Reintroduction of greater prairie chickens using egg substitution on Arrowwood National Wildlife Refuge, North Dakota

by Howard Raymond Burt

A thesis submited in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University

Abstract:
Reintroduction of greater prairie chickens (Tympanuchus cupido pinnatus) to Arrowwood National Wildlife Refuge, North Dakota, was attempted in the spring and summer of 1988 and 1989. The method entailed substituting prairie chicken eggs into sharp-tailed grouse (Tympanuchus phansianellis Jamesi) nests. Thirty-five sharp-tailed grouse hens were captured on dancing grounds or nests and instrumented with radio transmitters. Thirty-five sharptail nests were located by telemetry or cable-chain drag. Most (54%) nests were located in vegetation containing a combination of brush and grass. Success of all nesting sharptail hens was low (48%), with predators destroying 37% of the nests. Twenty-six sharptailed grouse and 1 ring-necked pheasant (Phasianus colchi-cus) nests were provided with 523 prairie chicken eggs. Fifteen nests were provided with unincubated prairie chicken eggs and 12 were provided with prairie chicken eggs incubated at least 20 days. Nests provided with unincubated prairie chicken eggs had a lower (33%) nest success than nests provided with incubated eggs (92%). Hatchability of unincubated prairie chicken eggs (43%) was significantly lower than for incubated eggs (79%). Only 2% of 102 prairie chicken chicks that left the nest with radioed sharptail hens survived until the end of the field seasons. Sharp-tailed grouse with prairie chicken broods were located most often (61%) in vegetation types with a combination of brush and grass, and appeared to select brood habitat which may have been less than optimum for prairie chicken chicks. Only 2 prairie chicken cocks were observed on the study area in 1990. Weather, predation, and lack of optimum prairie chicken habitat may have caused the apparent failure of this reintroduction effort.

REINTRODUCTION OF GREATER PRAIRIE CHICKENS USING EGG SUBSTITUTION ON ARROWWOOD NATIONAL WILDLIFE REFUGE, NORTH DAKOTA

by

Howard Raymond Burt

A thesis submited in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Fish and Wildlife Management

MONTANA STATE UNIVERSITY
Bozeman, Montana

March 1991

APPROVAL

of a thesis submitted by

Howard Raymond Burt

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.

March 14, 1991
Date

Robert P. Eng
Chairperson, Graduate Committee

Approved for the Major Department

13 March 1991
Date

Robert E. Moore
Head, Major Department

Approved for the College of Graduate Studies

March 26, 1991
Date

Henry L. Parsons
Graduate Dean

STATEMENT OF PERMISSION TO USE

In presenting this thesis in partial fulfillment of the requirements for a master's degree at Montana State University, I agree that the Library shall make it available to borrowers under rules of the Library. Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgment of source is made.

Permission for extensive quotation from or reproduction of this thesis may be granted by my major professor, or in his absence, by the Dean of Libraries when, in the opinion of either, the proposed use of the material is for scholarly purposes. Any copying or use of the material in this thesis for financial gain shall not be allowed without my written permission.

Signature Mark R. Burt

Date March 14, 1991

ACKNOWLEDGEMENTS

I would like to thank my advisor, Dr. R. L. Eng for his guidance and education throughout this project. Committee members, Drs. W. R. Gould, L. R. Irby, and J. E. Taylor provided helpful suggestions and critically reviewed the manuscript. I would also like to thank P. VanNingen and D. Sterns of the U. S. Fish and Wildlife Service and personnel of Arrowwood National Wildlife Refuge for providing vehicles, equipment, and assistance in the field. I am grateful to A. Kruse and personnel of Northern Prairie Wildlife Research Center for providing suggestions and prairie chicken eggs during the study. I am especially grateful to John Toepfer for his contribution to the study design and assistance in the field. P. Byorth, P. Gunderson, K. Johnson, R. Northrup, M. Restani, and C. Sime provided invaluable suggestions and friendship. Special thanks to my parents for their encouragement. Finally, I would like to thank my wife Sandy for her support and patience. This study was funded by the U. S. Fish and Wildlife Service.

TABLE OF CONTENTS

TABLE OF CONTENTS--Continued

LIST OF TABLES

LIST OF TABLES--Continued

LIST OF TABLES--Continued

LIST OF FIGURES

ABSTRACT

Reintroduction of greater prairie chickens (*Tympanuchus cupido pinnatus*) to Arrowwood National Wildlife Refuge, North Dakota, was attempted in the spring and summer of 1988 and 1989. The method entailed substituting prairie chicken eggs into sharp-tailed grouse (*Tympanuchus phansianellis jamesi*) nests. Thirty-five sharp-tailed grouse hens were captured on dancing grounds or nests and instrumented with radio transmitters. Thirty-five sharptail nests were located by telemetry or cable-chain drag. Most (54%) nests were located in vegetation containing a combination of brush and grass. Success of all nesting sharptail hens was low (48%), with predators destroying 37% of the nests. Twenty-six sharp-tailed grouse and 1 ring-necked pheasant (*Phasianus colchicus*) nests were provided with 523 prairie chicken eggs. Fifteen nests were provided with unincubated prairie chicken eggs and 12 were provided with prairie chicken eggs incubated at least 20 days. Nests provided with unincubated prairie chicken eggs had a lower (33%) nest success than nests provided with incubated eggs (92%). Hatchability of unincubated prairie chicken eggs (43%) was significantly lower than for incubated eggs (79%). Only 2% of 102 prairie chicken chicks that left the nest with radioed sharptail hens survived until the end of the field seasons. Sharp-tailed grouse with prairie chicken broods were located most often (61%) in vegetation types with a combination of brush and grass, and appeared to select brood habitat which may have been less than optimum for prairie chicken chicks. Only 2 prairie chicken cocks were observed on the study area in 1990. Weather, predation, and lack of optimum prairie chicken habitat may have caused the apparent failure of this reintroduction effort.

INTRODUCTION

The original distribution of the greater prairie chicken (Tympanuchus cupido) included much of the eastern Great Plains from approximately the 100th meridan eastward to Kentucky, Ohio, and Tennessee, and northward to Michigan, Minnesota, and South Dakota (Johnsgard 1983). As a result of white settlement and patch farming, the species' range was extended north and west into northern Michigan and southern Ontario, northern Wisconsin, most of Minnesota, Manitoba, Saskatchewan, Alberta, North Dakota, Kansas, and eastern Montana, Wyoming and Colorado. The combination of undisturbed native prairie nesting areas and availability of winter food in farmed areas led to peak numbers of greater prairie chickens in the early 1900's (Evans 1968).

These peak numbers began to decline in the 1930's as native prairie was converted to cropland, agricultural practices became more intensive, and overgrazing and annual haying became more prevelant. Since then the greater prairie chicken has been virtually extirpated from its Canadian range (Hammerstrom and Hammerstrom 1961), and in the United States has had its range and numbers drastically reduced (Fig. 1.).

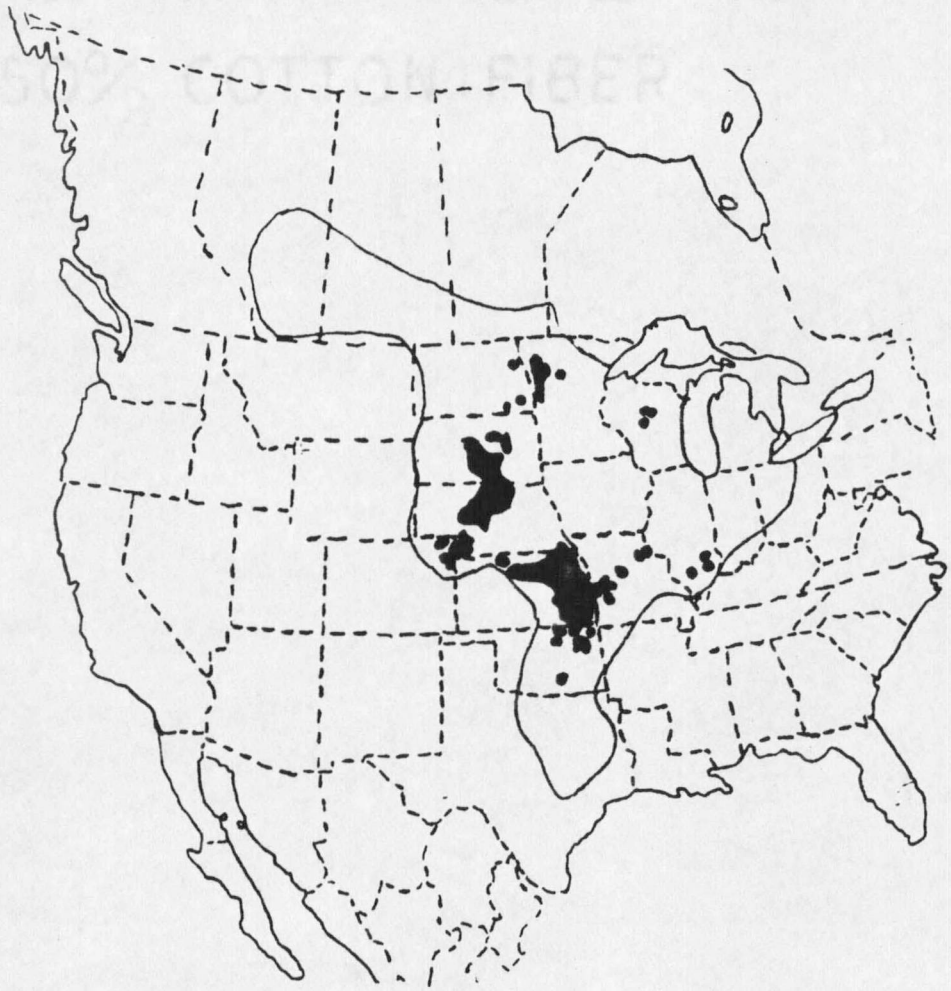

Figure 1. Historical (outline) and current (shaded) distribution of the greater prairie chicken in North America (Johnsgard 1983).

Since 1950 there have been at least 26 attempts to establish greater prairie chickens populations. They have been successfully re-established in Oklahoma and Wisconsin, but most efforts did not succeed (Toepfer et al. 1990).

Arrowwood National Wildlife Refuge (ANWR) was established in North Dakota in 1935. ANWR records indicated approximately 360 prairie chickens were present on the Refuge in 1941, while none were present by 1966 (Kirsch et al. 1973). The greater prairie chicken was listed in the Congressional Record as a species of enphasis on ANWR. It is the responsibility of the National Wildlife Refuge System to manage refuge lands to the benefit of those species for which they were established. Therefore, reintroducing the greater prairie chicken to ANWR would be in compliance with these objectives laid down in the Congressional Record.

My study was initiated in the spring of 1988 to evaluate efforts being made to reintroduce greater prairie chickens on ANWR. Specific objectives were:

(1) To evaluate the efficiency of substitution of greater prairie chicken eggs into sharptail grouse nests as a means of reintroduction.

(2) To reestablish a sustainable greater prairie chicken population on ANWR.

Fieldwork was conducted from 24 April to 15 August in 1988 and 1 April to 20 July 1989.

STUDY AREA

Arrowwood National Wildlife Refuge (ANWR) is located in east central North Dakota, approximately 48 kilometers (km) north of Jamestown. The refuge occupies 22 km of the James River Valley in Foster and Stutsman Counties.

The study area included the Jim Lake Unit and the southern part of the Mud Lake Unit of the refuge (Fig. 2.). The maximum north-south and east-west dimensions were 7.9 and 3.9 km respectively. The study area occupied a total of 1631 upland hectars (ha).

