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The Sharp-Tailed Grouse in Nebraska

Leonard Sisson
Nebraska Game and Parks Commission

A RESEARCH STUDY
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INTRODUCTION

The plains sharp-tailed grouse *(Pedioecetes phasianellus jamesii)* is one of four species of grouse (Family Tetraonidae) found in Nebraska. The other species are the greater prairie chicken *(Tympanuchus cupido pinnatus)*, sage grouse *(Centrocercus urophasianus)*, and ruffed grouse *(Bonasa umbellus)*. The plains sharp-tailed grouse is one of six subspecies of *Pedioecetes* found in North America (Aldrich 1963). Closely related to the sharptail, the greater prairie chicken occupies similar habitat. Although in different genera, the two species hybridize where their ranges overlap (Johnsgard 1968). Because of the similarities, the two species were often confused in historical accounts. Both species are commonly referred to as "prairie grouse."

An important wildlife resource in Nebraska, the sharptail occupies the Sand Hills, where hunters harvest approximately 40,000 birds annually. In addition, the spring breeding displays of male grouse attract an increasing number of observers each year.

The distribution of sharp-tailed grouse on the Great Plains prior to settlement by white man is poorly documented. However, sharptails were probably present thoughout the area now known as Nebraska, with the exception of the extreme southeast corner.

According to Johnson (1964), the Plains Indians used sharptails for both food and ornamentation, pointing out that "The sharptail, for instance, was mimicked in Indian ceremonies. The Red Man's 'chicken dance' was a takeoff on the dance of this bird." Prairie grouse were also hunted by early settlers for food. In describing pioneer life in Custer County, Nebraska, during the late 1800's, Chrisman (1971:14) recalled that prairie hens, grouse, and quail "frequently found their way into mother's stone jar of heavy salt brine, and we could eat two or three birds at our table in one meal."

During the late 1800's and early 1900's large numbers of grouse were harvested for market and sport. Regulations on taking prairie grouse existed as early as 1864, but were seldom enforced. Additional legislation came gradually, as hunting seasons and bag limits were established.

Rapid land-use changes during the same period had a great impact on both species of prairie grouse. As settlement moved westward into Nebraska, an increasing amount of prairie in the eastern and south-central regions of the state was converted to cropland. With the exception of limited areas along streams, the Sand Hills region of north-central Nebraska was not suited to cultivation and remained in prairie. Consequently, grazing has continued to be the primary land use in the Sand Hills. As more prairie was converted to cropland, the sharptail's range decreased. Presently, the sharptail is limited to areas dominated by prairie, primarily within the Sand Hills.

Prairie chickens responded differently to the land-use changes. Before settlement, Nebraska was not within the primary range of the prairie chicken. The prairie chicken was far more abundant in prairie areas to the east. "In contrast to the sharp-tailed grouse, prairie chickens initially prospered and rapidly followed agriculture northward..." (Johnsgard and Wood 1968:177). Prairie chickens were said to have "followed the plow" into Nebraska. Johnsgard and Wood (1968:177) also stated, however, that "almost as quickly as they flourished, prairie chickens began to suffer from the effects of too intensive agriculture."

As the percentage of cultivated land increased in south-central and eastern Nebraska, the range of the prairie chicken also decreased until it included only those areas on the eastern and southern edges of the Sand Hills and along stream courses in the Sand Hills where cropland and prairie were interspersed. Even with increased harvest restrictions, by 1929 prairie grouse populations declined to such an extent that the hunting season was closed. Intensifying land use and drought in the 1930's caused continued population decline. Viehmeyer (1940) stated that "During the drought period following 1933 there was an influx of livestock into the Sand Hills region from adjacent drought-stricken areas. All ranges were stocked far beyond their grazing capacity, and as a result vegetative cover suffered greatly. Most nesting areas were denuded of all cover and, as a result, very few birds were reared. These conditions of overgrazing continued until 1937 and with this destruction of nesting cover, the prairie chicken and sharp-tailed grouse populations fell to an all-time low."

In 1937, range management practices were initiated and range conditions started to improve with a subsequent increase in the amount of nesting cover for prairie grouse (Viehmeyer 1940). As a result of the drastic population decline during the early 1900's, public opinion favored protection of prairie grouse and illegal harvest subsequently dropped. Conover (1937) reported, "It is apparent that little hunting is going on with regard to prairie chicken and grouse. On over 6,000 miles of patrol, not a single bird violation was apprehended; in fact, no one was observed who showed any intentions toward taking these birds."

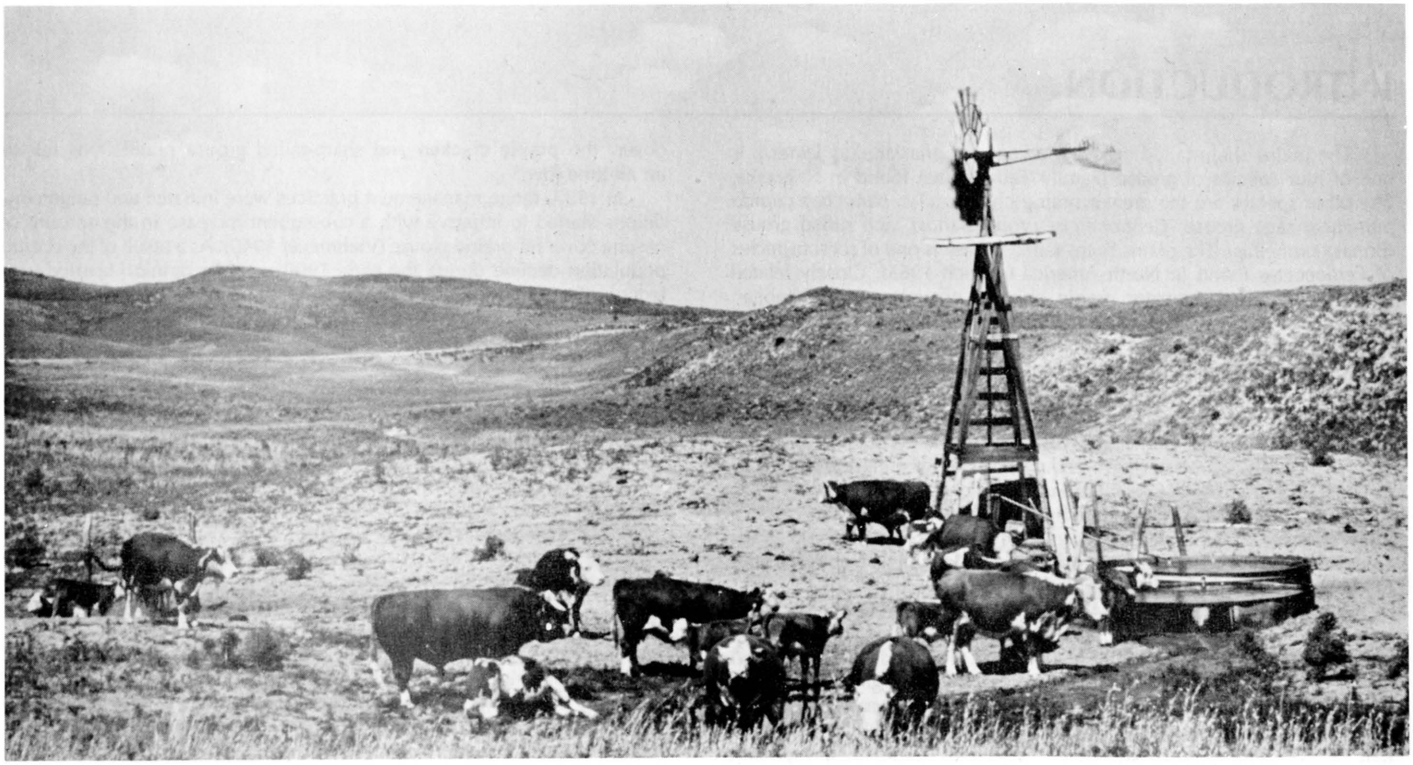
In response to improved range management and increased rainfall, the downward trend in prairie grouse populations reversed and populations began to increase in 1937.

The first objective effort to determine the status of prairie grouse in Nebraska was by Viehmeyer (1940) when he made automobile roadside counts of birds seen in several counties in 1935. He compared results of the 1935 count to those of a count in 1940. Based on these results and information gathered from farmers, ranchers, and sportsmen, he concluded that populations had increased 400 to 500 percent during the five-year period.

