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Winter Aspects of Prairie Chicken Ecology in Northwest Minnesota

Eric L. Rosenquist

WINTER ASPECTS OF PRAIRIE CHICKEN ECOLOGY IN NORTHWEST MINNESOTA

by

Eric L. Rosenquist

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Chairperson

Dean
School of Graduate and Continuing Studies

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Winter habitat characteristics, movements, survival and behaviors of radio-marked prairie chickens were investigated in northwest Minnesota from 1992-1994. One thousand six hundred and ninety-five relocations were collected from 111 radio-marked prairie chickens from October 25 to March 7 over both years.

Habitat use was diverse and varied with time period. Agriculture and grass/forb habitats were used in nearly equal amounts during the day (43% and 45%). Night habitat use was mostly grass/forb habitat with lesser amounts of agriculture and shrub habitat. Shrub habitat was used in small amounts. Prairie chickens were seldom found within the shrubs but rather in the herbacious vegetation associated with shrubs.

Private lands were used most often both day and night. Conservation Reserve Program lands and agriculture both received heavy use. Pubic lands were used in much lesser amounts. Greatest use of public lands occurred at night.

Vegetation 26-50 cm tall received most use for roosting and loafing whereas height class 0-8 cm was used during feeding. Lands disturbed more than >4 years previous were used most often for roosting, comparatively lands disturbed <than 6 months previous received high use during feeding periods.

Snow burrows were the preferred night roost type. The use of snow burrows was believed to serve a heat conservation function. The combination of grass and forbs were important at night roost areas. Areas with thick stands of grass prevented snow burrowing and received little use.

Mean seasonal home range was 1724.0 ±3561.8 ha. Females had the greatest home ranges. Males had the smallest home ranges and showed fidelity to their home booming ground. Mean daily home range was 82.3 ha. Prairie chickens tended to associate with booming grounds, 89.9% of locations were within 4.8 km of a booming ground.

Winter survival was 57.5% and 79.2% for 1992-1993 and 1993-1994, respectively. Decreases in survival are thought the result of snow covering regular feeding areas forcing birds to move. Survival increased and remained high once in stable feeding areas. Survival decreases at winters end are probably the result of birds suffering from the cumulative stresses incurred throughout the winter. Adult males had highest mean survival (85%) while immature females had lowest (62.5%)

Mean daytime flock size was 16.7±15.3 while mean night flock size (at night roosts) was 5.7±5.3.

Management efforts should strive to provide a combination of roosting cover and feeding areas. If food plots are required they should be located around a complex of booming grounds. CRP lands should be maintained and managed. Substituting hardy forbs in place of alfalfa would be beneficial.

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Approved by Research Committee:

Alfred H. Grewe, Jr.
Alfred H. Grewe, Jr. Chairperson

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Chapter I

INTRODUCTION

Northwest Minnesota is home to the northern-most population of greater prairie chickens (*Tympanuchus cupido pinnatus* L.)* in North America, yet the winter ecology of Minnesota's prairie chickens has never been studied in detail. To date, most research has dealt with nesting and brood rearing, which are accepted as being the limiting factors for prairie grouse populations (Svedarsky 1979). Amman (1957) indicates that winter makes up one-third of the prairie chickens' life history. To effectively manage for any species, management practices must provide for daily and year round needs (Jones 1963, Christiansen 1985). Information on all aspects of the prairie chicken life history will help guide wildlife managers in making the sound decisions needed to maintain a sustainable prairie chicken population in the northern great plains area.

While several field studies have examined the winter habitat needs, food habits and behaviors of prairie chickens in the midwest (Grange 1948, Hamerstrom and Hamerstrom 1949, Amman 1957 and Hamerstrom and Hamerstrom 1973), none of these studies involved radio-marked prairie chickens in areas where snow cover lasts more then a few days.

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*Scientific names of all species listed in this text appear in Appendix A.

In Kansas, Robel et al. (1970a) were the first to monitor seasonal movements of radio-marked prairie chickens. More recently Schroeder and Braun (1992) studied radio-marked prairie chickens in eastern Colorado. The environmental conditions and habitat use in the Kansas and Colorado studies are not comparable, however, to that of northwest Minnesota.

Toepfer and Eng (1988) conducted a one year study of the winter ecology of prairie chickens at the Sheyenne National Grasslands (SNG) in North Dakota. The population on the SNG was found over a small intensively grazed area and is geographically isolated from any contiguous prairie chicken range. These characteristics are drastically different from Minnesota's prairie chicken range thus the North Dakota study may not be directly comparable to conditions found in Minnesota.

Prairie chickens are mobile birds. It is believed that prairie chickens were historically migratory (Grange 1948, Amman 1957, Hamerstrom and Hamerstrom 1973). Records from the turn of the century describe large southerly migrations of prairie chickens. The magnitude of the migration south was believed to vary depending upon winter severity. It was also believed that hens were the more migratory of the sexes often leaving the cocks behind (Gross 1930). While trapping prairie chickens the winter of 1942 in Norman and Roselle (Roseau) counties in northwest Minnesota, Carlos Avery noted greater numbers of cocks compared to hens suggesting that the hens had moved away. Large movements to winter areas are thought to have been reduced with the introduction of agriculture, especially standing corn, to prairie chicken areas (Leopold 1931).

More recently winter movements of over 40 km by marked birds have also been noted by other investigators (Hamerstrom and Hamerstrom 1949, Hamerstrom and Hamerstrom 1973, Svedarsky 1979). These movements however, have not been of the magnitude reported prior to the advent of modern agriculture. Grange (1948) writes, "The extent of present day prairie chicken migrations and the reasons for them is one of the major research enigmas and one which directly affects the future of prairie chicken management."

Little is known about winter survival in prairie chicken populations. The significance of snow accumulation and cold temperatures on prairie chicken survival is undocumented. The presence of behavioral and anatomical characteristics in prairie chickens such as the ability to snow burrow and the presence of feathered nares and tarsi suggest that prairie chickens are well suited for winter conditions in areas of heavy snowfall and low temperatures. Toepfer (1988) attributed the decline of prairie chicken populations from 1972-1976 in central Wisconsin to reduced winter survival.

Toepfer and Eng (1988) reported winter survival of radio-marked prairie chickens in North Dakota. In addition, Svedarsky (1979) reported four of five prairie chicken hens survived from summers end to the following spring in Minnesota. Previous to my thesis these were the only data dealing with winter survival of prairie chickens in areas which experience winter conditions similar to that of northwest Minnesota.

The present day prairie chicken range in Minnesota has been transformed from prairie to an area dominated by agriculture, scattered woodlots and windrows. These changes have broken up critical grassland areas and produced habitats probably not common to the area in the past (Tester 1995).

Changes in habitat use at the onset of winter, specifically heavy snow accumulation, have been noted by several investigators (Schmidt from Grange 1948, Amman 1957, Hamerstrom and Hamerstrom 1973, Manske and Barker 1988, Toepfer and Eng 1988). Prairie chicken summer activities occur almost exclusively in grassland areas (Svedarsky 1979, Newell et al. 1988). Toepfer and Eng (1988) reported a slight increase in the use of shrub, wetland and tree habitat during winter.

Partch (1970) attributes the presence of prairie chickens in northwest Minnesota to the spread of agricultural practices through the state. The use of agriculture has been significant in all previous prairie chicken studies (Leopold 1931, Amman 1957, Hamerstrom and Hamerstrom 1973, Toepfer 1988, Toepfer and Eng 1988, Manske and Barker 1988, Schroeder and Braun 1991). It appears that food near quality roosting cover is vital for prairie chicken survival in the winter.

This study was developed to better understand the needs of prairie chickens in areas of heavy snow cover and extreme low temperatures. An extensive effort has been made to document habitat use, behaviors, survival and movements of prairie chickens in northwest Minnesota during the winters of 1992 and 1993. The purpose of this paper is to present biologically sound baseline data for the purpose of aiding wildlife managers and providing a foundation upon which further prairie chicken research can draw upon.

Chapter II

STUDY AREA

This study was conducted in parts of Clay, Norman and Polk counties in northwest Minnesota. The focal points of our trapping and monitoring activities were west of State Highway 32, east of State Highway 9, north of State Highway 10 and south of U.S. Highway 2 (Figure. 1). The cities of Felton, Twin Valley, and Fertile lay within the primary prairie chicken range, thus our activities centered around these areas. This primary range encompassed 1929 sq km consisting of agriculture, Conservation Reserve Program lands (CRP), state, federal and private lands extending in a strip 24 km wide and 100 km long south to north from 19 km east of Moorhead, Minnesota to the Crookston area along the glacial Lake Agassiz beach ridges (Ojakangas and Matsch 1982).

Formed by the advance and decline of glacial Lake Agassiz, the Lake Agassiz beach ridges consist of a series of parallel sand and gravel deposits running north - south throughout northwest Minnesota (Ojakangas and Matsch 1982). Topography is flat and open making it ideal for radio-telemetry.

Nikiforoff et al. (1939) divided the area into two physiographic regions: the upland and lake bottom. The lake bottom contains clayey, loamy and sandy soils.

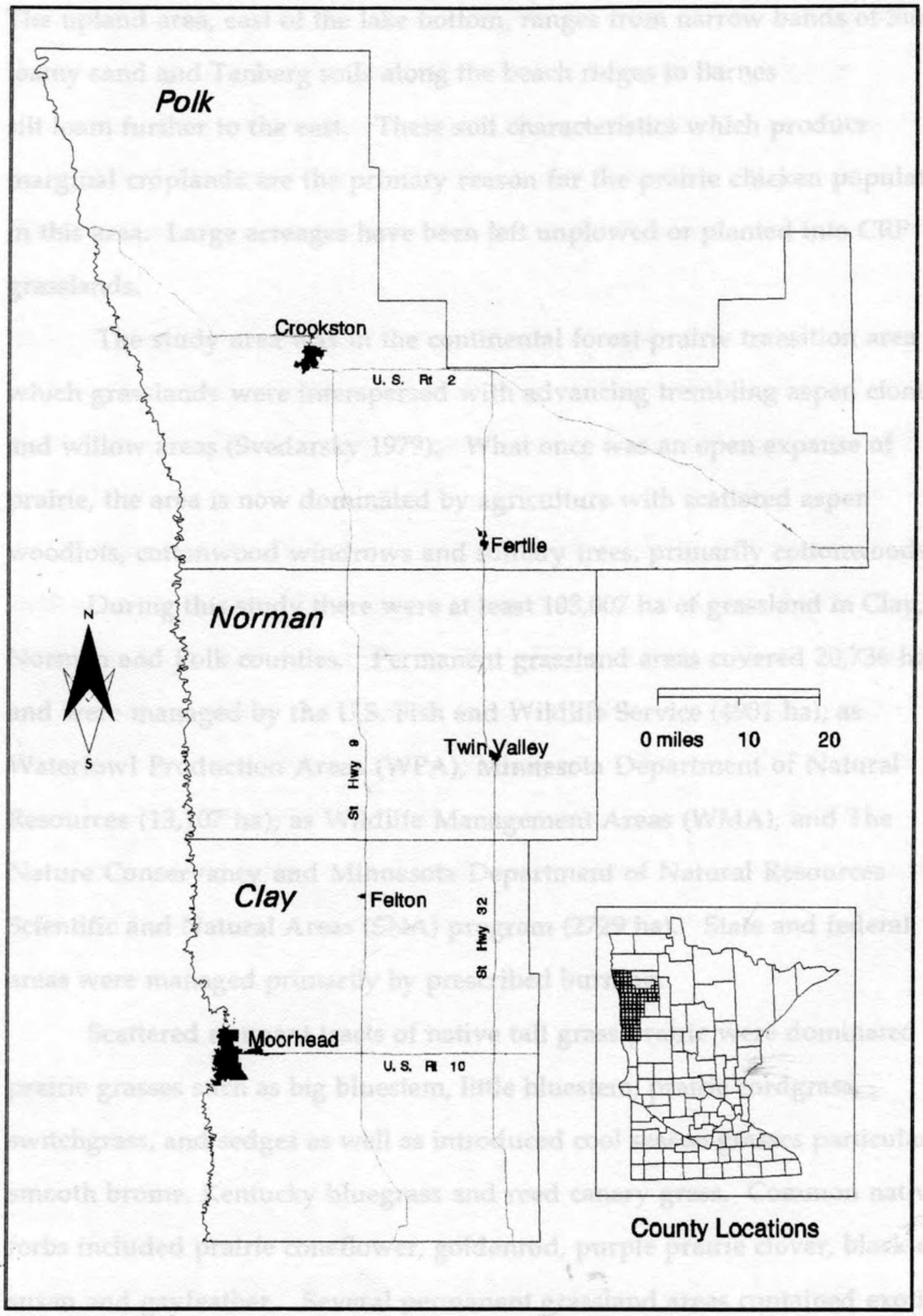

Figure 1. Prairie chicken study area in northwest Minnesota. 1992-1994.

The upland area, east of the lake bottom, ranges from narrow bands of Sioux loamy sand and Tanberg soils along the beach ridges to Barnes silt loam further to the east. These soil characteristics which produce marginal croplands are the primary reason for the prairie chicken population in this area. Large acreages have been left unplowed or planted into CRP grasslands.

The study area was in the continental forest-prairie transition area in which grasslands were interspersed with advancing trembling aspen clones and willow areas (Svedarsky 1979). What once was an open expanse of prairie, the area is now dominated by agriculture with scattered aspen woodlots, cottonwood windrows and solitary trees, primarily cottonwoods.

During this study there were at least 103,007 ha of grassland in Clay, Norman and Polk counties. Permanent grassland areas covered 20,736 ha and were managed by the U.S. Fish and Wildlife Service (4901 ha); as Waterfowl Production Areas (WPA), Minnesota Department of Natural Resources (13,107 ha); as Wildlife Management Areas (WMA), and The Nature Conservancy and Minnesota Department of Natural Resources Scientific and Natural Areas (SNA) program (2729 ha). State and federal areas were managed primarily by prescribed burning.