The study area was bordered on the east and west by private land, the north by Mud Lake, and the south by Depuy Marsh. Steep slopes rise from Jim Lake to a gently rolling to flat plain with elevations ranging from 436 to 488 meters (m). Seven shelterbelts were present on the study area.

Geology and Soils

The study area was located on a glacial drift plain that was last glaciated during the Pleistocene Epoch. Glaciers eroded the bedrock surface and deposited glacial drift from 3 to 15 m in depth (Winters 1963).

Chernozem soils, which were the most common on the

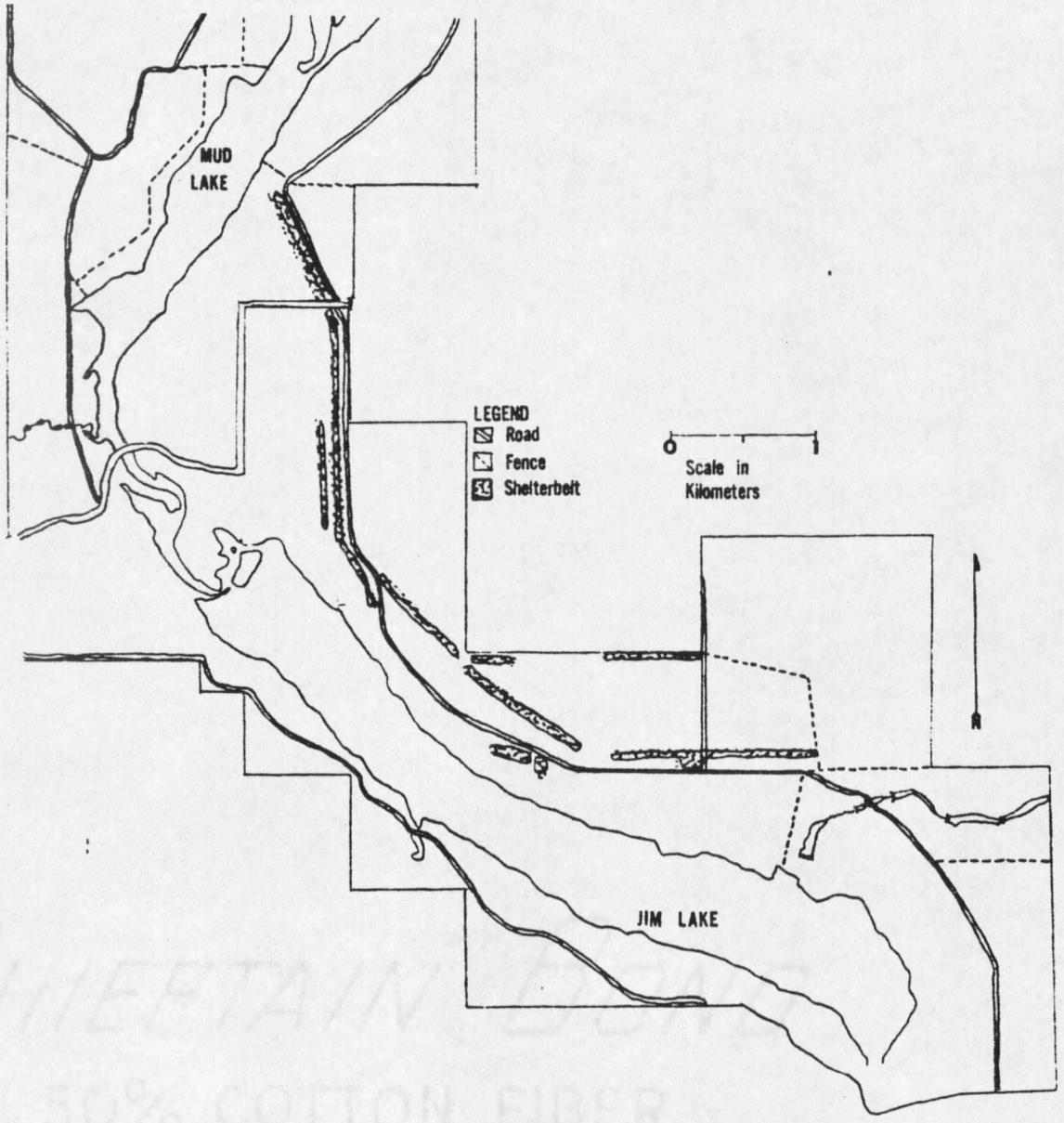

Figure 2. Location of the study area on ANWR in Stutsman County, North Dakota.

study area, were developed from granite, limestone, and shale deposited by 2 glaciers, 1 that moved out of central Manitoba and Saskatchewan and the other out of northwestern Manitoba (Bluemle 1977). Concentrations of carbonates are characteristic of the lower part of the soil. Alluvial soils were present along Jim Lake and the James River Valley (Winters 1963).

Climate and Weather

Climate of east central North Dakota is sub-humid and continental, which is characterized by warm summers and cold winters. Average annual precipitation at the refuge headquarters station is 46.7 cm, most of which accumulates from May to August (Table 1). The coldest month is January with an average temperature of -14 C. July is the warmest with an average temperature of 21 C (U.S. Dep. Commerce 1973).

The 1988 field season was characterized by an extreme drought with temperatures being far above and precipitation being far below normal for April through August. Although 1989 was also considered a drought year, temperatures were much closer to normal and precipitation was above normal in May, July, and August (Table 1).

Land Use

Major land uses on the study area were dryland

farming, haying and grazing. In 1988, farmed areas included 53 and 9 ha of wheat (Triticum aestivum) and corn (Zea mays), respectively. Also, 116 ha were hayed on or after July 15. In 1989, 59 ha of wheat and 8 ha of sunflowers (Helianthus sp.) were farmed and 110 ha were hayed. Recreational uses included hunting, fishing, and bird watching.

Table 1. Monthly precipitation (Ppt) in cm and temperature (C) and departures (Dep) from normal at ANWR headquarters, North Dakota, 1988 and 1989.[a]

		April		May		June		July		August	
Loc	Year	Ppt.	Dep.	Ppt.	Dep.	Ppt.	Dep.	Ppt.	Dep.	Ppt.	Dep.
ANWR	1988	0.99	-2.67	5.54	-1.09	3.02	-5.74	2.34	-5.08	3.94	-3.00
	1989	1.68	-1.98	9.19	2.56	3.50	-5.26	8.10	0.68	15.6	8.66

		April		May		June		July		Aug.	
Loc	Year	Temp.	Dep.	Temp.	Dep.	Temp.	Dep.	Temp.	Dep.	Temp.	Dep.
ANWR	1988	7.22	2.1	16.1	4.3	23.4	6.3	23.4	2.8	21.2	1.2
	1989	5.83	0.7	13.8	2.0	17.3	0.2	23.2	2.6	20.5	0.5

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

Vegetation

The study area contained plants typical of the mixed-grass prairie. The most common native grasses on the study area were blue grama (Bouteloua gracilis) and needlegrasses (Stipa spp.). Intermediate wheatgrass (Agropyron intermedium) and alfalfa (Medicago sativa) were seeded into dense nesting cover fields (DNC) on

approximately 36% of the study area. Kentucky bluegrass (Poa pratensis), smooth brome (Bromus inermis), and quackgrass (Agropyron repens) were common in DNC and native grasslands throughout the study area.

Snowberry (Symphoricarpus occidentalis) was the most common shrub throughout the area. Other common shrubs mostly found on hillsides or shelterbelts included serviceberry (Amelanchier alnifolia), chokecherry (Prunus virginiana), hawthorn (Crataegus douglasii), and Woods rose (Rosa woodsii). Willows (Salix spp.) occurred in riparian areas along Jim and Mud Lakes. Cottonwood (Populus deltoides) and aspen (Populus tremuloides) were confined to planted shelterbelts and shorelines of Jim and Mud Lakes. Common forbs include goldenrod (Solidago spp.), cudweed sagewort (Artemisia ludoviciana), and white prairie aster (Aster falcatus).

Two farming units occurred within the study area. These units, seeded with wheat, corn, and sunflowers, made up less than 8% of the study area. Scientific and common names of all plant species or genera are listed in Appendix, Table 23.

Mammals and Birds

Fifteen species of mammals were observed on the study area (Appendix, Table 24) including 7 species of carnivores, 6 species of rodents, 1 lagomorph, and 1

ungulate. In 1988 mammalian predators were reduced on the study area to improve nesting success. Conibear traps, #2 double-coiled spring leg-hold traps, and snares were used to trap predators. Red fox (Vulpes vulpes), striped skunk (Mephitis mephitis) and raccoons (Procyon lotor) were the primary predators trapped on the study area.

One hundred eight species of birds, including 9 species of raptors, were observed on the study area (Appendix, Table 25). Seventy-eight of these species are known to nest on the area. ANWR is an important stopover point during migration for many waterfowl species. Many areas of the refuge provide nesting sites for waterfowl and upland bird species.

METHODS

Censusing

Dancing grounds were censused in early April each year. The numbers of sharp-tailed grouse on dancing grounds within the study area were counted a minimum of 3 times each during early April.

Trapping, Banding and Radio-Tagging

Three dancing grounds were selected for trapping based on the number of grouse counted during censusing. Trapping was conducted from 26 April to 5 May 1988, and from 15 April to 29 May 1989.

Female sharptails were captured on dancing grounds by using clover-leaf and walk-in "W" traps (Toepfer et. al. 1987). Hens were also captured with a long handled net while incubating.

Grouse were weighed using a Pesola spring scale. Sex was determined by examination of central tail and crown feather patterns (Henderson et al. 1967). Age was determined by outer primary wear (Amman 1944).

In 1989, sharptail hens were banded with aluminum butt-end bands. Cocks were banded with 1 aluminum butt-end and a unique combination of 3 colored plastic bands. Bands were not available for the 1988 field season. Thirty-four

sharptail hens were fitted with radio transmitters mounted on a bib (Amstrup 1980). Grouse were released on or near dancing grounds where they were captured.

Radio-Tracking

Eighteen SM1 transmitters were purchased from AVM Instrument Company, California and 15 CHP-1H transmitters were purchased from Telonics, Arizona. The SM1 transmitters emitted a pulsed signal from 151.256 to 151.721 megahertz (mhz) and were powered by a single Nicad battery which was capable of supplying power for 270 days without recharging. The CHP-1H transmitters emitted a pulsed signal from 164.375 to 167.3125 mhz and were powered by a single Nicad battery which was capable of supplying power for 75 days without recharging. Radio packages weighed between 10.8 and 15.1 g.

Relocations were made using a hand-held H-antenna and a Falcon Five receiver in 1988 and a Telonics TS-1 Scanner/Programmer plugged into a Model TR-2E series receiver in 1989. Bird locations were determined by walking in and flushing the bird, by circling the location until the bird was pin-pointed, or by triangulating from 2 or 3 identifiable points. A fixed-wing aircraft with an H-antenna mounted on each strut was used to locate birds that could not be found from the ground. All walk-in locations and flush sites were recorded in one of the following

vegetation categories: 1) brush with no understory 2) brush with grass/forb understory 3) grass 4) forb 5) tree clump 6) wetland and 7) grass/forb. Locations, identified by date and bird identification number, were plotted on a 7.5-minute topographic map obtained from the United States Geological Survey (USGS). Grouse were monitored from April through August in 1988 and April through July in 1989.

Nests

Nests were located by telemetry or by cable-chain drag (Higgins et al. 1977). Cable-chain drags were not conducted until mid-May to minimize nest abandonment. Females located vie telemetry or cable-chain drag were flushed from the nest and a general nest site description, location, date, clutch size, and approximate laying and hatching dates were recorded.

