



Nesting and brood rearing ecology of sharp-tailed grouse on the Charles M. Russell National Wildlife Refuge, Montana
by Patrick Tay Gunderson

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:

Spring and summer habitat use was studied for plains sharp-tailed grouse (*Tympanuchus phasianellus jamesi*) during 1988 and 1989. The study area spanned 104 km² in south Valley County, Montana. Thirty-four sharptails with transmitters were followed. Males used 5 display grounds, slightly raised from surrounding topography and interspersed with big sagebrush (*Artemisia tridentata*), from the start of field seasons in April, until early June. Twenty-seven nests were located over 2 years and used to characterize nesting habitat vegetatively and topographically. Most nests (63%) were located in junipers (*Juniperus* sp. Canopy height over nests averaged 47 cm, and screening cover height was near 18 cm. Hatching occurred in early to mid-June.

Success of nesting hens was high (65%), but predators destroyed nearly 30%. Four hens nested in both years, and another renested in 1989. Fidelity to nesting areas was shown by 2 hens. Due to weather and predation, no chicks were alive after 2 weeks in 1988. Adults centered summer home ranges around Juniper, Shale, and Lakeshore cover types. In 1989, 5 hens with broods were followed until late August. Vegetative measurements were recorded at 105 location sites and at random points within cover types used. Broods also tended to use areas within Juniper, Shale, and Lakeshore cover types, along with *Poa sandbergii*/*Sarcobatus vermiculatus*. Cover type use by broods differed between early, middle, and late summer in 1989. Brood habitat contained significantly more grass than at random points. Brood home ranges (433 ha) were larger than for adults without broods (274 ha). Two hens were followed during both summers. Hen 1788 used the same summer area in both years. Only 14 chicks were raised in 1989. Low overall production was caused by weather and predation. Lack of production in 1988 was evidenced by census and trapping data collected in 1989: numbers of displaying males was reduced 33% from 1988 to 1989 and most birds (88%) captured in 1989 were adults.

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APPROVAL

of a thesis submitted by

Patrick Tay Gunderson

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.

7/20/90

Date

Robert P. Eng

Chairperson, Graduate Committee

Approved for the Major Department

20 July 1990

Date

Robert S. Moore

Head, Major Department

Approved for the College of Graduate Studies

August 10, 1990

Date

Henry L. Parsons

Graduate Dean

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ABSTRACT

Spring and summer habitat use was studied for plains sharp-tailed grouse (Tympanuchus phasianellus jamesi) during 1988 and 1989. The study area spanned 104 km² in south Valley County, Montana. Thirty-four sharptails with transmitters were followed. Males used 5 display grounds, slightly raised from surrounding topography and interspersed with big sagebrush (Artemisia tridentata), from the start of field seasons in April, until early June. Twenty-seven nests were located over 2 years and used to characterize nesting habitat vegetatively and topographically. Most nests (63%) were located in junipers (Juniperus sp.). Canopy height over nests averaged 47 cm, and screening cover height was near 18 cm. Hatching occurred in early to mid-June. Success of nesting hens was high (65%), but predators destroyed nearly 30%. Four hens nested in both years, and another renested in 1989. Fidelity to nesting areas was shown by 2 hens. Due to weather and predation, no chicks were alive after 2 weeks in 1988. Adults centered summer home ranges around Juniper, Shale, and Lakeshore cover types. In 1989, 5 hens with broods were followed until late August. Vegetative measurements were recorded at 105 location sites and at random points within cover types used. Broods also tended to use areas within Juniper, Shale, and Lakeshore cover types, along with Poa sandbergii/Sarcobatus vermiculatus. Cover type use by broods differed between early, middle, and late summer in 1989. Brood habitat contained significantly more grass than at random points. Brood home ranges (433 ha) were larger than for adults without broods (274 ha). Two hens were followed during both summers. Hen 1788 used the same summer area in both years. Only 14 chicks were raised in 1989. Low overall production was caused by weather and predation. Lack of production in 1988 was evidenced by census and trapping data collected in 1989: numbers of displaying males was reduced 33% from 1988 to 1989 and most birds (88%) captured in 1989 were adults.

INTRODUCTION

The plains sharp-tailed grouse (Tympanuchus phasianellus jamesi) is 1 of 6 subspecies of sharptails. Its range formerly encompassed an area from Kansas and Oklahoma to Alberta and Saskatchewan, but now extends only as far south as Nebraska (Johnsgard 1983) (Fig. 1). The plains subspecies is considered to be relatively secure across its range and is hunted in several states and provinces.

In Montana, plains sharp-tailed grouse occur throughout the eastern and central portions of the state. Sharptails inhabit areas from sagebrush plains into mountain foothills.

In 1936, under Executive Order 7509, Franklin D. Roosevelt set aside what is now the Charles M. Russell National Wildlife Refuge (CMRNR). One of the primary purposes was:

"...for the conservation and development of natural wildlife resources and for the protection and improvement of public grazing lands and natural forage resources...natural forage resources therein shall be first utilized for the purpose of sustaining in a healthy condition a maximum of 400,000 sharp-tailed grouse and 1,500 antelope, the primary species and such nonpredatory secondary species in such numbers as may be necessary to maintain a balanced wildlife population..."

In 1976, the nearly 450,000 hectare CMRNR was placed under jurisdiction of the U. S. Fish and Wildlife Service (USFWS) for wildlife management purposes. One of the primary wildlife objectives was to improve and maintain sharp-tailed grouse habitat and habitat for associated species in good to excellent condition, supporting 30

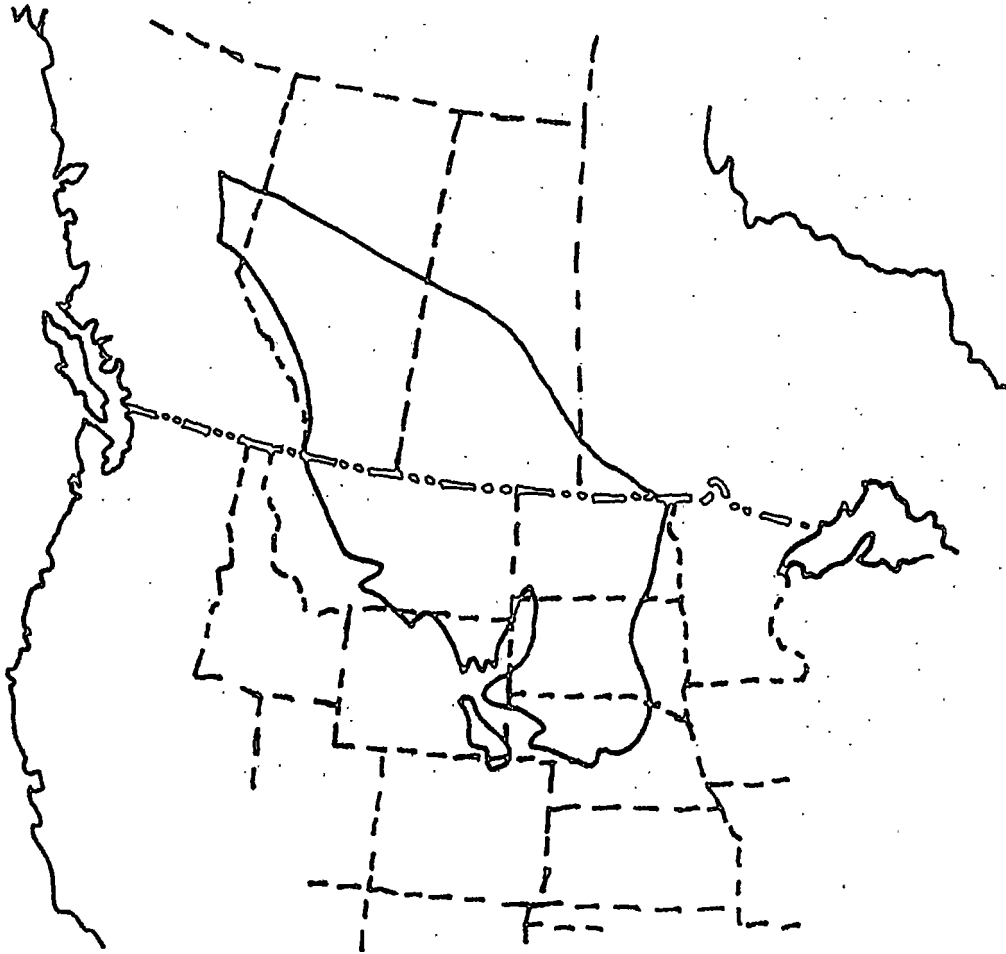


Figure 1. Distribution of the plains sharp-tailed grouse in North America (Johnsgard 1983).

spring breeding birds/2.6 km² when weather, predation life cycles, or other natural factors permit (USDI 1985).

In 1988, a study was initiated to document year round habitat use of sharptails on the refuge. My portion of the study dealt exclusively with the spring and summer periods. Specific objectives were to determine: (1) chronology of the display, pre-incubation, incubation, hatching, and brood rearing periods, (2) nest and brood rearing success and, (3) displaying, nesting, brood rearing, and seasonal habitats. Fieldwork was conducted from 1 April to 7 September 1988 and 4 April through 21 August 1989.

STUDY AREA

The study area, the Skunk Coulee Grazing Allotment, is located in Valley County in northeastern Montana, approximately 16 km southwest of the town of Fort Peck. This 104 km² area (Fig. 2) is comprised of federal (CMRNWR, Bureau of Land Management), state, and private land (Table 1).

Table 1. Land ownership of Skunk Coulee Grazing Allotment study area in northeastern Montana.

Owner	Hectares	Percent
CMRNWR	7,740	81.5
BLM	1,045	11.0
State	520	5.5
Private	195	2.0
Total	9,490	100.0

The northern and eastern borders of the study area abut Fort Peck Lake, a large reservoir formed behind Fort Peck Dam on the Missouri River. The eastern three-fourths of the area is dominated by a series of 4 moderate to steep ridges and adjoining coulees that extend from west to east to the reservoir. The greatest relief occurs here, rising from 3,600 m (reservoir full pool level) to 4,296 m above sea level. The remaining area, which extends over 6 km from the reservoir, is flat to gently rolling. Although ephemeral, the South Fork of Duck Creek dominates this portion.

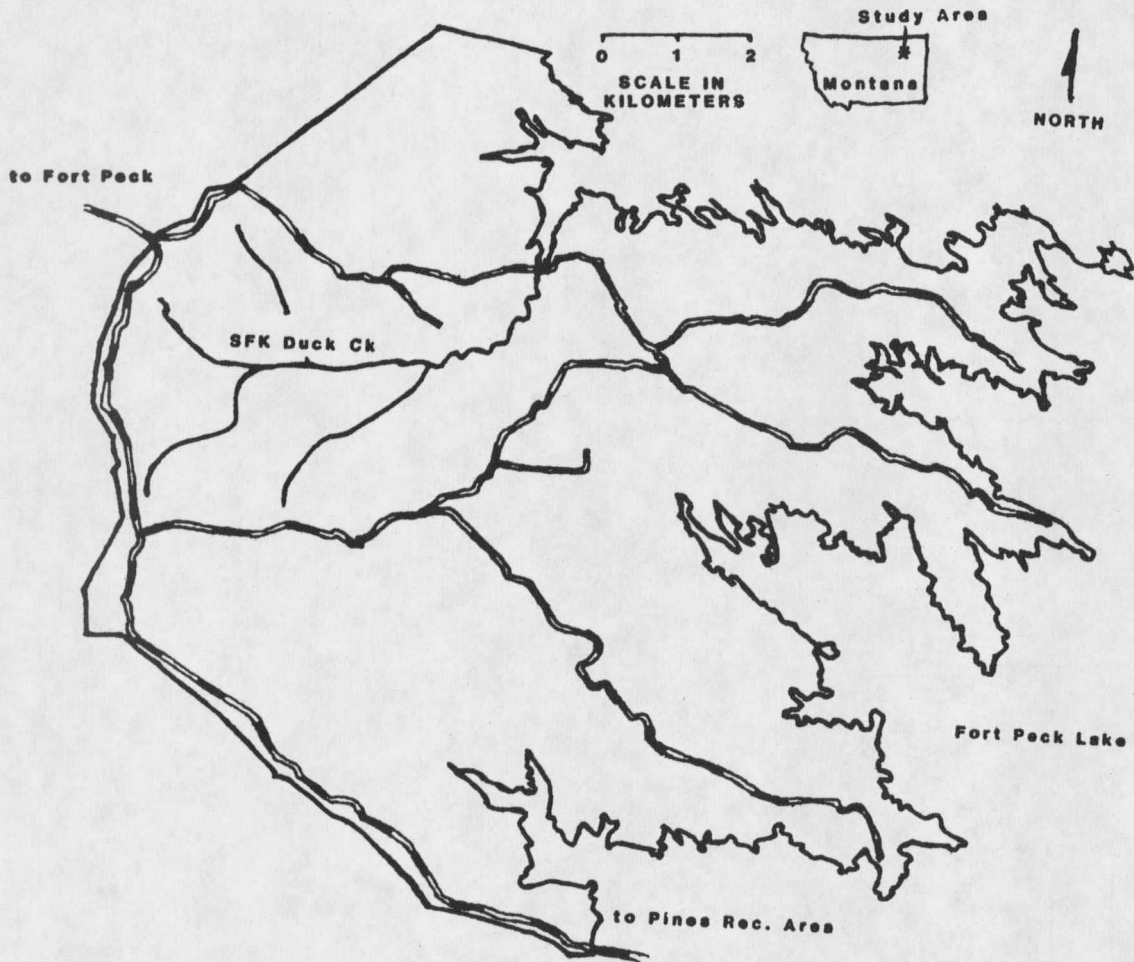


Figure 2. Location of the Skunk Coulee Grazing Allotment study area in south Valley County, Montana.

The Bearpaw Shale formation underlies the area. Clayey shale was deposited during the growth of a large inland sea in the Cretaceous Period (Veseth and Montagne 1980). Montmorillite is the predominant clay mineral. Soils of the Lisam and Dilts series are associated with these Bearpaw Shale uplands (Bingham et al. 1984). Due to the impermeability of these soils, runoff and erosion are high. These soils are extremely sticky when wet, hard when dry, and have a high salt content making them poorly suited for agriculture.

Typical of northeastern Montana, the Skunk Coulee study area experiences harsh winters and summers. Large temperature and precipitation fluctuations occur seasonally and annually. Summer months are characterized by sudden, sporadic afternoon and evening thunderstorms. Despite the capricious nature of these storms, precipitation totals probably more closely parallel those at Fort Peck than Glasgow due to the influence of the reservoir. Mean annual precipitation at Fort Peck is 29 cm, over 72% of which occurs from April through August (Table 2). As with precipitation, temperatures at Fort Peck are probably comparable to those on the study area (Table 3). With a mean of 22.1 C, July is the hottest month and January, at -11.4 C, is the coldest. High winds are common during spring and summer, occasionally persisting for days. Frost free period extends for 120 days and ice usually forms on the reservoir by December and disappears by May.

While Valley County was experiencing an extended drought during the study, large variations occurred in both precipitation and temperature between years. Temperatures in 1988, especially in June,

greatly exceeded those in 1989 (Appendix Fig. 12). Mean temperature in June 1988 was 6.6 C higher than normal. Precipitation totals were over 4 cm below normal in 1988. Weather conditions were considered normal in 1989 although precipitation totals were over 2 cm below the 30-year/long term mean.

Table 2. Monthly precipitation totals (cm) and departures from normal during April-August 1988 and 1989 for weather stations near Skunk Coulee study area in northeastern Montana.^a

Station	Year	<u>April</u>		<u>May</u>		<u>June</u>		<u>July</u>		<u>August</u>	
		Ppt.	Dep.	Ppt.	Dep.	Ppt.	Dep.	Ppt.	Dep.	Ppt.	Dep.
Fort Peck	1988	1.52	-0.86	3.56	-1.45	5.03	-0.99	5.18	+1.19	1.60	-2.13
	1989	6.12	+3.73	6.05	+1.04	3.23	-2.79	2.11	-1.88	2.82	-0.91
Glasgow	1988	0.84	-1.37	3.38	-1.09	3.91	-2.36	3.25	-0.94	1.19	-2.44
	1989	4.11	+1.91	5.31	+0.84	2.41	-3.86	2.41	-1.78	3.76	+0.13

^a Data from the National Oceanic and Atmospheric Administration 1988 and 1989.

Table 3. Mean monthly temperatures (C) and departures from normal during April-August 1988 and 1989 for weather stations near Skunk Coulee study area in northeastern Montana.^a

Station	Year	<u>April</u>		<u>May</u>		<u>June</u>		<u>July</u>		<u>August</u>	
		Temp	Dep.	Temp	Dep.	Temp	Dep.	Temp	Dep.	Temp	Dep.
Fort Peck	1988	9.1	+2.5	16.6	+3.4	25.0	+6.6	22.3	+0.2	21.7	+0.5
	1989	6.6	+0.2	13.9	+0.7	18.6	+0.2	24.4	+2.3	21.4	+0.2
Glasgow	1988	8.3	+2.5	16.9	+4.3	24.9	+7.5	23.1	+1.8	21.4	+1.0
	1989	6.4	+0.6	13.0	+0.4	17.7	+0.3	23.9	+2.6	21.2	+0.8

^a Data from the National Oceanic and Atmospheric Administration 1988 and 1989.

Vegetation on the Skunk Coulee study area is characteristic of the short grass prairie. Big sagebrush (*Artemisia tridentata*) and juniper (*Juniperus* sp.), predominantly Rocky Mountain juniper

(Juniperus scopulorum), are dominant shrubs. Rubber rabbitbrush (Chrysothamnus nauseosus), broom snakeweed (Gutierrezia sarothrae), and eriogonum (Eriogonum sp.) are associated with the flat and rolling areas. Skunkbush sumac (Rhus trilobata) and western snowberry (Symphoricarpos occidentalis) are found along the drainages near Fort Peck Lake. Black greasewood (Sarcobatus vermiculatus) occurs in more alkaline areas. Western wheatgrass (Agropyron smithii) dominates the grass component. Green needlegrass (Stipa viridula), prairie junegrass (Koeleria cristata), and Sandberg bluegrass (Poa sandbergii) are other important grasses. Common forbs include American vetch (Vicia americana), yellow sweet clover (Melilotus officinalis), phlox (Phlox sp.), and bastard toadflax (Comandra umbellata). Sedges (Carex sp.) are commonly found in association with junipers and ponderosa pine (Pinus ponderosa) stands in the southern portion of the study area.

In 1986, 9,300 people lived in Valley County (USDOC 1988); approximately 4,500 in Glasgow. Crop and livestock production dominates the local economy. The Skunk Coulee study area has probably been used for livestock grazing since the influx of cattle to the northern plains in the 1880's. Currently, approximately 160 cattle (1,200 AUM's) are grazed from mid April to late November (D. A. Mackie, unpubl. rep., CMRNWR files, Lewistown, MT, 1989). Excluding one small alfalfa field in the southwestern corner of the area, the closest cultivated land is > 8 km away. Access to the study area is good on one all weather county road. Once on the area, the slightest amounts of precipitation make over 40 km of "gumbo" roads impassable.