Scattered remnant tracts of native tall grass prairie were dominated by prairie grasses such as big bluestem, little bluestem, prairie cordgrass, switchgrass, and sedges as well as introduced cool season grasses particularly smooth brome, Kentucky bluegrass and reed canary grass. Common native forbs included prairie coneflower, goldenrod, purple prairie clover, black-eyed susan and gayfeather. Several permanent grassland areas contained exotic species such as sweet clover and birdsfoot trefoil. The base of the ridges often contained calcarous fens as well as elongate wetlands. Wetland areas were dominated by cattail, sedge, bulrush and often surrounded by shrubs.

Conservation Reserve Program (CRP) grasslands covered at least 82,271 ha in Clay (17,968 ha), Norman (24,990 ha) and Polk (39,313 ha) counties. These temporary grasslands consisted primarily of brome, switchgrass and alfalfa.

Agriculture is the dominant land use throughout the region. Corn, wheat, soybeans, sunflowers and alfalfa hay are the primary crops. Cattle operations and gravel mining are prominent industries along the beach ridge area.

Minnesota has a continental climate experiencing hot summers and cold winters. Records from the National Oceanic and Atmospheric Administration (N.O.A.A. 1993) weather station in Fargo, North Dakota, 48 km west of the primary study area, show a mean temperature of 4.5 °C. Temperatures ranged from 32 °C in the summer to lows of -20 °C in winter. Mean precipitation is 52.5 cm with a mean annual snowfall of 96.2 cm. Prevailing winds during winter are from the northwest, average wind speed is 24 km/hr, creating wind chill factors often below -40° C.

Chapter III

MATERIALS AND METHODS

TRAPPING

Prairie chickens were trapped on booming grounds in the spring, on winter feeding areas, and as broods. Walk-in funnel traps were used on booming grounds (Toepfer et al. 1988, Haukos et al. 1990, Schroeder and Braun 1991). In the late fall and winter, funnel traps without leads were baited with wheat, barley, corn or soybeans. Broods were night lighted in August and September.

Night Lighting

Broods were captured at 6-8 weeks of age by night lighting. Radio-marked hens with broods were located in their night roosts and caught by either placing an extendible handled dip net over the hen and chicks or by laying a modified mist net horizontally over the area. Modified mist nets were two sightly overlapped 30 m by 3 m, three-shelf mist nets supported by conduit poles joined end to end. Night lighting equipment consisted of a 100-watt spotlight mounted to a football helmet and powered by a 12-volt motorcycle battery carried on an external backpack frame as well as portable radio-telemetry equipment.

Bird Handling

Captured birds were immediately removed from traps or nets, placed in holding boxes and fitted with a radio transmitter and colored leg bands. Data including weight, age, sex, primary molt, calamus diameter, scapular molt, tarsus length, toe length and width, toe nail length and width, head width, bill length and width and presence or absence of pectinate were recorded. Ages were determined by scapular molt (Toepfer unpubl. data), primary wear (Amman 1944), and calamus measurements (Caldwell, 1980). Ages were classified as immature (up to 1 year) or adult (1 year or older). Sex was determined by the presence or absence of air sacs, pinnae length, and/or tail pattern (Hamerstrom and Hamerstrom 1973).

RADIO-TELEMETRY

Prairie chickens were located by standard triangulation techniques. The date, time (Central Standard Time), habitat, activity level, and vegetation height class were recorded for each location. Tracking was rotated between study areas and attempts were made to locate birds within the selected study area 1-4 times per day. Efforts were made to collect, at minimum, a night and day location on a sample of birds.

A signal could be detected by the vehicle mounted antenna up to 3.2 km, but more commonly range was about 1.2 km. Attempts to locate missing birds were made by conducting aerial searches. Radio signals could be detected at up to 24 km, but generally range was about 9 km at 365 m above ground level. Searches for missing birds began at the point of last contact and were expanded to a 50 km radius over a period of several flights. The radio was assumed to be functioning until the expected battery life had been surpassed. Flights for missing birds were conducted about three times per month.

Radio-locations

Radio-relocations were plotted on 1:660 acetate base maps made from ten sq km, 20 cm-1.6 km Soil and Conservation Service aerial photos and digitized. Relocations were digitized using Easydig 8.1 (Geocomp, LTD., 1993) and entered into the spreadsheet program Excel (Microsoft, 1995) for analysis. Times were classified into four categories: AM (1/2 hour before sunrise -11:00 AM), midday (11:01 AM -2 PM), PM (2:01 PM- 1/2 hour after sunset), and night (1/2 hour after sunset to 1/2 hour before sunrise). Distances from booming grounds were calculated using ARCINFO®. Home range was calculated following the minimum convex polygon method as described by Mohr (1947) using CALHOME (Kie et al. 1994). Home range was analyzed on daily and seasonal bases.

Radios

Radio transmitters were P2 type (AVM Instrument Co. Dublin, California) in the 150-152 Mhz frequency range; expected battery life was ± 380 days. Both the transmitter and battery were hermetically sealed in dental acrylic and mounted to a herculite bib similar to that described by Amstrup (1980). Adult radio packages weighed between 13-18 g. Radio weight never exceeded 3% of the birds body weight. Antennas were either tuned loop or modified whip antennas called coiled whips. Coiled whip antennas have the whip antenna curved around the herculite bib and are held in place with super glue and sewn to the bib with dental floss (Figure 2). Both radios were designed to keep the antenna out of the birds wings while flying (Figure 3).

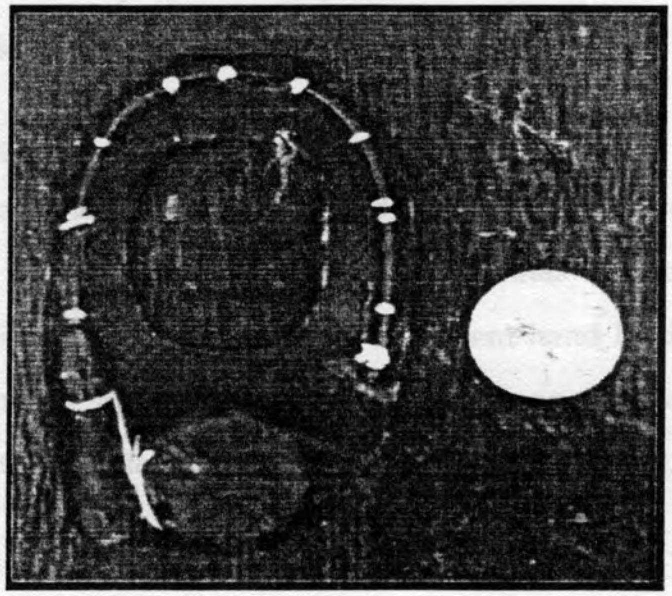

Figure 2. Coiled whip style radio. Note the antenna is attached to the herculite bib.

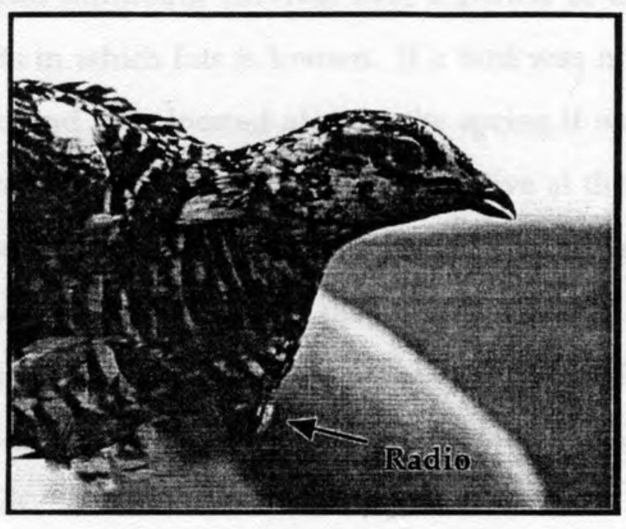

Figure 3. Hen prairie chicken fitted with a coiled whip style radio. Note there are no radio parts to inhibit flying.

Previous studies with radio-marked birds have shown the effect of the antenna in the wings as being significant to the behavior and survival of the bird (Marks and Marks 1982).

Receivers and Antennas

Birds were located with continuous band digital receivers from Advanced Telemetry Systems, Isanti, Minnesota. Antennas were either a vehicle mounted 5 element yagi antenna or a 3 element hand held antenna used for radio-tracking on foot and aerial tracking. Antennas were mounted to airplane wing struts with steel mounts designed by T. Tollefson, Beltrami, Minnesota.

SURVIVAL

Survival Analysis

Totals were calculated to determine the binomial distribution of both the known survival and minimum survival over a period of time. Known survival includes birds in which fate is known. If a bird was missing throughout the winter and then located alive in the spring it was included as a survivor. Similar to Porter et al. (1980) only birds alive at the beginning of a period were considered for analysis. Minimum survival assumes that all missing birds are dead and became part of the known mortality. Daily survival was calculated following Trent and Rongstad (1974). The use of the three different methods of analysis is intended to provide a range in which the actual survival lies.

HABITAT

Habitat types were placed into eight categories based on the visual classification of vegetation physiognomy. Habitat types were as follows. 1.) Grass/Sedge, in which those species were the dominants of the area; 2.) Forbs, were grouped in the same manner as grass/sedge; 3.) Grass/Forb, is defined as an area of nearly equal amounts of both. This was typical of most CRP and prairie areas. 4.) Agriculture, included cultivated crops and pastures, 5.) Shrubs, were areas with over 40% canopy coverage by shrubs, 6.) Trees, and 7.) Wetlands which were Type III and IV (Eggers and Reed 1987). 8.) Other was when birds were observed in areas not described in the previous categories. This included observations on roads, rock and debris piles.

Land Disturbance

Land disturbance was classified into four categories depending on how long since the last disturbance of a particular property: 0-6 months, 6 months - 1 year, 1-2 years, 2-4 years and greater than 4 years. Disturbance of an area was generally by mechanized crop land agricultural practices, burning or grazing.

Night Roosts

Night roost areas were marked, often without flushing the birds, by walking to within about 30 m of a radio-marked bird and leaving two markers 90° of each other. The following day the night roosts were located by triangulating with the markers. Vegetation species, height class, snow depth, snow burrow dimensions and the distance between birds were recorded as well as a vegetation transect. The two closest vegetation species, height and effective height class, and snow depth were recorded at each roost.

Vegetation Transects

The two closest species and snow depth were recorded at ten points spaced one meter apart in each of the cardinal directions at night roosts. Snow was recorded as a species when no vegetation was present. No efforts were made to determine vegetation species covered by snow.

Height Class

Effective height class measures the density similar to that of a Robel pole (Robel 1970b). Height class follows Toepfer and Eng (1988): Class I, up to a chickens belly (0-8 cm), Class II up to the eye of a bird (9-25 cm), Class III over the birds head (26-50 cm), Class IV (51-100 cm), Class V (1-2 m), and Class VI (over 2 m).

SEASONS

Winter was considered to be from October 25 to March 7. At this time most waste grains were covered by snow. Survival estimates were calculated begining November 1 to allow an adjustment period to winter. Winters end was marked by regular attendance on booming grounds by cocks. Display generally began in mid-March.

Chapter IV

RESULTS AND DISCUSSION

RADIO-RELOCATIONS

Between October 25 and March 7, 1992-1994, 1695 relocations from 111 radio-marked prairie chickens were collected to determine habitat use, vegetation disturbance, vegetation height class and land ownership. Both years have been combined for discussion. Data for individual years are located in Appendix B.

Daytime Habitat Use.

Daytime winter habitat use by radio-marked prairie chickens varied with the time of day as well as environmental conditions. Daytime habitat use was greatest in agricultural areas (45.0%) followed by grass/forb habitat (41.1%). Trees, shrubs, wetlands and grass were all used, however their use was small comparatively (Table 1). The decrease in the use of grass habitat as the winter progressed was due to heavy snow accumulation which packed down grass and sedge areas (Figure 4). The use of shrub habitat was slight but consistent.

Toepfer and Eng (1988) reported 53% of daytime locations in agriculture at the Sheyenne National Grassland (SNG) in North Dakota. However the use of grass and tree habitats were much higher than found in this study, 19%and 11% vs. 8% and 2.4%, respectively.

Table 1. Daytime habitat use (%) by radio-marked prairie chickens in northwest Minnesota. October 25-March 7, 1992-1994.

Habitat type	1992-1993 n=327	1993-1994 n=760	Both years n=1087
Agriculture	49.7	43.0	45.0
Grass/Forb	40.7	41.3	41.1
Grass	5.0	9.2	8.0
Shrub	0.9	2.8	2.2
Tree	3.4	2.0	2.4
Wetland	0.0	0.9	0.6
Forb	0.0	0.3	0.2
Other	0.3	0.5	0.5
Total	100.0	100.0	100.0

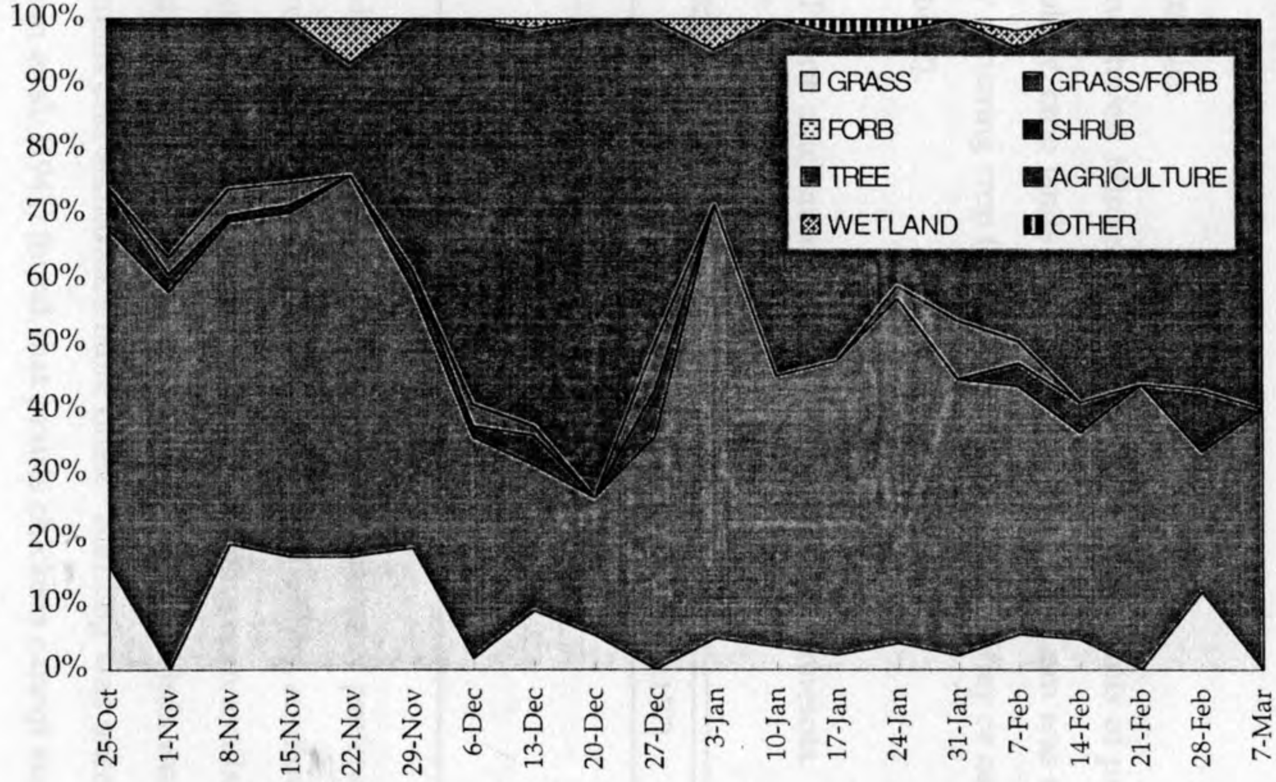

Figure 4. Weekly daytime habitat use by radio-marked prairie chickens in northwest Minnesota. Winters of 1992-1994.