Nests were recorded in one of the following general land use types distinguished on the study area: 1) dense nesting cover (DNC), largely planted fields of intermediate wheatgrass and alfalfa; 2) native non-use, areas of native prairie with a grass/shrub mixture that had not been burned or grazed in 1987, 1988 or 1989; 3) burn units, areas of native prairie that had been burned at least once in 1987, 1988, or 1989; and 4) grazing units, which included areas grazed in 1988 or 1989. Cover around each nest site was

then classified into 1 of 6 vegetation types: 1) brush with no understory, 2) brush with grass/forb understory, 3) grass, 4) forb, 5) grass/forb, 6) grass with brush understory.

Nest site descriptions also included identification of dominant vegetation at the nest, distance to nearest dancing ground, distance to home dancing ground, and distance to nearest other known sharptail nests. Photo-plots were taken at all nests in 1989. Four 10-m transects were established in the cardinal directions from the center of the nest. Two photo-plots were taken at the nest and 1 each at 5 and 10 m distances along the established transects, for a total of 10 photo-plots at each nest. A 1 m^2 piece of pegboard was held vertically behind the vegetation as a reference scale (Toepfer unpubl. data). Photos were taken 3 m from the pegboard at a height of 1 m.

Vegetation analysis was completed at the nest after nesting activities had ceased. In 1988, 4, 10-m transects were established in cardinal directions. Along these transects, canopy coverage by species was collected at 1 m intervals in 0.1-m^2 quadrants (Daubenmire 1959). In 1989, a modification of the step-point method (Evans and Love 1957) was used to estimate vegetative cover at each nest. Four transects were established in cardinal directions with the center being the middle of the nest bowl. Along each transect, 2 plant species closest to a notch in the

observers boot were recorded at 1 m intervals for 10 m. At the nest bowl 4, 5 decimeter (dm) transects were established in cardinal directions. Along these transects, 2 plant species closest to the mark on a 1-m stick were recorded at 1 dm intervals. At each nest site 50-70 readings were recorded. Readings taken from the center of the nest bowl were recorded in 1989 only.

Location of each nest, distance to nearest dancing ground, nearest home dancing ground, and nearest known sharp-tailed grouse nest were determined using 7.5-minute USGS topographic maps. Date and the time of day when the nest was found were also recorded. Nests were marked by placing a willow stick with a flag attached approximately 2 m north of the nest.

The approximate stage of incubation was determined by floating eggs in water. Laying and hatching dates were calculated assuming an incubation period of 23-24 days and a laying rate of 1 egg per day (Johnsgard 1973). Time spent at each nest was kept to a minimum to avoid disturbance during the incubation period. Observers were careful not to trample vegetation around the nest. Clutch sizes were determined during the egg substitution process.

Egg Substitution

The majority of the sharptail hens were allowed to incubate their eggs for approximately 2 weeks before egg

substitution to reduce chances of nest abandonment. Then all sharptail eggs were removed and replaced with up to 20 prairie chicken eggs. In 1988, 15 sharptail nests received non-incubated prairie chicken eggs and 4 nests received prairie chicken eggs which had been incubated 20 or more days. In 1989 all sharptail nests received prairie chicken eggs that were within 24 hours (h) of hatching.

Prairie chicken eggs were obtained from captive flocks at Northern Prairie Wildlife Research Center (NPWRC), Jamestown, North Dakota and North Dakota Wildlife Trust, Valley City, N.D.. In 1989, an additional 25 wild prairie chicken eggs were obtained from the Sheyenne National Grasslands in North Dakota. Sharp-tailed grouse eggs removed from wild birds on the study area were taken to North Dakota Wildlife Trust and North Dakota Game and Fish incubators and hatched.

Nests were checked to determine fate after a predetermined hatching date or when the hen was absent from the nest for more than 2 days. Nests were classified as either destroyed, abandoned or successful. Any nest in which at least 1 egg hatched was considered successful.

Movements and Home Range

Instrumented sharp-tailed grouse hens were monitored from April through August in 1988 and April through July in 1989. An attempt was made to locate each hen every day.

Hens with faulty transmitters and hens that moved great distances were located less frequently. Locations were classified into a coordinate system using the Universal Transverse Mercator (UTM) grid system. The UTM coordinates were entered into the computer program, TELDAY (Lonner and Burkhalter 1986) to calculate home ranges of sharp-tailed grouse hens. Home range is that defined by Burt (1943) and was calculated by computing the area of the convex polygon formed by relocations on the perimeter (Hayne 1949).

Data Analysis

Statistical analyses of all data were completed using the computer program MSUSTAT (Lund 1987). Nest distribution, hatchability, and home range data were statistically analyzed with student-t and paired-t tests. The Mann-Whitney U test was used for non-parametric nesting cover data. Utilization-availabilty data were statistically analyzed with the chi-square technique used by Neu et al. (1974).

RESULTS

Trapping

Trapping was conducted on 3 dancing grounds: 06, 09, and 10 (Fig. 3). A total of 172 sharp-tailed grouse were handled in 1988 and 1989, of which 166 were captured on the dancing grounds and 6 on nests.

Although 105 cocks were handled in 1988, bands were not available so the number of recaptures could not be determined. In 1989, 27 cocks were banded on the 3 dancing grounds; 5 were recaptured twice and 7 once. Approximately 55% of the sharptails handled were captured on dancing ground 09 (Table 2). Date of capture, ground number or nest captured on, sex, age, weight, and radio number of captured grouse are given in Appendix Table 26. Trapping mortalities consisted of 1 cock and 1 hen which died of shock and 1 cock killed by a red-tailed hawk (Buteo jamaicensis) while in the trap.

During both years, the earliest a hen was captured on a dancing ground was 18 April. The latest was 3 May. In 1988, 93% of the sharptail hens were captured between 27 and 29 April. In 1989, 53% of the hens were captured between 18 and 22 April.

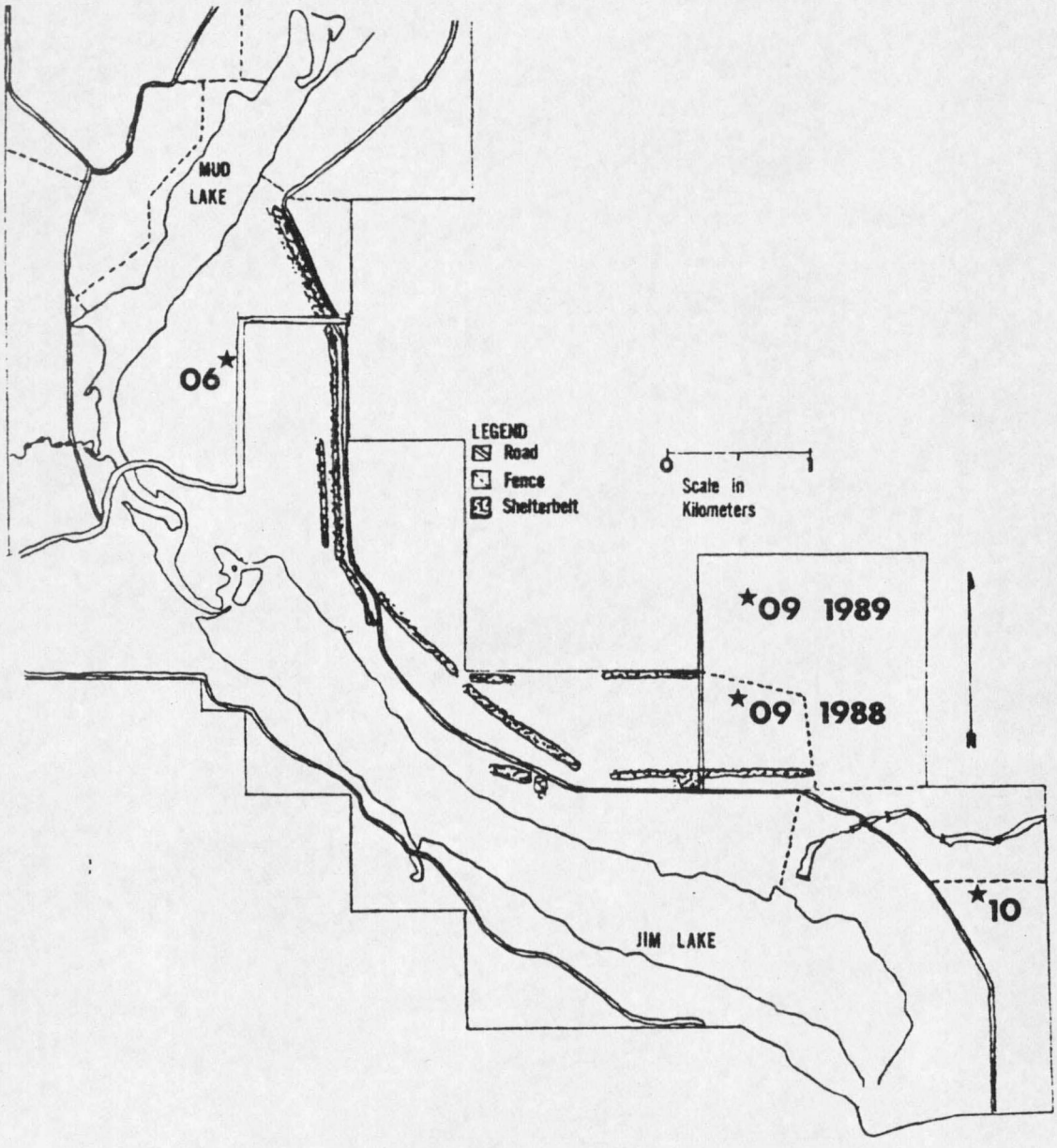

Figure 3. Sharp-tailed grouse display grounds (stars) on ANWR study area, North Dakota, 1988-1989.

Table 2. Number[a] and sex of sharp-tailed grouse caught on dancing grounds, ANWR, North Dakota, 1988-1989.

	Dancing ground number					
	06		09		10	
Year	Cocks	Hens	Cocks	Hens	Cocks	Hens
1988	35	7	65	8	5	0
1989	8	8	15	7	4	4
Total	43	15	80	15	9	4

[a]Includes cocks recaptured in 1988.

Radio Tagging and Banding

Thirty-five sharp-tailed grouse hens were fitted with radio transmitters in 1988-1989. Twenty-nine were caught in walk-in traps and 6 on their nests. Sex and age of individual sharptails caught are presented in Table 3. Cocks captured in 1988 are not included. Mean weights were calculated from all known age hens captured during both years but for known age cocks in 1989 only (Table 4).

Table 3. Sex and age of sharp-tailed grouse captured on dancing grounds, ANWR, North Dakota 1988-1989.

	Cocks[a]	Hens
Adult	20	20
Juvenile	3	9
Unknown	4	8
Total	27	37

[a]Only cocks captured in 1989.

Table 4. Mean weights of sharp tailed grouse captured, ANWR, North Dakota, 1988-1989.

	Cocks[a]			Hens		
	No.	Mean (g)	(SD)	No.	Mean (g)	(SD)
Adult	20	950.1	37.2	19	898.5	89.8
Juvenile	3	892.0	96.7	8	909.8	104.3

[a]Only for cocks captured in 1989.

All sharptail hens caught without visible injuries were fitted with radio transmitters. Three hens caught in 1988 with visible abrasions around the neck were released without transmitters. One hen in 1989 was released when she would not fly with the radio package. In 1988, 5 hens were instrumented on dancing ground 06, and 7 on dancing ground 09. In 1989, 6 hens were instrumented on dancing ground 06, 7 on dancing ground 09, and 4 on dancing ground 10.

