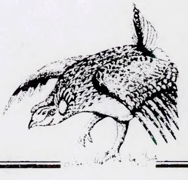
HABITAT SELECTION BY COLUMBIAN SHARP-TAILED GROUSE IN WEST-CENTRAL IDAHO

DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
BOISE DISTRICT, IDAHO



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BY

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1987
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ACKNOWLEDGMENTS

This research project was funded primarily by the U.S. Department of Interior, Boise District Bureau of Land Management, with additional support from the Idaho Department of Fish and Game and the Biology Department at Montana State University. Alan Sands, Boise District biologist, initiated the project and was a constant source of encouragement and support. Sam Mattise, Cascade Resource Area biologist, served as supervisor and saw to it that all of our field and office needs were met. Both of them assisted in all phases of the project. We are also grateful to Roger Rosentreter for helping with plant identification, Bob Stucker for installing solar panels at our field camp and for helping develop an efficient grouse-trapping method, Terri Thomason for helping with the word processor, Laurie Guntly for preparing the figures, and Raul Morales for helping during the 1984 field season. Brian Czech, Skip Lisle, and Janet Berryhill were hard-working volunteer field assistants.

Idaho Department of Fish and Game personnel provided a variety of assistance. Research biologist Bob Autenrieth was project leader for the first two years of the study, during which he supplied most of the field equipment, helped trap grouse, and gave freely of his time and expertise. Lou Nelson advised on computer use and statistical analyses, Fred Edwards and Andy Ogden provided historical information on sharptails in the Hog Creek study area, and Jack Connelly secured funding during the later stages of the study and reviewed the final report.

Bob Eng, Montana State University, served as advisor of Vicki's graduate committee. In that capacity he reviewed the chapters on summer habitat use and the Hog Creek study area, and was a valuable consultant to the project. Lynn Irby, Jack Taylor, and Bob White, also of Montana Sate University, provided additional comments on Vicki's thesis. Terri Lonner, Montana Department of Fish, Wildlife, and Parks, provided computer programs for home range and use-availability analyses. Nancy Shaw, Intermountain Forest and Range Experiment Station, was a valuable source of information on the range literature. The dancing sharptail on the cover was drawn by Shelley Watters.

Finally, and most importantly, this study would not have been possible without the cooperation of the Tarter, Nelson, and Dunham families, who generously granted us unlimited access to their lands. We especially thank George and Nellie Tarter for their friendship and assistance during the 3 years that we resided on their land.

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PREFACE

This study of the habitat relationships of Columbian sharp-tailed grouse (Tympanuchus phasianellus columbianus) was initiated by the Boise District Office of the Bureau of Land Management (BLM). Historically, Columbian sharptails were widespread and abundant in the Intermountain West. During this century, however, their numbers were drastically reduced such that they now occupy less than 10% of their original range. Columbian sharptails deserve the utmost attention of all people concerned with the conservation of native species on public lands.

The decline of the Columbian sharptail has been attributed to land use changes, particularly chronic overgrazing by livestock and conversion of native shrubsteppe and riparian vegetation to agriculture. At present, populations of sharptails in Idaho are small and fragmented, and they have not been hunted in western Idaho since 1975. With good reason, the sharp-tailed grouse is listed as a "Species of Special Concern" by the Idaho Department of Fish and Game and as a "Sensitive Species" by the BLM. It is the BLM's policy to maintain or increase current population levels of sensitive species by enhancement or protection of their habitats (BLM Manual 6840). However, only a small amount of information on the habitat needs of Columbian sharptails is available, and none of it has been based on an adequate sample of radio-tagged individuals.

This report provides information on the year-round habitat requirements of a remnant population of sharp-tailed grouse in western Idaho. It is intended to provide the BLM with the data and management recommendations necessary to maintain or increase Columbian sharp-tailed grouse numbers in Idaho and elsewhere within their historic range.

ABSTRACT

Habitat selection, population characteristics, and mortality of Columbian sharp-tailed grouse (Tympanuchus phasianellus columbianus) were studied near Mann Creek, western Idaho, from 1983-1985. Vegetative measurements and other site characteristics were recorded from spring to autumn at 716 flush sites of 15 radio-tagged grouse and at random sites within the major cover types in the study area. The mean size of spring-to-autumn home ranges was 1.87 ± 1.14 km^2. Of nine cover types identified in the study area, individual grouse used big sage (Artemisia tridentata) more than or in proportion to availability, low sage (A. arbuscula) in proportion to availability, and avoided shrubby eriogonum (Eriogonum spp.) sites. Properties of the big sage cover type (e.g., moderate vegetational cover, high plant species diversity, and high structural diversity) were probably important factors that determined the selection of big sage areas by grouse throughout summer. The dense cover types (i.e., mountain shrub and riparian) were used primarily for escape cover. Compared with random sites, sharptails selected areas with (1) greater density and canopy coverage of arrowleaf balsamroot (Balsamorhiza sagittata), (2) greater horizontal and vertical cover, (3) greater canopy coverage of decreaser forbs (as influenced by livestock grazing), and (4) greater canopy coverage of bluebunch wheatgrass (Agropyron spicatum) in big sage sites in 1984 and in low sage sites in 1985. The importance of arrowleaf balsamroot and bluebunch wheatgrass (both native perennials) as cover plants became apparent during a drought year when many annuals dried up and provided no cover. Overall, grouse appeared to select areas that were least modified by livestock grazing.

Two of four dancing grounds were active each year of the study. The maximum total counts for all dancing grounds each spring ranged from 17 to 30 males. Maximum counts in autumn were 2-5 times higher than spring counts. The estimated size of the Mann Creek sharptail population during summer was between 100 and 200 birds. The highest spring counts were in 1986, suggesting a slight increase in the population from 1983 to 1986.

Mountain shrub and riparian cover types were critical sources of winter food and cover. Buds of serviceberry (Amelanchier alnifolia) and chokecherry (Prunus virginiana), and fruits of hawthorn (Crataegus douglassii), were the primary winter foods. Flock sizes averaged 5.6 ± 6.4 birds across all winters. The availability of suitable winter habitat is probably the most critical component in determining the ability of an area to support sharptails.

A second study area, Hog Creek, was established in 1985. The Hog Creek study area was 32 km east of Mann Creek and had been severely modified by livestock and agricultural development such that sharptails were very rare. Vegetation measurements were taken at random transects at Hog Creek for comparison with the Mann Creek data. Compared with Mann Creek, the Hog Creek cover types had (1) less vertical and horizontal plant cover, (2) lower diversity of forbs and shrubs, (3) lower canopy coverage of decreaser forbs and grasses, and (4) fewer and more severely damaged mountain shrub and riparian areas. In general, habitat components that were most important to sharptails at Mann Creek were lacking or in poor condition at Hog Creek. Past land uses at Hog Creek and the habitat alterations that resulted probably are responsible for the decline in the sharptail population there. These data suggest that Columbian sharptails are a suitable indicator

species of range quality in mesic shrubsteppe habitats of the Intermountain West.

Although radio-collared sharptails provided useful information on summer habitat use, their annual mortality rate was 100%. Most of the mortality was caused by avian predators, primarily northern goshawks (Accipiter gentilis), which appeared to feed selectively on radio-collared individuals. All but two radio-collared grouse that survived the spring dancing period also survived the summer.

Management and research needs for Columbian sharptails were addressed at the local (i.e., Mann Creek) and state (i.e., Idaho) levels. At present, the most important management action would involve the acquisition and protection of habitats that currently support sharptails in western Idaho. There is a critical need to determine the year-round distribution of sharptails in western Idaho and to develop sound techniques for monitoring population fluctuations. Additional information is needed on the winter ecology of sharptails, and almost nothing is known about such basic life-history parameters as reproductive success, natal dispersal, and longevity.

CHAPTER I

INTRODUCTION

Life-History Notes

The six subspecies of sharp-tailed grouse (*Tympanuchus phasianellus*) currently occur from Alaska to western Quebec south to Michigan, Nebraska, Colorado, Utah, and Idaho. Native populations are gone from Oregon, California, Nevada, New Mexico, Oklahoma, Kansas, Iowa, and Illinois. Sharptails occupy a variety of habitats including brushy openings in boreal forest, seral stages of mixed conifer and broadleaf forest, shortgrass prairie, sagebrush steppe, and oak savannah.

Probably the most conspicuous aspect of the life history of sharptails is their mating system. The sharptail is a true lek species wherein males defend small territories on traditional "dancing grounds" in which they compete among one another for mating opportunities. Mating is nonrandom among males; typically, only a few males at or near the center of the assemblage perform most of the copulations. The height of display occurs in spring, when females visit dancing grounds and presumably choose among males for a suitable mate. Males provide no parental care nor resources required by females or broods (aside from gametes).

After copulating, females leave the dancing grounds to initiate egg laying. Eggs are laid at a rate of one per day; the average clutch is 12. Incubation begins with the laying of the last egg and continues for about 24 days. The precocial young hatch on the same day and feed primarily on insects and succulent herbaceous vegetation.

Males also display at dancing grounds during autumn. Females are not known to visit dancing grounds during this season, and males neither attend dancing grounds on a regular basis nor perform the full repertoire of behaviors seen during spring. The autumn display period is thought to function in recruitment of yearling males into the lekking group and in maintenance and improvement in territorial position among established males.

Thorough treatments of various aspects of sharptail life history can be found in Ammann (1957), Hamerstrom (1963), Lumsden (1965), Hjorth (1970), Rippin and Boag (1974a, 1974b), Moyles and Boag (1981), and Johnsgard (1983).

Past and Present Status of Columbian Sharptails

The Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*), one of six subspecies of sharptails, formerly ranged over most of the Intermountain region from central British Columbia south to California and Colorado (Figure 1). They are no longer found in California, Oregon, and Nevada, and have been reduced to remnant populations in Washington, Montana, Utah, and Wyoming. Their stronghold apparently is in British Columbia (Miller and Graul 1980), but very little is known about the sharptails there. In the United States, they are hunted in western Colorado, eastern Washington, and southeastern Idaho.

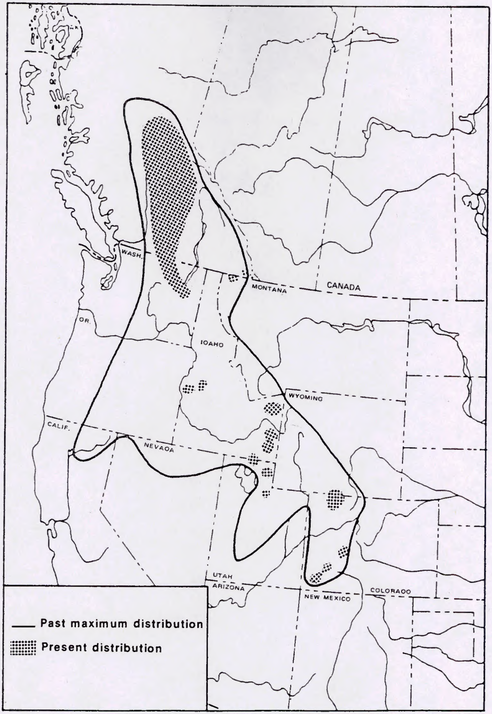

Figure 1. Past and present distribution of Columbian sharp-tailed grouse (modified from Miller and Graul 1980).

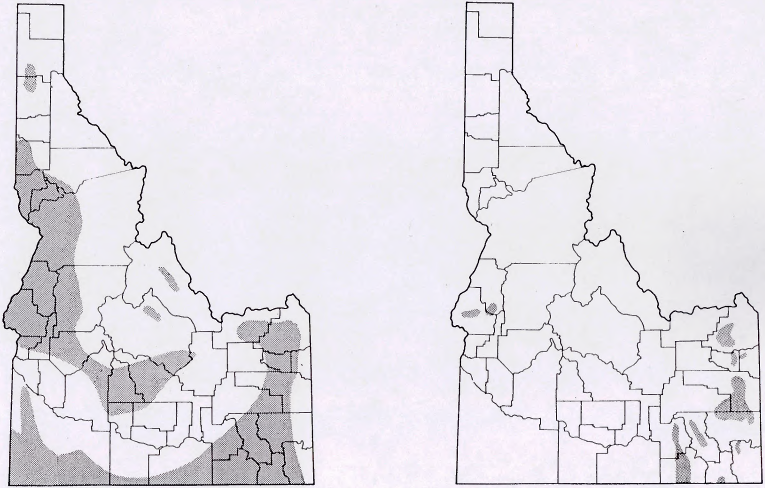

Figure 2. Past (left) and present (right) distribution of Columbian sharp-tailed grouse in Idaho (modified from Parker 1970).

The Columbian subspecies has undergone widespread decline in both numbers and distribution since early settlement. In 1805, Lewis and Clark reported sharptails on the sagebrush-bunchgrass plains of the Columbia River (Bent 1932). Bendire (1898) considered them to be one of the most abundant and well known game birds of the Pacific Northwest. In Idaho, their historic range included the Palouse and Camas prairies in the north, and extended into the sagebrush-bunchgrass hills of the west and south (Figure 2). Although sharptails were abundant when settlers arrived in Idaho, a marked decline was apparent by 1917 (Rust 1917). During the 1930s, Murray (1938) estimated that not more than 1,000 birds, and possibly half that number, remained in Idaho. However, because no accurate method exists to census Columbian sharptails, it is difficult to assess the soundness of Murray's estimate. Currently, known sharptail distribution in Idaho is restricted to the southeastern and a few locations in the western part of the state (Figure 2). Areas still occupied by sharptails are those with native grasses, forbs, and shrubs that have not been severely overgrazed (Hart et al. 1950, Parker 1970, Miller and Graul 1980, pers. obs.).

Modifications of native habitat by livestock grazing and agriculture are thought to be the major factors in this decline (Hart et al. 1950, Yocum 1952, Buss and Dziedzic 1955, Hamerstrom and Hamerstrom 1961, Aldrich 1963, Rogers 1969, Parker 1970, Zeigler 1979). Many historic use areas were overgrazed by livestock, which reduced bunchgrasses and perennial forbs that are important components of nesting and brood-rearing habitat (Yocum 1952, Jewett et al. 1953, Evans 1968). Additionally, conversion of rangeland to cropland destroyed nesting and brood-rearing habitat and deciduous shrubs that are critical sources of winter food and year-round cover (Marshall and Jensen 1937, Jewett et al. 1953, Rogers 1969, Zeigler 1979).

Past Research in Idaho

Owing to their low numbers and limited distribution, Columbian sharptails have not been highly sought by bird hunters. Consequently, little information has been gathered on their habitat affinities. Three research projects have been completed in Idaho on Columbian sharptails. Parker (1970) studied summer habitat use in Fremont County and provided a comprehensive report on past and present distribution of sharptails in Idaho. McCardle (1977) monitored the effects of sagebrush reduction on sharptail habitat use in Oneida County, and Ward (1984) studied the effects of vegetative cover and species composition on the location of grouse territories on dancing grounds. None of these studies was designed to assess year-round habitat requirements.

OBJECTIVES

The primary objective of this research was to determine the year-round habitat requirements of Columbian sharp-tailed grouse and to incorporate this information into recommended management actions to maintain or enhance current population levels of these birds. Specific tasks designed to help us meet the primary objective included:

(1) Describe and map the vegetative cover types in the study area and quantitatively describe the structural and floristic characteristics of these cover types.

(2) Locate and map all sharptail dancing grounds and spring, summer, autumn, and winter areas of use on the study area.

(3) Capture and radio-tag an adequate sample of adult grouse.

(4) Quantitatively and qualitatively describe the habitat characteristics selected by radio-tagged individuals.

(5) Evaluate grouse habitat selection in relation to livestock grazing.

(6) Assess reproductive success, mortality, size of the grouse population, and describe the current trend of the population.

We were not able to adequately address objective 5 because livestock grazing ended on most of the study area in 1982; only 20-60 cattle grazed a small portion of the study area during 1983-1985. These conditions made it difficult to relate current livestock use to grouse habitat selection. However, microsite use by grouse and microhabitat availability allowed an indirect assessment of the influence of livestock grazing on the present vegetative composition and on sharptail habitat use. Objective 6 was compromised because we were unable to trap a large sample of females, and because we could not devise an accurate method to census sharptails.

One major difficulty in assessing habitat selection is that most present day habitats have been modified by humans or their livestock such that optimal sharptail habitat may no longer exist in western Idaho (cf. Starkey and Schnoes 1979). Thus, even the best available habitat may not contain all the requirements of a healthy population of sharptails.

In an effort to best identify habitat features that are important to sharptails, we measured vegetation at two study areas, one in which sharptails were relatively abundant and the other in which they were very rare. The Mann Creek study area contained the largest known concentration of sharptails in western Idaho, and we have assumed that the habitat there was among the best available in western Idaho. The Hog Creek study area, located 32 km east of Mann Creek, had been severely modified by livestock, fire, and agricultural development. Only a few sharptails remained at Hog Creek, although historical records indicated they were once abundant there. The objective at Mann Creek was to obtain detailed information on habitat selection by radio-tagged sharptails. If habitat features selected by Mann Creek sharptails indeed were critical requirements, then we would have expected some of these features to have been absent at Hog Creek, thus in part explaining why sharptails had declined there.

MANN CREEK STUDY AREA

Location and Physiography

The Mann Creek study area is in the Weiser River drainage of western Idaho in Washington County about 23 km north of Weiser (Figure 3). The area includes 20 km^2 of private holdings and a small portion of state land. Prominent geographic features include Mann Creek on the west, Fairchild Reservoir on the north, and Sage Creek on the east. Public lands border the study area on the north and east. Elevations range from 970–1188 m. Topography is rolling with a few steep ridges running north/south. The general exposure is southerly, but small knolls and ridges dissecting the area produce a diversity of aspects.

Geology and Soils

The geology and soils information was summarized from unpublished data provided by the USDA (1986). The area consists of Columbia River basalts with inclusions of fine-grained volcaniclastic material and arkosic sandstone. Major soils are shallow to moderately deep and well-drained. Soils formed in residuum and alluvium derived mainly from basalt. Slopes range from 0 to about 60%. Typically, the surface layer is a dark grayish-brown, very stony loam about 18 cm thick. The subsoil is a grayish-brown clay loam and contains 0-60% rock fragments. The soil is underlain by bedrock at 38 to 102 cm.

Climate and Weather

The climate is semi-arid with hot summers and relatively cold winters (Franklin and Dyrness 1973). Annual precipitation averages 39 cm. Table 1 lists the average precipitation and temperatures from spring to summer during the study period. Data were obtained from the weather recording stations nearest the study area (Weiser and Cambridge, Idaho). The springs and summers of 1983 and 1984 were relatively cool and wet, whereas those of 1985 were unusually hot and dry such that drought conditions prevailed.

Vegetation

Vegetation is characteristic of a shrubsteppe community. Nine cover types were identified (Table 2), six of which correspond to an ecological classification scheme described by Daubenmire (1970) or Hironaka et al. (1983). Ecological condition was determined by the relative canopy coverage of climax vegetation supported by a given cover type (Dysterhuis 1949). All upland shrub types (ARTR, ARAR, ERIO, PUTR) were determined to be in fair ecological condition. The grass component of the upland cover types is dominated by an exotic species, bulbous bluegrass (*Poa bulbosa*). The ARTR cover type corresponds to the *Artemisia vaseyana* "*xericensis*" - *Agropyron spicatum* habitat type of Hironaka et al. (1983). In addition to big sagebrush (*Artemisia tridentata*), which is the dominant shrub, bitterbrush (*Purshia tridentata*) is scattered throughout these sites. The best development of bluebunch wheatgrass (*Agropyron spicatum*) is found in this cover type. The most abundant forbs are arrowleaf balsamroot (*Balsamorhiza sagittata*), lupine (*Lupinus laxiflorus*), common yarrow (*Achillea millefolium*), and lomatiums (*Lomatium* spp.). The ARAR cover type

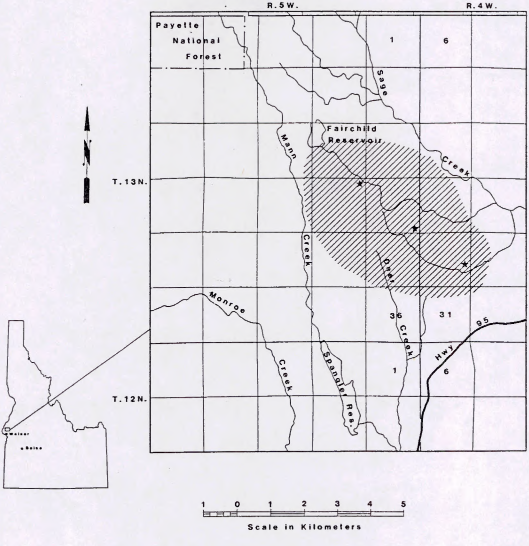

Figure 3. Mann Creek study area (shaded section) in Washington County, Idaho. Stars denote Upper, Middle, and Lower dancing grounds from upper left to lower right, respectively.

Table 1. Summary of March-July precipitation and temperature data at Weiser and Cambridge weather stations, 1983-1985.

Year	Location	Precipitation (cm)	Temperature (°C)
1983	Weiser	13.00 (+5.89)[a]	13.92 (-0.58)[a]
	Cambridge	25.25 (+9.96)	13.04 (+0.06)
1984	Weiser	15.49 (+8.38)	13.63 (-0.87)
	Cambridge	18.80 (+3.51)	12.16 (-0.82)
1985	Weiser	5.56 (-1.55)	14.78 (+0.28)
	Cambridge	10.13 (-5.16)	13.76 (+0.78)

[a] Departure from normal.

Table 2. Cover type areas and their proportions in the Mann Creek study area, Washington County, Idaho.

Cover type	Area (ha)	% of study area
Big sagebrush (ARTR)[a]	785.48	40
Low sagebrush (ARAR)	423.07	21
Shrubby eriogonum (ERIO)	401.81	20
Intermediate wheatgrass (AGIN)	131.21	7
Mountain shrub (MTSH)	74.48	4
Agriculture (AGRI)	61.74	3
Bitterbrush (PUTR)	44.40	2
Riparian (RIPA)	35.39	2
Meadow (MEAD)	13.20	1
Total	1970.78	100

[a] Cover type acronyms that will be used throughout the report.

corresponds to the Artemisia arbuscula - Agropyron spicatum habitat type of Hironaka et al. (1983). The understory is dominated by bulbous bluegrass with lesser amounts of bluebunch wheatgrass and Sandberg's bluegrass (Poa sandbergii). Common forbs include longleaf phlox (Phlox longiflora), autumn willoweed (Epilobium paniculatum), and knotweeds (Polygonum spp.). The ERIO cover type corresponds to two habitat types described by Daubenmire (1970), the Eriogonum sphaerocephalum - Poa secunda (= P. sandbergii) and Eriogonum thymoides - Poa secunda types. The herbaceous layer is relatively sparse and dominated by Sandberg's bluegrass. The PUTR cover type corresponds to the Purshia tridentata - Agropyron spicatum habitat type of Daubenmire (1970). The shrub layer is almost exclusively bitterbrush, while the herbaceous layer is similar to that found in the ARTR cover type. The RIPA and MEAD cover types correspond to the Crateagus douglasii - Heracleum lanatum and Juncus balticus - Carex douglasii habitat types (Daubenmire 1970), respectively. Riparian vegetation (RIPA cover type) is dominated by hawthorn (Crataegus douglasii) with lesser amounts of willow (Salix spp.), and Woods rose (Rosa woodsii). To date, no habitat type has been described for mountain shrub vegetation. Mountain shrub patches (MTSH cover type), which usually occur on hillsides, are dominated by bittercherry (Prunus emarginatus), chokecherry (Prunus virginiana), snowbrush ceanothus (Ceanothus velutinus), and serviceberry (Amelanchier alnifolia). Appendix 1 lists the scientific and common names of all plant species or genera identified in the study area. Nomenclature follows Hitchcock and Cronquist (1976).

A small portion of the study area contains intermediate wheatgrass (Agropyron intermedium) seedings and agriculture. The seedings were completed in 1963 and are still largely monocultures of intermediate wheatgrass.

Land Use

The study area has been grazed by sheep and cattle since at least the turn of the century. Before about 1940, large bands of sheep were driven through the area. Since that time, the major land use in the study area has been cattle grazing. From the mid 1970s through 1982, as many as 600 cattle grazed the Upper Dancing Ground (UDG) area for two months during spring and two during autumn. Since 1983, from 20-60 cattle used the Lower Dancing Ground (LDG) area during summer and fall. No major fires have occurred in the area for at least 60 years (G. Tarter, pers. comm.). A small amount of dryland farming occurs at the southern border of the study area. Recreational uses include hunting, fishing, and off-road driving.

METHODS

Trapping

Dancing grounds were observed from blinds (dome tents) early in the breeding season to determine activity centers and direction of grouse movements to and from the grounds. Sharp-tailed grouse were captured at dancing grounds by a funnel trap, mist net, or drop net. Funnel traps were constructed entirely of chicken wire and consisted of a catch box and funnel attached to wings placed around the dancing ground perimeter (Figure 4).