Because the county road leads to the Pines Recreation Area, traffic on it is relatively high. However, the study area itself receives very little recreational use except during the fall hunting season.

METHODS

Census

Mornings in early April were spent locating grounds by listening for lekking males from roads and then walking into more remote areas. Dancing males were clearly audible on still mornings up to 1.6 km from grounds. Listening stops were made 0.4 to 0.8 km apart to be sure of complete coverage.

Sharp-tailed grouse were censused in 1988 and 1989, by counting numbers of males on dancing grounds during April and early May. In 1990, grounds were censused on 20-21 April. These counts provided insight to population trends when compared between years and to counts made by refuge personnel since 1975.

Trapping and Marking

Trapping was conducted throughout April and early May. Due to accessibility, time, and cock numbers, 3 dancing grounds were used for trapping in 1988 and 2 in 1989 (Fig. 3). The majority of trapping occurred on 2 grounds (Appendix Table 27). Their proximity accommodated trapping on both grounds simultaneously.

Forty-six sharp-tailed grouse were trapped in 1988 (n=28) and 1989 (n=18) with walk-in funnel traps attached to wings constructed of chicken wire (Toepfer et al. 1988a). All were captured during the

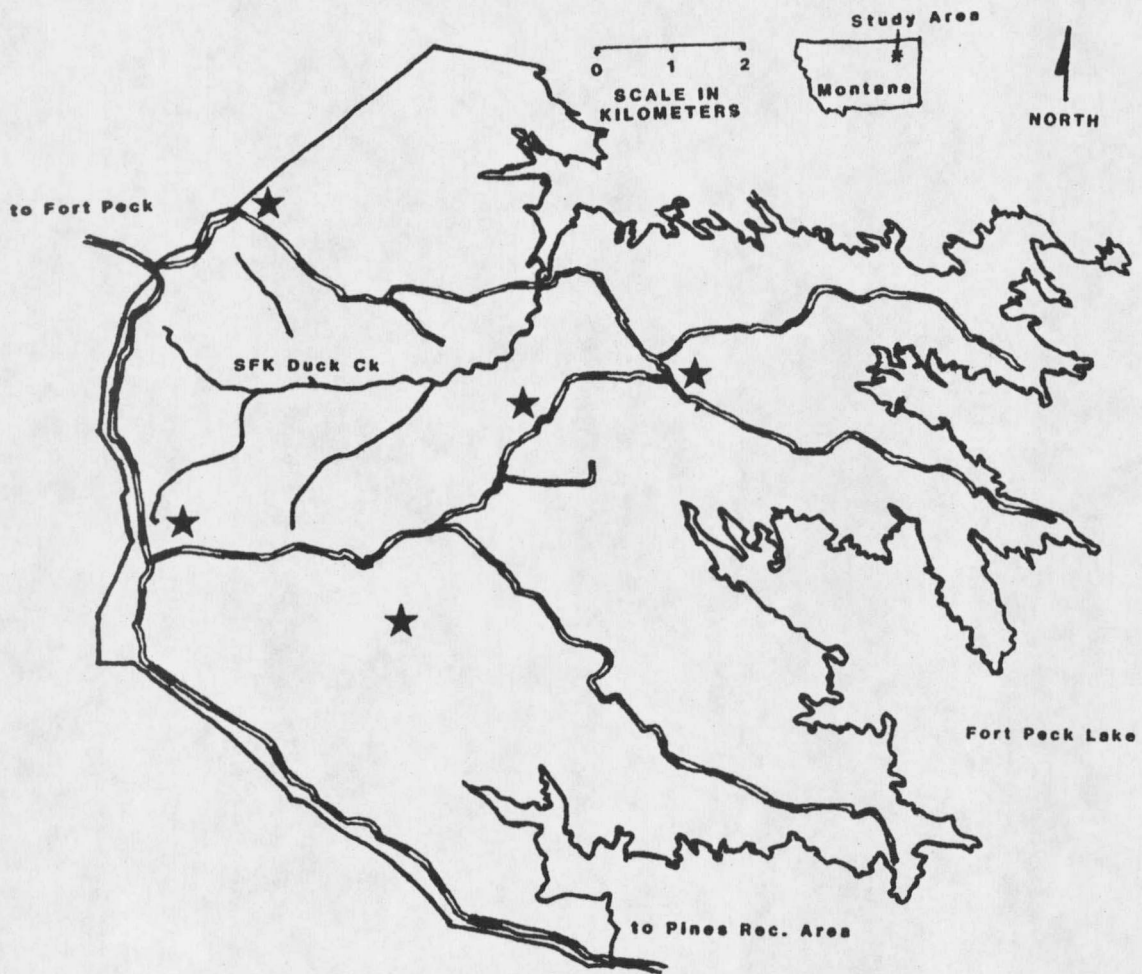


Figure 3. Location of sharp-tailed grouse display grounds on the Skunk Coulee study area, Montana. Stars denote display grounds.

morning display period, with the exception of 1 female captured in the evening. Traps were placed across the dancing grounds to intercept hens as they moved among the cocks and were baited with wheat and barley to help coax birds inside. Only 1 bird, which suffered a dislocated wing joint in the trap, was lost.

Captured birds were weighed with an electronic digital scale (Cole-Parmer Instrument Company, Chicago, IL), aged by outer primary wear (Ammann 1944), and sexed by examination of crown feathers (Henderson et al. 1967) and central retrices. Each was fitted with a unique combination of 3 colored and 1 aluminum leg bands. Thirty-one birds were equipped with bib mounted radio transmitters (Amstrup 1980). P2A and P2B solar powered transmitters weighing 15-22 g were used (AVM Instrument Co. Ltd., Livermore, CA). Transmitters were entirely covered by feathers except for 5 rows of solar panels and could store enough power to function for up to 4 days without recharging. Birds were released on the display ground from which they were trapped. Trap data and fates of trapped birds are presented in Appendix Table 28.

Radio Tracking

Radio-tagged birds were located by circling at close range or flushing them while using an AVM receiver attached to an H antenna. Accuracy was within 10 m. Although the road system prevented close range triangulation, some locations were collected with a roof mounted antenna (Wildlife Materials Inc., Carbondale, IL). Female movements were followed from the time of trapping until the end of field seasons

each year. Males were monitored to document the end of spring display and occasional summer "use" sites.

Cover Type Descriptions

During 1989, 11 cover types were delineated by gross vegetational differences and quantitatively described. Types were delineated on aerial photos and later refined by ground truthing. Up to 10 transects, 100 m long were established and measured in stands determined to be representative of each type. Percent shrub canopy coverage was measured by the line intercept method (Canfield 1941); total vegetation and bare ground coverage was measured within a 2 x 5 dm frame (Daubenmire 1959) placed every 10 m. Height-density pole (HDP) readings (CMRNWR Habitat Monitoring, unpubl.) were also recorded every 10 m and pooled for each transect. HDP readings are identical to vertical obstruction readings described by Robel et al. (1970) except that readings are expressed in 2.54 cm gradations. Resulting HDP measurements included the number of hits per 100 readings, or the number of times a portion of the pole was obstructed, by grass (GHI), shrub (SHI), and the total (THI). The height that grass and shrub obstructed the pole in 100 readings and their total (GHT, SHT, and THT, respectively) were also measured. Individual cover type contributions to the total area were measured using a Measurionics System I Linear Measuring set (video image analyzer). Plant nomenclature follows Hitchcock and Cronquist (1973) and Dorn (1984).

Photo-plots

Fourteen permanent photo-plots were established in 1989 throughout the study area. Photo-plots were taken of vegetation in front of a 1 m² piece of pegboard held upright (J. E. Toepfer, unpubl. data). Photographs were taken as 35-mm slides from 3 m at 1 m in height. Slides were taken every 2 weeks to record plant growth with respect to the timing of nest initiation and brood movements. The pegboard, with 0.6 cm holes every 2.5 cm permitted quantification of the horizontal screening cover at each plot.

Photo-plot slides were analyzed for 3 vegetation measurements. Ten equally spaced columns of dots in each photo were used to record total height of plant life (HT), height of effective coverage (EHT), or where the vegetation screened the board totally, and the dominant vegetation class. These 10 columns were then averaged for a HT and EHT reading from the plot. Vegetation classes included, grass, grass/forb, forb, grass/shrub, forb/shrub and shrub.

Nest Site Characteristics

Nests were located by monitoring radio-tagged hens. Birds which remained stationary for over 1 day were assumed to be incubating or dead. Each hen was flushed early in its incubation period. One 5-m transect, centered on the nest site, was set up in each of the 4 cardinal directions. Ten photo-plots were taken at each nest site. Two plots were located at the nest, while 4 each were taken at 1 m and 5 m from the nest. Clutch size, egg length, and egg width were also collected. Screening cover of vegetation was measured at each nest

bowl by an HDP reading. Using this entire procedure, nests were disturbed for less than 20 minutes.

Following measurements, females were monitored until the fate of the nest was determined. Thereafter, more in-depth measurements of each nest site were taken. Transects, 25 m in length, were set up in each of the 4 cardinal directions. Photo-plots and HDP readings identical to earlier nest site measurements were taken. Analysis of nest photo-plots was identical to permanent photo-plots. In addition, HDP readings were taken at 1 m intervals to 5 m to document nest site cover characteristics, and every 5 m to 25 m to describe the general area around the nest in terms of grass, shrub, and total hits (GHI, SHI, and THI, respectively) and height (GHT, SHT, and THT, respectively) per 100 height-density poles.

Canopy coverage of shrubs was measured along the transects using the line intercept method. Point-centered quarter measurements (Cottam and Curtis 1956) were also taken at the center of the nest and at 10 m in the 4 directions to record relative shrub density of the surrounding area. Nest canopy species was recorded along with crown heights and areas. Other measurements recorded for each site included: slope, aspect, aspect of the nest in relation to the canopy species, cover type, distance to the dancing ground on which the bird was caught (home dancing ground), distance to the nearest dancing ground, and distance to the nearest known nest. Locations of each nest were marked on United States Geological Survey (USGS) topographical maps and Universal Transverse Mercator system (UTM) coordinates recorded. In 1989, measurements of potential nests sites near actual

nests were taken to determine if any selection was occurring within the cover types used. Measurements included: percent shrub canopy coverage, shrub density, HDP nest bowl readings, slope, aspect, canopy species, and canopy height.

Cover types used for nesting were compared to cover type availability within 1.6 km of each dancing ground. Pepper (1972) found no nests over 1.6 km from a dancing ground. Several studies have determined that year round sharptail use is largely within 1.6 km of the dancing ground (Pepper 1972, Nielson and Yde 1982).

Success

Both nest success and nesting success were evaluated. Nests were successful if at least 1 egg hatched. Nest success was determined by dividing successful nests (SN) by the total number of nests found (TNF). This figure was adjusted by adding a destroyed initial nest (IN) that was not found ($SN/(TNF+IN)$). Nesting success was determined by dividing the number of successful hens (SH) by the total number of hens that nested (THN).

"Use" Site Characteristics

Microhabitat

"Use" sites were determined by relocating radioed females after hatch or nest destruction. Locations were determined by circling and occasionally flushing birds although flushing was not implemented until broods were approximately 3 weeks old. Sites were marked and within 1 week of marking, 4 transects, as at nest sites, were

stretched at each of these "use" sites. Shrub density and percent shrub canopy coverage were recorded. HDP readings were taken at the center of the "use" site and once every 5 m to 25 m. These readings were pooled to quantify the vegetation structure around the location and analyzed in a similar way to that used for the cover types and general nesting areas. Additional information recorded for each site included: location, date, time, cover type, and distance to nearest edge, home dancing ground, nest, nearest road, and last location.

In 1989, random points in 3 cover types were measured similar to "use" sites for comparison of microsite vegetation characteristics between random and actual locations. Microhabitat selection analysis was determined for locations in cover types in which random points were measured.

Macrohabitat

Macrohabitat characteristics and use relationships were first addressed by measuring the amount (%) of each cover type that occurred inside the perimeter of all locations for each individual bird. This was similar to Johnson's (1980) second order selection. I then determined the percent of locations in each cover type; i.e., Johnson's (1980) third order selection. Field evaluations of habitat use relative to availability can give indications of requirements, but are not definitive in differentiating between preferences and requirements (Peek et al. 1982). Therefore, use of cover types was considered more meaningful than attempting to prove selection for or against certain cover types.

Home Ranges

Home ranges were analyzed using the computer program TELDAY (Lonner and Burkhalter 1986). Home ranges were calculated using minimum convex polygons (Mohr 1947) for the pre-incubation, brood rearing, and overall spring and summer periods, among brood and non-brood hens.

Statistical Analysis

Statistical analysis followed Snedecor and Cochran (1980), using MSUSTAT (Lund 1987). Normal nest site and microsite characteristics were statistically analyzed with 2-tailed t, paired-t, and chi-square tests. Mann-Whitney U and Kruskal-Wallis tests were used for non-parametric nest and microsite data. Brood microsite data were tested by cover type with a Kruskal-Wallis test for differences between brood periods. If differences appeared, microsite data were tested against random points by individual brood period; those characteristics similar between brood periods were pooled for microsite comparisons.

RESULTS

Habitat Characteristics

Eleven cover types characterized by dominant vegetation and topography occurred on the study area (Table 4). Based on similarities, 9 types were grouped into 3 vegetation communities: conifer, grassland, and greasewood. Two were individually unique and are discussed separately.

Table 4. Total hectares and percent of total area contributed by 11 individual cover types on Skunk Coulee study area.

Cover type ^a	Hectares	Percent
Junip	3,175	30.5
Shale	1,685	16.2
Pipo	1,230	11.8
Agsm/Artr	1,220	11.7
Lakeshore	1,060	10.2
Agsm/Shale	925	8.9
Artr/Agsm	435	4.2
Junip/Agsm	255	2.5
Save/Shale	205	2.0
Posa/Save	165	1.6
Save/Artr	50	0.5
Total	10,405	100.1

^a Full name of cover type acronyms given in Appendix Table 29.

Conifer Community

Three cover types were dominated by conifers: Juniperus (Junip), Juniperus/Agropyron smithii (Junip/Agsm), and Pinus ponderosa (Pipo). Junip was found in the eastern portion on steeper shale slopes and

along drainages. It forms a border around the Pipo type. Juniper is the dominant shrub; while big sagebrush and skunkbush sumac are common. Individual juniper plants vary greatly in size, and some patches covered over 1000 m². Western wheatgrass is the only grass that occurs in abundance, although blue grama (Bouteloua gracilis) and green needlegrass can also be found throughout the type. Little bluestem (Andropogon scoparius) and prairie sandreed (Calamovilfa longifolia) occur in dense localized stands. Representative forbs include American vetch and yellow sweet clover. Sedges are quite abundant in all conifer types.

Junip/Agsm covers the transition zone from grassland to Junip. Topography is gentler than that associated with Junip and junipers are less abundant. However, overall species diversity is greater. Western wheatgrass and prairie junegrass are more abundant and bare ground is less prevalent than in either Junip or Pipo (Table 5). Forbs are similar to the Junip type, but bastard toadflax is also characteristic.

Pipo occurs largely along Fort Peck Lake in the southeastern portion of the area. The outer edges are characterized by a zone of transition to the juniper dominated type. Where ponderosa pine dominates, nearly full canopy coverage occurs. The herbaceous layer is again dominated by sedges, yellow sweet clover, American vetch and western wheatgrass.

Table 5. Mean percent canopy coverage (C) and percent frequency of occurrence (F) of plant taxa with coverage $\geq 1\%$ of cover types comprising the conifer community.

Cover type ^a	Junip C/F	Junip/Agsm C/F	Pipo C/F
<u>Shrubs</u>			
<u>Artemisia tridentata</u>	2/70	16/100	T/20
<u>Artemisia cana</u>	1/10	T/30	-
<u>Juniperus</u> sp.	35/100	16/100	30/100
<u>Pinus ponderosa</u>	-	-	29/100
<u>Rhus trilobata</u>	1/100	1/60	T/20
<u>Grasses</u>			
<u>Agropyron smithii</u>	5/31	16/51	3/9
<u>Bouteloua gracilis</u>	1/2	2/6	T/1
<u>Calamovilfa longifolia</u>	1/8	T/4	1/6
<u>Koeleria cristata</u>	T/4	5/26	T/1
<u>Andropogon scoparius</u>	2/8	2/7	-
<u>Stipa viridula</u>	1/10	T/1	-
<u>Forbs</u>			
<u>Carex</u> sp.	13/59	13/37	9/31
<u>Comandra umbellata</u>	T/2	2/20	-
<u>Melilotus officinalis</u>	2/19	8/34	9/10
<u>Vicia americana</u>	2/17	2/18	3/10
<u>Bare ground</u>	34/77	24/80	48/48

^a Full name of cover type acronyms given in Appendix Table 29.

Grassland Community

Grasslands occur on relatively gentle slopes throughout the area. The Agropyron smithii/Shale (Agsm/Shale) type is found in the western portion of the area where western wheatgrass, green needlegrass, and prairie junegrass are characteristic grasses. Forbs include yellow sweet clover, American vetch, bastard toadflax and summer cypress (Kochia scoparia). As in all 3 grassland cover types, big sagebrush is the dominant shrub (Table 6). Additional shrubs include prairie rose (Rosa arkansana), rubber rabbitbrush, and broom snakeweed.

Vegetation occurs predominately along drainage bottoms and sides, with ridgetops characterized by bare shale.

Table 6. Mean percent canopy coverage (C) and percent frequency of occurrence (F) of plant taxa with coverage $\geq 1\%$ of cover types comprising the grassland community.

Cover type ^a	Agsm/Shale C/F	Agsm/Artr C/F	Artr/Agsm C/F
<u>Shrubs</u>			
<u>Artemisia tridentata</u>	7/100	8/100	22/100
<u>Artemisia frigida</u>	T/30	T/80	1/90
<u>Chrysothamnus nauseosus</u>	1/90	T/30	T/10
<u>Rhus trilobata</u>	1/60	T/20	T/10
<u>Rosa arkansana</u>	1/60	-	-
<u>Grasses</u>			
<u>Agropyron smithii</u>	12/59	17/72	29/88
<u>Bouteloua gracilis</u>	-	5/25	4/18
<u>Koeleria cristata</u>	2/10	8/40	-
<u>Poa sandbergii</u>	T/11	T/3	2/14
<u>Stipa viridula</u>	5/20	5/25	4/18
<u>Forbs</u>			
<u>Allium</u> sp.	1/21	-	1/35
<u>Lepidium</u> sp.	T/4	T/17	2/37
<u>Comandra umbellata</u>	2/31	2/18	T/4
<u>Kochia scoparia</u>	2/16	-	-
<u>Lomatium</u> sp.	1/20	1/21	T/7
<u>Melilotus officinalis</u>	4/39	-	2/10
<u>Opuntia polyacantha</u>	T/3	T/6	1/11
<u>Phlox</u> sp.	1/10	1/23	T/2
<u>Vicia americana</u>	3/20	4/37	2/29
<u>Bare ground</u>	52/99	25/92	23/89

^a Full name of cover type acronyms given in Appendix Table 29.

