Sharp-tailed grouse habitat use during fall and winter on the Charles M. Russell National Wildlife Refuge, Montana
by Rick Dean Northrup

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University
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Abstract:
Sharp-tailed grouse (Tympanuchus phasianellus) habitat use and movements were studied during 1 autumn and 2 winter seasons on a 9,196 ha site on the Charles M. Russell National Wildlife Refuge in northeast Montana. Grouse occupied the juniper cover type exclusively during a winter of heavy snow and below normal air temperatures. The juniper, grass-shale, and shale cover types were used extensively during autumn and a winter of sparse snow cover and above normal air temperatures. Shoregrass habitat along Ft. Peck Reservoir was used for feeding during early autumn. Day roosts were confined to juniper (Juniperus sp.) cover. Based on shrub cover characteristics, grouse selected distinct sites during morning, midday, evening, and night. Major food items identified from fecal analysis included juniper berries and buds and composite seeds. Individual grouse movements commonly ranged beyond 1.6 km of respective dancing grounds. Shrub cover, which provides food and shelter during winter, and habitat interspersion are important components of sharptail habitat which should be protected.

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Rick Dean Northrup

A thesis submitted in partial fulfillment
of the requirements for the degree
of
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MONTANA STATE UNIVERSITY
Bozeman, Montana

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APPROVAL

of a thesis submitted by

Rick Dean Northrup

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

1/31/91

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Chairperson, Graduate Committee

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Date

Head, Major Department

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Date 1-31-91
In memory of
my father, Galen M. Northrup,
Wildlife Biologist.
VITA

Rick Dean Northrup was born June 21, 1966 in Rawlins, Wyoming, to Joann and Galen Northrup. He graduated from Brookings High School, Brookings, SD in 1984 and enrolled at South Dakota State University, Brookings, in Fisheries and Wildlife Sciences and Environmental Management. He married the former Lori M. Meidinger of Aberdeen, SD, in May 1988. He began studies toward a Masters of Science degree in Fish and Wildlife Management in August, 1988.
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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIST OF TABLES</td>
<td>ix</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>xi</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>xii</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>DESCRIPTION OF STUDY AREA</td>
<td>2</td>
</tr>
<tr>
<td>Climate and Geology</td>
<td>2</td>
</tr>
<tr>
<td>Habitat</td>
<td>4</td>
</tr>
<tr>
<td>Juniper cover type</td>
<td>4</td>
</tr>
<tr>
<td>Juniper-grass cover type</td>
<td>4</td>
</tr>
<tr>
<td>Grass-sage cover type</td>
<td>6</td>
</tr>
<tr>
<td>Sage-grass cover type</td>
<td>6</td>
</tr>
<tr>
<td>Grass-shale and shale cover types</td>
<td>6</td>
</tr>
<tr>
<td>Shore cover type</td>
<td>7</td>
</tr>
<tr>
<td>Greasewood-grass cover type</td>
<td>7</td>
</tr>
<tr>
<td>Pine cover type</td>
<td>8</td>
</tr>
<tr>
<td>Greasewood-shale cover type</td>
<td>8</td>
</tr>
<tr>
<td>Greasewood-sage cover type</td>
<td>8</td>
</tr>
<tr>
<td>METHODS</td>
<td>9</td>
</tr>
<tr>
<td>Cover Type Vegetation Analysis</td>
<td>9</td>
</tr>
<tr>
<td>Capture and Relocation</td>
<td>10</td>
</tr>
<tr>
<td>Microsite Vegetation Measurements</td>
<td>11</td>
</tr>
<tr>
<td>Snow Depth</td>
<td>12</td>
</tr>
<tr>
<td>Statistical Analysis</td>
<td>12</td>
</tr>
<tr>
<td>RESULTS</td>
<td>15</td>
</tr>
<tr>
<td>Male Display</td>
<td>16</td>
</tr>
<tr>
<td>Use and Selection of Habitat</td>
<td>16</td>
</tr>
<tr>
<td>Seasonal</td>
<td>16</td>
</tr>
<tr>
<td>Daily</td>
<td>20</td>
</tr>
<tr>
<td>Vegetative Characteristics of Sites Used by Grouse</td>
<td>20</td>
</tr>
<tr>
<td>Seasonal</td>
<td>20</td>
</tr>
<tr>
<td>Daily</td>
<td>23</td>
</tr>
<tr>
<td>Random</td>
<td>28</td>
</tr>
</tbody>
</table>
# TABLE OF CONTENTS—Continued

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeding Habits</td>
<td>30</td>
</tr>
<tr>
<td>Home Ranges and Dancing Grounds</td>
<td>31</td>
</tr>
<tr>
<td>Flocking</td>
<td>31</td>
</tr>
<tr>
<td>Snow Roosting</td>
<td>32</td>
</tr>
<tr>
<td>DISCUSSION</td>
<td>33</td>
</tr>
<tr>
<td>MANAGEMENT IMPLICATIONS</td>
<td>40</td>
</tr>
<tr>
<td>LITERATURE CITED</td>
<td>41</td>
</tr>
<tr>
<td>APPENDICES</td>
<td>45</td>
</tr>
<tr>
<td>Appendix A-Tables</td>
<td>46</td>
</tr>
<tr>
<td>Appendix B-Figures</td>
<td>52</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cover type proportions within combined sharptail home ranges and expected confidence intervals from the goodness of fit test</td>
<td>18</td>
</tr>
<tr>
<td>2. Percentage of all sharptail relocations in each cover type during 3 seasons</td>
<td>18</td>
</tr>
<tr>
<td>3. Percentage of all sharp-tailed grouse relocations in each cover type during 4 daily time periods</td>
<td>22</td>
</tr>
<tr>
<td>4. Mean and coefficient of variation in canopy coverage of 4 major shrub species at sites used by grouse during 3 seasons</td>
<td>22</td>
</tr>
<tr>
<td>5. Percentage frequency of occurrence of shrubs in point-quarter analyses at sites used by grouse during 3 seasons</td>
<td>23</td>
</tr>
<tr>
<td>6. Adjusted residuals identifying the shrub coverage-daily time period combinations responsible for a significant chi-square value</td>
<td>24</td>
</tr>
<tr>
<td>7. Adjusted residuals identifying the distance to nearest shrub-time period combinations responsible for a significant chi-square value</td>
<td>26</td>
</tr>
<tr>
<td>8. Adjusted residuals identifying shrub height-time period combinations responsible for a significant chi-square value</td>
<td>27</td>
</tr>
<tr>
<td>9. Mean and coefficient of variation in shrub canopy coverage of 4 major shrub species at sites used by grouse during 4 daily time periods</td>
<td>27</td>
</tr>
<tr>
<td>10. Percentage frequency of occurrence of shrubs at sites used by sharp-tailed grouse during 4 daily time periods</td>
<td>28</td>
</tr>
<tr>
<td>11. Median shrub measurements at random and grouse use sites within juniper and shale cover types</td>
<td>29</td>
</tr>
<tr>
<td>12. Percent relative density and frequency of discerned fragments from sharp-tailed grouse fecal samples during 3 seasons</td>
<td>30</td>
</tr>
<tr>
<td>Table</td>
<td>Plant canopy coverage estimates within each cover type by use of a Daubenmire frame (1959)</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>14</td>
<td>Shrub canopy coverage estimates within each cover type by use of line intercept transects</td>
</tr>
<tr>
<td>15</td>
<td>Height density pole measures within each cover type</td>
</tr>
<tr>
<td>16</td>
<td>Individual radioed grouse histories with date of capture and period of fall and winter relocation</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>-------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1.</td>
<td>Map of Skunk Coulee Grazing Allotment with roads, land boundary, and sharptail dancing grounds.</td>
</tr>
<tr>
<td>2.</td>
<td>Distribution of 11 cover types on the Skunk Coulee Grazing Allotment</td>
</tr>
<tr>
<td>3.</td>
<td>Top view of walk-in trap used on sharp-tailed grouse dancing grounds</td>
</tr>
<tr>
<td>4.</td>
<td>Overhead view of microsite analysis design</td>
</tr>
<tr>
<td>5.</td>
<td>Percentages of all midday sharptail locations recorded within each cover type compared to the</td>
</tr>
<tr>
<td></td>
<td>proportions of each type within the combined grouse home ranges and the entire study area.</td>
</tr>
<tr>
<td>6.</td>
<td>Relocations of 4 sharp-tailed grouse hens</td>
</tr>
<tr>
<td>7.</td>
<td>Home ranges of 5 sharp-tailed grouse males</td>
</tr>
<tr>
<td>8.</td>
<td>Frequency distributions of total shrub canopy coverage at sites used by grouse during 4 daily time</td>
</tr>
<tr>
<td></td>
<td>periods</td>
</tr>
<tr>
<td>9.</td>
<td>Frequency distributions of shrub spacing at sites used by grouse during 4 daily time periods</td>
</tr>
<tr>
<td>10.</td>
<td>Frequency distributions of shrub height at sites used by grouse during 4 daily time periods</td>
</tr>
<tr>
<td>11.</td>
<td>Snow depths at Glasgow, MT during winters 1988-89 and 1989-90.</td>
</tr>
<tr>
<td>12.</td>
<td>Mean daily air temperatures and normal monthly means at Ft. Peck, MT during winters 1988-89 and</td>
</tr>
<tr>
<td></td>
<td>1989-90</td>
</tr>
</tbody>
</table>
ABSTRACT