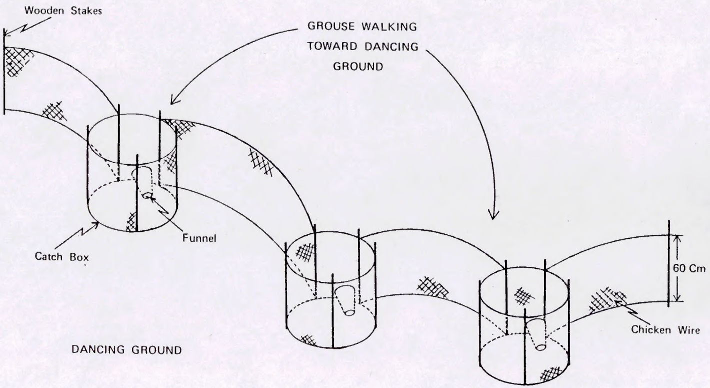

Figure 4. Funnel trap system used to catch sharp-tailed grouse on dancing grounds.

The wings created a barrier to grouse walking onto the dancing ground, and a grouse following a wing would enter a funnel into a catch box. Mist nets (4-inch mesh) were set near the activity center of a dancing ground and were effective in capturing both flying and flutter-jumping grouse. Drop nets were placed over activity centers and triggered by blasting caps. Funnel traps were staked into place in late March and remained throughout the trapping period (through early May). Mist nets and drop nets were moved among dancing grounds as needed.

Instrumenting and Monitoring

Each trapped bird received a numbered aluminum band and three colored plastic leg bands. Birds were weighed with a 1000-g Pesola scale and sex was determined by examination of crown feathers (Henderson et al. 1967). Age was determined by examining the two outermost primaries on each wing (Ammann 1944). Thirty-eight grouse were instrumented with solar-powered transmitters attached to Herculite ponchos (Amstrup 1980). Radio packages weighed between 13.5 and 15.5 g.

Radio-tagged grouse were located with a Telonics TR2 receiver and an H antenna. Grouse were systematically monitored from May to September in 1983, 1984, and 1985. At each location the grouse were flushed (hereafter called flush sites). Flush sites were taken throughout the day and stratified into four time intervals: dawn to 0800; 0801 to 1100; 1101 to 1700; and 1701 to dark. The sampling schedule was designed so that each radioed bird was flushed on four days a week, once in each of the four time intervals. Locations were plotted on a U.S. Geological Survey topographic map (scale 1:62,500) and assigned X and Y coordinates using the Universal Transverse Mercator (U.T.M.) meridians.

Habitat Sampling

A map of the cover types in the study area was prepared in 1983 (Figure 5). Cover types were digitized and areas (km^2) (Table 2) calculated for each type using GEOSCAN (Software Designs 1984), a geographic information program. Flush sites were plotted and home ranges analyzed using the computer program TELDAY (Lonner and Burkhalter 1986), with home range estimations based on the minimum convex polygon method (Mohr 1947).

Use vs. availability of macrohabitats (i.e., cover types) was assessed in two ways: (1) using the proportion of cover types within each bird's home range, and (2) using the proportion of cover types within a 1.2-km radius of the dancing ground at which each bird was captured. The 1.2-km radius around each dancing ground encompassed 90% of all grouse locations. Flush sites that were on or less than 50 m from a dancing ground during spring and autumn display periods were omitted from the macrohabitat analysis. Cover type proportions in each home range and in the 1.2-km radii were calculated with GEOSCAN (Software Designs 1984).

Microhabitat measurements were taken at each flush site to determine plant species composition, frequency, and percent canopy coverage using a 20 X 50 cm frame (Daubenmire 1959). Using this method, the observer estimated the percent canopy coverage of each plant species and bare ground (including

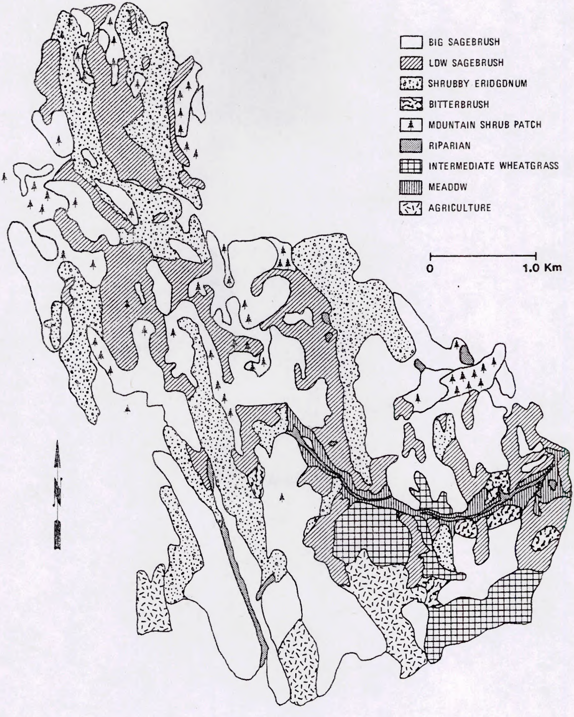

Figure 5. Cover types in the Mann Creek study area.

litter) within the frame and assigned it to a coverage class (1 = 0-5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-95%, 6 = 96-100%). Height of the tallest shrub and densities of shrubs and large perennials were also recorded at each frame. Five Daubenmire frames were read at each flush site: one at the approximate center and one in each of the four compass directions at either 2, 4, 6, or 8 m from the center location. The vertical structure of the vegetation was evaluated by the cover board technique of Jones (1968) as modified by Cogan (1982) (see Figure 6). Jones' cover board consisted of three 16.5 x 16.5 cm squares attached to one another with hinges to form a triangle, whereas our cover board was a 16.5 x 49.5 cm rectangle (see Figure 6). This modification enabled us to evaluate vertical cover at a greater range of height than would have been possible with Jones' (1968) cover board. A cover board was placed at the center location and read from 5 m away in each of the four compass directions while the observer was lying down and standing (i.e., a total of 150 squares possible from each compass direction). In total, five canopy coverage plots and four cover board readings were performed at each flush site. Other variables recorded at flush sites were: date, location, landing site vegetation, percent slope, topographic position, aspect, cover type, distance to edge, distance to water, and distance to nearest riparian or mountain shrub habitat.

Vegetative and topographic measurements were also recorded at randomly located transects to assess microhabitat availability in the major cover types in 1984 and 1985. Habitat characteristics were sampled with the same methods described at flush sites. Thirty random transects were performed each month from May through July. The number of transects located in each cover type was based on the percentage of area occupied by that cover type in the study area (Table 2). The origin of each transect was located at random. A Daubenmire frame and cover board reading were recorded at the origin and at points every 10 paces along a straight line until 20 such readings were completed. Topographic position, percent slope, distance to water, distance to edge, and distance to the nearest mountain shrub or riparian habitat were recorded only at the first, tenth, and twentieth frame of each transect.

Data Analysis

Data were analyzed with the Statistical Analysis System (SAS Inst. 1982). Use-availability analyses of habitat characteristics were conducted with chi-square goodness of fit tests (Neu et al. 1974). Preference, avoidance, or use in proportion to availability were determined with Bonferroni z-tests (Byers et al. 1984). For analyses of canopy coverage, each plant species and bare ground were placed into one of 11 categories (Table 3). Non-parametric statistics (Mann-Whitney and Kruskal-Wallis tests) were used to analyze canopy coverage and vertical structure because these data were found to be non-normal (Conover 1980). Vegetative measurements at flush sites from May through July were combined by cover type for comparisons with data collected at random sites for the same period. All multiple comparisons were computed with Tukey tests (Zar 1974). The Shannon-Weiner index was used to calculate plant species diversity (Hill 1973). Proportions entered into the diversity formula were derived from the total number of plant species occurrences within Daubenmire frames. The significance level for all tests was $P \leq 0.05$, and all tests of means were two-tailed. Means are followed by $\pm$ one standard deviation.

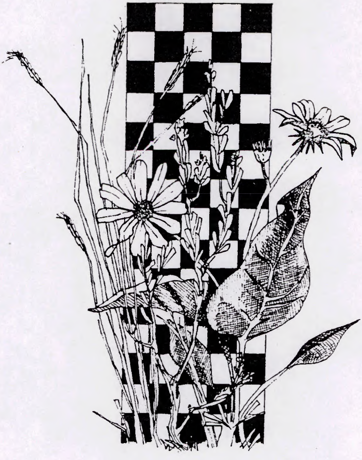

Figure 6. Cover board (75 squares total) used to assess vertical cover. The number of squares half or more visible were recorded twice from 5 m away (once while lying down and once while standing). The maximum possible reading was 150.

Table 3. Vegetative categories used for analysis of canopy coverage at grouse flush sites and random transects in the Mann Creek study area.

	Common name
Shrubs	Big sagebrush Low sagebrush Bitterbrush Other shrubs
Forbs	Arrowleaf balsamroot Other composites Non-composite forbs
Grasses	Bluebunch wheatgrass Bulbous bluegrass Other grasses
	Bare ground

CHAPTER II

SUMMER HABITAT USE

RESULTS

Trapping and Monitoring

Three dancing grounds in the study area were regularly attended by grouse (Figure 3). From 1983-1985, 46 adult sharptails were captured on these dancing grounds. Date of capture, trap type, sex, weight, fate, and radio number of captured grouse are in the Appendix 2. Fifteen of 38 grouse equipped with radio transmitters furnished enough data for all analyses (Table 4). Thirteen males and two females with broods were relocated 716 times during the study. Of these 716 flush sites, vegetation measurements were recorded at 696, and 680 were used for macrohabitat analysis (Appendix 3). An additional 41 locations, obtained from two radioed males monitored for 2-3 months and from 10 nonradioed birds, are included in the microhabitat analyses.

Home Ranges

The mean size of spring-to-autumn home ranges was 1.87 ± 1.14 km^2 (N = 15). There was a striking difference in home range size between LDG and UDG grouse (Figures 7-9). All five UDG home ranges were smaller than 1.5 km^2, whereas eight of nine LDG home ranges were larger than 1.5 km^2 (Table 4). The mean home range size of LDG grouse (2.47 ± 1.09 km^2) was significantly larger than that of UDG grouse (0.94 ± 0.34 km^2) (Mann-Whitney U-test, $P = 0.005$). Home range size was not correlated with the number of flush sites ($r = 0.41$, $P = 0.13$), which indicates that this difference was not an artifact of sample size.

Macrohabitat Selection

When grouse were considered individually, three trends emerged from use-availability analyses of cover types: (1) sharptails used the ARTR cover type (Table 2) more than or in proportion to availability, (2) the ARAR cover type was used in proportion to availability, and (3) the ERIO and AGIN cover types were avoided (Table 5). These trends were the same whether use-availability was assessed within estimated home ranges or within a fixed radius around dancing grounds (Table 5).

Cover type use by LDG and by UDG grouse differed significantly from availability (chi-square tests, $P < 0.001$ and $P < 0.05$, respectively). As a group, LDG grouse preferred ARTR; avoided ARAR, ERIO, and AGIN; and used other cover types in proportion to availability (Figure 10). UDG grouse selected MTSH, avoided ERIO, and used ARTR and ARAR in proportion to availability (Figure 11). The Middle Dancing Ground (MDG) grouse, which also did not use cover types in proportion to availability (chi-square test, $P < 0.001$), preferred ARTR and avoided ERIO (Figure 12). Overall, grouse seldom flushed from the denser cover types, i.e., RIPA and MTSH. However, they used these cover types as escape cover in 77% of the cases where the landing site of a flushed radioed bird was observed (Table 6).

Table 4. Data on radio-tagged sharp-tailed grouse trapped at three dancing grounds in the Mann Creek study area, 1983-1985.

Dancing ground	Year	Months monitored	Grouse no.[a]	Home range size (km^2)	No. locat.
Upper	83	May-Nov	M488	1.17	68
	83	May-Aug	M638	1.39	43
	84	May-Sep	F107	0.58	36
	85	May-Oct	M253	0.68	42
	85	May-Oct	M963	0.89	41
Middle	83	May-Oct	M588	1.07	55
Lower	83	May-Nov	M513[b]	4.84	64
	83	May-Oct	M538	2.08	57
	84	May-Sep	M004	1.66	44
	84	May-Oct	M164	2.58	50
	84	May-Aug	M225	1.21	41
	84	May-Nov	M981	3.09	52
	85	May-Nov	M240	1.47	42
	85	May-Oct	F272	2.55	38
	85	May-Oct	M865	2.74	43

[a] M = male, F = female; numbers refer to radio frequencies.

[b] Trapped on middle dancing ground but soon moved to lower dancing ground and acquired a territory.

Table 5. Spring-to-autumn use-availability analysis showing the number of radio-tagged grouse using the major cover types more than (+), less than (-), or in proportion to (NS) that expected by chance ($P < 0.05$). Males flushed on or near dancing grounds during the spring and autumn dancing periods are omitted from the analysis.

	Home range			1.2-km fixed radius		
Cover types	+	-	NS	+	-	NS
Upper Basin						
ARTR	2	0	3	0	0	5
ARAR	0	1	4	0	0	5
ERIO	0	5	0	0	5	0
MTSH	1	0	4	1	0	4
Middle Basin						
ARTR	1	0	0	1	0	0
ARAR	0	1	0	0	0	1
ERIO	0	1	0	0	1	0
Lower Basin						
ARTR	7	0	2	8	0	1
ARAR	0	3	6	0	1	8
AGIN	0	2	7	0	6	3

Table 6. Known landing sites of radio-tagged sharp-tailed grouse in the Mann Creek study area, 1983-1985.

Landing site	1983	1984	1985	Total
RIPA	31	38	16	85
MTSH	25	12	25	62
Subtotal (%)	56 (81.2)	50 (93.3)	41 (64.1)	147 (77.0)
ARTR	5	3	20	28
PUTR	7	4	3	14
ARAR	1	1	0	2
Total	69	58	64	191

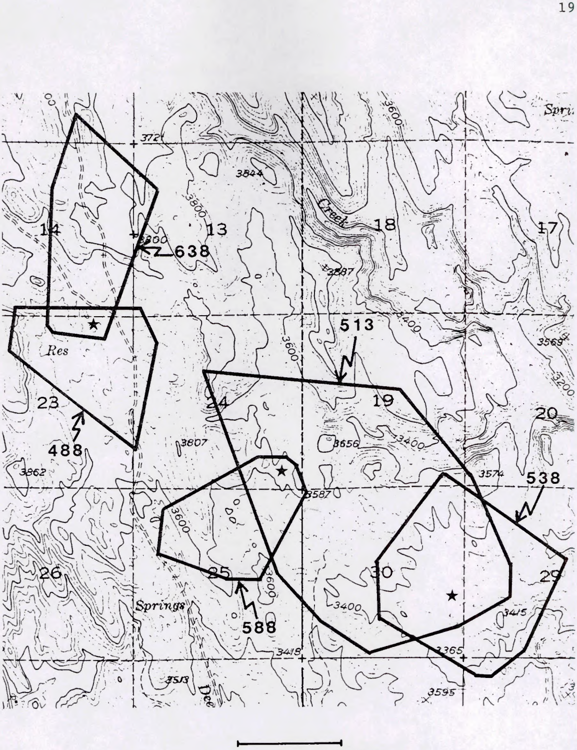

Figure 7. Spring-to-autumn home ranges of radio-tagged sharp-tailed grouse in the Mann Creek study area, 1983. Numbers are the radio frequencies of grouse listed in Table 4. Stars denote the Upper, Middle, and Lower dancing grounds from upper left to lower right, respectively.

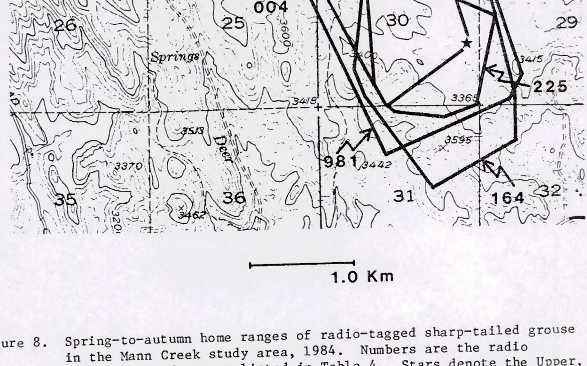

Figure 8. Spring-to-autumn home ranges of radio-tagged sharp-tailed grouse in the Mann Creek study area, 1984. Numbers are the radio frequencies of grouse listed in Table 4. Stars denote the Upper, Middle, and Lower dancing grounds from upper left to lower right, respectively.

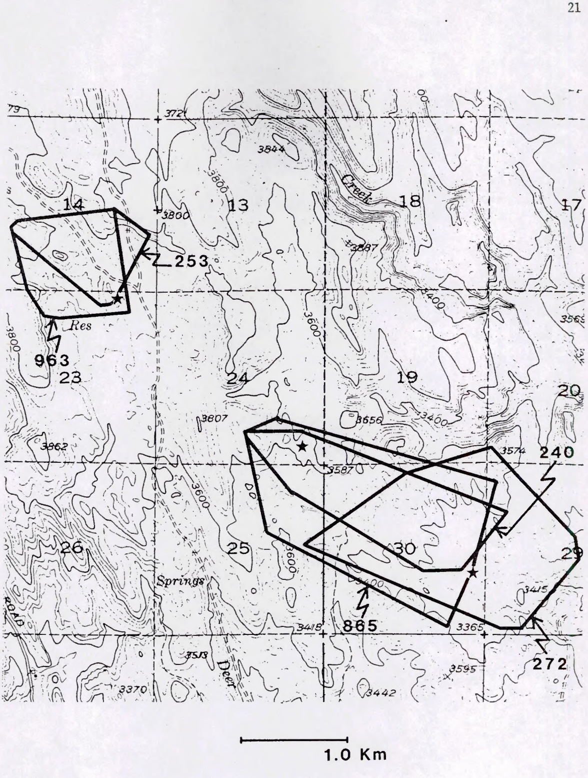

Figure 9. Spring-to-autumn home ranges of radio-tagged sharp-tailed grouse in the Mann Creek study area, 1985. Numbers are the radio frequencies of grouse listed in Table 4. Stars denote the Upper, Middle, and Lower dancing grounds from upper left to lower right, respectively.

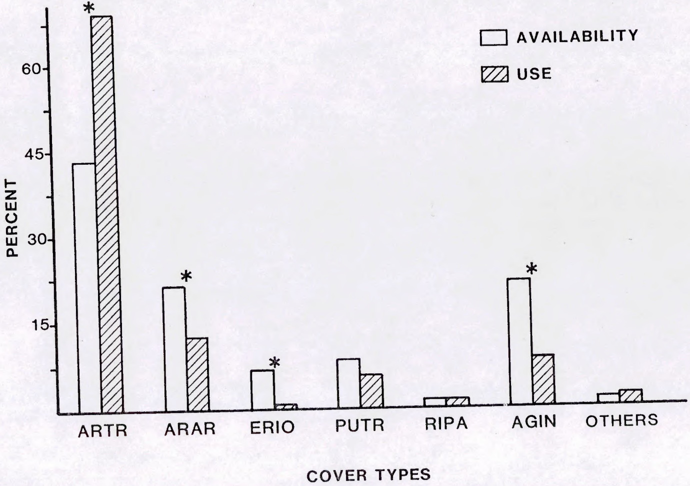

Figure 10. Cover type availability and use by nine grouse from the Lower Dancing Ground, 1983-1985. Significance levels (* = P < 0.05) computed with Bonferroni z-tests.

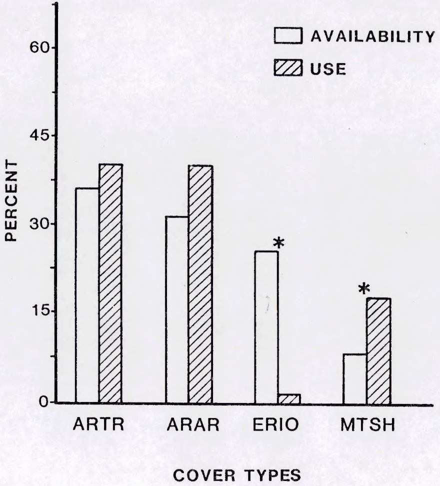

Figure 11. Cover type availability and use by five grouse from the Upper Dancing Ground, 1983-1985. Significance levels (* = $P < 0.05$) computed with Bonferroni z-tests.

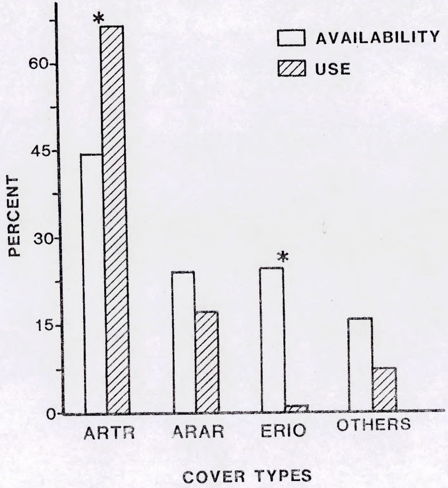

Figure 12. Cover type availability and use by one grouse from the Middle Dancing Ground, 1983. Significance levels (* = $P < 0.05$) computed with Bonferroni z-tests.

Microhabitat Selection

Random transect data from 1984 and 1985 were combined to estimate availabilities of slope, aspect, and distances to edge, water, and nearest mountain shrub or riparian habitat. We assumed that the availability of these parameters did not change during the two years.

The range of slopes used by grouse was 0-47%. Grouse used slopes >30% in only 25 of 737 flush sites. For analysis, slopes were placed into three intervals (0-9%, 10-29%, and ≥30%). Grouse used these slope intervals in proportion to availability in 1984 and 1985, and used the steeper slopes less than expected in 1983 (Table 7).

In each year, grouse did not use aspect in proportion to availability (Table 8). Although no strong trend emerged from this analysis, north slopes were preferred and south and west slopes were avoided in two of three years.

Distance to edge (i.e., a boundary between cover types of different structure) was recorded as ≤20m or >20m. Grouse used edge in proportion to availability in two of three years, suggesting little affinity for edge (Table 9). Mean distance to water did not differ significantly between flush sites and random transects during any year, and no evidence was found that sharp-tailed grouse sought out free water (Table 10).

Grouse did not show a strong preference for sites that were in close proximity to MTSH or RIPA except in 1985, the drought year (Table 11). Mean distances to RIPA or MTSH were significantly different at flush and random sites in all years. The mean distances measured at flush sites were farther than those measured at random sites in 1983 and 1984 but significantly closer in 1985.

Eighty-three percent of the flush sites for which microhabitat measurements were taken (N = 737) occurred in ARTR and ARAR cover types. There were not enough flush sites in the other cover types to make statistical comparisons with vegetative data from random transects. Therefore, vegetative data on microsite use vs. availability are reported only for ARTR and ARAR cover types. Canopy coverage and vertical cover data measured at all random transects and flush sites are reported in the Appendices 4-9.

Mean shrub height and density were always higher at flush sites; however, only in two cases were the means significantly different (Figure 13). In all cases, the mean density of arrowleaf balsamroot was significantly higher at flush sites than at random transects (Figure 13).

At random sites, vertical cover was not measured in PUTR in 1984, nor in MTSH or RIPA cover types, which have cover so dense it would have been meaningless to take cover board readings. Vertical structure measured at random transects differed among cover types (Kruskal-Wallis test, $P < 0.001$). Mean cover board readings indicated that ARTR and AGIN cover types provided more cover than all but PUTR sites (Figure 14). ERIO sites had very little cover, and ARAR provided intermediate cover. A drought during 1985 resulted in significantly less cover in 1985 than in 1984 (Figure 15).

Table 7. Availability vs. grouse use of slope in the Mann Creek study area, 1983-1985.

% Slope	% Available	% Grouse use 1983	1984	1985
0-9	45.25	43.20	42.91	39.41
>9-29	48.60	54.01	52.23	55.66
≥30	6.15	2.79[a]	4.86	4.93
N	179	287	247	203
Chi-square		7.27	1.64	4.10
P		<0.05	<0.25	<0.10

[a] Used less than that expected by chance ($P < 0.05$).

Table 8. Availability vs. grouse use of aspect in the Mann Creek study area, 1983-1985.

Aspect	% Available	% Grouse use 1983	1984	1985
North	18.99	32.75(+)[a]	35.63(+)	21.18(NS)
South	24.58	10.80(-)	13.77(-)	30.54(+)
East	14.53	14.63(NS)	23.08(+)	14.29(NS)
West	18.44	13.94(NS)	10.53(-)	9.85(-)
Zero[b]	23.46	27.87(NS)	17.00(-)	24.14(NS)
N	179	287	247	203
Chi-square		58.32	72.94	11.61
P		<0.005	<0.005	<0.01

[a] Used more than (+), less than (-), or in proportion to (NS) that expected by chance ($P < 0.05$).

[b] Valley bottoms or hill tops.

Table 9. Availability vs. grouse use of edge in the Mann Creek study area, 1983-1985.

Distance to edge	% Available	% Grouse use 1983	1984	1985
0-20 m	39.11	58.54	33.60	44.33
>20 m	60.89	41.46	66.40	55.67
N	537	287	247	203
Chi-square		45.48	3.14	2.33
P		<0.001	>0.05	>0.10

Table 10. Mean distance (m) to water from grouse flush sites and random transects in the Mann Creek study area, 1983-1985.