In addition the use of shrubs was higher in North Dakota (6% vs. 2.2%). It may be that prairie chickens in Minnesota have a broader range available to them than chickens on the SNG and thus are able to find more favorable daytime cover.

Agriculture Use

In northwest Minnesota, and all previous accounts of prairie chicken winter ecology, crop lands played a significant role. Corn was the most frequently occurring crop (47%) followed by wheat, barley or oats together (37%) (Table 2).

Table 2. Prairie chicken use of crops in northwest Minnesota. Winters 1992-1994.

Crop	%use	(n=157)
Corn	47	
Wheat, Barley or Oat	37	
Soybean	9	
Sunflower	8	

I believe the high use of corn was not a matter of preference but rather one of necessity. As snow accumulated residual grains, sunflowers and soybeans often were covered leaving only standing corn available. When snow conditions allowed access to all crops, however, birds were found in residual grains and sunflowers more often. Budding was uncommon. Hamerstrom et al. (1941) found that prairie chickens cannot sustain themselves on a diet of buds only.

Night Habitat Use

Night habitat use was similar over both years (Table 3). Night habitat use appears to be less diverse and more consistent than that used in the daytime (Table 4). Grass/forb was used most (65.7%) followed by nearly equal but lesser amounts of agriculture (14.7%) and grass (11.9%). My observations show the use of agriculture lands was the result of birds night roosting in their feeding areas, often standing corn fields.

The use of shrub was consistent but minimal (5.9%). My observations show slight increases in tree and shrub use to be the result of the more regularly used grass/forb areas becoming snow packed and hardened from the nearly constant winds (Figure 5). Snow within these areas were not as exposed to winds and did not become hard packed thus providing more favorable snow burrowing conditions.

Toepfer and Eng (1988) reported much lower nighttime use of agriculture (4%) but increased use of shrub (12% vs. 5.9%) and wetland (6.7% vs. 1.4%). I believe this is due to the prevalent land use during the SNG project. The SNG was managed primarily by grazing, making it unsuitable to prairie chickens for night cover leaving shrub and wetland areas as the most adequate cover.

Daily Patterns

Radio-telemetry data supports patterns observed in the field. Prairie chickens often left night roost areas shortly after sunrise and flew or walked to feeding where they fed for about 30 minutes to one hour. Following feeding they went to grassland habitat near the edges of feeding areas and loafed until shortly before sundown when they returned to feeding areas.

Table 3. Nighttime habitat use (%) by radio-marked prairie chickens in northwest Minnesota. October 25-March 7, 1992-1994.

Habitat type	1992-1993 n=117	1993-1994 n=491	Both years n=608
Grass/Forb	65.0	65.8	65.7
Agriculture	14.5	14.7	14.7
Grass	13.7	11.6	12.1
Shrub	5.1	6.1	5.9
Wetland	0.0	1.8	1.4
Tree	1.7	0.0	0.3
Forb	0.0	0.0	0.0
Other	0.0	0.0	0.0
Total	100.0	100.0	100.0

Table 4. Habitat use (%) by radio-marked prairie chickens in northwest Minnesota by time period. October 25-March 7, 1992-1994.

Habitat type	AM n=475	MD n=327	PM n=285	Night n=608
Agriculture	55.0	42.2	31.6	14.6
Grass/Forb	33.7	43.1	51.2	65.6
Grass	6.5	8.3	10.2	12.0
Shrub	2.1	2.1	3.1	5.9
Tree	1.7	3.0	2.5	0.3
Wetland	0.0	0.7	1.8	1.5
Forb	0.0	0.6	0.0	0.0
Other	1.0	0.0	0.0	0.0
Total	100.0	100.0	100.0	100.0

AM= one-half hour before sunrise to 1100.
MD= 1101 to 1400 (Midday).
PM= 1401 to one-half hour after sunset.
Night= time period after PM and before AM.

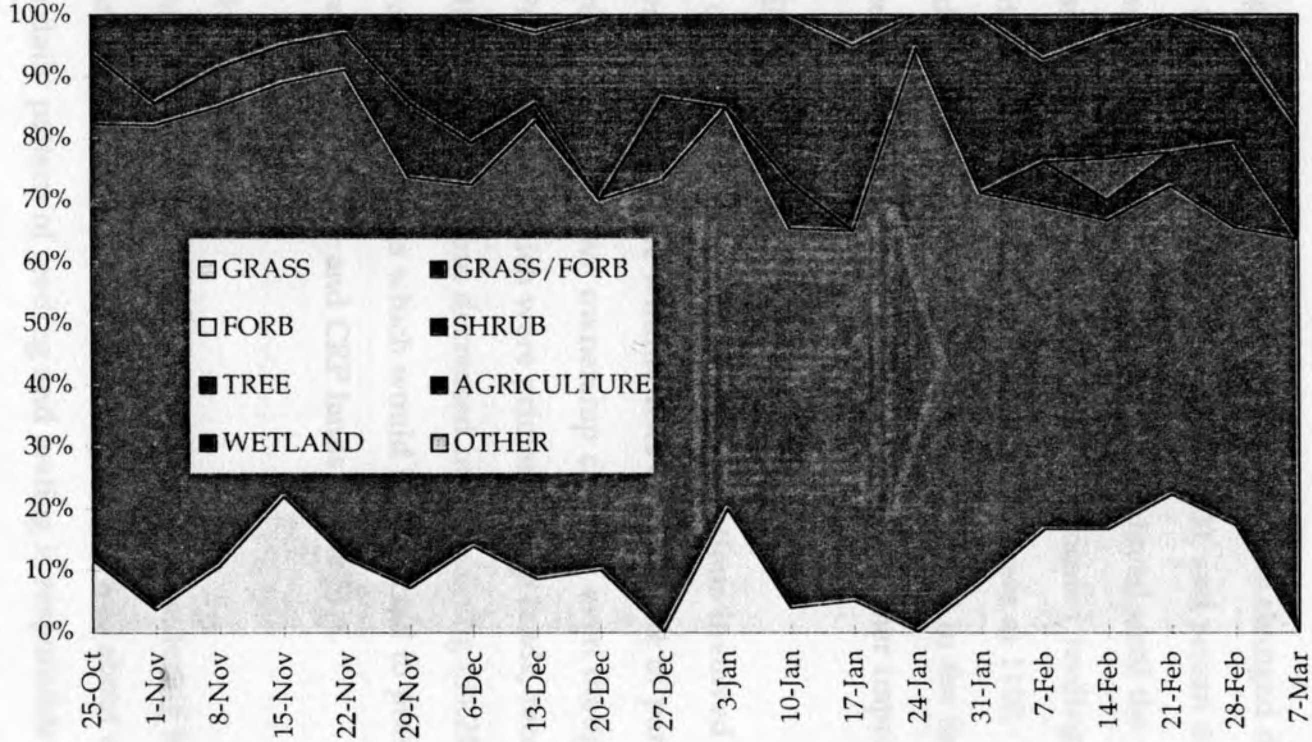

Figure 5. Weekly nighttime habitat use by radio-marked prairie chickens in northwest Minnesota. Winters of 1992-1994.

Following the evening feeding, prairie chickens loafed until sundown and then flew to night roosting areas. On occasion prairie chickens were observed loafing in trees at sundown.

During periods of extreme cold, daily patterns changed dramatically. Birds would begin feeding later, often about 0900, and return directly to night roosting areas where they snow burrowed and stayed until the next day. On several occasions feeding prairie chickens were located feeding then followed to night roosting areas and observed in snow burrows at 1100. Often prairie chickens feeding in standing corn fields night roosted in the fields in which they were feeding. This pattern continued until weather improved.

Land Ownership

Land ownership of prairie chicken relocations involved a mixture of public and private lands. The wildlife uses of CRP were of particular concern and thus considered in its own ownership category even though it is private property. Private lands, which were primarily crop lands, received high use throughout the day (60.9%) but decreased in the evening (34.2%). The reciprocal was found in lands which would be expected to provide favorable roosting cover such as public and CRP lands (Table 5).

Height Class

Height class data also follows expectations considering habitat and land ownership analysis (Table 6). Daytime height class was about equal in Class I and III. The daily pattern of feeding and loafing is responsible for high uses in Class I and III. Agricultural fields were usually plowed therefore considered Class I, and loafing areas were often in CRP areas which were often Class III. The data show very low use of height > Classes V.

Table 5. Land ownership (%) of lands used by radio-marked prairie chickens, by time period, in northwest Minnesota. October 25-March 7, 1992-1994.

Ownership	AM n=475	MD n=327	PM n=285	Night n=608
Private	66.1	59.6	53.7	34.2
CRP	20.0	27.8	29.5	40.3
WMA	6.9	8.3	10.5	13.5
SNA/TNC	6.5	4.0	6.0	11.7
WPA	0.4	0.3	0.3	0.3
Total	100.0	100.0	100.0	100.0

AM= one-half hour before sunrise to 1100.
MD= 1101 to 1400 (Midday).
PM= 1401 to one-half hour after sunset.
Night= time period after PM and before AM.

CRP (Conservation Reserve Program)
WMA (Wildlife Management Area)
SNA/TNC (Scientific and Natural Area/ The Nature Conservancy)
WPA (Waterfowl Production Area)

Table 6. Vegetation height class (%) of lands used by radio-marked prairie chickens in northwest Minnesota. October 25-March 7, 1992-1994.

Height class	Day n=1087	Night n=608	Combined n=1695
I (0-8 cm)	41.7	15.1	32.2
II (9-25 cm)	4.0	5.8	4.6
III (26-50 cm)	44.0	70.9	53.6
IV (51-100 cm)	1.8	2.5	2.1
V (1-2 m)	6.0	5.4	5.8
VI (over 2 m)	2.5	0.3	1.7
Total	100.0	100.0	100.0

Night use, height class trends illustrate the movements of prairie chickens from the Class I agriculture fields to the class III grasslands. Height class use above V is the result of wetland and shrub use for night roosting. The use of Class VI was less at night because during the day prairie chickens used trees for loafing. Prairie chickens did not roost in trees at night.

Land Disturbance

Disturbance plays a key role in prairie chicken winter habitat use. Lands with less disturbance provided more suitable roosting cover. This is where grassland managers can best focus efforts designed for prairie chickens.

Crop lands and pastures disturbed within the past 6 months were used most often during the day. Lands previously disturbed more than 4 years ago ranked second in use (Table 7). This was due to the daily pattern of agriculture and loafing cover throughout the day. During night, use of lands disturbed within the past 6 months decreased while use of lands disturbed more than two years increased. Twenty-five cm of snow was required before prairie chickens were able to snow burrow, thus the use of agriculture fields which tend to blow clear of snow was less than CRP and public lands.

Table 7. Time since last disturbance (%) of lands used by radio-marked prairie chickens in northwest Minnesota. October 25-March 7, 1992-1994.

Time since last disturbance	Day (n= 1087)	Night (n= 608)
< 6 months	60.9	34.2
6 months to 1 year	0.0	0.0
1-2 years	1.3	0.0
2-4 years	13.0	25.5
> 4 years	24.8	40.3

NIGHT ROOSTING

Snow Burrows

Lyon (1959) considered the evaluation of roost sites to be the most important facet when investigating pheasant habitat use. Since prairie chickens spend a considerable portion of their daily activity night roosting, special attention was given to night roosting sites. The tendency of grouse to snow burrow has been well documented (Bergerud and Grattson 1988). Prairie chickens appear to prefer snow burrowing when conditions permitted.

Winter Night Roost Types

The individual night roosts of 85 and 142 prairie chickens were analyzed the winters of 1992-1993 and 1993-1994 respectively. Snow burrows were used in 74.9% of night roosts over both years. Snow depressions, which were bowl shaped depressions in the snow surface, accounted for 12.8% of night roosts (Table 8). The remaining night roosts were either snow

Table 8. Breakdown of night roost types used by radio-marked prairie chickens in northwest Minnesota. Winters 1992-1994.

Type	1992-1993 % (n= 85)	1993-1994 % (n= 142)	Mean % (n= 227)
Snow burrow	78.9	72.5	74.9
Snow depression	15.3	11.2	12.8
Snow vegetation depression	1.1	13.4	8.8
Vegetation depression	0.0	2.1	1.3
Roosts unable to classify	4.7	0.6	2.2
Total	100.0	100.0	100.0

depressions associated with vegetation, vegetation roosts without snow, roosts which do not neatly fit into any of the above categories (Figure 6).