Sharp-tailed grouse (Tympanuchus phasianellus) habitat use and movements were studied during 1 autumn and 2 winter seasons on a 9,196 ha site on the Charles M. Russell National Wildlife Refuge in northeast Montana. Grouse occupied the juniper cover type exclusively during a winter of heavy snow and below normal air temperatures. The juniper, grass-shale, and shale cover types were used extensively during autumn and a winter of sparse snow cover and above normal air temperatures. Shoregrass habitat along Ft. Peck Reservoir was used for feeding during early autumn. Day roosts were confined to juniper (Juniperus sp.) cover. Based on shrub cover characteristics, grouse selected distinct sites during morning, midday, evening, and night. Major food items identified from fecal analysis included juniper berries and buds and composite seeds. Individual grouse movements commonly ranged beyond 1.6 km of respective dancing grounds. Shrub cover, which provides food and shelter during winter, and habitat interspersion are important components of sharptail habitat which should be protected.
INTRODUCTION

In 1936, approximately 450,000 ha of land along the Missouri River in northeast Montana was set aside by Executive Order 7509 for "... the conservation and development of natural wildlife resources and for the protection and improvement of public grazing lands and natural forage resources..." The primary species of interest in the Executive Order were plains sharp-tailed grouse (Tympanuchus phasianellus jamesi) and pronghorn antelope (Antilocapra americana). The land eventually became the Charles M. Russell National Wildlife Refuge (CMRNWR) and was transferred to the U.S. Fish and Wildlife Service management in 1976.

This project was designed to research autumn and winter habitat use of sharp-tailed grouse on a single grazing allotment within the CMRNWR. Plains sharptails have been studied in other parts of their range. Aldrich (1963) described plains sharptail habitat as subclimax brush in grassland areas and Rocky Mountain parks. Moyles (1981) reported use of a grassland - low shrub transition zone during fall with a shift to trees and marsh during winter. Similarly, Nielsen and Yde (1981) and Swenson (1985) reported use of upland grass habitat during summer and autumn with a gradual shift to wooded draws during autumn and winter.

The primary objective of this study was to determine autumn and winter sharptail habitat by evaluating use of cover types and characterizing vegetation at grouse use sites. Secondary objectives included determining home range characteristics and feeding habits.
DESCRIPTION OF STUDY AREA

The study was conducted in northeastern Montana on the Charles M. Russell National Wildlife Refuge on Skunk Coulee grazing allotment (SCGA) approximately 13 km southwest of Fort Peck (Figure 1). The 9,196 ha SCGA generally comprised an Agropyron-Stipa grassland association. The southeast two-thirds of the area was dissected by 4 major coulees, and the northwest one-third comprised rolling range and numerous smaller drainages. The waterways remained dry during most of the year and water was supplied to cattle by small stock dams and the Fort Peck Reservoir which bordered the east side of the area. Cattle were grazed on SCGA in a spring and summer, 2 pasture system. The only other agricultural activity in the immediate area was limited haying; the nearest grain fields were more than 8 km distant.

Climate and Geology

The climate is continental with a wide annual temperature range. Mean monthly temperatures in January and July are -12 C and 22 C respectively. Annual precipitation averages 25-30 cm with over 50% occurring between April and July (Caprio 1980).

Two major geologic events formed the parent soil on SCGA. First, a series of "oscillating inland seas" formed the Bearpaw Shale during the Late Cretaceous Period (Veseth and Montagne 1980). This formation is characterized by easily eroding gray and black shales resulting in a

Figure 1. Skunk Coulee Grazing Allotment, Charles M. Russell National Wildlife Refuge, Valley County, MT with roads (light internal lines), land boundary (heavy line), and sharptail dancing grounds (solid triangles).
fine dendritic drainage system over most of the study area. Second, continental glaciation during the Wisconsin stage produced a till mixture at the soil surface. The soils are well drained, shallow, and clayey with a high montmorillonite content (Bingham et al. 1984).

Habitat

Eleven separate cover types were recognized on SCGA based on vegetation and topographic characteristics (Figure 2). Borders between types were often characterized by gradual changes. Vegetation cover measurements of each type are presented in Appendix Tables 13, 14, and 15. Plant scientific nomenclature follows Hitcock and Cronquist (1973).

Juniper cover type

Heavy juniper cover, mostly Rocky Mountain juniper (J. scopulorum), was limited to sloped sides of the 4 major coulees. A scattering of big sagebrush (Artemisia tridentata) and skunkbush sumac (Rhus trilobata) occurred among large junipers and in grassy openings. Dominant grasses and grasslike species in this type included western wheatgrass (Agropyron smithii), green needlegrass (Stipa viridula), little bluestem (Andropogon scoparius), and sedge (Carex spp.). Bluebunch wheatgrass (Agropyron spicatum) occurred on boundaries with grass-sage habitat.

Juniper-grass cover type

A scattering of junipers occurred in a wide draw northwest of Fourth Ridge. Although similar to the juniper type, juniper was less abundant. Big sagebrush and skunkbush sumac were also common.
Figure 2. Distribution of 11 cover types on the Skunk Coulee Grazing Allotment, Charles M. Russell National Wildlife Refuge, Valley County, MT.
Dominant grasses included western wheatgrass, little bluestem, and green needlegrass.

Grass-sage cover type

The major ridges and a large flat separating Fifth Coulee from the northwest portion of SCGA were dominated by big sagebrush. The half-shrubs, broom snakeweed (*Gutierrezia sarothrae*) and fringed sagewort (*Artemisia frigida*) were also common. Dominant grasses were western wheatgrass and green needlegrass, followed by junegrass (*Koeleria cristata*) and blue grama (*Bouteloua gracilis*). Big sagebrush canopy coverage was moderate compared to the sage-grass type.

Sage-grass cover type

Plateaus in the northwest one-third of SCGA and slopes extending from large buttes on Fourth and Fifth Ridges were dominated almost exclusively by big sagebrush. Grasses were primarily western wheatgrass, green needlegrass, and blue grama. Narrow draws composed of the grass-shale type separated the plateaus.

Grass-shale and shale cover types

Alternating shale ridges and shallow drainages resulted in a mosaic of habitats. The grass-shale type was found in portions of the northwest one-third of SCGA. The shale type, which comprised more bare shale ridges, occurred directly above the Ft. Peck Reservoir shoreline in many parts of SCGA (Figure 2). Shrub dominance on these types correlated with topographical location. Ridges were either bare or covered with big sagebrush and grass; flats and hill sides were
dominated by a mix of big sagebrush, skunkbush sumac, and rose (Rosa sp.). North facing slopes were often occupied with junipers and dead buffaloberry (Shepherdia argentea) which apparently was killed several years earlier during a winter of extreme temperature fluctuations. Dominant grasses in both types were western wheatgrass and green needlegrass. The periphery of bare shale ridges and drainage bottoms often contained greasewood (Sarcobatus vermiculatus), rubber rabbitbrush (Chrysothamnus nauseosus), and Sandberg's bluegrass (Poa sandbergii).

Shore cover type

The band of exposed land between the high and low water level of Fort Peck Reservoir varied considerably in width. Bays, with their inherent low slopes, formed broad shorelines. Shrubs were absent due to periodic flooding. Dense stands of foxtail barley (Hordeum jubatum) and slender wheatgrass (Agropyron caninum) with Canada thistle (Cirsium arvense), cocklebur (Xanthium strumarium), and yellow sweet clover (Melilotus officianalis) were distributed in scattered patches with greatest abundances occurring where drainages opened to the reservoir. Other areas consisted of sparse cover and bare ground.

Greasewood-grass cover type

The saline flats between Third and Fourth Ridge were dominated by greasewood, big sagebrush, and broom snakeweed. Characteristic grasses included western wheatgrass, Sandberg's bluegrass, inland saltgrass (Distichlis stricta), and alkali-grass (Puccinellia nuttalliana). Narrow drainages inhabited with junipers were included in this type.
Pine cover type

The ends of Fourth and Fifth Ridges contained ponderosa pine (*Pinus ponderosa*) forest with an understory of scattered junipers. Grass and grasslike plant cover was sparse relative to other types and consisted mainly of carex.

