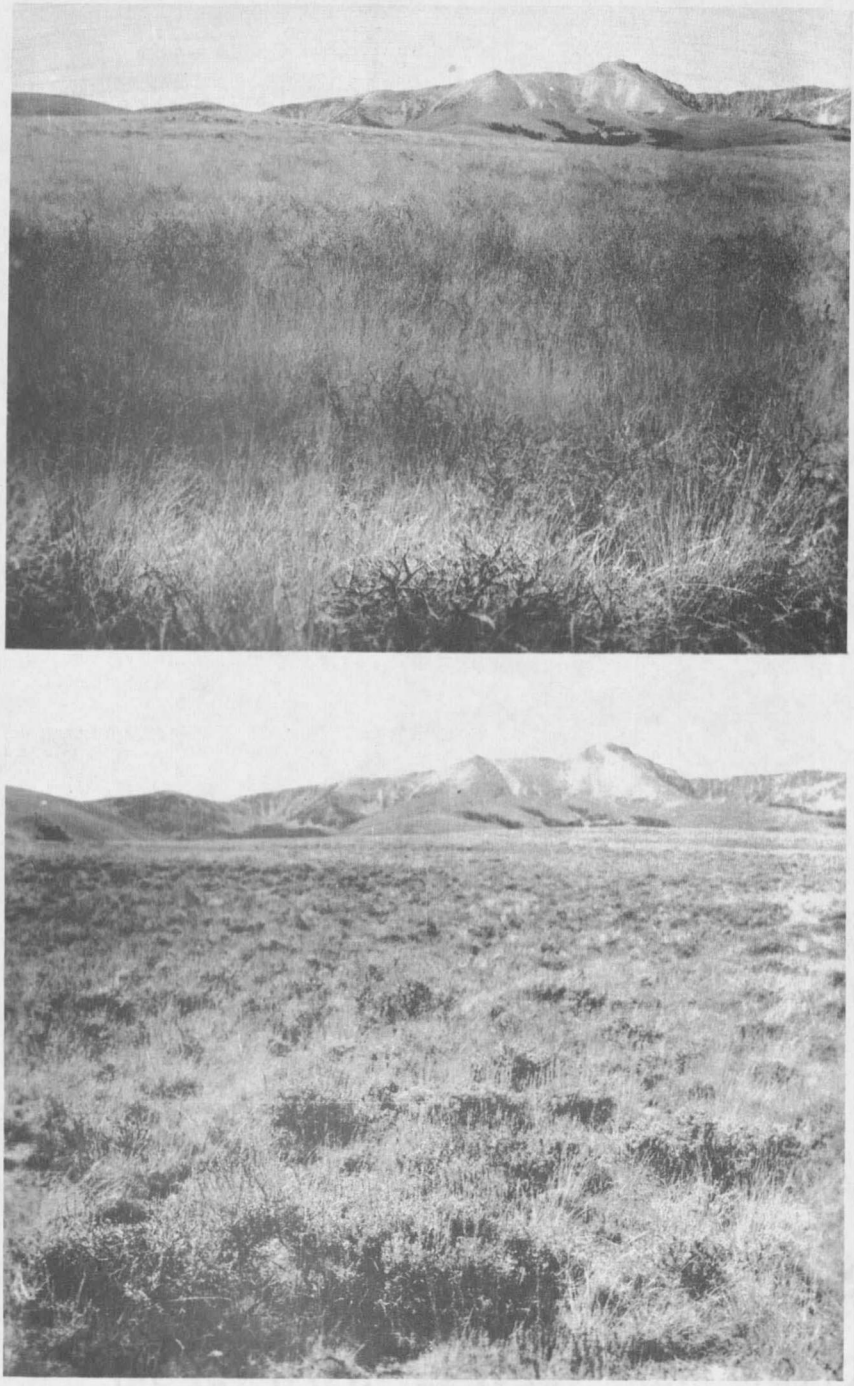


Figure 3. Photographs Showing General Aspect of Vegetation in Sprayed (top) and Unsprayed (bottom) Areas at the Approximate Midpoint of Section 3 (see enlargement of spray allotment, Figure 1).