The first intensive research on prairie grouse in Nebraska was reported by Mohler (1943). Although emphasis was placed on prairie chickens, both species were investigated. The research was designed to delineate the range of each species in the state and find means to maintain or increase the population. Range maps were developed for both species, based on observations and landowner interviews. A study area was established in Keith County and guidelines developed for statewide winter and spring inventories. Mohler initiated a statewide mail questionnaire in 1941. Selected landowners were requested to supply information on numbers of various game species on their land each year. This survey supplied population trend information on sharp-tailed grouse through 1954. In 1944, wildlife counts by rural mail carriers were begun and have been conducted each year since. These surveys have provided information on sharptail population trends.

Mohler (1943) recommended a census of spring breeding grounds. Such a census was conducted during 1945 and 1946 by driving selected 20-mile routes along state and county roads and making listening stops each mile. Approximate locations were recorded for each group of displaying birds heard. In 1955, an expanded form of the above census was resumed and has been conducted each spring since. An annual upland game bird brood survey was also begun in 1955. This survey was conducted by recording locations and sizes of broods of various species, including sharp-tailed grouse, seen incidental to other field work during a specified period in the summer. The brood survey has also been conducted each year to present.

By 1950 prairie grouse populations had increased sufficiently to allow hunting. The first season was opened in a restricted area for three days in November, 1950. Nebraska has had an annual prairie grouse season each year since 1950, except in 1954. The season was opened at various times during September, October, or November and ranged from 3 to 58 days. The daily bag limit has varied from two to four birds. Because of similarities in appearance of sharp-tailed grouse and prairie chickens, hunting regulations on the two species are the same. However, sharptails are more abundant, outnumbering prairie chickens about two to one in the harvest of recent years. Data on the size of the harvest, hunter success, sex and age composition have been gathered each year on sharp-tailed grouse as well as other species. Although the above surveys provided general information on sharptail population trends, it was felt that additional information was needed to properly manage the species. Therefore, a study of the life history and ecology of sharp-tailed grouse in the Nebraska Sand Hills was initiated in 1958. Data were gathered on population dynamics, mobility, habitat requirements, food habits, and effects of hunting over a 13-year period. This is a report on findings of that research.



The Nebraska Sand Hills

The distribution of sharp-tailed grouse in Nebraska corresponds to the region known as the Sand Hills (Figure 1), which includes approximately 19,300 square miles in north-central Nebraska. It is the largest sand-dune area in the Western Hemisphere and the largest continuous expanse of grassland in the Great Plains (Burzlaff 1962). The formation and characteristics of the Sand Hills have been summarized by Keech and Bentall (1971). The Sand Hills are believed to have been formed during the last major continental glacial period, the Wisconsin, when wind whipped sandy soil into dunes. In some areas the dunes are aligned in a southeast linear fashion, forming a series of ridges and valleys running roughly northwest to southeast, presumably the direction of the prevailing wind at the time of formation. In other areas dunes tend to be "equidimensional and haphazardly arranged." Relief varies from a few to 200 feet. Although stabilized by vegetation, the morphology of the dunes continues to be altered by wind. Where vegetative cover is disturbed, "blowouts" develop as sand is shifted by the strong winds characteristic of the Great Plains. Dune soils form a mantle over a thick sequence of permeable rocks of the Ogallala Formation. This formation, younger alluvial deposits, and dune sand form a large groundwater reservoir with a storage capacity of some 700 to 800 million acre-feet of water.

A comprehensive description of Nebraska soils is given in Elder (1969). Sand Hills soils fall into the Entisol and Mollisol orders and are referred to collectively as the Valentine-Dunday association. They are formed primarily on eolian sand and to a lesser extent on alluvium and gravel. The most common series present within the association are the Valentine and Dunday for which the association is named. The Valentine has a sand or loamy sand texture and is the primary soil of the dunes. The Dunday is of loamy sand texture and is characteristic of dry valley sites. Both are well drained. Elsmere soils are also common, having a loamy sand texture, but are somewhat poorly drained. Another common soil series, the Loup, is poorly drained. Several other soils with varying amounts of silt, clay, and degrees of drainage are present.

Sand Hills soils are often classified into one of four range sites or nontechnical soil types (Burzlaff 1961). These include: choppy sand hills, sands, sandy and subirrigated. Choppy sands are described as deep, loose, coarse textured soils, predominantly sand, on abrupt slopes of 20 percent or more. Sands or rolling sand soils are similar to choppy sands, but on gentle slopes. Sandy or dry valley soils are composed of sandy loams and loamy, very fine sands. Subirrigated or wet valley sites are somewhat poorly to poorly drained soils with the water table generally within one to three feet. The foregoing range site classification of soils will be used in this report.

The climate of the Sand Hills is semi-arid at the west edge, gradually changing to subhumid at the east edge. The mean annual temperature is approximately 48°F with extremes from −40°F to 110°F. Annual precipitation varies from approximately 16 inches in the west to about 24 inches in the east, with approximately 80 percent occurring from April through September (Keech and Bentall, 1971).

Small, shallow, inter-dune lakes are found in many areas, but are most abundant in the western part of the region. The area is drained by a number of streams which are maintained by groundwater and are characterized by unusually stable water levels.

Sand Hills vegetation has been studied and described by several authors, including Webber (1889), Pound and Clements (1900), Pool (1914), Weaver and Albertson (1956), Tolstead (1942), and Frolik and Sheperd (1940). Composition of vegetative cover is determined by soil, topography, availability of water, and the stage of succession. Rydberg (1895) based his definition of floral classes on topography and availability of water. He classified plants as sand hill, dry valley, wet valley, and aquatic.

The dominant vegetation of the Sand Hills is grass and grass-like plants which form an almost continuous cover of thin sod. A variety of forbs are also present. Several species of shrubs and trees occur along stream courses and are sparsely distributed throughout the dunes.

Weaver and Albertson (1956) delineated four plant communities in the Sand Hills: blowout, Sand Hill muhly, bunch grass, and a lake-wet meadow-postclimax true prairie complex. Of these, the bunch grass-type was cited as the prevailing and most typical community.

The Sand Hills are one of the major livestock-producing grasslands in the United States with 12 million acres devoted to production of forage for grazing animals (Burzlaff 1962). Raising of beef cattle is the dominant industry in the Sand Hills. According to Keech and Bentall (1971), the region supported 1,200,000 cattle valued at $165,000,000 in 1967. The hills provide pasture and shelter, while meadows provide hay crops for