Snow Burrow Characteristics

Snow burrows were found in areas with snow accumulation >25 cm. Mean snow depth at snow burrows was 40 cm (n= 214). Typical anatomy of a snow burrow included an entry hole, tunnel, the roosting cavity which often had a ice bottom from the heat created by the bird during the night, a plug which was snow packed behind the cavity in the entrance tunnel, the ventilation hole in the main cavity and the exit hole (Figure 7). Often entrance holes were blown closed at night so casual observation showed only the exit hole. This may have lent to the popular misconception that prairie chickens dove into snow burrows from flight. Tracks to entrance holes were common. Prairie chickens would land from 0-42.5 m from the actual burrow (mean 11.1 m) and walk to the area and roost. When startled, birds would "explode" into flight directly from the burrow, this was evident by the presence of wing marks at the exit hole. Prairie chickens were also known to walk from the snow burrow.

The actual construction of a snow burrow was not witnessed. I speculate that burrows were created by first creating a depression with their feet then lowering their head and walking into the snow, moving snow to the side with their head and bill, and kicking snow back with their feet. Once under the snow I believe that a plug was created by kicking snow from the main cavity into the tunnel.

Snow burrows had a mean length of 0.97 m and mean width of 9.1 cm Tunnels to the main cavity were not always straight. Often these tunnels

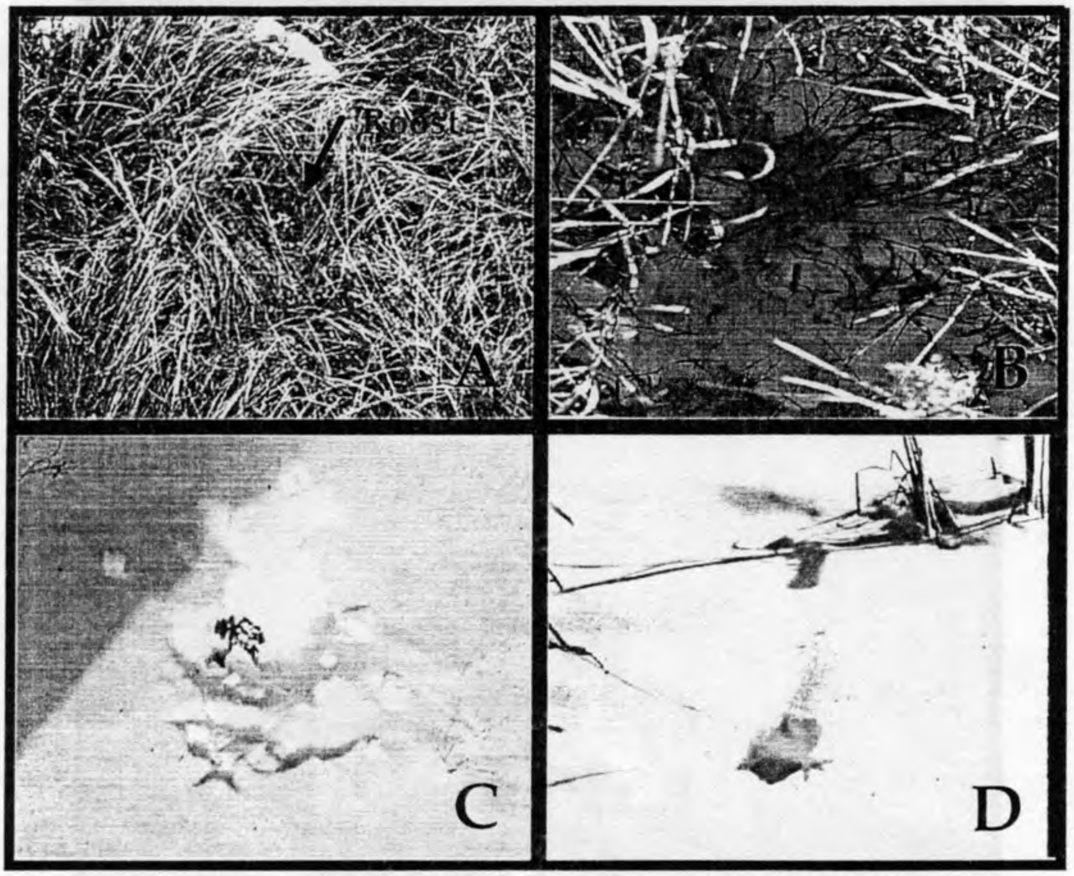

Figure 6. Night roost types used by prairie chickens during winter in northwest Minnesota. **(A)** Vegetation roost, **(B)** Snow depression associated with vegetation, **(C)** Snow depression, **(D)** Snow burrow.

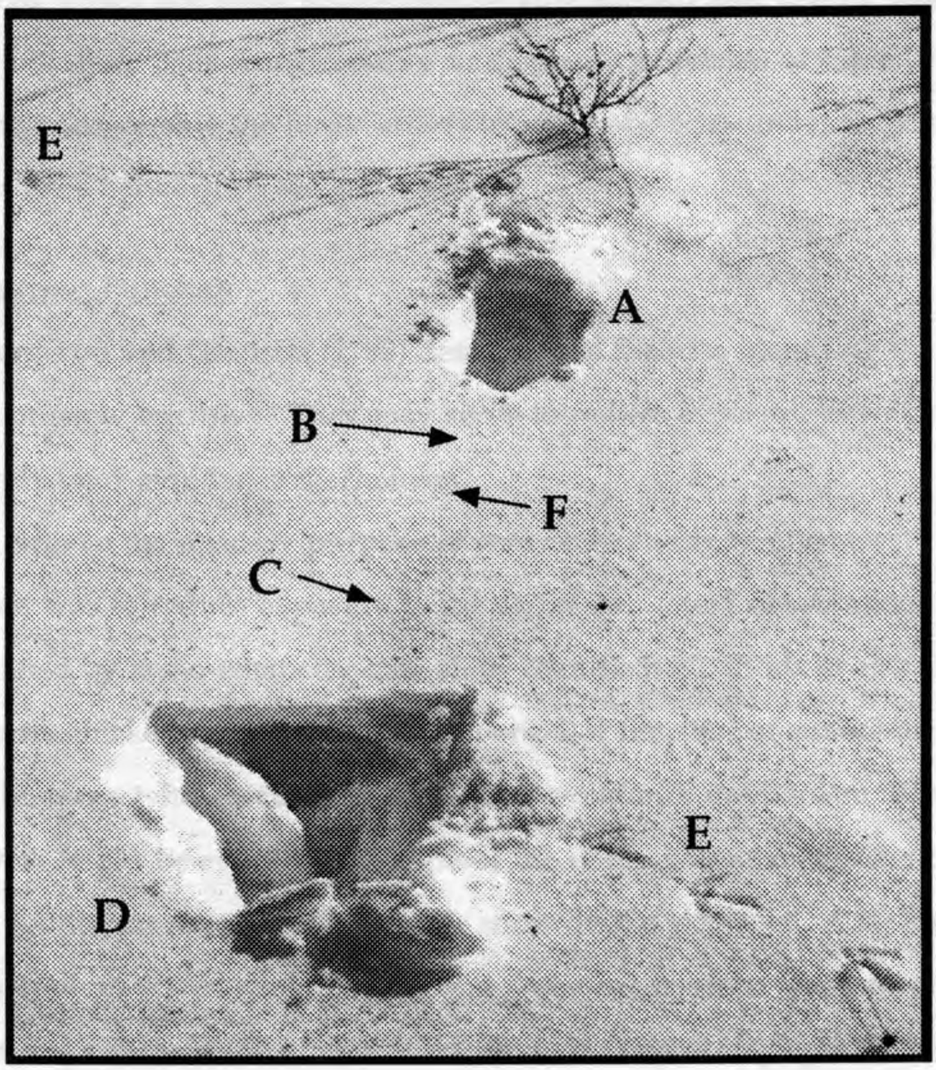

Figure 7. Typical snow burrow anatomy. (**A**) Entry hole, (**B**) tunnel area, under snow, (**C**) main chamber area under snow, (**D**) exit hole, (**E**) tracks to and from roost. (**F**) Tunnel plug, under snow.

meandered under the snow sometimes curving around and ending near the original entrance. This was necessary to deal with problems of tunnel collapsing and possibly the birds' efforts to avoid obstacles under the snow. Mean distance between roosts was 4.68 m.

Snow Burrow Function

Bergerud and Grattson (1988) describe two theories identifing the function of snow burrows. They may serve to reduce exposure to weather or act as a predator avoidance mechanism.

I believe the primary purpose of snow burrowing in northwest Minnesota was to reduce exposure to the elements. Field observations substantiated by radio-telemetry data show that during periods of extreme cold, prairie chickens spent only a short period of time out of snow burrows. If snow burrows where primarily a predator avoidance mechanism, this type of behavior might be expected throughout the entire winter regardless of weather conditions as long as acceptable snow depths persisted. Chickens did snow burrow on warm winter nights, but snow depressions were never found during cold periods. In addition, on warm winter days prairie chickens were often observed in their subsequent night roosting areas loafing above the snow until sundown.

Night Roost Vegetation Transects

Plant species occurring at night roosts were determined by vegetation transects. The two closest species above the snow along ten point transects in each of the four cardinal directions were recorded. Snow was recorded as a species in the absence of vegetation. Calculations were made including both snow as a species and also ignoring snow presence.

Grasses were dominant in both scenarios, followed by forbs (Table 9) and were often found together. Shrubs made up less than 5% of occurrences and the presence of trees was rare. Rocks, water and other miscellaneous debris were found more frequently in transects than were trees.

Of particular importance is the fact that shrubs were found in only 1.6% of transect points when snow was included as a species and 4.9% when snow was excluded. While prairie chickens do use shrub areas on occasion during the winter their use was minimal.

When prairie chickens roost in shrub habitats they seem to prefer to not roost directly among shrubs but rather in areas of herbaceous vegetation (Figures 8 and 9). Roosts were a mean of 4.5 m from shrubs.

Blowing snow dropping into open areas among the shrubs may have encouraged prairie chicken use of shrub habitat by creating favorable snow burrowing conditions. Areas such as this received the most use late in the winter when more open areas had developed an icy crust from the constant winds. Prairie chickens may have moved to the shrub areas because the preferred areas had become hard packed and difficult to burrow in.

On one occasion a prairie chicken roost was found directly under the branches of a willow. The bird which roosted there was killed that night by a coyote, possibly because its escape was hindered by the willow canopy. The tracks of the coyote went from one roost to the another suggesting a pouncing action at the burrows. It appears that the birds flushed one at a time as the coyote approached the individual roosts.

Night roosts were seldom found in areas consisting of grass only. The combination of forbs and grasses provided more favorable burrowing conditions since grass alone became packed down by snow (Figure 10). Snow

Table 9. Plant species occurence in vegetation transects at prairie chicken night roost areas. Winters 1992-1994.

Commonname	% including snow[1].	% excluding snow	n= 3516
Snow	66.8	-	2348
Grasses	25.8	77.6	906
Forbs	5.3	16.0	187
Shrubs	1.6	4.9	57
Water, rocks etc...	0.4	1.1	13
Trees	0.1	0.4	5
Grasses, sedges and rushs			
Cattail	6.0	18.2	213
Smooth brome	5.9	17.9	209
Switchgrass	3.2	9.9	116
Sedge	3.2	9.8	114
Prairie cord grass	1.4	4.3	50
Quack grass	1.3	3.9	46
Bulrush	0.9	2.9	34
Indiangrass	0.6	1.9	22
Reed canary grass	0.5	1.6	19
Timothy	0.48	1.5	17
Blue-joint	0.42	1.3	15
Big bluestem	0.3	1.0	11
Unknown grass	0.3	1.0	11
Little bluestem	tr	0.7	8
Redtop	tr	0.51	6
Junegrass	tr	0.43	5
Orchard grass	tr	0.3	4
Kentucky bluegrass	tr	0.25	3
Needle grass	tr	0.2	2
Rush	tr	tr	1
Forbs			
Goldenrod	1.5	4.5	53
Unknown forbs	1.0	3.2	37
Alfalfa	0.82	2.5	29
Wild sunflower	0.74	2.2	26
Canada thistle	0.54	1.6	19
Aster	0.25	0.8	9
Bergamot	0.15	0.4	5
Golden alexander	0.11	0.3	4
Milkweed	tr	0.2	2
Prairie rose	tr	0.2	2
Birdsfoot trefoil	tr	tr	1
Shrubs			
Willow	1.2	3.5	41
Dogwood	0.2	0.5	6
Snowberry	0.2	0.5	6
Unknown brush	0.1	0.3	4
Trees	0.1	0.4	5
Water/rocks etc...	0.4	1.1	13
Total	100.0	99.49	

tr = occurance > 0.01%

1. Snow is treated as a vegetation species.

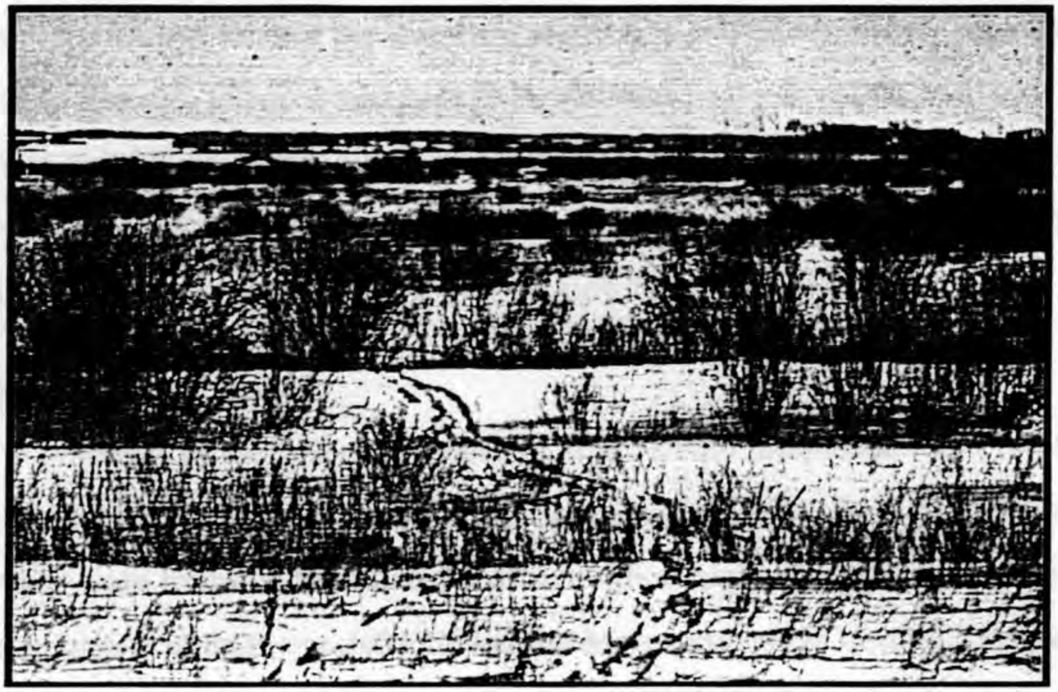

Figure 8. Overview of a prairie chicken night roost area associated with shrub habitat.