Greasewood-shale cover type

The rolling hill topography along the extreme northern border of SCGA supported nearly pure greasewood shrub stands inter-spaced with bare ground. Combined grass and forb cover in this type was sparse (Appendix Table 13).

Greasewood-sage cover type

Flood plains of major drainages on SCGA were dominated with dense big sagebrush and greasewood. Although this type covered only a small portion of the study area, it was distinctly different from surrounding types. Dominant grasses were western wheatgrass, Sandberg's bluegrass, and alkali grass.
METHODS

Cover Type Vegetation Analysis

The study area was mapped into 11 cover types by reconnaissance and use of 1:8000 black and white aerial photographs. Vegetation characteristics were analyzed using 3 different methods on 10 representative locations within each cover type. In the first method, a 100 m line intercept transect was used to estimate shrub conopy coverage (Canfield 1941). In the second method, grass, forb, and shrub coverage were measured using a 0.2 by 0.6 m frame (Daubenmire 1959) at 10 m intervals along the line intercept transect.

The third method measured height and visual obstruction of vegetation by use of a pole similar to that utilized by Robel et al. (1970). The height density pole (HDP), which was 2.54 cm square in cross section and 91.44 cm long, was marked and numbered at 2.54 cm intervals on each side. A 3.40 m cord with a 0.90 m sighting rod attached was tied at the top of the HDP for sighting from a standard distance and height. The highest completely obstructed increment was recorded from each side of the HDP and was qualified as either grass-, forb- or shrub-obstructed. These 4 readings, which ranged from 0 (no obstruction) to 36, were also taken at 10 m intervals along the line intercept transect. Any vegetation obstruction exceeding 0 was considered 1 "hit."
Capture and Relocation

Grouse were trapped on dancing grounds 1, 2, and 3 during the spring of 1988 and on grounds 1 and 2 during the spring and fall of 1989 (Figure 1). Traps were constructed of welded wire with a funnel entrance following the procedure of Toepfer et al. (1988). Chicken wire wings 10-25 m long were used to guide birds to the entrance. Nylon netting covered each trap for ease of extracting captured birds. Traps and wings were held erect with 1.27 cm steel rod stakes. A series of 3 traps was placed in a "W" pattern on individual dancing grounds (Figure 3).

Figure 3. Top view of walk-in trap used on sharp-tailed grouse dancing grounds during spring and autumn (Toepfer et al. 1988).

Captured grouse were banded with 1 aluminum and 3 colored plastic leg bands of unique combination. A P2A or P2B solar powered radio transmitter with battery back-up and a 17 cm antennae (AVM Instrument
Co., Livermore, CA) was affixed to selected grouse by use of a poncho as described by Amstrup (1980). Sex was determined by central retrices and crown feather color patterns (Henderson et al. 1967) and immature birds were distinguished by outer primary feather replacement (Ammann 1944).

Radio-collared grouse were relocated with an AVM LA12 receiver (AVM Instrument Co., Livermore, CA) and an "H" antennae. Over 95% of all relocated birds were circled or flushed. Locations were plotted on a 1:24000 USGS quadrangle map with a 1000 m Universal Transverse Mercator (UTM) grid. Winter travel on roads was facilitated by snow machine and 4-wheel drive all-terrain vehicle.

**Microsite Vegetation Measurements**

A series of vegetation measurements was performed at grouse use sites and random field locations generated by a GW-BASIC computer program (Microsoft Corporation, Redmond, WA). Four 25 m line intercept transects were extended in the cardinal directions from the approximate grouse location or random location.

The point-centered quarter (point quarter) method (Cottam and Curtis 1956) was used to estimate shrub density. Each 10 m point along the 4 line-intercept transects and the approximate grouse location or random location were divided into 4 quadrants (Figure 4). The distance from the quadrant’s origin to the nearest shrub over 15 cm tall and each shrub’s height were measured.
Snow Depth

Snow depth was monitored during the first winter field season on 2 permanent 50 m transects at 2 m intervals. One transect was placed near the top of a coulee on a wind-blown flat, the other was located at the bottom of a coulee where snow tended to accumulate. Snow monitoring was performed in the juniper cover type because of its predominant use by grouse during winter.

Figure 4. Overhead view of microsite analysis design. Four 25 m line intercept transects were laid out at right angles and a point-quarter analyses was performed at the center and 10 m from the center along each transect. The circle designates the approximate grouse location.

Statistical Analysis

Selection of cover types in relation to availability within grouse home ranges was analyzed using the chi-square goodness-of-fit test (Nue et al. 1974). Availability of each type was measured using a
Measuronics Linear Measuring Set (Measuronics Corporation, Great Falls, MT) which projected individual grouse home ranges from an acetate overlay onto a video screen. The area of each cover type was then measured with a computer that summed all the enclosed picture elements (pixels) and multiplied the sum by a conversion factor for area in hectares. Selection significance \((P < 0.05)\) was tested including and excluding the grass-sage cover type because of its high availability and low grouse use (Thomas and Taylor 1990).

Chi-square analyses were used to test for differences in vegetation characteristics at grouse use sites among 4 daily time periods and between seasons. If significant differences \((P < 0.05)\) were detected, an analysis of residuals was performed by calculating an adjusted residual for each cell in the contingency table (Everitt 1977). If the absolute value of the adjusted residual exceeded 1.96 (the 5% standard normal deviate), the cell was identified as being at least partially responsible for a significant chi-square value within the contingency table. A positive or negative value corresponded to bias for or against that particular category, respectively.

A Mann-Whitney U test was used to compare vegetation characteristics at random and grouse use sites. A limited number of vegetation-analyzed locations restricted the test to juniper and shale cover types. Both the chi-square and Mann-Whitney U tests were performed with MSUSTAT microcomputer statistical software (Lund 1988).

Seasonal home range sizes were calculated using TELDAY, a microcomputer program which utilizes UTM locations (Lonner and Burkhalter 1988). The minimum home range method (Mohr 1947), in which
the outermost location points are connected, was used to define seasonal home range boundaries.

Seasonal dates were defined after Moyles (1981) with fall extending from 1 September to 15 November and winter from 16 November to 31 March. The 24-hr cycle was broken into 4 time periods based upon Mountain daylight savings time (MDST): morning, dawn to 1030 hrs; midday, 1031-1600 hrs; evening, 1601 hrs-dusk; and night, dusk-dawn.
RESULTS

The number of radioed grouse studied during each season varied as a result of transmitter failure and/or mortality. Eight grouse were relocated 45 times between 1 January and 15 March 1989 (winter 1) and 11 were relocated 207 times during fall (13 September to 15 November 1989) and winter 2 (16 November 1989 to 28 January 1990). Two grouse were relocated through the fall and both winter seasons (Appendix Table 15). Field work to describe cover type vegetation and vegetation characteristics at random sites for comparison with sites used by grouse was conducted between 15 June and 20 August 1989.

Snow depth differed considerably between the winters (Appendix Figure 11). Field work efficiency was hindered during winter 1 by harsh weather conditions. Precipitation during December 1988 and January 1989, and February 1989 was 204, 86, and 24% above normal respectively whereas December 1989 and January 1990 were 45 above and 30% below normal respectively (NOAA 1988, 1989, 1990). Mean monthly air temperatures during February 1989 and January 1990 were 6.7 C below and 8.9 C above normal, respectively (Appendix Figure 12). Snow conditions during winter 1 were characterized by continuous snow cover with large drifts. Except for a few days in mid December, snow cover was extremely patchy to absent during winter 2.
Male Display

Male displaying was first detected at the end of winter 1 in mid March 1989. During the fall, males displayed consistently from early September to late October. Peak counts were recorded on display grounds in mid October; grounds 1 and 2 had 20 and 18 males, respectively (Figure 1). Intermittent display was observed from late October through mid January 1990. Grouse typically moved onto grounds at first light and left by 1000 hrs MDST. Mornings with strong winds caused early abandonment whereas cloudy, still mornings induced an extended display period.

Use and Selection of Habitat

Based upon midday relocations during fall and winter 2, radioed grouse did not use all cover types in proportion to availability, within either cumulative home ranges or the study area overall (Figure 5). Results from goodness of fit tests (Neu et al. 1974) on the same relocation data are shown in Table 1. In terms of use and availability significance, juniper was the only cover type influenced by the presence of the grass-sage type.

Seasonal

Habitat selection between seasons was variable. Unlike the following fall and winter, cover type use of radioed birds during winter 1 was confined to the juniper cover type (Table 2). Individual bird movements were responsible for the slight variation in cover type use between fall and winter 2.
Figure 5. Percentages of all midday sharptail locations recorded within each cover type during fall and winter 1989-90 ($n = 127$ relocations) compared to the proportions of each type within the combined grouse home ranges and the entire study area.

