U.S. Department of the Interior
Bureau of Land Management

Prineville District Office
185 East 4th Street, P.O. Box 550,
Prineville, Oregon 97754

December 1994

Sage Grouse in the High Desert of Central Oregon:

Results of a Study, 1988-1993

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United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Prineville District Office
P.O. Box 550 (185 E. 4th Street)
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In Reply Refer To:
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January 30, 1995

Dear Reader,

Unexpected production difficulties in the printing of Figures 4, 11, and 12, found in the attached bound report, December 1994, BLM/OR/WA/PT-95/002-4120.7 titled "Sage Grouse in the High Desert of Central Oregon: Results of a Study, 1988-1993", has resulted in figures of less than desireable quality and utility.

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Sincerely,

James L. Hancock
District Manager, Prineville

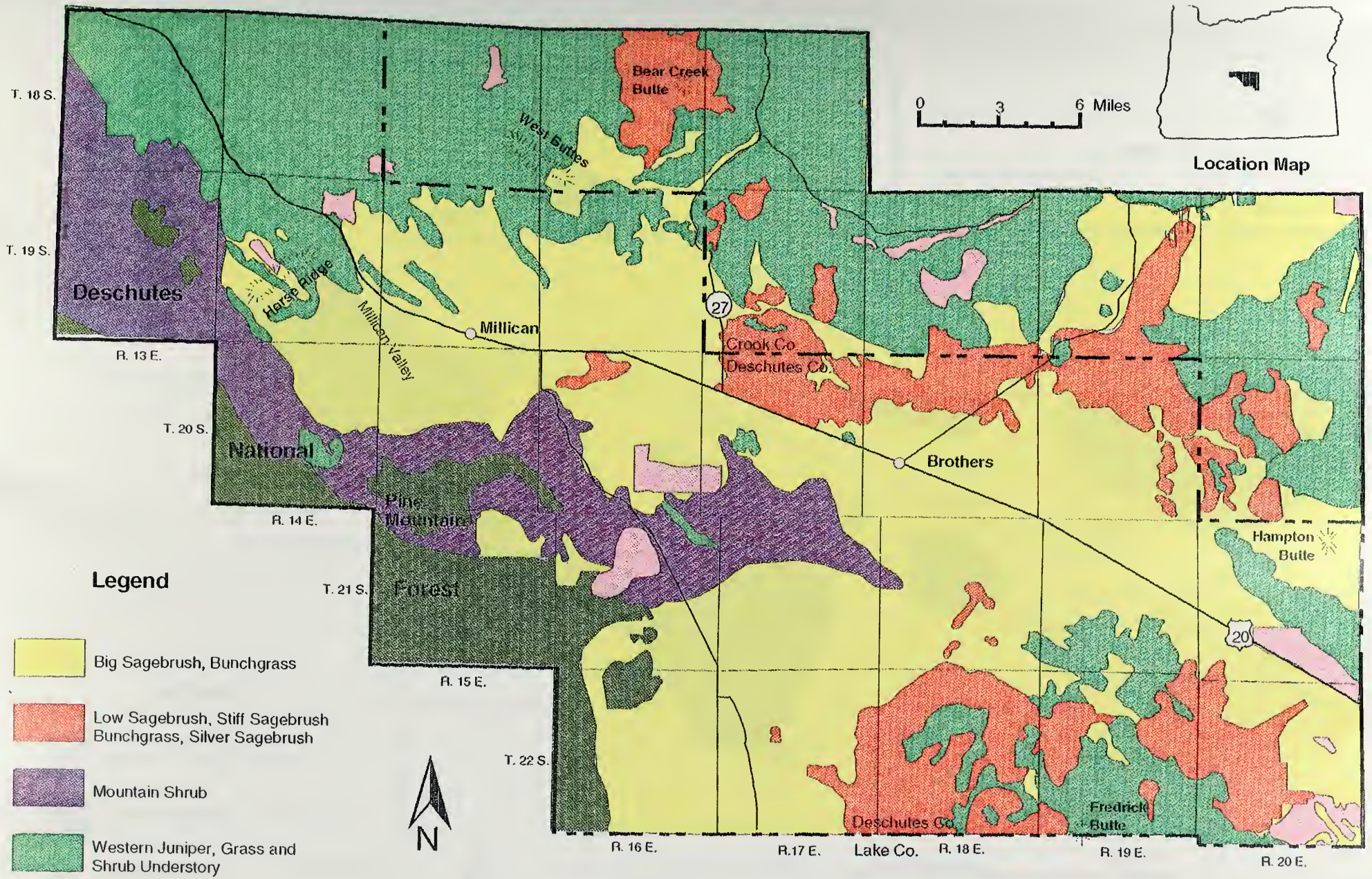

Fig. 4. Habitat Cover Types, Prineville District, BLM.

Habitat Cover Types

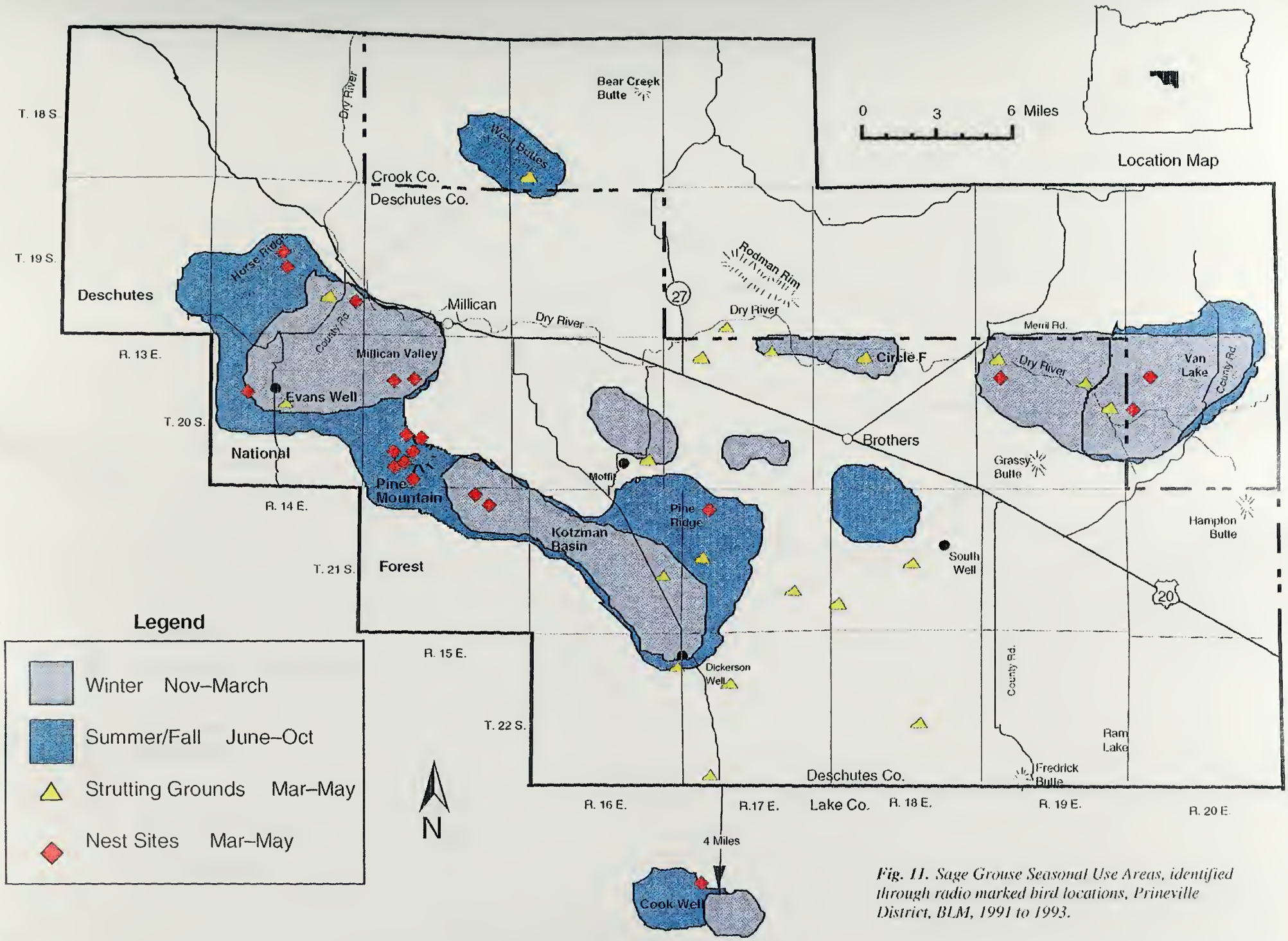

Fig. 11. Sage Grouse Seasonal Use Areas, identified through radio marked bird locations, Prineville District, BLM, 1991 to 1993.

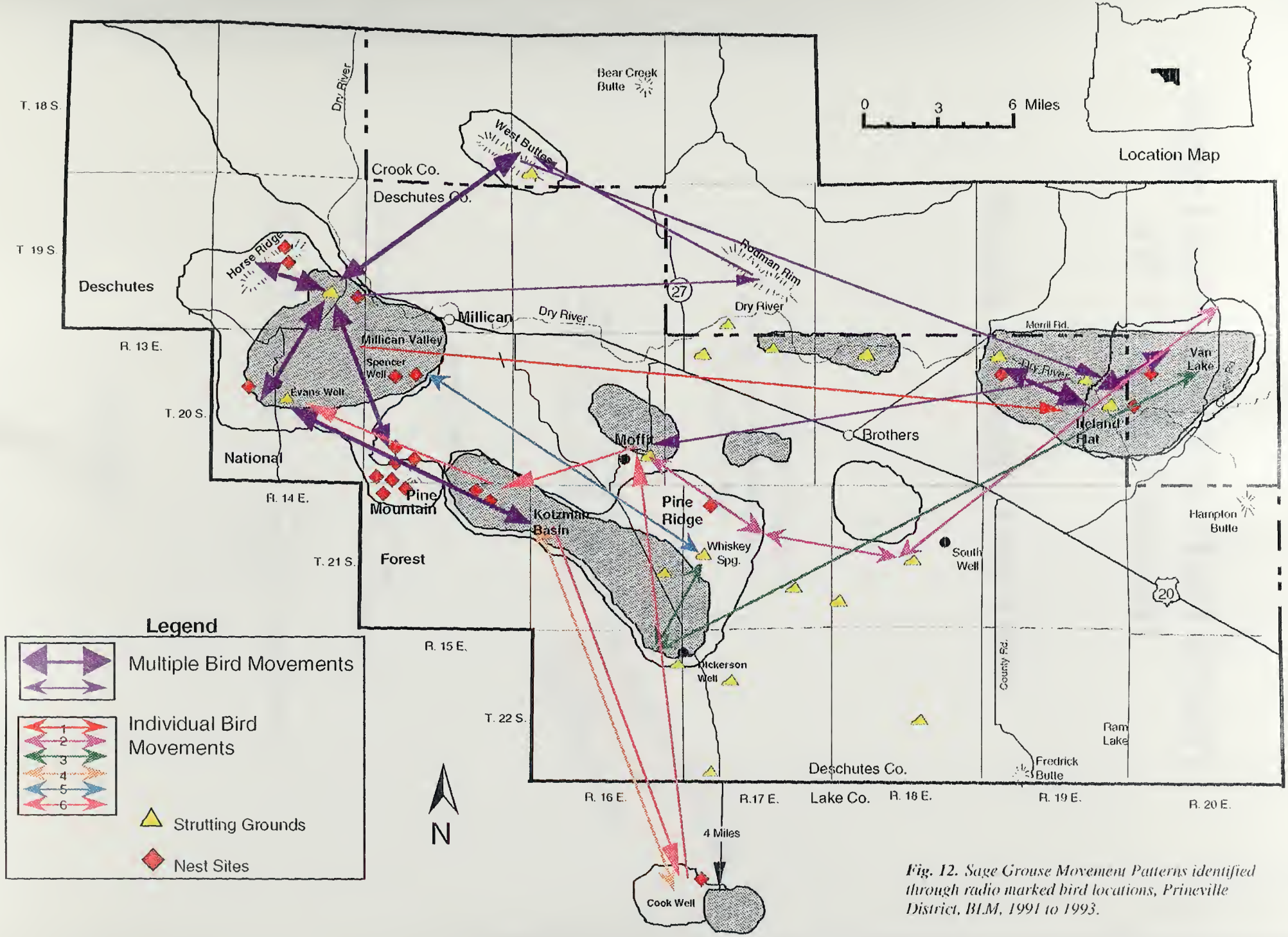

Fig. 12. Sage Grouse Movement Patterns identified through radio marked bird locations, Prineville District, BLM, 1991 to 1993.

Sage Grouse In The High Desert Of Central Oregon:

Results of a study, 1988-1993

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Preface

This document reports the results of a six year study of sage grouse in the High Desert of Central Oregon. Staff biologists collected and interpreted the data during the study period. In the following year, an interdisciplinary team consisting of wildlife biologists, range conservationists, a recreation specialist, and a supervisory natural resource specialist developed this report to provide general information about sage grouse in Central Oregon and to identify management recommendations for the species in the High Desert area. Team members committed a significant amount of time becoming familiar with the data to assist in the preparation and presentation of the document. Team members needed to be in concurrence about the information to be presented in the discussions of each section and the development of management recommendations specific to Prineville District's sage grouse population.

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Executive Summary

Sage grouse (*Centrocercus urophasianus*) numbers have been declining throughout the west for many years, primarily due to loss, degradation, and fragmentation of habitat (Wallestad 1975a). These declines led the U.S. Fish and Wildlife Service to list the Western subspecies of sage grouse (*C. u. phaios*), which is found in Washington, Oregon, Nevada, and California, as a candidate for threatened and endangered status in 1985. The Bureau of Land Management (BLM) administers approximately 90% of the lands currently inhabited by sage grouse. BLM policy directs the Bureau to place emphasis on determining the status and seasonal habitat requirements of candidate species. In Oregon, the Prineville District, BLM began a sage grouse study within the Deschutes Resource Area in 1988 after noting declines in the number of males on leks. The purpose of the study was to define seasonal use areas and to determine an overwintering sage grouse population estimate.

Between 14 and 20 leks were monitored from 1988-1993. The average number of males per lek declined 42% during this time on the 14 leks that were statistically analyzed. This was a statistically significant decline. Population estimates were calculated in 1992 and 1993, with values of 611 and 514 birds respectively. Current sage grouse numbers on the study area are low compared to historic numbers in this area and other parts of Oregon. Declines in sage grouse could be due to several factors such as habitat degradation in breeding, nesting, brood rearing/ summering, and wintering areas, increased predation due to poor habitat conditions, and drought.

Average lek counts were significantly correlated with precipitation from the previous year's water year (Oct.-Sept.) and the crop year (Oct. - June) of two years previous. Precipitation most likely affects sage grouse numbers through increased production of forbs and herbaceous cover at nests. Sage grouse population fluctuations in this area are cyclic, with population highs reached approximately every 7-15 years. Population highs have steadily declined since the 1950's. The last population high was reached in 1988.

Nesting information was gathered from 1991-1993. Sixty-eight percent (19/28) of monitored hens initiated nesting activity. An additional 12 hens monitored during the nesting period were lost due to predation or radio transmitter failure. Nest success was consistent and averaged 30%. Nest success rates on the study area were low compared to other states, but high compared to current rates in southeast Oregon. Sixty-five (13/20) percent of the nests were predated, which is consistent with that found at other study sites. One nest was abandoned and one renest attempt was made.

Sage grouse nested in 4 of 9 available cover types, and habitat use differed significantly from availability. Most of the nests were established in the mountain big sagebrush, mountain shrub, and grassland cover types. Vegetative characteristics at nests differed from those of random locations; nest centers had taller grass and greater medium shrub and total shrub cover. The nest center of successful nests had taller grass and more tall shrub cover than the nest center of unsuccessful nests. Habitat structure appears to be as important to nest success as habitat type. All of the nests monitored were within 12.8 km of the nearest lek. Fifty percent of the nests were within 8 km and 25% were within 3.2 km of the nearest lek. These distances are consistent with the literature.

Fifty percent (3/6) of successfully nesting hens produced a successful brood. Observations on broods were made in 3 habitat types; 83% (38/46) of the observations were in the mountain big sagebrush habitat type.

The crop contents of 8 hens collected in June - September, 1992 were nearly 100% plant material. Big sagebrush and rabbitbrush made up 57% of the combined crop contents of all 8 birds. Birds at one location ate 5 types of forbs, but these forbs made up only 13% of the combined crop contents. At another location, only 1 forb (Oregon Sunshine) was found in crops, but it made up 55% of the combined crop contents. Rabbitbrush had the highest amounts of crude protein and calcium of any of the plants found in crops.

Sage grouse (n=8 radio-marked birds, n=364 unmarked birds) drank water from all types of water developments studied (drink pools, troughs, guzzlers, dugouts). Troughs were used significantly less than other water developments. Sage grouse concentrated near water sources in the late summer and the fall. The silver sagebrush cover type, which had the highest density of water sources per area, received no use by radio-marked birds, but was used by unmarked birds (n=101).

Winter habitat use was studied during the winters of 1991-92 (a below-average precipitation winter) and 1992-1993 (a high precipitation winter). In 1991-92, radio tagged birds used 5 habitat types, with mountain big sagebrush and low sagebrush types used most frequently. In 1992-93, 98% of the observations were in the mountain big sagebrush habitat type. The more clumped distribution in 1992-93 can be attributed to the increase in snow that winter. Snow cover forced birds out of low sagebrush areas to mountain big sagebrush areas, where plants were still accessible above the snow. Millican Valley was an important wintering area, especially during the more severe winter, because the valley received less snow than surrounding areas. During both winters, birds most frequently used areas with a canopy cover of 12-16%.

Seasonal use areas for radio-marked sage grouse on the Prineville District were identified and mapped. Sage grouse made extensive movements between these seasonal use areas and used a large land area. This indicates that large areas of sagebrush habitat in its current condition are important to sage grouse. In better condition habitat, sage grouse may not need to range as far to meet their requirements. Lands between seasonal use areas are important to sage grouse as travel corridors and temporary use areas.

Management recommendations developed by an interdisciplinary team concentrated on 1) maintaining communication with US Fish and Wildlife Service (USFWS) and other federal, state and local agencies, 2) developing a Conservation Agreement for sage grouse with USFWS, 3) determining habitat conditions on the Prineville District with respect to the sage grouse life cycle, 4) improving the quality of the habitat where necessary, 5) limiting conflicting land uses during sensitive times in the sage grouse life cycle, 6) exploring possibilities to enhance land use practices on private lands that are important to sage grouse, and 7) continuing monitoring of the sage grouse population on the Prineville District, with emphasis on the eastern edge of the District.

Acknowledgements

We would like to thank the Oregon Department of Fish and Wildlife (ODFW) for their financial support of this project and their contribution of people and time in assisting with data collection. We would also like to thank the Redmond Chapter of the Oregon Hunters Association for their interest and financial support. Many Bureau of Land Management (BLM) staff members also helped in the field, and we greatly appreciate their help. Many private landowners provided information and access to their land; without their cooperation, much of the information couldn't have been collected. Also due thanks are all the reviewers of the Draft Report; their comments were invaluable. Additionally, we would like to thank the employees at the BLM Oregon State Office who assisted in the production of this document: Jim Alegria for assistance with the statistical analysis of data, and Michael Hamel and Cliff McClelland for assistance with graphics and printing. Finally, a special thanks to Edson and Ardith Fichter who graciously allowed the use of the sage grouse collage print for the cover.

Introduction

The sage grouse (*Centrocercus urophasianus*) is a Western bird that relies primarily on sagebrush for its nutritional and habitat needs. Sage grouse are found throughout the range of big sagebrush, but numbers throughout the West have been declining for many years. These declines primarily are due to loss, degradation, and fragmentation of habitat (Wallestad 1975a). From the late 1800s through 1931, degradation of habitat from grazing and excessive hunting caused severe declines of sage grouse populations (Edminster 1954). In Oregon, sage grouse were common to abundant in the non-forested areas east of the Cascades during much of the 19th century, but began to decline by the late 1890s (Crawford 1982a). Populations recovered in the teens, with birds being abundant in 1918 and early 1919, but a major die-off occurred in mid-1919 (Crawford 1982a). Population declines continued into the 1920s and extinction of the species in Oregon was predicted. Hunting restrictions brought a slight recovery, but populations declined seriously again during the 1930s (Crawford 1982a). By 1940, sage grouse occupied only half their historic range in Oregon, and numbers declined 60% between the late 1950s and the early 1980s (Crawford and Lutz 1985). During this period, productivity rates (chicks/hen and chicks/adult) had dropped significantly. These declines led the U.S. Fish and Wildlife Service (USFWS) to list the western subspecies of sage grouse (*C. u. phaios*; found in eastern Washington, eastern Oregon, and parts of Nevada and California) as a candidate for threatened and endangered status (Federal Register, 18 September 1985). This action means that the USFWS has determined that listing as a threatened and endangered species may be necessary, but more information is needed.