TABLE III. NUMBERS OF SAGE GROUSE OBSERVED IN SPRAYED AND UNSPRAYED STRIPS FROM JUNE 15 TO SEPTEMBER 14 FOR THE YEARS 1962 THROUGH 1964.

Month	1962					1963					1964						
	S	US				S	US				S			US			
		M	F	J	U	M	M	F	J	U	M	F	J	M	F	J	U
June			3	1				1			1				2	1	
July							5	5	4		1			1	2	5	
August		2	14	57	38	3	92	5	21	32	3	4	3	21	7	17	
September			3	10	8		11	2							5	20	8
Sub-Total	0	2	20	68	46	3	108	13	25	32	5	4	3	22	16	43	8
TOTAL	0	136				3	177				12			87			

S = Sprayed strip

US = Unsprayed strip

M = Male

F = Female

J = Juveniles

U = Unclassified

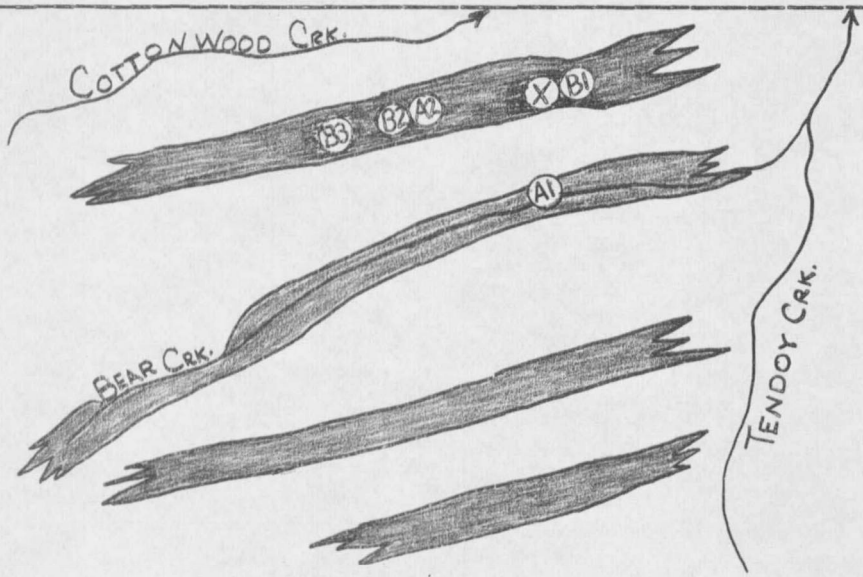
were in unsprayed strips. The increases in numbers of birds recorded during August for each year were thought to have reflected migrations through the area. Males, females, and juveniles were included.

During 1963 and 1964, the site of each of the 15 sage grouse observed in sprayed strips was marked and distance to the nearest unsprayed strip was measured. Distances ranged from 21 to 210 feet with 91 percent falling between 75 and 95 feet. The type of strip, sprayed or unsprayed, in which 184 sage grouse were seen alighting after flushing was also recorded. Ninty-four percent of the birds flushed were observed resettling in unsprayed strips.

Locations of a banded brood-hen in relation to sprayed and unsprayed strips are shown in Figure 4. The hen captured in June, 1962, was reobserved twice the same year and three times during 1963.

In 1962, the hen was observed with one chick and in 1963 with five, four of which were caught and banded. The brood remained intact during subsequent sightings. Two of the banded chicks were recaptured at 1963 relocations B2 and B3. Patterson (op cit.) stated that the close relationship between sagebrush distribution and sage grouse abundance is more than just a casual occurrence.

Figure 4. Locations of Observations of a Banded Hen in Relation to Sprayed and Unsprayed Strips During 1962 and 1963.



X Capture site (June 25, 1962)

A Locations of subsequent sightings in 1962 (July 12, 28)

B Locations of subsequent sightings in 1963 (July 17, 18; August 10)

Unsprayed strips

Characteristics of Vegetation at Sage Grouse Locations

Vegetation measurements were made at the location of 137 sage grouse, or group of sage grouse, sighted within Big Sheep Creek Basin including the 1,900 acre spray allotment (Tables IV, V, and VI). Ninty-two percent of these were outside the 1,900 acre spray allotment; 1,220 of the 4,035 sage grouse observations for the three years were involved.