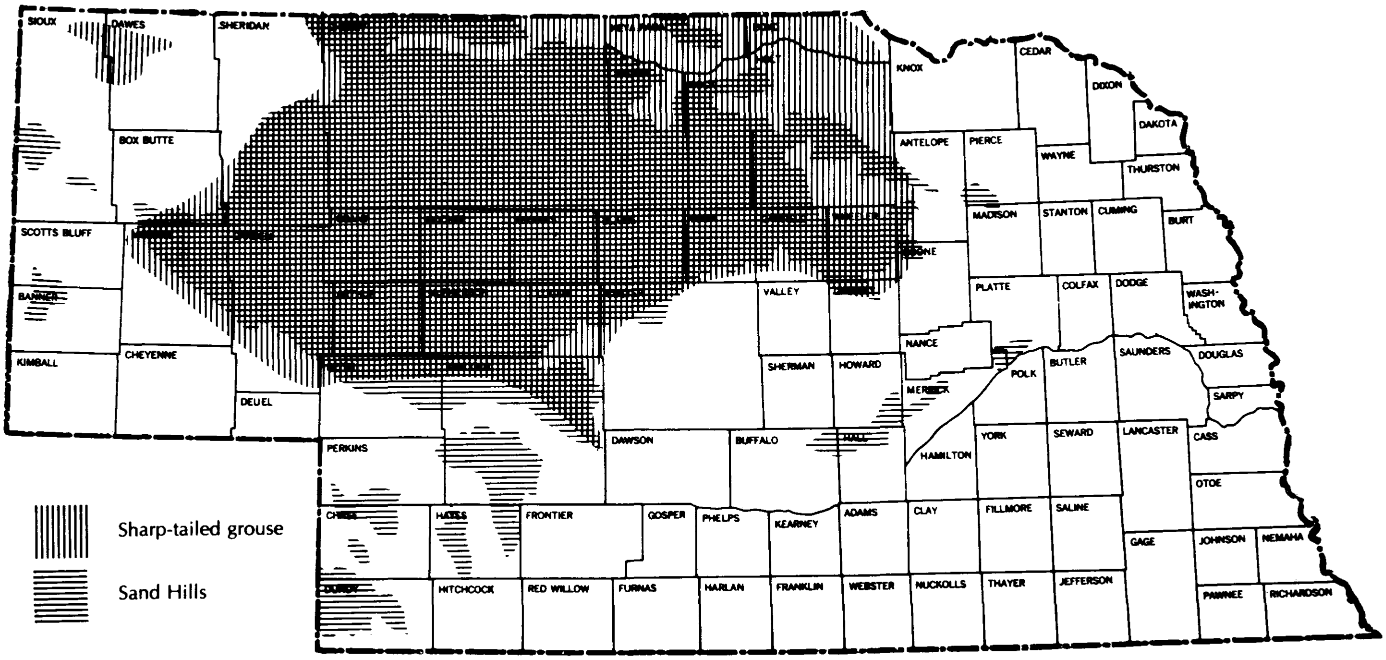


Figure 1. Distribution of sharp-tailed grouse in Nebraska

winter feed. Water for livestock is abundant. Consequently, the Sand Hills are well-suited to cattle-raising. Development of more intensive agricultural use of the Sand Hills has been limited by the sandy soil, which is subject to rapid wind erosion when vegetative cover is disturbed. Thus cattle-raising continues as the dominant industry, since it is compatible with the soil-vegetation complex.

Prairie wildlife species, such as the sharp-tailed grouse and prairie chicken, are present because the prairie has been maintained. However, some feel that the potential exists for considerably greater use of the natural resources of the region. According to Keech and Bentall (1971), "The natural facilities for storage and yield of groundwater constitute the region's greatest potential for development." Two forms of development are now in progress. Row and hay crops are being produced in areas of more stable soils through the use of center-pivot sprinkler irrigation systems. In an effort to grow row crops in the sandy soil and maintain vegetative cover, inter-sod planting is being used in some areas. Exportation of groundwater from the Sand Hills to adjacent areas is also being considered. Keech and Bentall (1971), further stated, "Although marked land-use changes are not an immediate prospect, cumulative small changes would be likely to so modify the environmental situation that natural conditions could no longer be restored."

Description of Study Areas

Work was conducted on three study areas referred to as Loup County, Swan Lake and Bessey. Locations of the study areas are shown in Figures 2 and 3. The Loup County and Swan Lake areas were 36 square miles each, while the Bessey area was 33.5 square miles. The Loup County and Swan Lake areas were under private ownership while the Bessey area was under control of the U.S. Forest Service. From 1958 through 1961 work was conducted on the Loup County and Swan Lake areas. In 1962 most work was transferred to the Bessey area with limited work continuing on the Loup County and Swan Lake areas from 1962 through 1966.

Although representative of the Sand Hills, the three areas differ somewhat in soils and topography. Land use on the Loup County and Swan Lake areas is described in Table 1 and Figures 4 and 5. All range sites from subirrigated to choppy sands were represented on the Loup County and Swan Lake areas. The water table was often at or near the surface, particularly on the Swan Lake area, resulting in numerous wet meadows and several small lakes. Approximately 95 percent of each area was grassland. Of the grassland, approximately 12 percent on the Loup County area and 30 percent on the Swan Lake area was mowed for hay with the remainder devoted to grazing. Approximately 3 percent of the Loup County and less than 1 percent of the Swan Lake areas was used for cropland, with corn and alfalfa the primary crops.

The Bessey area was centrally located on the Bessey Division of the Nebraska National Forest (Figure 3), hereafter referred to as the "Forest." When work was initiated on the Bessey area, the Forest included approximately 65,000 acres of prairie and 25,000 acres of coniferous tree plantings. In 1965, a fire destroyed 42 percent of the plantings.

The Forest is fenced into allotments which are leased for grazing. Approximately 5,300 cattle were grazed on the Forest annually during the study, primarily from May through October. The Bessey area was bounded by a gravel road, Road 203, and a sand trail, Road 201 (Figure 6). Road 212, a paved road which passed through the area, was constructed in 1965. In contrast to the Loup County and Swan Lake areas, the Bessey area consisted entirely of upland prairie with essentially all of the area classified as choppy sands or sands range sites. The Bessey area was characteristic of the central Sand Hills with rather well defined linear dunes aligned in a northwest to southeast direction. Approximately 82 percent of the area was in prairie with the remainder in established or newly-planted coniferous trees. Most of the prairie (84 percent) and plantation (78 percent) was grazed. The area included a 480-acre "natural area" which had been protected from grazing since 1952. There were some 18 miles of firebreak covering about 3 percent of the study area.

The most common method of regulating grazing on the study areas was called deferred rotation which consisted of using two or three pastures for a 2-3 month period each season, varying the order of use between grazing seasons. This system required moving the cattle from one pasture to another two or three times per season, depending on the number of pastures and the rotation schedule.

A complete list of plant species found on the Bessey area during the study is presented in Appendix 1.