Location	Year	Mean	SD	N	P[a]
Random	1984-1985	295.86	211.69	179	
	1983	295.69	212.23	287	0.99
Flush	1984	298.27	167.07	247	0.39
	1985	298.84	170.54	203	0.43

[a] Computed with Mann-Whitney U-test.

Table 11. Mean distance (m) to mountain shrub or riparian cover type from flush sites and random transects in the Mann Creek study area, 1983-1985.

Location	Year	Mean	SD	N	P[a]
Random	1984-1985	120.30	99.73	179	
Flush	1983	123.08	141.50	287	0.04
	1984	179.97	171.45	247	0.003
	1985	84.41	90.86	203	0.0001

[a] Computed with Mann-Whitney U-test.

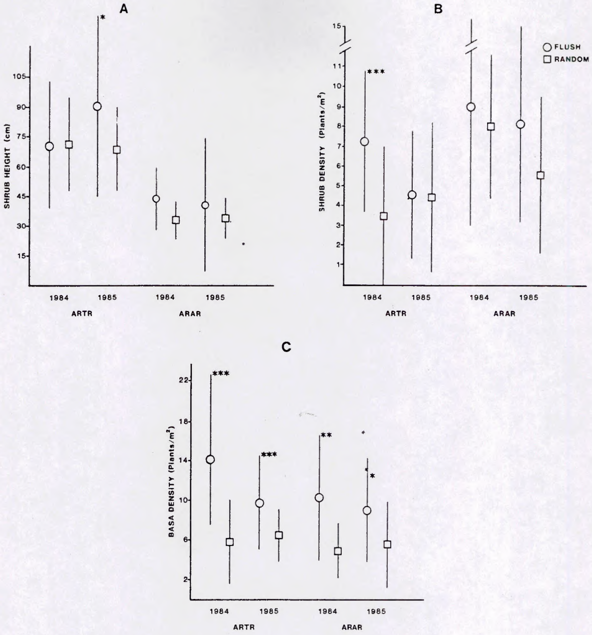

Figure 13. Means ($\pm$ SD) for shrub height (A), shrub density (B), and arrowleaf balsamroot (BASA) density (C) at flush sites vs. random sites. Significance levels computed with Mann-Whitney U-tests (* = $P < 0.05$; ** = $P < 0.005$; *** = $P < 0.001$).

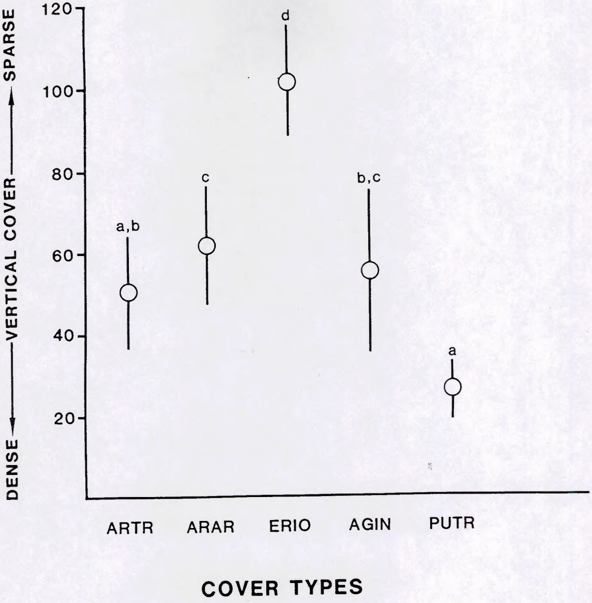

Figure 14. Mean (± SD) cover board readings at random transects, 1984 and 1985 combined. Different letters indicate that the corresponding means are significantly different (P = 0.05).

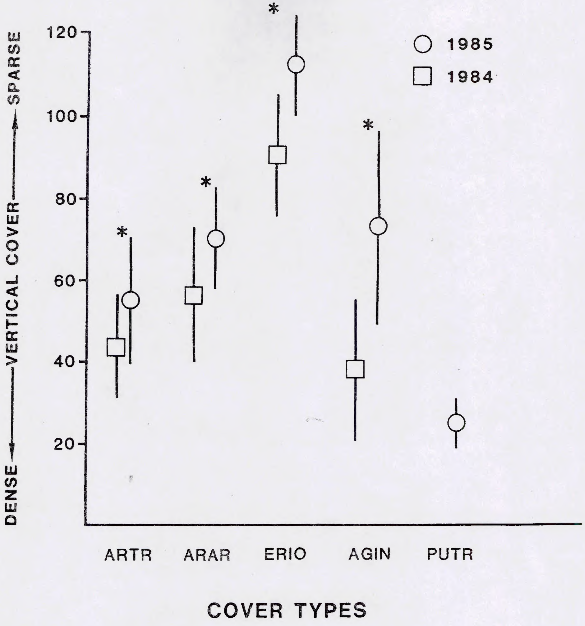

Figure 15. Mean (+ SD) cover board readings at random transects, 1984 vs. 1985. The PUTR cover type was not sampled in 1984. Significance levels computed with Mann-Whitney U-tests (* = $P < 0.01$).

However, the rank order of cover availability was the same among cover types for all but AGIN. Seedings of AGIN are composed mostly of grasses and not shrubs (Appendix 5), so greater changes in cover might be expected there during a drought year.

The cover types used most by sharptails, ARTR and ARAR, had a higher diversity of shrub, forb, and grass species than the other cover types (Figure 16). The ARTR cover type had the highest diversity of shrubs and grasses, and the ARAR cover type had the highest diversity of forbs. Overall, the ARTR cover type had the highest structural diversity because of its rich diversity of shrub species.

Vertical cover measured at flush sites differed among years in both ARTR and ARAR cover types (Kruskal-Wallis tests, $P < 0.01$) (Figure 17). As noted at random transects, there was significantly less cover in 1985 than in 1984. However, cover board measurements at flush sites did not differ significantly between 1983 and 1985. When comparing grouse flush sites with random sites, sharptails selected denser cover than that measured at random sites (Figure 18). This difference was significant in both 1984 and 1985.

Grouse selected different amounts of cover throughout the day in two of three years (Kruskal-Wallis tests, $P < 0.05$) (Figure 19). They tended to use sparser cover in mornings and evenings and heavier cover during midday. The trend for selection of heavier cover during midday than during evening was significant in 1984 and 1985. However, cover board readings were statistically equal across all time periods in 1983 ($P = 0.48$).

From 1983-1985, canopy coverage of shrubs at grouse flush sites averaged about 9% in both ARTR and ARAR cover types (Appendices 6 and 7). Forb coverage averaged about 30%, and grasses ranged from 28% to 32% canopy coverage in ARAR and ARTR cover types, respectively. Overall, compared with random transects, sharptail flush sites had greater horizontal plant cover (Tables 12, 13). Grouse chose sites with significantly higher arrowleaf balsamroot cover than that found in random plots in both 1984 and 1985. There was significantly higher bluebunch wheatgrass at grouse flush sites than at random sites in the ARTR cover type in 1984 and in the ARAR cover type in 1985. In all cases, random sites had significantly more bare ground.

Figure 20 is a comparison of canopy coverage at flush sites in ARTR, the most preferred cover type, from 1983-1985. Canopy coverage differed among years in five of six vegetative categories (Kruskal-Wallis tests, $P < 0.001$). During the drought of 1985, there was a significant increase in bare ground, and compared with 1983 and 1984, a significant decrease in bulbous bluegrass, other forbs, and other composites. However, bluebunch wheatgrass increased in 1985, while the amount of arrowleaf balsamroot cover was statistically equal across all years ($P = 0.24$). This suggests that these two species were the most reliable cover plants among grasses and forbs during a drought year.

Bluebunch wheatgrass and arrowleaf balsamroot are native perennials that are "local" decreaser species in western Idaho (M. Hironaka, pers. commun.), i.e., they are among the first plants to disappear under heavy livestock grazing. An analysis of the proportion of decreaser forbs at flush vs.

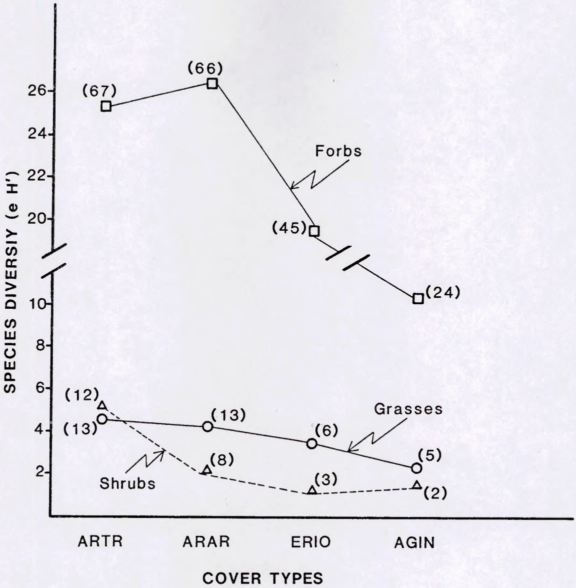

Figure 16. Plant species diversity ($e^{H'}$) at random transects for shrubs, forbs, and grasses in the major cover types. The total number of plant species sampled in each cover type is in parentheses.

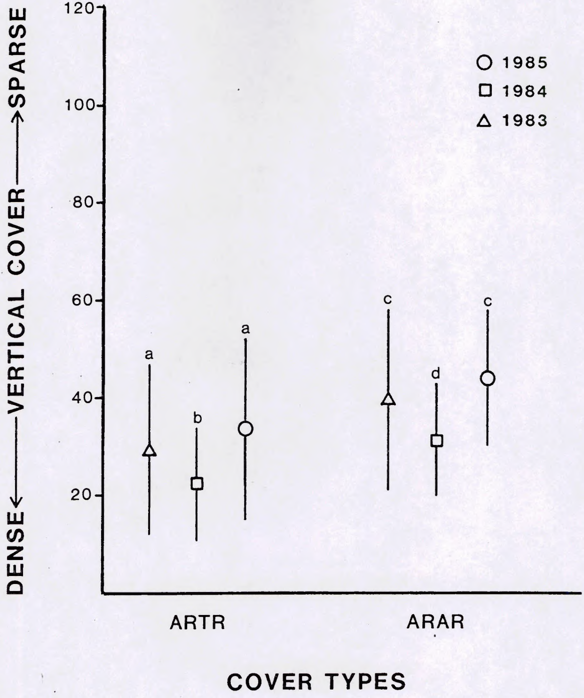

Figure 17. Mean (± SD) cover board readings at flush sites for 1983-1985. For each cover type, different letters indicate that the corresponding means are significantly different at P < 0.05.

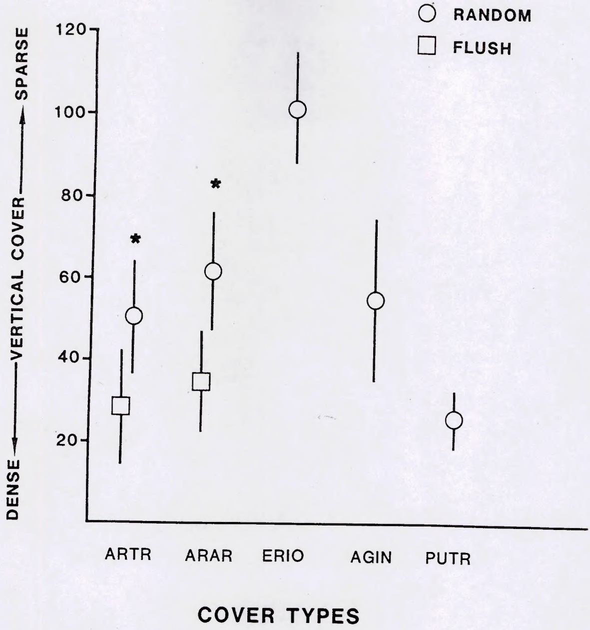

Figure 18. Mean (± SD) cover board readings at flush sites vs. random transects for 1984-1985 combined. Significance levels computed with Mann-Whitney U-tests (* = $P < 0.001$).

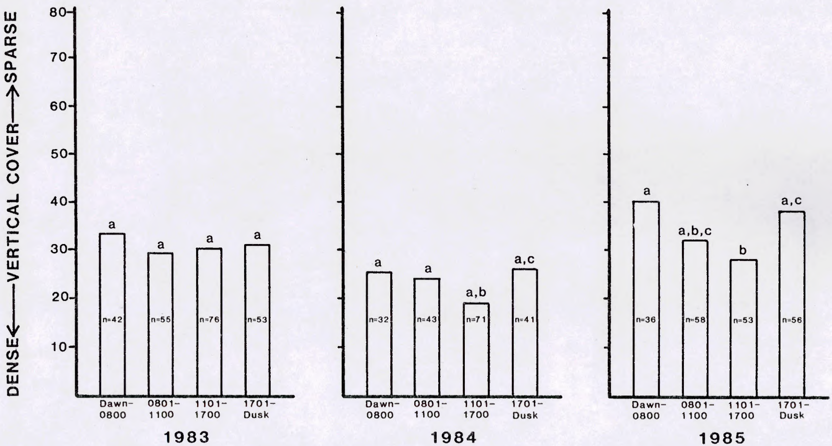

Figure 19. Mean cover board readings at grouse flush sites stratified by time of day. On each graph, different letters indicate that corresponding means are significantly different (P = 0.05).

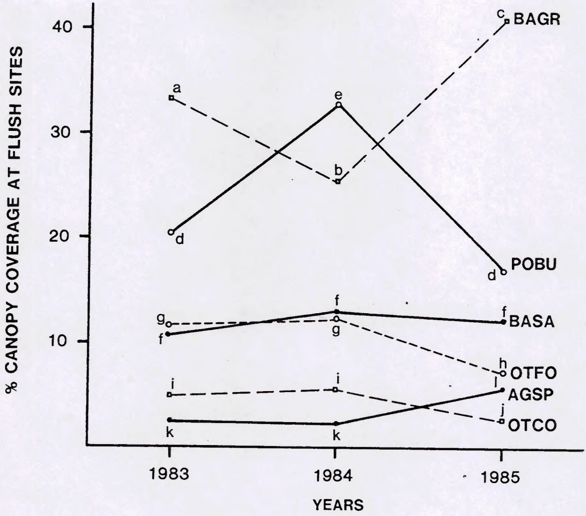

Figure 20. Comparison of canopy coverage at flush sites in ARTR cover type, 1983-1985. On each line, different letters indicate that corresponding means are significantly different at P = 0.05. (BAGR = bare ground; POBU = bulbous bluegrass; BASA = arrowleaf balsamroot; OTFO = other forbs; AGSP = bluebunch wheatgrass; OTCO = other composite forbs.)

Table 12. Mean canopy coverage (%) of vegetative categories in big sage and low sage cover types at grouse flush sites vs. random transects, Mann Creek study area, May-July 1984.

Vegetative category	Big Sage			Low Sage		
	Flush (N = 107)	Random (N = 42)	P[a]	Flush (N = 21)	Random (N = 24)	P[a]
Big sagebrush	3.43	4.03	0.04	0.02	0.07	0.36
Low sagebrush	0.21	0.49	0.001	5.45	7.84	0.08
Bitterbrush	1.52	1.02	0.001	0.86	0.17	0.27
Other shrubs	1.73	0.89	0.26	0.14	0.59	0.02
Total shrubs	6.89	6.43	0.17	6.47	8.67	0.08
Arrowleaf balsamroot	13.60	6.55	0.001	12.21	3.91	0.01
Other composite	7.05	3.78	0.003	5.14	2.95	0.03
Other forbs	12.76	15.31	0.03	12.83	14.24	0.54
Total forbs	33.40	25.64	0.004	30.18	21.10	0.04
Bluebunch wheatgrass	2.93	2.56	0.016	1.02	0.85	0.97
Bulbous bluegrass	35.87	24.59	0.001	36.83	23.09	0.08
Other grasses	3.76	4.32	0.17	2.52	3.32	0.42
Total grasses	42.56	31.47	0.001	40.37	27.26	0.08
Bare ground	23.93	35.93	0.001	28.05	42.30	0.001

[a] Computed with Mann-Whitney U-test.

Table 13. Mean canopy coverage (%) of vegetative categories in big sage and low sage cover types at grouse flush sites vs. random transects, Mann Creek study area, May-July 1985.

Vegetative category	Big Sage			Low Sage		
	Flush (N = 84)	Random (N = 41)	P[a]	Flush (N = 47)	Random (N = 25)	P[a]
Big sagebrush	4.97	6.52	0.01	0.22	0.33	0.006
Low sagebrush	0.55	0.79	0.005	7.03	7.88	0.34
Bitterbrush	2.76	1.84	0.007	1.15	0.88	0.16
Other shrubs	2.21	2.69	0.001	1.36	0.40	0.60
Total shrubs	10.49	11.84	0.06	9.76	9.49	0.74
Arrowleaf balsamroot	13.06	7.40	0.004	11.91	5.28	0.004
Other composites	2.90	3.33	0.26	3.02	3.19	0.99
Other forbs	9.70	7.87	0.11	14.97	7.22	0.001
Total forbs	25.66	18.60	0.003	29.90	15.69	0.001
Bluebunch wheatgrass	5.18	2.91	0.38	4.72	0.46	0.001
Bulbous bluegrass	15.97	16.52	0.67	13.20	22.33	0.001
Other grasses	3.01	2.02	0.78	3.33	3.29	0.39
Total grasses	24.16	21.45	0.35	21.25	26.08	0.03
Bare ground	40.23	48.62	0.001	39.31	48.94	0.001

[a] Computed with Mann-Whitney U-test.

random sites in the ARTR and ARAR cover types showed that there was significantly higher canopy coverage of decreaser forbs at flush sites in all cases (Figure 21). Decreaser species are listed in Appendix 1.

DISCUSSION

Habitat quality appears to be the key in determining whether or not an area is suitable for Columbian sharp-tailed grouse. As many others have noted (e.g., Hart et al. 1950, Buss and Dziedzic 1955, Yocum 1955, Parker 1970, Zeigler 1979), Columbian sharptails need large expanses of relatively unmodified native grass-shrubland.

Habitat conditions may also influence grouse movements. The spring-to-autumn home ranges of UDG grouse were smaller than those of LDG grouse. Perhaps this reflected differences in habitat quality. The pasture in the Lower Basin (vicinity of LDG) was grazed by cattle throughout the summer each year, while, with the exception of a few trespass cattle, the Upper Basin (vicinity of UDG) was not grazed. In mid-to-late summer, six of nine LDG grouse left the grazed area and moved into ungrazed habitats to the north and northwest, which accounted for their larger home ranges. Studies of plains sharptails (*T. p. jamesi*) marked in Saskatchewan (Pepper 1972) and Montana (Yde 1977) also reported that birds avoided heavily grazed areas.

Another important factor that may have influenced grouse movements was the distribution of mountain shrub patches and riparian hawthorn. It is well documented that mountain shrubs and riparian vegetation (e.g., chokecherry, bittercherry, serviceberry, hawthorn) are important to sharptails for winter food and year-round escape cover (Marshall and Jensen 1937, Parker 1970, Ziegler 1979, Oedekoven 1985, see Chapter IV). Mountain shrub patches in the Upper Basin were a prominent component of the vegetation, whereas this cover type was virtually nonexistent in the Lower Basin. The RIPA sites in the Lower Basin were very limited in distribution. In addition to using these areas for escape cover, sharptails at Mann Creek ate the fruits of these shrubs and trees during late summer when most other plant foods had dried (Marks and Marks, unpubl. data). Perhaps grouse home ranges in the Upper Basin were smaller because these grouse did not have to move as far as Lower Basin grouse to find suitable late summer habitat. Resource availability is known to influence territory and home range sizes of other birds (Schoener 1971, Wallestad 1971, Arvidsson and Klaesson 1986, Newton et al. 1986).

Overall, the mean spring-to-autumn home range size of sharptails at Mann Creek was 1.87 ± 1.14 km^2. Published areal measurements of sharp-tailed grouse home ranges based on marked birds are rare. Those available were calculated from movements of prairie (*T. p. campestris*) and plains sharptails. Artmann (1970) found that home ranges of females during spring and summer ranged from 0.13 to 1.05 km^2. In North Dakota, Christenson (1970) determined that summer home ranges of broods ranged from 0.32 to 2.00 km^2. In Minnesota, radio-marked hens with broods were tracked for a minimum of four weeks; their summer home ranges averaged 0.45 km^2 (Ramharter 1976). Gratson (1983) reported May-to-October home ranges of

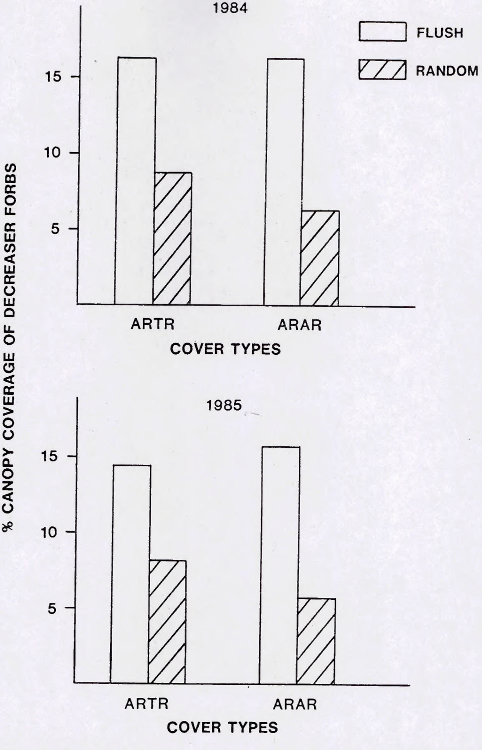

Figure 21. Proportion of decreaser forbs at flush sites vs. random sites in 1984 and 1985. In all cases, canopy coverage of decreasers was significantly greater at flush sites ($P < 0.001$), computed with Mann-Whitney U-tests.

radio-tagged sharptails to be 0.53 km^2 and 0.64 km^2 for males and females, respectively.

From spring to fall, more than 90% of grouse locations at Mann Creek were within 1.2 km of a dancing ground. This range of movement was similar to those found in other areas. Pepper (1972) studied plains sharptails in Saskatchewan and found that most summer observations of marked grouse were within 1.6 km of a dancing ground. Spring-to-fall locations of plains sharptails in Montana were usually less than 1.6 km from a dancing ground (Nielsen and Yde 1981). In Wyoming, Oedekoven (1985) found the summer ranges of Columbian sharptails to be within 1.0 km of a dancing ground.

When macrohabitat use of cover types was evaluated within the 1.2 km radii and within an individual bird's home range, grouse preferred the ARTR cover type. This was not surprising, because components of ARTR sites were characteristic of quality Columbian sharptail habitat elsewhere (Marshall and Jensen 1937, Jewett et al. 1953, Rogers 1969, Ziegler 1979, Oedekoven 1985). Compared with other cover types, ARTR sites had a high diversity of shrubs, forbs, and grasses; the highest structural diversity (measured as coefficient of variation of canopy coverage and cover board readings); the best development of perennial bunchgrasses; and more cover than all but the MTSH, RIPA, and PUTR cover types. The canopy coverage of big sagebrush in the ARTR cover type averaged about 5%. Unlike many areas that have suffered from overgrazing in the absence of fire (Ellison 1960, Christensen 1963, McAdoo and Klebenow 1979, Blaisdell et al. 1982), sagebrush cover had not increased to a point where it suppressed the native herbaceous vegetation.

The response of a particular site to livestock grazing varies with many factors (e.g., type of livestock, season of use, stocking rate) (Tisdale and Hironaka 1981), so it is difficult to determine exactly what is responsible for the range condition at Mann Creek. Nonetheless, the sparse canopy of sagebrush, the relative abundance of perennial forbs and grasses, and the rich diversity of plant species are indications that the Mann Creek study area has not been as severely impacted by livestock as have surrounding areas. Most grasses and forbs are more palatable to livestock than are shrubs; so, with overgrazing there is a tendency for shrubs to increase at the expense of herbaceous plants (Tisdale and Hironaka 1981, Blaisdell et al. 1982). This pattern of change in sagebrush communities has been well documented. Laycock (1967) found that heavy spring grazing by sheep resulted in increased big sagebrush coverage and decreased herbaceous cover. Similarly, Harniss and Murray (1973) reported that spring and fall sheep grazing caused a production increase of big sagebrush while desirable forbs and grasses declined. More recently, Stevens (1986) determined that with cattle grazing in a shrubsteppe community, shrub cover increased while forbs decreased. He also studied an area that received no cattle grazing for 22 years, after which total numbers of big sagebrush decreased significantly. Wambolt and Payne (1986) found that removal of livestock resulted in a 29% reduction in sagebrush canopy during an 18-year study.