Hen 389 shifted her home range over a distance of 5.8 km from shale and shoregrass to predominantly grass-shale habitat during a 2-day period in mid October 1989 (Figure 6). The early fall movements of hen 1288 started along the edge of shoregrass and juniper types. It subsequently moved away from the shoregrass type, along the edge of the greasewood-grass and juniper types, and deeper into the juniper type. A third hen, No. 1788, was only relocated in early fall and once the following winter as a result of transmitter failure. The fall locations were in the juniper and shore cover types up until contact.
Table 1. Cover type proportions within combined sharptail home ranges and expected confidence intervals from the goodness of fit test (Nue et al. 1974). Observed use was significantly greater than or less than expected when the cover type proportion was below or above the confidence interval respectively.

<table>
<thead>
<tr>
<th>Cover type</th>
<th>Proportion of combined sharp-tailed grouse home range areas</th>
<th>Confidence interval on proportion of relocations (95% family confidence coefficient)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Grass-sage type included</td>
</tr>
<tr>
<td>Juniper</td>
<td>0.528</td>
<td>0.526 &lt; $P_1$ &lt; 0.750</td>
</tr>
<tr>
<td>Grass-shale</td>
<td>0.075</td>
<td>0.091 &lt; $P_2$ &lt; 0.271</td>
</tr>
<tr>
<td>Shale</td>
<td>0.124</td>
<td>0.060 &lt; $P_3$ &lt; 0.224</td>
</tr>
<tr>
<td>Juniper-grass</td>
<td>0.067</td>
<td>0.000 &lt; $P_4$ &lt; 0.059</td>
</tr>
<tr>
<td>Shore</td>
<td>0.035</td>
<td>0.000 &lt; $P_5$ &lt; 0.029</td>
</tr>
<tr>
<td>Grass-sage</td>
<td>0.122</td>
<td>0.000 &lt; $P_6$ &lt; 0.029</td>
</tr>
</tbody>
</table>

* Proportions of combined home range areas do not sum to 1 because the greasewood-grass cover type was excluded due to a lack of grouse relocations.

Table 2. Percentage of all sharptail relocations in each cover type during 3 seasons.

<table>
<thead>
<tr>
<th>Cover type</th>
<th>Winter 1 (n = 47)</th>
<th>Fall (n = 110)</th>
<th>Winter 2 (n = 97)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Juniper</td>
<td>100.0</td>
<td>63.6</td>
<td>53.6</td>
</tr>
<tr>
<td>Grass-shale</td>
<td>10.0</td>
<td>22.7</td>
<td>22.7</td>
</tr>
<tr>
<td>Shale</td>
<td>16.4</td>
<td>9.3</td>
<td>9.3</td>
</tr>
<tr>
<td>Juniper-grass</td>
<td>7.2</td>
<td>7.2</td>
<td>7.2</td>
</tr>
<tr>
<td>Shore</td>
<td>4.5</td>
<td>2.1</td>
<td>2.1</td>
</tr>
<tr>
<td>Grass-sage</td>
<td>3.6</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Other</td>
<td>1.8</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

was lost. The single winter location was in the interior of the juniper type.

Shifts in habitat use among males during fall and winter 2 were less distinct. Generally, movements showed no progressive change between cover types. Instead males normally remained near their
Figure 6. Relocations of 4 sharp-tailed grouse hens during fall and winter 1989-90. Arrows represent movement trends.
respective dancing grounds.

The movements of 2 males did not fit this description. Grouse 2389 failed to return to the display ground shortly after being trapped in late October 1989. Instead, relocations of the bird were in juniper and shale types with 1 morning location in shoregrass (Figure 7). During a period of heavy snowfall in mid December it shifted deeper into juniper habitat, away from the shoreline. Relocations in January were also in juniper. The other exception, a young male, No. 2289, moved from DG-1, where it was trapped, to DG-3 where it eventually displayed in the spring 1990 (Figure 7). As the bird’s fall and winter home range extended west, 5 relocations occurred in the juniper-grass type.

**Daily**

Excluding displaying males, morning relocations during the fall and winter 2 often occurred in cover types rarely used during midday period. The shore, grass-sage, greasewood-grass, and sage-grass types accounted for 20.1% of all morning relocations compared to only 2.4% during midday (Table 3). Relative to midday, a higher proportion of evening and nighttime relocations also occurred in the shore, grass-sage, and greasewood-grass types.

**Vegetative Characteristics of Sites Used by Grouse**

**Seasonal**

Juniper provided the greatest amount of shrub canopy coverage at sharp-tailed grouse use sites during all 3 field seasons (Table 4).
Figure 7. Home ranges of 5 sharp-tailed grouse males during fall and winter 1989-90.
Although shifts in use of cover types between season were apparent, shrub canopy coverage at midday grouse locations did not differ significantly between the 3 seasons (chi-square, $n=100$, df = 6, $P = 0.3073$).

Table 3. Percentage of all sharp-tailed grouse relocations in each cover type during 4 time periods, fall and winter 1989-90 combined.

<table>
<thead>
<tr>
<th>Cover type</th>
<th>Morning (dawn-1030)</th>
<th>Midday (1031-1600)</th>
<th>Evening (1601-dusk)</th>
<th>Night (dusk-dawn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Juniper</td>
<td>54.3</td>
<td>61.4</td>
<td>52.1</td>
<td>59.1</td>
</tr>
<tr>
<td>Grass-shale</td>
<td>17.1</td>
<td>18.1</td>
<td>17.4</td>
<td></td>
</tr>
<tr>
<td>Shale</td>
<td>5.7</td>
<td>14.2</td>
<td>13.0</td>
<td>18.2</td>
</tr>
<tr>
<td>Juniper-grass</td>
<td>2.9</td>
<td>3.9</td>
<td>4.3</td>
<td></td>
</tr>
<tr>
<td>Shore</td>
<td>8.6</td>
<td>1.6</td>
<td>8.7</td>
<td></td>
</tr>
<tr>
<td>Grass-sage</td>
<td>5.7</td>
<td>0.8</td>
<td>4.3</td>
<td>18.2</td>
</tr>
<tr>
<td>Greasewood-grass</td>
<td>2.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sage-grass</td>
<td>2.9</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a Time periods based upon MDST.

Table 4. Mean and coefficient of variation in canopy coverage of 4 major shrub species at sites used by sharp-tailed grouse during 3 seasons. $n =$ Number of sites sampled.

<table>
<thead>
<tr>
<th>Shrub species</th>
<th>Winter 1 (n = 47)</th>
<th>Fall (n = 59)</th>
<th>Winter 2 (n = 93)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\bar{x}$</td>
<td>CV</td>
<td>$\bar{x}$</td>
</tr>
<tr>
<td>Juniper</td>
<td>24.7</td>
<td>51.8</td>
<td>21.5</td>
</tr>
<tr>
<td>Big sagebrush</td>
<td>1.9</td>
<td>115.8</td>
<td>2.5</td>
</tr>
<tr>
<td>Skunkbush sumac</td>
<td>1.5</td>
<td>120.0</td>
<td>1.2</td>
</tr>
<tr>
<td>Buffaloberry</td>
<td>0.2</td>
<td>300.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Junipers were also the most prevalent shrubs in the point-quarter analyses (Table 5). Frequency of occurrence of junipers at sites used by grouse during winter 1 was substantially higher than during fall and
winter 2. However, this may reflect the deep snow which eliminated short shrub species from the analysis rather than a seasonal shift in microsite selection.

Table 5. Percentage frequency of occurrence of shrubs in point-quarter analyses at sites used by sharp-tailed grouse during 3 seasons.

<table>
<thead>
<tr>
<th>Species</th>
<th>Winter 1 (n = 920)</th>
<th>Fall (n = 1722)</th>
<th>Winter 2 (n = 1083)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Juniper</td>
<td>68.5</td>
<td>44.9</td>
<td>44.1</td>
</tr>
<tr>
<td>Big sage brush</td>
<td>14.8</td>
<td>19.6</td>
<td>25.8</td>
</tr>
<tr>
<td>Skunkbush sumac</td>
<td>8.9</td>
<td>7.7</td>
<td>8.9</td>
</tr>
<tr>
<td>Buffaloberry</td>
<td>0.8</td>
<td>3.0</td>
<td>0.9</td>
</tr>
<tr>
<td>Other</td>
<td>7.0</td>
<td>24.8</td>
<td>20.3</td>
</tr>
</tbody>
</table>

* Five point-quarter analyses were performed at each site sampled.