A total of 47 sharptails were banded on dancing grounds in 1989. Eight banded grouse died during the field season and 1 was shot during the hunting season. Band number, date banded, dancing ground or nest on which the bird was banded, age, sex, and fate of each banded grouse is presented in Appendix, Table 27.

Nesting

A total of 26 initial sharptail nests and 9 second

nests were located in 1988 and 1989. Two of the 9 second nests were known renests from grouse equipped with radio transmitters. The 7 other nests were considered renests because of smaller clutch sizes and late incubation dates (Table 5).

Table 5. Sharptail nests located on ANWR study area, North Dakota, 1988-1989.

	1988	1989	Total
Initial nests	20	6	26
Renests	3	6	9
Known adult nests	6	4	10
Known juvenile nests	3	3	6
Hatched nests	7	9	16
Destroyed nests	11	2	13
Abandonded nests	4	0	4
Hens killed while incubating	1	1	2

Initiation Dates and Clutch Sizes

Nest initiation dates were calculated by assuming 1 egg layed per day and back dating from the first day of incubation. Seventy-three percent of all first nests were initiated between 30 April and 9 May. All second nests found were initiated between 29 May and 6 June.

Average clutch size of 23 initial nests was 13.9 (SD 2.2) and 10.6 (SD 1.4) for 9 second nests. The largest complete clutch recorded for an initial nest was 21 and smallest was 10. The largest complete clutch for a second nest was 13 and the smallest was 9.

Success

All nests located were used to calculate nest and nesting success. Nest success was determined by dividing successful nests (SN) by the total number of nests found (TNF), and by dividing successful nests by total nests found plus destroyed initial nests (IN) that were not found (SN/TNF+IN). Hen success was determined by dividing hens successful in hatching a brood (SH) by total number of hens that nested (THN).

Nest success and hen success were higher in 1989 than 1988 (Table 6). This may be attributed to the different egg substitution methods used in 1988 and 1989. In 1988, non-incubated eggs were substituted under sharptail hens that had already been incubating up to 14 days which essentially increased the incubation and exposure period by that many days. In 1989, prairie chicken eggs which had been incubated 20 to 23 days were substituted under incubating sharptail hens. This reduced the hens incubation time and the exposure time of prairie chicken eggs to 24-48 hours.

Predators destroyed 37% of all nests located in 1988 and 1989. Mammalian predators destroyed 9 nests, avian predators destroyed 1 nest and killed 2 incubating hens, and 3 nests were destroyed by unknown predators. Additional nest losses included 4 abandoned nests and 1

trampled by cattle.

Table 6. Nest and hen success of sharptail nests located on ANWR study area, North Dakota, 1988-1989.

	Nest success		Hen success
	SN/TNF(%)[a]	SN/TNF+IN(%)[b]	SH/THN[c]
1988	30.4	29.2	33.3
1989	75.0	50.0	75.0
Total	45.7	38.1	48.9

[a] Successful nests/total nests found.
[b] Successful nests/total nests found + destroyed initial nests not found.
[c] Successful hens/total hens nesting.

General Nest Site Characteristics

Of the 35 sharptail nests, most were initiated in the native non-use and DNC land use types. Most initial nests were found in the native non-use type, while the majority of the second nests were initiated in DNC (Table 7).

Table 7. Number and percent of sharptail nests in land use types on ANWR study area, North Dakota, 1988-1989.

Land use type	Initial	%	Second	%	Total	%
DNC	10	38.5	6	66.7	16	45.7
Native non-use	14	53.8	3	33.3	17	48.6
Graze unit	2	7.7	-	-	2	5.7
Burn unit	-	-	-	-	-	-
Total	26	100.0	9	100.0	35	100.0

Land-use changes on the study area between 1988 and 1989 were minor, therefore percentage of land use types available were averaged for both years (Table 8).

Table 8. Number of hectares and percent of entire study area for each land use type, ANWR, North Dakota, 1988-1989.

Cover type	Ha	% of total
DNC	581	35.6
Native (NU)	749	45.9
Burn unit	65	4.0
Grazing unit	125	7.7
Other	111	6.8
Total	1631	100.0

Sharptails used DNC, native non-use, and grazing unit land use types in proportion to occurrance on the study area (X^2=0.674, df 2, p=0.25) (Table 9).

Table 9. Availability and use of land use types for on the study area, ANWR, North Dakota 1988-1989.

Land use type	Total ha	Proportion of total ha	# nests found	Expected # of nests	Proportion observed in each type	CI on proportion of occurrance
DNC	581	.399	16	14	.457	.278-.636
Native (NU)	749	.515	17	18	.486	.306-.666
Grazing unit	125	.086	2	3	.057	.026-.140

Alpha= .10

Nesting Cover

Of the 6 vegetation types identified, those containing a combination of brush and grass accounted for 62, 44, and 54% of initial, second, and all nests found, respectively. The grass and grass/forb types accounted for 27, 56, and 34% of initial, second, and all nests, respectively (Table 10).

Table 10. Number and percentage of initial, second, and all nests found in vegetation types on the study area, ANWR, North Dakota, 1988-1989.

Vegetation type	Initial	%	Second	%	Total	%
Grass with brush understory	9	34.6	2	22.2	11	31.4
Brush with grass/ forb understory	7	26.9	1	11.1	8	22.9
Grass	6	23.1	2	22.2	8	22.9
Forb	2	7.7	1	11.1	3	8.6
Grass/forb	1	3.8	3	33.3	4	11.4
Brush with no understory	1	3.8	-	-	1	2.8

Photo plot analysis also showed a vegetative structure with a combination of brush and grass as the most important nesting cover. A combination of brush and grass made up 53.5, 42.3, and 35.1% of the vegetation causing visual obstruction at the nest and 5 and 10 m from the nest,

respectively (Fig. 4).

Canopy coverage was determined for 4 successful and 14 unsuccessful nests in 1988. Mean canopy coverage at successful and unsuccessful nests was not significantly different (Table 11).

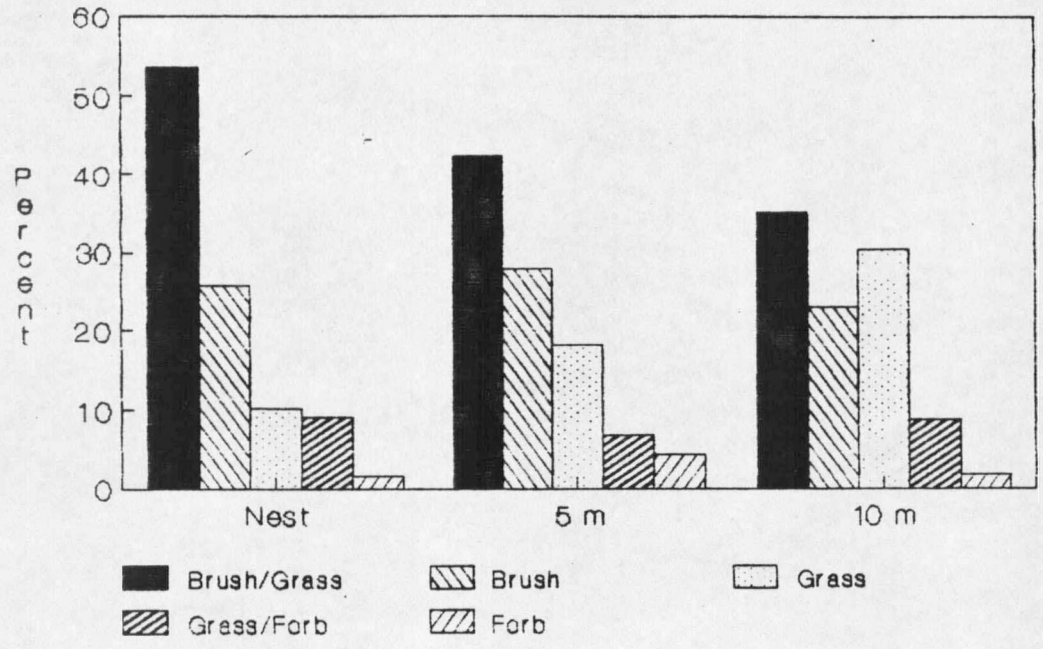

Figure 4. Vegetation causing visual obstruction at nest, and 5 and 10 m from the nest, ANWR study area, North Dakota, 1989.

Grass and brush contributed the most to the cover around successful and unsuccessful nest sites in 1988.

Table 11. Average percent cover at successful and unsuccessful sharp-tailed grouse nests, ANWR study area, North Dakota, 1988.

	Successful (n=4) % Cover		Unsuccessful (n=14) % Cover		
	Mean	SD	Mean	SD	p[a]
Total grass	110.6	76.15	94.5	57.99	.8734
Total brush	40.4	40.89	31.6	36.80	.7500
Total forb	11.0	5.76	22.2	20.90	.3392

[a] Mann-Whitney U-test.

Species contributing most to the canopy cover around nest sites in 1988 were Kentucky bluegrass, snowberry, and smooth brome. Forbs contributed only 4.2% of the canopy cover found around all nest sites in 1988 (Table 12). Frequency and species composition data collected in both 1988 and 1989 corroborate the canopy coverage data, with the same species being the most frequently encountered at nest sites (Table 13).

Table 12. Dominant species providing canopy cover at nest sites on ANWR study area, North Dakota 1988.

	Successful (n=4)	Unsuccessful (n=14)
Species	% Cover contributed	% Cover contributed
Poa pratensis	47.4	41.4
Symphoricarpos occidentalis	23.6	20.7
Bromus inermis	15.5	17.3
Agropyron intermedium	5.0	2.9
Solidago mollis	1.2	1.2
Amorpha canescens	1.2	3.9
Medicago sativa	1.2	2.2
Euphorbia esula	-	3.5
Artemisia ludoviciana	.6	1.4

Table 13. Frequency of dominant species at nest sites, ANWR, North Dakota, 1988-1989.

	Frequency	Species composition
Grasses/Sedges		
Poa pratensis	68.6	38.0
Bromus inermis	22.9	12.7
Agropyron intermedium	12.5	6.9
Agropyron species	2.6	1.4
Agropyron repens	2.4	1.4
Stipa species	2.2	1.2
Carex species	.5	.3
Bouteloua gracilis	.3	.1
Koeleria cristata	.1	-
Total		61.9
Brush		
Symphoricarpos occidentalis	27.1	15.0
Rosa arkansana	2.5	1.4

Table 13. (continued)

	Frequency	Species composition
Rosa woodsii	.3	.2
Total		16.6
Forb		
Medicago sativa	9.5	5.3
Artemisia ludoviciana	6.9	3.8
Solidago mollis	6.1	3.4
Amorpha canescens	4.6	2.5
Aster falcatus	2.4	1.3
Euphorbia esula	1.4	.8
Ambrosia psilostachya	1.4	.8
Asclepias sp	1.2	.7
Helianthus rigidus	1.1	.6
Solidago missouriensis	1.0	.6
Other	3.2	1.8
Total		19.8

Photo plots were taken at 9 nest sites during the incubation period in 1989. Although no clear pattern existed between heights (HT) and effective heights (EHT) of vegetation at successful, unsuccessful, initial, and renests, the photo plots reflect accurately the height and density of the vegetation when the nest was selected (Table 14).