In other areas, however, protection from livestock grazing has done little to reduce shrub cover. Robertson (1971) studied an area in Utah that was ungrazed for 30 years and found increases in cover of both big sagebrush and perennial herbs. Similar results were reported by Anderson and Holte (1981), who determined that cover of shrubs and perennial grasses nearly

doubled on ranges ungrazed for 25 years in southeastern Idaho. On rangeland in New Mexico, Holechek and Stephenson (1983) reported that big sagebrush dominated the canopy cover in two adjacent sites, one protected and the other moderately grazed for 22 years. These studies support the idea that range sites respond differently to livestock grazing. The nature of past disturbances and the species composition of the remaining flora are probably important underlying factors that influence the response of range vegetation to livestock removal (see Anderson and Holte 1981).

Although grazing often causes an increase in shrub densities following a decline in herbaceous cover, shrubs were an important component of many pristine rangelands (Vale 1975). However, a dominant canopy coverage of sagebrush with low plant species diversity was probably not a natural condition (Harris 1967), and is largely avoided by sharptails and other wildlife (McAdoo and Klebenow 1979). At Mann Creek, the overall preference of sharptails for the ARTR cover type indicated that grouse were selecting for habitat diversity relative to surrounding areas. Sage grouse (Centrocercus urophasianus) are also known to select areas with relatively high habitat diversity within sagebrush communities (Klebenow 1972, Dunn and Braun 1986).

Collectively, grouse associated with the UDG used the ARAR cover type in proportion to availability, and LDG grouse avoided ARAR. It is possible that the avoidance of ARAR sites in the Lower Basin but not in the Upper Basin was a reflection of the overall higher quality of the vegetation in the latter area, which was not regularly grazed by cattle. In general, ARAR sites had a high diversity of forbs and a rich mixture of grasses. Although this cover type provided good cover up to about 20 cm above ground, it did not provide taller cover nor have the structural diversity of the ARTR cover type.

The ERIO cover type was strongly avoided by sharptails. It contained a low diversity of forbs and very low structural diversity. This cover type occurred on shallow, rocky soils, and even in the absence of grazing provided little cover. Excluding dancing grounds, sharptails studied elsewhere have exhibited similar selection against areas of sparse cover (Hart et al. 1950, Pepper 1972, Hillman and Jackson 1973, Sisson 1976, Ziegler 1979).

The AGIN cover type, present only in the Lower Basin (and immediately adjacent to the Lower Dancing Ground), was avoided by grouse. Although AGIN seedings provided relatively dense vertical cover, they did not have the diversity of shrubs, forbs, and grasses found in the cover types preferred by grouse (ARTR and ARAR) and probably did not provide many plant foods for sharptails. In support of this idea, most of the use of AGIN seedings by sharptails occurred in 1984, when a grasshopper outbreak provided an abundant food source there. Few flush sites occurred in AGIN during non-outbreak years.

MTSH, RIPA, and PUTR habitats were areas of dense shrub and tree cover that were used primarily as escape cover from spring through summer. Beginning in late summer, MTSH and RIPA species produced fruits that became an important part of the sharptails' diet. In other areas, sharptails have commonly used these cover types for escape cover and for late summer-autumn

food (Rogers 1969, Parker 1970, Ziegler 1979, Oedekoven 1985). In two of three years, grouse locations were no closer to MTSH or RIPA sites than were random locations. Proximity to this shrubby vegetation may not have been critical during early-to-mid summer when the cover types preferred by grouse were providing adequate food and cover. Interestingly, sharptails were found closer to MTSH and RIPA habitat than expected by chance only in the drought year (1985), when vertical cover decreased significantly in all cover types that were measured (ARTR, ARAR, ERIO, AGIN).

Although slopes ≥30% were used in proportion to availability in two of three years, sharptails used steep slopes only when such slopes were adjacent to flatter areas (i.e., near the top or bottom of a steep slope). Sharptails at Mann Creek avoided extremely steep slopes (>50%). Avoidance of steep slopes by Columbian sharptails has been noted elsewhere. In Utah, Hart et al. (1950) reported that sharptails were usually observed in rolling terrain and rarely used slopes greater than 45%. Sharptails in Colorado seldom used slopes greater than 15%, and preferred flat or rolling areas interspersed with broken topography (Dargan et al. 1942 in Rogers and Stearns 1964), and Parker (1970) indicated that sharptails in eastern Idaho usually avoided steep areas.

There was a tendency for grouse to select north slopes and avoid south and west aspects. In Colorado, Dargan et al. (1942 in Rogers and Stearns 1964) flushed most sharptails from north exposures, whereas west slopes appeared to be avoided. North slopes were highly preferred by sharptails nesting in Nebraska (Sisson 1976). Sisson (1976) reported that north slopes were dominated by residual cover and deep plant litter, which made those areas attractive for nest sites. Generally, south and west slopes are drier and do not have the vegetation development of north slopes (Nelson 1977, Birkeland 1984). Perhaps north slopes in the Mann Creek area provided more lush vegetation and thus better food and cover for sharptails, which in some cases may have accounted for their preference of these slopes.

Sharptails at Mann Creek seldom were found at the edge of adjoining cover types. In contrast, over 70% of McArdle's (1977) grouse observations were within 30 m of the nearest edge. In McArdle's southeastern Idaho study area, most grouse were in areas of >20% shrub canopy, which was primarily sagebrush. This suggests that his study area was structurally homogeneous compared to the Mann Creek study area, where sharptails selected areas of 6-9% shrub canopy. Vegetation within cover types preferred by grouse at Mann Creek was structurally diverse, perhaps explaining the sharptails' lack of association with edge. Grouse also lacked an affinity for open water, which indicated that they did not require free water. This was consistent with findings in two Utah studies that found no evidence that sharptails sought out free water (Marshall and Jensen 1937, Hart et al. 1950).

There was no significant difference in mean shrub height or density between flush sites and random sites. Although shrub densities (plants/m^2) measured at flush sites were not statistically different from those available, areas with dense canopy coverage of big sagebrush apparently were avoided by sharptails. Canopy coverage of big sagebrush at grouse locations averaged 4%, whereas the densest stands of sagebrush in the study area averaged 32%. Grouse did not use these dense stands of sagebrush, perhaps because such stands were rare, or more likely because

they were unsuitable for grouse. Oedekoven's (1985) findings in Wyoming were consistent with those at Mann Creek: shrub height in sharptail summer ranges was not significantly different from adjacent areas, and grouse did not use areas with a dense canopy of big sagebrush. Sharptails probably avoided these areas because dense sagebrush sites usually have a reduced understory of forbs and grasses (West 1979, Blaisdell et al. 1982). Others have reported that dense shrub habitats tend to be avoided by sharptails (Rogers 1969, McArdle 1977, Kessler and Bosch 1979, Oedekoven 1985). Generally, sharptails are grouse of open country (Evans 1968), and perhaps they do not detect predators as easily in dense cover as they do in more open habitats.

Grouse tended to select sparser cover during morning and evening and heavier cover at midday, a trend similar to that found in other areas (Hart et al. 1950, Pepper 1972, Moyles 1981). This pattern of use reflected their daily activities in summer: sharptails generally feed in the cooler parts of the day, i.e., mornings and evenings, and rest during midday (Marshall and Jensen 1937, Christenson 1970). Use of heavier cover for roosting during warm summer afternoons probably provided shade and concealment from predators (Moyles 1981). Sage grouse have shown a similar daily pattern in habitat use (Dunn and Braun 1986).

Microsite use and availability allowed assessment, by inference, of the influence of livestock grazing on sharptail habitat selection. Range deterioration as a result of past abuses by livestock can be evaluated by plant species composition and relative abundance in the community (Pechanec 1945, Christensen 1963, Blaisdell et al. 1982, Society for Range Management 1983). Characteristics of poor range condition, due largely to overgrazing, were reviewed by Blaisdell et al. (1982). Properties that they described include: a decrease in number and vigor of palatable perennial forbs and grasses, also known as decreasers (Dyksterhuis 1949); an increase of undesirable annuals and other poor forage plants, also known as increasers (Dyksterhuis 1949); dense stands of sagebrush; and increased soil erosion.

Compared with random transects, grouse flush sites were characterized by greater grass and forb cover, nearly equal percentages of shrub cover, and less bare ground. Over an 18-year period, Stevens (1986) found a 9% increase and a 17% decrease in bare ground at locations with and without grazing, respectively. This implies that areas with relatively little bare ground were the least modified by grazing. Such sites were selected by grouse in the Mann Creek study area. Based on the random transects, vegetation in the study area was in fair ecological condition. The vegetation at flush sites was in good ecological condition, suggesting that sharptails selected rangelands that were in better than average condition for the study area.

Microhabitat selection of arrowleaf balsamroot and bluebunch wheatgrass were other properties of flush sites that reflected the sharptails' preference for relatively undisturbed areas. These native perennials are major components of later seral stages (Hironaka et al. 1983). This suggests that sharptail habitat should be managed for the "potential natural community" (Society for Range Management 1983). In addition, arrowleaf balsamroot and bluebunch wheatgrass are sensitive to livestock grazing and decline with overuse (Blaisdell and Pechanec 1949, Evans and Tisdale 1972, Mueggler and Stewart 1980). The significantly greater proportion of

decreaser forbs at grouse locations was another indication that sharptails selected sites that were not as modified by livestock as were surrounding areas. This suggests that Columbian sharptails are a suitable indicator species of range quality in the mesic shrubsteppe of the Intermountain West.

The presence of arrowleaf balsamroot and bluebunch wheatgrass as cover plants during a drought year is especially noteworthy. Many native perennial forbs and grasses are drought tolerant (Pechanec et al. 1937, Harris 1967, Sauer and Uresk 1976), and bluebunch wheatgrass and arrowleaf balsamroot are particularly drought resistant (Tisdale and Hironaka 1981, Wasser 1982). Roots of perennials characteristically are deep and heavily constructed, allowing them to access a reservoir of soil water (Harris 1967, Sauer and Uresk 1976). These properties are lacking in annuals. Bulbous bluegrass, the most abundant and widespread grass in the study area, is an introduced perennial that has some characteristics of annuals. The roots die each year and like many annuals, the grass is virtually nonexistent during years of low moisture (Monsen, in prep.). Bulbous bluegrass, although a good producer in wet years (Monsen, in prep.), was not reliable cover for grouse at Mann Creek during the drought. Bulbous bluegrass grew to only a fraction of its normal height and provided almost no cover. In contrast, growth of bluebunch wheatgrass appeared normal, with plants providing good cover for grouse throughout the dry summer. In the absence of native perennials, sharptails would not have had as much cover during drought years. The loss of these important cover plants has probably been a major factor in the disappearance of Columbian sharptails from large portions of their historic range.

Columbian sharptails have suffered the most severe distributional decline among the six subspecies of sharptails, and currently occupy only a fraction of their former range (Hamerstrom and Hamerstrom 1961, Miller and Graul 1980, Johnsgard 1983). In contrast, plains sharptails are abundant throughout most of their historic range, and their populations appear to be quite stable (Miller and Graul 1980). Plains sharptails evolved in the Great Plains, where prairie vegetation developed with and was adapted to large herds of grazing ungulates, particularly bison (Bison bison)(see Hillman and Jackson 1973). Most of the grasses in the Great Plains are rhizomatous, and thus were resistant to grazing and trampling by ungulates (Mack and Thompson 1982). The introduction of domestic herbivores into these grasslands had relatively little effect on the vegetation there (Mack and Thompson 1982). This is in marked contrast to the Intermountain region, where Columbian sharptails and shrubsteppe vegetation evolved in the absence of large herds of grazing ungulates (see Harris 1967, Daubenmire 1970, Tisdale and Hironaka 1981). Caespitose grasses (i.e., bunchgrasses), which dominate the Intermountain West, reproduce mostly by seed, and thus had little resistance to continued overuse by large ungulates (Mack and Thompson 1982). The introduction of large herds of livestock into this region has resulted in widespread changes in the structure and species composition of the vegetative communities; e.g., the replacement of native perennials with exotic species that are adapted to overgrazing by livestock (Daubenmire 1970, West 1979, Mack and Thompson 1982). This habitat modification by introduced livestock apparently led to the decline of Columbian sharptails, which show a strong preference for relatively undisturbed native grass-shrublands.

CHAPTER III

DANCING GROUNDS, NESTS, AND BROOD SITES

RESULTS

Dancing Ground Counts

Cogan (1982) censused four dancing grounds in the Mann Creek study area in 1981. Two of them were traditional grounds (the Upper and Lower dancing grounds) and two were new. The Upper and Lower dancing grounds were also active during each year of our study, whereas the two "satellite" grounds found by Cogan in 1981 were unoccupied from 1983-1985. In addition, we found two new dancing grounds during spring 1983 (Middle and Fairchild). The Fairchild Dancing Ground was never occupied after the spring of 1983, and the Middle Dancing Ground was active only intermittently. Grouse danced on a patch of bare ground near the Middle Dancing Ground during early spring 1985 but moved to the Lower Dancing Ground as soon as the snow melted from it. The only cases of marked birds moving between dancing grounds involved movements away from the Middle Dancing Ground in 1983: a male radio-tagged on the Middle Dancing Ground acquired a territory on the Lower Dancing Ground within two weeks, and a male color-banded on the Middle Dancing Ground was captured on a territory on the Upper Dancing Ground in 1984.

Dancing males were counted each morning that we attended blinds on the dancing grounds. Because we were also trying to trap these birds, which often resulted in us flushing the birds before sunrise, it was not possible to obtain an accurate count on each morning that we visited a dancing ground. Thus, we probably underestimated the number of dancing males on some mornings.

The minimum number of males counted each morning varied considerably (Appendix 10). Spring counts peaked in March and early April and tapered off through the end of April. Most dancing activity ceased by mid-May. The highest counts for a dancing ground in spring ranged from nine in 1983 to 15 in 1986 (both the Upper and Lower dancing grounds had 15 birds in 1986). The sums of the highest counts for all dancing grounds each spring were 23, 23, 17, and 30, for 1983-1986, respectively (Appendix 10).

The only accurate way to count dancing males in autumn was to flush them. Thus, it was not possible to determine whether all birds counted in autumn were dancing or whether some were merely observing from the periphery of the dancing grounds. Maximum counts in autumn were 2-5 times higher than spring counts but were also extremely variable (Appendix 10). The highest counts were on the Upper Dancing Ground each autumn and ranged from 24 in 1983 to 45 in 1985.

Based on a 1:1 adult sex ratio and on all males attending a dancing ground each spring, at a minimum, the number of sharptails on the study area during spring ranged between 35 and 60 over the study period. If 50% of the hens raise an average of five young each year, then the number of grouse on the study area in mid-summer would have varied between 80 and 135 from 1983-1986. We caution that no data are available on adult sex ratios, the

proportion of nonbreeding adults present, the proportion of hens that raise broods each year, or the average number of young raised per brood. Given the large number of variables for which no data are available, it is impossible to accurately estimate the size of the Mann Creek population. Our best guess is that between 100 and 200 birds (including young of the year) reside on the study area during summer.

Nests

We found only nine nests during the study. Four of the nests belonged to radio-tagged hens, four were found inadvertently after the eggs had hatched or been destroyed, and one was found by flushing a nonradioed hen off the eggs (this hen was later captured and radio-tagged). Of the five nests found during incubation, two were successful, two were destroyed by mammalian predators, and one was deserted after we flushed the hen to obtain a clutch count. At least three of the remaining four nests were successful. Clutch size averaged 10.8 ± 1.3 eggs ($N = 5$).

Nest site characteristics are presented in Table 14. Most of the nests were on hillsides of gentle slope; there was no apparent preference for one aspect over another. The average distance to the nearest dancing ground was 539 ± 380 m (range = 50-1100 m). One nest was in the MTSH cover type and eight were in either the ARTR or ARAR cover types. Seven nests were placed beneath live sagebrush, one beneath a dead sagebrush, and one beneath a live arrowleaf balsamroot. Two nests also had live bluebunch wheatgrass in the overstory. Only one nest had residual bluebunch wheatgrass above it. Four nests were placed adjacent to live arrowleaf balsamroots, and three were next to live clumps of bluebunch wheatgrass.

Canopy coverage and cover board readings were taken in the vicinity of each nest in the same manner as at flush sites, with the nest serving as the center location for all measurements (Table 15). The total canopy coverage of shrubs, forbs, and grasses at nests averaged 15.5%, 27.8%, and 18.8%, respectively. Bare ground and litter averaged 39.3%. The canopy coverage and cover board measurements indicate that grouse preferred to nest in heavier than average cover; in most cases this was accomplished by placing the nest beneath a live sagebrush plant. The small sample of nests precluded meaningful conclusions regarding the vegetational characteristics in the area surrounding nest sites.

Brood Sites

Two radio-tagged females raised broods. Habitat and home range data from these two females have been combined with the data from radio-tagged males and reported in Chapter II. Female 107 laid 10 eggs in 1984, nine of which hatched on 29 June. The brood was reduced to five young by early August, and three full-grown young were alive at the end of September when the adult was killed by an avian predator. Female 272 laid 11 eggs in 1985, 10 of which hatched on 9 June. The brood was reduced to six young by late June, all of which survived to adult size. By the end of September only two young accompanied the hen, and by 8 October the hen was alone. We assumed that the disappearance of young was due to brood break-up, which typically occurs during late summer or autumn (Hart et al. 1950), rather than to mortality.

Table 14. Characteristics of nine sharptail nests in the Mann Creek study area, 1983-1985.

Year	Overstory	Dist. (m) to danc. grnd.	Aspect	% Slope	Topog. posit.	Cover type	Clutch size
1983							
1	Low sage	300	---	0	Valley	ARAR	12
2	Big sage	1100	W	4	Hillside	MTSH	--
1984							
3	Big sage	1000	E	22	Hillside	ARTR	--
4	Big sage	650	NE	17	Hillside	ARTR	--
5	Low sage[a]	50	E	9	Hillside	ARAR	10
6	Low sage[b]	175	S	14	Hillside	ARAR	9
7	Low sage	750	---	0	Hilltop	ARAR	12
1985							
8	Big sage[c]	175	---	0	Valley	ARTR	11
9	Balsamroot	650	S	16	Hillside	ARTR	--

[a] Overstory also included live and residual bluebunch wheatgrass and live arrowleaf balsamroot.

[b] Overstory also included live bluebunch wheatgrass and live arrowleaf balsamroot.

[c] Big sagebrush overstory was dead.

Table 15. Percent canopy coverage of shrubs, forbs, and grasses, and mean cover board readings in the vicinity of nine sharptail nests in the Mann Creek study area, 1983-1985.

Vegetative category	1983		1984					1985	
	1	2	3	4	5	6	7	8	9
Big sagebrush	0.0	12.5	19.5	8.5	0.0	0.0	0.0	4.0	0.0
Low sagebrush	12.5	0.0	0.0	0.0	10.5	7.0	10.5	0.0	0.0
Bitterbrush	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other shrubs	3.5	36.0	0.5	0.0	3.0	0.0	0.5	0.0	11.0
Arrowleaf balsamroot	0.5	0.0	0.0	1.0	11.0	10.5	26.0	0.0	19.0
Other forbs	34.0	34.5	20.5	31.5	15.5	7.0	15.5	13.0	10.5
Bluebunch wheatgrass	0.0	3.0	0.0	3.0	3.0	3.0	11.0	0.0	0.0
Bulbous bluegrass	8.5	0.0	19.5	12.0	26.0	21.5	0.0	19.5	4.0
Other grasses	1.5	2.0	0.5	1.5	0.0	2.5	2.5	21.5	3.0
Bare ground	47.5	16.5	37.5	38.5	29.0	47.5	33.0	47.0	57.0
Mean cover board	36.2	11.8	18.0	26.0	14.8	32.2	34.0	53.5	29.8
(SD)	7.6	23.5	19.2	10.8	3.1	12.3	12.2	24.7	6.8

We encountered only 28 broods of nonradioed females. Some of these undoubtedly were multiple encounters of the same broods. The earliest brood sighting was of three newly-hatched chicks 1.1 km northwest of the Upper Dancing Ground on 15 May 1983. For all years combined, the mean size of nonradioed broods was 7.3 $\pm$ 2.0 in June (N = 6), 6.0 $\pm$ 2.6 in July (N = 10), 8.3 $\pm$ 2.5 in August (N = 7), and 5.7 $\pm$ 1.1 in September (N = 3). Especially during June and early July, brood sizes were probably higher than we report because smaller young tend to crouch and freeze rather than fly. The largest broods observed were 10, 11, and 10 in June, July, and August, respectively. Twenty-one (75%) of the brood sites were within 1 km of an active dancing ground, and none was farther than 1.6 km from a dancing ground.

Of the nonradioed brood sites, 13 occurred in the ARTR cover type, seven in the ARAR cover type, two each in the AGIN and MTSH cover types, and one each in the PUTR, MEAD, AGRI, and ERIO cover types. The mean percent canopy coverage of shrubs, forbs, and grasses at 20 brood sites in the ARTR and ARAR cover types is presented in Table 16. Although sample sizes were too small for statistical analyses, bare ground and the mean canopy coverages of arrowleaf balsamroot, bluebunch wheatgrass, bitterbrush and other shrubs were substantially higher at nonradioed brood sites than at random sites.

DISCUSSION

Dancing Grounds

In 1981, Cogan (1982) counted 28-30 males each on the Upper and Lower dancing grounds and 23 males total on the two satellite grounds. Thus, 79-83 males attended dancing grounds in the study area in 1981 vs. 17-30 males from 1983-1986. Although dancing ground counts cannot be easily translated into population estimates, it nonetheless seems reasonable to conclude that the Mann Creek grouse population has declined by 60-80% from the early 1980s.

Counts of dancing males made during 1983-1986 were well below those made by Cogan in 1981 and were either lower or similar to counts of dancing Columbians elsewhere. Rogers (1969) reported an average of 9.9 males on 36 dancing grounds in western Colorado and mentioned that some dancing grounds had only two to four males. Oedekoven (1985) reported a range of 2-20 males per dancing ground (N = 9) in south-central Wyoming. In eastern Washington, the average number of males on 38 dancing grounds was highly variable. The lowest average was 3.8 and the highest was 23.7; 10 dancing grounds averaged more than 15 males. Parker (1970) censused 12 dancing grounds in southeastern Idaho. The average number of males was 8.8 with a range of 3-15. Each dancing ground was censused only once.

Based on dancing ground counts, the size of the Mann Creek population is slightly below those of Columbian sharptails in other areas and has clearly decreased since 1981. Despite these figures, however, the highest spring counts were made in 1986, suggesting a slight increase in the population from 1983-1986. This increase is encouraging considering the disturbance created during three years of research, including the capture and radio

Table 16. Percent canopy coverage of shrubs, forbs, and grasses at 20 brood sites of unradioed sharptails in the ARTR and ARAR cover types at Mann Creek, 1983-1985. N = the number of brood sites in each cover type.

Vegetative category	ARTR (N = 13)		ARAR (N = 7)	
	Mean	SD	Mean	SD
Big sagebrush	3.5	5.9	0.0	0.0
Low sagebrush	0.0	0.0	8.9	8.3
Bitterbrush	6.8	7.4	1.1	2.8
Other shrubs	8.2	8.0	4.1	6.5
Arrowleaf balsamroot	14.3	8.6	12.3	11.2
Other composites	5.4	3.0	6.4	3.5
Other forbs	7.9	5.6	8.8	2.7
Bluebunch wheatgrass	6.5	6.5	8.1	8.2
Bulbous bluegrass	20.9	14.9	16.4	16.2
Other grasses	6.7	5.8	4.0	6.7
Bare ground	30.3	10.9	32.3	14.3

instrumentation of 38 adults, all of which failed to survive to the year following capture (see Chapter V). If weather conditions are favorable and if no major changes in land use occur, the grouse population should increase as range conditions continue to improve in the study area.

Nests

Of 127 nests observed from 1935-1940 in Utah, 81.1% were in alfalfa, wheat, or stubble fields, and only 18.1% were in native vegetation (Hart et al. 1950). Hart et al. believed that the general lack of native vegetation that provided adequate cover explained the high incidence of nestings in agricultural fields. Parker (1970) found two nests in southeastern Idaho. One was under a big sagebrush plant and the other beneath a bitterbrush; both were within 1.6 km of a dancing ground. Two Wyoming nests found by Oedekoven (1985) were beneath snowberry plants. Two species of sagebrush were the most important species for nesting cover in our study area, and our small sample of nests also suggested that nesting cover often includes arrowleaf balsamroot and bluebunch wheatgrass. Unlike the Utah study, native vegetation types provided all of the nesting cover in our study area.

Brood Sites

Hart et al. reported an average brood size of 8.7 in Utah (N = 150). The average size of 48 brood sightings in southeastern Idaho was 5.1 (Parker 1970). Average brood sizes at Mann Creek are well within the range reported in the above two studies. Sharptail broods are notoriously difficult to locate (cf. Rogers 1969, Parker 1970), and little can be said about brood sizes based on our small sample. That all brood sightings were within the range of distances moved by radio-tagged males suggests that management considerations based on the patterns of use by adult males should be sufficient for broods as well.

CHAPTER IV

WINTER HABITAT USE

Sharp-tailed grouse are well adapted to harsh winter conditions. Nonetheless, their habitat requirements are narrower in winter than in any other time of year. For this reason, the availability of winter habitat is probably the most important factor in determining whether or not an area will support a population of sharptails. In this chapter, we present a description of what constitutes critical winter habitat for Columbian sharp-tailed grouse in western Idaho.