The Bureau of Land Management (BLM) administers approximately 90% of all land currently inhabited by sage grouse. Until recently, BLM Districts in Oregon played a limited role in the study of sage grouse populations. Today, BLM policy (BLM MANUAL Rel 6-116, 6840.06C) directs the Bureau to place greater emphasis on determining the status and seasonal habitat requirements of the sage grouse. Specifically, the BLM manual requires that sage grouse (and other candidate species) be managed "consistent with the principles of multiple use, for the conservation of candidate species and their habitats and shall ensure that actions authorized, funded, or carried out do not contribute to the need to list any of the species as threatened or endangered." In addition, BLM should "determine the distribution, abundance, reason for current status, and habitat needs for candidate species occurring on lands administered by BLM, and evaluate the significance of lands administered by BLM or action in maintaining those species" (BLM MANUAL Rel 6-116, 6840.06C). Also, in Fish and Wildlife 2000, BLM's national strategy for management of fish and wildlife, it is stated that BLM shall conduct or support research to determine habitat requirements for upland game birds, and conduct invento-

ries to learn the location and condition of crucial upland game bird habitat (Fish and Wildlife 2000 Upland Game Bird Strategy Plan, 1992). The BLM Wildlife and Fisheries Program Status Report (1988) states that inventories should also be used to gather baseline information on fisheries and wildlife resources. This will provide the foundation for land use and activity planning, monitoring, and habitat development work. The Prineville District of the BLM recognized a need for sage grouse study on the Deschutes Resource Area after recent declines in the number of males on leks. A study was initiated in 1988 to define seasonal use areas and to determine an overwintering sage grouse population estimate.

Seasonal use areas include areas for breeding, nesting, brood rearing/summering and wintering. These areas can most easily be described in a review of the current knowledge on the life cycle and habitat requirements of the sage grouse.

The Sage Grouse Life Cycle

Sage grouse belong to the family *Phasainidae* in which the most common characteristic is feathered feet and toes. The average life span for a sage grouse is 2-4 years (Drut 1994). Each year, sage grouse go through three seasonal stages: breeding/nesting, brood rearing/summering, and wintering. Habitat requirements for each stage differ.

Breeding/Nesting

In late winter to early spring, sage grouse gather on traditional breeding grounds known as leks. The males arrive first, with hens arriving a few weeks later to mate (Call and Maser 1986). Leks are usually small, open areas of 0.04 to 4 ha, preferably surrounded by dense sagebrush that strutting birds can use for food and cover. Leks are generally used from late February to late May. Surrounding sagebrush is crucial, because strutting birds are especially vulnerable to predators and feed almost entirely on sagebrush during the breeding season. The loss of this adjacent food and cover may cause grouse to abandon a lek (Call and Maser 1986).

After mating, sage grouse hens leave the lek to lay their eggs, usually building a nest within 7-10 days. The nest is typically hollowed out ground and is placed between or beneath sagebrush plants. A basic requirement of nesting cover is concealment of the sage grouse hen and her nest (Girard 1935, Patterson 1952, Autenrieth 1981). Quality nest sites will offer shelter from above by branches, good growth of understory grasses, and sagebrush within 70 centimeters (cm) (Appendix 4) of the nest (Girard 1935, Nelson 1955, Autenrieth 1981, Gregg et al. 1994). A late seral condition is near optimum (Hall 1985). There does not appear to be any relationship between nest placement and proximity of water (Autenrieth 1981). Availability of forbs is also important to the hen in the pre-laying condition. Forbs are more nutritious than sagebrush and may help to increase hen productivity. When available, forbs are selected over sagebrush and may make up 20-50% of the pre-laying diet (Barnett and Crawford 1994). Sage grouse usually lay 6-8 eggs, a low reproductive rate compared to other gallinaceous birds, and have an incubation period of 25-27 days. Peak hatching occurs from the last week of May through the second week of June.

Brood Rearing/Summering

Hens with broods require well-sheltered areas that provide protection from predators and the weather. Nearness of preferred foods is also important. Chicks leave the nest and begin feeding several hours after hatching. However, they have limited mobility, so suitable food such as insects and forbs must be close by. To accommodate both food and cover requirements, broods tend to use areas that have open sites for feeding and small areas of dense sagebrush for roosting.

As plants mature and dry, broods move to areas still supporting succulent vegetation, such as native or irrigated meadows, playas, and high elevation drainages. These areas are important as a source of forbs, insects and free water (Call and Maser 1986). Adult and juvenile birds congregate in these wetter areas during late summer and early fall. As these areas dry, sage grouse consumption of sagebrush increases and the grouse move to lowlands for the winter season.

Wintering

During the winter, sage grouse feed almost entirely on the leaves of sagebrush. Typical winter ranges are large expanses of dense sagebrush ($\geq$ 20% canopy cover) with an average height of 25 cm, on land having little, if any, slope (Eng and Schladweiler 1972). A late seral condition is preferred. This association with dense sagebrush stands typically begins in September and continues through the breeding season. Wintering areas are crucial to sage grouse and are a major factor determining sage grouse distribution. Elimination of winter range habitat would reduce sage grouse populations over large areas (Eng and Schladweiler 1972).

The extent of the seasonal movements just described depends on the proximity of quality seasonal habitats and the severity of the winter. Where all seasonal requirements can be met in the same area, populations are relatively sedentary. Other populations migrate as far as 24-160 kilometers (km) (Appendix 4) between nesting and wintering areas (Call and Maser 1986).

Objectives

A study was initiated on the Prineville District, BLM to define seasonal use areas and to determine a breeding sage grouse population estimate.

Objectives of this study were to:

1) locate all active leks within the study area and determine an overwintering sage grouse population estimate
2) determine use and selection of cover types and habitat characteristics by sage grouse hens during the breeding season
3) compare habitat use and selection between successful and unsuccessful nesting hens
4) determine habitat use by hens with broods
5) collect summer diet information from hens and locate foraging areas
6) determine habitat types used by wintering sage grouse
7) track movements of sage grouse to determine seasonal use areas and distances travelled

Information gathered during the first year of the study led to the development of two additional objectives:

8) determine relationship between precipitation and the average number of males on leks
9) determine use and selection of artificial water developments

Study Area

Location and Description

The study area centers near Brothers, Oregon (67 km east of Bend, Oregon) and encompasses land in Crook, Deschutes and northern Lake counties (Fig. 1). The area is divided by U.S. Highway 20, a 2-lane blacktop. The study area lies within the northwest portion of The Great Basin region of Southeast Oregon and covers approximately 170,000 hectares (ha) (Appendix 4) of semi-arid sagebrush rangeland with scattered lakebeds and playas. Juniper expansion into sagebrush grasslands has occurred at various locations on the study area; its distribution was not examined for this study. New juniper woodlands are usually found on sites previously occupied by big sagebrush/Idaho fescue and mountain big sagebrush/bluebunch wheatgrass plant communities (Bedell et al. 1993). The study area is on the edge of current sage grouse range.

Elevation ranges from 1,275 to 1,925 meters (m) (Appendix 4). A unique feature of the area is the Dry River Drainage, which runs the length of the study area from Hampton Buttes to Horse Ridge. The Dry River area has a large low sage component and high use by sage grouse.

The BLM administers approximately 60% of the land within the study area and the U. S. Forest Service administers approximately 3%. The remaining 37% consists of widely scattered private and state owned lands, occurring mainly in the northern and eastern portions of the study area.

Soils in this area are influenced by the eruptions of Mt. Mazama and Newberry Crater approximately 7000 and 2000 years ago, respectively. The soil is moderately deep (50 - 100 cm to bedrock) and well drained, with sandy and sandy loam textures, and has a thin mantle of pumiceous ash and small pebbles over buried horizons of a loamy texture. Low sage and juniper/low sage sites in the northern and eastern sections of the study area have shallow (25 - 50 cm to bedrock), rocky soils, with a sandy loam surface and clay subsoils. The moister, deep, stratified soils on the playas consist of silty loam (wetland soils).

Climate

The area receives 18 - 30 cm of precipitation annually. Precipitation occurs mainly during the winter and spring, with summer thunderstorms adding a small amount. Temperature varies greatly, ranging from lows of -25°C to highs of 40°C (Appendix 4). The relative humidity is low much of the year and winds are moderate.

Vegetation

Dominant overstory vegetation consists of mountain big sagebrush (*Artemisia tridentata vaseyana*), low sagebrush (*Artemisia arbuscula*), green rabbitbrush (*Chrysothamnus viscidiflorus*), silver sagebrush (*Artemisia cana*), antelope bitterbrush (*Prushia tridentata*), and western juniper (*Juniperus occidentalis*). Common grasses include Idaho fescue (*Festuca idahoensis*), western needlegrass (*Stipa occidentalis*), Thurbers needlegrass (*Stipa thurberiana*), bluebunch wheatgrass (*Agropyron spicatum*), and bottlebrush squirreltail (*Sitanion hystrix*). Common forbs include small-flowered blue-eyed Mary (*Collinsia parviflora*), microsteris (*Microsteris gracilis*), Oregon sunshine (*Eiophyllum lanatum*), everlasting (*Antennaria* spp.), milk-vetch (*Astragalus* spp.), buckwheat (*Erigonum* spp.), desert parsley (*Lomatium* spp.), lupine (*Lupine* spp.), monkey flower (*Mimulus* spp.), and phlox (*Phlox* spp.).

Primary Land Use Activities

Many human activities take place on the study area. In the past, homesteaders moved into Central Oregon by the thousands to make a living through dry-land farming and stock raising. Most of the movement into this area occurred between the late 1800s and the early 1900s (Allen 1987). Thousands of cattle and hundreds of

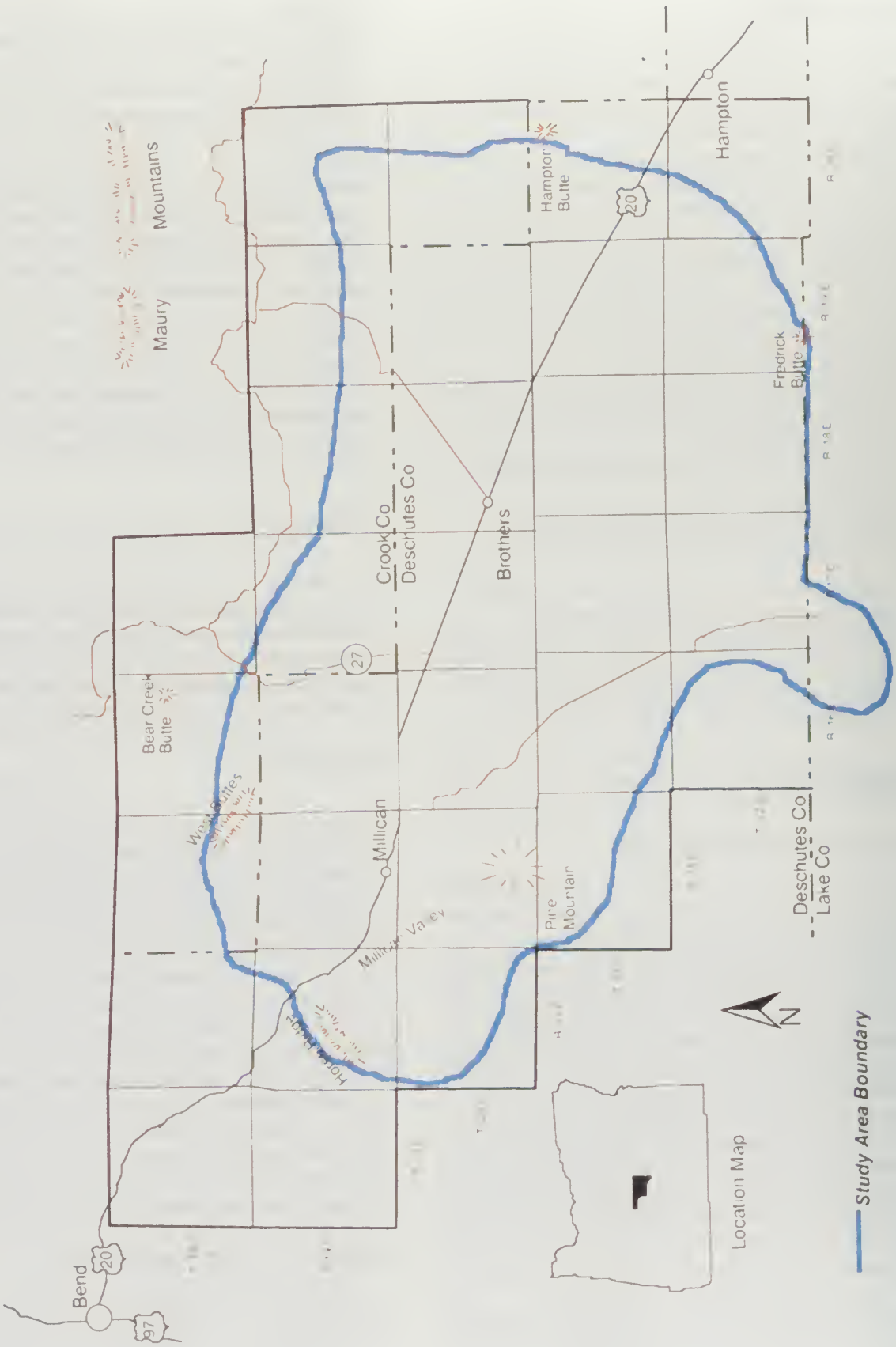


Fig. 1. Sage Grouse Study Area, Prineville Distict, BLM.

thousands of sheep competed for rangelands by the late 1800s (Bregan 1964). Sagebrush was converted into farmland by many homesteaders, though it is unknown how much of the study area was affected. By 1920, most of the farmers had left, often selling their land to neighboring ranchers (Bureau of Land Management 1993). Central Oregon was better suited to stock raising than farming, so many ranchers stayed. Much of the sagebrush conversion for agricultural purposes ceased by mid-1960.

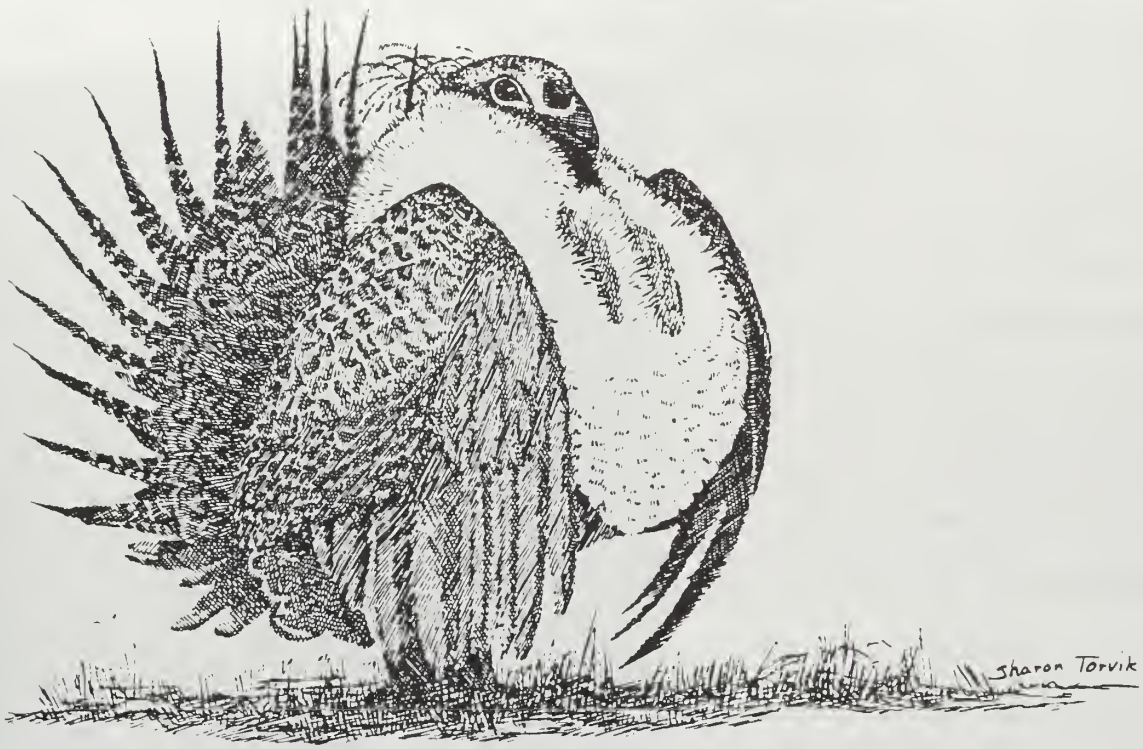
Grazing still occurs on much of the study area, with a variety of grazing systems used, including deferred grazing, deferred rotation, rest rotation, short duration/ high-intensity, and winter grazing. Active grazing preference on the 19 BLM allotments within the study area is 30,280 AUMs. Actual/licensed use during the study period was 24,330 AUMs in 1988, 31,700 AUMs in 1989, 24,400 AUMs in 1990, 24,190 AUMs in 1991, 15,320 AUMs in 1992, and 13,370 AUMs in 1993. Grazing use in specific allotments ranged from total non-use to 240% above active preference. Period of use for most of the allotments was spring (April-June) or spring-summer (April-September). However, there are a few allotments that were normally grazed in the fall-winter (October-March).

Recreational uses were also prevalent on the study area. Off-highway vehicle (OHV) use occurred on 22,000 ha in the western portion of the study area, where it overlaps with the BLM Millican Valley OHV Area. The OHV area is divided by U.S. Highway 20 and seasonal use restrictions differ on the north and south sides. The south area was closed from March 15 to August 31 to protect sage grouse strutting areas and to reduce erosion of loose soils. The north area was closed from December 1 to March 14 to restrict use in crucial deer winter range. Competitive OHV events also occurred on this area during the same periods as casual use. During the study period (1988-1993), from 6 to 9 competitive events (motorcycle, vehicle, horse) occurred each year, with 349 - 869 participants per year.

Other important recreational activities on the study area include hang-gliding, which occurred off the north and south sides of Pine Mountain, and hunting for species such as mule deer, antelope, elk, and jackrabbit. Sage grouse were hunted on the study area in the Wagontire and Paulina units (see ODFW hunting regulations) during the study period, except in 1991-1993, when the Paulina unit was not hunted.

A variety of other activities have taken place on the study area, such as residential development, wildfires, mining, and juniper and sagebrush control projects.

Section 1 - Lek Counts and Population Estimate



Introduction

The lek, or strutting ground, is the hub of year-round sage grouse activity (Eng and Schladweiler 1972, Wallestad and Pyrah 1974, Wallestad and Schladweiler 1974), with most male sage grouse attending leks sometime during the breeding season (Emmons and Braun 1984). Due to this fact, censusing of males on strutting grounds can be used to determine the estimated number of males in a given area (Patterson 1952, Bibby et al. 1992). A population estimate can be derived using the highest yearly count from each lek. Yearly information can be used to monitor long-range trends in male survival, which may suggest changes in the condition of sage grouse habitat (June 1963).

Methods

BLM biologists counted leks with assistance from Oregon Department of Fish and Wildlife (ODFW), from 1988 to 1993. A minimum of three counts per lek was obtained during peak lek attendance for the years 1989 to 1993 (Patterson 1952, Jenni and Hartzler 1978). Lek counts conducted in 1988 were less intensive, with one count made per year on several leks. Also, several leks had not been located in 1988. For these reasons, lek data from 1988 is not included in any statistical analyses.

There were 14 known leks on the study area in 1988. Radio telemetry and aerial surveys were used from 1989 to 1993 to locate 6 new leks within the study area. We are confident that all leks in the study area were located through these intensive searches. Strutting grounds were counted from first light and watched for fifteen to thirty minutes. Longer periods of time were spent on leks that were difficult to get to. Sage grouse counts were made from a vehicle with binoculars and spotting scopes. Leks that were close together were counted on the same day to account for movement between leks.

Highest male counts from all leks were combined annually to determine the estimated number of males within the study area. It was assumed that 90% of the birds present were being counted (Jenni and Hartzler 1978). Additional birds were added to the number counted to compensate for the 10% of the birds that were assumed to be missed. A 40:60 male/female sex ratio, developed from ODFW harvest data, was then used to develop a population estimate for the study area (Patterson 1952, Rogers 1964). This estimate was only calculated for 1992 and 1993 because these were the only years for which all leks in the study area were identified and counted. Counting all leks is a prerequisite for using lek data to get a population estimate.

The average number of males per lek was calculated for all leks and all years to look for trends in the number of males attending leks. Only the averages calculated for the 14 leks that had no gaps in the data from 1989 to 1993 (Table 1) were used in statistical analyses. Including the data from the remaining 6 leks would have resulted in a weak statistical analysis (See Appendix 1).4

Table 1. The highest count of males on each lek surveyed, on the Deschutes Resource Area, BLM, Deschutes and Crook counties, Oregon, 1988 to 1993.