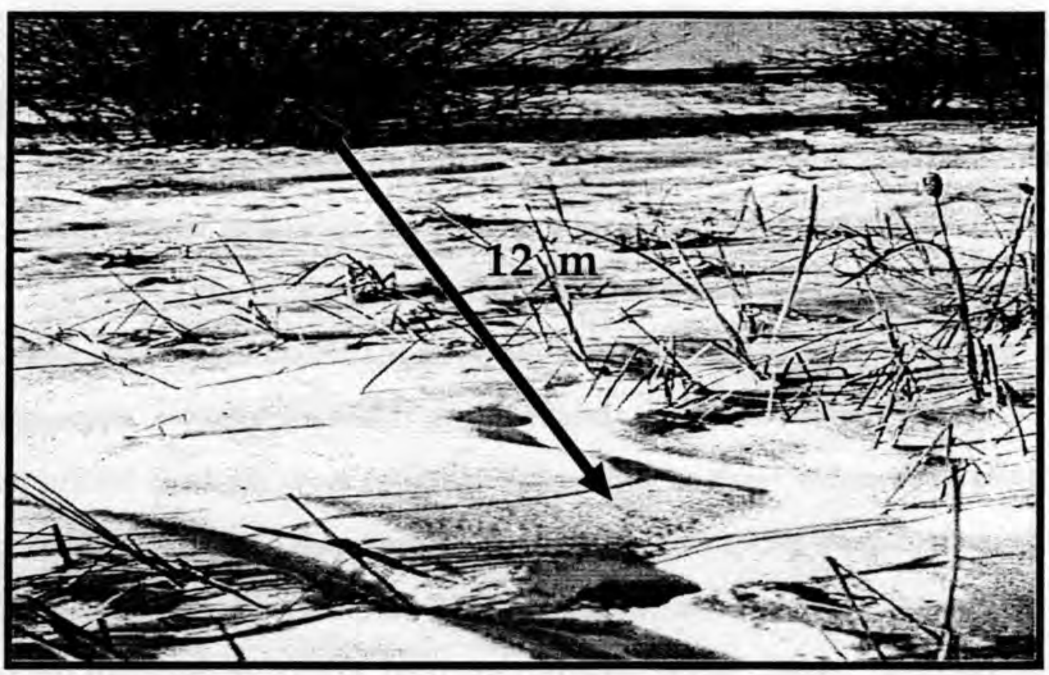

Figure 9. Actual location of night roost area seen in Figure 8. The roost is in vegetation associated with shrub area, not actually under the shrubs.

then accumulated among the standing vegetation which ultimately provided an area favorable to snow burrowing. Areas with heavy densities of grass, such as switchgrass fields, were seldom packed down by snow. These areas had thick stands of grass under the snow which restricted the movements of prairie chickens attempting to burrow (Figure 11).

Individual Night Roosts

Analysis of the two closest species at the actual individual night roosts is consistent with data from vegetation transects (Table 10). Trees and shrubs together were found at less than 6% of individual night roosts. Switchgrass was the most common species followed by high occurrences of cattail, sedge and goldenrod. My field observations, however, differ from the trends indicated in Table 10.

Sedges show a high occurrence however personal observations show that sedges were used only during the early periods of winter. As winter progressed snow accumulation covered sedges and prairie chickens moved to areas with higher occurrences of forbs. Sedges also were associated only with snow depressions and never found where birds had snow burrowed.

I believe the high occurrence of cattail and switchgrass was due to sampling bias. Field observations of night roosting areas showed that the use of monotypic switchgrass fields and wetlands were uncommon; therefore, when prairie chickens were found to be roosting in these areas, extra efforts were made to evaluate these roost sites. Had night roosts been evaluated in proportion to actual occurrence, I believe that brome would be the most common followed by alfalfa, both are common in CRP fields. Switchgrass

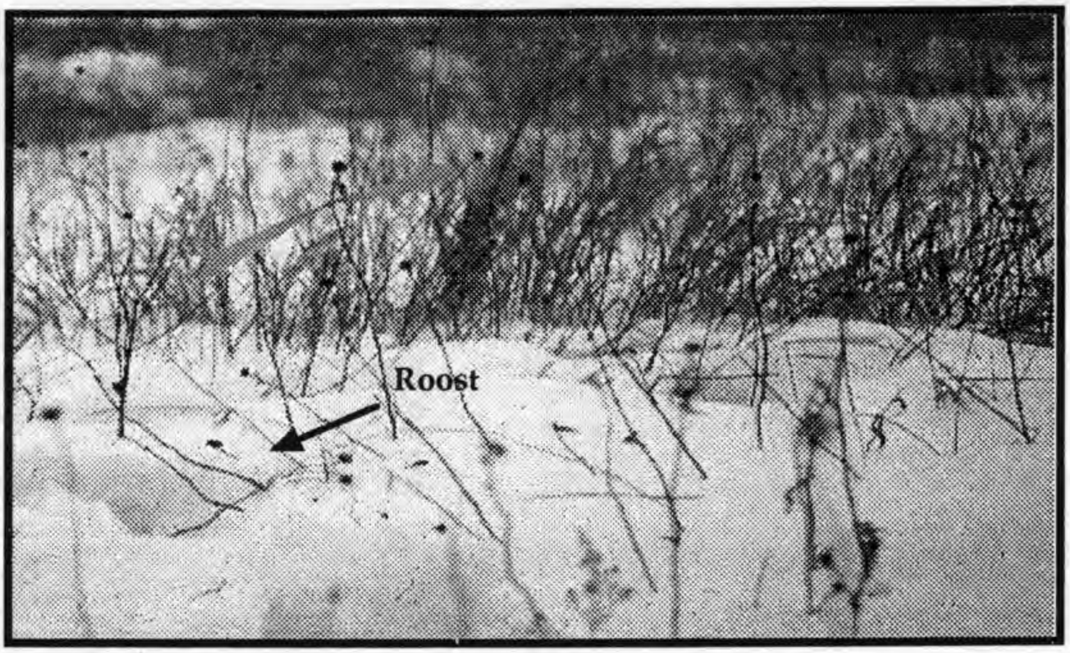

Figure 10. Example of night roost habitat preferred by radio-marked prairie chickens. Roost is directly under orange tape. Note that the roost is in the forb area rather than in the grass which surrounds the area.

Figure 11. Example of habitat type which received minimal use for night roosting by radio-marked prairie chickens. Stands of switchgrass were too dense and prevented snow burrowing.

Table 10. Percent occurence of plant species at individual night roosts of prairie chickens in northwest Minnesota. Winters 1992-1994.

Species	Including snow as a species (n= 212)	Excluding snow as a species (n= 170)
Grass	48.6	60.6
Snow	19.8	-
Forb	19.3	24.1
Agriculture crops	6.6	8.2
Shrub	5.2	6.5
Tree	0.5	0.6
Snow	19.8	-
Switchgrass	12.7	15.9
Cattail	11.8	14.7
Sedge	9.0	11.2
Goldenrod	6.1	7.6
Unknown forbs	5.7	7.1
Smooth brome	5.2	6.5
Alfalfa	4.7	5.9
Big bluestem	4.3	5.3
Sunflower	4.3	5.3
Unknown shrubs	2.4	2.9
Corn	2.4	2.9
Blue-joint	1.9	2.4
Willow	1.9	2.4
Bulrush	1.9	2.4
Aster	1.9	2.4
Timothy	0.9	1.2
Red osier dogwood	0.9	1.2
Golden alexander	0.9	1.2
Junegrass	0.5	0.6
Little bluestem	0.5	0.6
Tree	0.5	0.6

fields in the area were often far too dense to permit snow burrowing. In addition switchgrass and cattails are more likely to stick up above the snow due to their tall dense nature.

HOME RANGE

Seasonal Home Range

Home ranges of prairie chickens were variable with age and sex. Seasonal home ranges include only prairie chickens that survived the entire winter (November 1 - February 28). Female home ranges were larger than those of males (Table 11). Females showed little fidelity to booming grounds, whereas males seldom left their home booming ground for more than a few weeks.

Daily Home Range

Prairie chicken daily home ranges centered around stable feeding areas associated with roosting cover. Mean home range over a 24-hour period was 89.9 ha. Daily home ranges ranged widely throughout the season (Table 12). Home ranges were reduced during periods of colder than normal temperatures and increased when regular food sources were covered by snow. The sometimes large seasonal home ranges are the result of birds moving from food source to food source, often several km apart. Daily ranges centered around these areas.

Relationship to Booming Grounds

Almost 90% (1525 of 1695) of prairie chicken winter locations were within 4.8 km of a known booming ground and 64.8% (1099 of 1695) were within 1.6 km This is key to prairie chicken management.

Table 11. Seasonal home ranges (ha) of radio-marked prairie chickens in northwest Minnesota. November 1-February 28, 1992-1994.

	Mean and standard deviation
Both years	1724.0 ±3561.8
1992-1993	3354.7 ±5289.0
1993-1994	1301.6 ±2802.8
Adult	2085.0 ±4214.3
Immature	970.0 ±1112.7
Male	788.8 ± 801.1
Female	2824.8 ±4894.4

Table 12. Mean daily home ranges (ha) of radio-marked prairie chickens in northwest Minnesota by month. November - February, 1992-1994.

Month	Mean	Standard deviation	n=
November	87.3	±366.6	51
December	47.8	± 62.7	46
January	60.3	±123.6	48
February	81.7	± 96.6	61

The movement of a prairie chicken from the southern edge of the range to the northern range may by spectacular, but in a management perspective it is irrelevant. Since prairie chickens associate themselves with booming ground areas, the management of a radius of these areas over the entire range would consider the majority of prairie chickens.

FLOCK CHARACTERISTICS

Prairie chickens are social animals. In 639 visual observations of day flocks, during both winters, 94% were of two of more birds. Mean day flock size was 16.7 ± 15.7. Night roost areas show a mean night flock size of 5.7 ± 5.3 (n= 86). The larger flocks in the day are the result of several night roosting groups coming together in feeding areas. Fields with plentiful food have had as many as 200 birds at one time. The maximum number found in a night roost was 30.

Flocks were dynamic and subject to continual interchanging of individuals. Radio-marked birds did not show fidelity to one flock, and there does not appear to be sex segregation.

Significant differences (p>0.05) in habitat use appear when visual observations are compared to radio telemetry data (Table 13.). Seventy percent of flock observations were of birds in height Class I agricultural fields. Very few were in areas with > Class III (18.8%). Birds in heavier cover would obviously be seen less than the ones in more conspicuous agriculture fields. Of all visual observations 11% were in trees; however, radio-telemetry data showed only 2.4% of relocations in trees.

Table 13. Comparison of visual observations and daytime radio relocations of prairie chicken winter habitat use in northwest Minnesota, 1992-1994.

Habitat	Visual observations (%) n= 537	Radio relocations (%) n= 1087
Grass	3.0	8.0
Forb	0.0	0.2
Grass/Forb	7.0	41.1
Shrub	1.0	2.2
Tree	11.0	2.4
Wetland	0.0	0.6
Agriculture	70.0	45.0
Other	7.0	0.5

Radio-telemetry analysis shows that the use of height classes greater than III are used often (44.0%) by prairie chickens in the winter. Analysis and manipulation of habitat based on casual observations should be avoided. Where prairie chickens are commonly seen, when compared to radio-telemetry data, is not a viable representation of habitat usage.

SURVIVAL

Trapping Summary

A total of 111 prairie chickens were monitored over two years. As of November 1, 37 and 56 prairie chickens were equipped with radio-transmitters in 1992 and 1993, respectively. An additional six and 12 prairie chickens were radio-marked during the winters of 1992-1993 and 1993-1994 respectively. Sex and age distribution are shown in Table 14. Immatures were hatched the summer previous to the winter season, and were reclassified as adults on July 1 the following summer.

Table 14. Sex and age of radio-marked prairie chickens in northwest Minnesota during the winters of 1992-1994.

Year		Adult	Immature	Unknown	Total
1992-1993	Male	14	10	2	26
	Female	8	4	0	12
	Unknown			5	5
	Total	22	14	7	43
1993-1994	Male	13	12	0	25
	Female	17	19	7	43
	Unknown				
	Total	30	31	7	68

Seasonal Survival

Known seasonal survival for the winters of 1992-1993 and 1993-1994 was 57.5% (19 of 33) and 79.2% (38 of 48), respectively. Trends in cumulative weekly survival for each year presented in Figure 12 and Figure 13 show that survival decreases in 1992-1993 occurred during mid-winter. In comparison the winter of 1993-1994 exhibited a more consistent mortality rate. Periods of decreased survival may be due to snow accumulation.

Only one radioed bird, an immature hen, was known to have died from exposure. All others had been at least partially consumed, preventing an accurate determination of cause of death. In two separate instances a fox and a coyote killed non-radioed prairie chickens in night roost snow burrows.