METHODS

Using snowmobiles and snowshoes, we searched for grouse throughout the winter beginning with the first snows in late November each year and ending with snowmelt, which occurred in late March in 1984, in early April in 1985, and in late February in 1986. The study area was visited at least weekly throughout the winters of 1983-84 and 1984-85 and at irregular intervals during 1985-86. Although searches were focused along riparian areas and mountain shrub patches, all cover types were searched each winter. Because no radio-tagged grouse survived the winter (see Chapter VI), we did not follow a systematic schedule in searching for grouse.

The data reported here are based on 108 grouse locations, 88 in which grouse were observed and 20 in which only their tracks were observed. Sharp-tailed grouse were the only grouse using the habitats in which track sites were recorded. At each grouse location, we recorded the following: (1) number of birds present (track sites excluded), (2) mercator coordinates, (3) distance to nearest dancing ground, (4) cover type in which grouse were first observed, (5) distance to nearest mountain shrub (MTSH) or riparian (RIPA) cover type, (6) topographic position, (7) % slope, (8) aspect, and (9) species of plants fed upon by grouse. Data were analyzed with the same nonparametric techniques described in Chapter I.

RESULTS

Distribution

Grouse were distributed near MTSH and RIPA cover types throughout the study area. These cover types were most numerous in and adjacent to the Middle and Upper basins. Overall, the mean distance to the nearest dancing ground was 1.7 $\pm$ 1.2 km, and 80% of the locations were within 2 km of a dancing ground. One color-banded male wintered within the study area along Deer Creek during 1983-84. Two radio-tagged birds spent part of the 1985-86 winter outside of the study area across Mann Creek about 2.6 km west of the Upper Dancing Ground. Unmarked birds thought to be from the study area were found in mountain shrubs up to 5.0 km north of the Upper Dancing Ground.

A helicopter survey conducted from 20-21 February 1985 located 36 grouse; 11 of these were near Monroe Creek 7.2 km west of the Upper Dancing

Ground and five were west of Keithly Creek 6.9 km northeast of the Upper Dancing Ground. Only 12 grouse were observed in our study area proper during the helicopter survey. To our knowledge, no birds wintered south or east of the study area, which is not surprising as very little suitable winter habitat existed in these directions.

Habitat Use

The onset of winter triggered a marked shift in habitat use by the Mann Creek sharptails. Males stopped visiting dancing grounds as soon as the study area was covered with snow, and all grouse decreased their use of sagebrush-grasslands and increased their use of mountain shrub patches and riparian hawthorn. The amount of use in different cover types differed among years (Table 17). In 1983-84, the RIPA cover type constituted 42% of all grouse locations. In the two succeeding years, however, RIPA was used in only three of 56 grouse locations (5%; Table 17). The MTSH and ARTR cover types received the most grouse use in 1984-85 and 1985-86. Grouse use of slope and aspect during winter did not differ significantly from slope and aspect measured at random sites.

The most striking feature of grouse locations during winter was their proximity to MTSH or RIPA cover types: 88% of all grouse locations were within 50 m of MTSH or RIPA, and we never observed a grouse on the ground that was farther than 125 m from one of these cover types. In all three winters, grouse locations were significantly closer to MTSH or RIPA cover types than were random sites (Table 18). Mountain shrubs and hawthorns provided excellent escape cover, and grouse flew to these cover types in 74% of the cases where the landing site of a flushed bird was observed (N = 42). Grouse also roosted within these cover types (but usually near the edge) between feeding bouts.

During each winter, bare ground occurred only at small seeps, four of which were regularly used by grouse. Grouse use of seeps depended on snow conditions. The snow was deep and powdery from November to mid-January in 1983-84 and 1984-85, and grouse often burrowed beneath the snow to roost after feeding. In only one case was a grouse found at a seep when snow conditions were suitable for burrowing. The use of seeps increased dramatically in midwinter when a crust that formed on the snow prevented grouse from snow-roosting. In 1985-86, the snow was suitable for burrowing until early February, and grouse were not observed at seeps. All snow burrows observed were placed immediately adjacent to (but never within) a patch of mountain shrubs or a stand of riparian hawthorn.

Feeding Sites

In many cases, it was very easy to determine the species of plants fed upon by grouse either by (1) directly observing foraging grouse or by (2) following their tracks and inspecting twigs for the recent removal of buds. In cases where grouse fed on hawthorn fruits, nearby droppings were packed with hawthorn seeds. In contrast, it was difficult to determine the extent to which grouse fed on individual plants because grouse often flew from shrub to shrub leaving no tracks between feeding sites and feeding at heights too high for us to count the number of buds eaten. Thus, a feeding site was defined as the direct observation of feeding grouse or of sign left

Table 17. Cover types used by wintering sharp-tailed grouse in and around the Mann Creek study area, 1983-84 to 1985-86. Numbers are the sums of flush sites and track sites in each cover type.

Year	Cover type						Total
	MTSH	RIPA	ARTR	ARAR	AGRI	SEEP	
1983-84	7	22	9	1	1	12	52
1984-85	19	2	16	0	0	6	43
1985-86	9	1	3	0	0	0	13
Total	35	25	28	1	1	18	108

Table 18. Mean distance (±SD) to MTSH or RIPA cover types from sharptail flush sites and track sites in winter, 1983-84 to 1985-86.

Year	Mean dist. (m) to MTSH or RIPA	N	P[a]
Flush sites			
1983-84	17.9 ± 33.8	52	< 0.0001
1984-85	26.4 ± 34.3	43	< 0.0001
1985-86	9.2 ± 15.9	13	< 0.0001
Overall	20.2 ± 32.7	108	< 0.0001
Random sites			
1984-1985	120.3 ± 99.7	179	

[a] Mann-Whitney U-test comparing flush sites vs. random sites.

by feeding grouse, regardless of the amount of feeding that occurred on a plant. Adjacent plants of the same species were counted as single feeding sites at each grouse location. Furthermore, in our attempt to assess foraging preferences of wintering sharptails, we have assumed that our ability to detect a feeding site was equal for all plant species.

We recorded 132 feeding sites during the three winters (Table 19). Grouse fed extensively on hawthorn fruits in the RIPA cover type during December and January 1983-84, after which the remaining fruits were dry and apparently unpalatable. During the severe grasshopper outbreak of 1984, virtually all hawthorn fruits were consumed by the insects during late summer; consequently, grouse did not feed in hawthorns during the 1984-85 winter (Table 19). The hawthorn fruit crop failed for unknown reasons in 1985, and the single record of hawthorn-feeding by grouse in that year occurred outside the study area in a fruit-laden patch of shrubs 2.6 km west of the Upper Dancing Ground. A large flock of grouse, including two radio-tagged males that later died, apparently spent much of the winter in the small valley that contained this hawthorn patch. We never observed sharptails feeding on hawthorn buds, nor did we see any signs that buds had been removed from hawthorns. This, along with the nearly complete avoidance of the RIPA cover type during the winters when the fruit crop failed (see Table 17), suggested that hawthorn buds are not suitable winter food for sharptails.

When hawthorn fruits were unavailable, grouse fed primarily in mountain shrubs (i.e., serviceberry and cherry). Of the three most common species of mountain shrubs in the study area, serviceberry was the least abundant but appeared to be the most preferred for foraging. Chokecherry was intermediate in abundance and was fed upon at about the same rate as serviceberry (Table 19). Bittercherry was the most numerous mountain shrub but was seldom fed upon by grouse. On numerous occasions, grouse walked among bittercherry plants without feeding on them. In several cases, we observed grouse walking or flying directly to feeding sites in serviceberry or chokecherry plants that were growing amidst dense patches of bittercherry. At eight of 12 bittercherry feeding sites, grouse ate only one or a few buds. In contrast, grouse usually consumed numerous buds on serviceberry plants and often ate a few buds from many chokecherry plants at a feeding site. Within stands of serviceberry, however, grouse seemed to feed selectively on some plants while completely avoiding others.

All seven feeding sites in willows occurred within or adjacent to seeps. Seeps also provided green grasses and forbs throughout the winter, although grouse on seeps seemed to spend most of their time loafing rather than foraging. Grouse ate the fruits and foliage of junipers in at least two cases. During the 1984-85 winter, grouse ate large quantities of thistle seeds in two patches that grew adjacent to mountain shrubs. However, thistle seeds appeared to pass through the digestive tract intact, and their food value to wintering sharptails is questionable. Perhaps thistle seeds served as grit to aid in the digestion of buds.

Flock Size

Flock sizes averaged 5.6 ± 6.4 birds across all winters (Table 20). There was no significant difference in mean flock size among winters

Table 19. Winter feeding sites of sharp-tailed grouse in the Mann Creek study area, 1983-84 to 1985-86.

Feeding site	Month					Total
	November	December	January	February	March	
Serviceberry[a]	2, 0, 0[b]	3, 0, 5	2,11, 1	0, 4, 1	1, 0, 0	30
Chokecherry	1, 0, 1	0, 1, 5	2, 9, 1	1, 5, 0	2, 0, 0	28
Bittercherry	1, 0, 0	0, 0, 3	0, 6, 1	0, 1, 0	0, 0, 0	12
Hawthorn	0, 0, 0	6, 0, 1	10, 0, 0	1, 0, 0	0, 0, 0	18
Willow	0, 0, 0	0, 0, 0	0, 0, 0	3, 3, 0	1, 0, 0	7
Juniper	0, 0, 0	0, 0, 0	0, 0, 1	1, 0, 0	0, 0, 0	2
Thistle	0, 0, 1	0, 0, 0	1, 6, 0	0, 6, 0	1, 0, 0	15
Composite	0, 0, 1	0, 0, 0	0, 0, 0	0, 0, 0	0, 0, 0	1
Seep	0, 0, 0	0, 0, 1	0, 0, 0	3, 7, 1	7, 0, 0	19
						132

a Food types: buds (serviceberry, chokecherry, bittercherry, willow); fruit (hawthorn, juniper); foliage (juniper); seeds (thistle, composite); green herbaceous vegetation (seep).

b Within each month, numbers are 1983-84, 1984-85, and 1985-86 from left to right, respectively.

Table 20. Mean flock size (±SD) in winter, 1983-84 to 1985-86, Mann Creek study area.

Year	Mean flock size	Max. count	N
1983-84	5.8 ± 6.6	29	52
1984-85	4.2 ± 3.3	11	27
1985-86	8.9 ± 10.2	32	9
Overall	5.6 ± 6.4		88

(Kruskal-Wallis test, $P > 0.05$), but sample sizes were small for all but the first winter. The largest flocks (20-32 birds) occurred in hawthorn stands where grouse were feeding on fruits. Flock sizes in areas other than riparian hawthorn never exceeded 14 birds.

In 1983-84 (i.e., the hawthorn winter), mean flock sizes peaked in December and January when hawthorn fruits were abundant (Table 21). The combined mean flock size for December and January (7.2 ± 8.2) was significantly larger than that for February and March (4.6 ± 3.6) (Mann-Whitney U-test, $P < 0.05$).

DISCUSSION

The core of the winter distribution of sharptails at Mann Creek appeared to be in and adjacent to the Upper Basin. Although most of the grouse we observed were unmarked, we have assumed that grouse that wintered in the study area also bred there. Sharptails in Nebraska moved up to 5.3 km between dancing grounds and wintering areas (Kobriger 1965), so it is possible that all grouse we observed during winter were from our study population. Nonetheless, we could never account for more than 30-40 grouse during a winter, suggesting that many wintering birds were undetected. There remains the need to determine (1) the fraction of the Mann Creek population that winters within the study area, (2) the wintering location of birds that leave the study area, and (3) the effects of winter movements on survival.

Although the plant species vary among regions, the winter habitat requirements of sharp-tailed grouse are structurally similar in that clumps of trees or tall shrubs must be present to furnish food and cover regardless of snow depth. In western Idaho, the winter habitat of sharptails consists primarily of patches of mountain shrubs on hillsides and stands of hawthorn along stream bottoms, i.e., the MTSH and RIPA cover types. Wintering sharptails are almost completely dependent on these cover types, which constitute about 5% of the Mann Creek study area. The MTSH and RIPA cover types are critical habitat in the truest sense, because sharptails could not exist in western Idaho without them.

Serviceberry, chokecherry, bittercherry, and hawthorn are the most important species in the MTSH and RIPA cover types. It is worth noting that serviceberry and chokecherry are decreaser species (Appendix 1) that are sometimes heavily damaged by livestock (some of the MTSH stands in our study area showed signs of overuse by livestock, e.g., a hedged or "notched" growth form and a lack of young plants). Chokecherry also provides important winter habitat for sharptails in southeastern Idaho (Parker 1970), and chokecherry and serviceberry are heavily used by sharptails in Utah (Hart et al. 1950). In Washington, sharptails winter in creek bottoms and draws in stands of water birch (*Betula occidentalis*), hawthorn, and serviceberry (Yocum 1952, Ziegler 1979).

Snow-burrowing is a common behavior in ruffed grouse (*Bonasa umbellus*) (Gullion 1984), hazel grouse (*B. bonasia*)(Andreev and Krechmar 1976 *in* Johnsgard 1983), black grouse (*Tetrao tetrix*)(Marjakangas 1984), capercaillie (*T. urogallus*)(Marjakangas et al. 1984), and sharp-tailed

Table 21. Mean flock size (±SD) by month, winter 1983-84.

Month	Mean flock size	Max. count	N
November	1.3 ± 0.6	2	3
December	8.6 ± 10.0	29	10
January	6.5 ± 7.2	23	18
February	4.8 ± 3.0	10	10
March	4.4 ± 4.3	14	11

grouse (Marshall and Jensen 1937, Hart et al. 1950, pers. obs.). Snow burrows allow grouse to conserve heat and to roost in relative safety from predators. Temperatures in the snow burrows of black grouse and capercaillie may be 20°C warmer than at the surface, allowing birds to roost in or close to a thermoneutral environment (Marjakangas et al. 1984). Above the snow, grouse are especially conspicuous to avian predators, and snow-roosting allows grouse to minimize the amount of time that they are exposed to raptors. The snow burrows we observed were up to 1 m long and appeared to follow random directions from the entrances. It would have been very difficult for mammalian predators to determine the location of grouse in these burrows before the grouse escaped.

We were unable to estimate the amount of time that sharptails spent beneath the snow. In one instance, however, seven grouse that snow-roosted from 1236-1313 MST were still in their burrows at sundown. We suspect that when snow conditions are suitable, sharptails spend most of the day and all of the night in snow burrows. Black grouse and capercaillie spend up to 23 hours a day in snow burrows (Pulliainen 1982, Marjakangas 1984).

Seeps were important to grouse only after snow conditions were unsuitable for burrowing. Grouse were well camouflaged on seeps, and because dark ground absorbs heat, roosting sites on seeps were probably warmer than those on snow. Seeps also provided green herbaceous food that was available nowhere else during winter. Thus, seeps served the same functions as snow burrows: they enabled grouse to conserve heat and to reduce their vulnerability to avian predators. However, the timing of seep use strongly suggested that grouse preferred snow burrows over seeps. Unlike seeps, snow burrows could be constructed close to preferred feeding sites, and they also provided a better thermal advantage.

Especially during winter, the habitats that provide cover for grouse must also provide food. Thus, grouse avoid stands of sagebrush and bitterbrush during winter because these cover types provide no food. When the ground is covered with snow, grouse feed on hawthorn fruits and on serviceberry and chokecherry buds. Hawthorns provide a long, narrow band of dense escape cover and an abundance of palatable food when fruits are present. Winter flock sizes are largest during the period that hawthorns bear fruit, and grouse abandon hawthorn stands as soon as the fruit supplies become exhausted or unpalatable. Grouse never fed in hawthorns during the two winters that the the fruit crop failed in the study area.

Grouse probably preferred hawthorn fruit over the buds of mountain shrubs. Evans and Dietz (1974) noted that hawthorn fruit was among the most palatable winter foods of captive plains sharptails, even though the fruits were relatively low in metabolizable energy and crude protein. Grouse compensated for this deficiency by consuming large quantities of fruit, and they were able to maintain or gain weight on a diet of hawthorn fruit alone.

The hawthorns in our study area produced fruit during only one of three winters, and even during the good year the fruits were dry and unpalatable by midwinter. Hawthorn fruits were also prized winter food for red squirrels (Tamiasciurus hudsonicus), chipmunks (Tamias sp.), and a variety of passerine birds. Thus, large numbers of birds and mammals feeding on hawthorn fruit conceivably could deplete the food supply during early winter

in some years. Even if it were the preferred food, hawthorn clearly could not serve as the sole source of winter food for sharptails.

Because fruits are not available every year, an alternate source of food, such as buds or catkins, must be available throughout the winter year after year. Serviceberry and chokecherry buds were available throughout each winter and were readily consumed by sharptails at Mann Creek. These species have also been reported in the winter diets of Columbian sharptails in Utah (Marshall and Jensen 1937; Hart et al. 1950) and Colorado (Dargan et al. 1942 in Rogers 1969) and are probably preferred winter foods wherever they occur with sharptails. The buds and catkins of water birch are the most important winter foods of Columbian sharptails in Washington (Ziegler 1979). Aspen buds (*Populus tremuloides*) are consumed in winter by plains sharptails in Alberta (Moyles 1981) and by prairie sharptails in Wisconsin (Grange 1948). Aspen is common in much of the Intermountain West and thus is also a potential source of winter food for Columbian sharptails.

CHAPTER V

HOG CREEK

STUDY AREA

Location and Vegetation

The Hog Creek study area is in Adams County about 32 km east of the Mann Creek study area (Figure 22) and contains about 8 km^2 of private land. Compared with Mann Creek, topography at Hog Creek is flatter with a few smooth hills and no steep ridges. Elevations range from 1005-1055 m. A few stock ponds are scattered throughout the area. The climate and weather are similar to that at Mann Creek. The major land uses are cattle grazing and agriculture.

The vegetation is shrubsteppe that has been highly modified by livestock, agriculture, and fire. The most numerous shrub is big sagebrush. In contrast to Mann Creek, there are no low sagebrush or shrubby eriogonum cover types and very few bitterbrush plants, mountain shrub patches, or riparian shrubs. Stiff sagebrush (Artemisia rigida) occurs on sites similar to those containing low sagebrush but on more shallow, rocky soils (Blaisdell et al. 1982). Intermediate wheatgrass seedings, dry pastures, and agriculture constitute 36% of the area (vs. 10% at Mann Creek). A list of the nine cover types and their areas and proportions at Hog Creek is presented in Table 22. The scientific and common names of all vascular plants identified at Hog Creek are in the Appendix 1.

The Sharptail Population

Sharp-tailed grouse are very scarce in the Hog Creek area but formerly were numerous. Local landowners remember sharptails being very abundant in the 1930s and declining sharply afterwards. Within the last 30 years, a peak in sharptail numbers occurred in the late 1960s or early 1970s followed by a steady decline to the present (F. Edwards, pers. commun.). Boundaries of the Hog Creek study area were defined in 1985 near recent grouse sightings and a dancing ground found by Fred Edwards in 1969 or 1970. At that time the dancing ground had approximately 15 males attending it. This dancing ground was inactive when checked by BLM biologists in 1984 and 1985.

A search of Idaho Fish and Game files in 1986 revealed count data from a dancing ground next to Granger Butte about 5 km south of Hog Creek (see Figure 22). Up to 34 males were counted here in 1958, 19 in 1959, only four in 1960, and none in 1962 (Table 23). An agricultural field now occupies the former dancing ground.

During 115 hours of field work in the Hog Creek study area from 1984-1985, only five sharptails were observed, and no active dancing grounds were found on or near the study area. A 16-ha patch of relatively undisturbed sagebrush-bunchgrass habitat (known as Clark Hill) bordering the northwest boundary of the study area was discovered in spring 1985. On 24 September 1985, 11-14 sharptails were flushed from this patch of habitat.

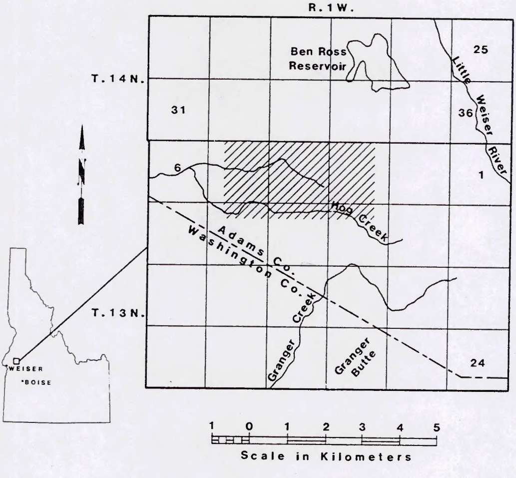

Figure 22. Hog Creek study area (shaded section) in Adams County, Idaho.

Table 22. Cover type areas and their proportions in the Hog Creek study area, Adams County, Idaho.

Cover type	Area (ha)	% of study area
Big sagebrush (ARTR)[a]	274.34	35
Stiff sagebrush (ARRI)	185.19	24
Intermediate wheatgrass (AGIN)	157.63	20
Agriculture (AGRI)	69.23	9
Pasture (PAST)	54.20	7
Big sage-stiff sage (MIXX)	28.43	4
Riparian (RIPA)	10.39	1
Meadow (MEAD)	2.68	Trace[b]
Mountain shrub (MTSH)	1.10	Trace
Total	783.19	100

[a] Cover type acronyms that will be used throughout the report.
[b] Less than 0.5%.

Table 23. Counts of dancing male sharp-tailed grouse on the Shirts Creek dancing ground near Granger Butte, Washington County, Idaho. All counts were conducted by Idaho Department of Fish and Game personnel.

Date	Time	No. of males	Observer
16 March 1958	0845	21	Chappell
26 March	0720	34	Chappell
1 April	0700	25	Chappell & Haynes
13 April	0655	19	Haynes
15 April	0700	17	Chappell
29 April	0713	19	Chappell
14 March 1959	0650	19	Haynes
21 March	0700	14	Hester
25 March	0645	14	Hester
27 March	0700	15	Hester
30 April	0615	12	Hester
9 April 1960	0745	4	Hester & Bizeau
26 April 1961	----	1	Hester
14-21 April 1962	----	0	Plummer

[illegible]

This was the only flock of sharptails observed in the Hog Creek area. From these observations, it is clear that the sharptail population at Hog Creek is much reduced from that of 50 years ago, and the grouse probably are near extirpation in the area.

METHODS

Using a 1:7920 scale aerial photograph, a 2 X 4 km rectangle (see Figure 22) was drawn around the above-mentioned grouse sightings near the dancing ground found at Hog Creek by Fred Edwards. Nine cover types were identified and a vegetative cover map prepared in the same manner as at Mann Creek (Figure 23). The area of each cover type was determined with a planimeter.

Starting in May 1985, vegetative characteristics (% canopy coverage of shrubs, forbs, and grasses; vertical cover) were measured at randomly located transects using the same methods and sampling schemes as at Mann Creek (see page 15), except that 15 rather than 30 transects were measured each month from May-July. Compared with Mann Creek, the vegetation within cover types at Hog Creek was homogeneous, and we believe that 15 random transects per month provided a reasonable estimate of the vegetative characteristics there. Vegetation measurements were taken in the ARTR, ARRI (stiff sagebrush), AGIN, and PAST cover types only. These were the major non-agricultural cover types in the study area (Table 22).

Hog Creek data were compared with the Mann Creek random transect data from 1985 using the same vegetative categories and statistical procedures outlined in Chapter I. For comparative purposes, the Hog Creek cover types ARRI and PAST (neither of which occurred at Mann Creek) were paired with Mann Creek cover types ARAR and ERIO, respectively. These cover type pairs differed in plant species composition but were similar in structure. Statistical comparisons of percent canopy coverage between study areas were restricted to the ARTR cover type because this cover type was preferred by radio-tagged sharptails at the Mann Creek study area.

RESULTS

The percent canopy coverages of the 11 vegetative categories in four Hog Creek cover types are presented in Table 24. Canopy coverage of shrubs ranged from 0% in PAST to 6% in the ARRI cover type. Forb coverage ranged from less than 7% in AGIN seedings to more than 18% in ARTR. Total grass cover, mostly bulbous bluegrass, ranged from 23% in ARTR to more than 42% in AGIN. Bare ground and litter constituted 50-60% of the horizontal cover across all cover types.

The ARTR cover types at Hog Creek and Mann Creek were similar only in mean canopy coverage of big sagebrush and of bulbous bluegrass; all other canopy coverage comparisons were significantly different between study areas (Table 25). Mann Creek had greater canopy coverage of bitterbrush, other shrubs, arrowleaf balsamroot, and bluebunch wheatgrass, whereas Hog Creek had greater canopy coverage of other composite forbs, noncomposite forbs, other grasses, and bare ground (Table 25).