LEK	1988	1989	1990	1991	1992	1993
1. MILLICAN	50	39	27	25	26	24
2. EVANS WELL	9	15	9	5	6	6
3. MOFFIT RANCH	34	26	16	16	17	12
4. THE GAP	1	4	2	4	4	3
5. DICKERSON WELL	4	1	0	0	0	0
6. WHISKEY SPRINGS	12	18	11	7	16	14
7. SPICER FLAT	NA	25	24	14	12	10
8. LITTLE MUD LAKE	NA	7	11	4	5	1
9. SQUAW LAKE	NA	7	15	14	12	10
10. THE ROCK	33*	18	30	27	22	28
11. AUDUBON	24	12	15	10	7	5
12. GOVERNMENT WELL	10	1	7	2	0	0
13. DRY RIVER	5*	5	4	0	0	0
14. CIRCLE F	0*	27	28	28	16	8
15. JAYNES WELL	0	0	0	0	0	0
16. SOUTH WELL	NA	NA	NA	17	12	7
17. WEST BUTTE	18	9	NA	2	2	3
18. MERRIL ROAD	NA	NA	NA	NA	21	15
19. TODD WELL	1*	28	NA	31	26	19
20. IRELAND FLAT	NA	NA	NA	NA	13	21
TOTAL	**201**	**242**	**199**	**206**	**220**	**185**
MALES/LEK	14.4	14.2	13.3	11.4	11.0	9.3

*ONLY ONE COUNT PERFORMED
NA NUMBER OF BIRDS NOT AVAILABLE

NOTE: The shaded area represents 14 leks used to determine trend in the number of males per lek from 1989 through 1993.

Results

Lek Counts

Lek activity was documented as early as 1 March and as late as 1 May. In 1988, 14 leks were monitored. Six new leks were located over the next 4 years; 17 leks were monitored in 1989, 15 leks were monitored in 1990 (2 identified leks were not monitored due to access problems), 18 leks were monitored in 1991, and 20 leks were monitored in 1992 and 1993.

The average number of males attending all 20 monitored leks dropped from 14.4 males per lek in 1988 to 9.3 males per lek in 1993 (Table 1). For the reasons mentioned above, it could not be determined if this was a statistically significant difference. On the 14 leks that were statistically analyzed, the average dropped from 14.6 males per lek in 1989 to 8.6 males per lek in 1993 (Fig. 2). This 42% reduction over five years is a statistically significant decline in the number of males per lek (REGRESSION ANALYSIS P=0.0001). Total number of males counted also declined over this period.

Sage grouse were observed being flushed off leks by livestock and people. In instances when birds were flushed before a reliable count had been taken, an additional count was made on another day.

Population Estimate

Using a 40:60 male to female ratio, and assuming that 90% of the birds present were being counted by lek counts, population estimates were calculated for 1992 and 1993. The estimated population size for these years was 611 and 514 birds, respectively.

Discussion

Population estimates for this study were based on lek counts of male sage grouse. Because a relationship between lek counts and population size has not been determined (Beck and Braun 1980) lek monitoring may not be as reliable a measure of population trends for sage grouse as monitoring which focuses on hens and chicks. However, in this area, brood routes did not produce enough sightings to allow for population estimating. Lek counts are presently the best information available in this area.

Many researchers believe that lek counts produce an accurate population estimate. Patterson (1952) and Bibby et al. (1992) feel that censusing of males on strutting grounds can be used to determine the total number of males in an area, if all leks are being counted. Jenni and Hartzler (1978) think that peak numbers of males can be estimated to within 90% by taking the highest of 3 counts.

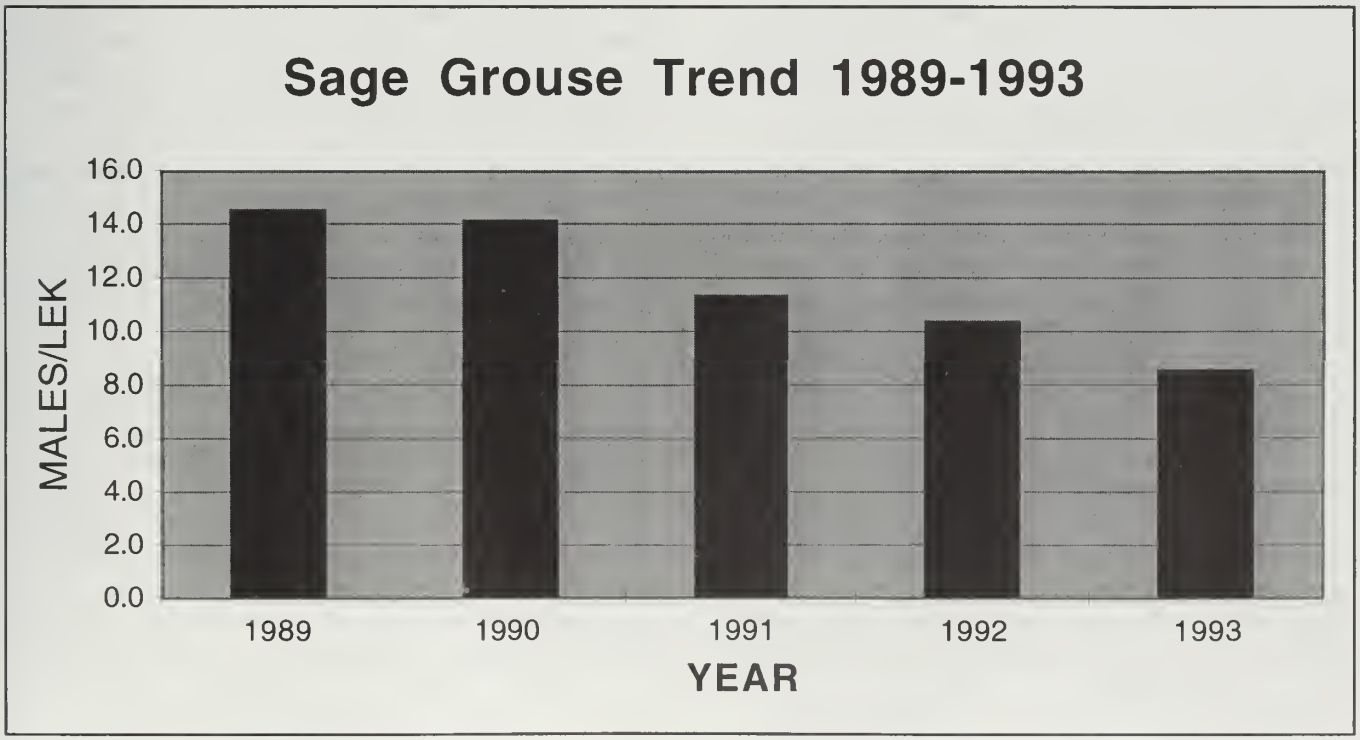


Fig. 2. Trend in males per lek, 1989-1993, Prineville District, BLM.

Braun (Colorado Division of Wildlife, pers. comm., 1994) after reviewing the data from the current study, feels that we are more likely only counting 70% of the male population. However, biologists from the current study feel that 90% of the males were being counted. The reasons for this assumption are that 1) all leks were being counted, 2) the average lek counts on this study area are smaller than in other areas, making them easier to count, 3) the number of strutting birds at a lek during peak activity was consistent from count to count, and 4) birds were watched leaving leks in several instances and the number of birds that flew off the leks was the same as the number that had been counted strutting. Also, in some cases, a lek area was walked after birds had left to locate birds that may not have been visible. In most cases, birds were not located.

The results of this study show a definitive decline in the average number of males per lek on the 14 leks analyzed and suggest a decline in total bird numbers. Some leks which historically supported breeding sage grouse are now abandoned, with some leks being abandoned within the current study period. Although new leks were also located during the study, it is felt that these were newly discovered leks, not newly formed leks.

Current sage grouse numbers on the study area are low compared to historic numbers in this area and in other parts of Oregon, and compared to sage grouse numbers from other states. These numbers indicate that this population of sage grouse is at risk of extirpation (extinction in a limited area). This is not an isolated population, but loss of birds here would result in a further reduction of the range of sage grouse in Oregon. Sage grouse counts conducted by ODFW since 1950 from 4 leks on the study area, show that the number of males per lek averaged 62 in 1950 and 30 in 1960, compared to 11 males per lek recorded on the same four leks in 1993. The average number of males per lek in 1993 for the 14 leks statistically analyzed was 8.6 males per lek. The average for all 20 leks in 1993 was 9.3 males per lek. Less than 15 males per lek were recorded for every year of the study period. In the 1940s and 1950s, the average number of males per lek in Oregon was estimated at 36 and 44 respectively (Crawford 1982b), while in Colorado, Rogers (1964) reported an average of 30 males per lek. Braun (1991) considers leks with less than 50 males to be marginal, and feels that in areas with such small populations, management needs to be intensified to ensure the existence of the population. Braun (Colorado Division of Wildlife, pers. comm., 1994) also has said that populations with less than 4 birds per square kilometer are at risk of extirpation. Within our study area, there is less than .4 bird per square kilometer. However, Braun makes his calculations based solely on occupied habitat, while we used occupied and potential (currently unoccupied, but suitable) habitat, which we feel is more appropriate. Braun (1994) also has said that he considers populations with greater than 500 birds to be persistent. The population sizes estimated for this study were 611 birds in 1992 and 514 birds in 1993. Although these estimates are above Braun's criteria for a persistent population, they are close to this level, and further point out the risk that this population faces.

It may not be realistic to expect sage grouse numbers on this study area as high as seen in other states, due to habitat differences, lower reproductive rates, and the prolonged drought that occurred in Central Oregon for most of the study period. However, based on historic grouse numbers on the study area (Appendix 2), we would expect the population to be at higher levels than it is.

There are several factors that could be causing the decline in sage grouse. Many researchers (Rogers 1964, Martin 1970, Wallestad 1975b, Braun et al. 1977, Call and Maser 1986) have reported that practices which remove sagebrush around a lek can cause population declines or even abandonment of the lek. In Montana, Wallestad (1975b) reported that a 31% loss of habitat adjacent to a lek coincided with a 63% decline in strutting males at that lek. As mentioned earlier, sagebrush surrounding leks is crucial to strutting birds for food and cover. Habitat alteration around leks was not specifically studied here, but it is possible that such alterations may be the cause of the abandonment of certain leks.

Another possible cause of the decline in sage grouse numbers is degradation of nesting, brood or winter habitat. In Wyoming, a sagebrush control project on sage grouse winter range reduced the population of sage grouse from greater than 1000 sage grouse to zero in four years (Higby 1969). Similar control projects in Idaho led to the cessation of nesting on an area sprayed the year the study was conducted (Klebenow 1969b). Other areas in Klebenow's study that had been sprayed up to 5 years previously showed almost no use by nesting birds. Sagebrush control, including spraying, burning, crested wheatgrass plantings, and agricultural land conversions, has occurred on over 32,000 ha of the current BLM study area within the last 35 years. Sagebrush has grown back in some of the sprayed areas.

Another factor that can affect sage grouse habitats is grazing. Several studies have addressed this issue. Autenrieth (1973) found that livestock competition with broods on wet meadows negatively affected some sage grouse populations in Idaho. Klebenow (1982), working in Nevada, found that heavily grazed meadows in poor condition were avoided by sage grouse broods. In Autenrieth's study, livestock were removing forbs before the arrival of broods on the meadows. Klebenow found that loss of cover due to heavy grazing was causing the avoidance of these areas. Other biologists share this opinion that grazing can be detrimental to sage grouse.

Braun (1992, letter of 19 March) feels that the biggest threat to sage grouse continues to be overgrazing by domestic livestock and management of rangelands for livestock. Sixty-five BLM biologists surveyed for the Fish and Wildlife 2000 Upland Game Bird Strategy Plan (1992), most frequently reported that livestock grazing impacts to riparian and upland habitats, and management in support of livestock were the primary reasons they perceived for the decline in sage grouse. However, Klebenow (1982) found that dense grassy meadows that had been grazed lightly or moderately were attractive to sage grouse, and Evans (1986) found that sage grouse broods used grazed meadows more frequently than ungrazed meadows on the Sheldon National Wildlife Refuge in Nevada. Evans thought that broods were attracted to these areas due to forb regrowth stimulated by grazing. Grazing occurred on the current BLM study area at the levels described in the Study Area section of this report.

Another possible factor in the decline of sage grouse is nest and brood predation. During the late 1950s and 1960s, when coyote and raven populations in Oregon were suppressed with 1080 poisonous baits, sage grouse indices (chicks/adult, chicks/hen, grouse/16 km) rose (Willis et al. 1993). The use of 1080 was ended in 1972, and declines in sage grouse productivity since then may be due in part to increases in coyote and raven populations. In recent years, all studies on nesting sage grouse in Oregon have shown a high incidence of predation during nesting and early brood rearing (Willis et al. 1993). However, it is generally thought that while predation is an immediate cause of poor reproduction, the underlying cause is poor habitat condition, which leaves birds more vulnerable to predators (Braun 1994, Crawford and DeLong 1993, J. Connelly, Idaho Fish and Game, pers. comm.,1993). Predation rates on our study area were comparable to that found in other areas and are discussed more fully in Section 3 of this report. No information is available on predator control on the study area.

As mentioned in the methods, high counts from each lek were used in the analysis of sage grouse numbers, as is suggested in the literature (Patterson 1952). However, it was observed that a few males frequently moved between neighboring leks. By using the highest count from these leks, we may be counting some birds twice.

Section 2 - Precipitation and Lek Counts

Introduction

Sage grouse researchers have suspected a correlation between sage grouse abundance and precipitation, but little information exists on the subject. Patterson (1952) speculated that sage grouse population cycles were related to precipitation, but he did not present any data to support this hypothesis. Rich (1985) found a correlation between weather variables and population size, but none of the variables were useful in predicting population size. Finding a correlation between precipitation and sage grouse numbers would be helpful in interpreting yearly fluctuations in sage grouse population numbers.

Methods

Precipitation data from 1959 to 1993 was gathered from the Climatological Survey of Oregon for the Brothers weather station, located in the center of the study area. Precipitation from crop year (October - June) and water year (October - September) was compared with lek numbers gathered from 4 leks on the study area during the same time period. Correlations were considered significant at the P=0.10 level. Data from 1959-1987 was collected by ODFW and BLM, and data from 1988-1993 was collected by BLM for this study. The 1959-1987 lek counts had only one observation for each lek and this observation was used in the analysis. Three or more counts were obtained from 1988-1993 and the highest count was used in the analysis. All leks were within 12.8 km of the Brothers weather station. Lek data from 1950 to 1993 for the same four leks was examined to look for evidence of a population cycle. (See Appendix 2.)

Results

Average lek counts were positively correlated with precipitation from the previous year's water year and the crop year of two years ago. In other words, the number of males on leks in 1994 is influenced by the amount of precipitation in the 1991-92 crop year (P=0.09) and the 1992-1993 water year (P=0.004). Using water year and crop year together produced a stronger relationship with bird numbers than when analyzed separately.

A graph of sage grouse numbers over time (Fig. 3) reveals that population fluctuations in this area are cyclic. Population highs have steadily declined since the 1950s. The last population peak was reached in 1988.

Discussion

The results of this study suggests that sage grouse numbers are influenced by the precipitation received in the previous 2 years. Precipitation most likely affects sage grouse numbers by influencing the production of forbs and herbaceous cover at nests. High levels of precipitation in the winter lead to an increased availability of forbs in the spring. Availability of forbs, a more nutritious food than sagebrush, during the breeding season may influence reproductive success of female sage grouse (Barnett and Crawford 1992). For ruffed grouse, it has been suggested that it is the physiological condition of the bird prior to nesting that determines its productivity and, subsequently, the current season's production (Gullion 1970). Also, forbs are an important part of the sage grouse chick's diet. Increased precipitation also will lead to greater growth of shrubs and grasses, resulting in better nesting cover and, possibly, increased nesting and brooding success. Either of these situations could result in an increase in the adult population 1 to 2 years later.

Autenrieth et al. (1982) believed that cold, wet weather during the nesting period could reduce chick survival, and would therefore be correlated with sage grouse numbers. We found no correlation between precipitation during the nesting season and abundance of sage grouse. However, precipitation during much of the study period was less than the historical average for this area.

The data presented here show that sage grouse numbers in this area are cyclic (Fig. 3). Rich (1985) found a 10-year cycle for sage grouse in Idaho, Utah and Nevada. Time between population highs on the BLM study area ranged from 7-15 years. Rich found precipitation variables to be correlated with lek counts and thought that precipitation may be involved in the cycling of populations. The data collected in this study also suggests that precipitation plays a role in the cycle. However, it is widely accepted that weather variables alone are not sufficient to cause populations to cycle (Lack 1954, Bergerud 1970, Watson and Moss 1979); other factors are probably involved as well. A statistical model to predict sage grouse numbers based on precipitation and other factors is currently in development using the data collected as described in the Methods for this section.

The recognition of a population cycle has important implications to research and management of sage grouse. Evaluations of population health, population responses to habitat changes, and critical habitat are often based on the size of the population. When a population cycle exists, the year in which data is collected is important. Accurate descriptions of habitat and population health may require many years of data (Rich 1985).

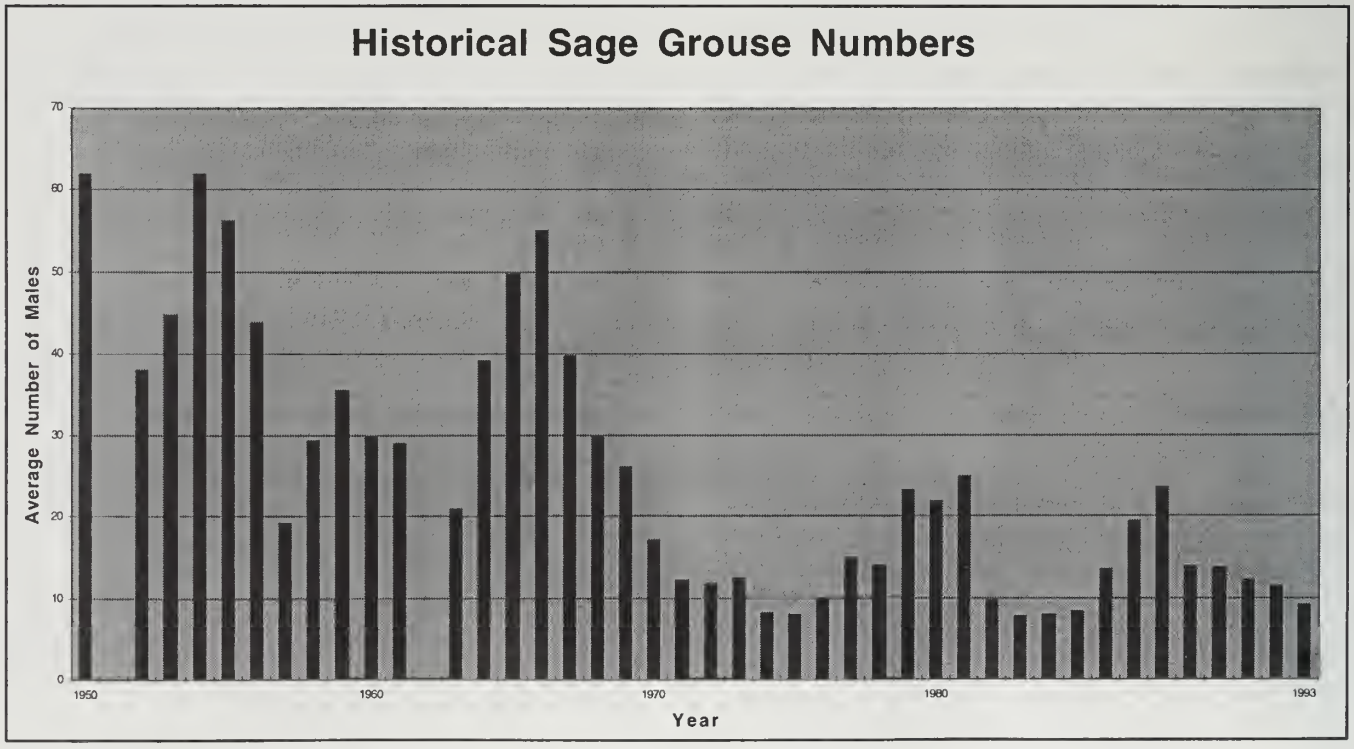


Fig. 3. Historic lek counts representing the average number of males per lek at four sites, Prineville District, BLM, 1950-1993.