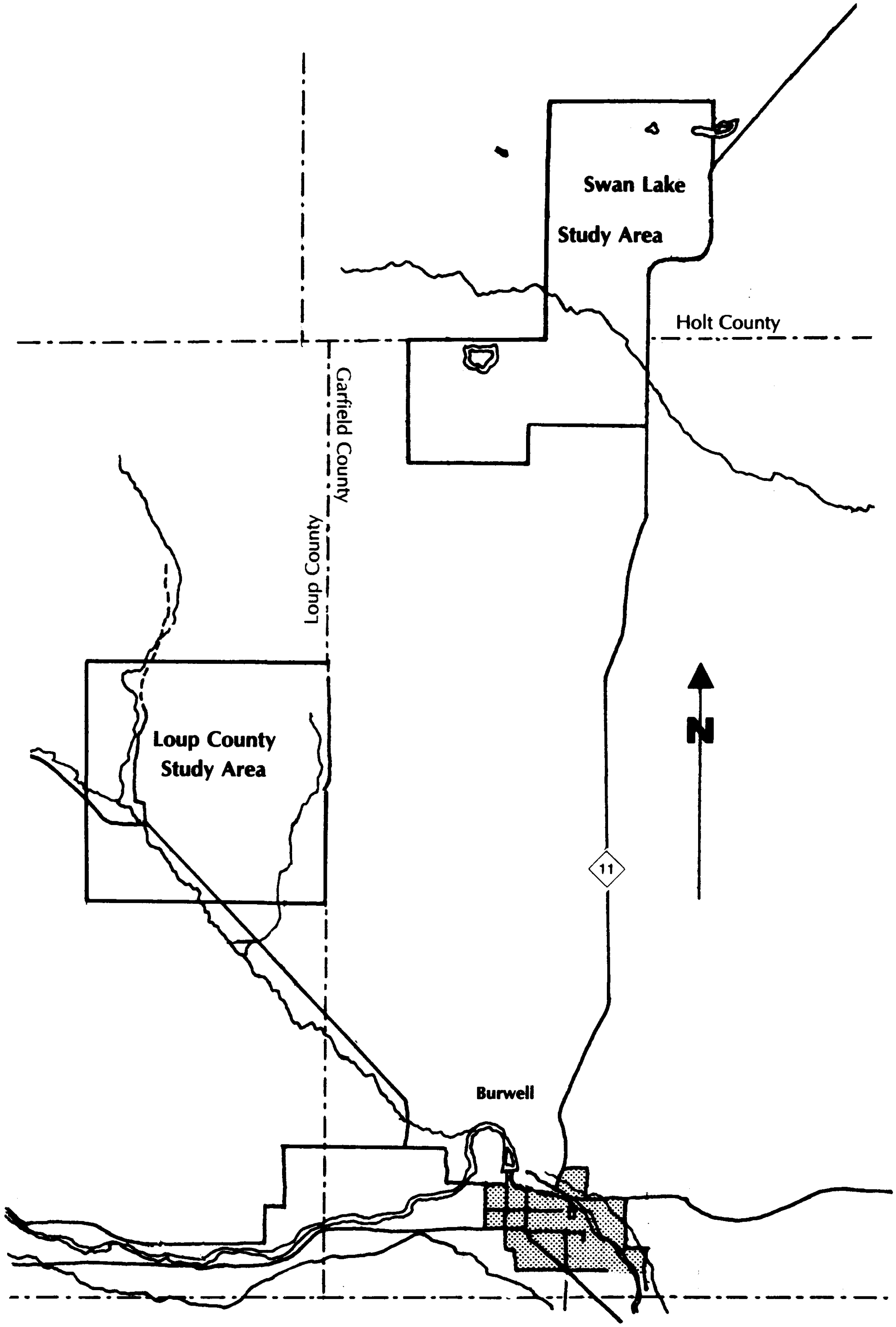


Figure 2. Loup County and Swan Lake Study Areas

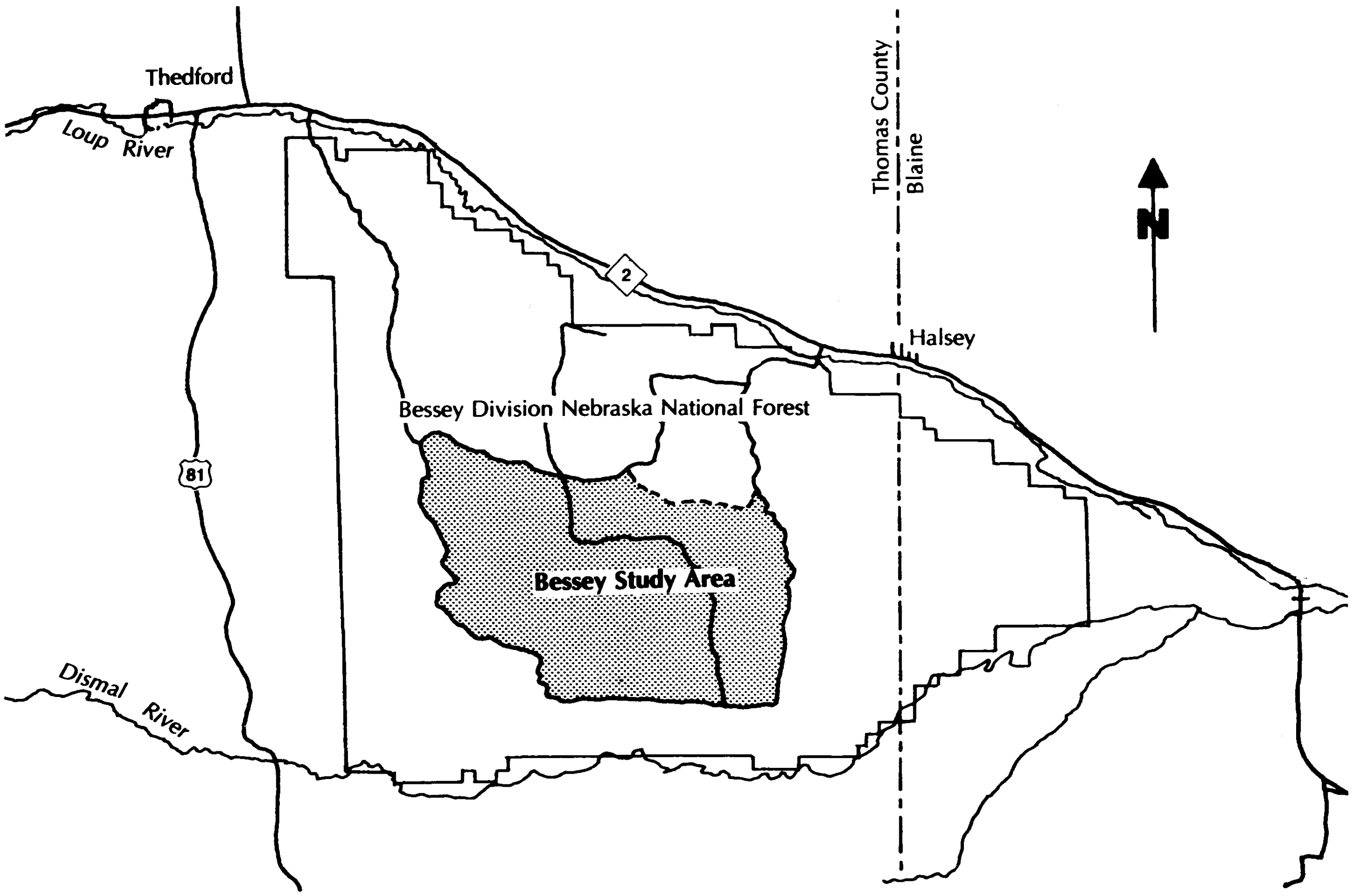


Figure 3. Bessey Study Area,

Table 1. Land use on the Loup County and Swan Lake study area in summer, 1959.

Land Use	Percent of Study Area: Loup County	Swan Lake
Grassland	94.41	95.13
Mowed meadow	11.64	28.39
Pasture	82.76	66.75
Cropland	3.17	0.45
Corn	0.73	0.18
Alfalfa	1.54	0.15
Other	0.89	0.12
Trees	0.66	0.78
Marsh	0.66	0.00
Lakes	0.25	2.44
Abandoned fields, annual weeds	0.26	0.70
Ranchsteads	0.44	0.43
Roadway	0.15	0.08
TOTALS	100.00	100.01

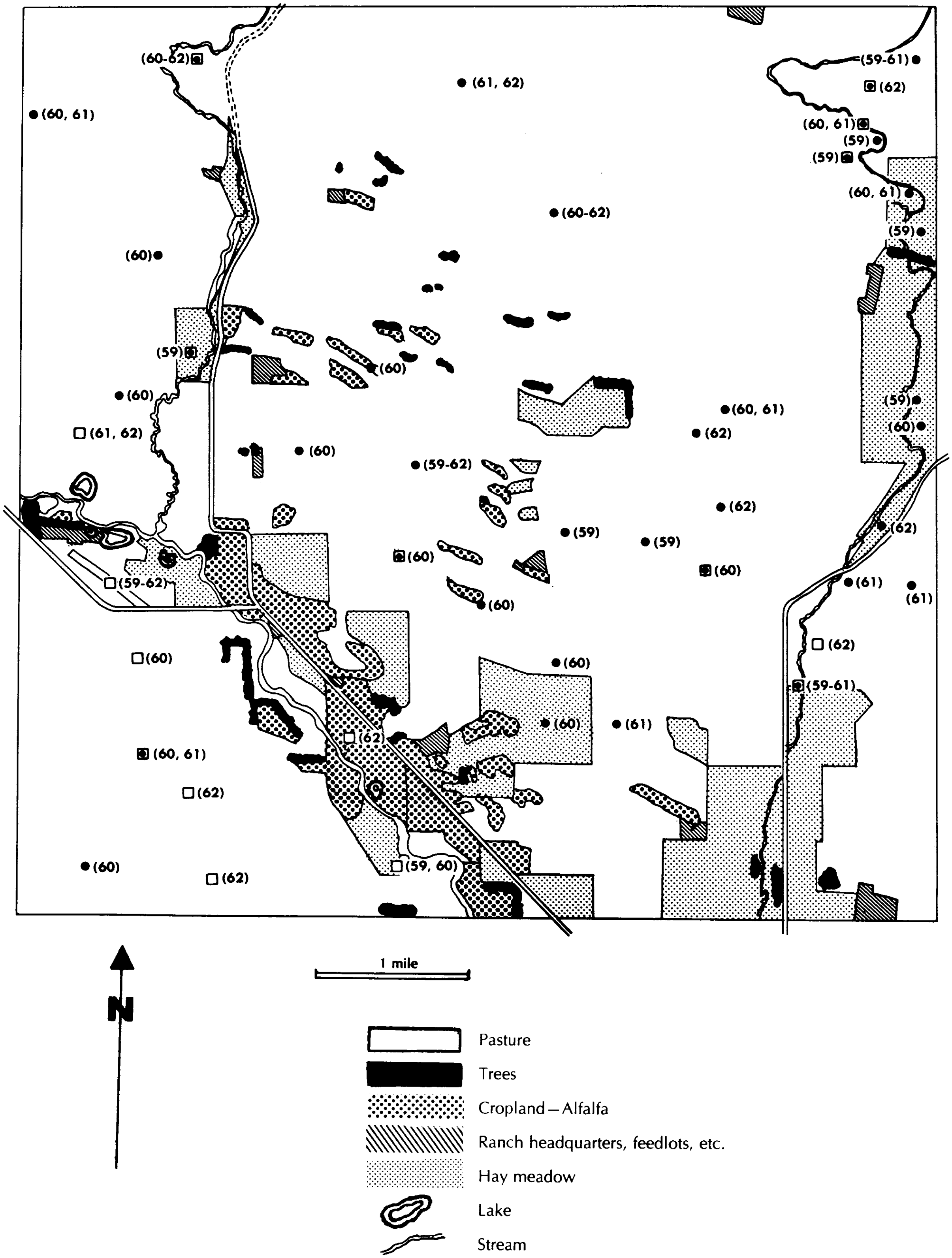


Figure 4. Loup County Study Area showing land use and dancing grounds.