Monthly Survival

The lowest survival rate during both winters (82% and 89%), occurred in February and December, respectively (Figure 14). November and January had the highest survival. The sudden loss of local food resources, due to

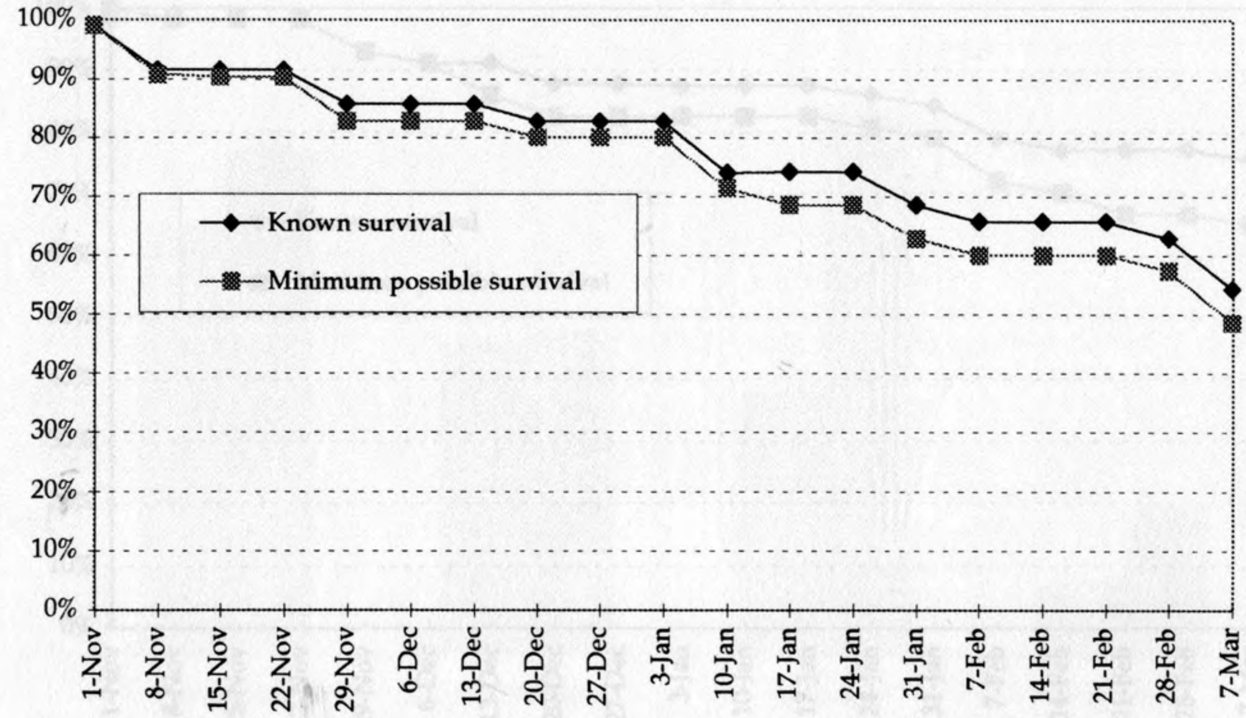

Figure 12. Cumulative known and minimum possible survival[1] of radio-marked prairie chickens in northwest Minnesota, November 1-March 7, 1992-1993.
[1] Assumes missing birds are dead.

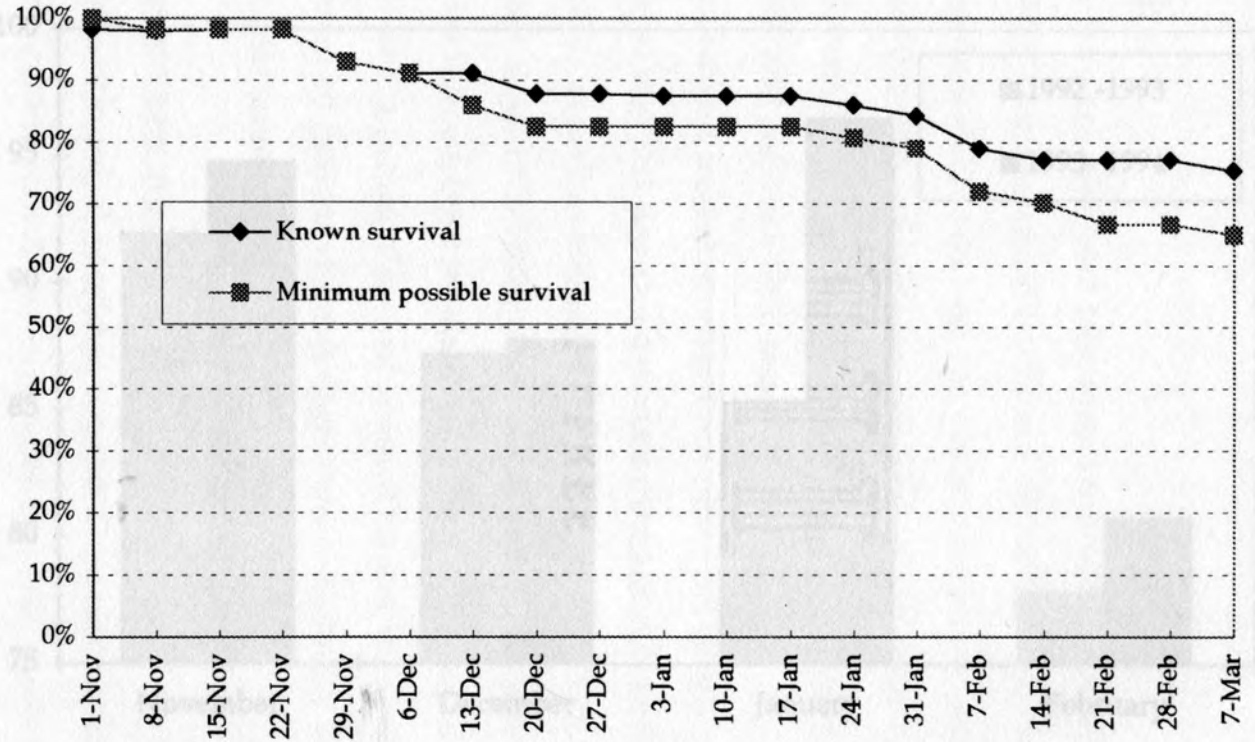

Figure 13. Cumulative known and minimum possible survival[1] of radio-marked prairie chickens in northwest Minnesota, November 1-March 7, 1993-1994.

1. Assumes all missing birds are dead.

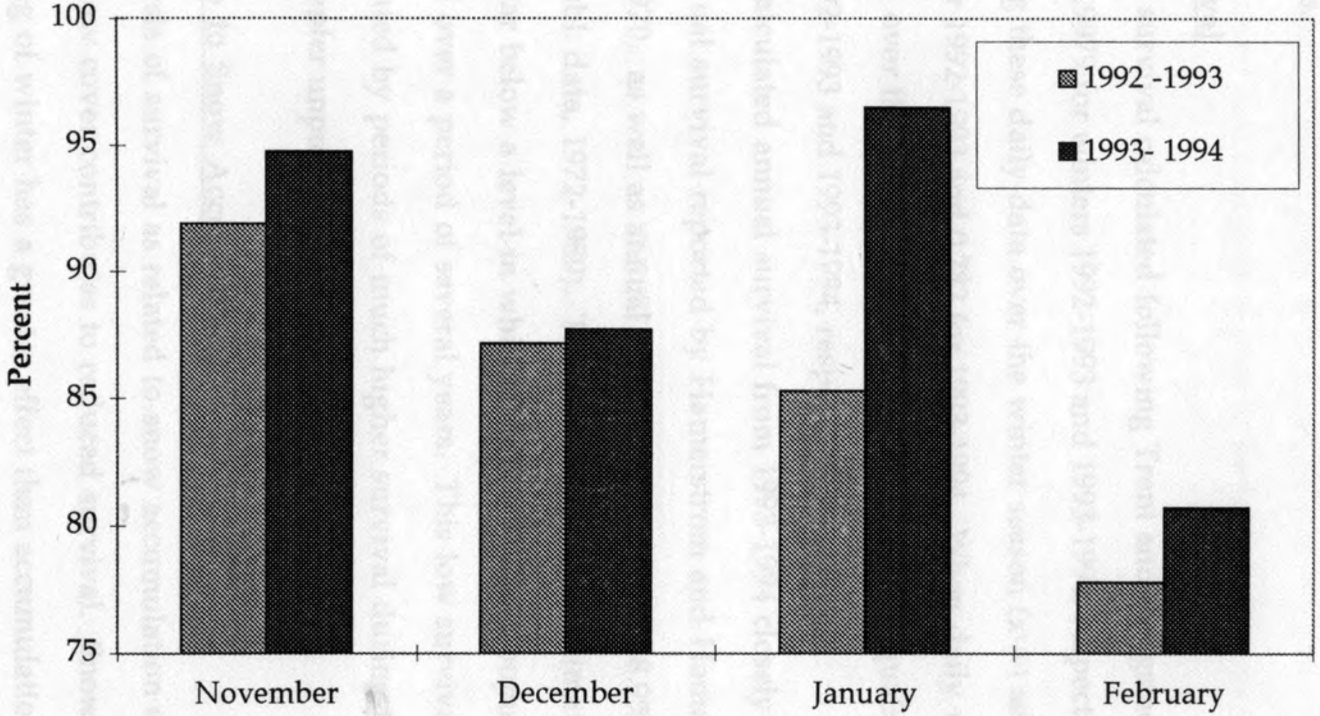

Figure 14. Monthly survival of radio-marked prairie chickens in northwest Minnesota, 1992-1994.

snow accumulation, may explain the low survival in December. The decrease in survival during February may be attributed to the cumulative stresses incurred throughout the winter and movements back to their spring home ranges.

Daily Survival

Daily survival calculated following Trent and Rongstad (1974) was 0.9952 and 0.9979 for winters 1992-1993 and 1993-1994, respectively, ($p>.05$). By extrapolating these daily data over the winter season (x^{120}) seasonal survival was 0.567 for 1992-1993 and 0.782 for 1993-1994. When daily winter survival is extrapolated over the entire year (x^{365}) annual survival equals 0.173 and 0.464 for years 1992-1993 and 1993-1994, respectively.

The calculated annual survival from 1993-1994 closely corresponds to the 46% annual survival reported by Hamerstrom and Hamerstrom (1973) from 1956-1970, as well as annual survival estimates of 48.9% by Toepfer and Tesky (unpubl. data, 1972-1980). The annual survival estimate of 0.173 however is far below a level in which a prairie chicken population could sustain itself over a period of several years. This low survival is believed to be compensated by periods of much higher survival during the remainder of the year (Toepfer unpubl. data, 1992-1996).

Relationship to Snow Accumulation

Analysis of survival as related to snow accumulation suggest that increased snow cover contributes to reduced survival. Snow accumulation at the beginning of winter has a greater effect than accumulation during the middle of winter since birds have already moved to winter feeding areas with a stable food source. As birds developed regular feeding patterns in

December and January survival increased despite increasing snow accumulation (Figure 15).

When snow accumulation is plotted as related to cumulative survival on a weekly basis there appears to be a correlation (Figures 16 and 17). Sudden increases in snow accumulation appear to be followed by periods of increased mortality.

Relationship to Temperature

Winter temperature does not appear to negatively influence prairie chicken survival (Figure 18). As temperature decreased survival increased.

Prairie chickens altered their behavior during periods of extreme cold by feeding only once per day and spending up to 22 hours in snow burrows. On several occasions of temperature < -29° C, prairie chickens were followed from feeding areas to roosting areas where they were observed roosting in snow burrows by 1100. Radio monitoring throughout the day and evening showed this to be the permanent night roost until about 0900 the next morning. This pattern would be repeated until the weather improved. Birds often restricted daily movements by roosting in the same field in which they were feeding. I believe the reduction of movements around stable food sources may be the primary reason for the increase in survival.

Sex and Age Differences in Survival

Adult birds showed a higher mean survival rate (80.4%) than immatures (65.4%). Survival rates among males and females were about equal. Immature females had the lowest mean survival (58.3%) with adult males experiencing the highest mean survival (Table 15).

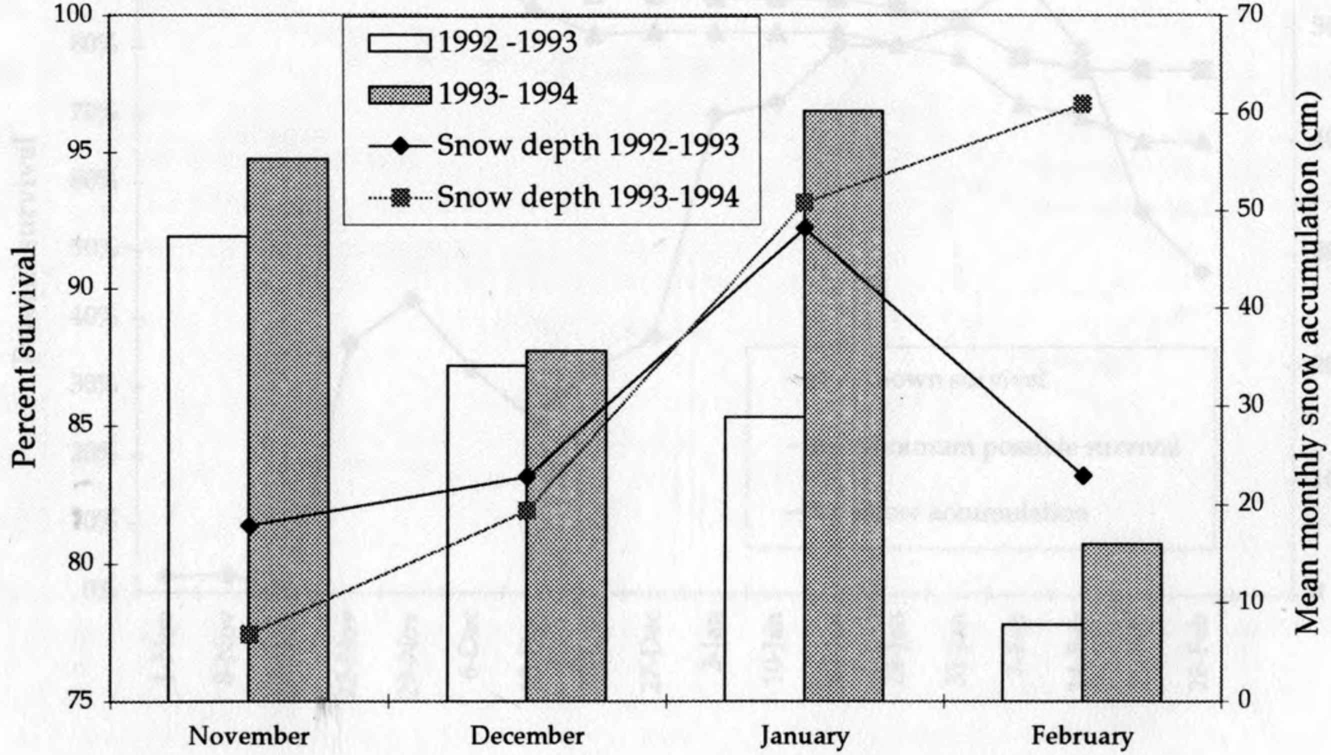

Figure 15. Monthly survival of radio-marked prairie chickens as related to mean monthly snow accumulation in northwest Minnesota. Winters 1992-1994.