TABLE IV. MEAN PERCENT CANOPY COVERAGE FOR GRASSES, FORBS, AND LOW SHRUBS AT 137 SAGE GROUSE LOCATIONS DURING JUNE, JULY, AUGUST, AND SEPTEMBER OF 1962 THROUGH 1964.

	1962	1963		1964		1962-1964	
	B	B	A	B	A	B	A
Grasses	33	26	34	41	38	35	34
Forbs	17	18	20	28	27	22	23
Total herbaceous	50	44	54	69	65	57	57
Low shrubs	23	24	24	25	25	24	24
No. of observations	23	24	36	19	35	66	71

B = Broods; A = Adults

Although there were differences each year in mean percent canopy coverage for grasses and forbs at brood locations as compared with adult locations, the 1962 through 1964 averages were similar. Grasses comprised approximately 60 percent and forbs 40 percent of the total herbaceous vegetation at both brood and adult locations. The mean percent canopy coverage for low shrubs at all sage grouse locations was similar from year to year, and the averages at brood and adult locations for the three years were identical.

The average percent frequency of occurrence of plants recorded in the plots at brood and adult sage grouse locations is presented in Table V.

Bluegrass (Poa spp.) combined with Bluebunch Wheatgrass (A. spicatum), and Bluegrass (P. spp.) combined with Idaho Fescue (F. idahoensis) had the greatest yearly and three-year

TABLE V. AVERAGE PERCENT FREQUENCY OF OCCURRENCE OF PLANTS AT EACH OF 137 SAGE GROUSE LOCATIONS DURING JUNE, JULY, AUGUST, AND SEPTEMBER OF 1963 AND 1964.

Plant taxa[1]	1963		1964		1963-1964	
	B	A	B	A	B	A
GRASSES						
Agropyron smithii	15	16	21	10	18	12
Agropyron spicatum	48	36	49	27	49	31
Festuca idahoensis	33	58	39	73	36	65
Koeleria cristata	34	26	22	22	29	24
Poa spp.	52	55	66	71	59	64
FORBS						
Achillea millefolium	16	14	10	23	12	19
Antennaria spp.	22	36	23	29	22	32
Arenaria congesta	22	18	12	30	17	23
Aster spp.	13	8	10	7	12	8
Astragalus miser	32	24	37	36	34	31
Lupinus sericeus	15	9	9	18	12	14
Selaginella densa	14	16	15	15	15	15
Taraxacum officinale	36	39	27	23	31	33
LOW SHRUBS						
Artemisia arbuscula	8	<1	9	<1	8	<1
Artemisia tridentata[2]	63	75	67	80	64	78

B = Broods; A = Adults

[1] All taxa except Artemisia arbuscula with less than ten percent frequency of occurrence were excluded. (See Table X, Appendix)

[2] Dead plants were not included

average percent frequency of occurrence at brood and adult sites, respectively. With the possible exception of three or four species, the average percent frequency of occurrence of forbs at brood and adult locations was similar. Milkvetch (Astragalus miser) and Dandelion (Taraxacum officinale) had

the highest combined frequency of occurrence for the three-year period at both brood and adult locations.

The single low shrub that occurred at both brood and adult sage grouse sites with a greater percent frequency than ten was Big Sage. The average percent frequency of occurrence was greater in 1964 than in 1963 at both brood and adult sites, but was greater at the latter each year. Of the Big Sage plants evaluated for all years and locations, 92 percent were recorded as living. Low Sage (A. arbuscula), 90 percent of which was recorded during June and July, occurred with a greater average percent frequency at brood locations than at adult locations each year.

Density, percent crown coverage, and maximum height of Big Sage plants at brood and adult locations during 1963 and brood, adult, and nesting hen locations during 1964 are given in Table VI.