Daily

Based upon the combined relocations for fall and winter 2, shrub canopy coverage, shrub spacing, and shrub height differed significantly at sites used during 4 daily time periods. Shrub canopy coverage was generally sparsest at morning feeding sites and heaviest at midday roosts (Figure 8). Shrub coverage at night locations was the most variable. Midday and night locations were the only 2 time periods which did not differ significantly (chi-square, df = 3, \( P = 0.3655 \)). The adjusted residuals are listed in Table 6. A positive residual value indicates the frequency of use for that category was higher than expected and a negative value indicates the frequency of use was lower than expected in relation to the other 3 time periods. Relative to other locations, grouse selected areas of less shrub cover during morning hours and more shrub cover during midday (Table 6).
Figure 8. Frequency distributions of total shrub canopy coverage at sites used by grouse during 4 daily time periods.

Table 6. Adjusted residuals identifying the shrub coverage-daily time period combinations responsible for a significant chi-square value ($\chi^2 = 30.10, \text{df} = 6, P < 0.001$). Any residual value $> |1.96|$ is significant. See text for further explanation.

<table>
<thead>
<tr>
<th>Percent shrub canopy coverage</th>
<th>Daily time period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dawn-1030 (n = 27)</td>
</tr>
<tr>
<td>0.0-15.0</td>
<td>3.68</td>
</tr>
<tr>
<td>15.1-30.0</td>
<td>-0.09</td>
</tr>
<tr>
<td>&gt; 30.1</td>
<td>-3.43</td>
</tr>
</tbody>
</table>

Distance between shrubs also tended to be greatest at sites used during morning (Figure 9). Midday locations had a greater proportion
of distances in the 0.0 m category indicating the origin of the point quarter quadrants was directly over the shrub. The adjusted residuals provide another perspective of the same data combinations (Table 7). The pattern follows closely to that expected based on shrub canopy coverage (Figure 8, Table 6).

![Graph](graph.png)

Figure 9. Frequency distributions of shrub spacing at sites used by grouse during 4 daily time periods.

Of the microsite measurements, shrub height varied the least between time periods (Figure 10). The only significant shrub height differences existed between sites used during morning and midday (chi-square, df = 4, $P < 0.001$) (Table 8).
Table 7. Adjusted residuals identifying the distance to nearest shrub-daily time period combinations responsible for a significant chi-square value ($\chi^2 = 124.7$, df = 9, $P < 0.001$). Any residual value $> |1.96|$ is significant.

<table>
<thead>
<tr>
<th>Distance to nearest shrub in each quarter (m)</th>
<th>Daily time period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dawn-1030</td>
</tr>
<tr>
<td></td>
<td>(n = 513)*</td>
</tr>
<tr>
<td>0.0</td>
<td>-6.47</td>
</tr>
<tr>
<td>0.10-1.50</td>
<td>0.65</td>
</tr>
<tr>
<td>1.51-3.00</td>
<td>0.90</td>
</tr>
<tr>
<td>≥ 3.01</td>
<td>8.18</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1031-1600</td>
</tr>
<tr>
<td></td>
<td>(n = 1527)</td>
</tr>
<tr>
<td>0.0</td>
<td>6.71</td>
</tr>
<tr>
<td>0.10-1.50</td>
<td>-3.38</td>
</tr>
<tr>
<td>1.51-3.00</td>
<td>-0.51</td>
</tr>
<tr>
<td>≥ 3.01</td>
<td>-4.13</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1601-dusk</td>
</tr>
<tr>
<td></td>
<td>(n = 374)</td>
</tr>
<tr>
<td>0.0</td>
<td>-2.86</td>
</tr>
<tr>
<td>0.10-1.50</td>
<td>1.49</td>
</tr>
<tr>
<td>1.51-3.00</td>
<td>2.23</td>
</tr>
<tr>
<td>≥ 3.01</td>
<td>-0.30</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Night</td>
</tr>
<tr>
<td></td>
<td>(n = 416)</td>
</tr>
<tr>
<td>0.0</td>
<td>0.67</td>
</tr>
<tr>
<td>0.10-1.50</td>
<td>2.95</td>
</tr>
<tr>
<td>1.51-3.00</td>
<td>2.42</td>
</tr>
<tr>
<td>≥ 3.01</td>
<td>-2.88</td>
</tr>
</tbody>
</table>

* Twenty shrub distances (5 point-quarters) were measured at each location.

Figure 10. Frequency distributions of shrub height at sites used by grouse during 4 daily time periods.
Table 8. Adjusted residuals identifying shrub height-daily time period combinations responsible for a significant chi-square value \((X^2 = 131.8, df = 12, P < 0.001)\). Any residual value > |1.96| is significant.

<table>
<thead>
<tr>
<th>Height of nearest shrub in each quarter</th>
<th>Dawn-1030 (n = 513)</th>
<th>1031-1600 (n = 1527)</th>
<th>1601-dusk (n = 374)</th>
<th>Night (n = 416)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>9.50</td>
<td>-4.80</td>
<td>-0.67</td>
<td>-2.95</td>
</tr>
<tr>
<td>0.15-0.50</td>
<td>2.09</td>
<td>-1.20</td>
<td>0.60</td>
<td>-1.18</td>
</tr>
<tr>
<td>0.51-1.00</td>
<td>0.83</td>
<td>-1.60</td>
<td>-0.54</td>
<td>1.83</td>
</tr>
<tr>
<td>1.01-1.50</td>
<td>-3.14</td>
<td>1.68</td>
<td>0.40</td>
<td>0.69</td>
</tr>
<tr>
<td>≥ 1.51</td>
<td>-5.16</td>
<td>4.18</td>
<td>-0.39</td>
<td>0.14</td>
</tr>
</tbody>
</table>

^a Twenty shrub heights (5 centered point quarters) were measured at each location.

Shrub species composition provides another perspective of factors involved when grouse select sites during 4 daily time periods. Junipers were the most common shrub overall and appear to have had the greatest influence on total shrub cover (Tables 9 and 10).

Table 9. Mean and coefficient of variation in canopy coverage of 4 major shrub species at sites used by sharp-tailed grouse during 4 daily time periods.

<table>
<thead>
<tr>
<th>Shrub species</th>
<th>Dawn-1030 (n = 27)</th>
<th>1031-1600 (n = 82)</th>
<th>1601-dusk (n = 21)</th>
<th>Night (n = 22)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(\bar{x})</td>
<td>CV</td>
<td>(\bar{x})</td>
<td>CV</td>
</tr>
<tr>
<td>Juniper</td>
<td>11.7</td>
<td>79.0</td>
<td>23.4</td>
<td>57.4</td>
</tr>
<tr>
<td>Big sagebrush</td>
<td>2.1</td>
<td>167.4</td>
<td>2.2</td>
<td>115.5</td>
</tr>
<tr>
<td>Skunkbush sumac</td>
<td>0.9</td>
<td>123.7</td>
<td>1.5</td>
<td>106.8</td>
</tr>
<tr>
<td>Buffaloberry</td>
<td>0.3</td>
<td>242.3</td>
<td>0.8</td>
<td>371.2</td>
</tr>
</tbody>
</table>

Sites used in morning had the lowest average canopy coverage and frequency of occurrence of juniper, whereas midday and night locations
had the highest average juniper coverage (Table 9). Juniper cover varied substantially at nighttime locations. Four night locations had juniper cover exceeding 50%, whereas at 5 other night locations juniper was absent. The night locations lacking junipers were in grass-sage and greasewood-grass habitats with 5 to 12% big sagebrush canopy coverage (Table 9).

Table 10. Percentage frequency of occurrence of shrubs at sites used by sharp-tailed grouse during 4 daily time periods.

<table>
<thead>
<tr>
<th>Shrub species</th>
<th>Time period</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dawn-1030 (n = 493)</td>
<td>1031-1600 (n = 1522)</td>
<td>1601-dusk (n = 374)</td>
<td>Night (n = 416)</td>
<td></td>
</tr>
<tr>
<td>Juniper</td>
<td>29.0</td>
<td>49.4</td>
<td>45.7</td>
<td>44.7</td>
<td></td>
</tr>
<tr>
<td>Big sagebrush</td>
<td>23.3</td>
<td>21.1</td>
<td>20.1</td>
<td>25.2</td>
<td></td>
</tr>
<tr>
<td>Skunkbush sumac</td>
<td>9.7</td>
<td>7.6</td>
<td>10.7</td>
<td>6.0</td>
<td></td>
</tr>
<tr>
<td>Buffaloberry</td>
<td>1.8</td>
<td>1.5</td>
<td>4.8</td>
<td>3.1</td>
<td></td>
</tr>
<tr>
<td>Greasewood</td>
<td>10.8</td>
<td>3.3</td>
<td>0.5</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Broom snakeweeds</td>
<td>3.3</td>
<td>2.6</td>
<td>2.1</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>Winterfat</td>
<td>11.6</td>
<td>7.6</td>
<td>9.6</td>
<td>7.9</td>
<td></td>
</tr>
<tr>
<td>Rabbitbush</td>
<td>8.5</td>
<td>5.6</td>
<td>5.9</td>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>0.2</td>
<td>2.0</td>
<td>0.5</td>
<td>2.4</td>
<td></td>
</tr>
</tbody>
</table>

* Approximately 20 shrubs were identified at each location.