Distribution of Nests

Hens nested 0.4 to 2.5 km from dancing grounds. Fifteen of 19 hens (79%) that nested after having been trapped on dancing grounds nested within 1.5 km of the dancing ground on which they were trapped ($\bar{x}$= 1.0,

SD=0.6). Adults nested an average of 1.2 km (SD=0.6, N=9), and juveniles 0.7 km (SD=0.2, N=6) (p=0.09) from their dancing grounds. The average distance to the nearest other known sharptail nest was 0.7 km (SD=0.5, N=10) for adults and 0.4 km (SD=0.2, N=6) (p=0.15) for juveniles.

Table 14. Mean heights (HT) and effective heights (EHT) of vegetation (in centimeters) at nest, and 5 and 10 m from nest, ANWR, North Dakota, 1989. Standard deviations are in parentheses.

		At Nest		5-M		10-M	
	No.	HT	EHT	HT	EHT	HT	EHT
Initial	6	37.5 (8.41)	24.9 (8.76)	37.9 (13.8)	25.1 (12.8)	35.9 (18.6)	24.0 (16.7)
Renest	3	41.8 (8.61)	20.9 (11.8)	41.6 (10.1)	24.2 (11.9)	43.1 (10.8)	24.9 (11.8)
Successful	6	38.3 (8.66)	21.8 (9.98)	39.3 (12.3)	22.8 (11.8)	39.2 (15.3)	23.7 (14.1)
Unsuccessful	3	38.1 (9.19)	27.2 (9.22)	38.8 (13.7)	28.7 (13.0)	36.6 (19.3)	25.4 (17.1)
Total	9	38.3 (8.84)	23.6 (10.1)	39.2 (12.8)	24.8 (12.5)	38.3 (16.8)	24.3 (15.2)

Egg Substitution

In 1988, 18 sharp-tailed grouse and 1 ring-necked pheasant (*Phasianus colchicus*) were provided with 379 prairie chicken eggs. Five of the 15 nests which were provided with unincubated prairie chicken eggs were successful. The remaining 4 nests were provided with prairie chicken eggs incubated at least 20 days; 3 were successful. In 1989, 8 sharp-tailed grouse nests were provided with 144 prairie chicken eggs incubated at least 20 days. All nests were successful (Table 15).

Table 15. Nests which received prairie chicken eggs on ANWR study area, North Dakota, 1988-1989.

	UNI[a]	Number hatched	%	IN[b]	Number hatched	%	Total[c]	Number hatched	%
1988	15	5	33.3	4	3	75.0	19	8	42.1
1989	-	-	-	8	8	100.0	8	8	100.0
Total	15	5	33.3	12	11	91.7	27	16	59.2

[a] Nests receiving unincubated prairie chicken eggs.
[b] Nests receiving prairie chicked eggs incubated at least 20 days.
[c] All nests substituted with prairie chicked eggs.

Hatchability

Eggs in 16 nests survived through incubation. In these nests, 100 of 304 (32.9%) prairie chicken eggs did not hatch and 21 chicks were found dead in or near nests.

Prairie chicken eggs which had not been incubated prior to being placed under sharptail hens had lower hatchability than prairie chicken eggs which had been incubated at least 20 days prior to placement (N=304) (p=0.01) (Table 16).

Movements and Home Range

Pre-incubation Period

The pre-incubation period consisted of the time interval between capture of the hen on the dancing ground or nest and the beginning of incubation. This time period

varied from 9-51 days, with an average of 27.6 (SD 11.1).

Table 16. Hatchabilty of prairie chicken eggs on ANWR study area, North Dakota, 1988-1989.

	UNI eggs substituted[a]	% hatch	IN eggs substituted[b]	% hatch	Total eggs	% hatch
1988	100	43.0	60	71.1	160	53.8
1989	-	-	144	81.9	144	81.9
Total	100	43.0	204	78.9	304	67.1

[a] Unincubated prairie chicken eggs.
[b] Prairie chicken eggs incubated at least 20 days.

Locations from 20 radioed sharptail hens were used to determine the preincubation home range sizes. Included are relocations of 3 hens that renested after losing their initial nest prior to the start of incubation.

The home range size for all hens during the preincubation period was < 1 to 161 ha with an average of 27.5 (SD 38.86). Preincubation home ranges of adults and juveniles were similar (Table 17).

Brood Period

Brood home ranges were divided into two catagories, hens with prairie chicken broods ≤ 15 days and hens with prairie chicken broods > 15 days. Home ranges for 7 hens with prairie chicken broods ≤ 15 days varied from < 1 to 22 ha with an average of 5.7 (SD 7.8). Home ranges for 3

hens with prairie chicken broods > 15 days varied from 6 to 10 ha with an average of 8.7 (SD 2.3).

Table 17. Preincubation home range sizes (ha) for sharp-tailed grouse hens on ANWR study area, North Dakota, 1988-1989.

	Home range size		
	Mean	SD	Number
Adults	28.3	48.84	13
Juveniles	25.7	22.19	6
Total	27.5	38.86	19

Non-brood Hens

Summer home ranges of 8 hens that either lost their broods or had their nests destroyed varied from 37 to 193 ha with a mean of 93.1 (SD 48.6). Summer home ranges for adults and juveniles were similar (Table 18). Home range sizes, number and dates of locations for individual birds are in the Appendix, Table 28.

Table 18. Summer home ranges (ha) for sharp-tailed grouse hens without broods on ANWR study area, North Dakota, 1988-1989.

	Summer home range size		
	Mean	SD	Number
Adults	95.6	55.6	5
Juveniles	89.0	45.3	3
Total	93.1	48.6	8

Brood Rearing

Brood Survival

Brood survival was determined for 10 radioed sharptail hens that hatched 102 prairie chicken chicks in 1988 and 1989 (Table 19). Brood survival was divided into two periods: from the time when the hen left the nest until the chicks were capable of short sustained flight, and from this first period until it was determined that the hen had lost her brood or the end of the field season.

Table 19. Production of sharptail hens provided with prairie chicken eggs on ANWR study area, North Dakota, 1988-1989.

	1988	1989	Total
Nests hatched	5	5	10
Chicks hatched	39	63	102
Broods surviving field season	1	1	2
Chicks surviving field season	1	1	2

In 1988 brood hens were first observed an average of 26.0 (SD 5.4) days after leaving the nest. Thirty-five (89.7%) chicks died during this period, resulting in a loss of 0.27 chicks/hen/day. The second period averaged 24.0 (SD 6.0) days, with 3 chicks being lost during the period

(0.08 chicks/hen/day). In 1989 brood hens were first observed an average of 15.0 (SD 1.9) days after leaving the nest. Fifty-seven (90.5%) chicks died during this period, a loss of 0.76 chicks/hen/day. The second period averaged only 7.5 (SD .50) days, with 4 chicks being lost (0.33 chicks/hen/day). The shortness of this period could explain the rather high rate of chick loss. Although chick loss in the late brood period in 1989 also was high, the majority of the chicks were lost in the first 15-26 days. Overall, 10 sharptail hens hatched 102 prairie chicken chicks, with only 2 (2.0%) surviving to the end of the field season in 1988 and 1989.

Habitat Use

Relocations from 10 radioed sharptail hens with prairie chicken broods were used to determine habitat use. Number of brood relocations per hen varied from 3-25 with an average of 8.9 (SD 7.39). The majority of relocations were in brush with grass/forb understory and grass/forb vegetation types (Table 20). No broods were relocated in brush with no understory or forb vegetation types.

Hen Survival

Survival was determined for 28 radioed sharptail hens in 1988 and 1989. In 1988, 10 of 15 (67%) radioed hens survived until the end of the field season. In 1989, 6 of 13 (46%) hens survived until the end of the field season.

Avian predators killed 50%, mammalian predators 25%, and unknown predators 25% of the radioed hens during the study (Table 21).

Table 20. Number and percent of relocations within each vegetation type for 10 sharptail hens with prairie chicken broods on ANWR study area, North Dakota, 1988-1989.

Vegetation type	Number of relocations	Percent of total
Brush with grass/ forb understory	54	60.7
Grass/forb	28	31.4
Grass	3	3.4
Tree clump	3	3.4
Wetland	1	1.1
Total	89	100.0

Table 21. Fate of radioed sharptail hens on ANWR study area, North Dakota, 1988-1989.

	1988	1989	Total
Hens radioed	17	18	35
Hens surviving field season	10	6	16
Hens killed/avian predator	2	4	6
Hens killed/mammalian predator	2	1	3
Hens killed/predator unknown	1	2	3
Radio failures	2	5	7

Non-brood Hen Habitat Use

Relocations from 5 radioed sharptail hens without broods and that survived the field season were used to determine habitat use. Number of relocations per hen varied from 13-35 with an average of 22.6 (SD 8.8). Over 90% of the relocations were in brush with grass/forb understory, grass/forb, and tree clump vegetation types (Table 22). Hens were never relocated in wetland vegetation type.

Table 22. Number and percent of relocations within each vegetation type for 5 non-brood sharptail hens on ANWR study area, North Dakota, 1988-1989.

Vegetation type	Number of relocations	Percent of total
Brush with grass/ forb understory	45	39.8
Grass/forb	32	28.3
Tree clump	26	23.0
Brush with no understory	4	3.5
Forb	4	3.5
Grass	2	1.9
Total	113	100.0

DISCUSSION

The use of unincubated prairie chicken eggs resulted in a much lower nesting success than was obtained through the use of eggs which had been incubated at least 20 days. Placing unincubated prairie chicken eggs under sharptail hens that had already been incubating up to 14 days increased the exposure period for those nests by that many days. Also, observer visits to the nest may have negatively influenced nesting success as has been suggested by Baskett (1947), and Pepper (1972).

Hatchability of prairie chicken eggs may have been negatively influenced by abnormally high temperatures. Temperatures in 1988 were well above normal throughout the incubation and hatching periods, and could have been a factor in the inordinately low hatchability. Prairie chicken eggs incubated at least 20 days also had lower hatchability in 1988 than 1989. Gunderson (1990) also found lower hatchability of sharptail eggs in 1988 (81%) than 1989 (100%) while experiencing similar temperature extremes. McMullan and Ebarhardt (1953) determined that pheasant embryos became more vulnerable to exposure to temperature extremes as incubation progressed.

Hatchability of unincubated prairie chicken eggs (43.0%) was significantly lower than incubated eggs

(78.9%). The hatchability of all substituted prairie chicken eggs (67.1%) was much lower than that reported in Wisconsin (Hamerstrom 1939), North Dakota (Newell 1987), in Minnesota (Svedarsky 1988) for wild prairie chickens. In Michigan, Fay (1963) found hatching success of ruffed grouse (Bonasa umbellus) eggs taken from the wild and hatched in incubators to be 77%.

Ninety percent of all prairie chicken chicks that left the nest died within 15-26 days with only 2 of 102, surviving until the end of the field seasons. Other sharptail (Brown 1966) and prairie chicken (Newell 1987, Svedarsky 1988) studies also indicate high mortality rates of chicks within the first 2-3 weeks of life. However, none of these studies recorded mortality as high or overall chick survival as low as in this study. Only Gunderson (1990) had a similarly low survival with 9% of 160 chicks surviving in Montana. Prolonged drought, above normal temperatures, and predators may be the cause of such low chick survival in this study.

In 1988, temperatures in June and July were well above normal and precipitation was well below normal. In 1989 temperatures were closer to normal although drought conditions persisted. These conditions may have negatively influenced chick survival during the study. Evans (1968) stated that weather conditions in early June are important in determining brood success. Chicks do not have full

thermoregulatory ability until fully feathered (Speirs et al. 1974) and are very vulnerable to temperature extremes. Martinson and Grondahl (1966) reported high reproductive success in pheasants associated with relatively cool, wet weather in May and June, and low productivity during drought years. Sharptails also have shown improved chick survival in wet springs (Bergerud 1988). However, most studies indicate cold, wet weather as being detrimental to chick survival in gallinaceous birds (MacMullan and Eberhardt 1953, Ritcey and Edwards 1963, Svedarsky 1988).