Section 3 - Nesting Habitat and Reproductive Success

Introduction

Quality of nesting habitat is one of the most important factors in the success of sage grouse populations. A primary function of nesting habitat is the protection of the hen and her nest from predation, which is the primary factor influencing sage grouse nesting success in Oregon (Batterson and Morse 1948, Nelson 1955). While predation may be the most immediate cause of nest failure, the underlying cause may be a lack of adequate cover at nests. This would make the nest easier to see and, therefore, more vulnerable to predation (Gregg et al. 1994). To properly manage the nesting habitat, we need an understanding of what habitat types sage grouse are selecting at this time and how this selection is affecting the success of their nests. This is also true of brood habitat. Previous studies of summer habitat use by sage grouse have shown that sagebrush and forbs are essential components of brood habitat (Wallestad 1971, Drut et al. 1994) and that broods require a variety of habitat types during the brood rearing phase (Wallestad 1971, Dunn and Braun 1986). Typical brood habitat identified in earlier studies is not prevalent on this study area, so observations were needed on broods to determine which habitat types were being used. Radio-telemetry was used in this study to help answer these questions.

Methods

Radio Telemetry

Trapping and Radio-Marking

Sage grouse were captured periodically between spring 1991 and spring 1993 and fitted with a poncho-mounted 23g solar powered radio transmitter with nicad batteries (Amstrup 1980) Birds were fitted with numbered leg bands, which were used to help identify recaptured birds. Birds were trapped on leks in 1991 and on summer, fall and winter roosting areas in 1992 and 1993. Net guns, spotlights and long handled nets were used to capture sage grouse, using methods described by Giesen et al. (1982). The spotlighting technique was used most frequently with 50 of 52 of the sage grouse captured with this method. The remaining 2 birds were captured using a hand held net gun. The sex and age of the birds were determined at the time of capture.

Monitoring Radio-Marked Sage Grouse

Habitat use by sage grouse was determined year round by locating radio-marked hens using a hand-held directional antenna and portable receiver. Flights from fixed winged aircraft with a wing-mounted antenna were used periodically to locate birds. Hens were monitored two to three

days per week during the spring (15 March to 15 June) to determine location, movement, cover type use, and nest site locations.

Radio-marked hens that produced a successful brood (n=3) were monitored two to three times weekly until the first week of August. All locations were recorded with respect to bird frequency, date, time, township, range, section, quarter section, UTM coordinates, number of birds with the radio-marked bird, weather condition, and habitat type at the location site.

Nine cover types were defined based on dominant shrubs and grasses (Table 2) and marked on study area topographic maps. Ground verification of cover types was made at each location site of radio-marked grouse. Habitat availability was determined (km^2 and %) and the location and range of available habitat cover types were displayed on a study area map (Fig. 4).

Vegetation Measurements

Nesting and Brood Rearing Habitat Components

Vegetation measurements were taken at 20 nests and at 40 randomly selected locations. Random locations were distributed throughout the study area and were selected by randomly generated UTM coordinates. Measurements at random locations were used to compare available habitat types to sage grouse nesting sites.

Table 2. Description of cover types on the Deschutes Resource Area, BLM, Deschutes and Crook counties, Oregon 1991 to 1993.

COVER TYPE	COVER TYPE DESCRIPTION
Mountain big sagebrush (MBS)	Common throughout the area on varied soil types. Primary vegetation consist of mountain bigsagebrush (*A. t. vaseyana zericensis*), associatedwith understory grasses of Idaho Fescue (*Festuca idahoensis*), bottlebrush squirreltail (*Sitanion hystrix*), and needlegrass (*Stipa* spp.)
Mountain shrub (MS)	Occurs in deep sandy or pumice soils bordering forested areas of Ponderosa pine (*Pinus ponderosa*). Dominated by mountain big sagebrush (*A. t. vaseyana zericensis*), and antelope bitterbrush (*Purshia tridentata*), supporting understory grasses of Idaho Fescue (*Festuca idahoensis*), and needlegrass *Stipa* spp.).
Low Sagebrush (LS)	Found on shallow clay soils near drainages or scabrock flats. Primary vegetation of this cover type is low sagebrush (*Artemisia arbuscula*), supporting understory grasses of Idaho Fescue (*Festuca idahoensis*), needlegrass (*Stipa* spp.), and sedge (*Carex* spp.).
Grassland (GRA)	Natural grasslands and areas disturbed by fire. Sagebrush cover of <5 percent. Primary plant types are Idaho Fescue (*Festuca idahoensis*), bluebunch wheatgrass (*Agropyron spicatum*), bottlebrush squirreltail (*Sitanion hystrix*).
Silver sagebrush (SS)	Occurs in drainages and depressions that support water during winter and spring months. Primary vegetation of this cover type is silver sagebrush (*A. cana bolanderi*), mat muhly (*Muhlenbergia richardsonis*), and sedge (*Carex* spp.).
Juniper/MBS (JUOCMBS)	Found on exposed ridges and side slopes in deep sand or rocky soils. Dominate vegetation consist of western juniper (*Juniper occidentalis*), mountain big sagebrush (*A. t. vaseyana zericensis*), with understory grasses of Idaho Fescue (*Festuca idahoensis*), bluebunch wheatgrass (*Agropyron spicatum*), bottlebrush squirreltail (*Sitanion hystrix*).
Juniper/LS (JUOCLS)	Found on shallow clay soils near drainages or scabrock flats. Primary vegetation consist of western juniper (*Juniper occidentalis*), low sagebrush (*Artemisia arbuscula*), supporting understory grasses of Idaho Fescue (*Festuca idahoensis*), and sedge (*Carex* spp.).
Basin big sagebrush (BBS)	Occurs in drainages and dry lake basins. Primary vegetation consist of basin big sagebrush (*A. t. tridentata*), needlegrass (*Stipa* spp.), and sedge (*Carex* spp.).
Ponderosa pine (PIPO)	Occurs on deep sandy or pumice soils associated with areas receiving >30 cm of moisture. Primary vegetation consist of Ponderosa pine (*Pinus ponderosa*), mountain big sagebrush (*A. t. vaseyana zericensis*), antelope bitterbrush (*Purshia tridentata*), associated with understory grasses of Idaho fescue (*Festuca idahoensis*), and bottlebrush squirreltail (*Sitanion hystrix*).

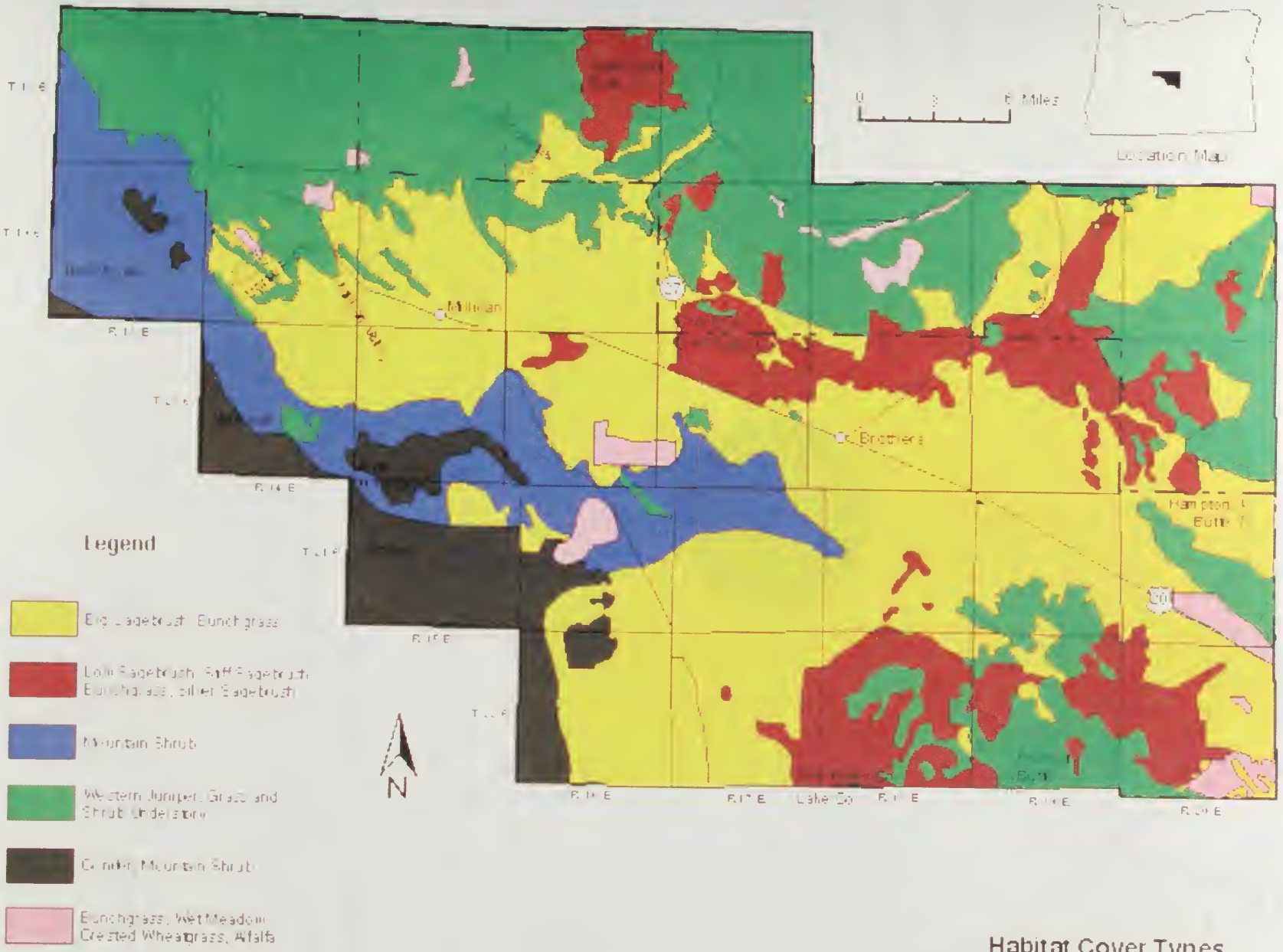


Fig. 4. Habitat Cover Types, Prineville District, BLM.

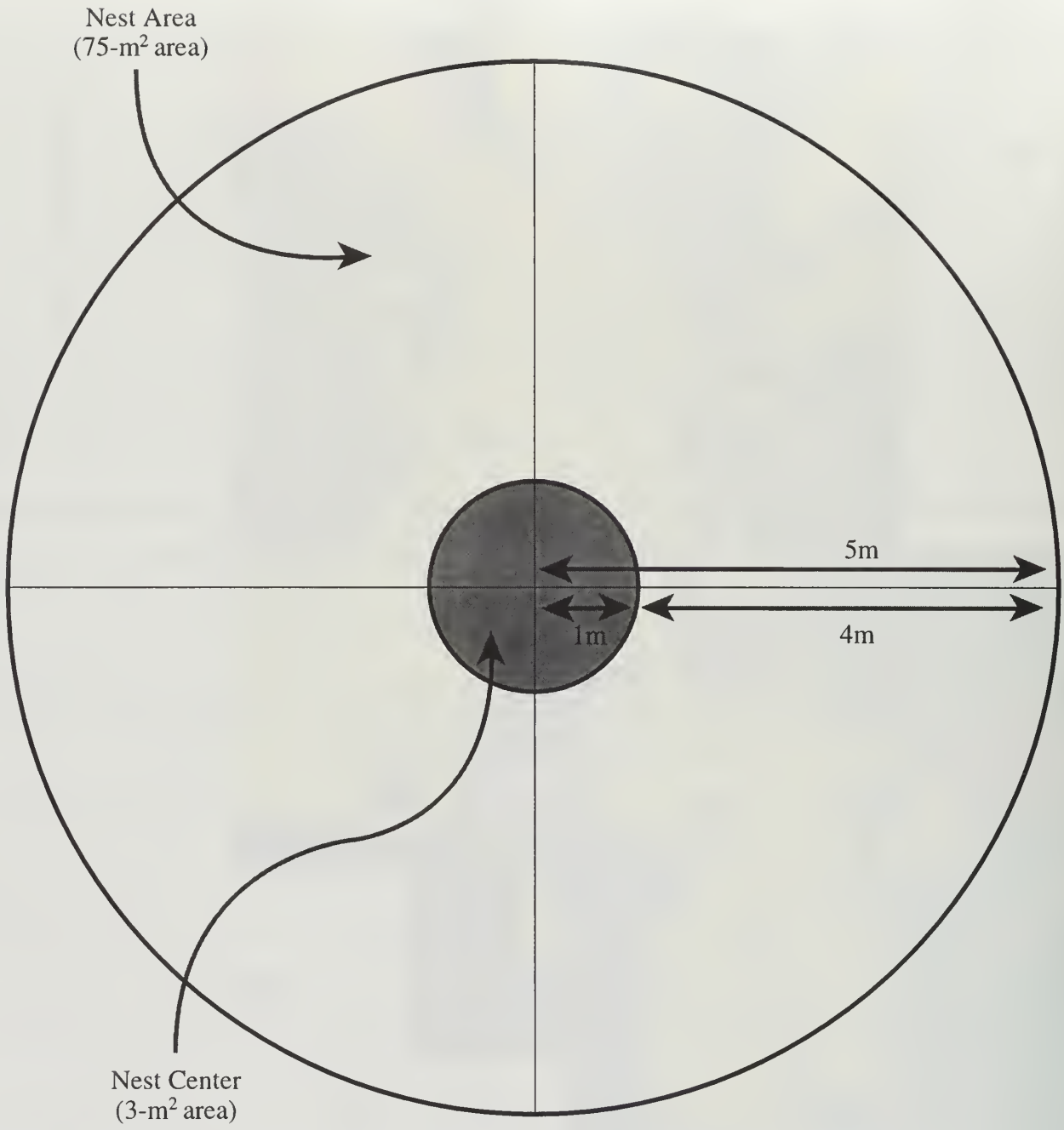


Fig. 5. Nest plot (78m²) is used to measure vegetative characteristics at nest sites and random locations. The nest center (3m²) is the center of the nest or nest bowl, and the nest area (75m²) that surrounds the nest center.

The following habitat characteristics were measured at nests and random sites: percent cover of shrubs, grasses, forbs, litter and bare ground; height of shrubs; frequency of herbaceous vegetation; and horizontal cover. Two 10m perpendicular transects intersecting at the nest center were arranged forming a 78m² area with a 5m circular radius (Fig. 5) (Gregg et al. 1994). Canopy cover of all shrubs was recorded along each transect using the intercept distance (cm) method (Candfield 1941). Height of each shrub intercepted was measured and classified into three classes: low (0-40 cm), medium (40-80 cm) and tall (>80 cm). Grass and forb cover were also measured along each transect using Daubenmire plots (Daubenmire 1959). Values taken at the nest center were averaged to represent cover there, while the rest of the measurements were averaged to represent cover within the nest area. Comparisons of all measured habitat variables were made between nest sites and random sites and between successful and unsuccessful nests using a Kruskal-Wallis test (See Appendix 3).

Hens that had established nests were monitored two to three times per week. If a hen was more than 500 m from her nest, the nest was checked for evidence of hatching,

predation or abandonment. If nesting was concluded due to any of these causes, vegetation measurements were collected immediately. Nest fate was determined, with a nest considered successful if at least one chick hatched. Vegetation measurements were taken on all nests within three days of hatching, predation or abandonment.

Vegetation measurements were taken at brood locations using the same procedure as described for nesting habitat. Due to small sample sizes, statistical comparisons between brood habitat use and availability would not be valid and, therefore, were not made.

Results

Nesting and Brood Rearing Success

Nesting success information was obtained from 28 radio-marked hens from 1991 through 1993 (Table 3). An additional 12 hens were monitored, but no information could be gathered due to death of the hen, inability to locate the bird, or radio failure.

During the three seasons, 19 of 28 (68%) monitored hens initiated nesting activity by beginning a nest (Table 3). The remaining nine hens were not observed nesting. These birds may have started and abandoned a nest before they were located. Seven of these birds remained alone for several days and then joined other non-nesting hens, while the other two remained alone for most of the summer.

Nest success was consistent over the three years of study, with an average of 30% (6/20) nest success (Table 3).

Sixty-five percent of the nests (13/20) were predated, with ravens (*Corvus corax*) and coyotes (*Canis latrans*) being the primary nest predators. Badgers (*Taxidea taxus*) were responsible for the loss of 2 nests. No information is available on predator numbers on the study area during the study period. During the 3 years of the study, 1 nest was abandoned and 1 renest attempt was made. Three of the six (50%) successfully nesting hens produced a successful brood, which was defined as a brood from which one chick was recruited into the August population.

Habitat Components

Nesting

Habitat component measurements were collected from 20 nests and 40 random sites. Sage grouse nested in 4 of 9 available cover types within the study area (Table 4). Habitat use by nesting hens differed significantly from habitat availability (Log likelihood ratio test, P=0.01) (Appendix 3); however, it could not be statistically determined which habitat types were being selected for or avoided. Most of the nests (60%) were established in the mountain big sagebrush cover type, which was also the most available cover type (64%). Fifty percent of the successful nests were in this habitat type. Thirty-five percent of nests occurred within the mountain shrub and grassland cover types, which comprised only 3 percent of the available habitat. Only one nest occurred in the low sagebrush cover type (Table 4). Ninety-five percent (19/20) of the nests were under medium-height sagebrush and the remaining nest was under medium-height currant.

Vegetative characteristics at nests and random locations differed. Nest centers had taller grass ($\bar{x}$ = 22 cm; Kruskal

Table 3. Reproductive status of radio-marked sage grouse hens during the nesting and brooding period (March-August), on the Deschutes Resource Area, BLM, Deschutes and Crook counties, Oregon, 1991 to 1993.

	Total Live Hens	Nests Initiated	Renest Attempts	Nest Unsuccessful	Nests Successful	Brood Success
1991	5	4	0	3	1	0
1992	12	6	0	4	2	1
1993	11	10	1	7	3	2
Total	28	20	1	14	6	3

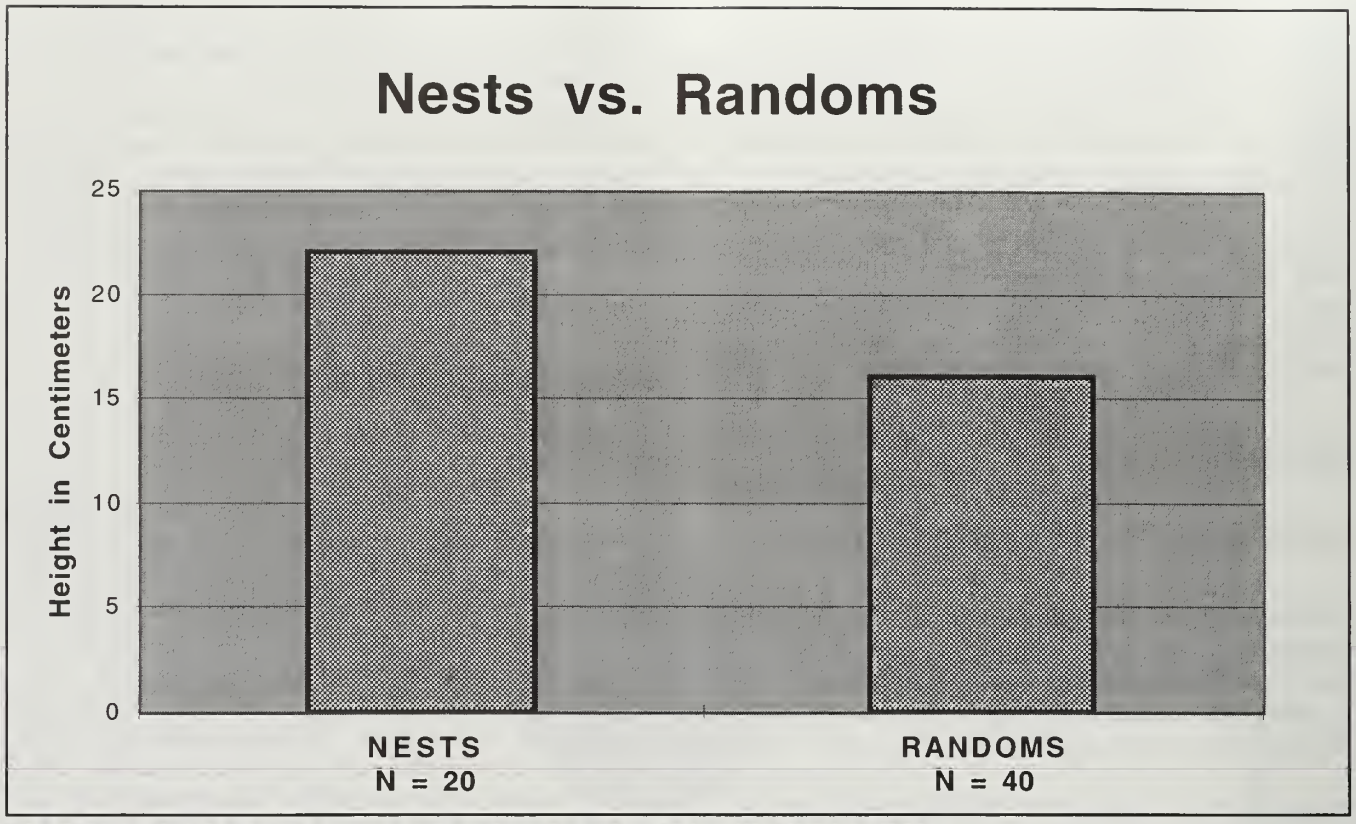


Fig. 6. Grass height at sage grouse nests and random plots, Prineville District, BLM.