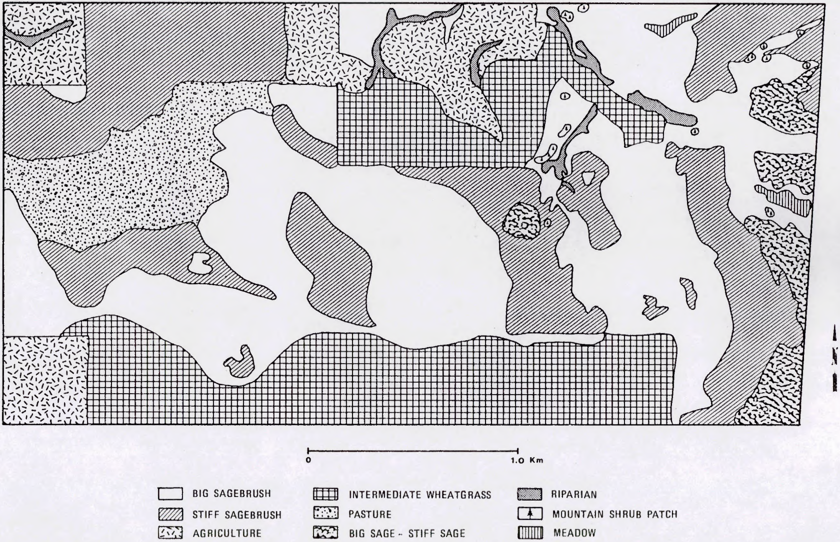

Figure 23. Cover types in the Hog Creek study area.

Table 24. Mean canopy coverage (%) of vegetative categories at random transects in the four major cover types at Hog Creek study area, May-July 1985. The number of random transects in each cover type is in parentheses.

Vegetative category	Cover types ARTR (N = 12)	ARRI (N = 18)	AGIN (N = 9)	PAST (N = 6)
Big sage	3.88	0.00	0.08	0.00
Stiff sage	0.28	6.08	0.17	0.00
Bitterbrush	0.48	0.00	0.00	0.00
Other shrubs	0.29	0.31	0.00	0.00
Total shrubs	4.93	6.39	0.25	0.00
Arrowleaf balsamroot	0.94	1.44	0.00	0.00
Other composites	5.21	2.76	3.22	9.54
Other forbs	12.02	10.13	3.49	8.54
Total forbs	18.17	14.33	6.71	18.08
Bluebunch wheatgrass	0.45	0.33	0.00	0.00
Bulbous bluegrass	19.42	21.06	19.81	24.44
Other grasses	3.49	3.35	22.86	3.23
Total grasses	23.36	24.74	42.67	27.67
Bare ground	55.41	57.49	49.19	56.50

Table 25. Mean canopy coverage (%) of vegetative categories in ARTR cover type at Hog Creek and Mann Creek study areas, May-July 1985.

Vegetative category	Mann Creek	Hog Creek	p[a]
Big sagebrush	6.52	3.88	0.79
Stiff sagebrush	--	0.28	--
Bitterbrush	1.84	0.48	0.03
Other shrubs	2.69	0.29	0.0004
Arrowleaf balsamroot	7.40	0.94	0.0001
Other composites	3.33	5.21	0.04
Other forbs	7.87	12.02	0.04
Bluebunch wheatgrass	2.91	0.45	0.002
Bulbous bluegrass	16.52	19.42	0.32
Other grasses	2.02	3.49	0.01
Bare ground	48.62	55.41	0.02

[a] Determined by Mann-Whitney U-tests.

Overall, the Hog Creek study area was more open than the Mann Creek area. This openness was reflected in the cover board readings: Hog Creek had less vertical cover than Mann Creek in the four comparable cover types. These differences were significant in the ARTR-ARTR and ARRI-ARAR comparisons (Figure 24).

Plant species diversity indices for shrubs and forbs were lower at Hog Creek than at Mann Creek in all comparisons except for forb diversity in the AGIN cover type (Figure 25). These differences were most pronounced in the ARTR-ARTR and ARRI-ARAR comparisons, and together with the cover board readings they indicated that the overall structural diversity of the vegetation was greater at Mann Creek than at Hog Creek. The diversity of grass species was similar among cover types in both areas, perhaps because bulbous bluegrass was so abundant in both areas.

The canopy coverages of decreaser grass and forb species in the ARTR and ARRI cover types were lower than those in the ARTR and ARAR cover types at Mann Creek (Figure 26). These differences were significant ($P < 0.05$) for each comparison except for the proportion of decreaser forbs in the ARAR-ARRI cover types.

DISCUSSION

Clearly, sharp-tailed grouse have undergone a wholesale decline in numbers at Hog Creek. This decline probably is the result of changes in habitat, particularly the loss or modification of most of the native plant communities there (cf. Hart et al. 1950, Yocum 1952, Buss and Dziedzic 1955, Parker 1970, Starkey and Schnoes 1979, Ziegler 1979, Miller and Graul 1980). If changes in habitat are responsible for the sharptail decline, and assuming that the pre-settlement habitat at Hog Creek resembled that at Mann Creek (i.e., for the ARTR, MTSH, and RIPA cover types), then one would predict that the habitat features selected by sharptails at Mann Creek would in large part be absent at Hog Creek. In this manner, research at Hog Creek provides an indirect test of the conclusions drawn from radio-tagged sharptails at Mann Creek. The relatively undisturbed 16-ha patch of sagebrush-bunchgrass habitat at Clark Hill appears identical in species composition and structure to habitat selected by sharptails at Mann Creek. Thus, the ARTR cover type probably once was widespread at Hog Creek and very similar to that at Mann Creek.

Sharptails used the ARTR cover type above its availability at Mann Creek. The ARTR cover type had a high diversity of shrubs, forbs, and grasses (i.e., high structural diversity) and provided more cover than all but the densest cover types, MTSH, RIPA, and PUTR, which were used primarily as escape cover by the grouse. Compared with random sites, Mann Creek sharptails used areas with (1) greater horizontal and vertical cover, (2) greater canopy coverage of arrowleaf balsamroot, (3) greater canopy coverage of decreaser plant species, and (4) greater canopy coverage of bluebunch wheatgrass in ARAR sites during a drought year. Overall, the grouse appeared to select habitats that were in the best available ecological condition.

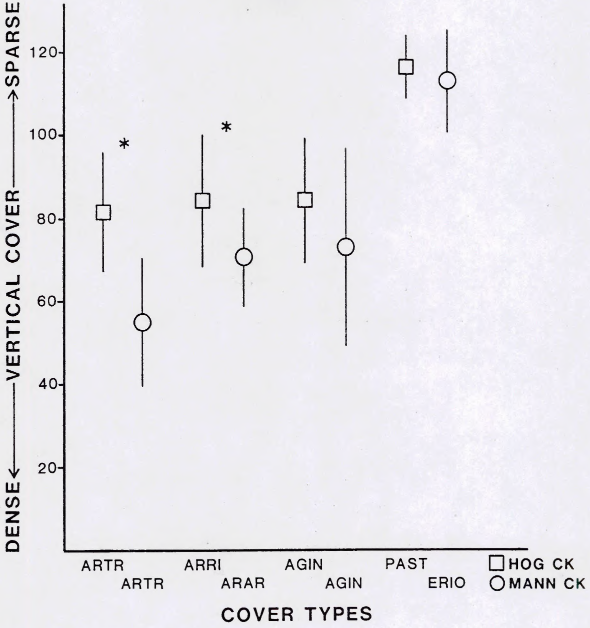

Figure 24. Mean (± SD) cover board readings at random transects in the Hog Creek and Mann Creek study areas. Significance levels computed with Mann-Whitney U-tests ($* = P < 0.01$).

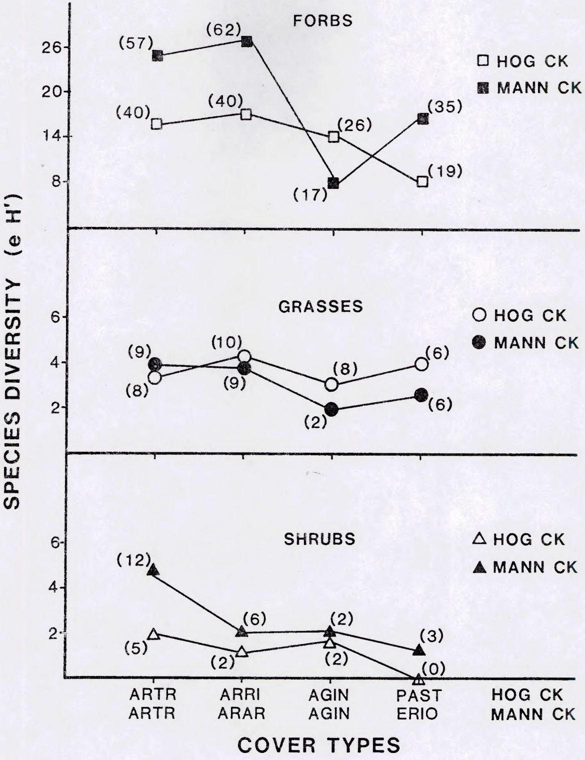

Figure 25. Plant species diversity ($e^{H'}$) at random transects for shrubs, forbs, and grasses in the Hog Creek and Mann Creek study areas. The total number of plant species sampled in each cover type is in parentheses.

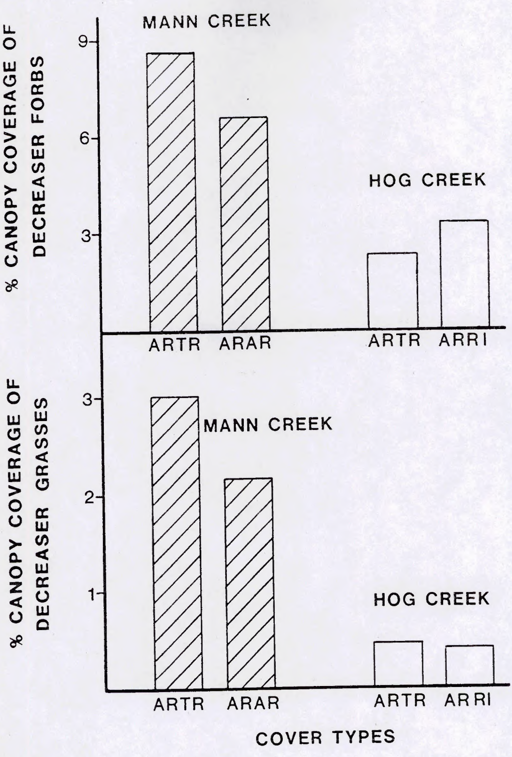

Figure 26. Proportion of decreaser forbs and grasses at random transects, Hog Creek vs. Mann Creek. Proportions were significantly greater ($P < 0.05$) at Mann Creek in all cases except for forbs in the ARAR-ARRI comparison.

Plant species associated with summer flush sites at Mann Creek (arrowleaf balsamroot and bluebunch wheatgrass) were very scarce at Hog Creek. Mann Creek grouse also used bitterbrush plants for mid-day roosting sites, but this species was very scarce at Hog Creek (although two of the five sharptails seen at Hog Creek were flushed from beneath bitterbrush plants). In addition, when compared with Mann Creek, the sagebrush cover types (ARTR and ARRI) at Hog Creek provided significantly less vertical cover and were lower in species diversity of forbs and shrubs. There was also a marked reduction in canopy coverage of decreaser forbs and grasses at Hog Creek. Hog Creek was also almost completely devoid of mountain shrub patches and riparian vegetation, both of which were critical sources of year-round escape cover and of winter food for sharptails at Mann Creek (see Chapters II and IV). The few serviceberry and hawthorn shrubs present were old-aged, decadent, or dead, indicating years of continuous overbrowsing. Thus, with the exception of the small patch of habitat at Clark Hill, the current vegetation at Hog Creek showed little resemblance to that at Mann Creek, especially in the habitat features most preferred by sharptails.

Two factors, agricultural development and livestock grazing, appear to have been responsible for most of the habitat destruction at Hog Creek. Vast areas of sagebrush shrubland were burned or plowed during the first half of this century. These disturbances, followed by continued livestock grazing, have been responsible for the replacement of native shrubland by invader plants (cf. Ellison 1960, Harniss and Murray 1973, Blaisdell et al. 1982). If the current usage by livestock in the area continues, it is unlikely that the disturbed pastures will revert to native shrubland. Given the sharptails' preference for native sagebrush-bunchgrass interspersed with patches of mountain shrubs and riparian hawthorn, the present condition of the vegetation at Hog Creek cannot provide habitat for a viable population of sharptails. As such, Hog Creek provides a worst-case scenario for what could happen to the sharptail population at Mann Creek should the area be developed for agriculture and/or subjected to prolonged overgrazing by livestock.

CHAPTER VI

MORTALITY AND THE INFLUENCE OF RADIO COLLARS ON SURVIVAL

It is almost axiomatic that the attachment of a marker or radio transmitter to an animal can alter that individual's behavior and survival. At the same time, radio transmitters often provide the best means of assessing habitat use and mortality. In this chapter, we report data on the causes and seasonal timing of mortality of radio-tagged and nonradioed sharptails. We also assess the effects of radios on behavior and survival. We gathered this information incidental to our study of habitat use, and the sample sizes of radioed and control birds are small. Nonetheless, our results clearly suggest that researchers should continue to evaluate the influence of radio transmitters on the animals they study.

The effect of harness-mounted radio packages (i.e., backpacks) on the behavior and survival of gallinaceous birds has received much recent attention (Herzog 1979, Warner and Etter 1983, Hines and Zwickel 1985). Some authors have reported that radio harnesses have little effect on galliforms, whereas others have documented reduced survival of radio-equipped individuals (see Hines and Zwickel 1985). Amstrup (1980) designed a poncho-mounted radio collar that eliminated some of the drawbacks of radio harnesses (e.g., restricted mobility) and used it successfully on sharp-tailed grouse. Subsequently, Small and Rusch (1985) found that survival of radio-collared ruffed grouse was higher than that of those with radio harnesses. Although Amstrup's radio collar appeared to be an improvement over backpacks, no study has compared the annual survival of radio-collared vs. nonradioed grouse.

METHODS

From 1983 to 1985, we captured 46 sharp-tailed grouse (36 males and 10 females) on dancing grounds using funnel traps, mist nets, and drop nets (see Appendix 2). Grouse were weighed with a Pesola spring balance, and 38 were equipped with solar-powered radio transmitters attached to herculite ponchos (Amstrup 1980). These packages weighed 13.5-14.5 g, or about 1.7-2.5% of the body weight of grouse at the time of capture. All captured grouse, including nine released without radios, were marked with unique combinations of four colored leg bands. A nonradioed grouse captured in 1983 was recaptured and radio-collared in 1984.

We recovered both radio-collared and nonradioed grouse and determined cause of death from field sign (Dumke and Pils 1973). Avian predators normally removed the head, plucked feathers, and left an articulated skeleton with the meat stripped off the bones. Streaks of "whitewash" often were visible at the kill site. Mammalian predators usually chewed their prey such that broken bones and feathers were present, and leg bands and radio packages had tooth marks.

From late March to late April 1984 to 1986, the two occupied dancing grounds in the study area were observed from blinds for returning

color-banded grouse. Dancing grounds were observed almost daily in 1984 and 1985 and on six mornings in 1986. We assumed that any bird not observed in the spring following capture had died. This assumption is reasonable because marked grouse were observed in the study area year-round, and we believe we found every dancing ground there. Although we could not be certain that captured birds never left the study area, such movements should have been independent of the method of marking. We searched for missing radio-collared birds throughout the year, both from the ground and from aircraft, but would not have found dead birds whose transmitters failed or landed face down.

To assess differential mortality between radio-collared and nonradioed grouse, it was important that the two groups differed only in the method of marking (Hines and Zwickel 1985). We determined age of captured grouse by examining their outer primaries. We used t-tests to compare the weights of radio-collared vs. nonradioed grouse (wts were normally distributed), and Mann-Whitney U-tests to compare dates of capture of the two groups of grouse. All tests were two-tailed. A chi-square test with Yates' correction was used to determine if survival for one year following capture depended on whether the birds had been radio-collared or color-banded only.

RESULTS

All captured grouse were adults. Upon release, all but one flew without difficulty. The single exception was a nonradioed male that damaged some primaries during capture and was killed by a raptor the next day. Body weight comparisons between radio-collared and nonradioed grouse were restricted to males because females weighed less than males ($P < 0.05$), and all captured females were radio-collared. There were no significant differences in the mean weights of: (1) radio-collared vs. color-banded only males ($P > 0.10$), (2) radio-collared males that survived the summer vs. those that died during the spring of their capture ($P > 0.80$), or (3) color-banded males resighted a year following capture vs. those not resighted ($P > 0.35$). There was no difference in the date of capture of radio-collared vs. nonradioed grouse in 1983 ($P > 0.10$), and all captured grouse were radio collared in 1984. In 1985, date of capture of nonradioed grouse was significantly earlier than that of radio-collared birds ($P < 0.05$). Thus, in no case were radio-collared grouse captured earlier in the season than were nonradioed birds.

Causes of Mortality

We recovered 31 grouse in the study area, 23 of which had been radio-collared and one color-banded only. Avian predators accounted for 19 of 22 cases where we determined cause of death (Table 26). The three cases of mammalian predation were on females, at least one of which was nesting at the time of death. Coyotes (*Canis latrans*) were the most numerous mammalian predators in the study area. In two cases we flushed adult goshawks from freshly-killed, radio-collared males. We also found a golden eagle (*Aquila chrysaetos*) pellet beside the remains of a radio-collared female, and a great horned owl (*Bubo virginianus*) feather next to the remains of a radio-collared male.

Table 26. Suspected cause of death of 31 sharp-tailed grouse recovered in Washington County, Idaho, 1983-86. Nonradioed grouse are in parentheses.

Sex of grouse	Type of predator		
	Avian	Mammalian	Unidentified
Male	11(4)[a]	0	4(1)
Female	3	3	2
Unknown	(1)	0	(2)
Total	14(5)	3	6(3)

[a]Includes 1 color-banded grouse.

Radio Collars and Survival

Thirty-five grouse were radio-collared during spring and 3 during autumn. None of these birds survived to the following spring, although 14 of the spring-captured birds survived at least until early autumn of the same year. In contrast, four of nine males released in spring without radios were resighted the following year. Based on this return rate, 17 radio-collared birds should have been alive the next year. That all were dead strongly indicates that survival for one year following capture depended on whether or not a grouse was equipped with a radio collar ($P < 0.001$).

Seasonal Timing of Mortality

From approximately 220 hours of observation during the spring dancing period, we observed attacks on dancing males by five goshawks, six golden eagles, two red-tailed hawks (*Buteo jamaicensis*), and six northern harriers (*Circus cyaneus*). Eagles, redtails, and harriers made unsuccessful passes, and except for one eagle, did not pursue grouse. Goshawks struck grouse twice, and pursued them during each attack. Although we never saw a raptor kill a dancing grouse, we recovered seven males (five of which were nonradioed) on or near dancing grounds during spring, suggesting that dancing males were vulnerable to avian predation.

Male sharp-tailed grouse attended dancing grounds from early March to mid-May and from early September to mid-November. The study area typically was snow-covered from mid-November to mid-March. We recovered 15 radio-collared grouse in spring, four in autumn, and two in winter. All but two of 16 radio-collared birds surviving the spring dancing period also survived the summer. The two exceptions were a male killed by a great horned owl in July and another by an unknown raptor in late August. Six nonradioed grouse were recovered in spring and two in winter. Autumn mortality coincided with onset of the autumn dancing period. Goshawks were present in the study area during both dancing periods and during winter, but were not present from mid-May to September. Timing of mortality also coincided with seasonal lows in the amount of vegetative cover in the study area.

DISCUSSION

Radio-collared and nonradioed grouse were similar in all respects but the method of marking. Although radio collars did not seem to encumber flight, they did alter the appearance, sound in flight, and perhaps the behavior of grouse. The radio transmitter was visible as a "lump" on the breast, and occasionally a glare was reflected from the solar panels. In flight, the antenna slapped against the leading edge of the wing, making a sound that was audible more than 50 m away. We noted on a number of occasions that radio-collared grouse were the last in a flock to flush, usually after nonradioed flock members had flushed simultaneously. (Unfortunately, we failed to record all of the times that radio-collared males in flocks were the last to fly.) A slapping antenna may have made radio-collared grouse more reluctant to fly than were nonradioed birds (D. A. Boag, pers. commun.).

Avian predators in general (Mueller 1971, 1974), and goshawks in particular (Pielowski 1959, Kenward 1978), have been shown to select odd prey, viz. individuals that differ in some way from most other prey. Raptors were the primary cause of grouse mortality and may have preyed selectively on radio-collared individuals because these birds were "odd" in comparison with other grouse. Rothenmaier (1979) and Gratson (1982) came to a similar conclusion in explaining raptor predation on radio-tagged sage grouse and sharp-tailed grouse, respectively.

Hines and Zwickel (1985) found that radio-harnessed and nonradioed blue grouse (Dendragapus obscurus) survive at similar rates despite high mortality. Compared with lek-breeding grouse in open habitats, blue grouse are more solitary and make shorter flights to cover when attacked by predators (F. C. Zwickel, pers. commun.). Such behaviors may hinder the ability of avian predators to detect differences between radio-tagged and nonradioed individuals.

Summer was a period of low mortality for adult grouse, and three factors may have influenced the seasonal pattern of mortality: (1) presence of goshawks, (2) grouse attendance on dancing grounds, and (3) amount of vegetative cover. Goshawks are efficient predators of ruffed grouse (Gullion 1984), and also prey on dancing sharp-tailed grouse (Ammann 1959, Blus 1967) and booming greater prairie-chickens (Tympanuchus cupido) (Moran 1966, Sparling 1976). Dancing sharp-tailed grouse in our study area were vulnerable to avian predators, and goshawks may have caused most of the mortality we observed. Mortality all but ceased after the spring dancing period and resumed with the onset of autumn dancing (and the reappearance of goshawks). Vegetative cover that might have helped conceal grouse from predators was at its peak during the period of low mortality and may have been an additional factor in enhancing grouse survival during summer.

CONCLUSIONS

Although radio-collared grouse provided useful information on habitat selection, their annual mortality rate was 100%. Surely, the population would have vanished had this rate occurred naturally. However, counts of males attending dancing grounds suggested a slight increase in the population over 4 years (see Chapter III). We conclude that raptors (especially goshawks) preyed on radio-collared birds selectively and that data from radio-tagged sharp-tailed grouse should not be used to estimate survival. Clearly, the effects of radio collars on grouse warrant additional attention. Future studies should closely monitor the influence of antenna "slap" on the behavior and survival of radio-collared grouse, and develop a means of preventing the antenna from contacting the wings during flight.

CHAPTER VII

MANAGEMENT OF COLUMBIAN SHARP-TAILED GROUSE

In this chapter we address management of Columbian sharp-tailed grouse at the local (i.e., Mann Creek) and state (i.e., Idaho) levels. We also identify needs for population monitoring and additional research. Three major stumbling blocks could influence the success of attempts to improve the current status of Columbian sharptails: (1) their preference for shrubsteppe habitats in advanced seral stages, (2) the fragmentary nature of existing populations, and (3) the inherent difficulties of reintroducing a lek-breeding grouse. First, the ecological condition of BLM rangelands in the Cascade Resource Area (CRA) (which contains the Mann Creek study area) has been estimated as follows: excellent 0.5%, good 7%, fair 47%, poor 43%, burned 0.5%, and seeded 2% (USDI 1986). Range conditions have further declined owing to recent range fires not included in this estimate. Thus, very little suitable sharptail habitat exists on public land in western Idaho, and the prospects of increasing the amount of good and excellent rangeland are dim. The situation on other BLM lands within historic Columbian sharptail range most likely is no better, and in many cases is worse, than the present situation in the CRA. Second, isolated groups of sharptails are highly vulnerable to extinction from natural or man-caused disturbances such as wildfire, poaching, overgrazing, brush removal, and conversion of rangeland to agriculture. Locally extinct groups very likely would not be replaced by other birds. Finally, there has been very little success in introducing captive-reared or wild-caught lek-breeding grouse into suitable, unoccupied habitat, which is in marked contrast to the success obtained with wild turkeys (Meleagris gallopavo), quail (e.g., Colinus and Lophortyx), and exotic phasianids.

For the above reasons, the conservation of Columbian sharptail populations clearly will require special considerations by land managers. It is our opinion that the Columbian sharp-tailed grouse will continue to decline in the absence of a concerted multi-agency management effort (see Starkey and Schnoes 1979).

Mann Creek

The sharp-tailed grouse population in western Idaho (Washington and Adams counties) almost certainly is completely isolated; the nearest populations are about 400 km distant in eastern Washington and eastern Idaho. Given the wholesale decline of the Columbian sharptail and the fragmented nature of extant populations, conservation of all potential sources of genetic variation should be a critical concern to managers. As the largest known group of sharptails in western Idaho, the Mann Creek birds should receive first priority in any effort to protect or enhance existing populations. It is also important that existing populations be assured of protection before large efforts are expended in transplanting Columbian sharptails to new areas (see below).

Habitat features that make the Mann Creek area particularly suitable for sharptails begin with a flat-to-rolling rangeland that is in relatively good

condition such that a rich diversity of native shrubs, forbs, and grasses is present. Also of critical importance is the presence of riparian hawthorn and numerous patches of mountain shrubs for winter food and cover. In short, all of the year-round habitat requirements of sharptails are met at Mann Creek.