Agropyron smithii/Artemisia tridentata (Agsm/Artr) and Artemisia tridentata/Agropyron smithii (Artr/Agsm) are found on ridgetops surrounded by the Junip type and also adjacent to the Agsm/Shale type. These types are differentiated by density of big sagebrush and forb composition. Artr/Agsm is characterized by a denser big sagebrush

canopy than Agsm/Artr. Characteristic forbs include American vetch, wild onion (Allium sp.), yellow sweet clover, plains prickly pear (Opuntia polyacantha), and prairie pepperweed (Lepidium sp.).

Agsm/Artr also includes American vetch, but other important forbs are bastard toadflax, biscuitroot (Lomatium sp.), and phlox. Bare ground is more prevalent in Agsm/Shale than in either of the other 2 associated types.

Greasewood Community

Three types are dominated by black greasewood: Sarcobatus vermiculatus/Artemisia tridentata (Save/Artr), Poa sandbergii/Sarcobatus vermiculatus (Posa/Save), and Sarcobatus vermiculatus/Shale (Save/Shale). All 3 are dominated by black greasewood, but are distinguished by associated vegetation (Table 7). These types cover very little of the study area. The Save/Artr type is associated with the flood plain of South Fork of Duck Creek and its major tributaries. These areas have deep soils and are considered a saline lowland range site. Although characterized by black greasewood and big sagebrush, Nuttall's saltbush (Atriplex nuttalli) and silver sagebrush (Artemisia cana) also occur in some abundance. The herbaceous layer is poorly developed. Western wheatgrass, Sandberg bluegrass, plains prickly pear, and summer cypress are sparsely scattered throughout.

Posa/Save occurs in flat, broad drainages. Black greasewood is less abundant in this type than in the 2 associated types, but the total shrub community is more diverse. Broom snakeweed, big sagebrush, and fringed sagewort (Artemisia frigida) are conspicuous.

Table 7. Mean percent canopy coverage (C) and percent frequency of occurrence (F) of plant taxa with coverage $\geq 1\%$ of cover types comprising the greasewood community.

Cover type ^a	Save/Artr C/F	Posa/Save C/F	Save/Shale C/F
<u>Shrubs</u>			
<u>Artemisia cana</u>	1/60	-	-
<u>Artemisia frigida</u>	T/50	1/80	-
<u>Artemisia tridentata</u>	10/100	3/100	-
<u>Atriplex nuttallii</u>	3/90	T/10	-
<u>Gutierrezia sarothrae</u>	T/30	1/80	-
<u>Sarcobatus vermiculatus</u>	14/100	6/100	12/100
<u>Grasses</u>			
<u>Agropyron smithii</u>	3/20	10/64	-
<u>Bouteloua gracilis</u>	-	7/18	-
<u>Distichlis stricta</u>	-	3/50	-
<u>Koeleria cristata</u>	T/2	3/13	-
<u>Poa sandbergii</u>	2/25	7/41	-
<u>Puccinellia nuttalliana</u>	-	3/50	-
<u>Forbs</u>			
<u>Allium</u> sp.	T/13	2/37	-
<u>Ambrosia</u> sp.	-	1/16	-
<u>Astragalus missouriensis</u>	-	2/9	-
<u>Kochia scoparia</u>	3/28	-	27/52
<u>Melilotus officinalis</u>	T/4	1/16	-
<u>Opuntia polyacantha</u>	1/7	T/5	-
<u>Bare ground</u>	59/97	49/98	60/58

^a Full name of cover type acronyms given in Appendix Table 29.

Grasses comprise much more of the total coverage than in either Save/Artr or Save/Shale. Sandberg bluegrass, western wheatgrass, blue grama, prairie junegrass, inland saltgrass (Distichlis stricta), and Nuttallii alkali grass (Puccinellia nuttalliana) occur. Forbs also contribute more in this type with wild onion, yellow sweet clover, ragweed (Ambrosia sp.), and Missouri milkvetch (Astragalus missouriensis) being dominant species. Bare ground is less prevalent as compared to other greasewood community types.

Save/Shale, located in the extreme northern portion of SCGA, is a very desolate cover type. Only black greasewood and summer cypress occur in any amount. Grass did not occur in any of the transects and bare ground exceeded 60%.

Lakeshore and Shale Cover Types

Availability of the Lakeshore type varies with fluctuating lake levels as it is located between the high water mark and existing water levels. During 1989, this type accounted for 10.1% of the total area (Table 4). Due to the unpredictable, periodic flooding of these areas, shrubs are lacking (Table 8). Grass and forb cover can be very dense with broad stands of foxtail barley (Hordeum jubatum) and yellow sweet clover. Other important forbs include cocklebur (Xanthium strumarium), dock (Rumex sp.), and Canadian thistle (Cirsium arvense).

The Shale cover type occurs in the zone between the high water mark and the Junip type. Steep, bare shale slopes dominate the area, with the tops of ridges generally devoid of vegetation except in flatter, more stable areas. Bare ground is dominant (63%) in canopy coverage. Where it occurs, vegetation is a mixture of other cover types, nearly all of which exist in selected areas within the Shale type. This diversity is clearly evident when the vegetation is addressed. No one species dominates, although western wheatgrass was most evident in the grass segment. More species appear in measurable abundance than in any other type.

Table 8. Mean percent canopy coverage (C) and percent frequency of occurrence (F) of plant taxa with coverage $\geq 1\%$ in Shale and Lakeshore cover types.

Cover type ^a	Shale C/F	Lakeshore C/F
<u>Shrubs</u>		
<u>Artemisia tridentata</u>	2/70	-
<u>Chrysothamnus nauseosus</u>	1/90	-
<u>Eriogonum</u> sp.	1/70	-
<u>Juniperus</u> sp.	2/30	-
<u>Rhus trilobata</u>	2/80	-
<u>Rosa arkansana</u>	1/50	-
<u>Grasses</u>		
<u>Agropyron canium</u>	-	5/11
<u>Agropyron smithii</u>	7/38	3/9
<u>Hordeum jubatum</u>	-	41/49
<u>Puccinellia nuttalliana</u>	2/7	T/1
<u>Stipa viridula</u>	3/10	-
<u>Forbs</u>		
<u>Astragalus missouriensis</u>	-	1/1
<u>Carex</u> sp.	1/8	-
<u>Cirsium arvense</u>	-	9/12
<u>Kochia scoparia</u>	6/28	-
<u>Melilotus officinalis</u>	3/23	29/32
<u>Rumex</u> sp.	-	8/12
<u>Thermopsis rhombifolia</u>	3/21	-
<u>Xanthium strumarium</u>	-	3/9
<u>Bare ground</u>	63/97	35/22

^a Full name of cover type acronyms given in Appendix Table 29.

Height-density pole (HDP) readings provided a measure of relative screening cover between cover types (Table 9). They were also indicative of the dominant lifeform in each type. Junip and Lakeshore cover types have the highest number of total hits (THI) and total height (THT). The Lakeshore cover type, dominated by grass cover, had the highest number of grass hits (GHI) and grass height (GHT), and no shrub cover. The Junip type, dominated by junipers and other shrubs, had the highest number of shrub hits (SHI) and shrub height (SHT).

Save/Shale has less total vegetation than any cover type, as evidenced by GHT and THT measurements.

Table 9. Vegetation screening cover characteristics of cover types determined by the height-density pole (GHI, SHI, THI = number of times grass, shrub, and the total vegetation, respectively, obstructed the pole/100 readings taken. GHT, SHT, THT = height in which grass, shrub, and the total vegetation, respectively, obstructed the pole/100 readings taken).

Cover type ^a	GHI	GHT	GHT/ GHI	SHI	SHT	SHT/ SHI	THI	THT	THT/ THI
Junip	13	83	6	45	1,291	29	58	1,372	24
Junip/Agsm	16	62	4	29	532	18	45	594	13
Agsm/Artr	22	100	5	20	154	8	41	253	6
Artr/Agsm	17	77	5	41	419	10	58	496	9
Posa/Save	8	39	5	15	171	11	23	210	9
Save/Artr	2	11	6	29	274	9	31	285	9
Agsm/Shale	9	39	4	19	124	3	71	163	6
Shale	6	30	5	17	173	10	23	203	9
Save/Shale	0	0	-	11	150	14	11	150	14
Lakeshore	76	1,502	20	0	0	-	76	1,502	20
Pipo	7	46	7	35	626	18	42	672	16

^a Full name of cover type acronyms given in Appendix Table 29.

Permanent Photo-plots

At first measurement, in early May, total plant height (HT) and effective plant height (EHT) were at 29 and 14%, respectively, of the 15 August maximum readings (Fig. 4). The period of greatest growth was 1 May-15 June. Vegetation HT and EHT increased 58 and 72%, respectively, during this period.

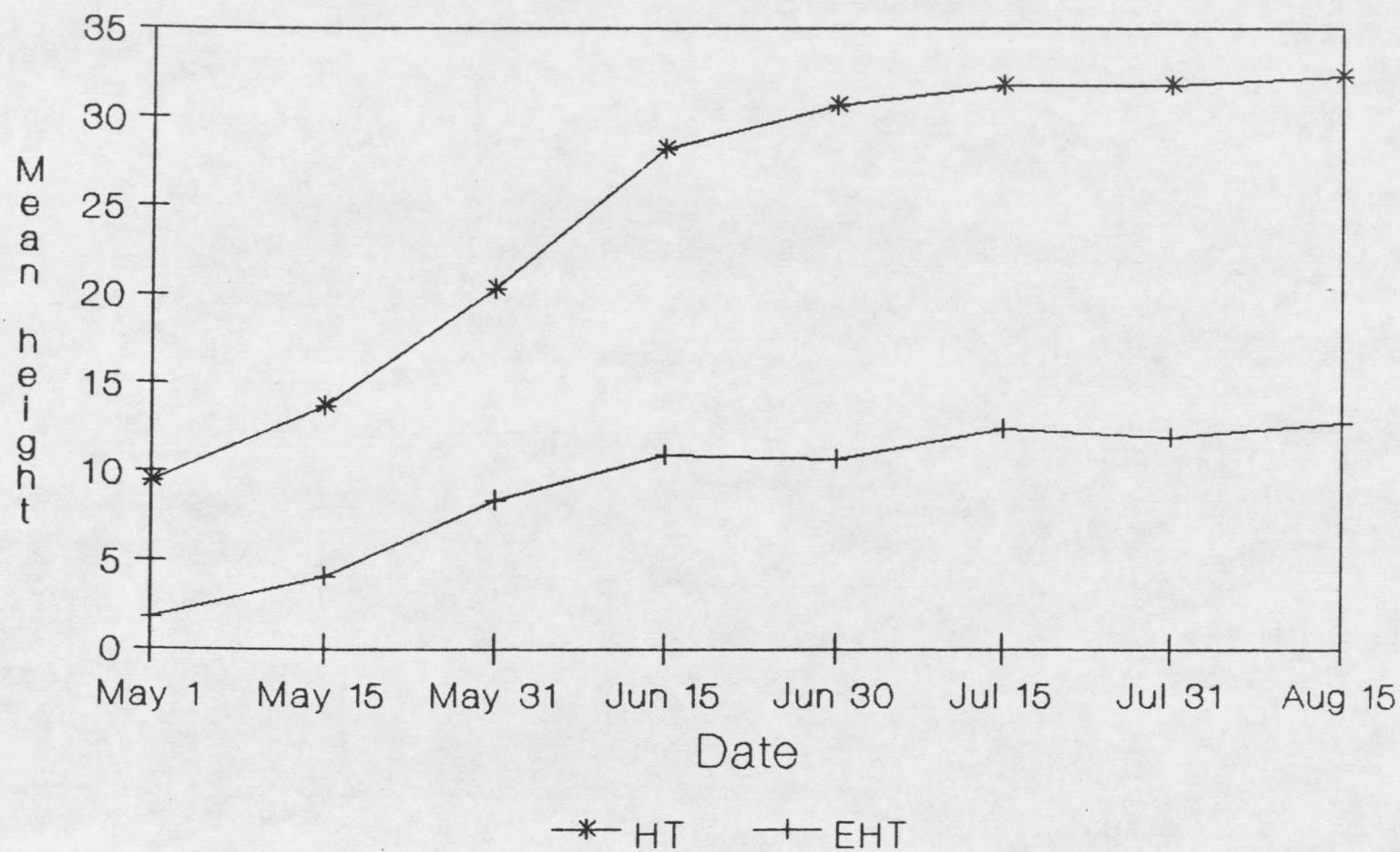


Figure 4. Measurements at permanent photo-plots, of grass and forb height (HT) and effective height (EHT) in centimeters, during 1989 on the Skunk Coulee study area, Montana.

Census

Historically, 3 display grounds were known to exist on Skunk Coulee study area (CMRNWR files, Lewistown, MT). Table 10 shows counts of these grounds, made by refuge personnel since 1975. One of the 3 was abandoned in 1986. Three additional grounds were found during my study, although one may be the result of a 1.2 km shift by the birds from the ground vacated in 1986. The grounds, spaced 2.1-4.2 km apart, were all located on small ridges or knolls elevated slightly above surrounding terrain. Vegetation is relatively sparse, although big sagebrush was scattered throughout each ground. The 5 active grounds were located an average 0.5 km from the nearest road.

Display ground counts indicated a one-third reduction of total numbers between 1988 and 1989 and again between 1989 and 1990. The reductions were quite uniform among the 5 grounds.

Table 10. Sharp-tailed grouse dancing ground counts from the Skunk Coulee study area between 1975-1990^a.

Dancing ground	Year															
	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
ST-1	-	-	37	-	-	-	-	-	16	28	9	17	39	34	21	18
ST-2	28	36	48	-	-	-	23	22	30	24	4	5	21	34	20	15
ST-3	-	-	-	-	-	-	-	-	-	-	-	-	-	21	12	9
ST-4	-	-	-	-	-	-	-	-	-	-	-	-	-	22	13	6
ST-4 ^b	16	17	18	-	19	-	10	6	9	15	4	0	0	0	0	0
ST-5	-	-	-	-	-	-	-	-	-	-	-	-	-	11	6	4
Total	44	53	103	-	19	-	33	28	55	67	17	22	60	122	72	52

^a Data from 1975-1987 obtained from CMRNWR files, Lewistown, Montana.

^b Indicates dancing ground no longer present and probably shifted to new ground with same number.

Trapping and Marking

The earliest a bird was caught was 9 April, the latest was 4 May; both were females. In 1988, 65% of the females were captured between 20-26 April; in 1989, 83% of the females were captured from 18-23 April. There was a marked difference in the age ratios between the 2 years ($p=0.005$, $X^2=7.79$, $df=1$) (Table 11). Adults dominated in 1989 (88%), while juveniles prevailed in 1988 (57%).

Table 11. Age ratios from birds trapped on 3 dancing grounds during 1988 and 1989 on Skunk Coulee study area in northeastern Montana.

Sex	1988		1989	
	Adult	Juvenile	Adult	Juvenile
Male	6	5	5	0
Female	6	11	10	2
Total	12	16	15	2

Trapping success was 0.82 birds/trap day over the 2 years. Twenty-seven of the 31 grouse that were fitted with radio transmitters were females. Only 2 birds were recaptured during the study. An adult male was recaptured a few days after being marked in 1988 and a juvenile female caught in 1988 was recaptured on the same ground in 1989.

Mean weights by sex and age are reported in Appendix Table 30. Males ($\bar{x}=857$ gms, $SD=51$, $n=16$) weighed significantly more than females ($\bar{x}=781$ gms, $SD=43$, $n=27$) ($p=0.000$, $t=5.26$, $df=41$).

Spring Movements

Home Range

Seven hens were intensively followed during the pre-incubation period in 1989. Shortly after being trapped, hens moved to and eventually nested within small areas that averaged 39 ha ($SD=0.31$). Hens trapped in 1988 were arbitrarily considered to be in the pre-incubation phase after 15 April.

Mortality

In 1988, no radioed hens died during the pre-incubation period. Sixteen of the 17 incubated clutches, while radio contact was lost with the other. In 1989, 11 new hens were radioed and 4 hens remained from 1988. Four of the 15 (26.7%) were killed during pre-incubation. Three of the losses were attributed to avian predation, 1 was undetermined.

Nesting

Twenty-five initial nests and 2 renests were located (Table 12). Sixteen were nests of adults and 11 were juveniles. One adult and 1 juvenile renested. Four initial nests found in 1989 were by hens whose nests had also been located in 1988.

Chronology

Peak nest initiation occurred between 1-10 May in both 1988 and 1989. These peaks were determined by backdating from known start of incubation and/or hatching dates. Hatching peaked in 1988 during 6-12

June and 11-17 June 1989. The 2 renests were only 5-10 days later in all phases of nesting from most initial nests. One renesting hen began incubating her second nest on 27-28 May; hatching occurred on 21-22 June.

Table 12. Summary data from nesting sharp-tailed grouse during 1988 and 1989 on Skunk Coulee study area in northeastern Montana.

	1988	1989	Total
Initial nests located	16	9	25
Renests located	0	2	2
Adult nests located	6	10	16
Juvenile nests located	10	1	11
Successful nests	10	7	17
No. nests destroyed by predators	4	4	8
No. nests destroyed by heat	1	0	1
No. nests abandoned	1	0	1
Total nests located	16	11	27

Distribution of Nests

Nests were found 0.6-4.8 km from home dancing grounds, with 67% within 1.6 km of the hens home dancing ground. Adult hens nested an average of 1.6 km (SD=0.8) from home grounds, juveniles averaged 1.9 km (SD=1.6) ($p=0.670$). Nests of hens in 1988 averaged 1.9 km (SD=1.4) from home dancing grounds, while in 1989 they averaged 1.4 km (SD=0.6) ($p=1.00$). Eight of 27 hens (29.6%) nested closer to dancing grounds other than their own. Overall, nests averaged 1.3 km (SD=0.8) from the nearest dancing ground.

Fidelity to one nesting area was somewhat evident for 3 of 4 hens monitored during 1988 and 1989. These 4 hens had nests located 0.2, 0.3, 0.7, and 2.4 km apart between years. One hens initial nest and reneest were 0.5 km apart. Nests averaged 0.9 km (SD=0.6) from roads,

with the closest being 40 m. Slightly less than 150 m separated the 2 closest nests of marked hens.