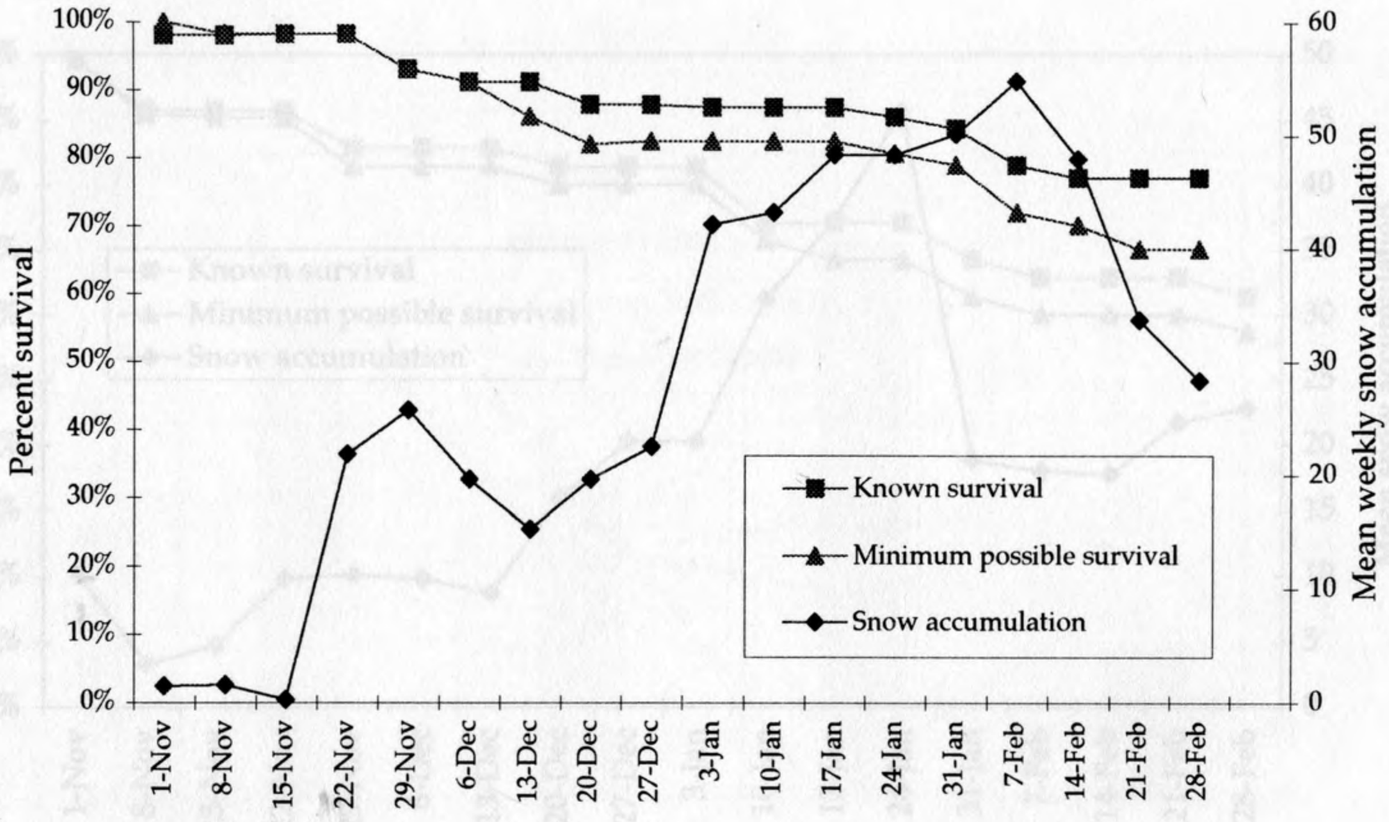

Figure 16. Cummulative weekly known and minimum survival[1] as related to snow accumulation (cm). 1993-1994.
[1] Assumes all missing birds have died.

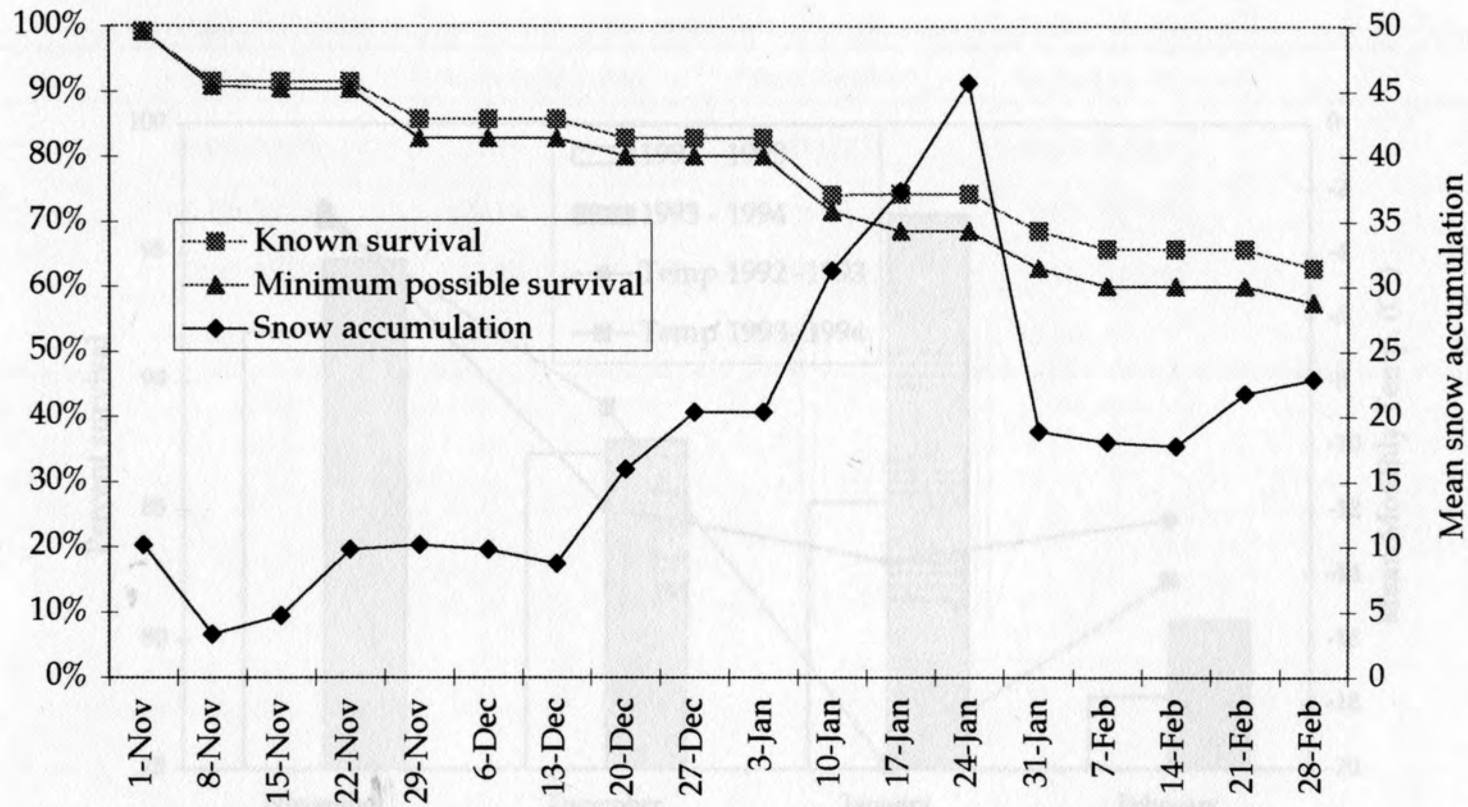

Figure 17. Cummulative weekly known and minimum survival[1] as related to snow accumulation (cm). 1992-1993.

[1] Assumes all missing birds have died.

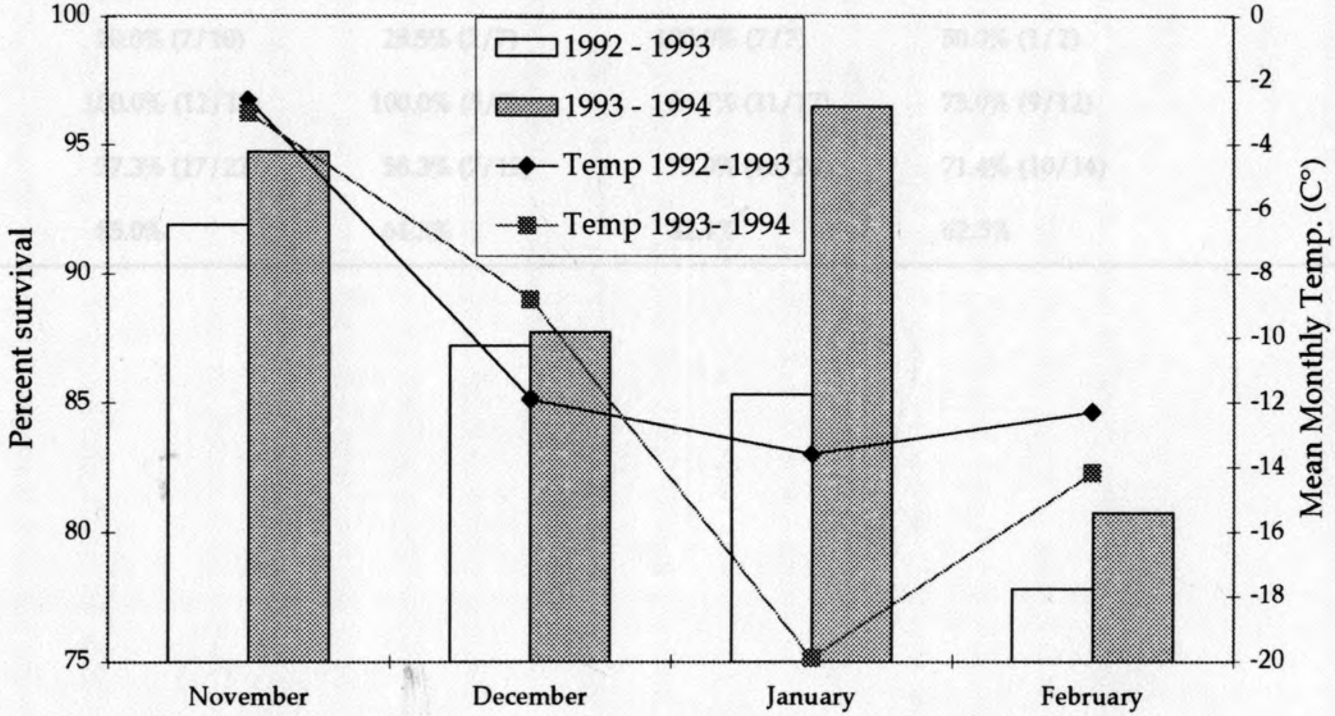

Figure 18. Monthly survival of radio-marked prairie chickens as related to mean monthly temperature in northwest Minnesota. Winters 1992 -1994.

Table 16. Survival of radio-marked prairie chickens in northwest Minnesota as related to age/sex combination. Winters 1992-1994.

	Adult males	Immature males	Adult females	Immature females
1992-1993	70.0% (7/10)	28.5% (2/7)	100.0% (7/7)	50.0% (1/2)
1993-1994	100.0% (12/12)	100.0% (5/5)	64.7% (11/17)	75.0% (9/12)
Total	77.3% (17/22)	58.3% (7/12)	75.0% (18/24)	71.4% (10/14)
Mean	85.0%	64.3%	82.4%	62.5%

Four birds that were marked before the winter of 1992 and survived to the winter of 1993-1994 also survived their second winter. Older more experienced birds may develop habits which increase effectiveness at surviving the winter.

Further Discussion

Wildlife managers in areas of heavy snow cover should expect winter survival of 75% at best. In 1988, Toepfer and Eng reported winter survival of 58.8% in North Dakota. Toepfer (1988) also reported winter survival of 41.9% in Wisconsin and attributed the decline of prairie chickens in Wisconsin to low winter survival.

Considering that prairie chickens average about 50% annual survival (Hamerstrom and Hamerstrom 1973), a survival rate of 75% in the winter encompasses a significant portion of the total annual survival. It appears that improvements in winter survival would increase the number of birds available to reproduce the following spring.

Weather plays a role in prairie chicken winter survival. Snowfall at the beginning of winter covers regular feeding areas and forces birds to new areas with accessible food above the snow near roosting cover. It is at this time that increases in mortality were observed. Once birds settled into stable feeding areas, in December and January, survival increased and remained high.

The cold and snow appear to again take their toll at the end of winter. During both years February had lower survival then the other months. I believe that at this time birds are suffering from the cumulative effects of the winter.

In addition, at this time, cocks especially, began to move back to booming grounds at which foods resources were minimal.

Chapter V

MANAGEMENT RECOMMENDATIONS

Management efforts to improve prairie chicken winter conditions should consist of three basic components: habitat management; food accessibility; and population monitoring. Recommendations made here deal only with winter aspects of prairie chicken ecology. Nesting and brood rearing habitat have been long accepted as the critical components of prairie grouse management.

Although winter encompasses a significant portion of the prairie chickens life history I do not believe that adverse conditions will seriously harm stable prairie chicken populations. Improvements of winter survival could serve as an additive function, and leave more birds for reproduction the following spring.