Random

Total shrub coverage was significantly lower at morning locations within the juniper cover type than at random sites within the same habitat (Table 11). Juniper comprised 87.3 and 86.4% of the total shrub coverage at morning and random sites respectively whereas juniper cover at random sites (median = 24.5%) was significantly greater than at morning sites (median = 18.1%) (Mann-Whitney U, P < 0.001). This indicates juniper was primarily responsible for differences in shrub cover between morning grouse and random locations.
Juniper, which made up approximately 60% of the shrubs measured at point-quarter transects, was also responsible for the significant difference in shrub height between midday grouse and random locations (Table 11).

Table 11. Median shrub measurements at random and grouse use sites within juniper and shale cover types. The P-value is the probability of equality with random site shrub measurements (Mann-Whitney U).

<table>
<thead>
<tr>
<th>Site</th>
<th>n</th>
<th>Shrub canopy coverage (%)</th>
<th>Shrub distance (m)</th>
<th>Shrub height (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>median</td>
<td>median</td>
<td>median</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>Juniper type</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Random</td>
<td>35</td>
<td>29.2</td>
<td>0.80</td>
<td>0.59</td>
</tr>
<tr>
<td>Morning</td>
<td>15</td>
<td>20.5</td>
<td>1.36</td>
<td>0.64</td>
</tr>
<tr>
<td>Midday</td>
<td>42</td>
<td>30.8</td>
<td>0.82</td>
<td>0.87</td>
</tr>
<tr>
<td>Evening</td>
<td>10</td>
<td>27.6</td>
<td>0.74</td>
<td>0.84</td>
</tr>
<tr>
<td>Night</td>
<td>13</td>
<td>32.9</td>
<td>0.73</td>
<td>0.70</td>
</tr>
<tr>
<td>Shale type</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Random</td>
<td>34</td>
<td>3.0</td>
<td>1.68</td>
<td>0.30</td>
</tr>
<tr>
<td>Actual&lt;sup&gt;a&lt;/sup&gt;</td>
<td>21</td>
<td>24.3</td>
<td>0.87</td>
<td>0.72</td>
</tr>
</tbody>
</table>

<sup>a</sup> Actual includes all daily time periods combined within the shale cover type.

Based on all relocations within the shale cover type, it is apparent that grouse sought areas of extensive shrub cover relative to what was available (Table 11). Juniper made up 80.3% of the total shrub cover at sites selected by grouse as compared with 43.9% at random sites. Average percentages of juniper cover on grouse selected and random sites was 20.3 and 2.7%, respectively. The sharptail's preference for juniper cover within the shale type was also responsible for the substantial difference in median shrub height between actual and random sites (Table 11).
Feeding Habits

Twenty five fecal samples collected through the 3 field seasons were analyzed for feeding habits. Juniper berries and buds and composite seeds, probably thistle and pussytoes (*Antennaria* sp.), were the most common identifiable food items (Table 12). Small sample sizes precluded statistical comparisons between seasons. However, few food items appeared to be selected during winter 1 as compared with the following fall and winter (Table 12). Snow tracking also indicated feeding on juniper berries and buds as well as skunkbush sumac buds.

Table 12. Percent relative density (microscope slide) and frequency of discerned fragments from sharp-tailed grouse fecal samples during 3 seasons.

<table>
<thead>
<tr>
<th>Species</th>
<th>Winter 1 (n = 7)</th>
<th>Fall (n = 12)</th>
<th>Winter 2 (n = 6)</th>
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<tr>
<td>Carex</td>
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<td>0.3 / 1</td>
<td>0.7 / 1</td>
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<td>0.3 / 1</td>
<td>0.7 / 1</td>
</tr>
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<td>Stipa comata</td>
<td>0.2 / 1</td>
<td>0.3 / 1</td>
<td>0.7 / 1</td>
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<tr>
<td>Forb</td>
<td>0.6 / 1</td>
<td>0.3 / 1</td>
<td>0.7 / 1</td>
</tr>
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<td>Achillea</td>
<td>0.6 / 1</td>
<td>0.3 / 1</td>
<td>0.7 / 1</td>
</tr>
<tr>
<td>Alyssum</td>
<td>20.0 / 2</td>
<td>17.5 / 8</td>
<td>45.9 / 6</td>
</tr>
<tr>
<td>Compositae</td>
<td>12.6 / 7</td>
<td>5.8 / 5</td>
<td>3.6 / 4</td>
</tr>
<tr>
<td>Shrub</td>
<td>67.2 / 7</td>
<td>64.8 / 12</td>
<td>46.7 / 6</td>
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<td></td>
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<td>0.2 / 2</td>
<td>1.7 / 1</td>
</tr>
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<td>Juniperus</td>
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<td>3.6 / 4</td>
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<tr>
<td>Juniperus berry</td>
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<td>64.8 / 12</td>
<td>46.7 / 6</td>
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<td>0.4 / 1</td>
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<tr>
<td>Rhus seed</td>
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<td>1.4 / 2</td>
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<td></td>
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<td>Animal</td>
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<tr>
<td>Arthropod parts</td>
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</tbody>
</table>
The crop contents from a single grouse harvested on the study area in mid November comprised 65.4% juniper berries, 18.7% green forb leaves, and 15.9% skunkbush sumac buds by volume.

Home Ranges and Dancing Grounds

Seasonal home range sizes, calculated from all locations during fall and winter 2, ranged from 93 to 577 ha (11 home ranges, 205 relocations, $\bar{x} = 268.1$ ha, SD = 153.8). The 3 largest exceeded 400 ha. The juvenile male referred to earlier (p. 21) had the largest seasonal home range. The 2 distinct home ranges of hen No. 389 were 122 and 152 ha ($n = 14, n = 21$ relocations respectively).

As might be expected from the fall and winter 2 grouse relocations, males generally stayed closer to the dancing grounds upon which they were trapped than did females. Excluding dancing ground locations, 95% of male relocations were within 3.11 km ($n = 135, \bar{x} = 1.55$ km, median = 1.27 km) of their resident dancing grounds whereas 95% of female relocations were within 4.53 km ($n = 71, \bar{x} = 2.76$ km, median = 2.60 km).

Flocking

Group size during the first winter field season commonly ranged from 1 to 4 birds. A group of 7 birds was observed on 2 occasions. There was no apparent combining of flocks into packs during either winter season. Males during the autumn and winter display sometimes left the grounds in a group of 15 or more birds and spent the rest of the morning apparently feeding in a loose flock. During the autumn and
winter 2, groups of 4 to 7 birds often roosted together within a 50 m diameter circle at night.

Snow Roosting

Snow roosting was observed only during winter 1. Most snow roosts comprised a shallow open depression lacking overhead snow cover. Actual snow burrows were present at 3 out of 10 night snow roosts. I observed only 1 day roost location with snow burrows. Tunnel lengths ranged from 18 to 48 cm and were usually restricted to fresh snow drifts.
DISCUSSION

In sharp-tailed grouse most new display territories on dancing grounds are established by young males during the autumn and early winter after older males initiate display activities (Caldwell 1976, Moyles and Boag 1981). The number of displaying males in fall during this study increased gradually to a peak number in mid October. This date corresponds closely to Nielsen's (1978) findings in north-central Montana. Both Nielsen (1978) and Hamerstrom and Hamerstrom (1951) reported fall dancing intensity to be greatest on cold quiet mornings. In this study, males often spent 1 more hour roosting on the display ground during cloudy, still mornings.

One juvenile male grouse emigrated from the dancing ground on which it was trapped to an adjacent ground approximately 4.8 km (3 miles) distant by the following spring. Whether this is a common phenomena is unknown because most researchers have not captured grouse on display grounds during autumn in prior studies. Caldwell (1976) reported adult males chasing and fighting young males during autumn, which occasionally resulted in them leaving the dancing ground. I witnessed a number of similar chases on the ground from which the young male emigrated. Sharp-tailed grouse may continue to display through mid winter (Hamerstrom 1939, Moyles and Boag 1981). In this study, birds were active on display grounds through January 1990 of winter 2; however display did not occur during January or February 1989. Snow
accumulations and/or cold air temperatures apparently prevented such activity until early March that year.

Grouse habitat selection was also affected at least in part by weather conditions. Numerous studies have reported sharptails shifting to brushy cover during late autumn or winter (Marshall and Jensen 1937, Baumgartner 1939, Hamerstrom and Hamerstrom 1951, Evans 1968, Nielsen and Yde 1981, and Swenson 1985). Marshall and Jensen (1937) and Swenson (1985) related the shift to brush as a direct result of snow accumulations. My results provide a similar conclusion. Heavy snow and/or cold temperatures presumably forced grouse to use the juniper type almost exclusively for cover and food during winter 1.