Most of the study area is privately owned. In general, surrounding public lands are not in as good a condition nor do they contain as many sharptails (most contain none) as do the private lands. Management to protect and enhance the western Idaho sharptail population could take one of two paths. The first would involve actions to improve range conditions on the State and Federal lands that already support (or have the greatest potential to support) sharptails. Such improvements would begin with a reduction in livestock grazing and with the development of suitable winter food plants for sharptails if these plant species are in short supply. Two problems with this course of action are that (1) grazing permittees would be forced to curtail or relinquish grazing privileges, and (2) we do not know of any public lands in western Idaho that currently support a viable group of sharptails.

The second action would involve acquisition of the private land at Mann Creek and the formation of a special sharptail management area, such as an Area of Critical Environmental Concern (ACEC). Without question, habitat acquisition would be the best means of assuring that a viable population of sharptails continued to exist in western Idaho. On the other hand, loss of the Mann Creek grouse ultimately could foment the extirpation of sharptails from western Idaho.

The Nelson ranch contains all known sharptail dancing grounds in the Mann Creek study area. At present the ranch is for sale, and there is no guarantee that the welfare of sharp-tailed grouse will be of concern to future owners of the ranch. If private holdings on the ranch are heavily stocked with cattle for prolonged periods during spring or summer, range conditions could deteriorate at the expense of the grouse population. The BLM or the Idaho Department of Fish and Game (IDFG) should make every effort to acquire the Nelson ranch, which would then serve as the core area of an ACEC.

The ACEC could be enhanced if surrounding private lands presently supporting sharptails were managed for the maintenance or improvement of sharptail habitat. Several avenues of approach could be pursued. The first would involve acquisition of private lands to the west (T13N, R5W, sect. 21 and 22) and south (T13N, R5W, sect. 25) of the Nelson ranch for incorporation into the ACEC. Both of these areas contain winter habitat currently used by sharptails. If acquisition is not feasible, then the BLM could pursue an exchange-of-use agreement whereby permittees would curtail or eliminate grazing in sharptail habitat in exchange for grazing privileges on BLM lands that do not contain (nor hold the potential to support) sharptails. It might also be possible to allow limited grazing on portions of the Nelson ranch that could withstand such use without detriment to the sharptails.

Once acquired, the east boundary of the ranch must be fenced and the rest of the boundary fences maintained to exclude livestock from sharptail

habitat. As stated previously, the area already contains all of the components of suitable sharptail habitat, although all have not reached their potential condition. We believe that the range is in a recovery phase on the Nelson ranch, and that continued exclusion of livestock will result in further range improvement. Plantings of serviceberry and chokecherry, which are the primary winter budding foods of sharptails, should be encouraged. Native hawthorns should be planted along perennial stretches of streams, particularly Brood Creek and Deer Creek, to provide a continuous stretch of winter food and escape cover along riparian areas (most of the perennial stretches of these two creeks already support dense hawthorn thickets). We envision no benefit to grouse from planting agricultural crops in the management area. Chaining in areas where canopy coverage of sagebrush exceeds 20-30% could improve nesting and brooding cover. Chained areas should be seeded with a mixture of bluebunch wheatgrass and arrowleaf balsamroot, with bitterbrush seed added to the mixture used in big sage sites.

The sharptail management area should be given top priority in fire suppression, as a hot, severe fire could render the area unsuitable for year-round use by grouse. In the event of fire, rehabilitation efforts should strive to use native species wherever possible, especially bluebunch wheatgrass, arrowleaf balsamroot and other native forbs, bitterbrush, big sagebrush, and low sagebrush in appropriate sites. Particular attention should be directed toward restoring any winter food plants (e.g., mountain shrubs and hawthorn groves) eliminated by fire.

Most recreational use of the Mann Creek area is in the form of hunting. The sharp-tailed grouse season has been closed in Mann Creek since 1975 and in the rest of western Idaho since 1976. Very few bird hunters used the area from 1983-1986, but the area has been heavily used by deer hunters each year. The greatest potential for illegal harvest of sharptails will come from hunters who chance upon an occupied dancing ground or spot a grouse from the road in the Upper Basin. If game bird populations (e.g., gray partridge, chukar, ring-necked pheasant) continue to increase in western Idaho, more hunters will use the Mann Creek area and the potential for hunter-sharptail encounters will increase. Sharptails are more vulnerable to over-harvest than most upland game birds because males are concentrated on display grounds during much of the fall hunting season. Without question, the sharptail hunting closure in western Idaho should continue because populations are small and isolated, and because most of the natural mortality occurs during winter when the birds aggregate in flocks. Hunting mortality can be additive under these conditions (see Bergerud 1985). However, legal hunting of other species (both upland and big game) in the management area should continue until it has been shown that hunters are harvesting sharptails. To help prevent illegal harvest, the Nelson ranch should be posted with signs alerting hunters to the sharptail closure. The area must also be patrolled during the hunting season and game law violators prosecuted to the fullest extent of the law. Off-road driving from spring through summer and snowmobiling in sharptail winter use areas should be discouraged within the sharptail management area.

Most mortality of adult sharptails in western Idaho probably results from predation. Avian predators, particularly goshawks, are efficient

grouse-killers during spring, fall, and winter (see Chapter VI). Adult females are vulnerable to mammalian predators, particularly coyotes, during the nesting and brood-rearing periods. However, at present we have no evidence that predation is the ultimate factor limiting population size of the Mann Creek sharptails. Moreover, as the vegetative cover improves in the reduction or absence of livestock grazing in the management area, predation-caused mortality of sharptails should decline from present levels (albeit unknown at this time). All raptors are protected by state and federal law, and such protection should continue. Coyotes are harvested year-round in western Idaho, and they have been trapped and shot in autumn and winter on the Nelson ranch for many years. We therefore recommend that no special predator control programs be established in the sharptail management area.

An intensive monitoring program of the response of both vegetation and sharptails would be required to evaluate the success of the management action and to develop any necessary improvements. Vegetation monitoring should include trend plots (photographs included) in sagebrush-bunchgrass areas as well as long-term assessments of the condition of mountain shrub patches and riparian areas, particularly serviceberry, chokecherry, bittercherry, and hawthorn. All traditional dancing grounds should be visited early each spring to assess occupancy. Occupied dancing grounds should be censused a minimum of five times beginning the first week that the snow is gone and continuing until mid- to late April. Occupied dancing grounds should be observed from an elevated vantage point and an attempt made to count dancing males from a distance before approaching the grounds to flush the birds for a final count. Census personnel should also search for new dancing grounds each spring, especially if the grouse population shows signs of increasing over time. Dancing grounds occupied during spring should also be censused on at least two mornings during September or October when dancing males are present.

Any biologist visiting the management area should record and map all grouse observed, including a description of the cover type in which grouse were encountered. Over time, these incidental observations could provide a valuable index to population trends. If time and money permit, systematic surveys on foot during the brood-rearing period and by snowmobile or helicopter during winter should also be conducted. Some of the birds wintered on private and public lands outside of the Nelson ranch. Proper management of the winter habitat of these grouse will require that major wintering areas outside of the study area be identified.

As a final note, we point out that BLM lands within the Cascade Resource Area have not been inventoried for the presence of sharptails. Some of these lands undoubtedly contain grouse during some parts of the year. It is very important that a complete survey of suitable habitat be made in the CRA. Any tracts found to contain grouse should be systematically searched for occupied dancing grounds and winter use areas. Every effort should be made to enhance habitat on BLM lands currently occupied by sharptails.

Idaho

Aside from the regulation of hunting, no specific effort has been made to manage sharp-tailed grouse in Idaho. However, in eastern Idaho

sharptails occur on at least four Wildlife Management Areas owned and managed by the IDFG. Two of these management areas (Tex Creek and Sand Creek) are over 6000 ha in size and contain good range conditions and healthy populations of grouse.

In their Upland Game Management Plan, the IDFG has recognized that more information is needed on the distribution, abundance, and habitat needs of sharptails in the state (IDFG 1985). Accordingly, the IDFG's stated goals are to protect and enhance sharptail habitat and to upgrade the data base on distribution and population trends. Specifically, the IDFG plans to step up efforts to monitor trends in population and harvest and to conduct systematic inventories of present and potential sharptail habitat. The Department will also consider transplanting grouse to unoccupied habitats that appear suitable for sharptails. We believe that the IDFG's goals and monitoring plans will be a critical element in the management of Columbian sharptails. We also believe that other agencies, particularly the BLM, should cooperate with IDFG in the monitoring and management of sharptail habitat in Idaho.

Given the relatively high reproductive potential of gallinaceous birds, it seems that augmentative transplants of grouse would serve little purpose in most situations. In only one case have sharp-tailed grouse been successfully reintroduced into unoccupied habitat (see Rodgers 1984-1986). To ensure as successful an operation as possible, reintroduction efforts must carefully consider (1) identification and protection of suitable habitat; (2) the source of suitable transplant stock; (3) the number, sex, and age of birds necessary for successful release; (4) the method and timing of release; (5) subsequent evaluation of the outcome of the release; and (6) cost effectiveness. Any successful reintroduction effort in Idaho almost surely will require a comprehensive plan.

Clearly, the problems involved in successfully reintroducing lek-breeding grouse have no simple solutions. Although we encourage the development of reintroduction technology, we believe that reintroduction plans should not supersede efforts to conserve existing populations of sharptails. Until reintroduction methods and rangeland conditions improve, the best method of conserving sharptails in Idaho is to protect quality habitats that contain grouse (see Parker 1970).

Additional Research Needs

An obvious need for new research is to develop sound reintroduction techniques. The Oregon Committee for the Reintroduction of Columbian Sharp-tailed Grouse was formed in 1985 and consists of state, federal, and university personnel concerned with re-establishing Columbian sharptails in Oregon. One of the goals of the committee is to develop a reintroduction plan (see Crawford 1986) that would address minimum viable population requirements and release techniques. This plan will have widespread application, and the formation of the committee is an important step toward the multi-agency approach needed for the conservation and management of Columbian sharptails.

Surprisingly little is known about the factors that regulate sharptail populations, including such fundamental life history characteristics as productivity, nesting success, mortality rates, natal and breeding dispersal

patterns, and migration. Considering the isolated nature of many Columbian sharptail populations, knowledge of these factors is especially important. Answers to these basic questions will require long-term studies of marked individuals, including radio-tagged birds. As noted in Chapter VI, there is also a need for studies designed specifically to assess the influence of radio transmitters on grouse survival and to improve methods of radio attachment.

Because winter habitat is one of the most critical elements in the management of Columbian sharptails, future research should be directed at assessing the quantity and quality of winter food plants needed to sustain sharptail populations. In particular, very little is known about the effect of plant chemical defenses on the winter foraging habits of sharp-tailed grouse. Wintering ptarmigan (Lagopus spp.) and ruffed grouse feed selectively on buds and twigs with low resin content, presumably because antimicrobial resins inhibit cecal digestion of plant material (Bryant and Kuropat 1980). Similarly, sage grouse feed selectively on a subspecies of big sagebrush that contains low levels of monoterpenes (Remington and Braun 1985). Some of the sharptails we observed seemed to avoid certain serviceberry plants while feeding heavily on others nearby. Perhaps sharptails choose feeding sites based on resin content in buds. If so, the mere presence of preferred budding species may not be indicative of the quality of the habitat for wintering grouse. A study needs to be designed specifically to determine (1) selectivity of sharptail winter foraging habits, (2) amount and variability of secondary chemical constituents in sharptail winter foods, and (3) factors that control the amount of secondary chemicals produced by winter food plants (e.g., do winter food plants produce defense chemicals in response to browsing by ungulates or budding by grouse?).

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Appendix 1. Vascular plant species identified in the Mann Creek (M) and Hog Creek (H) study areas, 1983-1985.

Scientific name	Common name	Study area
Forbs		
Achillea millefolium	Common yarrow	M,H
Agoseris grandiflora*	Bigflower agoseris	M,H
Agoseris heterophylla*	Annual agoseris	M
Allium simillimum	Simil onion	M
Allium textile	Textile onion	M
Allium sp.	Onion species	M,H
Amsinckia retrorsa	Rough fiddleneck	M,H
Antennaria flagellaris	Whip pussytoes	M
Antennaria sp.	Pussytoes species	M
Arabis cusickii	Cusick's rockcress	M
Arabis holboelii	Holboell's rockcress	M
Arabis divaricarpa	Spreadingpoc rockcress	M
Arenaria congesta	Ballhead sandwort	M,H
Artemisia ludoviciana	Louisiana sandwort	M,H
Aster chilensis	Pacific aster	M
Astragalus eremiticus	Hermit milkvetch	M,H
Balsamorhiza hookeri*	Hooker's balsamroot	M,H
Balsamorhiza sagittata*	Arrowleaf balsamroot	M,H
Blepharipappus scaber	Rough eyelashweed	M,H
Boisduvalia densiflora	Dense spikeprimrose	M
Brodiaea douglassii	Douglas brodiaea	M,H
Calochortus elegans*	Elegant cats-ear	M
Calochortus eurycarpus*	White mariposa lily	M,H
Calochortus macrocarpus*	Sagebrush mariposa lily	M,H
Camassia quamash*	Common camas	M,H
Camelina microcarpa	Littleseed falseflax	M
Castilleja grandulifera	Gland indianpaintbrush	M
Chaenactis douglassii	Douglas duskymaiden	M
Cirsium sp.	Thistle species	M,H
Clarkia rhomboidea	Rhomboid clarkia	M
Claytonia lanceolata*	Lanceleaf springbeauty	M
Collinsia parviflora	Littleflower collinsia	M,H
Collomia grandiflora	Largeflowered collomia	M,H
Collomia linearis	Slenderleaf collomia	M
Comandra umbellata	Falsetoadflax	M
Convolvulus sp.	Bindweed species	M,H
Crepis acuminata*	Tapertip hawksbeard	M,H
Crepis intermedia*	Grey hawksbeard	M,H
Cryptantha sp.	Cryptantha species	M,H
Delphinium depauperatum	Slim larkspur	M
Delphinium nuttallianum	Nuttall's larkspur	M
Descuriana sp.	Tansymustard species	M

Appendix 1. Contd.

Scientific name	Common name	Study area
Forbs contd.		
Dicentra cucullaria*	Dutchmans breeches	M
Dodecatheon conjugens	Sailorcaps shootingstar	M
Draba verna	Spring draba	M
Epilobium paniculatum	Autumn willoweed	M,H
Erigeron sp.	Fleabane species	M
Eriogonum elatum	Rush eriogonum	M
Eriogonum umbellatum	Sulfur eriogonum	M
Eriophyllum lanatum	Wooly eriophyllum	M
Erodium cicutarium	Filaree	M
Fritillaria atropurpurea	Purplespot fritillary	M
Fritillaria pudica	Yellow fritillary	M,H
Galium aparine	Catchweed bedstraw	M
Gayophytum sp.	Groundsmoke species	M
Gilia aggregata	Skyrocket gilia	M
Gilia capillaris	Hairstem gilia	M
Grindelia squarrosa	Curlycup gumweed	M,H
Haplopappus carthamoides	Loved goldenweed	M,H
Haplopappus lanuginosus	Cespitose goldenweed	M
Helianthus annuus	Common sunflower	M
Heracleum lanatum	Common cowparsnip	M
Hesperochiron pumilis	Dwarf hesperochiron	M
Hydrophyllum capitatum	Ballhead waterleaf	M,H
Idahoa scapigera	Oldstem idahoa	M,H
Lactuca serriola	Prickly lettuce	M,H
Lathyrus palustris*	Slenderstem peavine	M
Lepidium perfoliatum	Clasping pepperweed	M
Lewisia rediviva	Bitterroot	M
Lithophragma bulbifera	Bulbous prairiestar	M,H
Lithophragma parviflora	Smallflower prairiestar	M,H
Lithospermum arvense	Corn stoneseed	M
Lithospermum ruderale	White stoneseed	M
Lomatium dissectum	Fernleaf biscuitroot	M,H
Lomatium grayi	Gray's biscuitroot	M,H
Lomatium nudicale	Barestem biscuitroot	M,H
Lomatium triternatum	Nineleaf biscuitroot	M,H
Lotus purshiana*	Pursh birdsfoottrefoil	M
Lupinus laxiflorus	Spur lupine	M,H
Lupinus sp.	Lupine species	M,H
Madia glomerata	Cluster tarweed	M
Madia gracilis	Grassy tarweed	M,H
Medicago sativa*	Alfalfa	M,H
Mertensia longiflora*	Small bluebells	M,H
Microseris troximoides	Weevil microseris	M,H

Appendix 1. Contd.

Scientific name	Common name	Study area
Forbs contd.		
Microseris sp.	Microseris species	M
Microsteris gracilis	Falsephlox	M,H
Mimulus guttatus	Common monkeyflower	M
Montia linearis*	Narrowleaf minerslettuce	M
Montia perfoliata*	Clapsleaf minerslettuce	M
Navarretia breweri	Brewer's navarretia	M,H
Orobanche uniflora	One-flowered broomrape	M
Orogenia linearifolia	Indian potato	M,H
Orthocarpus hispidius	Bristly owlcolver	M
Orthocarpus tenuifolius	Slender owlclover	M
Oxytropis parryi	Parry crazyweed	M
Penstemon cusickii	Cusick's penstemon	M
Penstemon deustus	Hotrock penstemon	M,H
Penstemon eriantherus	Fuzzytongue penstemon	M
Penstemon glandulosus	Stickystem penstemon	M
Perideridia bolanderi*	Bolander yampa	M,H
Perideridia gairdneri*	Common yampa	M
Phacelia glandulifera	Oak phacelia	M
Phacelia heterophylla	Varileaf phacelia	M
Phacelia linearis	Threadleaf phacelia	M
Phlox longiflora	Longleaf phlox	M,H
Phoenicaulis cheiranthoides	Daggerpod	M
Plectritis macrocera*	Longhorn plectritis	M
Polygonum douglasii	Douglas' knotweed	M,H
Polygonum kelloggii	Kellogg's knotweed	M,H
Polygonum persicaria	Spotted knotweed	M
Polygonum polygaloides	Polygala knotweed	M
Potentilla sp.	Cinquefoil species	M
Ranunculus arvensis	Corn buttercup	M
Ranunculus glaberrinus	Sagebrush buttercup	M,H
Ranunculus oresterus	Blue Mountain buttercup	M
Rumex sp.	Dock species	M,H
Senecio intergerrimus*	Lambstongue groundsel	M,H
Sidalcea oregana*	Oregon checkermallow	M,H
Sisymbrium altissimum	Tall tumblemustard	M
Sisyrinchium inflatum	Blue-eyed grass	M
Solidago sp.	Goldenrod species	M
Taraxacum officinale	Common dandelion	M,H
Tragopogan dubius	Yellow salsify	M,H
Trifolium longipes*	Longstalk clover	M
Trifolium macrocephalum*	Bighead clover	M,H
Veronica anagallis-aquatica*	Water speedwell	M
Veronica biloba	Twolobe speedwell	M

Appendix 1. Contd.

Scientific name	Common name	Study area
Forbs contd.		
Viola beckwithii*	Beckwith's violet	M
Viola nuttallii*	Nuttall's violet	M
Wyethia amplexicaulis	Mule's ear wyethia	M,H
Wyethia helianthoides	Whitehead wyethia	M,H
Grasses		
Agropyron intermedium*	Intermediate wheatgrass	M,H
Agropyron spicatum*	Bluebunch wheatgrass	M,H
Aristida longiseta	Threeawn	M,H
Bromus carinatus*	California brome	M
Bromus japonicus	Japanese brome	M
Bromus tectorum	Cheatgrass brome	M,H
Danthonia sp.	Danthonia species	M,H
Elymus sp.*	Wildrye species	M
Festuca idahoensis*	Idaho fescue	M
Hordeum branchyantherum	Northern barley	M
Koeleria cristata*	Prairie junegrass	M,H
Melica bulbosa*	Bulbous oniongrass	M,H
Phleum pratense*	Common timothy	M
Poa ampla*	Big bluegrass	M,H
Poa bulbosa	Bulbous bluegrass	M,H
Poa pratensis	Kentucky bluegrass	M
Poa sandbergii	Sandberg's bluegrass	M,H
Sitanion hystrix	Bottlebrush squirreltail	M,H
Stipa occidentalis*	Western needlegrass	M,H
Taeniatherum asperum	Medusahead wildrye	M,H
Shrubs and trees		
Acer glabrum*	Rocky Mountain maple	M
Acer negundo	Boxelder	M
Amelanchier alnifolia*	Serviceberry	M,H
Artemisia arbuscula	Low sagebrush	M
Artemisia rigida	Stiff sagebrush	M,H
Artemisia tridentata	Big sagebrush	M,H
Artemisia tripartita	Threetip sagebrush	M
Berberis repens	Oregongrape	M
Ceanothus velutinus	Snowbrush ceanothus	M
Chrysothamnus nauseosus	Gray rabbitbrush	M,H
Chrysothamnus viscidiflorus	Green rabbitbrush	M,H
Crataegus columbiana	Columbia hawthorn	M
Crataegus douglassii	Black hawthorn	M,H
Eriogonum heracleoides	Wyeth eriogonum	M,H
Eriogonum sphaerocephalum	Scabland eriogonum	M

Appendix 1. Contd.

Scientific name	Common name	Study area
Shrubs and trees contd.		
Eriogonum thymoides	Thyme-leaved eriogonum	M
Juniperus occidentalis	Western juniper	M
Peraphyllum ramosissimum*	Squaw-apple	M
Philadelphus lewisii*	Mockorange	M
Populus tremuloides*	Quaking aspen	M,H
Populus trichocarpa	Black cottonwood	M
Prunus emarginata*	Bittercherry	M
Prunus virginiana*	Chokecherry	M,H
Pseudotsuga menziesii	Douglas fir	M
Purshia tridentata	Antelope bitterbrush	M,H
Ribes aureum*	Golden currant	M
Robinia pseudoacacia	Black locust	M,H
Rosa woodsi	Woods rose	M,H
Salix spp.*	Willow species	M,H
Sambucus caerulea*	Blue elderberry	M
Others		
Carex sp.	Sedge species	M,H
Eleocharis sp.	Spikerush species	M
Equisetum sp.	Horsetail species	M
Juncus sp.	Rush species	M
Scirpus sp.	Bulrush species	M

* Decreaser species (U.S.D.A.-U.S.F.S. 1937, R. Rosentreter pers. commun., M. Hironaka pers. commun.).

Appendix 2. Data from sharp-tailed grouse captured at the Mann Creek study area, 1983-1985. Sex: M = male, F = female; Dancing ground: L = lower, M = middle, U = upper; Trap: M = mist net, F = funnel trap, D = drop net.

Date	Sex	Dancing ground	Trap	Wt.(g)	Radio	Fate
1983						
April						
3	M	L	M	730	538	Survived summer; killed by goshawk in October.
3	M	L	F	750	438	Missing after capture.
4	M	M	M	742	513	Survived summer; killed by unk. predator in January.
5	M	L	M	720	488	Killed by avian predator.
6	M	U	M	705	None	Unknown.
6	F	U	F	710	463	Killed by mammalian predator.
6	M	U	M	742	None	Recaptured and radioed (025) 11 April 1984.
6	F	M	M	661	563	Killed by mammalian predator.
7	M	U	F	760	None	Unknown.
7	M	M	F	808	588	Survived summer; suspected shot in October.
10	M	M	F	752	None[a]	Recaptured 28 March 1984.
10	M	U	F	648	613	Killed by avian predator.
13	M	U	M	738	488	Survived summer; missing.
28	M	U	M	702	638	Killed by avian predator.
1984						
March						
28	M	U	M	758	---[a]	Killed by avian predator.
31	M	L	D	739	090	Killed by avian predator.
31	M	L	D	723	880	Radio failure; missing.
April						
1	F	U	M	586	908	Killed by unk. predator.
3	M	U	M	684	195	Killed by goshawk.
4	F	L	D	677	285	Killed by unk. predator.
4	M	L	D	702	981	Survived summer; missing.
5	M	U	F	697	205	Killed by unk. predator.
7	M	L	D	672	164	Survived summer; missing.
9	M	U	M	696	865	Killed by unk. predator.

Appendix 2. Contd.

Date	Sex	Dancing ground	Trap	Wt.(g)	Radio	Fate
1984						
April contd.						
9	F	U	F	648	044	Missing.
11	M	U	F	---	025	Killed by avian predator.
11	M	L	D	647	073	Missing.
11	M	L	D	697	225	Survived summer; killed by avian predator in September.
15	F	U	M	---	927	Killed by mammalian predator.
16	F	U	F	---	059	Killed by avian predator.
16	M	L	D	679	004	Survived summer; missing.
17	F	U	M	674	107	Survived summer; killed by golden eagle in September.
28	M	U	D	716	890	Killed by avian predator.
October						
31	M	U	D	736	031	Missing during winter.
31	M	U	D	717	935	Missing during winter.
1985						
April						
4	M	U	M	709	---[b]	See footnote.
4	M	U	M	750	None	Unknown.
5	M	U	M	774	None	Observed in spring 1986.
11	M	U	M	672	---[c]	See footnote.
11	M	U	M	695	None	Unknown.
12	F	U	D	664	996	Killed by avian predator.
12	M	U	D	695	None	Observed in spring 1986.
14	M	U	D	686	None	Unknown.
15	M	U	D	742	181	Killed by great horned owl in July.
18	M	U	D	713	963	Survived summer; missing during winter.
18	M	L	D	667	865	Survived summer; missing.
24	M	U	D	---	253[c]	Survived summer; missing.
May						
3	M	L	M	648	240	Survived summer; missing.
16	F	L	M	---	272	Survived summer; missing.