Nesting hens used 4 different cover types, including: 19 in Junip, 4 in Artr/Agsm, 3 in Agsm/Shale, and 1 in Agsm/Artr. Figures 5 and 6 show nest locations in relation to cover type availability within 1.6 km of the dancing grounds. Junip appeared to be selected (used more than expected based on availability) (Table 13), but small sample sizes precluded statistical analysis. Nests were placed in the Junip cover type by 3 of 4 birds nesting both years. The fourth nested in the Artr/Agsm cover type in 1988 and Junip in 1989. One initially nested in Agsm/Shale and renested in Artr/Agsm.

Table 13. Percentage of nests in and availability of cover types within 1.6 km of 3 dancing grounds on Skunk Coulee study area in northeastern Montana.

Cover type ^b	Dancing ground 1		Dancing ground 2		Dancing ground 3	
	Nests ^a n=15	Avail.	Nests n=7	Avail.	Nests n=5	Avail.
Junip	66.7	48.6	85.7	65.3	60.0	16.9
Artr/Agsm	13.3	18.5	0.0	1.4	40.0	6.9
Agsm/Shale	20.0	21.5	0.0	0.2	0.0	17.3
Agsm/Artr	0.0	0.2	14.3	18.2	0.0	46.5
Other ^b	0.0	11.2	0.0	16.5	0.0	12.4

^a Includes all nests of hens captured on specific ground.

^b Full name of cover type acronyms given in Appendix Table 29.

^c Includes Junip/Agsm, Lakeshore, Pose/Save, Save/Artr, and Shale.

Clutch Size and Hatchability

Three hundred and fifty-seven eggs were laid in 27 nests in 1988 and 1989. Average clutch size was 13.2 (SD=1.5). Mean clutch size in

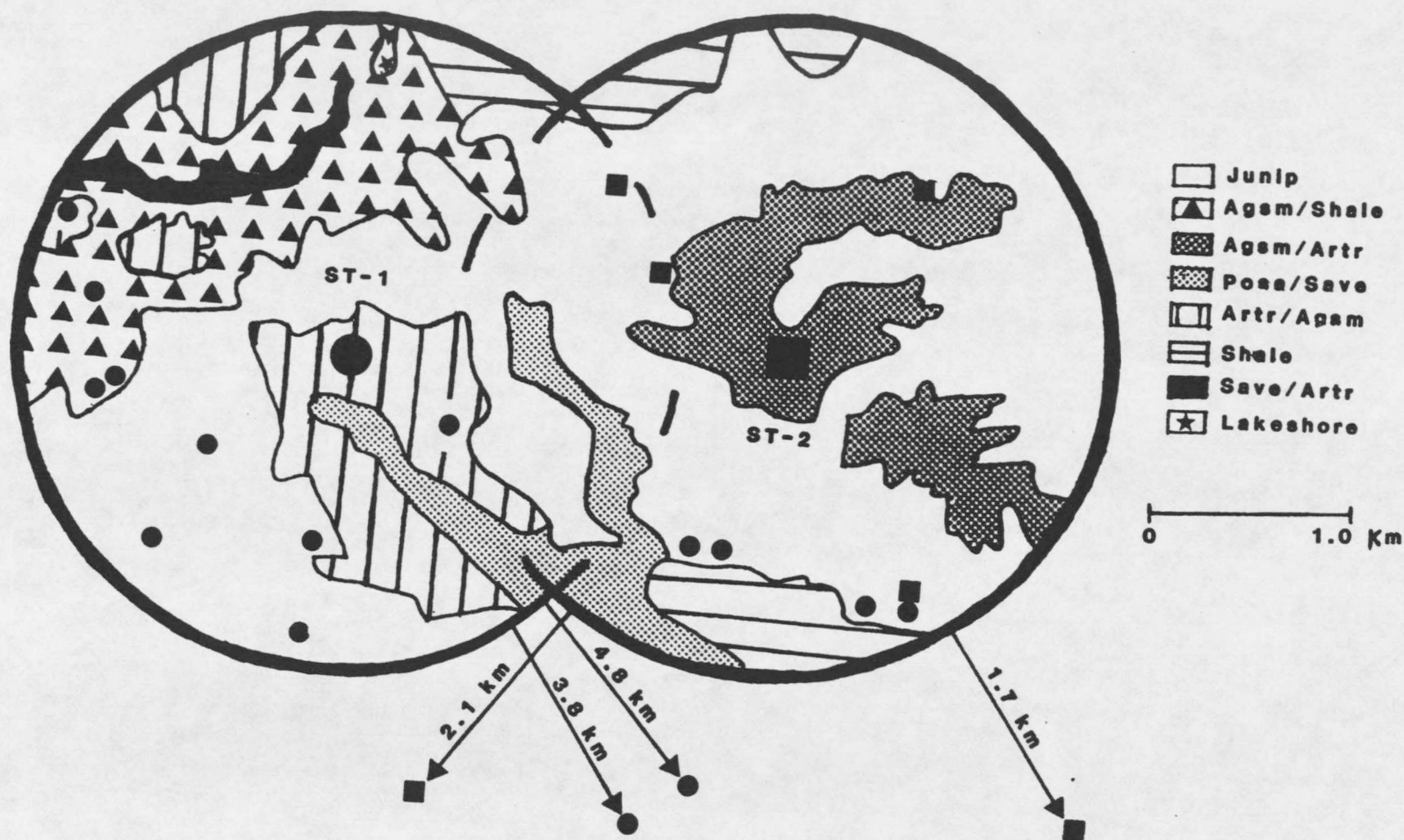


Figure 5. Nest site locations of sharp-tailed grouse related to cover types within a 1.6 km radius of display grounds ST-1 and ST-2 during 1988 and 1989 on the Skunk Coulee study area, Montana. Small circles and squares denote nest sites of hens captured on ST-1 and ST-2, respectively.

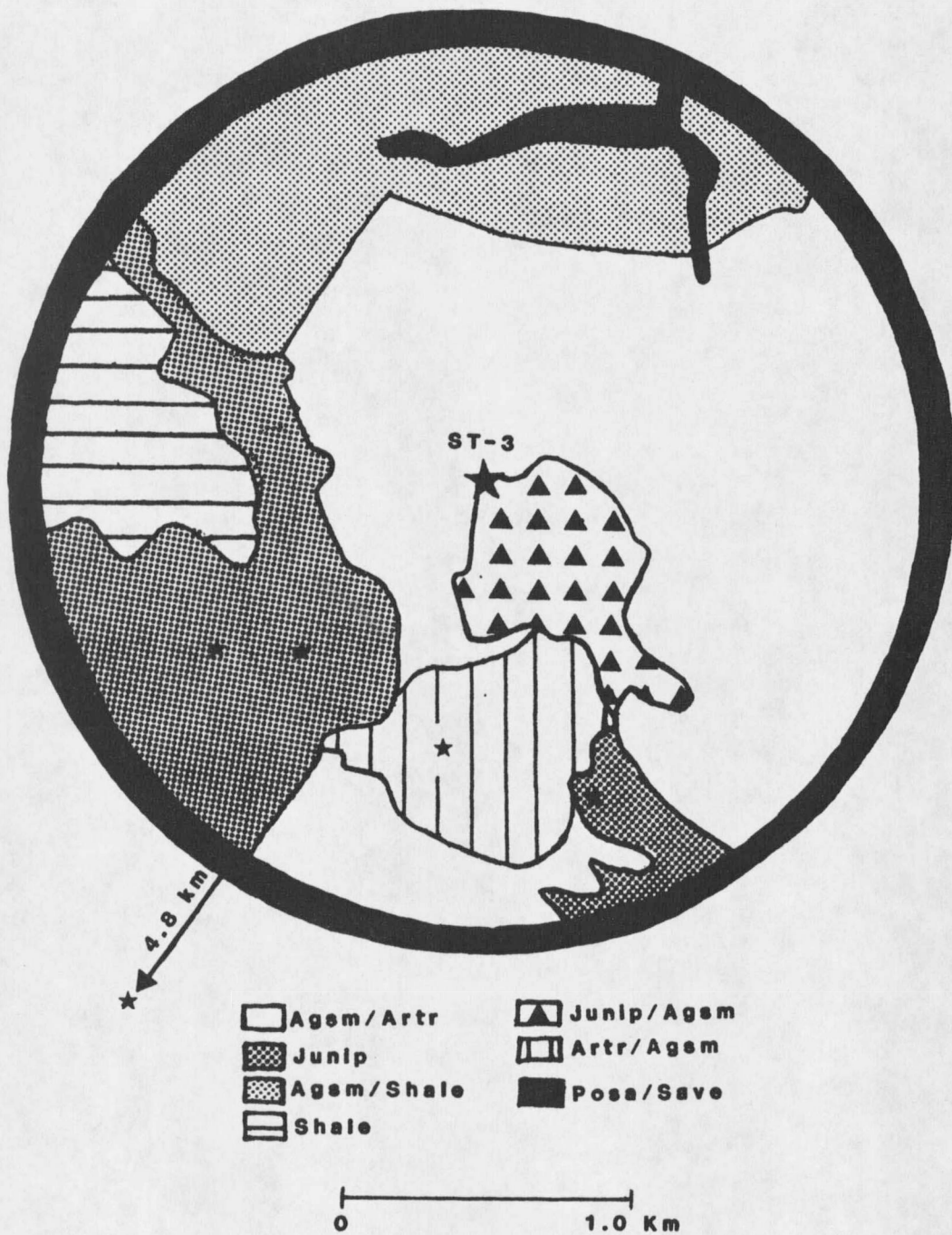


Figure 6. Nest site locations of sharp-tailed grouse related to cover types within a 1.6 km radius of display ground ST-3 during 1988 and 1989 on the Skunk Coulee study area, Montana. Small stars denote nest sites.

1989 ($\bar{x}$ =13.7, SD=1.1) was slightly larger than in 1988 ($\bar{x}$ =12.9, SD=1.7) (p =0.217). Mean clutch size for adults (13.7, SD=1.1) was larger than for juveniles (12.5, SD=2.0) (p =0.132). The largest clutches were 15 (n =6) which included nests of adults (n =4) and juveniles (n =2). A juvenile laid the smallest clutch, 9. Eggs measured 42.5 cm (SD=1.3, n =166) by 31.8 cm (SD=0.7, n =166).

For 18 nests surviving through incubation, 163 of 184 (88.6%) eggs hatched. The 21 eggs not hatching, included a clutch of 12 nearly full term embryos that died a few days before hatching in 1988. In addition, 10 chicks were unsuccessful in exiting the shell and 2 were found dead near nests.

Success

Nesting adults had higher nest success rates (SN/TNF and SN/TNF+IN) than juveniles (p =0.118, p =0.074, respectively) (Table 14). There were differences between years in SN/TNF and SN/TNF+IN (p =0.952, p =0.823, respectively).

Differences in nesting success rates (SH/THN) between adults and juveniles were nearly significant (p =0.067). Nesting success was similar between years (p =.6957).

Predation destroyed 8 of 27 nests (29.6%). The incubating hen was killed in 5 of these nests. Avian (n =1), mammalian (n =2), and unknown (n =2) predators were responsible for the hens death. In addition, 1 hen abandoned her nest and 1 incubated her clutch for over 35 days, but the embryos had died earlier, within 1 week of hatching.

Table 14. Percent success of nests and nesting for sharp-tailed grouse on the Skunk Coulee study area in northeastern Montana.

	Nest success		Nesting success
	SN/TNF ^a	SN/TNF+IN ^b	SH/THN ^c
Adults	75.0	75.0	80.0
Juveniles	45.5	41.7	45.5
1988	62.5	62.5	62.5
1989	63.6	58.3	70.0
Total	63.0	60.7	65.4

^a Successfully hatched nests/total number of nests found.

^b Successfully hatched nests/total number of nests found +initial nests of renesters that were not found.

^c Hens successful in hatching a clutch/total number of hens that nested.

Nest Site Vegetation

Hens nested under vegetation that provided dense cover.

Seventeen nests (63.0%) were found under junipers, generally (65%) under low lying boughs on the periphery of the plant (n=11). Other nests were found under big sagebrush (n=5), silver buffaloberry (*Sheperdia argentea*) (n=1), common snowberry (n=1), and in residual and new growth grasses (n=3). Nearly all of the nests (92.6%) had grass intermixed with the nest canopy shrub.

Three of 4 hens with 2 years nest data, placed nests under different dominant canopies between years: from big sagebrush to juniper, grass to juniper, and juniper to grass, respectively. The fourth nested under junipers both years. The hen renesting in 1989 moved from a juniper canopy to big sagebrush.

Height of nest canopy plants averaged 47 cm (SD=20, n=24). Nest canopies of juniper and silver buffaloberry ($\bar{x}$ =51, SD=22, n=18) were

significantly taller than big sagebrush, common snowberry, and grass canopies ($\bar{x}=34$, $SD=4$, $n=7$) ($p=0.007$). Juniper canopy heights were similar between nests sites and random sites ($p=.7591$). Comparisons of all actual and random nest site characteristics are summarized in Table 15.

Table 15. Nest site characteristics of sharp-tailed grouse from actual and random sites on Skunk Coulee study area in northeastern Montana.

Nest site characteristic	Actual nest sites			Random nest sites			p-value
	N	$\bar{x}$	SD	N	$\bar{x}$	SD	
Slope (%)	27	8.8	5.8	24	11.3	5.1	0.044*
% shrub canopy	27	27.7	11.7	26	25.8	12.1	0.544
Canopy height (cm)							
Juniper	17	50.2	22.2	23	47.7	27.0	0.759
Big sage	4	34.0	5.4	4	21.0	7.0	0.020*
Shrubs/ha	24	338.3	185.2	29	598.1	553.1	0.908
HDP ^a							
Nest	27	16.5	7.1	30	13.2	8.4	0.105
1 m	26	11.7	6.6	30	8.9	7.4	0.161
2 m	26	8.1	4.3	30	7.6	6.4	0.723
3 m	26	7.1	5.6	30	6.1	5.1	0.481
4 m	26	7.1	7.4	30	5.1	4.3	0.200
5 m	26	6.6	5.8	30	4.6	3.8	0.128

* Indicates a significant difference between actual and random ($p < 0.05$, Mann-Whitney U).

^a Height-density pole readings measuring vegetation screening height (cm).

Height-density measurements taken at the nest bowl during and after incubation were similar, with vegetation screening height averaging 17 and 18 cm respectively ($p=0.491$). Thus the before and after measurements were pooled for further comparisons (Appendix Table 31). Vegetation height was greater at nest sites with juniper canopies than those without this canopy ($p=0.049$). Height of

vegetation at the nest increased from 1988 to 1989 ($p=0.034$).

Additionally, height was only slightly higher at nests of adults than at juvenile nests ($p=0.452$), and at unsuccessful nests as compared with successful ($p=0.390$).

Average HDP readings at the nest bowl were higher than those 1-5 m from the nest ($p < 0.01$, Mann-Whitney U). No significant differences were found in nest HDP readings between actual ($\bar{x}=17.4$, $SD=8.1$) and random nest sites ($\bar{x}=13.2$, $SD=8.4$) ($p=0.058$). Only 2 cover types, Junip and Artr/Agsm, had enough nests present to document grass and shrub screening influence. Differences between types were evident, but each was similar to its own cover type description. Nest sites in both types were strongly influenced by shrubs, but the Junip type provided more shrub height.

Photo-plots taken at nest sites during incubation differed in vegetation height (HT) and effective height (EHT) from those taken after incubation (Table 16). In 1988, HT and EHT were higher during incubation than after ($p=0.096$, $p=0.446$, respectively); the opposite was true in 1989 ($p=0.017$, $p=0.031$, respectively).

Nest vegetation EHT was larger in 1989 than in 1988, both during incubation and after ($p=0.013$, $p=0.000$, respectively). Nest HT during incubation was similar between years ($p=0.778$), but differed after incubation ($p=0.010$). Successful and unsuccessful nests were similar during and after incubation in HT ($p=0.643$, $p=0.975$, respectively), and EHT ($p=0.575$, $p=0.980$, respectively) of vegetation. Nests of adults were similar to juveniles in HT readings during and after

incubation ($p=0.581$, $p=0.310$, respectively), but EHT readings were different ($p=0.043$, $p=0.038$, respectively).

Table 16. Height (HT) and effective height (EHT) of vegetation from sharp-tailed grouse nest sites in northeastern Montana as determined by photo-plots.

	N	HT (cm)				EHT (cm)			
		<u>During^a</u>		<u>After^b</u>		<u>During</u>		<u>After</u>	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
1988	15	39 ^c	13	34 ^c	9	16 ^e	6	15 ^e	5
1989	10	40 ^c	12	47 ^d	14	21 ^f	4	26 ^g	8
Adult	15	41 ^h	14	41 ^h	14	20 ⁱ	6	22 ⁱ	9
Juvenile	10	38 ^h	11	36 ^h	9	15 ^j	5	15 ^j	4
Successful	17	40 ^k	14	39 ^k	15	19 ^l	6	20 ^l	9
Unsuccessful	8	38 ^k	9	39 ^k	7	17 ^l	5	20 ^l	6

^a Photo-plots taken during the incubation period.

^b Photo-plots taken after the incubation period.

^c Different letters within sections indicate significant differences between means ($p < 0.05$, Mann-Whitney U).

Photo-plots taken early in incubation were relatively representative of vegetative structure during nest initiation and were therefore used in comparing photo-plots at the nest with those 1 and 5 m away (Table 17). In both years, significant differences were found in HT of nest vegetation when compared to that at 1 m ($p=0.031$, $p=0.002$, respectively) and 5 m ($p=0.001$, $p=0.002$, respectively). Significant differences were also found in EHT in both years when comparing nest photo-plots to those at 1 m ($p=0.006$, $p=0.002$, respectively), and at 5 m ($p=0.000$, $p=0.000$, respectively). Vegetation decreased in both HT and EHT as one moved away from the nest.

Table 17. Comparison of height (HT) and effective height (EHT) of vegetation between nest photo-plots and to those at 1 and 5 m from the nest during incubation in northeastern Montana.

	N	Nest		1 m		5 m	
		<u>HT(cm)</u> <u>$\bar{x}$(SD)</u>	<u>EHT(cm)</u> <u>$\bar{x}$(SD)</u>	<u>HT(cm)</u> <u>$\bar{x}$(SD)</u>	<u>EHT(cm)</u> <u>$\bar{x}$(SD)</u>	<u>HT(cm)</u> <u>$\bar{x}$(SD)</u>	<u>EHT(cm)</u> <u>$\bar{x}$(SD)</u>
1988	15	39(13)	16(6)	31(7)	11(4)	25(11)	6(4)
1989	10	40(12)	21(4)	24(7)	13(6)	21(7)	9(4)

The dominant vegetation category at nest sites was determined from photo-plots (Fig. 7). Grass was more abundant at sites away from the nest, but provided limited screening cover. Shrubs were more dominant around nests and declined in abundance at 1 and 5 m.