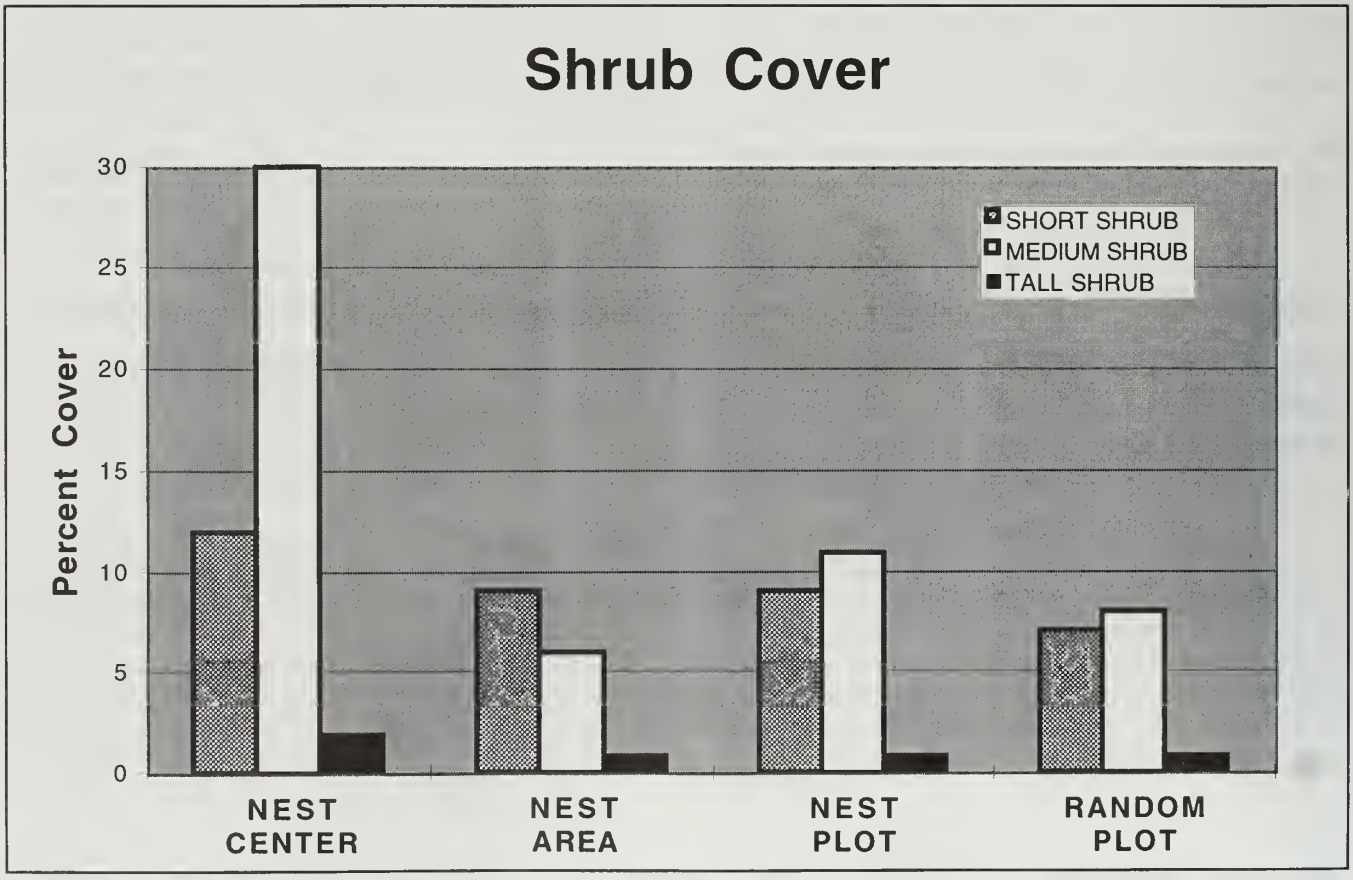


Fig. 7. Shrub cover at sage grouse nests and random plots, Prineville District, BLM.

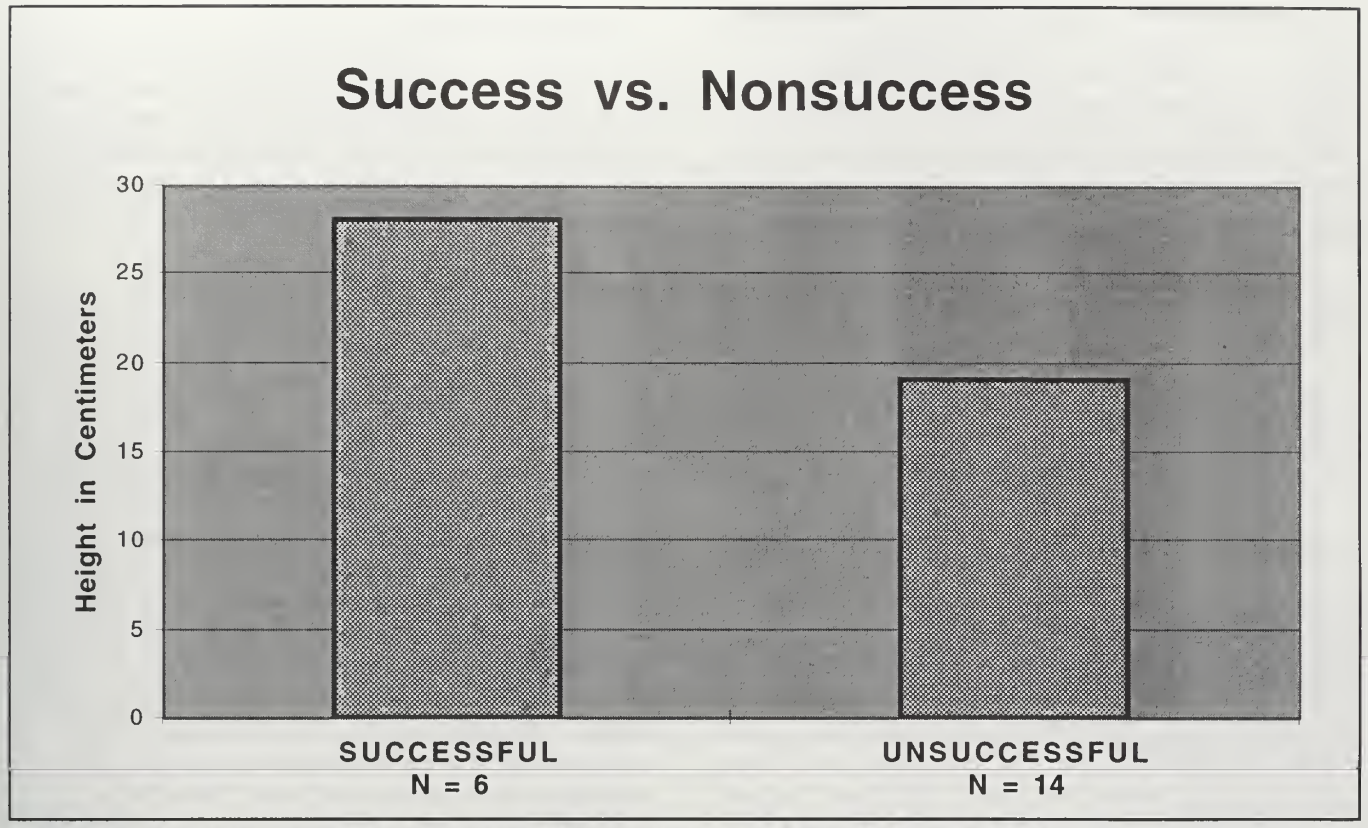


Fig. 8. Grass height at successful and unsuccessful sage grouse nests, Prineville District, BLM.

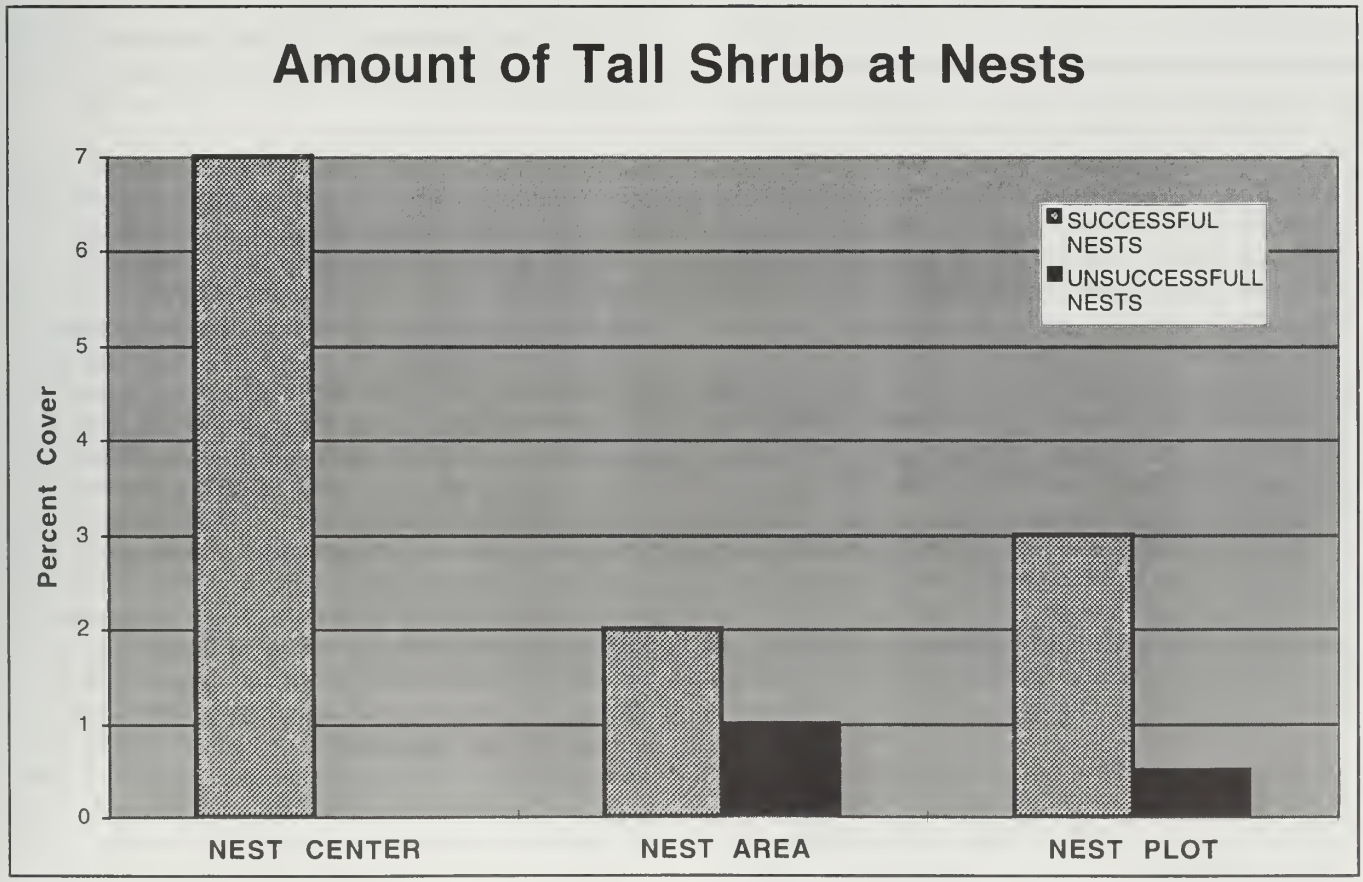


Fig. 9. Tall shrub cover at successful and unsuccessful sage grouse nests, Prineville District, BLM.

Table 4. Cover types, cover types available, and percent of nests (n = 20) in cover types used by radio-marked sage grouse hens on the Deschutes Resource Area, BLM , Deschutes and Crook counties, Oregon, 1991 to 1993.

Cover type	% Available	% of Nests
Mountain big sagebrush	64	60
Mountain shrub	2	25
Grassland	1	10
Low sagebrush	9	5
Juniper/Mountain big sagebrush	20	0
Juniper/Low sagebrush	2	0
Silver sagebrush	1	0
Basin big sagebrush	<1	0
Ponderosa pine	<1	0

Wallis, P=0.088)(Fig. 6) and greater medium shrub (40 - 80 cm; Kruskal Wallis, P=0.0021) and total shrub cover (Kruskal Wallis, P=0.0001) than did random sites. Total shrub cover was significantly greater at nest plots than at random sites (Kruskal Wallis, P=0.012) (Fig. 7) (Appendix 3).

Habitat characteristics at successful and unsuccessful nests also differed. Nest centers of successful nests had significantly taller grass ($\overline{x}$ = 28 cm; Kruskal Wallis, P=0.001) and more tall shrub cover (>80 cm; Kruskal Wallis, P=0.001) than the nest centers of unsuccessful nests. The nest area of successful nests had significantly more tall shrub cover (Kruskal Wallis, P=0.033) than the nest area of unsuccessful nests. In the nest plot, the amount of tall shrub cover was significantly greater at successful nests than at unsuccessful nests (Kruskal Wallis, P=0.012) (Fig. 8 and 9) (Appendix 3).

All of the nests monitored were within 12.9 km of the nearest lek. Fifty percent of the nests were within 8.0 km of the nearest lek and 25% of the nests were within 3.2 km of the nearest lek.

Brood Rearing

Forty-six observations were made on three broods from 1991 to 1993. Observations were made in 3 habitat types: mountain big sagebrush, mountain shrub and grassland. Eighty-three percent (38/46) of the observations were in the mountain big sagebrush habitat type.

Discussion

Nesting

Nest success on the BLM study area (30%) was low compared to areas in Idaho and Wyoming, but high when compared with recent studies in southeast Oregon. In Wyoming, Patterson (1952) found nest success on his two study areas to be 52.4% and 38.4%. In Idaho, Autenrieth (1981) reported a nest success of 61% on the portion of his study area that had the best nest cover. Recent studies in southeast Oregon show lower success rates. Crawford et al. (1992) reported an average nest success of 15% at Hart Mountain National Antelope Refuge (HMNAR) and Jackass Creek, both in southeastern Oregon, during the same years our study was conducted (1989-1992). Crawford and DeLong (1993), also working at HMNAR, reported a nest success of 20% in 1992. Nesting success in Oregon may be low due to a combination of poor habitat conditions (habitat degradation, fringe of sage grouse range), habitat loss, recent drought, and high raven populations. Ravens were primary nest predators on our study area.

Information on predation rates on sage grouse nests from other study areas suggests that our predation rates are average. We reported that 65% of nests were predated, with 93% of failed nests being the result of predation. Patterson (1952) found that in Wyoming, 33% of nests in an agricultural area and 59% of nests in an undeveloped semi-desert area were predated. He felt the lower predation rate in the agricultural area was due to the loss of some mammalian predators due to agricultural development. Crawford and Delong (1993), working in Southeast Oregon, found that 71% of artificial nests were predated and that 96% of nest failure was attributable to predation. Predator species in Southeast Oregon were similar to those found on our study area, with coyotes, ravens, badgers and ground squirrels being the primary predators. Crawford and Delong (1993) also reported that differences in predation rates between areas were attributable to differences in vegetative cover. This supports the idea that while predation is an immediate cause of nest failure, lack of appropriate nesting cover is the underlying cause. This point is also supported by Braun et al. (1994) and Connelly (Idaho Fish and Game, pers. comm., 1993) who have both said that when good quality habitat exists in large blocks, predation is not a problem for sage grouse.

One nest was abandoned during the study period. The abandoning hen was the only yearling that nested during the study period. Yearling hens do not nest as frequently as adult hens (Connelly 1993) and are more prone to nest abandonment (Autenrieth et al. 1982). This yearling was flushed off the nest once, but it is not known if this contributed to her abandonment of the nest.

Only one unsuccessful hen in this study renested, a renesting rate of 6% for the study period. Renesting rates for sage grouse are typically low, with both Patterson (1952) and Eng (1963) reporting renesting rates of <10%. However, higher rates have been reported. Connelly (1993) found a 15% renesting rate in Idaho and Petersen (1980) found that 41% of unsuccessful hens in North Park, Colorado renested. Crawford et al. (1992) found renesting rates at HMNAR and Jackass Creek, Oregon to be 10% and 11% respectively. Renesting rates on our study area may be low due to poor nutrition caused by drought during the study period. If the hens are not getting adequate nutrition, they may not be in good enough condition to renest. This is supported by Barnett and Crawford (1994) who found that consumption of forbs during the pre-laying period may affect reproductive success by improving the nutritional status of hens. Low renesting rates may also be due to the breakup of leks by early summer (Eng 1963).

Hens that did not nest or were unsuccessful nesters gathered in summer and fall areas. Thus, these areas are not only important during the summer and fall months, but are used by this segment of the population during the spring months, as well.

Results of this study indicate that sage grouse hens selectively choose habitat types for nesting. Although tests could not be conducted to statistically determine which habitat types were being selected or avoided, certain habitat types seem to be important. The mountain big sagebrush type contained 60% of all nests and 50% of the successful nests. This habitat type is prevalent on the study area. However, half is in an early (8%) or mid-seral (42%) stage (from Range Sites developed by SVIM and SCS surveys, 1978 and 1979), which is not optimum for nesting (Hall 1985). Also important is the mountain shrub habitat, which contained 25% of the nests, though it made up only 2% of the available habitat.

Within a plant community, grass height and shrub cover were important determinants of nest success. Taller grass was found at nest sites than at random sites and successful nest sites had taller grass than unsuccessful sites. Medium and tall shrubs were also recurrent components of successful nest sites. These results are consistent with results from previous studies, which noted the importance of medium height sagebrush (Patterson 1952, Nelson 1955, Gill 1965, Gray 1967, Klebenow 1969a, Wallestad and Pyrah 1974, Peterson 1980, Schoenberg 1982, Crawford et al. 1992) and a herbaceous understory (grasses and forbs) to nest success (Gregg 1991, Crawford et al. 1992).

An important conclusion from these results is that habitat structure is as important to nest success as plant composition. This conclusion was also made by Crawford et al. (1992) who suggested that use of mixed sage communities by nesting hens at Jackass Creek, Oregon was due to the structurally diverse nature of this habitat type. They also found that greater amounts of residual tall grass cover and medium shrub cover at nest sites reduced the probability of predation. Grazing by domestic livestock is one factor associated with the amount of residual grass cover found at a site (Crawford et al. 1992). Grazing that occurs just prior to nesting (winter and early spring) has the most immediate effect on residual cover; adequate herbaceous cover should be left for concealment of nests.

Distances from nest sites to the nearest lek were similar to that found in other areas. Gill (1965), Wallestad and Pyrah (1974) and Autenrieth (1976, unpubl. data) each found that all nests were within 12.9 km of the nearest lek, as did we. The similarity between our study and Autenrieth's (Idaho Dept. of Fish and Game,1976, unpubl. data) continues in that both found 50% of nests to be within 8.0 km of a lek, and 25% of nests to be within 3.2 km of the nearest lek. This contradicts the findings of early researchers that most nests occur within 3.2 km of the nearest lek. These early assumptions were based on populations in areas where grouse could find most of their requirements in a small area. Other populations need to range farther to find suitable nesting areas. This is seen on our study area at the Millican lek, where good nesting habitat is not found surrounding the lek. Most of the hens bred here nested greater than 3.2 km (3.2 - 12.8 km) from the lek. It is possible that hens nested closer to this lek in the past when habitat conditions were more suitable. This is supported by the fact that one hen did nest within 2 miles of the Millican lek during the study period. It is possible that part of the population that used to nest close to the lek has been lost due to habitat alterations. Female sage grouse show strong nest site fidelity (Gates 1983, Fischer et al. 1993). Thus, those birds that nested close to the lek would return there, even if their success was low. Eventually, this segment of the population would not replace itself and would be lost.

Additional analysis of nest placement with respect to leks is needed using leks where quality nesting habitat is found close to the lek to allow for the comparison of the behavior of these birds to those at Millican lek.

Brood Rearing

Most of the brood observations were found in the mountain big sagebrush habitat type, which was also important to nesting hens. This underscores the importance of this

habitat type, and the importance of preserving and improving it, as was discussed in the nesting discussion of this section.

Broods in this study moved only short distances (< 3.2 km) while they were monitored. This suggests that broods met all of their requirements in a small area, suggesting that these locations provide good brood rearing habitat. As discussed in the life cycle section of this report, good brood rearing habitat has open sites for feeding, with adequate amounts of forbs and insects, and small areas of dense sagebrush for roosting. Forbs were abundant at brood sites in this study and included small-flowered blue-eyed Mary, microsteris, Oregon sunshine, everlasting, milk-vetch , buckwheat, desert parsley, lupine, monkey flower, and phlox.