Red fox, northern harriers (Circus cyaneus), redtail (Buteo jamaicensis) and Swainson's hawks (Buteo swainsoni) were commonly observed on the study area, and probably were the major chick predators. Bergerud (1988) determined that raptors and foxes were the major chick predators, and that chicks are most vulnerable to ground predators before they can fly and thermoregulate. Grange (1948) suggested that northern harriers may be important chick predators.

Although prairie chicken chick survival was extremely low, survival from April-August of non-brood sharptail hens for 2 years averaged 57%. Newell (1987) and Svedarsky (1988) reported similar summer survival of prairie chicken hens. Avian predators accounted for 50% of all sharptail hens killed. Brown (1967) and Weigand (1980) found high incidence of avian predation on sharptails and gray

partridge in Montana. All sharptail hens found dead in this study had either been killed or fed on by avian or mammalian predators. Bergerud (1988) stated that predation accounts for 85% of all grouse mortalities.

Radio packages may have reduced the hens' chances for survival, at least until they got through an adjustment period. Sixty-seven percent of the hens found, that were killed by predators, survived an average of only 23 days after being instrumented. Other studies have suggested that attaching radio transmitters may negatively influence bird survival (Hessler et al. 1970, Newell 1987, Bergerud 1988). Hens probably adjusted to the radio packages rather rapidly, but may have been more vulnerable, in some instances, for about a month. The radio packages only transmitted signals into late August-early September; therefore, no data on overwinter survival were available. Three sharptail hens radioed in 1988 were either trapped (2) or observed (1) on the study area in the spring of 1989.

Hunting is allowed on the study area but did not seem to have much effect on the sharptail population. Only 1 radioed hen was known to have been harvested by hunters in 2 years.

Moyles (1981) stated that factors such as food requirements, presence of conspecifics, familiarity with an area, and avoidance of predators may be important in

influencing choice of habitats used by grouse. He suggested that a mosaic of grasslands and grass-shrub habitats provide optimum habitat for sharptails. Sharptail hens with prairie chicken broods in this study were located most often in brush with grass understory and grass/forb vegetation types. This is similar to the findings of other sharptail studies (Hamerstrom 1963, Kobriger 1965, Pepper 1972, Sisson 1976, Gratson 1988). Only 3.4% of the brood locations were associated with strictly grassland vegetation type. Hamerstrom (1957) stated that grass was the key component of brood habitat for prairie chickens, and most other studies agree (Manske and Barker 1987, Toepfer 1988, Svedarsky 1988). Thus sharptail hens appeared to select brood habitat which may have been less than optimum for prairie chicken chicks.

In most aspects non-brood hen summer habitat use was similar to brood-hen habitat use, agreeing with other sharptail studies (Kobriger 1965, Pepper 1972, Moyles 1981). The tree clump vegetation type was used much more by non-brood hens than hens with broods in this study. This type consisted mainly of shelterbelts or tall shrub clumps that were used mostly during midday high temperatures. Kobriger (1965) and Moyles (1981) found similar use of trees and tall shrubs for shade at midday. Only 1.9% of all locations of non-brood sharptail hens were in grass vegetation type. Swenson (1985), in Montana,

reported sharptails using mainly upland grass habitat during spring and summer but suggested that the best habitat was a mixture of upland grass-shrub and riparian hardwood draws.

Cattle were present on only a small portion of the study area. Brood and non-brood hens tended to avoid these areas, a response reported in other sharptail and prairie chicken studies (Pepper 1972, Yde 1977, Nielson and Yde 1981, Newell 1987).

CONCLUSIONS AND MANAGEMENT RECOMENDATIONS

Two prairie chicken cocks were observed displaying on the study area in 1990 (P. VanNingen pers. comm.). If 2 hens also survived, it is apparent that the production of only 4 prairie chickens from 523 eggs substituted in 2 years, that the reintroduction effort was not successful. Only 2% of the prairie chicken chicks that hatched from nests of radioed sharptails survived. Most chick mortality occurred within 2-3 weeks after hatching.

If this reintroduction method or some other method is to be tried again on ANWR, the following recommendations may provide managers some assistance in making their decisions.

1. If the egg substitution method is to be used, eggs should be incubated at least 20 days prior to substitution to reduce nest losses to predators. If possible, eggs should be obtained from wild prairie chickens.

2. The habitat should be surveyed to determine suitability for prairie chickens prior to any reintroduction effort. Toepfer et al. (1990) suggested that the first objective of any reintroduction project should be to establish suitable habitat to meet year round needs of at least 200 birds. Hamerstrom (1957) stated that prairie chickens must have large areas of open grassland.

The native non-use land use type made up 53.8% of the study area and consisted mainly of a mixture of grass and low shrubs. This type of habitat is considered ideal for sharp-tailed grouse (Moyles 1981, Swenson 1985). The main grassland type on the study area was DNC, which made up 38.5% of the area. Kirsh (1974) felt that these areas were acceptable prairie chicken nesting and brood rearing habitat after 2-3 years when some residual cover had accumulated. However, most of the DNC fields were bordered by shelterbelts with large cottonwood trees. Hamerstrom (1957) suggested that a relatively small percentage of timber, in the form of tall fencerows or windbreaks around fields would destroy the breeding potential of the area for prairie chickens. Thus, nesting and brood rearing habitat for prairie chickens appears to be limited on the study area, since prairie chickens prefer grassland to a grass/shrub mixture. Kirsh (1974) in North Dakota, stated that brushy species tend to invade undisturbed prairie and make it unsuitable for prairie chickens.

3. Grassland chould be improved by controlling woody vegetation with fire. A prescribed burning program is currently underway on the study area and should be continued. Ammann (1963) and Kirsh (1974) consider prescribed burning, at 3-5 year intervals, to be the most successful method for controlling woody species and maintaining a high quality grassland habitat. Furthermore,

removal of all or some of the shelterbelts by fire or cutting may reduce predators and improve breeding habitat.

4. Food plots should be planted in order to ensure availability of winter food for prairie chickens. Winter survival of prairie chickens, especially in the northern parts of their range, is mainly dependent on availability of agricultural waste for food. Other studies have also indicated agricultural waste, especially corn, as an important winter food for prairie chickens (Grange 1948, Rumble et al. 1987, Toepfer 1988). There is essentially no winter food (agricultural waste) available on or near the study area. In 1988 a 9.3 ha corn food plot was planted on the study area but failed because of the drought conditions.

5. A concentrated and intensive predator control program on the study area may improve survival of released adult pen-reared prairie chickens if there is suitable habitat. Predator control was instigated on the study area in 1988. It was not a very intensive effort and did not seem to improve nest and brood survival. Bergerud (1988) compared grouse studies where predators were reduced with studies where predators were undisturbed and found no significant difference in chick mortality. Toepfer (1988) did, however, suggest that predator control may be beneficial on areas where pen-reared prairie chickens are to be released. Studies of pheasants (Hessler et al.

1970), bobwhite quail (Colinus virginianus) (Roseberry et al. 1987), and prairie chickens (Toepfer 1988) indicate survival of released semi-wild and game farm birds was between 0 and 19 % over a period of 28-90 days. Observation of released semi-wild and game farm birds indicates that they exhibit behavior not conducive to avoiding predators. They are often less wary than wild birds and habituated to the constraints of a top-fence, making them less prone to sustained flight (Hessler et al. 1970, Roseberry et al. 1987, Toepfer 1988). If adult prairie chickens were to be released, an effort should be made to obtain wild birds.

6. If prairie chickens were to become established they would be competing with sharptails and pheasants on the study area. Sharptails are known to tolerate prairie chickens but dominant them socially and in winter feeding areas (Sharp 1957, Toepfer 1988). Sharptails have been known to displace prairie chickens, usually in areas with brush encroachment into grasslands (Ammann 1957, Toepfer 1988). Sharp (1957), Vance and Westemeier (1979) and Westemeier (1988) reported severe competition between prairie chickens and pheasants. They suggested that pheasants may eliminate isolated pockets of prairie chickens. The only way to avoid this type of competition is to improve prairie chicken habitat and reduce/remove sharptails and pheasants from the study area.

Toepfer (1988) suggested that it would be better to manage an area strictly for prairie chickens rather than to try to manage it for both prairie chickens and sharptails. The zone of overlap between sharptails and prairie chickens was greatly enlarged as a direct result of land-use changes associated with agriculture, mainly where patch farming provided winter food in combination with undisturbed native prairie nesting areas (Johnsgard and Wood 1968). Prairie chickens probably moved into ANWR as a result of the agricultural practices of the early 1900's and have been extirpated because habitat conditions have changed since then. Toepfer (1988) stated that areas that had prairie chickens and now have substantial sharp-tailed grouse populations are probably better suited for sharptails and should be managed as such.

The study area, at this time, is probably better suited for sharp-tailed grouse. Efforts to reintroduce prairie chickens should probably be suspended on the study area until habitat conditions for prairie chickens are improved.

REFERENCES CITED

Ammann, G. A. 1944. Determining the age of pinnated and sharp-tailed grouse. J. Wildl. Manage. 8:170-171.

_____. 1957. The prairie grouse of Michigan. Michigan Dept. of Conserv. Tech. Bull. 200pp.

_____. 1963. Status and management of sharp-tailed grouse in Michigan. J. Wildl. Manage. 27:802-809.

Amstrup, S. C. 1980. A radio collar for game birds. J. Wildl. Manage. 44:214-216.

Baskett, T.C. 1947. Nesting and production of the ring-necked pheasant in northcentral Iowa. Ecol. Monographs 17:1-30.

Bergerud, A. T. 1988. 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.

Bluemle, J.P. 1977. The face of North Dakota; The geologic story. North Dakota Geol. Survey. Educational Series 11. 73pp.

Brown, R. L. 1966. Sharptail grouse population study. Montana Fish and Game Dept. Proj. W-91-R-8, Job II-E. Mimeo. 16pp.

_____. 1967. Sharptail grouse population study. Montana Fish and Game Dept. Proj. W-91-R-9, Job II-E. Mimeo. 18pp.

Burt, W. H. 1943. Territoriality and home range concepts applied to mammals. J. Mammal. 3:346-352.

Daubenmire, R. 1959. A canopy-coverage method of vegetational analysis. Northwest Science 33:43-64.

Evans, R. A., and R. M. Love. 1957. The step-point method of sampling--A practical tool in range research. J. Range Manage. 10(5):208-212.

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.

Fay, L. D. 1963. Recent success in raising ruffed grouse in captivity. J. Wildl. Manage. 27:642-647.

Grange, W. B. 1948. Wisconsin grouse problems. Wis. Conserve. Dept., Madison, 318pp.

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.

Gunderson, P. T. 1990. Nesting and brood rearing ecology of sharp-tailed grouse on the Charles M. Russell National Wildlife Refuge, Montana. M.S. Thesis, Montana State Univ., Bozeman. 84pp.

Hamerstrom, F. N. Jr. 1939. A study of Wisconsin prairie chicken and sharp-tailed grouse. Wilson Bull. 51:105-120.

_____., O. E. Matson, and F. Hamerstrom. 1957. A guide to prairie chicken management. Wis. Conserv. Dept. Bull. 15. 126pp.