Shrub canopy characteristics in a 1/4 ha area around nests are summarized in Appendix Table 32. Canopy coverage of shrubs was similar between actual nest sites and random sites ($p=0.743$). Juniper, big sagebrush, and skunkbush sumac contributed 66.4%, 20.1%, and 7.4% respectively of the total shrub canopy coverage around all nests. Ten shrubs contributed the remaining 6.1%, some of which proved very important around individual nests. Juniper provided the most shrub cover around 19 nests. Big sagebrush ($n=7$) and silver buffaloberry ($n=1$) were the dominant shrubs around the other nests. Shrub canopy coverage around nests in the Junip type was higher than around nests in Artr/Agsm and Agsm/Artr, but less than at nests in

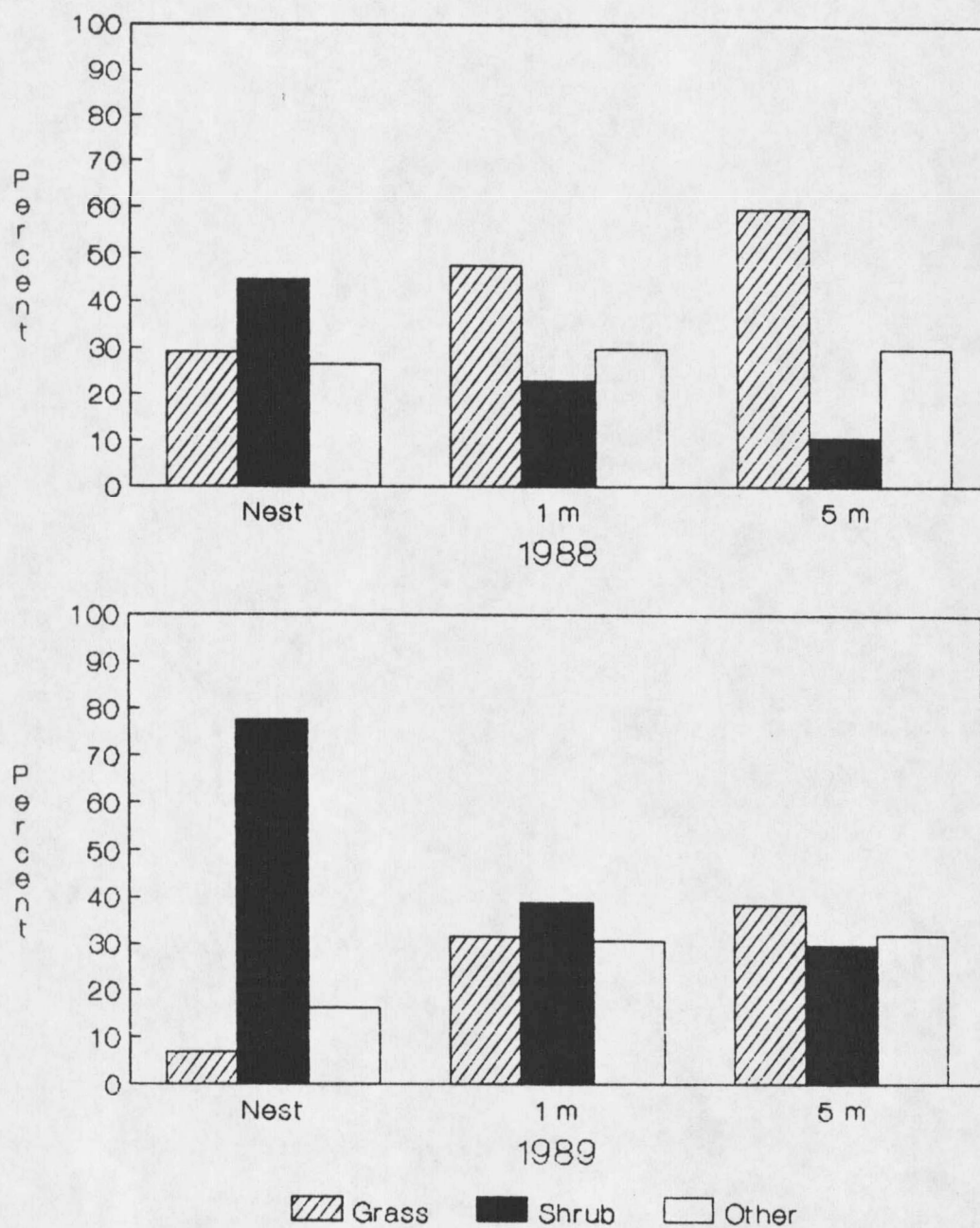


Figure 7. Dominant vegetation categories at sharp-tailed grouse nests and 1 and 5 m from nests, determined with photo-plots during 1988 and 1989 on the Skunk Coulee study area, Montana.

AgsM/Shale. Nests under junipers had a higher shrub canopy coverage ($p=0.015$) than nests under other shrub species. Although not statistically significant ($p=0.079$), 1988 nest canopy measurements were less than those in 1989. Measurements of successful and unsuccessful nests were similar ($p=0.633$). Adults nested in areas with slightly more shrub canopy coverage than juveniles ($p=0.135$).

Physiography

Slopes at nest sites averaged 8.8% ($SD=5.8$, $n=27$). Slopes at random nest sites were steeper than actual nest sites ($p=0.044$). Aspect seemed to favor an easterly direction (Fig. 8). Aspect of the nest in relation to the canopy shrub also favored an easterly direction.

Brood Rearing

Brood Survival

Brood survival differed between years (Table 18). In 1988, all broods were presumed dead within 2 weeks of hatching. Mammalian ($n=3$) and avian ($n=1$) predators killed 4 hens with broods, contact was lost with 2, and according to movements and willingness to flush, 4 hens lost their broods, but remained active themselves.

From 7 successfully hatched nests in 1989, 2 hens were killed by avian predators during the first week after hatch. One was apparently mortally wounded the day in which her clutch hatched as loose feathers

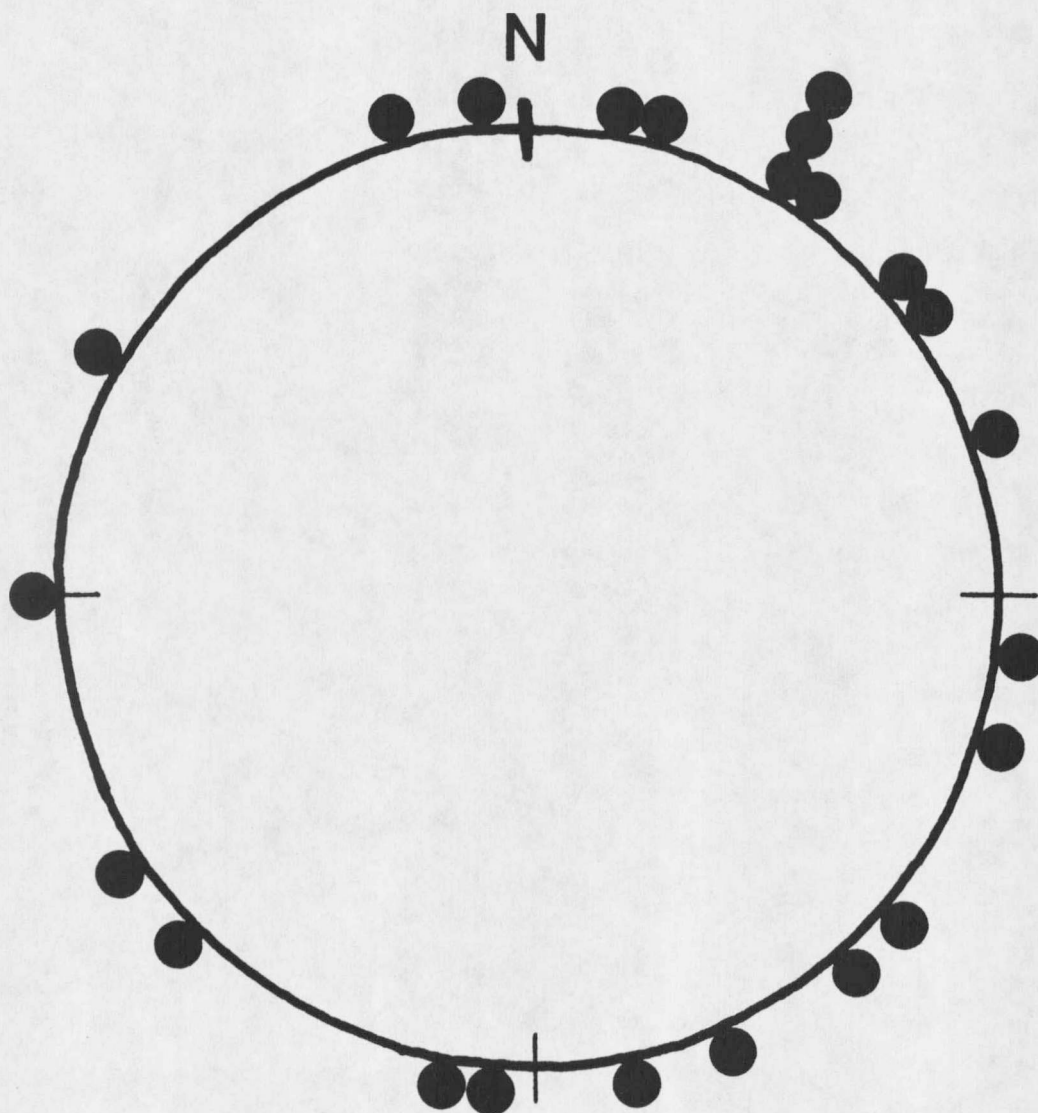


Figure 8. Slope aspect at sharp-tailed grouse nest sites during 1988 and 1989 on the Skunk Coulee study area, Montana.

Table 18. Production data on sharp-tailed grouse during 1988 and 1989 on the Skunk Coulee study area in northeastern Montana.

	1988	1989	Total
Nests hatched	10	7	17
Chicks hatched	90	76	160
Hen killed/brood dead	4	2	6
Hen alive/brood dead	4	0	4
Radio contact lost	2	0	2
Broods raised	0	5	5
Chicks raised	0	14	14

occurred around the nest and she was found uneaten, 0.4 km away. The remaining 5 hens successfully raised broods until the end of the study. In 1988, 90 eggs hatched. All chicks were dead within 2 weeks of hatching, a loss of 0.64 chicks/hen/day. Seventy-six eggs were known to hatch in 1989. Including the loss of complete broods of the 2 hens killed by predation, 55 chicks died in the first 26 days, or 0.30 chicks/hen/day. During the next 41 days, 7 chicks died (0.04 chicks/hen/day). At the end of the 1989 field season, 5 radioed hens with broods had a total of 14 live chicks.

The 5 broods surviving provided 105 locations. For home range and habitat analysis, locations were divided into 3 periods based on the following age classes: early (0-3 weeks old), middle (3-6 weeks old), and late (6+ weeks old) brood periods. These periods were characterized by distinct shifts in home ranges locations and cover type use.

90
76
156

Movements and Home Range

Total home range size of the broods for the entire summer varied from 165 to 1057 ha ($\bar{x}$ =433 ha, SD=353) (Fig. 9). Broods usually remained near the nest the first few days after hatching. Some, however, made relatively extensive movements within a week. Hen 0389 moved 2.4 km to a lowland area near Fort Peck Lake when her brood was between 4 and 7 days old.

Home ranges during the early brood period ranged from 29-301 ha in size ($\bar{x}$ =108 ha, SD=112). The home range of 0389 and brood decreased from 301 ha to an intensively used area of 52 ha after the long, early move. Brood hens 1688 and 1788 similarly moved into lowland areas, while hens 2588 and 1189 and their broods remained in the uplands. The geographical activity center (GAC) for each broods' home range during the early brood period, averaged 0.8 km (SD=0.7) from their nests.

Home ranges during the middle brood period averaged 60 ha (SD=35). During this period, hen 0389 and brood shifted their GAC 2.5 km to an intensive use area in the uplands. Hen 2588 and her brood remained in the same upland area as during the early brood period; 1688 and 1788 moved into the uplands, but did not settle in areas of intensive use; and 1189 remained within a 15 ha area in the uplands. The GAC of the 5 brood hens shifted an average of 1.1 km (SD=0.8) between the first 2 periods.

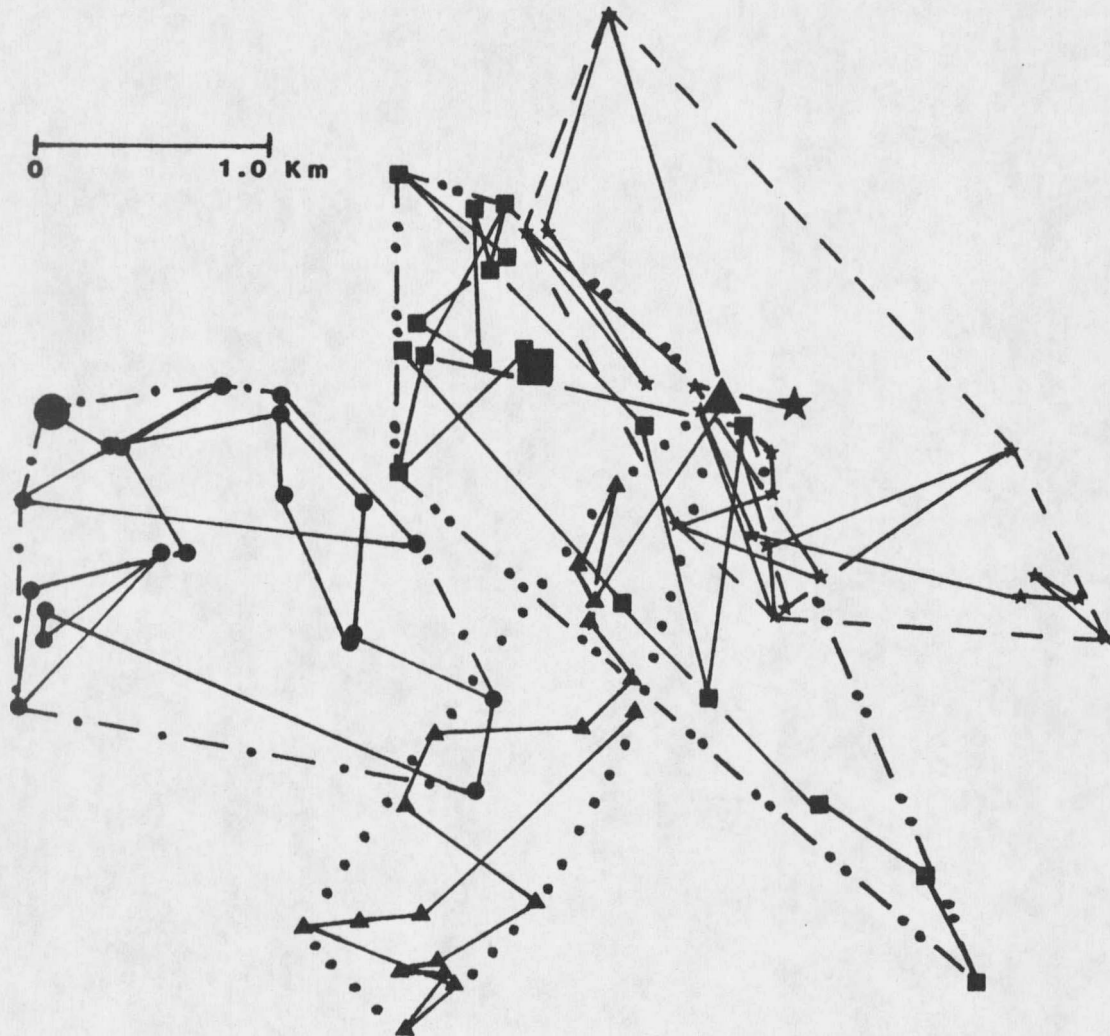


Figure 9. Summer home ranges of 4 sharp-tailed grouse broods during 1988 and 1989 on the Skunk Coulee study area, Montana. Large symbols denote nest sites.

Home ranges of broods during the late brood period ranged from 55 to 188 ha ($\bar{x}$ =106 ha, SD=53). All broods settled into localized areas. Broods of 1788, 2588, and 0389 shifted their GAC's 1.8, 2.0, and 2.3 km, respectively, to lowland areas near Fort Peck Lake. Hen 1688 and her brood moved slightly farther into the uplands and used an area of 17 ha until late in August when they also shifted to Lakeshore. Hen 1189 and her brood remained within the upland areas they had previously used.

Macrohabitat Use

Home Range Composition. Brood home ranges included 7 different cover types. Junip comprised 26.5-82.8% of the 5 individual ranges ($\bar{x}$ =46.6%, SD=21.8) (Table 19). Four of the 5 ranges included Shale ($\bar{x}$ =30.9%, SD=12.1) and Lakeshore ($\bar{x}$ =13.9%, SD=5.5) cover types. Artr/Agsm ($\bar{x}$ =11.3%, SD=12.4), Posa/Save ($\bar{x}$ =9.1%, SD=7.7), and Agsm/Artr ($\bar{x}$ =8.4%, SD=7.8) were found within 3 of 5. Four of 5 brood ranges were dominated by Junip, Shale, and Lakeshore, with either Artr/Agsm, Agsm/Artr, or Posa/Save comprising the remainder. The other was dominated by Junip with Artr/Agsm, Agsm/Artr, and Posa/Save also present.

Cover Type Use. Broods utilized 6 of 11 cover types on the study area. Most (49%) of the brood locations were in Junip. The remainder were distributed in Lakeshore (16%), Shale (14%), Posa/Save (10%), Artr/Agsm (8%), and Agsm/Artr (3%). Lakeshore and adjacent cover

Table 19. Percentage of each cover type found within individual brood home ranges (HR) and percent of relocations (LC) within each cover type - 1989.

Bird number	1688 n=19		1788 n=21		2588 n=20		0389 n=25		1189 n=20	
Cover Type ^a	HR	LC	HR	LC	HR	LC	HR	LC	HR	LC
Junip	48.0	42.1	42.5	38.1	33.9	60.0	26.5	36.0	82.8	70.0
Shale	18.6	15.8	29.0	42.9	29.5	0.0	47.5	12.0	-	-
Lakeshore	6.4	5.3	12.0	19.0	19.3	15.0	16.1	36.0	-	-
Artr/Agsm	25.0	31.6	-	-	-	-	0.7	8.0	8.3	5.0
Agsm/Artr	-	-	16.5	0.0	-	-	7.7	8.0	1.0	0.0
Posa/Save	2.0	5.3	-	-	17.3	25.0	-	-	7.9	25.0
Save/Artr	-	-	-	-	-	-	1.6	0.0	-	-

^a Full name of cover type acronyms given in Appendix Table 29.

types were used in a predictable pattern as broods became older.