Section 4 - Summer Diet

Introduction

Studies throughout sage grouse range have documented that sage grouse are solely dependent upon sagebrush from October through April (Girard 1937, Rasmussen and Griner 1938, Bean 1941, Patterson 1952, Leach and Hensley 1954, Nelson 1955, Klebenow and Gray 1968, Savage 1969, Martin 1970, Peterson 1970, Oakleaf 1971). During the spring, the sage grouse diet shifts primarily to forbs, which are very important to pre-laying hens and broods. Sage grouse consume fewer forbs and more shrubs as summer forbs begin to dry, but little is known about the exact composition of the summer diet. Patterson (1952) found summer diets to be 45% sagebrush by volume, while Martin (1970) reported that sagebrush comprised 34% of the summer diet of sage grouse in Montana, with forbs constituting most of the remaining 66%. Patterson (1952) found that a few insects were present in the crop throughout the warmer months (April to October). In Oregon, Batterson and Morse (1948) found that the summer diet of sage grouse consisted mostly of alfalfa leaves, dandelion, clover, wild mustard and insects. To help clarify summer food requirements for sage grouse in this area, a summer diet study was initiated on the Prineville District BLM study area.

Methods

Adult sage grouse hens were collected from two habitat types (a lakebed mountain big sagebrush/Idaho fescue habitat type at Van Lake, and a drier mountain big sagebrush/needlegrass habitat type with pumice soils in Kotzman Basin) during mid-June, mid-July, mid-August, and mid-September 1992. These habitat types were chosen to compare diets in typical summer habitat, as represented by the Van Lake site, with that of a less typical type, as represented by the Kotzman Basin site. Kotzman Basin is characterized by pumice soils and supports a large concentration of birds. Five birds were collected at Van Lake and 3 at Kotzman Basin over the 4 months. Hens were collected during the evening to ensure a full crop. Hens were aged and weighed, and their crops were extracted. Plants and insects eaten by the sage grouse were identified to genus and species. Vegetation measurements were taken at each collection site using the 78-m^2 plot (Fig. 5), to describe the foraging area and identify available plants. Crops were frozen immediately to preserve contents and were transferred to Oregon State University (OSU) for chemical nutrient analysis. Key foods eaten by female sage grouse, for which samples equalling 0.75 grams in dry weight could be obtained, were analyzed for levels of crude protein using the Kjeldahl procedure.

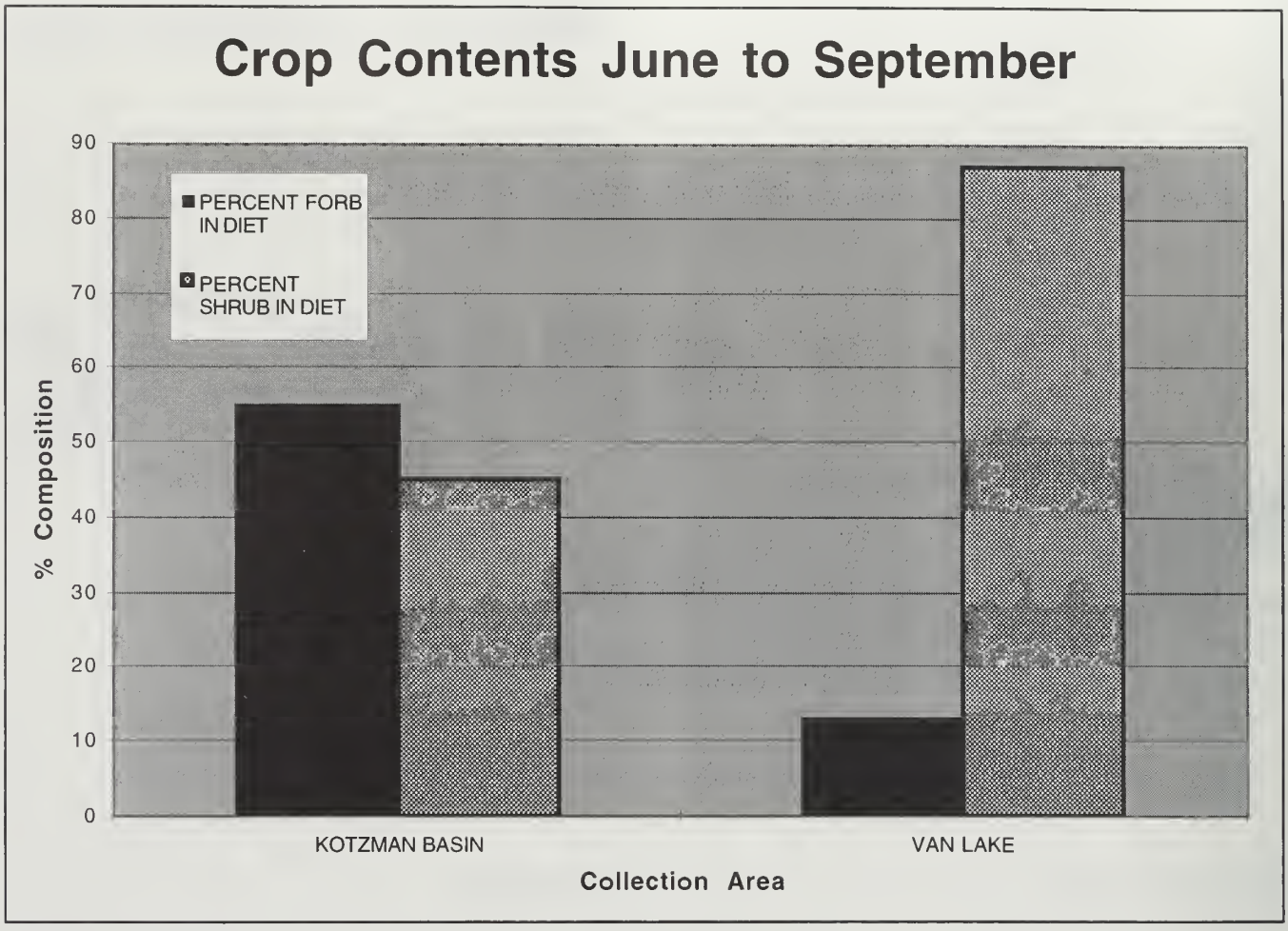


Fig. 10. Sage grouse crop contents, 1992, Prineville District, BLM.

Results

The crop composition of all 8 hens was nearly 100% plant material. Ants were occasionally found in crops, but made up less than 1% of the contents of any crop. Plants most abundant in crops were mountain big sagebrush (leaves and galls), green rabbitbrush, Oregon sunshine, mustard, locoweed, phlox, western yarrow and paintbrush. Big sagebrush and rabbitbrush made up 57% of the combined crop contents of all 8 birds. No grasses were found in crops.

At Van Lake, 5 types of forbs were eaten, but they made up only 13% of the crop contents of the 5 birds combined. The remaining 87% was shrub. At Kotzman Basin, only 1 forb, Oregon Sunshine, was found in the crops, but this forb made up 55% of the combined crop contents of the 3 birds (Fig. 10).

Rabbitbrush contained the highest amounts of crude protein (21.9%) and calcium (1.5%) of any of the plants found in crops. Sagebrush leaves and galls and Oregon sunshine leaves all contained approximately 12.5% crude protein.

Discussion

The feeding habits of the two groups of birds studied was noticeably different, but it is unclear whether these differences are due to selection or availability. In Kotzman Basin, where Oregon Sunshine made up over half the diet, no other commonly eaten forb was available in large numbers. Oregon Sunshine (Family *Compositae*), never described in sage grouse diets before, grows in the moisture-retaining pumice soil that is characteristic of Kotzman Basin. Sage grouse may be selecting for this forb in Kotzman Basin, which could help explain the congregation of birds there during the summer and fall. Nutritionally, there does not appear to be much benefit from choosing Oregon Sunshine over sagebrush, for both have the same levels of crude protein (12.5%). However, Oregon Sunshine may be more palatable or have a higher moisture content than sagebrush, making it a more attractive food. Additionally, there may be an unknown nutritional value gained from consuming this forb. Currently, little is known about the nutritional requirements of sage grouse, making it difficult to determine why

certain foods are eaten and whether these foods are meeting the nutritional needs of the sage grouse. It has been shown that sage grouse selectively choose foods with high nutrient content, especially high protein values. Remington and Braun (1985) found that sage grouse fed primarily on the subspecies of sagebrush containing the most protein, fed at sites where the preferred subspecies of sagebrush contained more protein, and fed on individual plants within subspecies that had the highest protein levels. Barnett and Crawford (1994) reported that pre-laying hens selectively ate forbs over sagebrush. These forbs were higher in crude protein and phosphorous than the sagebrush and eating them improved the nutritional status of the hens. Female ruffed grouse and ptarmigan that obtain high nutrition diets in spring produce larger clutches and larger, more viable chicks (Beckerton and Middleton 1982, Hanssen et al. 1982). Diets with high protein content may be important to the reproductive potential of female sage grouse.

Due to the low number of birds used for the diet study, these results are only preliminary and may not represent the diet of all sage grouse in this area. Also, this study was conducted in a low precipitation year. Diet samples should also be collected in a wetter year to ensure an accurate description of the sage grouse diet.

Section 5 - Water Developments

Introduction

Artificial water developments have been suggested as a method for enhancing sage grouse summer range (Autenrieth 1981, Autenrieth et al. 1982) and ODFW has suggested such a plan for Central Oregon. However, little information exists about sage grouse use of free water. The information that exists is contradictory, with some researchers suggesting that sage grouse do not require free water (Trueblood 1954, Nelson 1955), and others saying they do require water during the dry summer and fall (June 1967). It is well documented that sage grouse move into green meadows and lakebed habitats during late summer and early fall, bringing them close to water holes (Patterson 1952, Klebenow and Gray 1968, Klebenow 1969a, Savage 1969). Whether the water holes are used, or are incidental to use of these areas for forbs, is not clear.

Even less information is available on sage grouse use of artificial water developments than on their use of natural water sources. In Southeast Oregon, Batterson and Morse (1948) investigated the use of developed and undeveloped water sources by sage grouse and learned that sage grouse used undeveloped water sources 62.5% more than developed sources. A better understanding of sage grouse use of water developments would help land managers determine the usefulness of proposed water developments.

Methods

Sage grouse use of water developments was studied between 1 August and 1 October 1991. Use of water developments was assessed for both radio-marked and unmarked sage grouse.

Water developments were located 2 weeks prior to surveying. Four types of sources were identified: drink pools, guzzlers, dugouts and troughs. Water developments were selected for surveying based on accessibility to sage grouse. To assess use by unmarked grouse, water developments were visited one hour before sunrise and monitored until approximately one-half hour after sunrise. Observations were made from a vehicle with binoculars and a spotting scope at a distance of 90 m. To assess use by radio-marked sage grouse, marked hens were located with radio telemetry equipment one hour before sunrise and monitored until approximately one-half hour after sunrise. The location of each bird was marked on a topographic map and distance (km) to the nearest water source was estimated.

In addition, habitat cover type was recorded at radio-marked hen locations. The number of water sources within each cover type was used to investigate the relationship between habitat use and water source distribution (#/ km^2).

The mean distance of radio-marked hens to the nearest water development was determined. For each radio-marked hen location, a randomly selected point was chosen and the distance was estimated to the nearest water source. The mean distance to water of radio-marked hens was compared to the mean distance to water from random locations to determine if hens were concentrating near water sources.

Results

Sage grouse (n=8 radio-marked birds, n=364 unmarked birds) drank water from all types of water developments studied. Troughs were used significantly less than drink pools, guzzlers or dugouts (Chi-Square, $P<0.01$) (Table 5).

The mean distance to water of radio-marked sage grouse (=1.1 km, n=28 locations) was significantly shorter than for randomly chosen locations (=5.1 km, n=28 locations) (Unpaired t-test, $P<0.01$).

The silver sagebrush cover type, which contained the highest density of water sources per area (7.52/km^2), received no use by radio-marked birds, but did receive use by unmarked birds (n=101). The cover types used by radio-marked birds all had water source densities of between 0.0 and 0.17 water sources/km^2.

Discussion

Free water is important to sage grouse on this study area during the summer and fall months. In 1992, a dry year (precipitation levels 25% below average, January-June), sage grouse began using free water in early June, and by late August were concentrated in areas near water sources. Dugouts and wildlife guzzlers provided most of the free water, but birds were using any available water source. The lower use of troughs is probably due to their relative inaccessibility. Troughs are more difficult for sage grouse to use due to their height and so are generally avoided. Troughs that are sunken may be easier for sage grouse to use.

Sage grouse use of water developments will be influenced by precipitation levels during the year studied. Birds will be more likely to use water developments during dry years, such as 1992, than during a year when precipitation is high and natural water sources are more abundant. A longer study than the one conducted here is necessary to account for use differences between years with varying precipitation levels.

The mean distance to water of radio-marked grouse was significantly shorter than for randomly chosen locations, suggesting that sage grouse were concentrating near water sources. However, radio-marked birds did not use the silver sagebrush habitat type at all, though this type had the highest density of water sources. The small number of observations made on radio-marked hens (n=8 birds, x=28 observations) and the small amount of silver sagebrush may explain the lack of observations in this habitat type. The high mobility and large home ranges of sage grouse hens could further explain the scarcity of observations of radio-marked females using free water. Another explanation could be that females need less water than males. Although all of the radio-marked birds were female, most of the unmarked birds seen using water developments were male. This physiological difference between males and females, if it exists, would help to explain this discrepancy.

Table 5. Use of water developments by sage grouse during summer on the Deschutes Resource Area, BLM, Deschutes and Crook counties, Oregon (August-September) 1991.

Water Source type	Sources (n=14)	No. Visits (n=38)	Water Used	#Birds	Birds/ Observation
Drink Pool	3	17	6	142	23.7
Guzzler	5	13	4	122	30.7
Dugout	3	5	3	101	33.7
Trough	3	3	1	1	1.0

Section 6 - Winter Habitat

Introduction

Wintering areas are particularly important to sage grouse because the birds are completely dependent on sagebrush for food and cover during the winter (Patterson 1952, Call and Maser 1986). Sage grouse seem to have specific preferences for wintering areas. Studies have shown that sage grouse prefer dense stands (≥20% canopy cover) of low sagebrush (avg. height 25 cm) (Eng and Schladweiler 1972) and that they prefer certain species of sagebrush (Remington and Braun 1985, Welch et al. 1991). Also, during winter, sage grouse may use less than 10% of the sagebrush dominated lands in an area (Beck 1975). Because of this, wintering areas are a major factor determining sage grouse distribution. Elimination of winter range habitat would reduce sage grouse populations over large areas (Eng and Schladweiler 1972). This portion of the study was conducted to locate wintering areas and to determine the habitat types and shrub densities being used by wintering sage grouse.

Methods

Radio-tagged hens were monitored during the day (0900-1500) two days per week during the winters (15 November to 15 March) of 1991-92 and 1992-93 to determine winter habitat use.

Measurements of canopy cover and shrub height were taken from winter observation sites. At each flush site, three 15-m transects were arranged in parallel at 10-m intervals. The intercept distances of all species of shrubs along each transect were recorded to determine canopy coverage. Height of each shrub intercepted was measured and classified as either low (0-40 cm), medium (40-80 cm), or tall (>80 cm). The three transects were then averaged to determine the shrub canopy for the site. The number of birds using each site was also recorded to determine extent of use for a particular habitat type. Habitat use by birds at night was noted by biologists who were trapping grouse in the area, but habitat measurements were not taken.

Results

During the winter of 1991-92, radio-tagged birds used 5 habitat types, with mountain big sagebrush and low sage used most frequently. In 1992-93, only mountain big sage and low sage types were used by radio-tagged birds, with 50 of 51 (98%) observations made in the mountain big sagebrush habitat type (Table 6). During both winters, birds used the higher canopy cover (≥20%) areas on the study area. However, they tended to use patches within these areas that had less dense cover (12-16%) than the surrounding area.

Table 6. Winter habitat use by sage grouse on the Deschutes Resource Area, BLM, Deschutes and Crook counties, Oregon 1991 to 1993.

HABITAT TYPE	YEAR 1 #OBSERV.	YEAR 1 COVER	YEAR 1 #BIRDS	YEAR 2 #OBSERV.	YEAR 2 COVER	YEAR 2 #BIRDS
Mountain Big Sagebrush	24	12%	196	50	13%	698
Low Sagebrush	20	15%	311	1	16%	15
Silver Sagebrush	4	17%	49	0	0	0
Grassland	2	4%	33	0	0	0
Bare ground/Rabbitbrush	2	1%	14	0	0	0
TOTAL	**52**		**603**	**51**		**713**

Discussion

Sage grouse distribution was more clumped during the winter of 1992-93, which was a more severe winter than 1991-92. Snow was on the ground for 3-4 months during the winter of 1992-93 and accumulated up to a depth of 1.2 m. Plants that would be used for food and cover were under snow and therefore inaccessible to sage grouse. This would explain the movement of sage grouse out of low sage and into mountain big sagebrush habitat types, where plants would still be accessible. Millican Valley was especially important to sage grouse during the severe winter. Millican Valley does not accumulate as much snow as surrounding areas due to its lower elevation and rain shadowing by Horse Ridge. Twice as much snow accumulated in nearby Brothers (approx. 1.2 m) during the winter of 1992-93 than in Millican Valley (40-55 cm). Millican Valley was less crucial during 1991-92, when birds could use low sage areas.

During this study, winter grazing occurred on some sage grouse use areas. High intensity winter grazing can lead to damage of sagebrush, especially in years of heavy snow (Call 1974). If such use occurred on sage grouse winter use areas, sage grouse may have difficulty in obtaining sufficient forage (Call 1974). This would be especially true in severe winters, when the areas available to sage grouse are already limited. It is not known if winter grazing had an affect on sage grouse during this study.

During both winters, birds used the higher canopy cover (≥20%) areas on the study area, but tended to use less dense patches within these areas (12-16%). Past research has indicated that wintering birds prefer stands with a canopy cover of ≥20% (Eng and Schladweiler, 1972). However, the 20% canopy cover reported by Eng and Schladweiler (1972) was the average canopy cover used by birds in that study. The range of canopy cover used was 6.4-53.9%. The shrub cover used by the birds in this study fell well within this range. Although habitat measurements were not taken at nighttime observation sites, the birds appeared to be using the same areas at night that they used during the day.

Sage grouse congregated in large groups during the winter. This was especially true during the winter of 1992-93, when the same number of observations yielded 110 more birds than in 1991-92 (Table 6). However, it is unknown if any birds were counted more than once.

Section 7 - Seasonal Use Areas/Movements

Introduction/Methods

Much of this report has been spent describing habitat use by sage grouse males, hens, and broods. As has been mentioned previously, sage grouse use different habitats at different times of the year. These seasonal use areas and the corridors connecting them are important in the management of this population. For example, Beck (1975) found that during winter, sage grouse may be restricted to less than 10% of the sagebrush-dominated lands in a given area. This makes maintenance of these areas essential if the population is to be retained. In Montana, Peterson (1970) found that a lek which had averaged 54 males for 13 years dropped to 3 males within 2 years following spraying and since has been totally abandoned. To ensure that important habitats are not lost, seasonal use areas must be identified. Using radio telemetry data from this study, important seasonal use areas have been mapped, along with important and unusual movements. Seasonal use areas were defined based on over 1000 radio locations.

Results

Several locations on the study area were important as seasonal use areas for radio-marked and unmarked birds. Seasonal use areas identified through radio-marked birds are mapped in Fig. 11. One of the most important use areas was Millican Valley. This area was important to birds year round. As many as 59 males strutted on two leks that were located here, and several hens nested within 12.8 km of these leks. After breeding, many Millican birds left the area, moving to a variety of areas, such as West Butte, Kotzman Basin, Pine Mountain, and Horse Ridge. In the winter, birds from many areas moved into Millican Valley. Dense areas of big sagebrush and lower snowfall than surrounding areas make Millican Valley good winter habitat. During the winter of 1992-93, Millican Valley was especially important due to heavy snowfall in the surrounding area. Snow cover forced birds out of low sage areas into big sage areas where food was still accessible above the snow. More than 100 birds wintered in Millican Valley that year.

The Dry River was also important to sage grouse year-round. Sage grouse are probably attracted to the area by the low sage that runs the length of the drainage. Sage grouse commonly use low sage areas for brood rearing and prefer to eat low sage in the winter when it is available above the snow (Hall 1985). Sage grouse in this area were known to breed, nest, raise broods, and winter along the Dry River. Seven of the 20 leks monitored in this study were found along the Dry River; these leks supported approximately 60-100 males per year. Several hens nested near these leks. Radio-marked birds that wintered here were often together with large groups of unmarked birds.