The average number and percent crown coverage of Big Sage plants during each year was greater at adult locations than at brood locations. This was substantiated by the greater average percent frequency of occurrence of Big Sage at adult locations (Table V). Most of the difference that occurred between brood and adult locations each year was attributed to locations of broods of 6 weeks or less of age. Eighty-eight percent of these broods, located during June and July of both years, were found on areas having an average of 36 Big Sage plants per

TABLE VI. AVERAGE NUMBER, PERCENT CROWN COVERAGE, AND MAXIMUM HEIGHT OF BIG SAGE PLANTS WITHIN A 1/100 ACRE CIRCLE AT EACH OF 159 SAGE GROUSE LOCATIONS DURING JUNE, JULY, AUGUST, AND SEPTEMBER OF 1963 AND 1964.

	1963		1964			1963-1964	
	B	A	B	A	NH[1]	B	A
Number of plants	45	57	49	63	41	47	59
Percent crown coverage	19	25	18	24	22	19	25
Maximum heights	13	12	13	14	12	13	13
Number of observations	24	50	23	57	5	47	107

B = Broods; A = Adults only; NH = Nesting Hens

[1] During June only

1/100 acre and a percent crown coverage of 14. By August and September, broods and brood groups were located on areas comparable to that of adults. Figure 5 shows the general aspect of Big Sage at young brood locations, as well as that for older broods and adults.

The average maximum height of Big Sage plants was similar at both brood and adult locations, but a wider range in height was recorded at adult sites. Plant heights at young brood locations ranged from 9 to 15 inches as compared with 7 to 25 inches at adult locations. Keller, et al. (1941) reported sagebrush growth from 7 to 15 inches high was preferred for feeding, nesting, and roosting with taller plants being used for nesting, shade and escape cover.