Of the cover types used by sharptails in this study, juniper undoubtedly provided the best security cover and shelter from harsh winter weather. The sage-grass, grass-sage, and shoregrass types were almost completely drifted over during winter 1. Cover within the shale and grass-shale types was limited to juniper patches which apparently received little if any use during winter 1, but were used extensively the following autumn and winter. There are at least 2 possible reasons for this. First, the juniper patches, which at times drifted full with snow, may not have provided sufficient weather protection or security. Second, use of a patchy resource might require greater mobility at the cost of both energy and potential exposure to predators. Potapov and Andreev (1982) reported minimal activity as being an important adaptation for maintaining a daily energy budget below -10 C in 6 species of Tetraoninae.

Habitat selection during winter 2, a mild winter, resembled that of
the preceding autumn when the juniper, grass-shale, and shale types were commonly used. In addition, grouse fed regularly in shoregrass during autumn. After feeding, they typically moved to junipers within 0.5 km to roost during midday. Swenson (1985) reported sharptails feeding in cultivated cropland during autumn until snow accumulations forced them into wooded draws. In this study, shoregrass appeared to be a natural substitute for the absent cropland. The only obvious seasonal shift of habitat use between autumn and winter was the movement away from shoregrass and adjacent habitats by late October (Figure 6). The sage-grass and greasewood-grass types were occasionally used for night roosting.

Males did not occur in shoregrass as frequently as females. The nearest shoregrass habitat from dancing grounds was approximately 2 km (1.2 mi) distant. Both sex segregation resulting from the male's attraction to dancing grounds during autumn (Hamerstrom and Hamerstrom 1951) and the assumption that males would be reluctant to travel to shoregrass for feeding while remaining active at the display grounds may account for this niche separation during autumn. However, the males may have used shoregrass prior to the onset of fall display.

Although grouse selected for different cover types between seasons, shrub canopy coverage at midday roosts remained very similar through the fall and both winters. Juniper was associated with midday roosts throughout this study. Shrub height at midday locations in juniper was significantly greater than at random sites in juniper (Table 11). In contrast, morning feeding sites were generally grassy with sparse shrub cover relative to day roosts. Morning locations
within the juniper cover type also contained significantly less shrub cover than occurred at random sites in the juniper type (Table 11). Similarly, Moyles (1981), in the parklands of Alberta, reported sharptails used open vegetative cover in the early autumn mornings for feeding after which they occasionally moved to taller, heavier cover by mid morning.

Sites used by grouse during evening and at night were more difficult to characterize. Both feeding and roosting were observed during the evening period. Besides remaining in juniper cover, grouse occasionally fed in both grassy upland cover and shoregrass. Juniper coverage at sites used in the evening was intermediate to midday and morning locations. Moyles (1981) reported grouse moving back into more open vegetative cover in the evening. Grouse roosting in the evening occasionally remained at the same site through the night. However, on 2 occasions I witnessed sharptails flying to night roosts approximately 20 minutes after sunset.

Vegetative cover characteristics at night roosts varied. Four of the highest juniper coverages I recorded at any site during the autumn and winter 2 were at night roosts. However, 5 other night roosts in the sage-grass and greasewood-grass types completely lacked juniper. Flock sizes in night roosts on open sagebrush grassland normally exceeded 5 grouse, whereas roosts in dense juniper cover mainly consisted of 1 or 2 grouse. From this, it appeared the open cover was preferred by most grouse for night roosting. Gratson (1988) also reported the sharptail's preference for open night roosting cover in Wisconsin.
Overall, shrub cover, mostly in the form of junipers, was used throughout this study. Habitat used within the shale type had significantly more shrub cover than random locations in this type. Junipers were consistently used within both shale and grass-shale habitats although their canopy covered less than 3% in either type (Appendix Table 14).

Sharptail food habits have attracted a great deal of attention in past research. Most differences between studies relate to availability and seasonal variation (Evans 1968). Johnsgard (1973) generalized fall sharptail foods as seeds, fruit from shrubs, and green leaves of herbs, shrubs, and trees whereas winter diets are typically restricted to fruit and woody mast. Food habits in this study generally followed these trends. Juniper fruit and buds probably comprised the bulk of food consumed during autumn and both winters (Table 12). Composite seeds, probably a mixture of pussytoes (Antennaria sp.) and thistle, were also prevalent. Green forb leaves and skunkbush sumac buds may also have been important foods but were not easily identified because of their soft nature (Swanson 1940). Although sample size was small, there appeared to be a greater variety of food items during autumn and winter 2 relative to winter 1. This was expected as snow cover during winter 1 probably reduced the availability of some foods.

Juniper berries and buds have been reported as sharptail food by other researchers in Montana (Yde 1977, Nielsen 1978, and Swenson 1985). Yde reported both juniper fruit and buffaloberries as being important winter food. However, substantial quantities of juniper fruit were consumed only if buffaloberries were limited as a result of
poor fruit production. After testing a number of sharp-tailed grouse foods, Evans and Dietz (1974) reported the fruit of the buffaloberry was the best native winter food tested. It was high in energy, readily eaten, and persisted on the shrubs throughout the winter. Nearly all buffaloberry plants on the SCGA allotment had died apparently from a late spring frost, prior to this study. Dead shrubs were scattered in clumps across juniper, shale, and grass-shale habitats. However, an undetermined proportion of clumps were starting to show new growth at the time of this study.

Seasonal sharptail home range size for autumn and winter 2 combined averaged 268 ha (662 acres). Gratson (1981) reported average seasonal home ranges of 388 and 400 ha during autumn and winter respectively. Perhaps of equal or more importance from a management perspective is the distance grouse ranged from their dancing grounds. Nielsen and Yde (1981) reported the majority of male sharptail activities occurred within 1.6 km (1 mile) of their respective dancing grounds during summer and fall. In this study, 60.0 % of male relocations and only 19.7 % of female relocations were within 1.6 km of their dancing grounds. As expected, males were more strongly associated with dancing grounds than were females. Female activities were associated with the attraction of shoregrass and adjacent habitats during early fall when the majority of female relocations were made.

A number of sharptail roosts during winter 1 consisted of snow burrows and shallow snow depressions. Fresh drifts created from wind and large junipers or broken topography typically provided sufficient snow depth for burrowing. Single drifts were sometimes shared by 2 to
5 grouse. I observed burrow use only once during the daytime, whereas, at night, burrows were apparently preferred to snow depressions. As fresh drifts became available, grouse immediately switched to burrows. However, because snow developed a crust within days of a snowfall, depression snow roosts were the most common. Potapov and Andreev (1982) found grouse can maintain an ambient temperature of -7 C in a snow burrow when open air temperatures range from -10 to -60 C.
MANAGEMENT IMPLICATIONS

1. Juniper was an important source of food and cover on SCGA. Buffaloberry may also be a key shrub as it reestablishes itself in the future. Sharptail management objectives should include maintaining and/or enhancing shrub cover which provides protection and food especially during periods of harsh winter weather.

2. The proximity of a variety of cover types allowed grouse to use preferred and/or needed habitats on a daily and seasonal basis without traveling great distances. Land management should strive to protect habitat interspersion and diversity.

3. Grouse commonly ranged beyond 1.6 km (1 mile) of dancing grounds on the Skunk Coulee study site. If management concerns focus on habitat adjacent to dancing grounds, a minimum radius of 4.5 km should be considered.

4. Skunk Coulee Grazing Allotment was specifically chosen for this study because of its above-average grouse density relative to other CMRNWR allotments. Perhaps this is a result of juniper cover on SCGA. Moyles (1981) correlated number of displaying males to trembling aspen 
(Populus tremuloides) densities within 0.8 km of display sites. A study to correlate specific habitat attributes such as shrub coverage and number of displaying males may be useful for assessing sharptail habitat on a larger scale on CMRNWR.
LITERATURE CITED


Swanson, G. 1940. Food habits of the sharp-tailed grouse by analysis of droppings. J. Wildl. Manage. 4:432-436.


APPENDICES
APPENDIX A

TABLES
Table 13. Plant canopy coverage estimates in each habitat type by use of a Daubenmire frame (1959). Plant species with $\geq 1\%$ canopy coverage (C) were included in this table. F is percent frequency.