HABITAT MANAGEMENT

Ecological Patterning

The basic premise of ecological patterning as described by Hamerstrom et al. (1957) is that since prairie chickens are very mobile birds a large range consisting of scattered grassland plots is perhaps the most practical way, both biologically, politically and economically, to maintain a prairie chicken population.

Scattered tracts of grassland should be positioned within 5 km of prairie chicken booming grounds throughout the entire range. My data show that although prairie chickens can make very large movements, 89.9% of all locations were within 4.8 km of a booming ground.

My observations of prairie chicken seasonal movements show the least fidelity to booming grounds in the winter. Since almost 90% of all locations were within 4.8 km this is the maximum radius needed for management. Hamerstrom and Hamerstrom (1973) also found 85.8% of winter band returns within 8 km of a booming ground. Ecological patterning may prove to be of particular importance to dispersing broods. Immature birds showed the least fidelity to a booming ground and ranged over a greater area than adults.

Habitat Manipulation

My observations show that winter habitat use by radio-marked prairie chickens is much more diverse than habitat used during the nesting and brood rearing periods. Prairie chicken ranges should include a variety of habitats including grass/forb, wetland, shrub and agriculture.

Manipulation of these habitats has also proved to be significant. Since Class III vegetation was used most, areas receiving heavy livestock grazing or fall burning provided little roosting cover as snow blew clear creating unfavorable conditions for snow burrowing.

My observations of areas experiencing fall burns are that such burns adequately retard shrub growth. A shrub area burned during the fall would likely receive little use the following winter this burning would help to open the area and make it available for use in the future. Shrub encroachment in prairie chicken range should be avoided. Prairie chickens need open areas.

Conservation Reserve Program

Conservation Reserve Program (CRP) lands played a significant role in the winter habitat use of prairie chickens. Thirty-three percent of all locations were in CRP fields. The absence of CRP grasslands from the prairie chicken range will have negative effects. CRP acreages in the chicken range should be maintained and managed. It would be desirable if a portion of a CRP field were managed by fire, grazing or haying each year. CRP fields in the vicinity of booming grounds are of particular importance.

I noticed that CRP fields planted with brome and alfalfa had a decreasing forb component over time. The mixture of grasses and forbs were an important habitat characteristic for prairie chicken winter habitat use. CRP fields should be seeded with a greater variety of forbs so that the forb component will be maintained over the entire term of the CRP contract. Alfalfa does not last more than 5-6 years. Goldenrod, golden alexander, wild sunflower as well as other hardy forbs would be suitable substitutes.

Hybrid Aspen

The planting of hybrid aspen for paper pulp production has become increasingly popular in northwest Minnesota. Hybrid aspen will over time further reduce open space which is critical to prairie chickens and should be avoided.

Grass Control

Several grass associations received minimal use by radio-marked birds. Giant reed grass, reed canary grass and switchgrass provided poor night roosting cover. These associations should be removed from prairie chicken areas. Switchgrass could be a useful species if found in light densities.

FOOD ACCESSIBILITY

This study shows significant prairie chicken use of residual crops during the winter. The presence of food sources near adequate cover appears to be the major requirement of Minnesotas prairie chickens. Snow accumulation covering agricultural fields forces birds to alternative food sources often several km from their home booming ground.

These alternative sources were always exposed crops, particularly standing corn, in areas with grassland cover nearby.

Food Plots

Gross (1930) stated that winter feeding is of vital importance to the welfare of prairie grouse and advocated the establishment of feeding platforms throughout prairie chicken range in areas of heavy snow cover. Food plots appear to be the most effective method of providing food for a particular species or area. The chief disadvantage of food plots is that it is impossible to predict in the spring if winter conditions will require additional food.

My observations show that food plots for prairie chickens would be most beneficial within a complex of several booming grounds and in areas with large acreages of grassland (>243 ha) without corn fields within 1.6 km. Management practices should follow the guidelines established by Hamerstrom and Hamerstrom (1973). Agriculture is common throughout the prairie chicken range in northwest Minnesota so the need for winter food plots is minimal.

Landowners should be encouraged to practice minimum tillage which will leave more residual grain on the ground surface. Fall plowing reduces the amount of food available during the winter months. Little use was made of fields that were mold board plowed.

Monies spent on long term habitat acquisition and manipulation would be more effective then the development of winter feeding programs.

MONITORING

Annual spring census of prairie chicken booming grounds are essential. It has been my experience that winter flocks of prairie chickens are variable and scattered, depending on environmental conditions. It is also difficult to sex mixed flocks in contrast to booming ground counts which are primarily of males.

Winter movements to other areas would mislead managers as to the habitat conditions of specific areas. On several occurrences areas with high winter concentrations contained birds from several areas but at the onset of spring many birds moved to areas up to 48 km away. Spring monitoring provides a consistent index to which local habitat conditions can be indexed and monitored.

Chapter VI

SUMMARY

1. Winter ecology aspects of the greater prairie chicken in northwest Minnesota was studied from 1992-1994. Clay, Norman, and Polk counties were the primary study area.

2. Winter survival, habitat characteristics, movements and winter behaviors were documented.

3. Land use characteristics including, habitat, land disturbance, vegetation height class and land ownership was determined for 111 radio-marked prairie chickens from October 25-March 7, yielding 1695 locations.

4. Agricultural areas had the greatest daytime habitat use (44%). Forty-one percent of locations were in the grass/forb habitat type. The use of grass/forb habitat increased to 65.7% at night. The use of trees, shrubs and wetlands was minimal.

5. Corn was used for feeding most often but only because it was most accessible above the snow. Small grains were preferred. Feeding areas near roosting cover were the center of prairie chicken activities. Budding was uncommon.

6. Private lands received high use throughout the winter. The use of public land was light but consistent. Class III vegetation height class was used often both night and day.

7. Lands last disturbed <4 years ago received high nighttime use for roosting whereas lands disturbed within the last 6 months were used most during the day for feeding.

8. Prairie chickens restricted their movements during cold weather, often feeding only once per day and returning to night roosts by 1100.

9. Snow burrows were common night roost types occurring 74.9% of the time. Snow burrows appeared to serve a thermo-regulatory function.

10. Grasses and forbs were common in night roost vegetation transects. Trees and shrubs were seldom found in vegetation transects or at roosts. Chickens preferred to roost in herbacious vegetation associated with shrubs rather than in or under the shrubs.

11. Known survival for 1992-1994 (November 1-February 28) was 57.5% and 79.2%, respectively. Decreases in survival may be attributed to sudden snow accumulation in November. The lowest survival was recorded in February, probably due to the cumulative stresses incurred throughout the winter. Low winter temperatures did not decrease survival.

13. Immature females suffered the lowest mean survival (62.5%). Adult males and adult females both experienced survival > 80%.

14. Day flock size was 16.7 ±15.7 compared to night flock size of 5.7 ±5.3.

15. Management efforts should strive to provide suitable habitat within a 4.8 km radius of booming grounds. This should include accessible winter food in the vicinity of quality roosting cover.

16. Seasonal home ranges were variable. Females had the greatest home ranges (2215.7 ha) while males showed strong fidelity to home booming grounds and had much smaller home ranges (981.7 ha). Mean daily home range was 82.3 ha, and was related to environmental conditions.

17. The combination of grass and forbs was an important habitat component at prairie chickens night roosts. Thick stands of grasses were too thick to permit snow burrowing.

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APPENDIX A

Scientific Names of Plants and Animals Cited in Text

Plants from Ownbey and Morley (1991)

Grasses and sedges

Barley	*Hordeum vulgare* L.
Big bluestem	*Andropogon gerardii* Vitman
Bulrush	*Scirpus spp.*
Cattail	*Typha spp.*
Corn	*Zea mays* L.
Giant reed grass	*Phragmites australis* (Cav.) Steud.
Indian-grass	*Sorghastrum nutans* (L.) Nash
Junegrass	*Koeleria macrantha* (Ledeb.) Schultes
Kentucky bluegrass	*Poa pratensis* L.
Little Bluestem	*Andropogon scoparius* Michx.
Needle grass	*Stipa comata* Trin. & Rupr.
Orchard grass	*Dactilis glomerata* L.
Prairie cordgrass	*Spartina pectinata* Link
Quack grass	*Andopyron repen* s(L.) Beauv.
Redtop	*Agrostis stolonifera* L.
Canary grass	*Phalaris arundinacea* L.
Blue-joint	*Calamagrostis canadensis* (Michx.) Nutt.
Rush	*Juncus spp.*
Sedge	*Carex spp.*
Smoothbrome	*Bromus inermis* Leyss
Switchgrass	*Panicum virgatum* L.
Timothy	*Phleum pratense* L.
Wheat	*Triticum aestivum* L.

Forbs

Alfalfa	*Medicago sativa* L.
Aster	*Aster spp.*
Bergamot	*Monarda fistulosa* L.
Birdsfoot trefoil	*Lotus corniculatus* L.
Black-eyed susan	*Rudbeckia hirta* L
Canada thistle	*Cirsium arvense* (L.) Scop.
Gayfeather	*Liatris spp.*
Golden alexander	*Zizia aurea* (L.) Koch
Goldenrod	*Solidago spp.*
Leadplant	*Amorpha canescens* Pursh
Milkweed	*Asclepias syriaca* L.
Prairie rose	*Rosa spp.*
Purple coneflower	*Echinacea angustifolia* DC.
Purple prairie clover	*Petalostemum purpureum*(Vent.) Rydb.
Soybeans	*Glycine max* (L.) Merr.
White sweet clover	*Melilotus alba* Medic.
Wild Sunflower	*Helianthus annuus* L.
Yellow sweet clover	*Melilotus officinalis* (L.) Pallas

Trees and shrubs

Cottenwood	*Populus deltoides* March.
Dogwood	*Cornus spp.*
Snowberry	*Symphoricarpos albus* (L.) Blake
Trembling aspen	*Populus tremuloides* Michx.
Willow	*Salix spp.*

Birds from Green and Janssen (1987).

Greater prairie chicken	*Tympanuchus cupido pinnatus*
Sharptail grouse	*Tympanuchus phasianellus*
Ruffed grouse	*Bonasa umbellious*
Wild turkey	*Meleagris gallopavo*
Great horned owl	*Bubo virginianus*

Mammals from Jones and Birney. (1988).

Coyote	*Canius latrans*

Appendix B

Tables

Table 16. Habitat use (%) by time period by radio-marked prairie chickens in northwest Minnesota. October 25-March 7, 1992-1993.

Habitat type	AM n= 138	MD n= 100	PM n= 89	Night n= 117
Agriculture	65.9	51.0	22.5	14.5
Grass/Forb	29.0	38.0	61.8	65.0
Grass	2.2	5.0	10.1	13.7
Shrub	0.7	1.0	1.1	5.1
Tree	1.4	5.0	4.5	1.7
Wetland	0.0	0.0	0.0	0.0
Forb	0.0	0.0	0.0	0.0
Other	0.7	0.0	0.0	0.0
Total	99.9	100.0	100.0	100.0

Table 17. Habitat use (%) by time period by radio-marked prairie chickens in northwest Minnesota. October 25-March 7, 1993-1994.

Habitat type	AM n= 337	MD n= 227	PM n= 196	Night n= 491
Agriculture	50.4	38.3	35.7	14.7
Grass/Forb	35.6	45.4	46.4	65.8
Grass	8.3	9.7	10.2	11.6
Shrub	2.7	2.6	3.1	6.1
Tree	1.8	2.2	2.0	0.0
Wetland	0.0	0.9	2.6	1.8
Forb	0.0	0.9	0.0	0.0
Other	1.2	0.0	0.0	0.0
Total	100.0 (337)	100.0 (227)	100.0 (196)	100.0 (491)

AM= one-half hour before sunrise to 1100.
MD= 1101 to 1400 (Midday).
PM= 1401 to one-half hour after sunset.
Night= time period after PM and before AM.

Table 18. Vegetation height class (%) of land used by radio-marked prairie chickens in northwest Minnesota. October 25-March 7, 1992-1993.

Height class	Day n= 327	Night n= 117	Combined n= 444
I (0-8 cm)	37.3	17.1	32.0
II (9-25 cm)	4.6	9.4	5.9
III (26-50 cm)	38.8	67.5	46.4
IV (51-100 cm)	3.7	0.9	2.9
V (1-2 m)	12.2	4.3	10.1
VI (over 2 m)	3.4	0.9	2.7

Table 19. Vegetation height class (%) of land used by radio-marked prairie chickens in northwest Minnesota. October 25-March 7, 1993-1994.

Height class	Day n= 760	Night n= 491	Combined n= 1251
I (0-8 cm)	43.7	14.7	32.2
II (9-25 cm)	3.7	4.9	4.2
III (26-50 cm)	46.2	71.7	56.2
IV (51-100 cm)	1.0	2.9	1.8
V (1-2 m)	3.3	5.7	4.2
VI (over 2 m)	2.1	0.2	1.4

Table 20. Land ownership (%) of land used, by time period, by radio-marked prairie chickens in northwest Minnesota. October 25-March 7, 1992-1993.

Ownership	AM n= 138	MD n= 100	PM n= 89	Night n= 117
Private	73.9	70.0	62.9	59.8
CRP	23.2	27.0	34.8	34.2
WMA	2.2	2.0	1.1	4.3
SNA/TNC	0.7	1.0	1.1	0.9
WPA	0.0	0.0	0.0	0.9
Total	100.0	100.0	100.0	100.1

Table 21. Land ownership (%) of land used, by time period, by radio-marked prairie chickens in northwest Minnesota. October 25-March 7, 1993-1994.

Ownership	AM n= 337	MD n= 227	PM n= 196	Night n= 491
Private	62.9	55.1	49.5	28.1
CRP	18.7	28.2	27.0	41.8
WMA	8.9	11.0	14.8	15.7
SNA/TNC	8.9	5.3	8.2	14.3
WPA	0.6	0.4	0.5	0.2
Total	100.0	100.0	100.0	100.1

AM= one-half hour before sunrise to 1100.
MD= 1101 to 1400 (Midday).
PM= 1401 to one-half hour after sunset.
Night= time period after PM and before AM.

CRP (Conservation Reserve Program)
WMA (Wildlife Management Area)
SNA/TNC (Scientific and Natural Area/ The Nature Conservancy)
WPA (Waterfowl Production Area)