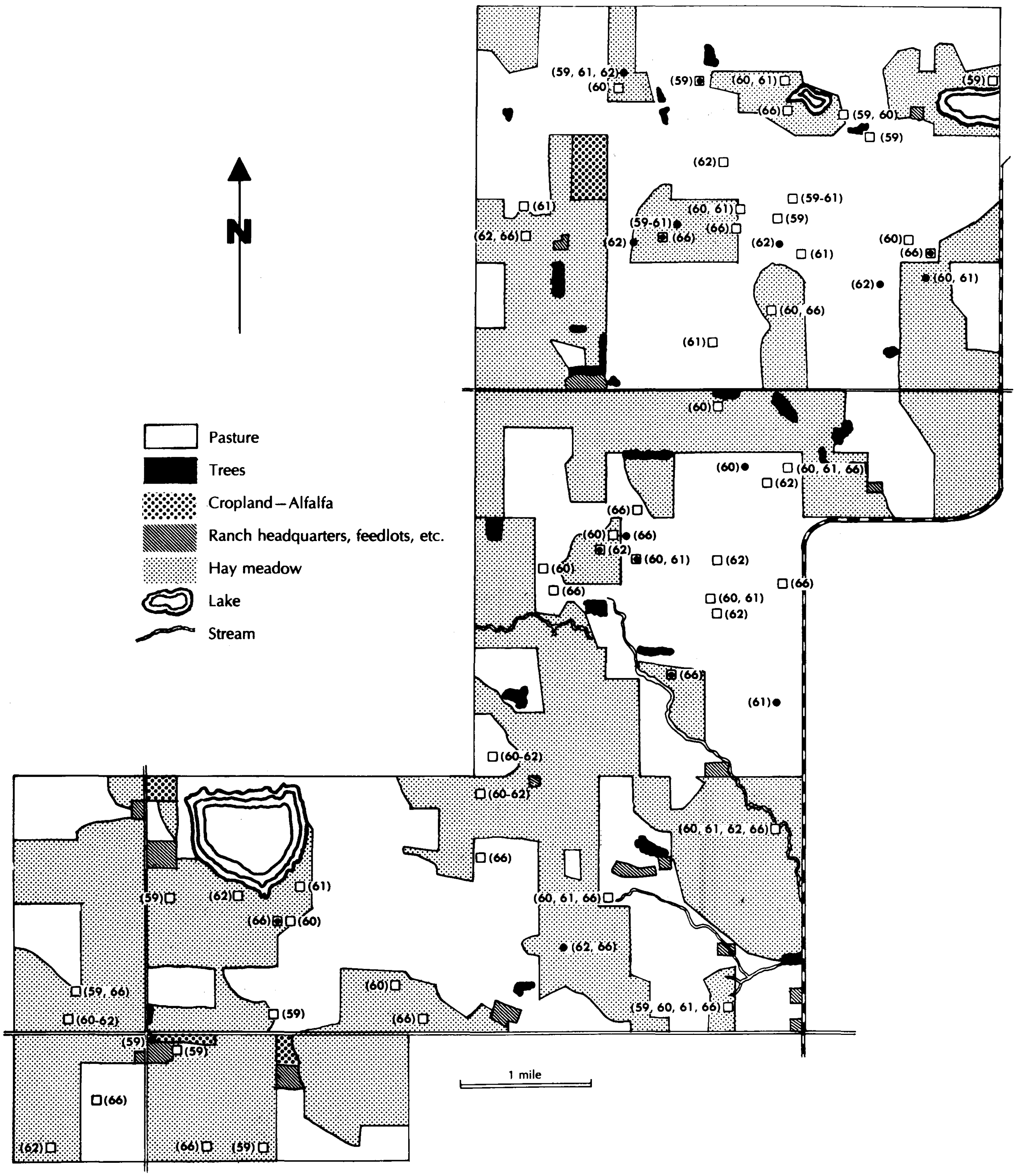


Figure 5. Swan Lake Study Area Map showing land use and dancing grounds.

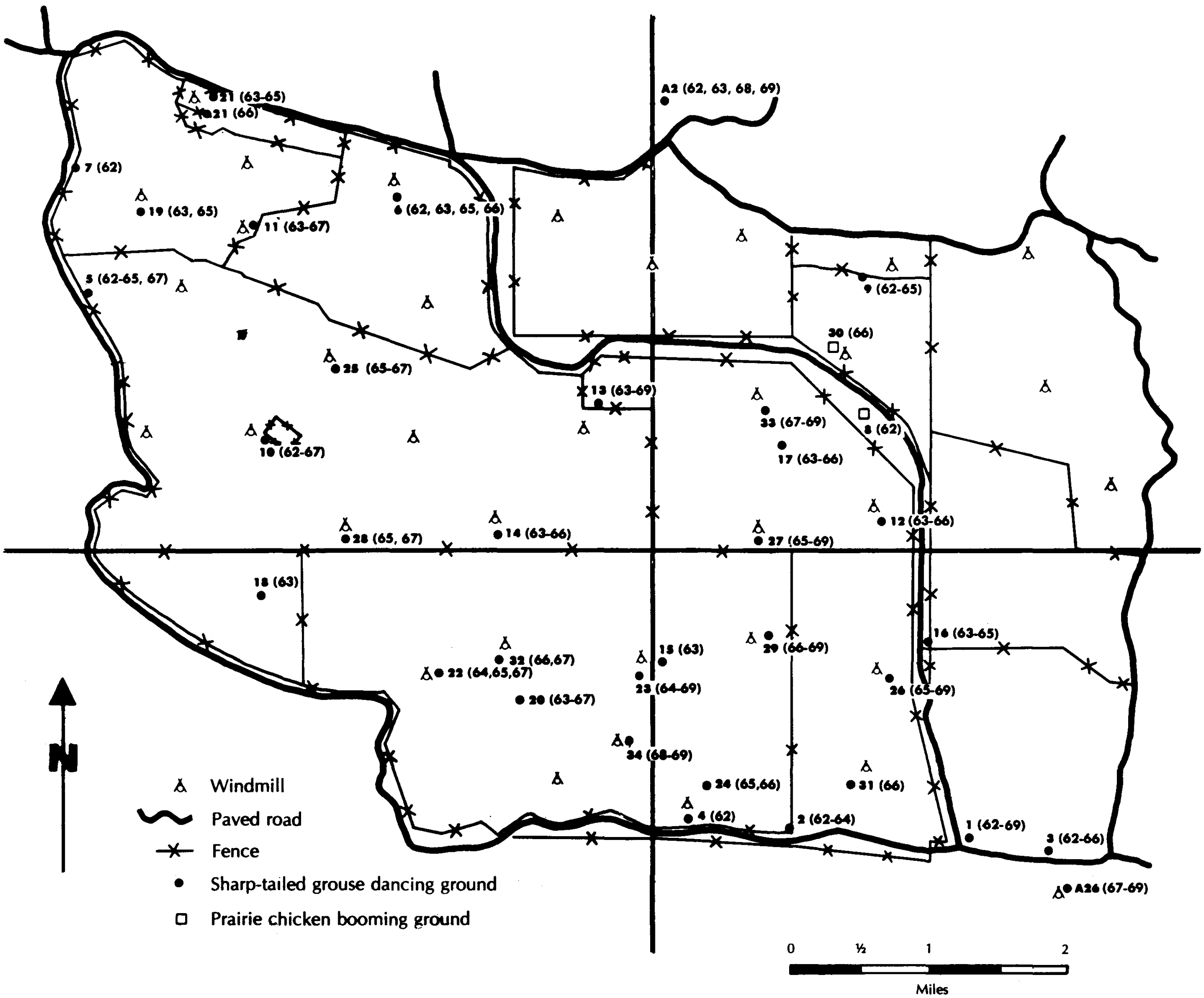
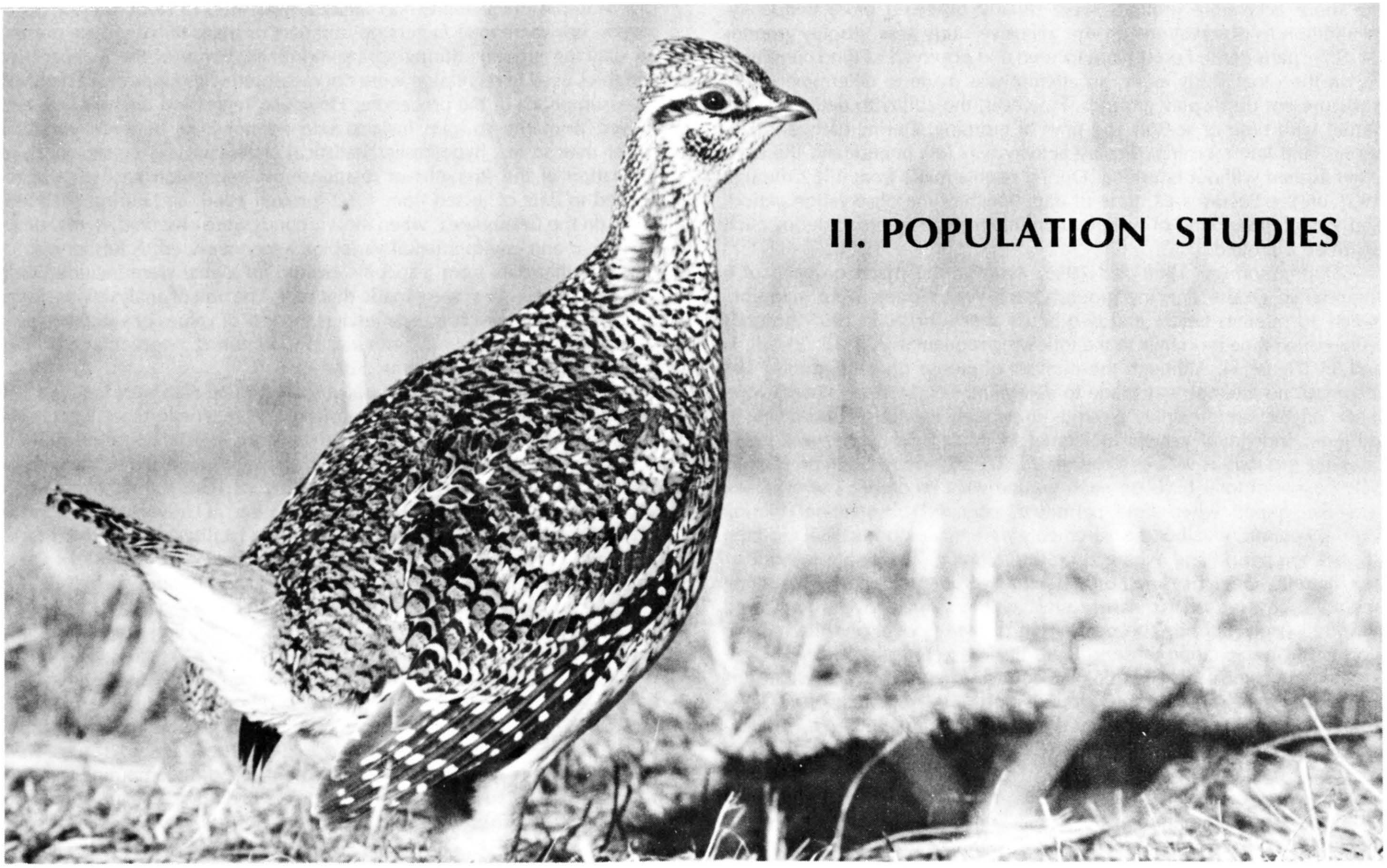