The average number and percent crown coverage of Big

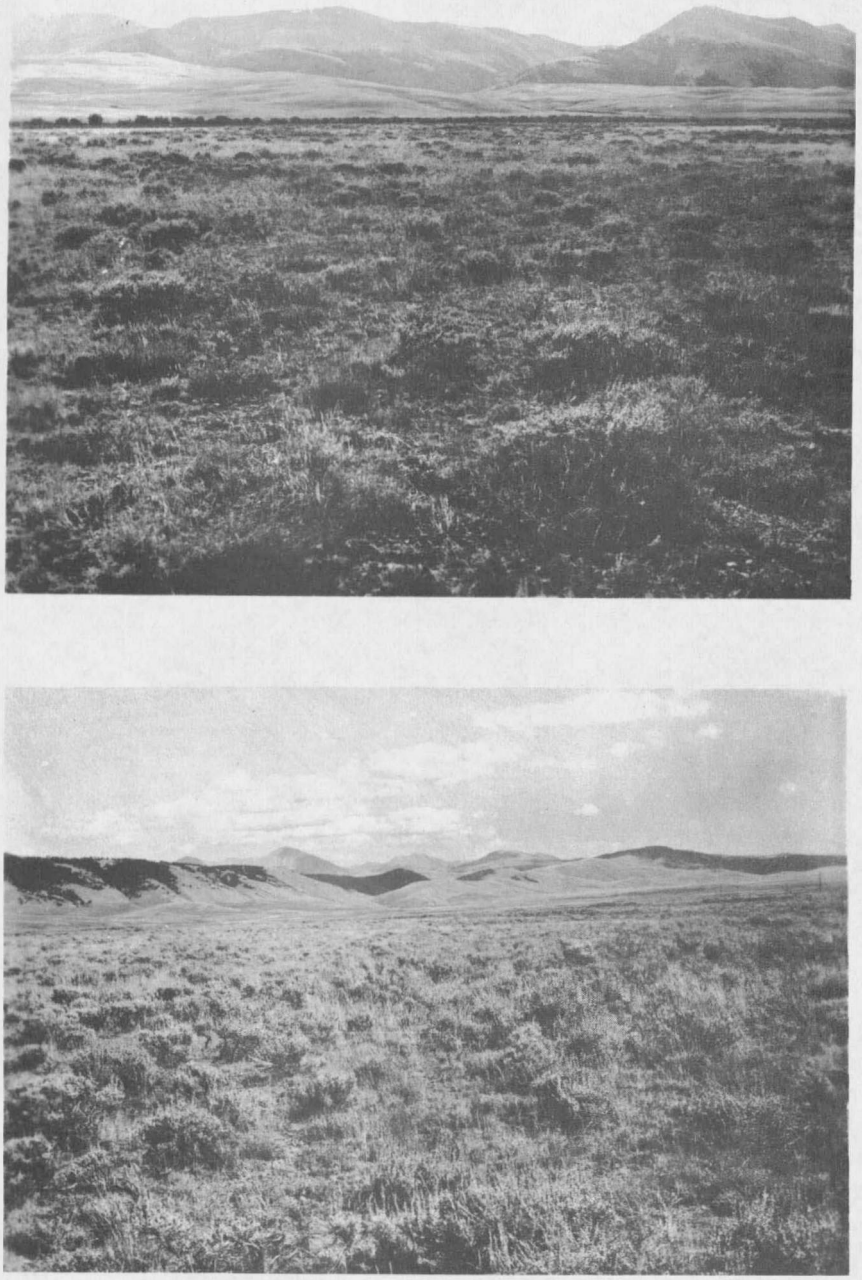


Figure 5. Photographs Showing the General Aspect of Big Sage Plants at Locations of Broods Six Weeks or Less of Age (top), as well as that for Older Broods and Adults (bottom).

Sage plants recorded at nest sites was not unlike that for brood sites, and all but one of the nests found, were in the same areas used by young broods. Four of five nests were each placed under one or more Big Sage plants averaging 12 inches in height. The other was located beneath a 13 inch Rubber Rabbitbrush plant (C. nauseosus). Keller, et al. (op cit.); Patterson (op cit.); and others reported that more than 90 percent of all nests found were placed under sagebrush.

Comparisons of the canopy coverage of grasses and forbs in sprayed and unsprayed strips (Table I) with that recorded at sage grouse locations (Table IV) indicated the similarity between the latter and the unsprayed strips. Grasses and forbs constituted about 60 and 40 percent, respectively, of the total herbaceous canopy coverage at sage grouse locations and in the unsprayed strips; whereas, the relationship was about 80 and 20 percent in the sprayed strips. The low shrub canopy coverage was greater at sage grouse locations than for either the sprayed or unsprayed strips, but the differential was much greater between the former and the sprayed strips. Big Sage, which was the dominant low shrub in both the sprayed and unsprayed strips (Table II) and at sage grouse locations (Table V), occurred with the greatest frequency at sage grouse locations.

The above comparison of vegetation characteristics leads to the conclusion that the differences in the numbers of sage

grouse observed in the sprayed strips as compared with unsprayed strips (Table III) was related to differences in vegetation composition.

FOOD HABITS

Percent volume and frequency of occurrence of plant and animal matter in 35 adult sage grouse crops collected during July, August, and September of 1963 and 1964 are given in Table VII.

TABLE VII. PERCENTAGE VOLUME AND FREQUENCY OF OCCURRENCE OF PLANT AND ANIMAL MATTER IN 35 ADULT SAGE GROUSE CROPS COLLECTED DURING JULY, AUGUST, AND SEPTEMBER OF 1963 AND 1964.

Years	1963		1964		1963-1964	
Sample Size	14		21		35	
Item — Percentage	Vol.	Freq.	Vol.	Freq.	Vol.	Freq.
PLANT MATERIAL						
Achillea	.2	11	.1	14	tr	13
Antennaria	.5	11	1.6	14	1.2	13
Artemisia	16.2	89	43.2	86	34.3	88
Astragalus	.4	22	8.1	52	5.6	47
Erigeron	4.4	11	1.5	14	2.7	13
Geum	.1	11	--	--	tr	3
Gramineae	.2	67	tr	29	tr	40
Taraxacum	69.1	89	33.7	90	45.1	90
Trifolium	7.7	67	10.5	33	9.6	43
Unidentitied forbs	.8	33	1.2	14	1.2	13
ANIMAL MATTER						
Coleoptera	.1	11	tr	5	tr	7
Hymenoptera	.3	33	tr	14	tr	13