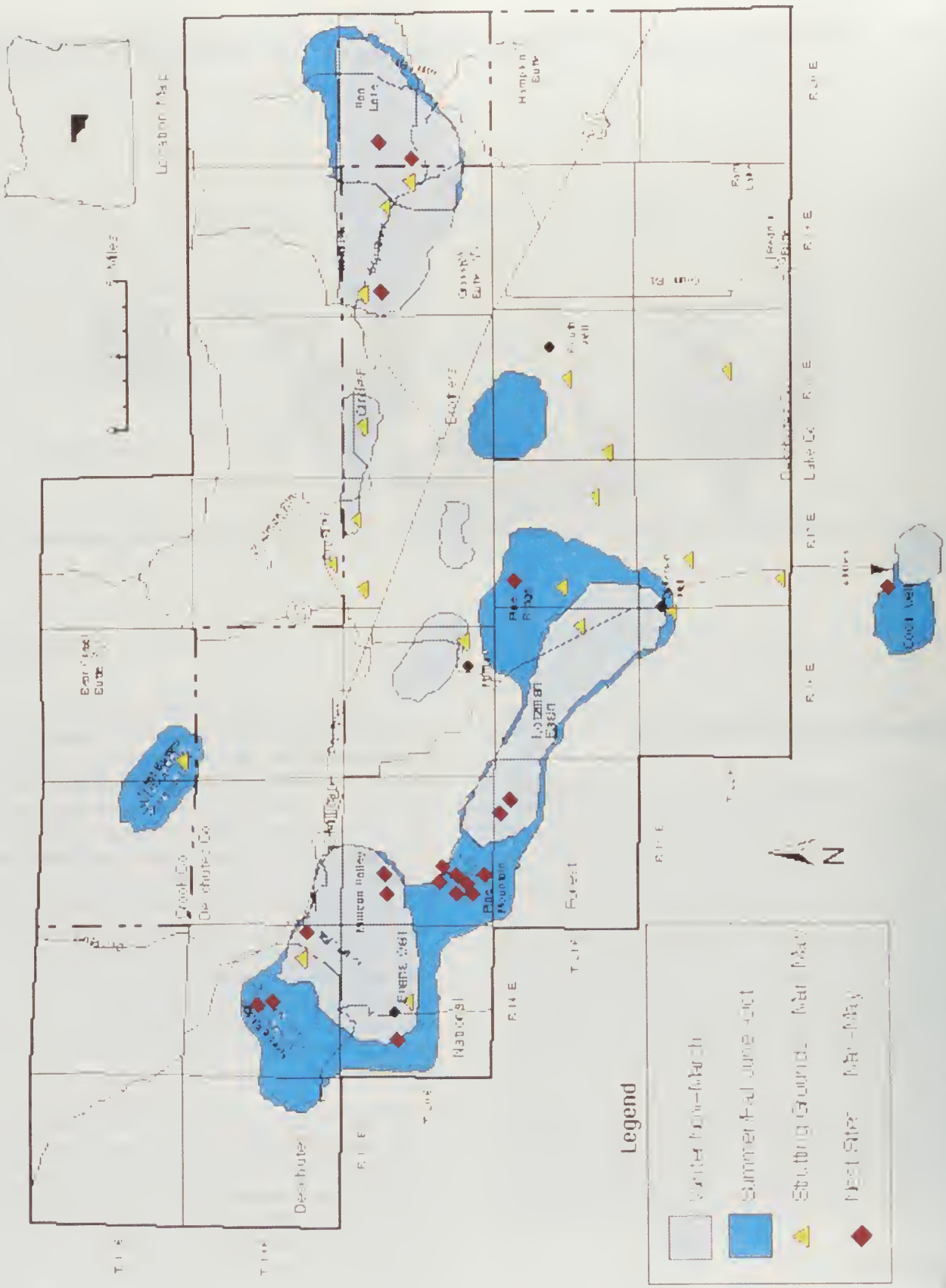


Fig. 11. Sage Grouse Seasonal Use Areas, identified through radio marked bird locations, Prineville District, BLM, 1991 to 1993.

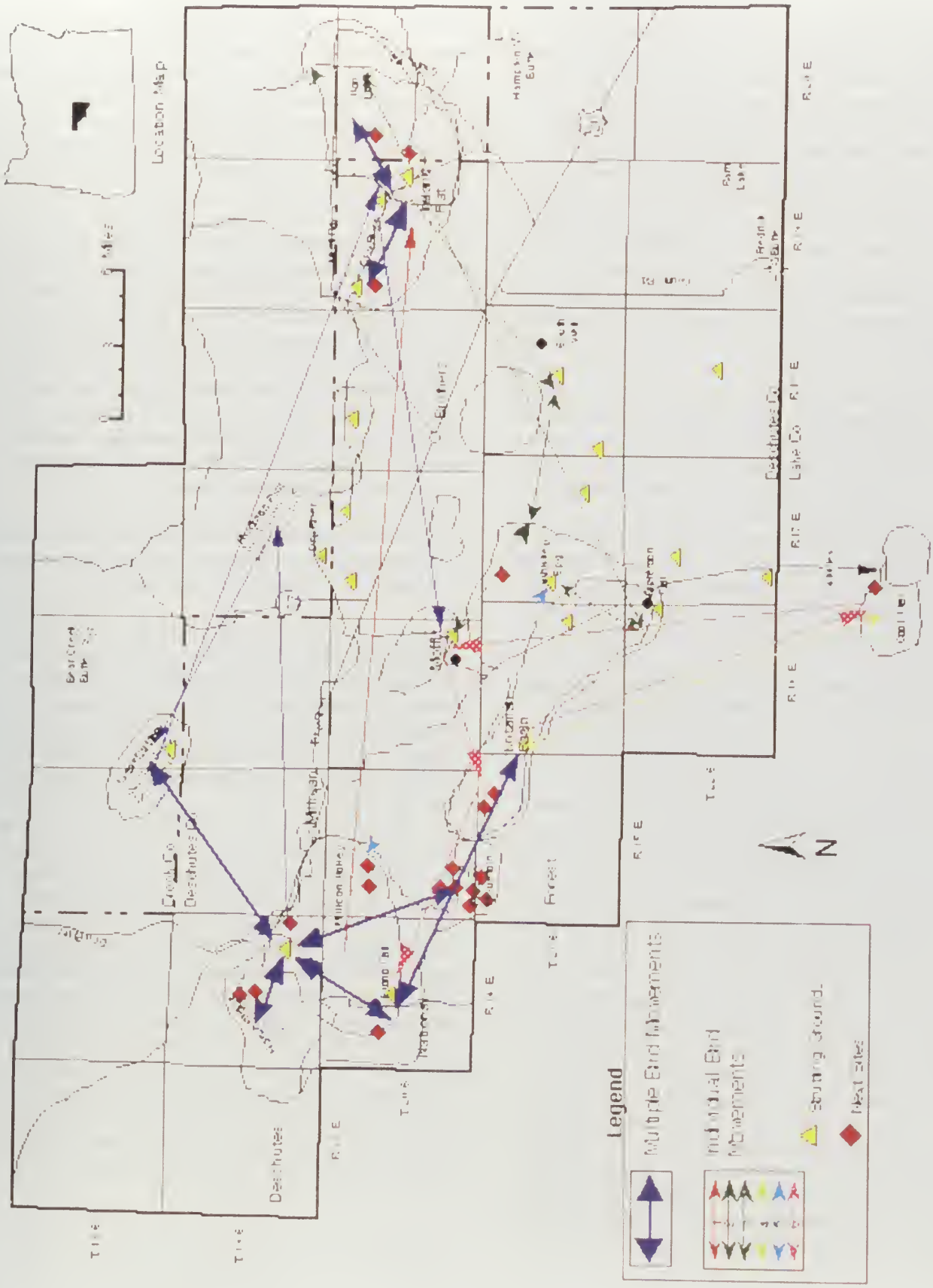


Fig. 12. Sage Grouse Movement Patterns, identified through radio marked bird locations, Prineville District, BLM, 1991 to 1993.

Van Lake was a significant summer and winter use area. Twenty one radio-marked birds used Van Lake during the study period. They were probably drawn to the area for its sagebrush component and its high diversity of forbs. Radio-marked birds began using Van Lake during late May. As the summer progressed, more birds began to gather here for brood rearing, with as many as 150 birds present by August. Many birds came to Van Lake from breeding areas along Dry River. During the fall, some of the birds moved to other areas to winter, but 6 radio-marked birds and about 50 unmarked birds remained through the winter. By spring, all radio-marked birds had moved to adjacent areas to breed and nest. No leks were identified in the Van Lake area.

Another important area for sage grouse was Kotzman Basin. Sage grouse came from many places, including Millican Valley, to summer and winter in Kotzman Basin. As many as 70 birds were seen in Kotzman Basin at one time. Twelve radio-marked birds that had been tagged at or near the Millican and Evans Well leks were later located in Kotzman Basin. High forb concentrations and water supplied by guzzlers may have attracted birds to this area. No leks have been found in Kotzman Basin and most birds move to other areas in early spring. Birds return to Kotzman Basin in early summer.

Just west of Kotzman Basin is Pine Mountain, a well-used sage grouse nesting area. Pine Mountain falls mostly under U.S. Forest Service jurisdiction. There are open sagebrush ridges that lead into coniferous forest at the top of the mountain. Seven nests were established by radio-marked hens on Pine Mountain during the study period. Broods from 2 of these hens, and broods from unmarked hens used Pine Mountain through late summer. Hens with broods were seen foraging on the top of Pine Mountain near a hang gliders' launch site, but only when hang gliders were not present. Sage grouse use of Pine Mountain lessened after late summer.

The area between Pine Ridge and Dickerson Well supported both summering and wintering sage grouse. Anecdotal information suggests that this area has been used as a summering and wintering ground since long before this study began. Birds appear to move into this area from elsewhere; there were many more birds here during the summer and winter than could be accounted for by the adjacent leks. Birds here use big sagebrush areas exclusively. They feed on forbs, which stay green until late summer because of the moisture-retaining pumice soil in the area. Guzzlers and drink pools provide water in the summer.

West Butte was used from March to November by several radio-marked birds collared in Millican Valley and the Moffitt area. There is one lek on West Butte which supported from 2 to 18 males during the study period. More than a dozen brood observations were made on the butte, and 20-30 birds summered there each year. Most of the bird observations were in big sage habitat near the top of West Butte. Much of the rest of West Butte is juniper forest and is not suitable sage grouse habitat. A few observations were made in the burned areas on the top of West Butte. No radio-marked birds were on West Butte during the winter.

The Cook Well, Moffitt, and South Well areas were all used by sage grouse. Use of Cook Well is notable because birds travelled long distances to use the area. Several radio-marked birds moved to Cook Well from Kotzman Basin and the Dickerson Well area. The Moffitt area is well used by breeding birds. Two leks in the area supported between 12 and 34 males during the study period. Some late winter use also was recorded in this area. The area west of South Well has a lek which supports approximately 17 males/year. About 20 birds use specific locations in this area during the summer.

Sites throughout the study area where juniper had been cut were also valuable to sage grouse. Several birds were seen using these areas throughout the study period.

As mentioned above, sage grouse moved between seasonal use areas throughout the study area. Radio-marked birds exhibited movement during all seasons, but most of the movement occurred in early spring and late summer. It is not feasible to report all movements made by radio-marked sage grouse, but the most interesting movements are shown in Fig. 12. All reported mileages are approximate.

The thick purple lines in Fig. 12 each represent movement by three or more radio-marked hens. These group movements originated at three locations. The first of these locations is the Millican strutting grounds from which birds dispersed in four directions. Most of these movements were made during the strutting period when hens left the lek to seek nesting areas. The two most common movements were from Millican to Evans Well and from Millican to Pine Mountain. As mentioned earlier, Pine Mountain is an important nesting area (Fig. 11); 35% of recorded nests in this study occurred here. Additional movements from Millican include two birds that moved from Millican to West Butte (9.6 km), one of them via Rodman Rim (32 km), and one bird that moved to West Butte, then to Ireland Flat, and finally to Moffitt (56 km) (small purple lines - Fig. 12).

The second group movement was made by 13 radio-marked hens that moved from Kotzman Basin to Evans Well (14.4 km). Many hens congregated in the Kotzman Basin during late summer and stayed there until late winter or early spring. At this time, they began moving to Evans Well. Many of these birds moved back and forth between the Millican lek area and Evans Well.

The third group movement was made by 12 radio-marked birds that moved from Van Lake to Todd Well (4.8 km). Some of these birds then moved to the Merrill Road area (8 km) before returning to Van Lake for the summer. This movement pattern corresponded with low sagebrush habitat and the old drainage portions of the Dry River.

Several lengthy movements took place on the study area (Figure 12). One bird wintered in Millican Valley and then moved to Ireland Flat in the spring, a 40-48 km movement (Bird No. 1). A hen that was radio-marked at the Moffitt lek moved to South Well, via Pine Ridge, by June 1 and then on to Van Lake by mid-August, a movement of over 32 km (Bird No. 2). This hen never nested; instead, she grouped with approximately 150 birds summering in the Van Lake area. Many of these Van Lake birds were then radio-marked. The timing of dispersement from Van Lake varied from late fall to early spring. A juvenile male that was radio-marked at Van Lake during September wintered at Dickerson Well (32 km) and strutted the following spring at Whiskey Spring (4.8 km) (Bird No. 3). Another lengthy movement was made by a bird radio-marked at Van Lake in the fall that wintered about 24 km away at the GI Ranch, and then continued to the east an additional 11.2 km (Not shown).

The Kotzman Basin also was a summer concentration area in which birds were radio-marked. Movement from this area occurred from early fall until early spring. A hen that was radio-marked here in the fall wintered along the Dry River (16 km) and then moved to the Moffitt Lek during the spring (9.6 km) (Not shown). Two other birds moved to Cook Well in the Lakeview District (19.2 km) (Bird No. 4).

Several radio-marked hens made unusual movements. Two hens radio-marked at Spencer Well in the spring moved to distant leks to breed instead of going to the nearby Millican and Evans Well Leks. One of them moved to the Whiskey Springs lek and then returned to Spencer Well to nest (48 km round trip) (Bird No. 5), while the other bird moved to the West Butte lek (12.8 km) and then nested on Pine Mountain (16 km) (Not shown). A hen captured in Kotzman Basin during the fall moved to Cook Well, and then to Pine Ridge and Moffitt, before returning to Kotzman Basin. She then moved to Evans Well (41.6 km). This movement took approximately two months, from November to January (Bird No. 6).

Discussion

It is important to emphasize that seasonal use areas other than the ones shown here probably exist on the study area. The use areas mapped in this report represent only those locations that were located through radio-marked birds. Unmarked birds were seen using additional areas, but these areas are not mapped here. The mapped sites were used by birds year after year during the study. Sage grouse seem to be consistent in their selection of areas, making these locations important for future management.

Some birds in this study moved considerable distances, however, the population would not be considered migratory. In truly migratory populations, most of the birds will travel long distances, sometimes over 45 miles, between seasonal use areas (Pyrah 1954, Connelly et al. 1988). No marked birds in our population moved that far and most birds moved substantially shorter distances than that. However, significant movements were made by some birds and a large land area was used by this population.

The use and movement patterns seen here indicate that large areas of sagebrush habitat in its current condition are important to sage grouse. In better habitat condition, birds may not need to range as far to meet their requirements. While the lek and seasonal use areas are important at specific times of the year, the lands between these areas are equally valuable as travel corridors and temporary use areas. The idea that sage grouse need vast expanses of suitable habitat annually is supported by the literature (Eng and Schladweiler 1972, Berry and Eng 1985, Connelly et al. 1988).

Section 8 - Management Recommendations

Management recommendations for BLM lands were developed by an interdisciplinary team (range, recreation, wildlife) from the results of this research, the results of previous studies, and interdisciplinary team discussions. Some management actions have already resulted from these recommendations. The other recommendations should be implemented using the appropriate decision-making process. These recommendations can also be useful to private landowners.

General Recommendations

1) **Continue the sage grouse study, extending the study area to the east to encompass more of the High Desert area of the Prineville District.**

Rationale: To properly manage sage grouse on the district, population information and seasonal land uses need to be known throughout sage grouse habitat on the District. Therefore, lek monitoring and radio telemetry of grouse should continue on an expanded study area. Due to time and budget constraints, seasonal use areas would be identified, and reproductive success would be monitored, but detailed habitat measurements at bird locations would not be taken. Nest predation would be also be monitored and used as an indicator of habitat quality.

2) **Establish and maintain communication with the U.S. Fish and Wildlife Service (USFWS), Oregon Department of Fish and Wildlife, local government agencies, Division of State Lands, U.S. Forest Service (USFS), Lakeview District BLM, and private landowners. A Conservation Agreement between BLM and USFWS should be developed to ensure communication and consultation and to document BLM's commitment to habitat management for sage grouse.**

Rationale: Communication with these parties will lead to better management through cooperation and information exchange. Communication is especially important with the USFWS. The Western subspecies of sage grouse is a candidate threatened or endangered species, and the USFWS needs information on its status that BLM can provide. The USFWS can provide us with technical expertise and guidance in the appropriate management of a sensitive species, to help BLM meet its policy to not contribute to the need to list any species. In addition, the BLM currently has a Memorandum of Understanding (effective March 1994) with the USFWS, USFS, and other federal and state agencies, which states that BLM districts will develop Conservation Agreements for candidate species under their jurisdiction.

3) **Encourage the USFWS to review the data within this report to clarify the status of sage grouse.**

Rationale: The Western subspecies of sage grouse is a candidate for threatened or endangered status. This study has revealed low population numbers with a continuing downward trend in this area. This information will be important to the USFWS in its determination of whether a petition to list the sage grouse as a threatened or endangered species is warranted.

4) **Continue to determine the condition and trend of habitat (i.e., grass height, shrub cover, species composition) throughout the study area with respect to the sage grouse life cycle.**

Rationale: Habitat condition needs to be determined so that land managers know which areas need to be maintained or improved. This information can be used to develop and prioritize land use strategies and habitat management projects. Habitat condition can be determined using existing SVIM data and on-site evaluations.

5) **Design projects and management practices to benefit sage grouse through habitat improvement, and work to reduce habitat fragmentation. Monitor sage grouse responses to habitat improvement projects and other uses of the land.**

Rationale: The Brothers/Lapine Resource Management Plan states that "management activities in the habitat of listed or candidate threatened or endangered and sensitive species will be designed specifically to benefit those species through habitat improvement" (Brothers/LaPine Resource Management Plan, Record of Decision, 1989, p.121). Specific management practices used to accomplish this will depend on the location (terrain, habitat type, condition class, soil type, site potential, species diversity, fire frequency) and the desired outcome, and may include small prescribed burns, spraying, seeding, brush beating, prescribed grazing treatments, juniper cuts, or restricting the timing of land uses that conflict with sage grouse management. Any such practice would be a small-scale, site specific project developed specifically for sage grouse habitat improvements. Guidelines developed by past researchers (Autenrieth et al. 1982, Call and Maser 1985) for sage grouse habitat management will be reviewed and combined with information gained locally to develop specific project plans. Due to present low population levels for sage grouse, low reproductive rate and the sage grouse's limited ability to adapt to habitat changes (i.e., habitat loss, degradation and fragmentation), these habitat improvement projects must be initiated immediately or our ability to sustain the viability of this population may be lost.

6) **Develop grazing strategies for known seasonal use areas to maintain sage grouse habitat.**

Rationale: Grazing strategies that will maintain or improve sage grouse habitats need to be developed. Because the amount and timing of grazing that can be authorized will differ based on the area and habitat management goals, these grazing strategies need to be site-specific (i.e., maintain shrub cover on sage grouse winter use areas).

7) **Develop OHV management strategies for known seasonal use areas to maintain sage grouse habitat.**

Rationale: OHV strategies that will maintain or improve sage grouse habitats need to be developed. Because the amount of OHV use and time of year that this activity can take place will differ based on the area and habitat management goals, these OHV strategies need to be site-specific.

8) **Locate seasonal use areas on private land within the District. Provide private landowners with support and information about sage grouse habitat management and explore the possibilities for enhancing land use and practices on these areas (i.e., cooperation with landowners, acquisition, conservation easement, leasing, land trades). Amend the Brothers/Lapine Resource Management Plan with respect to land tenure status where necessary to retain or acquire identified seasonal use areas.**

Rationale: Important seasonal use areas are found on both public and private land parcels throughout the District. While BLM can change many land uses on public lands, changes on some private parcels may also be necessary to change population trends. Without a total landscape approach, some habitat loss or fragmentation problems may not be solved. Fish and Wildlife 2000, BLM's national strategy for managing fish and wildlife, makes habitat protection through acquisition of crucial upland game bird habitat a priority. Priority should be given to lands in Kotzman Basin, Moffitt Ranch and Millican Valley, and areas next to or including the Dry River Drainage. For the reasons mentioned in Recommendation #5 of this section, this recommendation should be initiated immediately.