Figure 6. Bessey Study Area showing display grounds and physical features.



II. POPULATION STUDIES

Introduction

Males of several species of tetraonids, including prairie grouse, exhibit communal nuptial behavior. In such species, males congregate at traditional display sites or "leks" and occupy small territories which they defend from neighboring males by a repertoire of threatening displays and postures. For sharp-tailed grouse and prairie chicken these displays are known as "dancing" and "booming" respectively. Although the two species differ in vocalizations, postures, and movements, the general format and periodicity of the displays are similar. In Nebraska, the most active period of display occurs in April and May from about one hour before to two hours after sunrise. Females are attracted to the display sites, where copulation normally takes place. When ranges of sharp-tailed grouse and prairie chicken overlap, mixed display grounds with males of both species are relatively common and hybridization occurs. The role of the male in reproduction is limited to copulation.

This communal nuptial behavior results in grouse being concentrated at specific locations, permitting observation of relatively large numbers of birds, which are normally rather sparsely distributed over their range and difficult to observe.

Locating displaying birds is facilitated by their vocalizations, which are audible for a half mile or more. This behavior led to the use of surveys of displaying males as a measure of trends in population density.

In this study, locations of display grounds and numbers of displaying birds on the study areas were determined annually. The primary objective was to determine distribution and numbers of grouse on the study areas during spring. However, use of repetitive counts and measurement of weather variables allowed investigation of effects of several physical factors on display activity of sharp-tailed grouse on the Bessey area.

Methods

Courtship grounds were located during spring using a two-step procedure. The first step consisted of travelling along roads in the study area by automobile during early morning and making "listening" stops at about one-mile intervals in an effort to hear displaying birds. The distance at which displaying birds could be heard depended on weather conditions and terrain. Under optimum conditions sharp-tailed grouse could be heard up to 1 mile and prairie chickens up to 2 miles. In some areas, where vehicle travel was not possible, searching was conducted on foot. When display activity was heard, the approximate location was marked on a field map. In the second step, an effort was made to locate groups of displaying birds heard on previous mornings and count the numbers of males and females present. A car could usually be driven to within 100 yards of displaying birds without flushing them. When flushed, the birds usually returned after several minutes to resume display. Prairie grouse do not exhibit obvious sexual dimorphism. However, males can be identified in spring by their behavior and secondary sex characteristics during courtship display. Displaying activity is commonly interspersed with periods of inactivity. As a result, sex determination was sometimes time-consuming, requiring at least ten minutes of observation after the birds had resumed normal activity. On the Bessey area a distinction was made between "permanent" display grounds and "transient" grounds. Display sites were considered permanent when activity was observed consistently throughout a spring. When displaying activity was observed only once or only infrequently on a site during a season, the ground was classified as transient. Since most references will be to permanent grounds, the terms courtship ground, dancing ground, booming ground, and ground will refer to permanent grounds unless otherwise specified.

Searching was conducted on the Loup County and Swan Lake areas from 1959 through 1962. Each year an effort was made to locate all courtship grounds on those areas and to obtain at least one complete count of the birds on each ground.

On the Bessey area searching was conducted each year from 1962 through 1967; however, the extent of searching varied from year to year. During 1962, searching was conducted only along the perimeter of the Bessey area from Road 203 the only all-weather road on the area at that time. During subsequent years, a four-wheel-drive vehicle was used to search the entire area, and an attempt was made to visit every ground on the study area three or more times each spring. As would be expected, the more accessible grounds were usually observed more frequently. In addition to observations on the intensive study area, display grounds on other parts of the Forest were located and observed as time permitted. As on the other study areas, an attempt was made to determine sex of birds present on display grounds. However, the ability to determine sex varied with time of season and time of morning. During early and late spring, and late morning, display activity was less intense and the birds often flushed without returning. During counts made from 1962 through 1967 on the Bessey area, time of day, length of the observation period, and a brief description of weather conditions were recorded during each count on a ground.

During springs, 1968 and 1969, counts were made on each of 6 sharp-tailed grouse dancing grounds each year. Counts were made between 30 minutes before and two hours after sunrise. In 1968, grounds were visited nine mornings in the following sequence: A-2, 13, 33, 26, 1, and 34 (Figure 6). Although the number of grouse on each ground was recorded, no attempt was made to determine sex. In 1969, counts were made on the same display grounds in sequence on eight mornings. In addition, individual counts incidental to other field work were made on those grounds as well as Grounds 23, 27, 36, and A-22. In most cases only counts of total birds on each ground were recorded; however, sex was determined when time permitted extended observation. During 1968-69 counts, weather measurements were made during each morning observation period and averaged for the morning. Temperature and relative humidity were measured on a Bendix hygrothermograph. A totalizing anemometer was used to measure average wind velocity over a 30-second period at each ground. The percentage of cloud cover and the relative amount of precipitation (absent, light, heavy) were estimated.