_____., and F. Hamerstrom. 1961. Status and problems of North American grouse. Wilson Bull. 73:284-294.

_____. 1963. Sharptail brood habitat in Wisconsin's northern Pine Barrens. J. Wildl. Manage. 27:793-802.

Hayne, D. W. 1949. Calculation of size of home range. J. Mammal. 30:1-18.

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.

Hessler, E., J. R. Tester, D. B. Siniff, and M. M. Nelson. 1970. A biotelemetry study of survival of pen-reared pheasants released in selected habitat. J. Wildl. Manage. 34:267-274.

Higgins, K. F., L. M. Kirsch, H. F. Duebbert, A. T. Klett, J. T. Lokemoen, H. W. Miller, and A. D. Kruse. 1977. Construction and operation of cable-chain drag for nest searches. U.S. Fish and Wildlife Service, Wildlife Leaflet 512. 14pp.

Johnsgard, P. A., and R. W. Wood. 1968. Distributional changes and interactions between prairie chickens and sharp-tailed grouse in the midwest. Wilson Bull. 80:173-188.

_____. 1973. Grouse and quails of North America. Univ. Nebraska Press, Lincoln. 553pp.

_____. 1983. Grouse of the world. Univ. Nebraska Press, Lincoln. 413pp.

Jones, R. E. 1963. Identification and analysis of lesser and greater prairie chicken habitat. J. Wildl. Manage. 27:757-778.

Kirsch, L. M., A. T. Klett, and H. W. Miller. 1973. Land use and prairie grouse population relationships in North Dakota. J. Wildl. Manage. 37:449-453.

_____. 1974. Habitat management considerations for prairie chickens. Wildl. Soc. Bull. 2:124-129.

Kobriger, G. D. 1965. Status, movements, habitats, and foods of prairie grouse on a sandhills refuge. J. Wildl. Manage. 29:788-800.

Lonner, T. N., and D. E. Burkhalter. 1986. User's manual for the computer program TELDAY. Mont. Dept. 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.

Manske, L. L., and W. T. Barker. 1987. Habitat usage by prairie grouse on the Sheyenne National Grasslands. Pages 8-19 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.

Martinson, R. K., and C. R. Grondahl. 1966. Weather and pheasant populations in southwestern North Dakota. J. Wildl. Manage. 30:74-81.

Moyles, D. L. J. 1981. Seasonal and daily use of plant communities by sharp-tailed grouse (Pediocetes phasianellus) in the parklands of Alberta. Can. Field-Nat. 95:287-291.

Neu, C. W., C. R. Byers, and J. M. Peek. 1974. A technique for analysis of utilization-availability data. J. Wildl. Manage. 38:541-545.

Newell, J. A. 1987. Nesting and brood rearing ecology of the greater prairie chicken in the Sheyenne National Grasslands, North Dakota. M. S. Thesis, Montana State Univ., Bozeman. 111pp.

Nielson, L. S., and C. A. Yde. 1981. 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.

NOAA. 1988. Climatological data annual summary for North Dakota. NOAA Environ. Data and Info. Serv. Natl. Climatic Center, Asheville, NC.

Pepper, G. W. 1972. The ecology of sharp-tailed grouse during spring and summer in the aspen parklands of Saskatchewan. Sask. Dept. Nat. Resour. Wildl. Rep. 1. 56pp.

Ritcey, R. W., and R. Y. Edwards. 1963. Grouse abundance and June temperatures in Wells Gray Park, British Columbia. J. Wildl. Manage. 27:604-606.

Roseberry, J. L., D. L. Ellsworth, and W. D. Klimstra. 1987. Comparitive post-release behavior and survival of wild, semi-wild, and game farm bobwhites. Wildl. Soc. Bull. 15:449-455.

Rumble, M. A., J. A. Newell, and J. E. Toepfer. 1987. Diets of greater prairie chickens on the Sheyenne National Grasslands. Pages 49-54 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.

Sharp, W. M. 1957. Social and range dominance in gallinaceous birds - pheasants and prairie grouse. J. Wildl. Manage. 21:242-244.

Sisson, L. 1976. The sharp-tailed grouse in Nebraska. Nebr. Game and Parks Comm., Lincoln. 88pp.

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.

Swenson, J. E. 1985. Seasonal habitat use by sharp-tailed grouse (Tympanuchus phasianellus) on mixed-grass prairie in Montana. Can. Field-Nat. 99:40-46.

Toepfer, J. E., J. A. Newell, and J. Monarch. 1987. 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.

_____. 1988. The ecology of the greater prairie chicken as related to reintroductions. Ph.D. Thesis, Montana State Univ., Bozeman. 536pp.

_____, R. L. Eng, and R. K. Anderson. 1990. Translocating prairie grouse: What have we learned? Tran. N. Amer. Wildl. and Nat. Resourc. Conf. 55:569-579.

U.S. Dep. Comerce. 1973. Monthly normals of temperature, precipitation, and heating and cooling degree days 1941-1970. Climatography of the U.S. No. 81 (North Dakota). U.S. Dep. of Comerce, NOAA, Environ. Data Serv. Climatic Center, Asheville, NC.

Vance, D. R., and R. L. Westemeier. 1979. Interactions of pheasants and prairie chickens in Illinois. Wildl. Soc. Bull. 7(4):221-225.

Weigand, J. P. 1980. Ecology of the hungarian partridge in north-central Montana. Wildl. Monogr. No. 74. 106pp.

Westemeier, R. L. 1988. An evaluation of methods for controlling pheasants on Illinois prairie chicken sanctuaries. Pages 267-288 in D. L. Hallett, W. R. Edwards, and G. V. Burger, eds. Pheasants: Symptoms of wildlife problems on agricultural lands. North Central Section of The Wildl. Soc., Bloomington, IN. 345pp.

Winters, H. A. 1963. Geology and ground water resources of Stutsman County, North Dakota Part I - Geology. North Dakota Geological Survey. Bull. 41:1-84.

Yde, C. A. 1977. The distribution and movements of sharp-tailed grouse during spring and summer in relation to rest-rotation grazing. M.S. Thesis, Montana State Univ., Bozeman. 70pp.

APPENDIX

Table 23. Plant species observed on ANWR study area, North Dakota, 1988-1989.

Scientific name	Common name
Grasses/sedges	
Agropyron cristatum	Crested wheatgrass
Agropyron intermedium	Intermediate wheatgrass
Agropyron repens	Quackgrass
Agropyron smithii	Western wheatgrass
Bouteloua gracilis	Blue grama
Bromus inermis	Smooth brome
Carex spp.	Sedge species
Koeleria cristata	Prairie junegrass
Poa pratensis	Kentucky bluegrass
Spartina gracilis	Cordgrass
Stipa comata	Needle and thread
Stipa spartea	Porcupine needlegrass
Stipa viridula	Green needlegrass
Shrubs/trees	
Amelanchier alnifolia	Serviceberry
Crataegus spp.	Hawthorn spp.
Elaeagnus angustifolia	Russian olive
Elaeagnus commutata	Silverberry
Populus deltoides	Plains cottonwood
Populus tremuloides	Trembling aspen
Prunus virginiana	Chokecherry
Rosa arkansana	Prairie rose
Rosa woodsii	Woods rose
Salix spp.	Willow spp.
Symphoricarpos occidentalis	Western snowberry
Forbs	
Achillea millefolium	Common yarrow
Ambrosia psilostachya	Western ragweed
Amorpha canescens	Leadplant
Artenisia dracunculus	Tarragon sagewort
Artemisia ludoviciana	Cudweed sagewort
Asclepias spp.	Milkweed spp.
Aster falcatus	White prairie aster
Aster pansus	Tufted white prairie aster
Astragalus spp.	Milkvetch spp.
Cirsium spp.	Thistle spp.
Echinacea angustifolia	Purple coneflower
Equisetum spp.	Horestail spp.
Euphorbia esula	Leafy spurge

Table 23. (Continued)

Scientific name	Common name
Galium boreale	Northern bedstraw
Gaura coccinea	Scarlet gaura
Helianthus rigidus	Showy sunflower
Lactuca pulchella	Chicory lettuce
Lygodesmia juncea	Skeletonweed
Medicago sativa	Alfalfa
Panicum virgatum	Switchgrass panicum
Psoralea argophylla	Silverleaf scurfpea
Solidago missouriensis	Missouri goldenrod
Solidago mollis	Velvety goldenrod
Solidago rigida	Stiff goldenrod
Spiraea alba	Narrowleaf spiraea
Viola pedatifida	Prairie violet

Table 24. Mammalian species observed on ANWR study area, North Dakota, 1988-1989.

Common name	Scientific name
Coyote	*Canis latrans*
Red fox	*Vulpes vulpes*
Striped skunk	*Mephitis mephitis*
13-lined ground squirrel	*Spermophilus tridecemlineatus*
Richardsons ground squirrel	*Spermophilus richardsonii*
White-tailed deer	*Odocoileus virginianus*
Racoon	*Procyon lotor*
Fox squirrel	*Sciurus niger*
Badger	*Taxidea taxus*
Franklins ground squirrel	*Spermophilus franklinii*
Mink	*Mustela vison*
Meadow vole	*Microtus pennsylvanicus*
Muskrat	*Ondatra zibethicus*
Cottontail	*Sylvilagus floridanus*
Least weasel	*Mustela nivalis*

Table 25. Avian species observed on ANWR study area, North Dakota, 1988-1989.

Common name	Scientific name
Pied-billed grebe	*Podilymbus podiceps*
Horned grebe	*Podiceps auritus*
Eared grebe	*Podiceps nigricollis*
Western grebe	*Aechmophorus occidentalis*
American white pelican	*Pelecanus erythrorhynchos*
Double-crested cormorant	*Phalacrocorax auritus*
American bittern	*Botaurus lentiginosus*
Great blue heron	*Ardea herodias*
Black-crowned night-heron	*Nycticorax nycticorax*
Greater white-fronted goose	*Anser albifrons*
Snow goose	*Chen caerulescens*
Canada goose	*Branta canadensis*
Wood duck	*Axis sponsa*
Green-winged teal	*Anas crecca*
Mallard	*Anas platyrhnchos*
Northern pintail	*Anas acuta*
Blue-winged teal	*Anas discors*
Cinnamon teal	*Anas cyanoptera*
Northern shoveler	*Anas clypeata*
Gadwall	*Anas strepera*
American wigeon	*Anas americana*
Canvasback	*Aythya valisineria*
Redhead	*Aythya americana*
Ring-neck duck	*Aythya collaris*
Greater scaup	*Aythya marila*
Lesser scaup	*Aythya affinis*
Common goldeneye	*Bucephala clangula*
Bufflehead	*Bucephala albeola*
Hooded merganser	*Lophodytes cucullatus*
Common merganser	*Mergus merganser*
Ruddy duck	*Oxyura jamaicensis*
Osprey	*Pandion naliaetus*
Bald eagle	*Haliaeetus leucocephalus*
Northern harrier	*Circus cyaneus*
Coopers hawk	*Accipiter cooperii*
Swainsons hawk	*Buteo swainsoni*
Red-tailed hawk	*Buteo jamaicensis*
Golden eagle	*Aquila chrysaetos*
American kestrel	*Falco sparverius*
Gray partridge	*Perdix perdix*
Ring-necked pheasant	*Phasianus colchicus*
Sharp-tailed grouse	*Tympanuchus phasianellus*
Virginia rail	*Rallus limicola*
American coot	*Fulica americana*

Table 25. (Continued)