Appendix 2. Contd.

Date	Sex	Dancing ground	Trap	Wt.(g)	Radio	Fate
1985 contd.						
November						
1	M	U	M	746	122[b]	Killed by avian predator during winter.

[a] Released without radio on 10 April 1983; released without radio and killed by raptor the next day after injuring primaries during recapture on 28 March 1984.

[b] Released without radio on 4 April 1985; recaptured and radioed on 1 November 1985.

[c] Released without radio on 11 April 1985; recaptured and radioed on 24 April 1985.

Appendix 3. Flush sites of radio-tagged sharp-tailed grouse used in use-availability analyses of macrohabitat selection at Mann Creek, 1983-1985. Flush sites on or near dancing grounds during spring or autumn dancing periods are omitted.

	Cover types								
Radio no.	ARTR	ARAR	ERIO	AGIN	PUTR	MEAD	RIPA	MTSH	Total
Lower basin									
1983									
538	37	6	0	2	9	0	0	0	54
513	27	10	1	9	2	0	8	3	60
1984									
981	40	6	0	3	1	0	0	0	50
004	29	6	0	3	0	0	0	3	41
225	25	4	0	7	1	2	0	1	40
164	34	3	0	9	3	0	0	0	49
1985									
272[a]	24	4	0	0	4	4	2	0	38
240	32	6	0	1	0	0	0	3	42
865	37	4	0	0	0	0	0	1	42
Middle basin									
1983									
588	35	10	1	0	2	0	1	6	55
Upper basin									
1983									
488	22	24	2	0	0	0	0	9	57
638	15	11	3	0	0	0	0	13	42
1984									
107[a]	12	18	1	0	0	0	0	5	36
1985									
253	18	15	0	0	0	0	0	4	37
963	15	14	0	0	0	0	0	8	37
Totals	402	141	8	34	22	6	11	56	680

[a] 272 and 107 are females; all others are males.

Appendix 4. Mean % canopy coverage of 11 vegetative categories at random sites in ARTR and ARAR cover types, Mann Creek, May-July 1984-1985. N = number of random transects in each cover type.

Vegetative category	1984				1985			
	ARTR		ARAR		ARTR		ARAR	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
May	(N = 14)		(N = 8)		(N = 14)		(N = 8)	
Big sagebrush	2.21	2.56	0.11	0.31	6.70	9.89	0.73	1.36
Low sagebrush	0.46	1.01	4.89	3.55	0.44	0.82	6.45	5.22
Bitterbrush	1.40	1.34	0.09	0.26	1.93	1.80	0.58	1.10
Other shrubs	0.22	0.45	0.22	0.41	1.91	1.91	0.88	1.30
Arrowleaf balsamroot	5.05	3.29	2.70	4.38	8.04	4.49	8.26	9.28
Other composites	2.67	1.40	1.83	1.71	3.43	2.49	2.52	1.74
Other forbs	18.97	6.75	16.44	4.64	12.03	4.95	10.08	4.66
Bluebunch wheatgrass	2.69	2.47	0.39	0.68	3.75	4.38	0.16	0.26
Bulbous bluegrass	27.51	13.69	24.17	11.31	13.29	9.80	19.12	6.52
Other grasses	1.88	2.87	1.48	1.99	1.00	0.95	2.30	4.68
Bare ground	35.24	10.04	42.52	10.59	48.29	9.14	47.92	5.61
June	(N = 14)		(N = 8)		(N = 13)		(N = 9)	
Big sagebrush	5.40	5.19	0.02	0.04	5.47	5.98	0.25	0.66
Low sagebrush	0.46	1.10	8.16	6.37	0.81	1.31	11.30	8.14
Bitterbrush	0.82	1.66	0.11	0.26	1.07	1.74	1.15	2.55
Other shrubs	1.82	2.60	1.06	1.49	1.79	2.24	0.01	0.04
Arrowleaf balsamroot	6.63	6.21	6.84	8.19	6.20	5.66	0.83	2.14
Other composites	4.96	3.56	2.61	2.30	4.31	3.92	5.00	6.22
Other forbs	15.88	5.42	17.20	9.14	7.13	4.43	6.18	2.69
Bluebunch wheatgrass	2.27	3.23	1.39	2.40	2.52	2.81	0.19	0.35
Bulbous bluegrass	24.26	15.17	20.39	14.70	23.43	9.15	26.96	11.92
Other grasses	6.25	3.86	4.19	4.44	1.98	1.56	4.68	4.70
Bare ground	31.36	9.97	39.78	6.44	46.91	6.69	45.29	10.51
July	(N = 14)		(N = 8)		(N = 14)		(N = 8)	
Big sagebrush	4.59	6.12	0.09	0.26	7.32	9.19	0.03	0.06
Low sagebrush	0.53	0.94	10.48	5.02	1.13	2.28	5.22	5.10
Bitterbrush	0.84	1.26	0.30	0.55	2.46	3.43	0.86	1.25
Other shrubs	0.62	1.08	0.50	1.14	4.29	4.00	0.36	0.71
Arrowleaf balsamroot	7.96	7.45	2.17	3.52	7.87	6.42	7.30	6.18
Other composites	3.71	2.80	4.41	2.52	2.31	1.67	1.84	1.58
Other forbs	11.06	5.40	9.09	2.40	4.39	2.74	5.53	2.82
Bluebunch wheatgrass	2.73	5.63	0.78	1.11	2.42	3.37	1.06	1.53
Bulbous bluegrass	22.01	12.74	24.70	15.64	13.32	12.20	20.34	16.67
Other grasses	4.82	3.54	4.28	3.07	3.06	2.68	2.72	1.74
Bare ground	41.18	9.47	44.59	10.10	50.52	6.13	54.08	11.53

Appendix 5. Mean % canopy coverage of 11 vegetative categories at random sites in ERIO and AGIN cover types, Mann Creek, May-July 1984-1985. N = number of random transects in each cover type.

Vegetative category	1984				1985			
	ERIO		AGIN		ERIO		AGIN	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
May	(N = 5)		(N = 3)		(N = 4)		(N = 3)	
Big sagebrush	0.00	0.00	2.12	2.12	0.00	0.00	0.00	0.00
Low sagebrush	0.42	0.82	0.00	0.00	0.78	1.56	0.00	0.00
Bitterbrush	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other shrubs	7.68	4.19	0.00	0.00	5.59	3.48	0.00	0.00
Arrowleaf balsamroot	0.88	1.29	0.29	0.50	0.03	0.06	0.00	0.00
Other composites	1.12	0.96	6.83	4.63	3.72	3.60	3.96	3.02
Other forbs	16.52	4.55	5.46	3.14	12.00	2.96	5.67	4.40
Bluebunch wheatgrass	1.48	2.02	0.88	1.52	0.00	0.00	0.00	0.00
Bulbous bluegrass	13.92	8.09	13.67	6.31	10.41	15.82	6.75	4.77
Other grasses	2.52	2.29	25.38	6.36	1.19	1.65	19.00	1.84
Bare ground	55.98	13.89	43.38	10.83	66.59	15.93	63.54	12.43
June	(N = 5)		(N = 3)		(N = 4)		(N = 3)	
Big sagebrush	0.00	0.00	0.04	0.07	0.00	0.00	0.00	0.00
Low sagebrush	0.15	0.34	0.00	0.00	0.00	0.00	0.04	0.07
Bitterbrush	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other shrubs	6.78	2.00	0.00	0.00	6.75	2.15	0.00	0.00
Arrowleaf balsamroot	0.35	0.43	0.00	0.00	0.00	0.00	0.00	0.00
Other composites	2.28	1.80	4.83	2.65	0.28	0.26	0.67	0.47
Other forbs	9.32	4.55	6.08	2.98	4.84	1.63	3.08	1.73
Bluebunch wheatgrass	0.10	0.06	0.00	0.00	0.00	0.00	0.00	0.00
Bulbous bluegrass	9.18	7.66	6.83	6.38	13.19	3.77	7.75	4.32
Other grasses	3.45	2.72	13.83	6.20	2.97	2.04	26.04	3.47
Bare ground	71.65	4.56	68.25	5.52	72.00	4.08	61.88	7.27
July	(N = 4)		(N = 3)		(N = 4)		(N = 3)	
Big sagebrush	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.43
Low sagebrush	0.03	0.06	0.00	0.00	0.03	0.06	0.00	0.00
Bitterbrush	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other shrubs	9.97	2.16	0.00	0.00	6.81	2.88	0.00	0.00
Arrowleaf balsamroot	0.19	0.38	0.00	0.00	0.00	0.00	0.00	0.00
Other composites	0.44	0.36	1.46	0.62	1.31	1.63	0.71	0.56
Other forbs	8.91	2.59	2.00	1.27	8.03	3.36	4.62	3.40
Bluebunch wheatgrass	0.03	0.06	0.00	0.00	0.88	1.75	0.00	0.00
Bulbous bluegrass	8.38	7.68	2.04	0.44	9.69	6.86	14.25	4.02
Other grasses	5.16	0.61	29.38	5.66	3.19	2.44	19.83	12.28
Bare ground	68.06	8.46	67.08	4.85	68.99	7.80	56.75	12.03

Appendix 6. Mean % canopy coverage of 11 vegetative categories at sharp-tailed grouse flush sites in the ARTR cover type at Mann Creek, May-September 1983-1985. N = number of flush sites.

	1983		1984		1985	
	Mean	SD	Mean	SD	Mean	SD
May	(N = 13)		(N = 18)		(N = 22)	
Big sagebrush	5.19	5.73	4.03	5.48	2.98	3.55
Low sagebrush	0.04	0.14	0.44	1.76	0.20	0.65
Bitterbrush	3.19	6.13	0.03	0.12	1.25	5.23
Other shrubs	1.23	2.49	0.69	1.27	0.41	1.40
Arrowleaf balsamroot	14.65	8.42	17.75	11.19	13.80	9.56
Other composites	3.27	2.97	6.67	4.82	4.36	3.37
Other forbs	20.38	8.28	19.69	9.64	13.27	7.24
Bluebunch wheatgrass	0.31	0.97	1.36	2.98	4.95	6.73
Bulbous bluegrass	19.23	12.93	37.14	12.68	17.45	12.86
Other grasses	5.54	8.98	1.06	1.51	2.16	5.15
Bare ground	30.69	11.95	20.89	11.00	39.27	9.07
June	(N = 32)		(N = 48)		(N = 31)	
Big sagebrush	5.28	7.21	4.03	5.14	5.26	10.00
Low sagebrush	0.53	1.78	0.07	0.44	1.29	4.19
Bitterbrush	2.20	4.87	0.25	1.16	1.68	4.03
Other shrubs	2.03	3.60	0.66	2.26	1.74	3.83
Arrowleaf balsamroot	8.62	9.06	12.84	10.30	14.85	11.11
Other composites	5.84	4.51	9.73	8.80	3.13	3.34
Other forbs	12.19	5.00	14.64	5.62	10.44	7.59
Bluebunch wheatgrass	3.16	5.30	3.04	5.36	5.58	6.49
Bulbous bluegrass	21.72	12.89	42.55	15.55	14.44	14.64
Other grasses	6.75	5.43	4.06	5.42	3.22	3.48
Bare ground	33.64	14.07	16.66	9.98	41.27	12.29
July	(N = 39)		(N = 41)		(N = 31)	
Big sagebrush	4.29	7.56	2.46	3.86	6.10	7.34
Low sagebrush	0.44	1.31	0.26	1.11	0.05	0.15
Bitterbrush	2.28	5.08	3.66	7.58	4.92	9.08
Other shrubs	2.79	4.14	3.45	6.45	3.95	6.21
Arrowleaf balsamroot	12.37	9.71	12.66	8.97	10.74	10.35
Other composites	5.81	5.16	4.06	3.79	1.63	1.90
Other forbs	7.61	5.07	7.50	4.14	6.43	3.33
Bluebunch wheatgrass	3.90	6.94	3.48	5.99	4.95	6.76
Bulbous bluegrass	23.10	15.90	27.50	17.84	16.45	11.72
Other grasses	4.95	4.77	4.60	5.88	3.39	3.47
Bare ground	32.68	19.05	33.78	13.82	39.85	12.07

Appendix 6. Contd.

	1983		1984		1985	
	Mean	SD	Mean	SD	Mean	SD
August	(N = 24)		(N = 14)		(N = 37)	
Big sagebrush	2.25	2.97	4.54	7.93	3.08	3.62
Low sagebrush	0.02	0.10	0.78	2.22	0.99	2.92
Bitterbrush	3.19	5.43	7.54	12.85	3.31	8.06
Other shrubs	6.33	8.37	5.61	7.20	3.92	6.11
Arrowleaf balsamroot	9.88	9.38	8.32	7.87	11.55	9.36
Other composites	5.40	6.50	3.21	2.32	1.82	2.28
Other forbs	7.40	4.90	7.07	6.56	3.78	3.00
Bluebunch wheatgrass	3.73	5.88	2.25	4.00	7.61	8.34
Bulbous bluegrass	17.92	12.60	23.61	18.41	17.99	15.98
Other grasses	6.77	8.41	5.36	5.28	3.15	4.09
Bare ground	37.54	16.44	32.32	12.45	40.49	10.67
September	(N = 14)		(N = 19)			
Big sagebrush	3.54	4.17	1.39	3.10		
Low sagebrush	0.96	3.61	0.00	0.00		
Bitterbrush	2.71	5.59	6.08	8.49		
Other shrubs	2.50	3.38	1.63	4.50		
Arrowleaf balsamroot	4.28	7.16	9.10	9.39		
Other composites	5.11	4.96	1.79	2.00		
Other forbs	5.93	3.03	2.53	2.69		
Bluebunch wheatgrass	1.64	3.36	2.97	7.74		
Bulbous bluegrass	26.36	18.18	39.24	18.03		
Other grasses	8.86	7.20	3.66	4.01		
Bare ground	37.82	12.18	33.89	13.84		

Appendix 7. Mean % canopy coverage of 11 vegetative categories at sharp-tailed grouse flush sites in the ARAR cover type at Mann Creek, May-September 1983-1985. N = number of flush sites.

	1983		1984		1985	
	Mean	SD	Mean	SD	Mean	SD
May	(N = 14)		(N = 6)		(N = 22)	
Big sagebrush	1.64	4.19	0.00	0.00	0.00	0.00
Low sagebrush	8.36	4.72	4.92	3.25	6.59	8.37
Bitterbrush	0.04	0.13	1.25	3.06	0.02	0.11
Other shrubs	1.50	4.54	0.50	1.22	0.75	1.82
Arrowleaf balsamroot	7.00	13.13	6.58	7.21	14.11	11.74
Other composites	4.71	5.36	4.08	2.33	4.18	2.44
Other forbs	19.35	12.88	17.00	6.01	17.60	7.40
Bluebunch wheatgrass	0.54	1.60	0.17	0.41	4.00	4.42
Bulbous bluegrass	21.11	21.35	46.75	19.47	16.57	13.19
Other grasses	3.64	3.98	0.83	1.33	1.95	1.73
Bare ground	28.14	12.69	23.08	12.44	35.50	13.13
June	(N = 15)		(N = 5)		(N = 16)	
Big sagebrush	0.57	2.06	0.00	0.00	0.66	1.97
Low sagebrush	6.17	4.67	8.10	9.60	8.28	8.01
Bitterbrush	0.00	0.00	0.00	0.00	2.97	5.49
Other shrubs	1.10	1.80	0.00	0.00	0.06	0.17
Arrowleaf balsamroot	8.73	8.15	2.50	2.55	9.81	9.74
Other composites	4.83	6.59	7.00	5.88	2.31	2.77
Other forbs	15.73	7.68	9.70	5.93	16.22	6.54
Bluebunch wheatgrass	2.07	3.84	0.20	0.27	4.22	5.08
Bulbous bluegrass	15.50	11.64	52.50	23.54	13.62	17.58
Other grasses	3.70	3.22	4.80	4.01	3.81	2.39
Bare ground	44.70	15.48	24.80	16.63	41.25	12.53
July	(N = 24)		(N = 10)		(N = 9)	
Big sagebrush	0.56	2.55	0.05	0.16	0.00	0.00
Low sagebrush	5.69	7.69	4.45	5.02	5.89	4.08
Bitterbrush	2.25	5.58	1.05	3.32	0.67	1.32
Other shrubs	2.27	6.56	0.00	0.00	5.17	6.44
Arrowleaf balsamroot	10.09	8.72	20.45	13.30	10.28	10.00
Other composites	5.71	4.56	4.85	2.75	1.44	2.24
Other forbs	11.92	7.84	11.90	4.64	6.33	2.28
Bluebunch wheatgrass	2.12	4.29	1.95	2.75	7.39	7.38
Bulbous bluegrass	15.34	9.92	23.05	17.83	4.22	9.00
Other grasses	4.31	5.42	2.40	0.99	5.83	4.37
Bare ground	39.34	10.08	32.65	10.14	45.17	21.27

Appendix 7. Contd.

	1983		1984		1985	
	Mean	SD	Mean	SD	Mean	SD
August	(N = 9)		(N = 11)		(N = 10)	
Big sagebrush	0.33	1.00	0.14	0.32	0.00	0.00
Low sagebrush	2.83	3.53	1.23	1.97	4.10	4.12
Bitterbrush	0.06	0.17	2.27	5.06	0.35	1.11
Other shrubs	1.72	2.90	0.68	2.26	1.35	3.35
Arrowleaf balsamroot	11.72	12.08	10.77	8.88	15.85	12.09
Other composites	4.94	7.11	4.86	8.43	2.10	3.46
Other forbs	7.22	7.62	6.93	2.52	4.05	1.86
Bluebunch wheatgrass	0.11	0.22	3.41	4.10	4.65	2.65
Bulbous bluegrass	17.33	10.95	34.64	18.04	24.30	17.36
Other grasses	2.56	2.79	3.50	2.66	1.50	1.76
Bare ground	49.00	13.86	30.45	9.81	40.25	11.38
September	(N = 7)		(N = 11)			
Big sagebrush	0.00	0.00	0.04	0.15		
Low sagebrush	8.50	12.26	3.68	4.26		
Bitterbrush	0.00	0.00	1.50	3.35		
Other shrubs	0.43	0.53	3.41	4.71		
Arrowleaf balsamroot	7.93	8.88	6.91	7.42		
Other composites	2.00	2.00	1.59	3.65		
Other forbs	7.21	6.28	3.73	3.42		
Bluebunch wheatgrass	1.50	1.87	0.77	1.40		
Bulbous bluegrass	24.21	22.64	35.82	16.46		
Other grasses	3.21	3.52	3.14	3.03		
Bare ground	49.50	15.88	38.59	14.47		

Appendix 8. Mean cover board readings at random sites in ARTR, ARAR, ERIO, and AGIN cover types, Mann Creek, May-July 1984-1985. The range of possible values is from 0 (complete cover) to 150 (no cover). The number of transects in each cover type is shown in parentheses.

	ARTR				ARAR			
	1984		1985		1984		1985	
Month	Mean	SD	Mean	SD	Mean	SD	Mean	SD
May	49.9	12.6	54.6	15.8	75.6	13.8	68.1	6.9
	(N = 14)		(N = 14)		(N = 8)		(N = 8)	
June	35.3	9.1	58.5	13.0	49.8	6.3	61.9	9.1
	(N = 14)		(N = 13)		(N = 8)		(N = 9)	
July	45.7	9.7	53.7	17.8	47.6	6.3	80.3	12.3
	(N = 14)		(N = 14)		(N = 8)		(N = 8)	

	ERIO				AGIN			
	1984		1985		1984		1985	
Month	Mean	SD	Mean	SD	Mean	SD	Mean	SD
May	87.4	20.0	116.4	9.1	56.1	6.7	95.1	6.5
	(N = 5)		(N = 4)		(N = 3)		(N = 3)	
June	89.5	4.7	108.5	11.7	36.4	6.2	49.4	7.7
	(N = 5)		(N = 4)		(N = 3)		(N = 3)	
July	92.9	19.3	115.5	16.9	21.8	10.1	76.6	21.1
	(N = 4)		(N = 4)		(N = 3)		(N = 3)	

Appendix 9. Mean cover board readings at sharp-tailed grouse flush sites, Mann Creek, May-September 1983-1985. The range of possible values is from 0 (complete cover) to 150 (no cover). The number of flush sites during each period is in parentheses.

	ARTR						ARAR					
	1983		1984		1985		1983		1984		1985	
Month	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
May	38.8	13.7	23.7	12.7	41.2	14.0	49.0	14.7	39.6	10.5	45.9	9.8
	(N = 13)		(N = 18)		(N = 22)		(N = 13)		(N = 6)		(N = 22)	
June	26.6	13.1	23.3	8.8	28.2	11.5	37.9	16.4	25.4	10.4	35.3	12.1
	(N = 32)		(N = 48)		(N = 31)		(N = 15)		(N = 5)		(N = 16)	
July	28.1	12.0	22.8	11.1	32.4	24.0	31.4	14.6	30.5	6.6	39.9	23.8
	(N = 39)		(N = 41)		(N = 31)		(N = 24)		(N = 10)		(N = 9)	
August	28.2	15.1	21.5	12.3	34.6	15.4	49.1	13.1	32.9	14.1	52.0	5.7
	(N = 24)		(N = 14)		(N = 37)		(N = 9)		(N = 11)		(N = 10)	
Sept.	24.3	11.2	29.0	16.9			43.3	6.6	43.5	10.1		
	(N = 14)		(N = 19)				(N = 11)		(N = 7)			

Appendix 10. Minimum number of male sharp-tailed grouse counted each morning and overall maximum counts for spring and autumn on dancing grounds at the Mann Creek study area, 1983-1986.

Date	Dancing ground			
	Lower	Middle	Upper	Fairchild
1983				
March				
9	9	6		
17	8	4		
18	9	5		
21	5	5	3	
22		4	5	
23	7			
30		4		
31	9	4	7	
April				
1	6			
4		4	7	
5	5			
6		4	7	
7	3	5	6	
8	4			
9	4	3	6	
10		3	6	2
11	4			2
12		2		
13			5	1
14	2	1		
27			7	2
28			7	
September				
1			8	0
4	5			
7		4		
8			5	
14			10	0
17			8	0
18			24	0
19			7	0
21			15	
October				
8			10	0
12	18			

Appendix 10. Contd.

Date	Dancing ground			
	Lower	Middle	Upper	Fairchild
1983				
October contd.				
13			10	
18	17			
19				0
20			7	
November				
5			8	
7	0			
8			14	
12	3			
1984				
March				
19	14			
20	7			
27	10			
28	10	0[a]	6	0[a]
29	8			
30	12		5	
31	6			
April				
1			4	
2			6	
3	10		9	
4	8			
5	7		6	
7	12			
9			9	
10	10		5	
11	10		6	
13	9			
14			3	
15	6		4	
16	6		4	
17			2	
18	4		4	
19	4			
20	7			
21	8		3	
22			3	

Appendix 10. Contd.

Date	Dancing ground			
	Lower	Middle	Upper	Fairchild
1984				
April contd.				
28			3	
29	8			
September				
3	7			
13			2	
14	18			
15			2	
17	16			
22			2	
28	13			
29	15			
30	15			
October				
4	15			
10	21			
16	7			
17			25	
24	0		21	
25	0			
30	2		19	
November				
1	0		9	
2			1	
7			8	
8			0	
1985				
March				
20	5	1[b]	9	
26	3	4	9	
28	2	7	7	
29	3	3	6	
30	2	7		
31			8	
April				
3	5	2	7	
4	5		6	

Appendix 10. Contd.

Date	Dancing ground			
	Lower	Middle	Upper	Fairchild
1985				
April contd.				
5	5		7	
6	8		8	
7	5		8	
10	6		8	
11			7	
12	4		8	
13		0	9	
14	5		8	
15	4	0	7	
16	5		8	
17	5		7	
18	4		7	
19			7	
20			7	
24	4		8	
25	4	0		
26	4			
27	3			
29	3			
30	2			
May				
1	3			
2	3			
3	3			
September				
21			45	
22	4		21	
30	16			
October				
8			31	
1986				
March				
4			14	
29	15		11	
30			14	

Appendix 10. Contd.

Date	Dancing ground Lower	Middle	Upper	Fairchild
1986 contd.				
April				
5	11		14	
22	12		13	
24			15	
Maximum counts				
1983				
Spring	9	6	7	2
Autumn	18	0	24	0
1984				
Spring	14	0	9	0
Autumn	21	0	25	0
1985				
Spring	8	0	9	0
Autumn	16	0	45	0
1986				
Spring	15	0	15	0

[a] The Middle Dancing Ground was vacant in 1984, and the Fairchild Dancing Ground was vacant from 1984-1986.

[b] Grouse dancing near Middle Dancing Ground, which was vacant after early April 1985.

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