Although most observations on courtship grounds were made during mornings in spring, a few grounds on the Bessey area were visited during afternoons in the spring and mornings in the fall. These observations were made incidental to other field work and therefore, were not systematic.

Locations of display grounds on the study areas were documented each year. The minimum density of males on each study area each year (1962 through 1967) was defined as the sum of the highest counts of males on the individual grounds. When sex was not determined for any counts on an individual ground in a given year, the average ratio of females to males (0.7:1), based on 85 counts when sex was determined, was applied to the highest count of birds on the ground to estimate the number of males. Display grounds found on the Bessey area from 1962 through 1969 were numbered consecutively as located. Designations for display grounds found adjacent to the Bessey area were prefixed with "A" (i.e. A1).

Multiple linear regression analysis was used to study the effects of several environmental factors on numbers of sharp-tailed grouse present on dancing grounds during spring mornings. Some of the independent variables used in regression were not measured without error, as required by assumptions of the procedure. However, regression analysis was employed primarily to gain insights into relationships between variables rather than to test hypotheses. Statistical significance is presented as an indication of the strengths of relationships. Regression analysis was restricted to data collected from 1962 through 1966, and during 1968 and 1969 on the Bessey area, when most grounds were observed several times each year and environmental variables were measured. A further restriction was that data from a specific ground for a year were included only if five or more counts were made that year. The unit of analysis was designated a "case", which was defined as the sets of values of variables measured during a count on a particular ground during a particular morning. Therefore, each count generated one case.

To facilitate statistical analysis, display ground data were keypunched on standard punch cards and transferred to magnetic tape. Data were analyzed by computer using SPSS (Nie *et al.* 1970). Isometric plotting was by means of a Calcomp plotter and software supported by the Lincoln Computing Facility. Automatic processing of data during this project was done on an IBM 360-65-J computer housed at University of Nebraska at Lincoln Computing Facility. Processing was facilitated by an IMB Model 2741 remote terminal located in the Nebraska Game and Parks Commission's Lincoln office. Remote processing was controlled by NUROS (Nebraska University Remote Operating System).

Since it was desired to use counts of grouse from several years and several dancing grounds in analysis of effects of physical factors on attendance, it was necessary to account for differences between years and between grounds as sources of variation. This was done by transforming the raw scores of numbers of grouse on each ground within a year to standard scores (standard normal deviates). The standard scores were then used in the regression analyses. The method of computing standard scores is presented in Appendix 2. Since standard scores are somewhat abstract, standard score results were converted to raw score for discussion. Conversion between standard and raw score is illustrated in Appendix 2. This transformation required that the mean and standard deviation associated with the raw score be specified. Consequently, the mean and standard deviation (8.5, 2.989) from 16 counts made on Ground 26 in 1969 were arbitrarily chosen.

Data from counts made during 1962 through 1966 were used to determine the relationship of time of spring and time of morning to attendance. Time of spring was measured in days starting March 1. Time of morning was expressed in minutes from one hour before sunrise. In addi-

Table 2. Means of the maximum numbers of male prairie grouse per courtship ground from observations during mornings in spring, 1959 through 1962 on the Loup County and Swan Lake areas, and in 1966 on the Swan Lake area.

	Loup County			Swan Lake		
		Number of Males			Number of Males	
Year	Number of Grounds	Mean	S.E.[1]	Number of Grounds	Mean	S.E.
		SHARP-TAILED GROUSE				
1959	7	7.57	1.702	3	4.67	0.333
1960	15	8.73	1.958	3	6.67	1.856
1961	10	19.20	3.329	4	7.75	1.109
1962	6	15.00	4.712	5	7.00	0.447
1966	–	–	–	2	10.50	4.500
		PRAIRIE CHICKEN				
1959	2	12.00	4.000	11	6.09	1.116
1960	3	7.00	4.509	19	9.00	1.259
1961	5	11.40	2.731	15	9.73	1.611
1962	6	7.50	2.802	11	5.00	1.036
1966	–	–	–	16	6.13	1.287

[1]Standard error (standard deviation of mean).

Table 3. Means of maximum numbers of prairie grouse per courtship ground from observations of mixed species grounds during mornings in spring, 1959 through 1962, on the Loup County and Swan Lake areas, and in 1966 on the Swan Lake area.

Year	Number of Grounds	Sharp-tailed Grouse Mean	Sharp-tailed Grouse S.E.[1]	Prairie Chicken Mean	Prairie Chicken S.E.
		LOUP COUNTY			
1959	3	9.33	4.910	7.33	5.365
1960	6	2.83	0.910	6.33	1.706
1961	1	1.00	–	13.00	–
1962	2	5.00	1.000	6.00	5.000
		SWAN LAKE			
1959	1	2.00	–	4.00	–
1960	1	4.00	–	8.00	–
1961	1	9.00	–	5.00	–
1962	1	3.00	–	6.00	–
1966	4	7.50	2.958	4.75	2.394

[1]Standard error (standard deviation of mean).

tion to information from the study area, counts of grouse on display grounds off the study area proper were included in the regression analysis. Data gathered during 1968 and 1969 were excluded from the analyses involving times of day, because most counts in those years were taken in a fixed sequence over time of day. Effects of weather variables were studied using data collected during 1968 and 1969, the years when quantitative weather measurements were available. Weather variables subjected to analysis included temperature, relative humidity, wind, and cloud cover.

Results and Discussion

Distribution of courtship grounds and attendance.—During the springs of 1959 through 1962, 44 courtship grounds were located on the Loup County study area (Figure 4). These included 27 sharptail dancing grounds, 8 prairie chicken booming grounds, and 9 mixed grounds. Eleven dancing grounds, 48 booming grounds, and 7 mixed grounds were found on the Swan Lake area during the springs of 1959 through 1962, and in 1966 (Figure 5).

Average numbers of dancing and booming grounds active annually on the Loup County area were 9.5 and 4 respectively (Table 2). In addition, an average of 3 active mixed species grounds were located on the Loup County area each year (Table 3). On the Swan Lake area, an average of 3.4 active dancing grounds, 14.4 booming grounds, and 1 mixed ground were located annually (Tables 2 and 3). One sharp-tailed grouse X prairie chicken hybrid male was observed on a dancing ground on the Swan Lake area in 1959.

On the Forest, observations were made on courtship grounds on and adjacent to the Bessey area. During the springs of 1962 through 1969, 34 permanent courtship grounds and 16 transient grounds were found on the Bessey area. Locations of permanent courtship grounds located on the Bessey area are represented in Figure 6. During the same period, 26 permanent grounds and 10 transient grounds were located adjacent to the study area.

Although most courtship grounds on the Bessey area were sharptail dancing grounds, a few prairie chicken booming grounds were found. One booming ground (No. 8) with a single prairie chicken male was located in 1962. Another booming ground (No. 30) was located in 1966 with two prairie chicken males and was active in 1967 with one male. Although no courtship grounds on the Bessey area were considered mixed species grounds, prairie chicken males were observed infrequently on dancing grounds. In 1964, a single male prairie chicken was observed displaying on Ground 22. In 1968, two male prairie chickens were observed periodically on Ground 33. A prairie chicken male visited Ground 33 regularly in 1969. Also, in 1969, copulation by a male sharp-tailed grouse and female prairie chicken was observed on Ground 26. During

Table 4. Means of maximum numbers of male sharp-tailed grouse[1] per dancing ground from observations during mornings in spring on the Bessey area, 1962 through 1967.

Year	Number of Grounds	Mean	S.E.[2]
1962	9[3]	9.56	1.345
1963	18	8.56	1.004
1964	16	5.88	0.851
1965	22	6.46	0.844
1966	21[4]	5.81	1.001
1967	13[4]	8.62	1.715

[1]A prairie chicken male was observed on ground 4 in 1962 and another on ground 22. in 1964. A few hybrids were observed in some years and are included in this table as sharptails.

[2]Standard error (standard deviation of mean).

[3]In addition, one booming ground (8) was present with one male.

[4]In addition, one booming ground (30) was present with 2 males in 1966 and 1 male in 1967.

Table 5. Means of numbers of sharp-tailed grouse flushed on selected courtship grounds on the Bessey Area during mornings in April, 1968 and 1969.