While there was considerable yearly variation in amounts of individual items consumed, two members of the Compositae, sagebrush (Artemisia, mainly Big Sage) and Dandelion (Taraxacum), provided more than two-thirds by volume of the total crop contents for each year and for the two years combined. For the two year period, sagebrush and three genera of forbs

together constituted 94.6 percent of the total volume of identifiable food. Leaves and flower clusters of sagebrush and dandelion, with the latter having the greater total percent volume, composed 79.4 percent of the crop contents. Sagebrush and dandelion also had the greatest total percent frequency of occurrence of all food items. Griner (op cit.) and Girard (op cit.) reported that plant materials, mainly dandelion and sagebrush, furnished 95 percent or more by volume of the adult sage grouse summer diet. Patterson (op cit.) stated that only during the summer months did sagebrush compose less than 80 percent of the total volume of food consumed during the year.

The percent frequency of occurrence of those plants which constituted a significant portion of the sage grouse diet are shown in Table VIII for sprayed strips, unsprayed strips, sage grouse locations, and sage grouse crops.

TABLE VIII. PERCENT FREQUENCY OF OCCURRENCE IN SPRAYED STRIPS, IN UNSPRAYED STRIPS, AT SAGE GROUSE LOCATIONS, AND IN SAGE GROUSE CROPS FOR THOSE PLANTS WHICH CONSTITUTED A SIGNIFICANT PORTION OF THE SAGE GROUSE DIET (See Tables II, V, VII).

	Sprayed Strips	Unsprayed Strips	Sage Grouse Locations B	Sage Grouse Locations A	35 Sage Grouse Crops
Artemisia tridentata	4	50	64	78	88
Astragulus	27	34	34	31	47
Taraxacum	5	8	31	33	90
Trifolium	1	4	4	7	43

B = Brood; A = Adult

Considerable differences are apparent. Each of the plants listed in Table VIII had a greater percent frequency of occurrence in the sage grouse crops than in any of the other categories listed. This indicated the selectivity of sage grouse in feeding. The differential in frequency of occurrence for Big Sage in the crops as compared with the other categories was less than for the other plants which indicated the importance of this plant. The favored food plants were more abundant in unsprayed than in sprayed strips, supporting the conclusion that the greater number of sage grouse observed in unsprayed strips, as compared with sprayed strips (Table III), was related to the differences in vegetation composition.

Miscellaneous Observations

Observations on the life history and ecology of sage grouse that were not necessarily pertinent to the main consideration of this study are included in the Appendix.

APPENDIX

TABLE IX. LIST OF TAXA WHICH OCCURRED IN SPRAYED AND/OR UNSPRAYED PLOTS WITH A PERCENT FREQUENCY OF LESS THAN TEN (see Table II, Text).

Plant taxa	1963 S	1963 US	1964 S	1964 US
GRASSES				
Agropyron smithii				x
Carex spp.	x	x	x	x
Hesperochloa kingii		x		x
Stipa comata		x		x
FORBS				
Agoseris galuca		x		
Allium textile	x	x	x	
Arnica rydbergii		x		x
Artemisia frigida	x	x	x	x
Aster spp.	x	x		x
Astragalus striata	x		x	x
Besseya cinera	x	x	x	x
Castilleja flava	x	x	x	x
Dodecathon radicatum			x	x
Erigeron compositus		x	x	x
Eriogonum ovalifolium		x		x
Eriogonum umbellatum	x	x	x	x
Geum triflorum	x	x	x	x
Haplopappus acaulis		x	x	x
Musineon divaricatum	x	x	x	x
Penstemon cyaneus		x		x
Penstemon procerus		x	x	x
Potentilla spp.	x	x	x	
Ranunculus glaberrimus			x	
Selaginella densa	x	x	x	x
Senecio werneriaefolius		x		x
Stellaria longifolia	x	x	x	x
Taraxacum officinale	x	x	x	x
Trifolium longipes	x	x	x	x
Trifolium repens		x		x
LOW SHRUBS				
Artemisia arbuscula		x		x
Chrysothamnus viscidiflorus	x	x		x
Tetradymia canescens		x		x