<table>
<thead>
<tr>
<th>Plant species</th>
<th>Sagebrush-grass cover type</th>
<th>Grass-sagebrush cover type</th>
<th>Greasewood-grass cover type</th>
<th>Greasewood-shale cover type</th>
<th>Sand cover type</th>
<th>Shale cover type</th>
<th>Grass-shale cover type</th>
<th>Juniper cover type</th>
<th>Pine cover type</th>
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<td>17/72</td>
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<td>T/5</td>
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<td>Puccinellia nuttalliana</td>
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<td>T/7</td>
<td>T/6</td>
<td>T/1</td>
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<tr>
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<td></td>
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<tr>
<td>Rosa woodsii</td>
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<tr>
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<td>1/10</td>
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<td>T/2</td>
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<tr>
<td>Vicia americana</td>
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<tr>
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</table>
Table 14. Shrub canopy coverage estimates in each habitat type by use of line intercept transects (Canfield 1941). Shrubs with ≥ 1% canopy coverage (C) were included in this table. Frequency (F) ranged from 0 (blank) to 10.

<table>
<thead>
<tr>
<th>Shrub species</th>
<th>Sagebrush-grass cover type</th>
<th>Grass-sagebrush cover type</th>
<th>Greasewood-grass cover type</th>
<th>Greasewood-shale cover type</th>
<th>Shale cover type</th>
<th>Grass-shale cover type</th>
<th>Juniper cover type</th>
<th>Pine cover type</th>
<th>Juniper-grass cover type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artemisia cana</td>
<td>C/F</td>
<td>C/F</td>
<td>C/F</td>
<td>C/F</td>
<td>C/F</td>
<td>C/F</td>
<td>C/F</td>
<td>C/F</td>
<td>C/F</td>
</tr>
<tr>
<td>A. frigida</td>
<td>1/9</td>
<td>T/8</td>
<td>1/8</td>
<td>T/5</td>
<td>T/1</td>
<td>T/1</td>
<td>1/1</td>
<td>T/3</td>
<td>T/2</td>
</tr>
<tr>
<td>A. tridentata</td>
<td>22/10</td>
<td>8/10</td>
<td>3/10</td>
<td>10/10</td>
<td>2/7</td>
<td>7/10</td>
<td>2/7</td>
<td>T/1</td>
<td>T/1</td>
</tr>
<tr>
<td>Atriplex numtallii</td>
<td>T/6</td>
<td>T/4</td>
<td>T/1</td>
<td>3/9</td>
<td>1/9</td>
<td>1/9</td>
<td>T/4</td>
<td>T/5</td>
<td>T/2</td>
</tr>
<tr>
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<td>T/1</td>
<td>T/3</td>
<td>T/2</td>
<td>1/8</td>
<td>1/9</td>
<td>1/9</td>
<td>T/6</td>
<td>T/2</td>
<td>T/2</td>
</tr>
<tr>
<td>Eriogonum sp.</td>
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<td>T/3</td>
<td>T/3</td>
<td>T/2</td>
<td>T/1</td>
<td>T/1</td>
<td>T/6</td>
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<td>T/1</td>
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<td>35/10</td>
<td>T/10</td>
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<tr>
<td>Juniperus sp.</td>
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<td>T/6</td>
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<td>T/1</td>
<td>30/10</td>
<td>16/10</td>
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<tr>
<td>Pinus ponderosa</td>
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<td>T/2</td>
<td>T/1</td>
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<td>1/6</td>
<td>1/10</td>
<td>T/2</td>
<td>1/6</td>
<td>T/1</td>
</tr>
<tr>
<td>Rhus trilobata</td>
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<td>T/1</td>
<td>1/5</td>
<td>1/6</td>
<td>1/10</td>
<td>T/2</td>
<td>T/4</td>
<td>T/1</td>
</tr>
<tr>
<td>Rosa sp.</td>
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<td>6/10</td>
<td>14/10</td>
<td>5/10</td>
<td>T/5</td>
<td>T/2</td>
<td>T/2</td>
<td>T/1</td>
<td>T/1</td>
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<tr>
<td>Sarcobatus vermiculatus</td>
<td>T/1</td>
<td>6/10</td>
<td>14/10</td>
<td>5/10</td>
<td>T/5</td>
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<td>T/2</td>
<td>T/1</td>
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</tr>
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</table>
Table 15. Results from height density pole measures within each habitat type. Height (Ht) ranges from 0 (no hit) to 36.

<table>
<thead>
<tr>
<th>Habitat type</th>
<th>Grass/forb</th>
<th>Shrub</th>
<th>Total</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Hit/100</td>
<td>Ht./100</td>
<td>Hit</td>
</tr>
<tr>
<td>Sagebrush-grass</td>
<td>17.3</td>
<td>30.3</td>
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<tr>
<td></td>
<td>40.5</td>
<td>165.0</td>
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<tr>
<td></td>
<td>57.8</td>
<td>195.3</td>
<td>3.4</td>
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<tr>
<td>Grass-sagebrush</td>
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<td>39.3</td>
<td>1.8</td>
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<tr>
<td></td>
<td>19.8</td>
<td>60.5</td>
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<tr>
<td></td>
<td>41.3</td>
<td>99.8</td>
<td>2.4</td>
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<td>15.3</td>
<td>2.0</td>
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<td></td>
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<td>591.5</td>
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<td>75.5</td>
<td>591.5</td>
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</tr>
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<td>Shale</td>
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<td>11.8</td>
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<td>Juniper</td>
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<td>45.3</td>
<td>233.8</td>
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a Hit/100 = the total number of hits/100 readings

b Ht./100 = the sum of the heights/100 readings
Table 16. Individual radioed grouse histories with date of capture and period of relocation during fall and winter.

<table>
<thead>
<tr>
<th>Grouse ID</th>
<th>Sex a</th>
<th>Display ground</th>
<th>Time of capture Season/Year</th>
<th>Number of relocations</th>
<th>Period of relocation</th>
<th>Fate</th>
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<tbody>
<tr>
<td>388</td>
<td>M</td>
<td>1</td>
<td>spring/1988</td>
<td>6</td>
<td>1/16/89-2/21/89</td>
<td>contact lost b</td>
</tr>
<tr>
<td>588</td>
<td>F</td>
<td>3</td>
<td>spring/1988</td>
<td>5</td>
<td>1/23/89-3/04/89</td>
<td>contact lost</td>
</tr>
<tr>
<td>788</td>
<td>F</td>
<td>3</td>
<td>spring/1988</td>
<td>3</td>
<td>1/21/89-3/05/89</td>
<td>radio failure</td>
</tr>
<tr>
<td>1288</td>
<td>F</td>
<td>1</td>
<td>spring/1988</td>
<td>20</td>
<td>3/04/89-10/28/89</td>
<td>predation</td>
</tr>
<tr>
<td>1688</td>
<td>F</td>
<td>1</td>
<td>spring/1988</td>
<td>6</td>
<td>1/27/89-3/07/89</td>
<td>contact lost</td>
</tr>
<tr>
<td>1788</td>
<td>F</td>
<td>2</td>
<td>spring/1988</td>
<td>12</td>
<td>1/26/89-10/14/89</td>
<td>radio failure</td>
</tr>
<tr>
<td>1888</td>
<td>M</td>
<td>2</td>
<td>spring/1988</td>
<td>7</td>
<td>1/15/89-3/06/89</td>
<td>contact lost</td>
</tr>
<tr>
<td>389</td>
<td>F</td>
<td>1</td>
<td>spring/1989</td>
<td>35</td>
<td>9/16/89-1/27/90</td>
<td>living c</td>
</tr>
<tr>
<td>1189</td>
<td>F</td>
<td>1</td>
<td>spring/1989</td>
<td>11</td>
<td>9/17/89-10/02/89</td>
<td>contact lost</td>
</tr>
<tr>
<td>1789</td>
<td>IM</td>
<td>2</td>
<td>fall/1989</td>
<td>32</td>
<td>10/28/89-1/27/90</td>
<td>living</td>
</tr>
<tr>
<td>1889</td>
<td>M</td>
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<td>fall/1989</td>
<td>12</td>
<td>10/28/89-11/20/89</td>
<td>predation</td>
</tr>
<tr>
<td>1989</td>
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<td>fall/1989</td>
<td>19</td>
<td>10/28/89-1/13/90</td>
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</tr>
<tr>
<td>2089</td>
<td>M</td>
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<td>20</td>
<td>10/30/89-1/27/89</td>
<td>living</td>
</tr>
</tbody>
</table>

a M = adult male; F = adult female; IM = young of the year male
b contact lost = possible predation or radio failure during or between field seasons
c living = grouse alive and radio working as of last relocation
APPENDIX B

FIGURES
Figure 11. Snow depths at Glasgow, MT, approximately 35 km north of the study area (NOAA 1988, 1989, 1990). The dotted line represents average transect snow depths on the study area during winter 1988-89.
Figure 12. Mean daily air temperatures and normal monthly means at Ft. Peck, MT, approximately 13 km, northeast of the study area (NOAA 1988, 1989, 1990).