Broods fed in the lakeshore vegetation during the morning and loafed and roosted in nearby types, usually Junip and Shale. Attempts were made to collect locations equally spaced throughout the day, but samples during late afternoon/early evening were deficient (Table 20). Thirty-four (67%) of 51 brood locations in the Junip type occurred between 0900 and 1700. Seven of 15 locations (47%) in Shale were made during the same period. Eight of 17 locations in the Lakeshore cover type (47%) were before 0900.

Cover Type Use by Brood Age Class. Early (0-3 weeks old) broods used Junip (n=11), Lakeshore (n=7), Shale (n=6), Posa/Save (n=5), Agsm/Artr (n=2), and Artr/Agsm (n=2). Broods of hens 1189 and 2588 were found in the grassy drainages and nearby uplands of Junip and Posa/Save cover types. Lakeshore and Shale types were used by 1688,

Table 20. Brood use of cover types by time period on Skunk Coulee study area in northeastern Montana.

Cover type ^a	Time				Total
	Rise-0900	0901-1700	1701-Set	Night	
Junip	5	34	3	9	51
Lakeshore	8	7	2	0	17
Shale	3	7	1	4	15
Posa/Save	3	7	0	1	11
Artr/Agsm	3	1	0	4	8
Agsm/Artr	1	2	0	0	3
Total	23	58	6	18	105

^a Full name of cover type acronyms given in Appendix Table 29.

yellow sweet clover and foxtail barley throughout the day. Hens 1688 and 1788 used similar areas for feeding and then moved into nearby Shale and Junip types to loaf and roost. Thirty-three percent of the locations (n=11) during the early brood period were < 50 m from the nearest ecotone.

During the middle brood period, 79% of all locations (n=22) were in Junip. Shale, Agsm/Artr, and Posa/Save were the only other types used. Hens 1688, 1788, and 0389 shifted from Lakeshore and Shale areas into upland Junip areas; 2588 and 1189 and their broods remained in the Junip type. Only 18% (n=5) of the locations were within 50 m of another cover type.

Broods used all 6 cover types during the late brood period. Junip (n=20) was used the most, but Lakeshore (n=10) and Shale (n=6) were also important. Hens 1788, 2588, 0389 and their broods shifted from the uplands into the Shale and Lakeshore types; 1688 moved further into the uplands using strictly the Junip and Artr/Agsm cover types; and 1189 remained within the types used during the earlier

periods of the summer. A significantly greater percentage (60%) of locations were within 50 m of a different cover type during this period compared to the early and middle brood periods ($p=0.021$, $p=0.000$, respectively).

Microhabitat Use

Eighty random points were analyzed in Junip ($n=33$), Shale ($n=31$), and Posa/Save ($n=14$). Junip brood site measurements differed significantly between brood periods in GHI ($p=0.002$), THI ($p=0.030$), and GHT ($p=0.002$). Brood sites in shale had microsite characteristics that were similar between the brood periods. The remaining cover types had insufficient number of brood locations and were not tested between periods. Data from random points were similar between these same periods and measurements were pooled by cover type.

Microsite measurements of brood sites in the Junip type are compared to those at random points in Table 21. Brood sites had significantly lower average shrub height ($p=0.028$) than random sites. Broods sites had more grass than random points during the first 2 periods. GHI during the early and middle periods ($p=0.001$, $p=0.003$, respectively), THI in the late period ($p=0.024$), and GHT in the early and middle periods ($p=0.001$, $p=0.001$, respectively) were significantly higher at brood sites than at random sites.

Table 22 shows vegetation characteristics at actual brood site and random microsites in the Shale cover type. Brood sites had significantly more grass and shrub cover than random points, indicated

by greater percent shrub canopy coverage ($p=0.020$), GHI ($p=0.001$), THI ($p=0.001$), GHT ($p=0.001$), SHT ($p=0.010$), and THT ($p=0.000$) readings.

Vegetation measurements at random and actual brood sites in the Posa/Save cover type are compared in Table 23. Brood sites had more grass cover when compared to random sites. Actual brood sites were significantly higher in shrub density ($p=0.035$), GHI ($p=0.001$), THI ($p=0.001$), GHT ($p=0.001$), and THT ($p=0.001$) than random sites.

Table 21. Comparison of vegetation characteristics at brood microsites and random points in the Junip cover type on Skunk Coulee study area.

	<u>Brood</u>			<u>Random</u>			p-value
	N	$\bar{x}$	SD	N	$\bar{x}$	SD	
% shrub canopy	42	29	15	35	31	14	0.344
Shrub/ha	41	5,056	6,795	35	2,865	2,387	0.142
Shrub ht (cm)	41	52	25	35	68	34	0.020*
GHI ^a							
0-3 wks old	8	29	14	34	8	9	0.001*
3-6 wks old	14	22	18	34	8	9	0.002*
6+ wks old	12	7	4	34	8	9	0.548
SHI	34	31	13	34	37	14	0.108
THI ^a							
0-3 wks old	8	54	23	34	45	15	0.269
3-6 wks old	14	56	13	34	45	15	0.024*
6+ wks old	12	42	9	34	45	15	0.671
GHT ^a (cm)							
0-3 wks old	8	65	42	34	17	27	0.001*
3-6 wks old	14	52	48	34	17	27	0.001*
6+ wks old	12	12	8	34	17	27	0.793
SHT (cm)	34	716	428	34	771	448	0.552
THT (cm)	34	820	403	34	816	448	0.854

^a Indicates characteristics are significantly different between brood periods and were not pooled.

* Indicates a significant difference between actual and random points.

Table 22. Comparison of vegetation characteristics at brood microsites and random points in the Shale cover type on Skunk Coulee study area.

	<u>Brood</u>			<u>Random</u>			p-value
	N	$\bar{x}$	SD	N	$\bar{x}$	SD	
% shrub canopy	15	15	8	31	9	7	0.020*
Shrubs/ha	15	3,687	3,027	31	4,166	4,463	0.898
Shrub ht (cm)	15	40	18	31	35	14	0.122
GHI	13	18	11	29	7	9	0.001*
SHI	13	17	10	29	13	9	0.201
THI	13	35	10	29	20	14	0.001*
GHT (cm)	13	127	133	29	41	64	0.001*
SHT (cm)	13	366	279	29	152	159	0.010*
THT (cm)	13	493	247	29	193	198	0.000*

* Indicates a significant difference between actual and random points.

Table 23. Comparison of vegetation characteristics at brood microsites and random points in the Posa/Save cover type on Skunk Coulee study area.

	<u>Brood</u>			<u>Random</u>			p-value
	N	$\bar{x}$	SD	N	$\bar{x}$	SD	
% shrub canopy	11	9	8	14	7	4	1.000
Shrubs/ha	11	2,935	2,865	14	14,280	16,580	0.035*
Shrub ht (cm)	11	31	14	14	27	8	0.622
GHI	11	25	15	14	6	6	0.001*
SHI	11	15	11	14	9	6	0.274
THI	11	39	17	14	16	9	0.001*
GHT (cm)	11	203	155	14	32	42	0.001*
SHT (cm)	11	229	203	14	88	62	0.147
THT (cm)	11	409	224	14	120	88	0.001*

* Indicates a significant difference between actual and random points.

The number of juniper plants at the brood sites was significantly lower than at random sites ($p=0.000$, $X^2=22.8$, $df=1$) in the Junip type. In the Shale type, significantly more juniper plants were found at brood than random sites ($p=0.000$, $X^2=98.9$, $df=1$). Significantly more greasewood plants were found at brood sites in Posa/Save when compared

to random sites ($p=0.000$, $X^2=75.2$, $df=1$). Brood microsite vegetation measurements in Lakeshore, Artr/Agsm, and Agsm/Artr are summarized in Table 24.

Night Roosts

Eighteen night roost sites of broods were located. Cover types used for roosting included Junip ($n=9$), Artr/Agsm ($n=4$), Shale ($n=4$), and Posa/Save ($n=1$). Over 70% of the roost sites ($n=13$) were located within 50 m of another cover type. Distances between night roosts and the previous days location averaged 0.7 km ($SD=0.4$, $n=12$).

Table 24. Vegetation characteristics at brood microsites during 1989 in Lakeshore, Artr/Agsm, and Agsm/Artr cover types.

Cover type ^a	Lakeshore ($n=12$)		Artr/Agsm ($n=8$)		Agsm/Artr ($n=2$)	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
% shrub canopy	0	0	22	7	14	8
Shrubs/ha	0	0	18,310	11,040	11,970	925
Shrub ht (cm)	-	-	64	23	60	9
GHI	67	26	13	9	35	11
SHI	0	-	38	14	20	16
THI	67	26	52	17	55	5
GHT (cm)	1,208	784	57	43	133	56
SHT (cm)	0	-	471	231	263	275
THT (cm)	1,208	784	528	229	396	219

^a Full name of cover type acronyms given in Appendix Table 29.

Table 25 shows microsite characteristics of all night roost sites. Individual roosts ($n=26$) had an average HDP reading of 6 cm ($SD=5$). The species for 351 shrubs were recorded around all roost sites during point-quarter measurements. Big sagebrush plants comprised 56% ($n=198$), while juniper contributed 17.7% ($n=62$).

Table 25. Night roost site characteristics of sharp-tailed grouse broods during 1989 in northeastern Montana.

	N	$\bar{x}$	SD
Shrub canopy (%)	18	19	8
Shrub height (cm)	18	34	9
HDP calculations:			
Individual roosts (cm)	26	6	5
GHI	18	24	36
SHI	18	29	14
THI	18	45	14
GHT (cm)	18	92	118
SHT (cm)	18	411	271
THT (cm)	18	503	230

Adults

Movements and Home Range

One male, along with 4 females that lost broods, provided movement data in 1988. Summer home ranges for these birds averaged 274 ha (SD=189). Hens made abrupt movements away from their nesting area within 2 weeks of hatching. They remained in these areas throughout the summer. These moves were likely the result of losing the entire brood. After the moves, summer use areas utilized by hens averaged 43 ha (SD=39).

Vegetation Composition of Adult Home Ranges

Home ranges of adults contained 7 of 11 cover types (Table 26). Three of 5 home ranges were dominated by the interspersions of Junip, Shale, and Lakeshore cover types, similar to brood home ranges. The 2 remaining adults had home ranges comprised almost entirely of Agsm/Shale.

Table 26. Percentage of each cover type found within individual adult home ranges (HR) and percent of relocations (LC) within each cover type - 1988.

Bird number	0588 n=17		1288 n=14		1688 n=23		1788 n=13		1888 n=11	
Cover type ^a	HR	LC	HR	LC	HR	LC	HR	LC	HR	LC
Junip	5.1	17.6	-	-	18.2	21.7	13.7	30.8	-	-
Shale	-	-	-	-	50.9	56.5	49.3	38.5	72.9	81.8
Lakeshore	-	-	-	-	7.7	17.4	35.1	30.8	14.2	18.2
Agsm/Shale	83.8	76.5	83.9	78.6	-	-	-	-	-	-
Pose/Save	11.1	5.9	-	-	23.2	4.3	1.8	0.0	12.9	0.0
Artr/Agsm	-	-	12.2	21.4	-	-	-	-	-	-
Save/Artr	-	-	3.9	0.0	-	-	-	-	-	-

^a Full name of cover type acronyms given in Appendix Table 29.

Cover Type Use

Cover type use within individual adult home ranges is compared to cover type availability in Table 26. The 3 hens that used Junip, used this type to greater extent than expected based on availability.

Shale and Lakeshore types were used more than expected in 2 of 3 home ranges. Posa/Save was present in 4 home ranges, but use was less than expected in each.

The remaining 2 hens used Agsm/Shale over 75% of the time. This was less than expected on the basis of amount available. Hen 0588 used Junip and hen 1288 used Artr/Agsm more than its availability would have indicated.

Comparison of Brood and Adult Characteristics

Hens 1688 and 1788 were broodless in 1988, but successfully raised broods in 1989. Nests of 1688 in 1988 and 1989 were 0.2 km apart. In 1988, this hen used an area near her nest until 7 July.

1988; she then moved 3.5 km to an 18 ha area on which she remained throughout the summer (Fig. 10). The long move occurred following the loss of her brood. The area of use before she lost her brood in 1988 overlapped with her brood home range in 1989. Summer home range for this bird as a broodless hen was larger (545 ha) than as a brood hen (165 ha).

Nests of 1788 were 0.3 km apart between years. Home ranges during both years were centered around areas of Lakeshore, Shale, and Junip (Fig. 11). No major movements were made during either year, except a move into the Junip uplands during the middle brood period in 1989. Home range size as a brood hen in 1989 (279 ha) was larger than as a broodless hen in 1988 (84 ha).

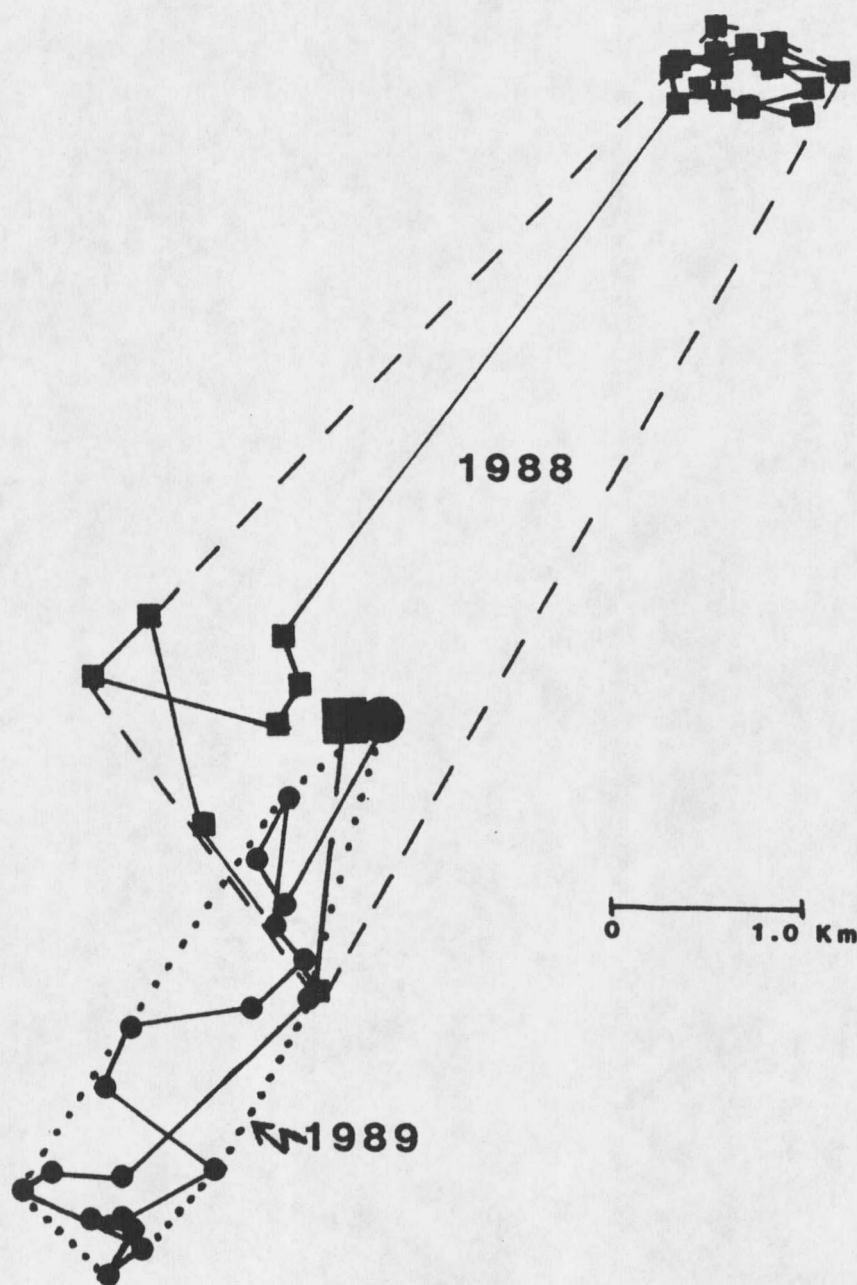


Figure 10. Summer movements and home ranges of sharp-tailed grouse hen 1688, broodless in 1988 and with a brood in 1989, on the Skunk Coulee study area, Montana. Large square and circle denote nest sites in 1988 and 1989, respectively.

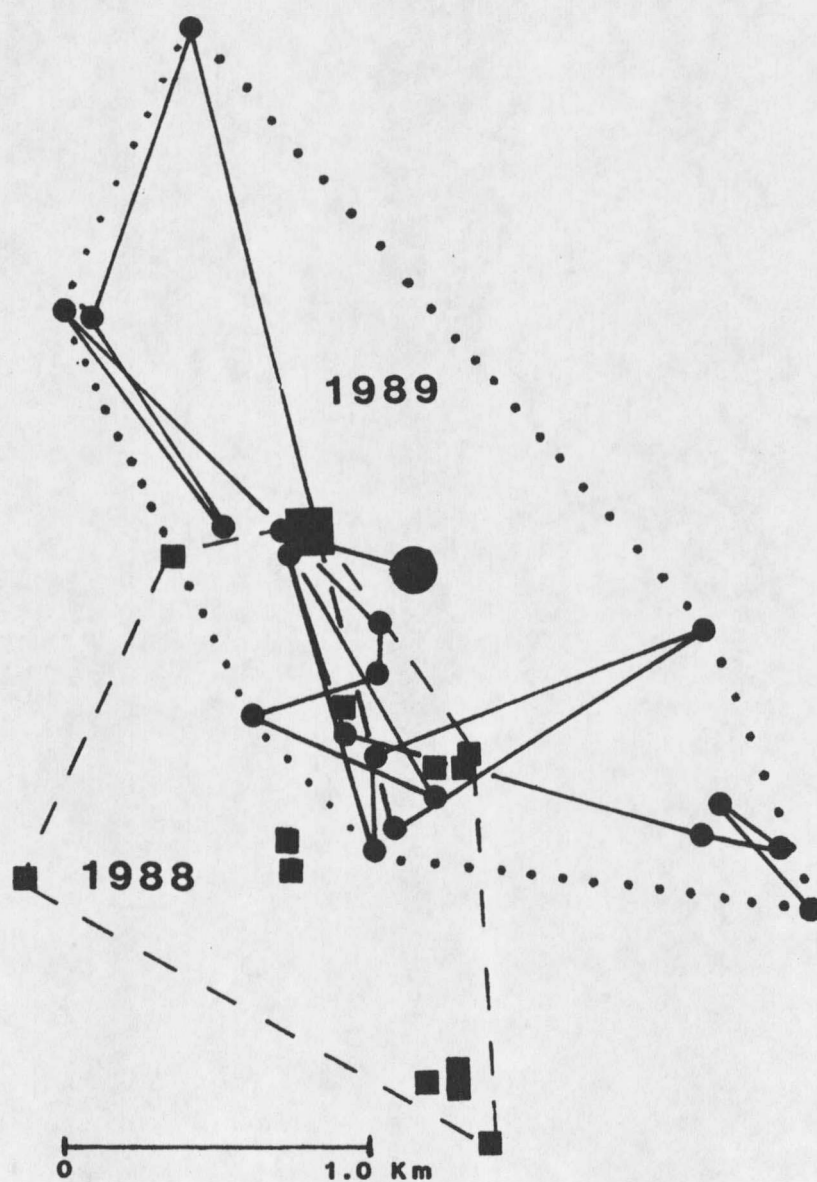


Figure 11. Summer movements and home ranges of sharp-tailed grouse hen 1788, broodless in 1988 and with a brood in 1989, on the Skunk Coulee study area, Montana. Large square and circle denote nest sites in 1988 and 1989, respectively.