S = Sprayed; US = Unsprayed

TABLE X. LIST OF TAXA WHICH OCCURRED AT SOME SITE(S) OF 137 SAGE GROUSE LOCATIONS WITH A PERCENT FREQUENCY OF LESS THAN TEN. (See Table V, Text)

Plant taxa	1963 B	1963 A	1964 B	1964 A
GRASSES				
Agropyron subsecundum	x	x	x	x
Carex spp.	x	x	x	x
Hesperochloa kingii		x		
Hordeum brachyantherum		x		
Hordeum jubatum	x	x	x	x
Phleum alpinum			x	
Stipa comata	x	x		x
FORBS				
Agoseris glauca	x		x	
Allium textile	x	x		x
Arnica rydbergii	x	x	x	x
Artemisia frigida	x	x	x	x
Aster spp.		x		x
Astragalus striata	x	x		x
Besseya cineria	x	x		x
Capsella bursa-pastoris		x	x	x
Castilleja flava	x	x	x	x
Comandra umbellata	x	x		x
Dodecatheon radicatum			x	x
Erigeron compositus	x	x	x	x
Eriogonum umbellatum	x	x	x	x
Galium boreale			x	
Geranium viscossissimum		x		
Geum triflorum	x	x	x	x
Haplopappus acaulis	x	x	x	x
Heuchera parvifolia	x	x		x
Iris missouriensis	x			
Lappula redowskii	x			
Lupinus sericeus	x	x	x	
Musineon divaricatum	x	x	x	x
Penstemon procerus	x	x	x	
Phlox caespitosa	x	x	x	x
Phlox hoodii	x	x		x
Phlox longifolia	x	x	x	x
Potentilla fruiticosa	x		x	
Potentilla spp.	x	x	x	x
Ranunculus glaberrimus				x
Sedum stenopetalum	x	x	x	x

TABLE X. CONTINUED

Plant taxa	1963 B	1963 A	1964 B	1964 A
Senecio werneriaefolius	x			x
Stellaria longifolia			x	x
Trifolium longipes	x	x	x	x
Trifolium repens	x	x	x	x
LOW SHRUBS				
Chrysothamnus nauseosus	x	x	x	x
Chrysothamnus viscidiflorus	x	x	x	x
Leptodactylon pungens	x	x	x	x
Tetradymia canescens	x	x	x	x

B = Brood; A = Adult

MISCELLANEOUS OBSERVATIONS

Strutting Grounds

Strutting activity in the basin was apparently confined to one large centrally located ground (Figure 1) situated on a heavily grazed area adjacent to dense sagebrush. During each of the three years, adverse weather conditions resulted in sporadic strutting activity; and, with the exception of 175 males recorded in April, 1962, strutting ground counts were not obtained. The peak of female attendance on the ground was observed to be the third week of April in 1962 and 1963, and the first week of May in 1964. Females moved onto the strutting ground just prior to daybreak and congregated around strutting cocks in groups of 40 to 50 or less. By sunrise, most of the hens had either walked or flown into the heavy sage bordering the strutting ground. Sage grouse were most active on clear calm mornings prior to sunrise and were not greatly distrubed when approached by vehicle.

Nesting

The date of location, distance to strutting ground, number of eggs and the ultimate fate of each of five nests found in May and June of 1964 are presented in Table XI.

Four of the five nests found were within two airline miles of the strutting ground. The one exception was located in one of the unsprayed strips in the 1,900 acre spray allotment. Gill (1964) reported 86.9 percent of 23 nests were

TABLE XI. DATE OF LOCATION, DISTANCE TO STRUTTING GROUND, NUMBER OF EGGS AND THE ULTIMATE FATE OF EACH OF FIVE NESTS FOUND IN MAY AND JUNE OF 1964.