Section 1 - Lek Counts and Population Estimates

1) **Continue lek monitoring and population estimation on the study area. With ODFW and USFWS, develop a management objective for bird numbers on the study area to ensure that the population is persistent.**

Rationale: The present population of sage grouse is at risk of extirpation from this area. It is possible that the population is already so low that some genetic diversity has been lost. Continued monitoring of sage grouse populations is necessary for the proper management of the species (Batterson and Morse 1948, Patterson 1952, Autenrieth et al. 1982). Intensive lek monitoring and population estimation will allow us to monitor how the population is faring, and to assess how our management is affecting grouse

numbers. With the present population status, all management activities must be evaluated to ensure that land management practices benefit sage grouse (Brothers/LaPine RMP, Record of Decision, p.121).

2) **Maintain or develop dense sagebrush adjacent to leks, to provide loafing areas for the birds during the breeding season. Specific management goals should be developed using the available literature to define the terms "dense" and "adjacent." Land uses that remove or degrade sagebrush should be prohibited adjacent to any lek. Sagebrush should be removed in areas where dense vegetation is present on leks.**

Rationale: Sage grouse prefer leks with adjacent dense sagebrush (Call and Maser 1985. Removal of this dense sagebrush has been shown to sometimes cause the abandonment of the lek. However, dense sagebrush on leks can make predators hard to detect and males hard to see.

3) **Minimize livestock and human activity adjacent to leks during the breeding season, and continue to monitor these activities.**

Rationale: Livestock and people were seen to disrupt strutting sage grouse during this study. Thus, efforts should be made to keep these uses to a minimum around leks during the breeding season.
This can be accomplished in a variety of ways, such as fencing off lek areas, restricting cattle during strutting from pastures that contain leks, considering lek sites when planning OHV routes, and restricting public viewing of birds at leks.

Section 2 - Precipitation and Lek Counts

1) **Develop a precipitation model and use it to predict sage grouse numbers in the future.**

Rationale: Predictions of sage grouse numbers could be used to direct land management. For instance, in years when the population is predicted to be low, the manager may choose to be more restrictive with respect to conflicting land uses or harvest levels to prevent further population declines. Such a model is in development using the data collected from this study.

Section 3 - Reproductive Success and Nesting Habitat

1) **Improve the quality of nesting habitat. This includes managing for appropriate habitat types and structural composition within nesting habitat, especially with respect to grass height.**

Rationale: Certain habitat types are frequently used by nesting sage grouse and these habitat types should be maintained and enhanced (see recommendation #2, this section). Additionally, the structural components of nesting habitat are important to nest success. Managing for appropriate plant height and percent cover of plants is vital to sustaining nesting success levels. This includes managing factors that affect grass height (grazing, fire), an important determinant of nest success, to ensure that sufficient height is maintained. It may also be necessary to change management in response to drought conditions. In this study, the average grass height at successful nests was 28cm. Other studies have recommended leaving grasses of 10 to 15 cm (Hall 1985) and greater than 18 cm (Crawford et al. 1992, J. Connelly, Idaho Fish and Game, pers. comm., 1993). Emphasis on management of residual grass cover is also essential.

2) **Maintain and enhance the mountain shrub/ bitterbrush habitat type.**

Rationale: This habitat was used frequently by nesting sage grouse. However, its availability on the study area is low. Mountain shrub/bitterbrush communities are important because they are species rich, have high forage production, and provide dense cover. For potential methods to accomplish this recommendation, see General Recommendation #5.

3) **Determine if nesting hens in this area are philopatric (return to nest in home area), and identify traditional nesting areas.**

Rationale: Sage grouse hens show fidelity to specific nesting areas (Fischer et al. 1993) and this was documented on our study area as well. Identifying traditional nesting areas is necessary if these areas are to be managed as suggested in recommendation #1 of this section. As mentioned in Section Three of the report, it is possible that nest site fidelity to areas that no longer have good nesting habitat (such as the area around Millican lek) is responsible for the loss of certain segments of the population. If sage grouse hens in this area prove to be philopatric, then identifying these areas becomes even more important, because use of traditional areas will continue for generations.

4) **Manage mountain big sagebrush areas and low sagebrush areas for increased forb production and good brood habitat.**

Rationale: This study identified the importance of the mountain big sagebrush habitat type for brooding. Forbs are important to broods, so known mountain big sagebrush brooding areas should be managed for forb production. Priority also should be given to potential brooding areas next to known areas, and low sage

areas associated with the Dry River Drainage and some playas, respectively. Managing potential areas such as these for brood habitat will allow for population expansion by providing new sites for birds to use. Additional brood rearing locations should be identified to allow for proper management of these areas.

Section 4 - Summer Diet

1) **Manage sage grouse habitats for increased forb production, concentrating on those forbs identified to be consumed by sage grouse during the pre-laying, nesting and brood rearing periods. Attention should be given to Oregon Sunshine, a newly determined and substantial component of the sage grouse diet at some locations in the study area.**

Rationale: Forbs are an important part of the diet of pre-laying hens, hens with broods and chicks. The diet study conducted here reinforced this point. Providing more forbs may improve the condition of pre-laying hens and broods, leading to higher reproductive and survival rates.

Section 5 - Water Developments

1) **Develop, maintain, or enhance quality habitat in areas with naturally occurring water either presently or historically.**

Rationale: Sage grouse congregate at areas with water, either presently or historically, such as drainages, riparian areas, playas, and dugouts. Quality habitat needs to be present so that these areas can continue to support these birds. This could be accomplished through water gap fencing around some dugouts and playas.

2) **Maintain existing water developments and construct developments where free water is limited. Improve the usefulness of water developments by allowing troughs to overflow, and, where feasible, by providing water (originating at wells) after livestock have been removed.**

Rationale: Water is important to sage grouse in the late summer, fall and winter, and water developments are heavily used during these times. Water developments are useful in areas with no natural water or as a temporary measure in areas where habitat around a natural water source is being restored. Land managers should work cooperatively with private landowners to provide water in these areas.

Section 6 - Winter Habitat

1) **Maintain and improve identified wintering areas. Sagebrush control projects should not be permitted in these wintering areas, because sage grouse are completely dependent on sagebrush for forage and cover during the winter. Efforts should be made to restore a healthy sagebrush community in areas where it has already been depleted or degraded.**

Rationale: Research has identified wintering areas as crucial to sage grouse and a major factor determining sage grouse distribution. Elimination of winter range habitat can reduce sage grouse populations over large areas (Eng and Schladweiler 1972). Good quality wintering areas are necessary for the maintenance and growth of this population. The Millican Valley, Moffitt and Dry River wintering areas are all linked with spring habitat, and can be identified as wintering-nesting complexes. Sage grouse would be more sensitive to the loss or degradation of these areas, because both wintering and nesting areas would be lost.

2) **Identify additional wintering areas, both on public and private land, within and adjacent to the study area.**

Rationale: Additional wintering areas need to be identified to ensure their proper management. Potential wintering areas such as the Grassy Butte region, which is in a late seral stage (1979 SVIM data), need to be managed to maintain this seral stage.

Section 7 - Seasonal Use Areas and Movements

1) **Manage the study area as an ecosystem, not as a collection of seasonal use areas.**

Rationale: The extensive movements exhibited by birds in this study show that large tracts of land are important to sage grouse, and that the lands between identified seasonal use areas are important as travel corridors and temporary use areas. Managing the whole area will ensure that the birds not only have quality breeding, nesting, brood rearing/summering, and winter habitat, but that they have quality habitat between seasons as well.

2) **Continue monitoring sage grouse movements and identifying, describing and mapping seasonal use areas.**

Rationale: Monitoring sage grouse movements will help locate previously unidentified seasonal use areas. Also, it will allow us to compare changes in movement patterns to use or avoidance of areas in which particular land use practices are taking place or have taken place in the past. This will assist us in determining whether a land management practice is harmful or beneficial.

3) **Use movement information to determine home ranges for individuals within the population.**

Rationale: Home range information on individuals will help managers determine how large a block of land is required by sage grouse populations, and therefore, how much land needs to be managed for them.

Explanation of Statistics

Following is a brief explanation of some statistical concepts used in this report.

When conducting research, we usually ask a question and have two possible answers, or hypotheses. One hypothesis is that the parameter we are studying has a specified value, an expected result; this hypothesis is called the null hypothesis. The other hypothesis is that the parameter being studied has a value other than that given in the null hypothesis; this hypothesis is called the alternative hypotheses. We then use the data we have collected to conduct statistical tests to either prove or disprove the null hypothesis. When we do this, there is always the chance that we will make the wrong decision, that we will reject the null hypothesis even though it is really true. We would like it if all our decisions were correct, but this is statistically impossible, because we will be basing our decision on a sample of the information available (our data set), not on all of the information available. To control the risk that we will make the wrong decision, we assign an acceptable probability (**P-value**) that it will happen. The probability most often used is .05 (5%). This number is called our **level of significance**. We use this level of significance to determine the critical value for the statistical test we will conduct. If the statistical test on our data gives us a value greater than this critical value, we say the test was **significant**, and we reject the null hypothesis.

Here is an example to help illustrate these concepts:

Suppose a math teacher who has been teaching for 10 years gives the same final exam every year. For the first nine years, he taught the material one way and the average score on the final exam was 87%. This year he used a new teaching method and the average score was 93%. The teacher wants to know if this year's average score is significantly greater than the score from the past 9 years, so he can decide if the new teaching method is better than the old one. His null hypothesis is that 87% and 93% are not statistically different (the two numbers are obviously different, but they may not be *statistically* different). His alternative hypothesis is that 87% and 93% are statistically different. For his statistical test, the teacher sets the level of significance at .05 (he accepts a 5% chance that he will reject the null hypothesis and determine that 87% and 93% are different, even if they are not), and finds his critical value to be 1.86. When he conducts the statistical test on his data (the test scores), he gets a value of 2.90. Since this value is greater than the critical value of 1.86, he determines that the test is significant and rejects the null hypothesis. He decides that 87% and 93% are significantly different.

Glossary

Active grazing preference - authorized number of AUMs of livestock grazing on public lands attached to base property owned or controlled by a permittee or lessee.

Allotment - An area of land where one or more livestock operators graze their livestock. An allotment may consist of one or several pastures.

AUM - Animal unit month: the amount of forage required to sustain one cow with one calf, or their equivalent for one month (800 pounds of forage).

Brood - A group of birds hatched at the same time.

Condition class - A term relating to present status of a unit of range in terms of specific values or potentials. Specific values or potentials must be stated.

Conservation agreement - A formal written document agreed to by the U.S. Fish and Wildlife Service and another agency to achieve the conservation of candidate species through voluntary cooperation. It documents the specific actions and responsibilities for which each party agrees to be accountable.

Conservation easement - Rights to protect the environmental qualities (i.e., wildlife values) of special areas, such as important wildlife use areas, may be acquired through a conservation easement.

Correlation - A relationship between two variables, such that when the value of the first variable changes, there is a change in the value of the second variable.

Cover type - The plant community present in an area.

Crop - A pouch in a bird's esophagus where food is partially digested.

Crop year - The time period between October 1st of one year and July 31st of the next year (i.e., October 1, 1994 - July 31, 1995).

Crude protein - A measure of the amount of Nitrogen in a plants tissues.

Deferred grazing - Provides total growing period rest for each pasture every year.

Deferred rotation grazing - Provides total growing period rest for each pasture on a regular basis.

Drink pools - Similar to a guzzler (see definition below), except that the source of water is a pipeline.
Dugout - An area where soils have been dug out of the bottom of a lakebed to reach the water table. Provides water for livestock and wildlife.

Erosion - Detachment and movement of soil or rock fragments by water, wind, ice, or gravity.

Extinction - No longer existing.

Extirpation - Extinction in a limited area; local extinction.

Foraging area - The area in which an animal looks for food.

Forbs - Any non-grasslike herbaceous plant.

Free water - Water not gained from vegetation.

Genetic diversity - Diversity in an population's hereditary material - allows the population to adapt more easily to change.

Guzzler - A system of tanks and troughs set up to catch and store rain water for wildlife use.

Habitat - The environment in which an animal lives.

Herbaceous - Non-woody plants.

Loam soils - Soils that are intermediate in texture and properties between fine-textured and coarse-textured soils.

Philopatric - Return to nest in home area.

Playa - A level area at the bottom of a desert basin that is sometimes covered with water.

Predation - The killing of one animal by another for food.

Pumiceous ash - Very fine material formed from pumice (a light, cavity-filled lava)

Radio telemetry - A method of tracking animals from a distance by following radio signals being emitted from a device (a transmitter) which has been attached to the animal.

Residual grass cover - Cover provided by grass that remains from the last growing season.

Rest rotation grazing - Provides total annual rest for each pasture on regular basis.

SCS - Soil Conservation Service

Seral stage/condition - The stage in the development of a plant community.

Short duration/high intensity grazing - Grazing is allowed during any one 2-3 week period, except between May 16 and June 30.

Silty loam soils - Soils that have the general properties of loam soils, but contain a greater percentage of silt.

Site potential - The biotic community that would be expected to become established at a particular site.
Species - A classification category made up of animals able to interbreed.

Subspecies - A taxonomic classification category that divides members of a species based on divergent external characteristic, such as color, size, and plumage.

Succulent - Full of moisture.

SVIM - Soil and vegetation inventory method.

Telemetry - see Radio telemetry

Transmitter - A device used in radio telemetry systems to send radio signals; attached to an animal to allow tracking from a distance.

Topographic map - A map which shows the physical features of a place or region.

Transect - A line that is set up along which data is collected.

UTM - Universal Transverse Mercator: a system of coordinates which specify particular points on a map. Used similarly to the latitude/longitude system.

Water gap fencing - A method of fencing around a water hole that allows access to the water at certain points.

Water year - The time period from October 1st of one year through September 30th of the next year (i.e., October 1, 1994 - September 30, 1995).

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Appendix 1

Statistical Methods and Data for Section 1
Lek Counts and Population Estimate

Sage Grouse Trend

Between 14 and 20 leks were monitored from 1988-1993. During this time, males per lek declined from 14.4 in 1988 to 9.3 in 1993. Although this intuitively seemed to be a significant decline, lack of a complete data set prevented use of proper statistical analysis for trend of males per lek. Incomplete data refers to leks not yet discovered and therefore not sampled, and some known leks did not meet the three count criteria needed to equal the data samples. Therefore, only 14 leks were used to determine the trend in sage grouse numbers (Table 1A).

Statistical Analysis

A regression analysis was used to determine the trend in the number of males per lek from 1989 to 1993. Data from each lek was tested to see if the slope of the line was different from zero. All 14 leks were determined to have slopes (positive or negative) different from zero. In addition, data from each lek had a common slope with independent intercepts. Therefore, the regression analysis encompassed all data from all 14 leks from 1989 to 1993 (A Complete Data Set).

From this analysis it was determined that the trend in males per lek from 1989 to 1993, for the 14 leks, was a significant decline (Regression Analysis P=0.0001) This was a 42% decline over a five year period.

Table 1A. The highest count of males on 14 leks surveyed, on the Deschutes Resource Area, BLM, Deschutes and Crook counties, Oregon, 1989 to 1993.

LEK	1989	1990	1991	1992	1993
1. MILLICAN	39	27	25	26	24
2. EVANS WELL	15	9	5	6	6
3. MOFFIT RANCH	26	16	16	17	12
4. THE GAP	4	2	4	4	3
5. DICKERSON WELL	1	0	0	0	0
6. WHISKEY SPRINGS	18	11	7	16	14
7. SPICER FLAT	25	24	14	12	10
8. LITTLE MUD LAKE	7	11	4	5	1
9. SQUAW LAKE	7	15	14	12	10
10. THE ROCK	18	30	27	22	28
11. AUDUBON	12	15	10	7	5
12. GOVERNMENT WELL	1	7	2	0	0
13. DRY RIVER	5	4	0	0	0
14. CIRCLE F	27	28	28	16	8
TOTAL	205	199	156	146	120
MALES/LEK	14.6	14.2	11.4	10.4	8.6

Appendix 2

Historical Lek Count Data

Number of Males Counted

Year	Lek				Total	Avg.*
	Moffitt	Audubon	Rock	Dickerson Well		
1950	53	NA	NA	71	124	62
1951	NA	NA	NA	NA	NA	NA
1952	45	43	36	28	152	38
1953	51	34	44	50	179	45
1954	76	46	72	54	248	62
1955	68	45	61	51	225	56
1956	49	33	50	43	175	44
1957	10	12	35	20	77	19
1958	26	10	51	31	118	30
1959	22	28	65	27	142	36
1960	40	15	37	28	120	30
1961	30	19	38	NA	87	29
1962	NA	NA	NA	NA	NA	NA
1963	46	13	10	15	84	21
1964	61	57	17	22	157	39
1965	81	46	57	15	199	50
1966	78	36	74	32	220	55
1967	58	30	50	21	159	40
1968	33	21	42	24	120	30
1969	38	12	48	07	105	26
1970	21	09	36	03	69	17
1971	11	06	32	00	49	12
1972	12	09	26	00	47	11
1973	03	12	35	00	50	13
1974	06	13	14	00	33	08
1975	14	04	14	00	32	08
1976	17	14	09	00	40	10
1977	28	28	04	00	60	15
1978	14	25	17	00	56	14
1979	48	21	17	07	93	23
1980	43	28	17	00	88	22
1981	32	35	12	21	100	25
1982	21	15	00	03	39	10
1983	16	12	00	03	31	08
1984	20	12	00	00	32	08
1985	10	07	NA	NA	17	09
1986	19	08	NA	NA	27	14
1987	29	10	NA	NA	39	20
1988	34	24	33	04	95	24
1989	26	11	18	01	56	14
1990	16	09	30	00	55	13
1991	12	10	27	00	49	12
1992	17	07	22	00	46	12
1993	12	05	28	00	45	11

NA - count not available

* rounded to nearest whole number

Appendix 3

Statistical Methods and Raw Data for Section 3

Nesting Habitat and Reproductive Success

Habitat Use versus Availability

Proportions of cover types used for nesting were compared with availability of cover types. Due to low frequency occurrences in some of the contingency table cells, a log-likelihood ratio test was used instead of a Chi-Square analysis. Results were considered significant at the P=0.05 level.

Vegetative Characteristics at Nest Sites

Habitat components measured at nest sites were analyzed with the SAS/STAT program (1990). Comparisons were made between nest center, nest area, nest plot, and random plots. Also, comparisons were made between successful and unsuccessful nest. A test for normality showed that a number of the variables were not normally distributed, therefore all comparisons were analyzed using the non-parametric Kruskal-Wallis chi-square approximation test. Using the Kruskal-Wallis test increases the likelihood of committing a Type I error, but this was deemed acceptable due to the non-normality of the data.

Raw Data

Table 3A. Habitat characteristics at nest centers, nest areas, nest plots and random plots on the Prineville District, BLM, Deschutes and Crook counties, Oregon, 1991-93.

Characteristic	Nest Center (n = 20) $\bar{x}$	SE	Nest Area (n = 20) $\bar{x}$	SE	Nest Plot (n = 20) $\bar{x}$	SE	Random Plot (n = 40) $\bar{x}$	SE
Grass height (cm)	22	3[a]	-	-	-	-	16	1[a]
Grass cover	15	2	17	2	17	2	13	1
Forb cover	5	2	4	1	4	1	5	1
Shrub cover	44	2[ab]	16	1[a]	22	1[c]	16	1[bc]
Short, < 40 cm	12	2	9	1	9	1	7	<1
Medium, 40-80 cm	30	3[ab]	6	1[a]	11	1	8	1[b]
Tall, > 80 cm	2	1	1	<1	1	<1	1	<1

[a,b,c] Means followed by the same letter within a row are significantly different (P < 0.05).
All other comparisons were made and were not found to be significant.

Table 3B. Habitat characteristics at successful (n = 6) and unsuccessful (n = 14) nests, Prineville District, BLM, Deschutes and Crook counties, Oregon, 1991-93.

	Nest Center				Nest Area				Nest Plot			
	Success		Nonsuccess		Success		Nonsuccess		Success		Nonsuccess	
Characteristic	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Grass height (cm)	28	6[a]	19	3[a]	-	-	-	-	-	-	-	-
Grass cover	12	4	16	3	16	4	18	3	15	4	17	3
Forb cover	2	1	6	2	4	<1	5	1	3	1	5	1
Shrub cover	48	5	42	2	19	3	15	1	25	3	20	1
Short, < 40 cm	10	4	13	2	7	1	9	1	8	1	10	1
Medium, 40-80 cm	31	8	29	4	10	3[a]	5	1[a]	14	4	10	1
Tall, > 80 cm	7	3[a]	0	0[a]	2	1[a]	1	<1[a]	3	1[a]	<1	<1[a]

[a] Means followed by the same letter within a row are significantly different ($P < 0.05$).
All other comparisons were made and were not found to be significant.

Appendix 4

Measurement Conversion Chart

Metric Unit	English Unit
Kilometer (1000 meters)	0.625 miles
Meter (100 centimeters)	3.3 feet
Centimeter	0.4 inches
Hectare	2.5 acres

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