DISCUSSION AND CONCLUSIONS

Male sharp-tailed grouse were actively displaying at the start of each field season. Due to topography and screening by sagebrush, birds present on grounds were sometimes difficult to count without flushing. Censuses were probably most reflective of cock numbers alone, during early April and early May, before and after peak hen attendance. Thus, the great variation in numbers since 1975 may be due in part to observer effort and/or the timing of the census.

The timing of peak male attendance corresponds closely with other studies on plains and prairie sharp-tailed grouse (Brown 1966, Evans 1968, Artmann 1970, Hillman and Jackson 1973). Male attendance on dancing grounds declined during May and ceased in early June.

All pre-incubation locations were within 400 m of the eventual nest. Pre-incubation ranges were similar in size to those found in Wisconsin (Gratson 1988). Hens used shrub cover almost exclusively during this period.

Clutches were initiated during the first 10 days of May. Mean clutch size was higher (13.2) than in many other studies (Artmann 1970, Christenson 1970, Pepper 1972, Sisson 1976, Grosz and Kirby 1986). The majority of nests hatched during the first 2 weeks of June in 1988 and during the second and third weeks of June in 1989. Later hatching in 1989 was possibly caused by a 5 day rainstorm in late April which may have delayed female attendance on dancing grounds.

Rain and snow have inhibited dancing activity in Minnesota (Artmann 1970) and North Dakota (Christenson 1970). Hatching dates in 1988 were similar to dates reported for Wisconsin (Hamerstrom 1939); those in 1989 were similar to dates reported for Minnesota (Artmann 1970) and Nebraska (Sisson 1976). Peak dates of hatch in South Dakota were earlier, from late May to early June (Hillman and Jackson 1973). Hatching dates in Saskatchewan varied from the second to the fourth week in June during 1968-1970 (Pepper 1972). Weather conditions during the breeding period may modify the peak of hatching in any given year.

Egg hatchability in 1988 (81%) was lower than 1989 (100%). This was probably due to the extremely high temperatures experienced during the 1988 hatching period. During the first 10 days of June, the maximum daily temperature was ≥ 40 C (104 F) twice, 7 days were ≥ 35 C (98 F). An entire clutch was found dead after the hen had incubated for over 35 days. The embryos were within a few days of hatching and probably died from overheating. In pheasants, embryos became increasingly vulnerable to exposure as incubation progressed (MacMullan and Eberhardt 1953). No eggs of domestic fowl survived continuous exposure to temperatures above 40.5 C (105 F) and the threat of embryo death through overheating was close at all times (Drent 1975). Cooler temperatures prevailed in 1989 and hatchability was comparable to other studies (Hamerstrom 1939, Brown 1967a and 1968, Pepper 1972, Sisson 1976).

Nests were found a mean 1.6 km from the dancing ground on which they were caught. Several hens nested closer to grounds other than

the one on which they were trapped. Distances between home dancing ground and nest site were unreported in earlier studies because telemetry was not used. However, distances from nests to the nearest dancing ground in my study were comparable to others (Artmann 1970, Pepper 1972, Ramharter 1976).

Fidelity to a general nesting area, returning to the same cover type and within 300 m of the previous year's nest, occurred in 2 of 4 hens. Another hen nested within 700 m of her previous year's nest, but utilized a different cover type. Fidelity to nesting areas has been reported in sage grouse (Berry and Eng 1985) and prairie chickens (Svedarsky 1988).

Most hens in this study (89%) utilized shrubs for nesting cover. Juniper was the dominant shrub used. Junipers were also used for nesting by sage grouse (Centrocercus urophasianus), American widgeon (Anas americana), mourning dove (Zenaida macroura), Western meadowlark (Sturnella neglecta), loggerhead shrike (Larius ludovicianus), and rufous-sided towhees (Pipilo erythrophthalmus). Vegetation used as nesting cover tends to differ throughout the sharp-tailed grouse's range. In the Lake states, sharptails nested in brushy willow (Salix sp.) areas (Hamerstrom 1939, Artmann 1970, Ramharter 1976). In many areas of the plains, residual and new growth grasses are most heavily used for nesting (Christenson 1970, Kobriger 1980, Kohn et al. 1982). Pepper (1972) in Saskatchewan and Grosz and Kirby (1986) in south central North Dakota, found that sharptails made extensive use of snowberry for nesting.

It appears that vegetative lifeform and species has limited effect on the selection of nest sites. Height and screening ability of the nest vegetation appear to be the most important characteristics affecting nest site selection. Canopy height at nests averaged 47 cm. Christenson (1970) felt hens needed uniform vegetation greater than 30 cm or patchy vegetation over 36 cm for adequate nesting cover. Screening ability of the vegetation may be even more important to nesting hens than the height of the canopy. Photo-plots taken at nests showed significant differences in height and effective height of vegetation between years. Nests in 1989 were more screened from view by vegetation than in 1988. Height-density pole readings were also significantly higher in 1989. This increase in vegetation was associated with a 7.1 cm increase in precipitation totals during April and May in 1989. In 1989, both vegetation height and effective height increased significantly throughout incubation. Permanent photo-plots in 1989 show that the majority of grass and forb growth occurred between nest initiation and hatching. In 1988, vegetation height and effective height decreased during this same period, albeit not significantly. The decrease in vegetation height and effective height, in 1988, was most likely caused by lack of grass and forb growth nests and natural reduction of residual vegetation. Lack of new growth may have contributed to the death of an entire clutch. This nest, in residual grasses, became increasingly exposed to the sun as incubation progressed.

Photo-plots taken at 1 m and 5 m from nests indicated a decrease in both height and effective height of vegetation as one moved away

from the nests. The dominance of shrubs at nests is evident as a decrease in shrub and an increase in the grass vegetation category occurs at sites away from nests. Shrubs intermixed with grass provided better screening cover than residual grasses in the areas immediately adjacent to nests.

Vegetation used for nesting on the Skunk Coulee study area was very effective in protecting the hen and her nest. Nest success (63%) was higher than reported from several other studies (Christenson 1970, Pepper 1972, Sisson 1976, Grosz and Kirby 1986). Lack of nest success on SCGA was attributed to avian and mammalian predation, abandonment, and exposure. Predators destroyed nearly 30% of the nests.

The majority of chick mortality occurred within 2 weeks of hatch. All chicks died during this time in 1988. Predation and weather were the major causes. The first 2 weeks of life is a period of extreme vulnerability, as chicks can neither fly nor thermoregulate (Bergerud and Gratson 1988a). Three hens were killed by predators within 2 weeks after their clutches had hatched. Although broods were not flushed during this period, an exception occurred when the researcher flushed a brood hen less than 1 week after hatching. The hen remained hidden until approached within 1 m. Instead of flying, she ran across the ground, a seemingly easy target for predation. The conspicuousness of sharptail brood hens, even in suitable early brood habitat, has a price since they often experienced a higher rate of early summer mortality than broodless hens (Christenson 1970, Bergerud and Gratson 1988a).

In 1988, high daily temperatures in June were over 32 C (90 F) and 38 C (100 F), 22 and 6 times, respectively. Ground temperatures on the shale soils were probably considerably higher. Two chicks were found dead within 10 m of nests and 10 chicks died while exiting their eggs. Because sharptail chicks are precocial, they need to maintain their body temperatures around 40 C (104 F) or lower. Japanese quail less than 15 days old have body temperatures lower than adults (Spiers et al. 1974). Whittow (1976) found that domestic fowl chicks required 3 weeks for their body temperature to equal adults. Young Japanese quail exhibited only 30-40% of the thermoregulatory capacity of adults (Ricklefs 1979). Full thermoregulation may not be attained until chicks develop feathers or until the increase in body weight decreases the surface to volume ratio (Spiers et al. 1974). In 1989, temperatures during the early brood period were mild and no loss of entire broods was recorded. Weather conditions in early June are important in determining brood success (Evans 1968). In pheasants, brood survival is better when May and June remain relatively cool (Martinson and Grondahl 1966). Although hot weather was a major cause of early chick mortality in this study, cold, wet weather is reported more often as having detrimental effects on young gallinaceous birds (Cartwright 1944, MacMullan and Eberhardt 1953).

Chick mortality during the early brood period in 1989 was roughly half that in 1988. During the middle and late brood periods in 1989, only 7 chicks disappeared. Due to the high mortality during the early brood period, no chicks lived in 1988 and only 14 chicks were alive at the end of the 1989 field season. Average brood size (2.8) was

considerably less than in other studies (Pepper 1972, Sisson 1976). Brown (1967b) found that to maintain stable breeding numbers an average recruitment of 1.5-2.0 young/hen was required. It appears that young in 1988 were initially affected by excessive heat prior to normal predation. The largest brood (n=5) at the end of the 1989 field season, made the longest, most extensive movements during the summer. Bergerud and Gratson (1988a) suggested that long, continuous movements by broods represent a behavioral adaptation to avoid encounters with predators that bring prey to a temporarily fixed place (i.e. nest sites).

Broods remained within 400 m of nests for a few days following hatching after which they moved up to 2.4 km to the nearest extensive stand of grass and yellow sweet clover. These areas were limited to wetter drainages and along the shores of Fort Peck Lake. Lengthy movements by young sharptail broods are not uncommon (Artmann 1970). Young prairie chickens are also very mobile soon after hatching, especially if adequate brood habitat is not nearby (Newell et al. 1988). Bergerud and Gratson (1988a) suggested that the need for long brood movements soon after hatch is because the female's first concern is to have a successful nest, using the best available nesting options in April and May, irregardless of distance from brood habitat.

Areas with abundant grass probably provided both adequate cover and insects. Rough examination of night roost droppings indicated insects were being fed upon by broods. Heavy feeding on insects by young sharptails (Kobriger 1965, Pepper 1972, Sisson 1976) and other

gallinaceous species (Peterson 1970, Weigand 1980, Kimmel and Samuel 1984, Whitmore et al. 1986, Toepfer 1988b) is well documented.

Distinct shifts in cover type use were made by broods. Early broods settled into small ranges after reaching grassy areas. Later, broods shifted to shrubby upland areas, usually within the Junip cover type. During late summer, broods moved back to Lakeshore, seemingly following a continuum of forb dessication from the uplands to moister lowlands. This type of movement has been recorded for sage grouse (Wallestad 1971).

Late broods used Lakeshore much differently than early broods. Early broods tended to use lakeshore vegetation throughout the day and occasionally moved into nearby uplands to roost. The older broods had more pronounced daily movements, using Lakeshore for intense morning and evening feeding and shifting to Junip or Shale uplands for loafing and roosting. Similar daily use patterns by broods were found in other studies (Christenson 1970, Pepper 1972, Moyles 1981). The pattern of cover type use during the late brood period paralleled that of adults without broods. Sharptail broods exhibited an excellent ability for flight by 6 weeks. Although chicks remained with the hen throughout the remainder of the field season, cover type use and mobility indicated that they were probably independent.

Two of 5 late broods used the same, distinct Lakeshore, Junip, and Shale areas as non-brood hens in 1988. During the late brood period, hen 0389 and her brood used an area that 1688 used after losing her brood in 1988. This area was 3.5 and 5.9 km, respectively, from their nests. Hen 1788 showed fidelity to a distinct summer

range, using the same area with and without a brood. The use by both non-brood and brood hens of these Lakeshore, Junip, and Shale areas indicates that it has some combination of characteristics making it attractive sharp-tailed grouse seasonal habitat. An area where Junip and Lakeshore cover types are in close proximity is possibly a factor in preferred adult sharptail habitat on the Skunk Coulee study area. Moyles (1981) suggested the choice of vegetation depends on food requirements, presence of conspecifics, familiarity with an area, avoidance of predators, and weather.

Within each cover type, broods selected areas of grass. Actual brood sites in Shale and Posa/Save had significantly higher grass hits and grass height than random sites. In the Junip type, the early and middle broods had higher grass hits and grass height readings than random sites. During the late brood period these readings were lower. Moyles (1981) found females with broods used grassland and grassland-low shrub transition significantly more than adults without broods. It appears that the older, more mobile broods are less dependent on herbaceous cover. Broods selected areas near shrub cover in Shale and Posa/Save cover types.

Brood ranges for the entire summer were highly variable (165-1057 ha). The largest brood home range was from a renest. Brood range sizes in Minnesota varied from 13-106 ha (Artmann 1970), while in North Dakota they ranged from 32-202 ha (Christenson 1970). The disparity in home range sizes may be due to the large size and long

distances between cover type stands. Home range sizes have been shown to be influenced by resource availability (Schoener 1971, Wallestad 1971).

Home ranges of brood hens (433 ha) were larger than those of non-brood hens (274 ha). Toepfer (1988_b) found prairie chickens with broods had ranges larger than hens without broods. The size of brood home ranges may depend on the distance between suitable brood habitat and the nest site.

It seems that 14 chicks from 27 nests, over 2 years indicates inadequate production to maintain this population. Adult grouse mortality rates vary from 25 to over 75% (Bergerud 1988_b). In 1 Montana study, average annual adult male turnover rate varied between 66 and 72% (Brown 1967_a). Total number of cocks on dancing grounds decreased substantially from 1988 to 1989, and again from 1989 to 1990. The 1990 decline may have been an artifact of the narrow sampling period of dancing ground counts during 1 weekend in mid-April. The lack of juvenile recruitment in 1989 is evidenced by the trapping data in 1988 and 1989. In 1988, 57% of the total birds trapped were juveniles, this was significantly greater than the 12% in 1989. Also indicative of low production in 1988, was increased nesting success and clutch sizes, and a decrease in distances hens nested from display grounds in 1989. Adults had higher success, larger clutch sizes, and nested closer to display grounds than juveniles. Wallestad and Pyrah (1974) found similar adult and juvenile nesting differences in sage grouse. This indicates that adults comprised a higher proportion of nesting hens in 1989.

Many factors can contribute to the failure of production in any given year. It is evident that hens were quite successful at the nesting stage in both years. The brood rearing period appeared to limit overall production. High brood losses appeared to be caused by the combination of weather and predation. Land use can have a major effect on populations of sharptails. Conversion of native cover to agriculture has been detrimental to Columbian sharptails (Marshall and Jensen 1937). Improper grazing practices have greatly impacted habitat crucial to sharptail populations (Nielson and Yde 1982). Season-long grazing has been less detrimental than rest-rotation grazing systems for sharptail grouse (Mattise et al. 1982, Nielson and Yde 1982). The overstocking of livestock would probably have a detrimental effect on sharptails in any grazing system.

REFERENCES CITED

- Ammann, G. A. 1944. Determining the age of pinnated and sharp-tailed grouse. J. Wildl. Manage. 8:170-171.
- Amstrup, S. C. 1980. A radio collar for game birds. J. Wildl. Manage. 44:214-216.
- Artmann, J. W. 1970. Spring and summer ecology of the sharp-tailed grouse. Ph.D. Thesis, Univ. of Minn., St. Paul. 129pp.
- Bingham, L. C., L. A. Daniels, J. H. Smith, and M. J. Koehler. 1984. Soil survey of Valley County, Montana. U.S.D.A.-S.C.S. 102pp.
- Bergerud, A. T., and M. W. Gratson. 1988a. Survival and breeding strategies of grouse. Pages 473-577 in A. T. Bergerud and M. W. Gratson, eds. Adaptive strategies and population ecology of northern grouse. Univ. of Minn. Press, Minneapolis. 809pp.
- 1988b. Population ecology of North American grouse. Pages 578-685 in A. T. Bergerud and M. W. Gratson, eds. Adaptive strategies and population ecology of northern grouse. Univ. of Minn. Press, Minneapolis. 809pp.
- Berry, J. D., and R. L. Eng. 1985. Interseasonal movements and fidelity to seasonal use areas by female sage grouse. J. Wildl. Manage. 49(1):237-240.
- Brown, R. L. 1966. Sharp-tailed grouse population study. Montana Fish and Game Dept. Proj. W-91-R-6 and 7, Job II-E. Mimeo. 23pp.
- 1967a. Sharp-tailed grouse population study. Montana Fish and Game Dept. Proj. W-91-R-8, Job II-E. Mimeo. 16pp.
- 1967b. Effects of land use practices on sharp-tailed grouse. Montana Fish and Game Dept. Proj. W-91-R-8, Job II-F. Mimeo. 4pp.
- 1968. Sharp-tailed grouse population study. Montana Fish and Game Dept. Proj. W-91-R-9, Job II-E. Mimeo. 18pp.
- Canfield, R. H. 1941. Application of the line interception method in sampling range vegetation. J. Forestry 39(4):388-394.
- Cartwright, B. W. 1944. The "crash" decline in sharp-tailed grouse and hungarian partridge in western Canada and the role of the predator. Trans. N. Amer. Wildl. Conf. 9:324-330.
- Christenson, C. D. 1970. Nesting and brooding characteristics of sharp-tailed grouse (Pedioecetes phasianellus jamesi Lincoln) in southwestern North Dakota. M.S. Thesis, Univ. of North Dakota, Grand Forks. 53pp.

- Cottam, G., and J. T. Curtis. 1956. The use of distance measures in phytosociological sampling. *Ecology* 37:451-460.
- Daubenmire, R. 1959. A canopy-coverage method of vegetational analysis. *Northwest Science* 33:43-64.
- Dorn, R. D. 1984. Vascular plants of Montana. Mountain West Publishing, Cheyenne, Wyo. 276pp.
- Drent, R. 1975. Incubation. Pages 333-420 in D. S. Farner and J. R. King, eds. *Avian Biology*, Vol. 5, Academic Press, New York. 523pp.
- Evans, K. E. 1968. Characteristics and habitat requirements of the greater prairie chicken and sharp-tailed grouse - a review of the literature. U.S. Dept. of Agric. Conserv. Res. Rep. No. 12. 32pp.
- Gratson, M. W. 1988. Spatial patterns, movements, and cover selection by sharp-tailed grouse. Pages 159-192 in A. T. Bergerud and M. W. Gratson, eds. *Adaptive strategies and population ecology of northern grouse*. Univ. of Minn. Press, Minneapolis. 809pp.
- Grosz, K. L., and D. R. Kirby. 1986. The nesting and brood-rearing ecology of sharp-tailed grouse in relation to specialized grazing systems. *North Dakota Farm Res.* 44:22-24.
- Hamerstrom, F. N., Jr. 1939. A study of Wisconsin prairie chicken and sharp-tailed grouse. *Wilson Bull.* 51:105-120.
- Henderson, F. R., F. W. Brooks, R. E. Wood, and R. B. Dahlgren. 1967. Sexing of prairie grouse by crown feather patterns. *J. Wildl. Manage.* 31:764-769.
- Hillman, G. W., and W. W. Jackson. 1973. The sharp-tailed grouse in South Dakota. *South Dakota Dep. Game, Fish, and Parks.* 62pp.
- Hitchcock, C. L., and A. Cronquist. 1973. *Flora of the Pacific Northwest*. Univ. of Wash. Press, Seattle. 730pp.
- Johnsgard, P. A. 1983. *Grouse of the world*. Univ. of Nebr. Press, Lincoln. 413pp.
- Johnson, D. H. 1980. The comparison of usage and availability measurements for evaluating resource preference. *Ecology* 61:65-71.
- Kimmel, O. R., and D. E. Samuel. 1984. Implication of ruffed grouse brood habitat studies in West Virginia. Pages 89-108 in W. L. Robinson, ed. *Ruffed grouse management: State of the art in the early 1980's*. BookCrafters, Chelsea, Mich. 181pp.