Date Located	Miles to Strutting Ground	Number of Eggs	Fate of Nest
May 10	2	5	Destroyed
June 7	.5	9	Hatched
June 15	.2	5	Deserted
June 24	6.5	-	Destroyed
June 30	.2	-	Destroyed

found within two miles of a permanent strutting ground.

Four of the nests were either deserted or destroyed. Ground squirrels (Citellus richardsoni) were observed destroying one of the nests. Patterson (op cit.), Gill (op cit.), and others found ground squirrels (Citellus spp.) to be a major cause of nest destruction. The success of the June 7 nest was determined by the presence of heavy intact egg membranes which were described by Ellig (1955) as the most conspicuous feature of a successful duck nest.

Broods

The average brood size and percent of hens with broods, as determined by observations from June 20 to August 10 during 1963 and 1964, are given in Table XII.

The average brood size for successful hens was similar both years and compared favorably with the reported 4.36 five year average brood size for sage grouse in Meagher County,

TABLE XII. AVERAGE BROOD SIZE AND PERCENT OF HENS WITH BROODS AS DETERMINED BY OBSERVATIONS FROM JUNE 20 TO AUGUST 10, 1963 AND 1964.

	1963	1964
No. of hens with broods	22	30
Percent of hens with broods	34	34
Total No. of young	103	120
Ave. brood size (hens with broods)	4.7	4.0
Ave. brood size (all hens)	1.6	1.4

Montana (Eng, 1952). A sizeable decrease in average brood size was apparent when unsuccessful hens were included. Each year after the first of July, broodless hens in groups of 25 to 30 were observed. These groups probably included birds that moved into the basin from the adjoining state of Idaho. Two sage grouse banded in Idaho were recovered in the basin by hunters during the 1964 hunting season.

Movements

Each of 76 sage grouse trapped on the strutting ground during the three years was marked and released. Ten were each relocated once at distances of .5 to 12 miles from the point of capture (Table XIII).

With respect to the strutting ground, juvenile females moved greater distances than either the adult males or females. All three juvenile females were relocated during July, 1964, the year of marking, in a drainage apart from those

TABLE XIII. DISTANCES FROM THE BIG SHEEP CREEK STRUTTING GROUND OF RELOCATIONS OF TEN MARKED SAGE GROUSE.

	Number of Relocations	Distance from Capture Site (Miles) Range	Average
Adult males	2	.5 - 4	1.1
Adult females	5	.5 - 4	1.4
Juvenile females	3	11 - 12	11.6

forming Big Sheep Creek Basin. The drainage (Muddy Creek), separated from the basin by a branch of the Tendoy Mountains, had one known strutting ground (Kirsch, 1964). These limited data suggest inter-strutting ground movement or possibly a lower social ranking for juvenile females.

Two adult males, three adult females, and two juvenile females, marked in 1962 or 1963 were retrapped on the strutting ground the year following marking. The return of sage grouse to permanently established strutting grounds in successive breeding seasons is well known (Scott, 1942; Patterson, op cit.; and others). Two of the adult males trapped in 1963 were retrapped at the same site in 1964, indicating that at least some sage grouse return to the same location within the strutting ground in successive years.

Age Structure of Hunter Killed Birds

Numbers of sage grouse bagged and young per adult ratios as determined from 1963 and 1964 hunter killed birds examined at checking stations are given in Table XIV.

TABLE XIV. NUMBERS OF SAGE GROUSE KILLED AND YOUNG/ADULT RATIOS AS DETERMINED FROM EXAMINATION OF HUNTER KILLED BIRDS IN 1963 AND 1964.

Year	Adults			Young	Young/Adult Females	Young/ Adult
	M	F	Total			
1963	79	41	120	163	3.9	1.3
1964	28	58	86	65	1.1	.8

M = Male; F = Female

While males and females comprised 67 and 33 percent of the adult bag, respectively, during 1963, the reverse was true for 1964. The number of young taken in 1963 was greater than the combined total of young and adults shot in 1964. The young per adult female ratios and the number of young shot for both years indicated decreased production in 1964. In 1963, 214 hunters shot about 1.4 times more adults and 2.5 times more juveniles than did 212 hunters in 1964.

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