Common Name	Scientific Name
Sandhill crane	*Grus canadensis*
Semi-palmated plover	*Charadrius semipalmatus*
Killdeer	*Charadrius vociferus*
American avocet	*Recurvirostra americana*
Greater yellowlegs	*Tringa melanoleuca*
Lesser yellowlegs	*Tringa flavipes*
Willet	*Catoptrophorus semipalmatus*
Spotted sandpiper	*Actitis macularia*
Upland sandpiper	*Bartramia longicanda*
Marbled godwit	*Limosa fedoa*
Semipalmated sandpiper	*Calidris pusilla*
Long-billed dowitcher	*Limnodromus scolopaceus*
Wilson's phalarope	*Phalaropus tricolor*
Franklin's gull	*Larus pipixcan*
Ring-billed gull	*Larus delawarensis*
California gull	*Larus californicus*
Fosters tern	*Sterna forsteri*
Black tern	*Chlidonias niger*
Rock dove	*Columba livia*
Mourning dove	*Zenaida macroura*
Great-horned owl	*Bubo virginianus*
Belted kingfisher	*Ceryle alcyon*
Red-headed woodpecker	*Melanerpes erythrocephalus*
Downy woodpecker	*Picoides pubescens*
Hairy woodpecker	*Picoides villosus*
Northern flicker	*Colaptes auratus*
Say's phoebe	*Sayornis saya*
Western kingbird	*Tyannus verticalis*
Eastern kingbird	*Tyannus tyrannus*
Horned lark	*Eremophila alpestris*
Purple martin	*Progne subis*
Tree swallow	*Tachycineta bicolor*
Bank swallow	*Riparia riparia*
Cliff swallow	*Hirundo pyrrhonota*
Barn swallow	*Hirundo rustica*
Black-billed magpie	*Pica pica*
American crow	*Corvus brachyrhynchos*
Black-capped chickadee	*Parus atricapillus*
House wren	*Troglodytes aedon*
Eastern bluebird	*Sialia sialis*
American robin	*Turdus migratorius*
Gray catbird	*Dumetella curolinensis*
Brown thrasher	*Toxostoma rufum*
Water pipit	*Anthus spinoletta*
European starling	*Sturnus vulgaris*
Tennessee warbler	*Vermivora peregrina*

Table 25. (Continued)

Common name	Scientific name
Yellow warbler	*Dendroica pectechia*
Yellow-rumped warbler	*Dendroica coronata*
Dicksissel	*Spiza americana*
American tree sparrow	*Spizella arborea*
Chipping sparrow	*Spizella passerine*
Vesper sparrow	*Pooecetes gramineus*
Savannah sparrow	*Passerculus sandwichensis*
Bairds sparrow	*Ammodramus bairdii*
Grasshopper sparrow	*Ammodramus savannarum*
Song sparrow	*Melospiza melodia*
Dark-eyed junco	*Junco hyemalis*
Bobolink	*Dolichonyx oryzivorus*
Red-winged blackbird	*Agelaius phoeniceus*
Yellow-headed blackbird	*X. xanthocephalus*
Western meadowlark	*Sturnella neglecta*
Common grackle	*Quiscalus quiscula*
Brown-headed cowbird	*Molothrus ater*
House sparrow	*Passer domesticus*

Table 26. Summary of sharp-tailed grouse captured during 1988 and 1989 on ANWR study area, North Dakota. Ground/Nest: G# = ground number, N = nest; Sex: M = male, F = female; Age: A = adult, J = juvenile.

Date	Bird/ radio #	Ground/ nest	Sex	Age	Weight	Fate
4/27/88	151.645	G 06	F	A	1100	Alive-8/12/88
4/28/88	151.506	G 06	F	A	1000	Dead-5/4/88, mammal.
4/28/88	151.632	G 06	F	A	900	Alive-8/12/88
4/28/88	151.681	G 09	F	A	900	Dead-5/4/88, avian.
4/28/88	151.302	G 09	F	A	1000	Alive-8/12/88
4/29/88	151.287	G 06	F	A	1050	Alive-7/28/88
4/29/88	151.256	G 09	F	A	900	Radio failure

Table 26. (Continued)

Date	Bird/ radio #	Ground/ nest	Sex	Age	Weight	Fate
4/29/88	151.547	G 09	F	J	1080	Dead-6/8/88, mammal.
4/29/88	151.334	G 09	F	A	950	Radio failure, 6/9/88.
4/29/88	151.464	G 09	F	J	1050	Alive-8/4/88
4/29/88	151.667	G 09	F	J	950	Dead-6/3/88, avian.
6/09/88	151.597	N	F	-	-	Alive-8/11/88
6/09/88	151.533	N	F	-	-	Alive-8/12/88
6/15/88	151.424	N	F	-	-	Alive-8/5/88
6/16/88	151.721	N	F	-	-	Alive-7/28/88
6/24/88	151.576	N	F	-	-	Alive-8/12/88
4/18/89	290	G 09	F	A	864	Dead-5/31/89, avian.
4/18/89	288	G 09	F	A	854	Dead-5/31/89, avian.
4/18/89	302	G 09	F	A	854	Radio failure
4/19/89	291	G 06	F	A	769	Radio failure, 5/23/89.
4/21/89	289	G 09	F	A	784	Dead-5/31/89, avian.
4/21/89	304	G 09	F	J	854	Alive-7/18/89
4/21/89	305	G 09	F	J	859	Alive-7/18/89
4/21/89	303	G 09	F	A	814	Dead-7/12/89, unknown.
4/21/89	306	G 06	F	-	788	Radio failure, 6/15/89.
4/22/89	287	G 06	F	-	909	Radio failure, 6/13/89.
4/27/89	310	G 06	F	J	819	Alive-7/19/89
4/27/89	309-a	G 10	F	A	814	Dead-5/5/89, unknown.
4/28/89	311	G 10	F	A	939	Alive-7/18/89
4/28/89	307	G 10	F	J	824	Radio failure

Table 26. (Continued)

Date	Bird/ radio #	Ground/ nest	Sex	Age	Weight	Fate
4/29/89	308	G 10	F	A	904	Dead-6/8/89, unknown.
5/25/89	151.001	G 06	F	J	844	Shot winter
5/25/89	309-b	G 06	F	A	839	Dead-5/30/89, mammal.
6/21/89	308-d	N	F	A	839	Alive-7/18/89

Table 27. Band data for sharp-tailed grouse captured on ANWR study area, North Dakota, 1989. Ground/ Nest: G# = ground number, N = nest; Sex: M = male, F = female; Age: A =adult, J = juvenile.

Date	Bird/ radio #	Ground/ nest	Sex	Age	Band #	Fate
4/15/89	-	G 06	M	A	2-72102	Unknown
4/15/89	-	G 06	M	A	2-72103	Unknown
4/16/89	-	G 06	M	J	2-72104	Unknown
4/18/89	-	G 09	M	A	2-72105	Unknown
4/18/89	290	G 09	F	A	2-72106	Dead-5/31/89
4/18/89	-	G 09	M	A	2-72107	Unknown
4/18/89	288	G 09	F	A	2-72108	Dead-5/31/89
4/18/89	302	G 09	F	A	2-72109	Radio failure
4/19/89	-	G 09	M	-	2-72110	Unknown
4/19/89	-	G 09	M	A	2-72111	Unknown
4/19/89	-	G 09	M	A	2-72112	Unknown

Table 27. (Continued)

Date	Bird/ radio #	Ground/ nest	Sex	Age	Band #	Fate
4/19/89	-	G 09	M	A	2-72113	Unknown
4/19/89	-	G 09	M	A	2-72114	Unknown
4/19/89	291	G 06	F	A	2-72115	Radio failure
4/19/89	-	G 06	M	A	2-72116	Unknown
4/20/89	-	G 09	M	A	2-72117	Unknown
4/20/89	-	G 09	M	A	2-72118	Unknown
4/20/89	-	G 09	M	A	2-72119	Unknown
4/21/89	289	G 09	F	A	2-72120	Dead-5/31/89
4/21/89	304	G 09	F	J	2-72121	Alive-7/18/89
4/21/89	305	G 09	F	J	2-72122	Alive-7/18/89
4/21/89	303	G 09	F	A	2-72123	Dead-7/12/89
4/21/89	-	G 09	M	-	2-72124	Unknown
4/21/89	-	G 09	M	A	2-72125	Unknown
4/21/89	-	G 09	M	-	2-72126	Unknown
4/21/89	-	G 09	M	A	2-72127	Unknown
4/21/89	306	G 06	F	-	2-72128	Radio failure
4/22/89	287	G 06	F	-	2-72129	Radio failure
4/24/89	-	G 09	M	A	2-72130	Unknown
4/25/89	-	G 06	F	J	2-72131	Unknown
4/27/89	-	G 06	F	A	2-72132	Dead-4/28/89
4/27/89	310	G 06	F	J	2-72133	Alive-7/19/89
4/27/89	309-a	G 10	F	A	2-72134	Dead-5/5/89
4/28/89	-	G 10	M	A	2-72135	Unknown

Table 27. (Continued)

Date	Bird/ radio #	Ground/ nest	Sex	Age	Band #	Fate
4/28/89	311	G 10	F	A	2-72136	Alive-7/18/89
4/28/89	307	G 10	F	J	2-72137	Radio failure
4/28/89	-	G 10	M	A	2-72138	Unknown
4/28/89	-	G 06	M	A	2-72139	Unknown
4/29/89	-	G 10	M	A	2-72140	Unknown
4/29/89	308	G 10	F	A	2-72141	Dead-6/8/89
4/29/89	-	G 06	M	-	2-72143	Unknown
5/17/89	-	G 10	M	J	2-72147	Unknown
5/22/89	-	G 06	M	A	2-72148	Unknown
5/25/89	309-b	G 06	F	A	2-72149	Dead-5/30/89
5/25/89	151.001	G 06	F	J	2-72150	Dead-winter 89
5/25/89	-	G 06	M	J	2-72151	Unknown
6/21/89	308-d	N	F	A	2-72152	Alive-7/18/89

Table 28. Home range sizes (ha) and number and dates of locations for sharp-tailed grouse hens on ANWR study area, North Dakota, 1988-1989. Age: A = Adult; J = Juvenile.

Bird #	Age	First location	Last location	Number of fixes	Home range size
151.256	A	5/09/88	5/17/88	05	< 1
151.287	A	4/29/88	7/26/88	24	193
151.302	A	5/01/88	8/12/88	31	64

Table 28. (Continued)

Bird #	Age	First location	Last location	Number of fixes	Home range size
151.334	A	5/03/88	6/08/88	07	7
151.424	_	6/15/88	8/12/88	18	152
151.464	J	5/03/88	8/04/88	17	110
151.533	-	6/09/88	8/12/88	18	110
151.547	J	5/05/88	6/08/88	12	10
151.576	-	6/24/88	8/12/88	24	11
151.597	-	6/09/88	8/11/88	18	93
151.632	A	5/02/88	8/12/88	35	57
151.645	A	4/29/88	8/12/88	35	80
151.667	J	5/03/88	6/03/88	14	63
151.721	-	6/16/88	7/28/88	19	17
287	-	5/01/89	6/13/89	11	15
288	A	4/19/89	5/31/89	11	21
289	A	4/24/89	5/31/89	09	5
290	A	4/24/89	5/31/89	09	16
291	A	5/01/89	5/25/89	06	3
304	J	4/24/89	7/18/89	21	37
305	J	4/24/89	7/18/89	24	120
306	-	4/04/89	6/15/89	14	291
308	A	5/02/89	6/08/89	09	1
308-d	A	6/21/89	7/18/89	09	33
310	J	5/01/89	7/19/89	28	43
311	A	5/02/89	7/18/89	23	84