- Kobriger, G. D. 1965. Status, movements, habitats, and foods of prairie grouse on a sandhills refuge. *J. Wildl. Manage.* 29: 788-800.
- 1980. Habitat use by nesting and brooding sharp-tailed grouse in southwestern North Dakota. *N.D. Outdoors* 43:2-6.
- Kohn, S. C., R. L. Linder, and G. D. Kobriger. 1982. Sharp-tailed grouse nesting habitat in southwestern North Dakota. Pages 166-174 in J. M. Peek and R. D. Dalke, eds. *Wildlife - Livestock relationships*. Dept. Wildl. Res., College of Forestry, Wildl., and Range Science, Univ. of Idaho, Moscow.
- Lonner, T. N., and D. E. Burkhalter. 1986. User's manual for the computer program TELDAY. Mont. Dep. Fish, Wildl., and Parks, Bozeman. 15pp.
- Lund, R. E. 1987. A user's guide to MSUSTAT statistical analysis package. Montana State Univ., Bozeman. 100pp.
- MacMullan, R. A., and L. L. Eberhardt. 1953. Tolerance of incubating pheasant eggs to exposure. *J. Wildl. Manage.* 17:322-330.
- Marshall, W. H., and M. S. Jensen. 1937. Winter and spring studies of sharp-tailed grouse in Utah. *J. Wildl. Manage.* 1:87-99.
- Martinson, R. K., and C. R. Grondahl. 1966. Weather and pheasant populations in southwestern North Dakota. *J. Wildl. Manage.* 30:74-81.
- Mattise, S. N., R. L. Linder, and G. D. Kobriger. 1982. Effects of grazing on sharp-tailed grouse habitat. Pages 124-132 in J. M. Peek and P. D. Dalke, eds. *Wildlife - Livestock relationships*. Dept. Wildl. Res., College of Forestry, Wildl., and Range Science, Univ. of Idaho, Moscow.
- Mohr, C. O. 1947. Table of equivalent populations of North American small mammals. *Amer. Midl. Nat.* 37:223-249.
- Moyles, D. L. J. 1981. Seasonal and daily use of plant communities by sharp-tailed grouse (Pedioecetes phasianellus) in the parklands of Alberta. *Can. Field-Nat.* 95:287-291.
- Newell, J. A., J. E. Toepfer, and M. A. Rumble. 1988. Summer brood-rearing ecology of the greater prairie chicken on the Sheyenne National Grasslands. Pages 24-31 in A. J. Bjugstad, tech coord., *Prairie chickens on the Sheyenne National Grasslands*. U.S. For. and Range Exp. Sta. Gen. Tech. Rep. RM-159. 73pp.

- Nielson, L. S., and C. A. Yde. 1982. The effects of rest-rotation grazing on the distribution of sharp-tailed grouse. Pages 147-165 in J. M. Peek and P. D. Dalke, eds. Wildlife - livestock relationships. Dept. Wildl. Res., College of Forestry, Wildl. and Range Science, Univ. of Idaho, Moscow.
- Peek, J. M., M. D. Scott, L. J. Nelson, D. J. Pierce, and L. L. Irwin. 1982. Role of cover in habitat management for big game in northwestern United States. Trans. N. Amer. Wildl. Nat. Resour. Conf. 47:363-373.
- Pepper, G. W. 1972. The ecology of sharp-tailed grouse during spring and summer in the aspen parklands of Saskatchewan. Sask. Dep. Nat. Resour. Wildl. Rep. 1. 56pp.
- Peterson, J. G. 1970. The food habits and summer distribution of juvenile sage grouse in central Montana. J. Wildl. Manage. 34:147-155.
- Ramharter, B. G. 1976. Habitat selection and movements of sharp-tailed grouse hens during the nesting and brood rearing periods in a fire maintained brush prairie. Ph.D. Thesis, Univ. of Minn., St. Paul. 78pp.
- Ricklefs, R. E. 1979. Patterns of growth in birds V. A comparative study of development in the starling, common tern, and Japanese quail. Auk 96:10-30.
- Robel, R. J., J. N. Briggs, A. D. Dayton, and L. C. Hulbert. 1970. Relationships between visual obstruction measurements and weight of grassland vegetation. J. Range Manage. 23:295-297.
- Schoener, T. W. 1971. Sizes of feeding territories among birds. Ecology 49:123-141.
- Sisson, L. 1976. The sharp-tailed grouse in Nebraska. Nebr. Game and Parks Comm., Lincoln. 88pp.
- Snedecor, G. W., and W. G. Cochran. 1980. Statistical methods. Iowa State Univ. Press, Ames. 507pp.
- Spiers, D. E., R. A. McNabb, and F. M. A. McNabb. 1974. The development of thermoregulatory ability, heat seeking, activities, and thyroid function in hatchling Japanese quail (Coturnix coturnix japonica). J. Comp. Phys. 89(2):159-174.
- Svedarsky, W. D. 1988. Reproductive ecology of female greater prairie chickens in Minnesota. Pages 193-239 in A. T. Bergerud and M. W. Gratson, eds. Adaptive strategies and population ecology of northern grouse. Univ. of Minn. Press, Minneapolis. 809pp.

- Toepfer, J. E., J. A. Newell, and J. Monarch. 1988a. A method for trapping prairie grouse hens on display grounds. Pages 21-23 in A. J. Bjugstad, tech. coord., Prairie chickens on the Sheyenne National Grasslands. U.S. For. Serv. and Range Exp. Sta. Gen Tech. Rep. RM-159. 73pp.
- , 1988b. The ecology of the greater prairie chicken as related to reintroductions. Ph.D. Thesis, Montana State Univ., Bozeman. 536pp.
- U.S. Department of the Interior. 1985. Final environmental impact statement for the management of Charles M. Russel National Wildlife Refuge. U.S. Dep. of the Interior, U.S. Fish and Wildlife Service, Washington, DC. 453pp.
- U.S. Department of Commerce. 1988. County and city data book. U.S. Dep. of Commerce, Bur. of Census, Washington, DC. 797pp.
- Veseth, R., and C. Montagne. 1980. Geologic parent materials of Montana soils. Mont. Agr. Exp. Sta., Montana State Univ. and U.S.D.A.-S.C.S. Bull. 721, Bozeman. 117pp.
- Wallestad, R. O. 1971. Summer movements and habitat use by sage grouse broods in central Montana. J. Wildl. Manage. 35:129-136.
- , and D. Pyrah. 1974. Movements and nesting of sage grouse hens in central Montana. J. Wildl. Manage. 38:630-633.
- Weigand, J. P. 1980. Ecology of the hungarian partridge in north-central Montana. Wildl. Monogr. No. 74. 106pp.
- Whitmore, R. W., K. P. Pruess, and R. E. Gold. 1986. Insect food selection by 2-week-old ring-necked pheasant chicks. J. Wildl. Manage. 50:223-228.
- Whittow, G. C. 1976. Regulation of body temperature. Pages 221-252 in P. D. Sturkie, ed. Avian Physiology, Springer-Verlag, New York. 400pp.

APPENDICES

APPENDIX A
TEMPERATURES

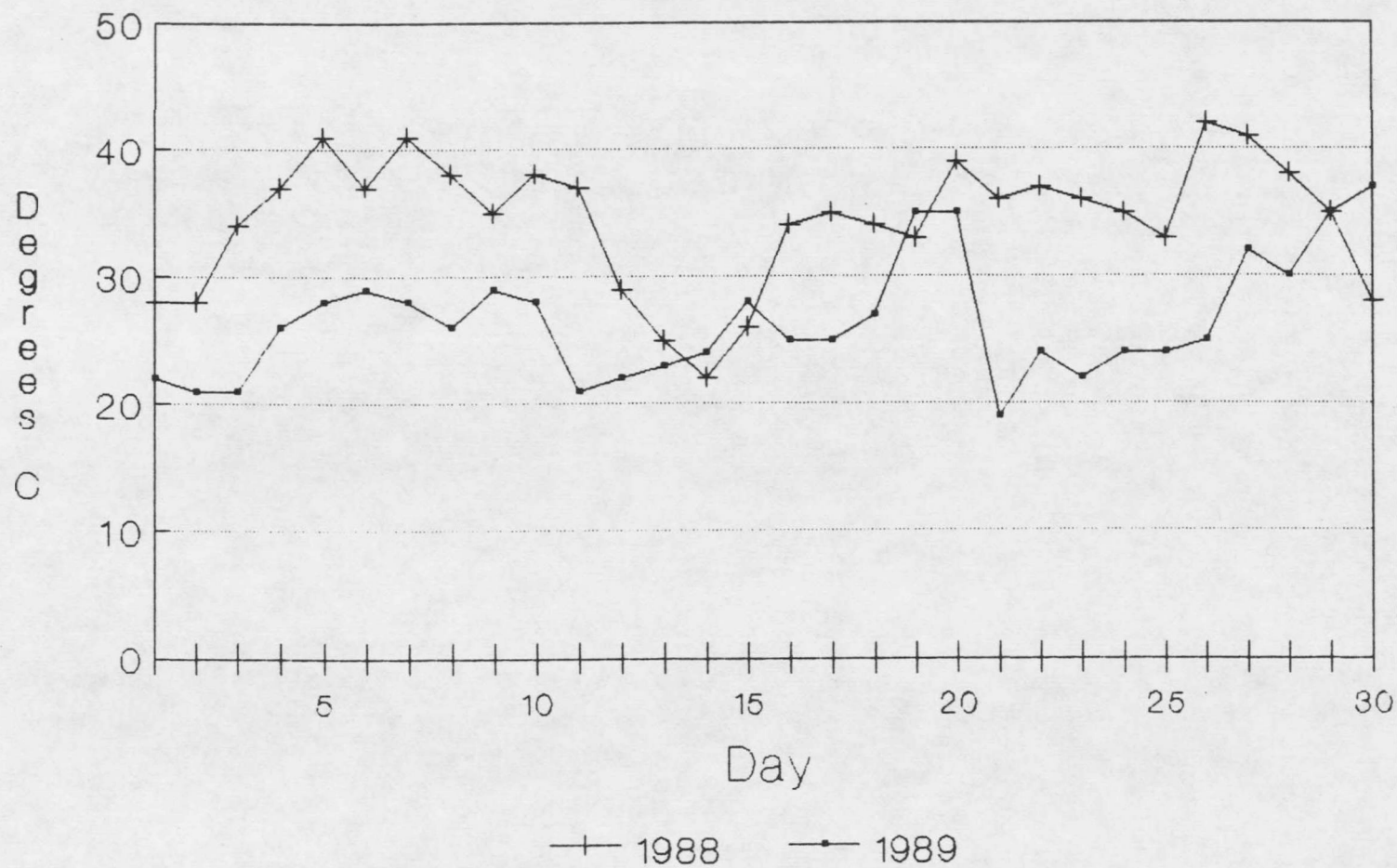


Figure 12. Daily maximum temperatures (C) during June 1988 and 1989 at the Fort Peck weather station.

APPENDIX B

TABLES

Table 27. Numbers of male and female sharp-tailed grouse captured on 3 dancing grounds during 1988 and 1989 on Skunk Coulee study area in northeastern Montana.

Dancing ground	1988		1989	
	Male	Female	Male	Female
ST-1	8	9	3	7
ST-2	3	4	3	5
ST-3	0	4	-	-
Total	11	17	6	12

Table 28. Data summary on sharp-tailed grouse captured during 1988 and 1989 on the Skunk Coulee study area. Sex: M = male, F = female; Age: A = adult, J = juvenile; Radio?: Y = yes, N = no.

Date	Bird	Sex	Age	Radio?	Days known alive	Fate
1988						
April						
9	0188	F	J	Y	62	Killed during brood period 1988, mammal.
10	0288	M	J	Y	403	Radio failure, summer 1989.
10	0388	M	A	Y	408	Radio failure, summer 1989.
10	0488	M	A	N	-	Unknown.
10	0588	F	A	Y	431	Killed during brood period 1989, avian.
10	0688	F	A	Y	47	Killed during brood period 1988, mammal.
10	0788	F	J	Y	428	Radio failure, summer 1989.
20	0888	F	J	Y	35	Killed during nesting period 1988, mammal.
20	0988	F	A	Y	35	Radio failure, summer 1988.
21	1088	M	J	N	-	Unknown.
23	1188	F	J	Y	57	Radio failure, summer 1988.
23	1288	F	J	Y	124	Survived summer 1988, fate unknown.
23	1388	F	J	Y	46	Killed during brood period 1988, mammal.

Table 28. Continued

Date	Bird No.	Sex	Age	Radio?	Days known alive	Fate
1988						
April cont..						
23	1488	F	J	Y	103	Killed during winter 1988-89, unknown.
23	1588	F	J	Y	0	Radio failure, spring 1988.
23	1688	F	A	Y	485	Active at end of 1989 field season.
24	1788	F	J	Y	483	Active at end of 1989 field season.
24	1888	M	A	Y	126	Killed during winter 1988-89, unknown.
24	1988	M	J	N	-	Unknown.
24	2088	M	J	N	-	Unknown.
25	2188	F	J	Y	31	Killed during nesting period 1988, mammal.
25	2288	M	J	N	181	Killed by hunter 10/24/88.
26	2388	F	A	Y	66	Killed during summer 1988, avian.
26	2488	M	J	N	-	Unknown.
27	2588	F	A	Y	481	Active at end of 1989 field season.
29	2688	M	A	N	-	Unknown.
May						
4	2788	M	A	N	-	Unknown.
4	2888	M	A	N	-	Unknown.
4	2988	F	J	Y	22	Killed during nesting period 1988, unknown.
1989						
April						
13	0189	M	A	N	-	Unknown.
13	0289	M	A	Y	14	Killed during summer 1989, unknown.
14	0389	F	A	Y	129	Active at end of 1989 field season.
18	0489	F	J	Y	109	Radio failure, summer 1989.
18	0589	F	J	Y	12	Killed during pre-nesting 1989,

Table 28. Continued

Date	Bird No.	Sex	Age	Radio?	Days known alive	Fate
1989						
April cont.						
18	0689	F	A	Y	58	Killed during brood period 1989, avian.
18	0789	F	A	Y	43	Killed during nest period 1989, mammal.
18	0889	F	A	N	-	Trap mortality.
18	0989	M	A	N	-	Unknown.
21	1089	M	A	N	-	Unknown.
21	1189	F	A	Y	122	Active at end of 1989 field season.
22	1289	F	A	Y	8	Killed during pre-nesting 1989, avian.
22	1389	F	A	Y	29	Killed during nesting period 1989, avian.
22	1489	F	A	Y	23	Killed during pre-nesting 1989, avian.
23	1589	M	A	N	-	Unknown.
23	1689	F	A	Y	0	Killed during pre-nesting 1989, mammal.

Table 29. Full names of cover type acronyms.

Acronym	Full name
Agsm/Artr	<u>Agropyron smithii</u> / <u>Artemisia tridentata</u>
Artr/Agsm	<u>Artemisia tridentata</u> / <u>Agropyron smithii</u>
Junip	<u>Juniperus</u>
Junip/Agsm	<u>Juniperus</u> / <u>Agropyron smithii</u>
Lakeshore	Lakeshore
Pipo	<u>Pinus ponderosa</u>
Posa/Save	<u>Poa sandbergii</u> / <u>Sarcobatus vermiculatus</u>
Save/Artr	<u>Sarcobatus vermiculatus</u> / <u>Artemisia tridentata</u>
Save/Shale	<u>Sarcobatus vermiculatus</u> /Shale
Shale	Shale

Table 30. Spring weights (gms) of sharp-tailed grouse captured during 1988 and 1989 on Skunk Coulee study area in northeastern Montana.

Year	Age	Male			Female			p-value
		N	$\bar{x}$	SD	N	$\bar{x}$	SD	
1988	Adult	6	879	51	6	753	40	0.000
	Juvenile	5	846	63	10	795	47	0.096
1989	Adult	5	845	39	9	788	32	0.013
	Juvenile	0	-	-	2	776	64	-
1988-89	Adult	11	863	47	15	774	38	0.000
	Juvenile	5	846	63	12	792	47	0.066
	Combined	16	857	51	27	782	43	0.000

Table 31. Height-Density Pole (HDP) readings from sharp-tailed grouse nest sites during 1988 and 1989 in northeastern Montana.

	HDP (cm)		
	N	$\bar{x}$	SD
Nest site			
Nest	26	16.8	7.1
1 m	26	11.7*	6.6
2 m	26	8.1*	4.3
3 m	26	7.1*	5.6
4 m	26	7.1*	7.4
5 m	26	6.6*	5.8
Canopy plant			
Juniper	17	7.8	3.1
Other	10	5.3*	2.8
Year			
1988	16	5.8	2.6
1989	11	8.4*	3.5
Age			
Adult	15	6.1	2.4
Juvenile	11	5.3	2.8
Fate			
Successful	17	5.5	2.5
Unsuccessful	9	6.4	2.7

* Significantly different from reading at top of same section.

Table 32. Percent shrub canopy coverage at sharp-tailed grouse nest sites in northeastern Montana.

	N	$\bar{x}(\%)$	SD
Cover type ^a			
Junip	19	27.2	11.1
Artr/Agsm	4	22.9	7.2
Agsm/shale	3	42.4	10.5
Agsm/Artr	1	13.0	-
Canopy plant			
Juniper	18	31.3	12.2
Other	9	21.2*	6.5
Year			
1988	16	24.1	11.0
1989	11	32.5	11.5
Age			
Juvenile	11	23.6	11.9
Adult	16	30.5	11.1
Fate			
Successful	17	28.5	13.2
Unsuccessful	10	26.3	9.1

^a Full name of cover type acronyms given in Appendix Table 29.

* Indicates significant differences between means of the same section ($p < 0.05$, Mann-Whitney U).

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