	BIRDS FLUSHED					
	1968			1969		
Ground Number	Number Counts	Mean	S.E.[1]	Number Counts	Mean	S.E.
A2	9	20.22	2.482	8	15.25	1.750
13	9	16.00	3.719	8	16.13	0.895
33	9	13.78	2.272	16	19.38	1.072
26	9	15.11	2.653	13	9.15	0.767
1	9	3.67	0.833	13	5.69	0.990
A26	9	8.33	2.539	12	7.58	0.965

[1]Standard error (standard deviation of mean).

the study, seven male sharptail-prairie chicken hybrids were observed on dancing grounds on the Bessey area. Although little effort was made to study courtship behavior, limited observations suggest that male prairie chickens and hybrids were usually successful in maintaining territories. One male hybrid observed several mornings in 1964 on Ground 12 appeared to be dominant over male sharptails.

Numbers of dancing grounds active each spring and means of maximum numbers of males per ground on the Bessey area 1962 through 1967 are presented in Table 4. Means of total grouse flushed per count on each of six permanent dancing grounds during 1968 and 1969 are presented in Table 5.

Densities of active courtship grounds and displaying male prairie grouse observed each year on the study areas are presented in Table 6. Data are presented for those years in which complete searches of the study areas were made by an investigator familiar with the area.

Average numbers of displaying males observed per square mile annually were 5.2, 4.2 and 4.7 for the Loup County, Swan Lake and Bessey study areas, respectively. Corresponding average annual densities of courtship grounds were one ground per 2.4, 1.9 and 1.5 square miles. Average distances between active courtship grounds were 1.5, 1.4 and 1.2 miles on the Loup County, Swan Lake and Bessy areas, respectively. Since active courtship grounds were usually at least 0.5 mile apart, the distribution pattern tended to be uniform rather than random. Since it is unlikely that all courtship grounds were located or all males observed, densities were considered minimal. An average of one transient courtship ground was found for every two permanent grounds located. Since, by definition, transient grounds were attended by displaying males infrequently during a season, the probability of locating such a ground should have been considerably less than that of locating a permanent ground. Therefore, transient grounds may have been as numerous or more numerous than permanent grounds on the Bessey area during the study. In a recent survey of prairie grouse distribution and numbers in North America, estimated spring densities of sharp-tailed grouse varied from less than one to more than 20 males per square mile in different parts of the occupied range (Sisson 1971). In 1972, the minimum density of sharp-tailed grouse along 18 courtship-ground survey routes in Nebraska ranged from 0.0 to 9.8 males per square mile, with a mean density of 2.8.

In addition to morning counts in spring, a few dancing grounds on the Bessey area were observed during late afternoon and evening incidental to other work. Birds were present on less than 50 percent of the afternoon counts. When found on a ground during the afternoon, there were usually fewer birds present than on the same ground during mornings and display activity was normally less intense. Displays by sharptails during late afternoon and evening in spring have been documented by several authors (Marshall and Jensen 1937:96, Baumgartner 1939:487, Edminster 1954:142, Ammann 1957:150, Folker 1964:12, Hillman and Jackson 1973:14). These investigators also found afternoon activity to be less intense with lower participation than during mornings.

Limited fall observations were made of sharptail attendance on dancing grounds on Bessey. Most observations were made during open hunting seasons (late September through November). Grouse were often found

Table 6. Densities of display grounds located and male grouse observed on the study areas during spring. Data for a study area was restricted to those years when the entire area was searched for display grounds.

		Density of Display Grounds Grounds/Mile²				Density of Displaying Males Males/Mile²		
Study Area	Year	Sharptail	Prairie Chicken	Mixed Species	All	Sharptail	Prairie Chicken	Total
Loup County	1959	.20	.06	.08	.33	2.25	1.28	3.53
	1960	.42	.08	.17	.67	4.11	1.64	5.75
	1961	.28	.14	.03	.43	5.36	1.94	7.31
	1962	.17	.17	.06	.38	2.78	1.58	4.36
Swan Lake	1959	.08	.30	.03	.42	0.44	1.97	2.42
	1960	.08	.53	.03	.67	0.67	4.97	5.64
	1961	.11	.42	.03	.56	1.11	4.19	5.31
	1962	.14	.30	.03	.48	1.06	1.69	2.75
	1966	.06	.43	.11	.63	1.42	3.25	4.67
Bessey	1963	.67	–	–	.67	5.58	–	5.58
	1964	.59	–	–	.59	3.41	–	3.41
	1965	.77	–	–	.77	5.15	–	5.15
	1966	.77	.04	–	.77	4.42	0.07	4.46

[1]Based on area of 36 miles² for the Loup County and Swan Lake study areas, and 27.58 miles² for the Bessey study area.

Table 7. Comparison of total numbers of sharp-tailed grouse observed on selected dancing grounds in spring and fall on or adjacent to the Bessey area, 1964, 1965 and 1967. All counts were made during mornings and include both sexes.

		SPRING			FALL		
			Number of Grouse			Number of Grouse	
Ground Number	Year	Number of Counts	Mean	S.E.[1]	Number of Counts	Mean	S.E.
1	1965	7	10.00	2.116	8	1.50	0.926
	1967	7	10.86	2.947	3	0.00	–
3	1965	4	4.75	0.479	4	5.00	2.887
5	1965	9	5.33	1.675	6	0.17	0.167
6	1965	5	5.80	0.663	3	1.67	1.732
9	1964	5	5.00	1.265	4	4.00	2.160
13	1964	7	7.42	3.429	4	19.50	2.467
	1965	5	14.60	1.568	3	10.33	1.732
17	1964	5	8.60	2.227	4	26.25	10.283
19	1965	3	2.33	0.333	4	10.00	10.000
21	1965	14	4.64	1.369	7	0.00	–
26	1967	3	20.67	4.177	3	2.00	1.155
33	1967	3	10.67	1.732	4	13.00	7.605
A8	1965	4	9.25	1.377	3	16.00	2.646

[1]Standard error (standard deviation of mean).

during early morning on grounds active the previous spring. Active displaying was often observed although much less intense than in spring. Usually, the birds present exhibited a loose attachment to the area used for display in spring and, if flushed, normally would not return. Frequently, however, hunters reported successfully stalking displaying grouse on dancing grounds and noted that displaying birds were sometimes unwary and reluctant to leave the vicinity. During the fall of 1965, six sharp-tailed grouse shot on dancing grounds were examined. Four were adult males and two were juvenile males. In the fall of 1966, 18 sharptails shot on dancing grounds included 10 adult males, six juvenile males, and two juvenile females. Based on these data, and observations of grouse on display grounds during fall, it was concluded that birds of both sexes are commonly present.

Fall display has been documented by several investigators. Hamerstrom and Hamerstrom (1951:181) stated that sharptails are most likely to dance in the fall "when there is a snap and sparkle in the air" and that the dance "is much less lively, or passed up altogether, when the morning is warm and lazy or raw and windy." The same authors suggested that some dancing grounds may be established during fall. This concept was supported by findings of the present study. During the fall of 1966 display activity was first observed at the location of Ground 33, which was actively used during the remainder of the study. On the function of fall display, Edminster (1954:139) stated that "young sharptail cocks begin to visit a dancing ground with their elders in early fall."

The present study verified attendance of juvenile and adult males and juvenile females on dancing grounds during fall. Fall display activity of prairie chickens is apparently similar to that of sharptails. Of lesser prairie chickens in Oklahoma, Copelin (1963:27) stated: "Fall bird courtship ground displays were almost as common as spring activities on the Davison study area, although birds appeared on fewer display grounds. But in other areas, fall displays rarely occurred." He suggested that fall display ground inventories should be conducted during mid-October. Robel *et al.* (1970:302), studying greater prairie chickens in Kansas by radio telemetry, found that both adult and juvenile males displayed in fall, but with less regularity than in spring.

From observations in the present study it was assumed that, although large numbers of sharptails were often seen on grounds in fall, the mean number of birds per count on a ground in spring was greater than the corresponding mean for counts on the same ground for mornings in fall. This assumption was tested using data from several dancing grounds, each of which was counted at least three times during a spring and three times during the subsequent fall (Table 7). Fourteen pairs of spring and fall

Table 8. Changes in use of display ground sites by prairie grouse on the study areas during years when all grounds active in one year were visited the following year to determine if active.

Area	Year	Number Active	Number Active From Previous Year	Percent Active From Previous Year
Loup County	1959	12	–	–
	1960	24	5	41.7
	1961	16	11	45.8
Swan Lake	1959	15	–	–
	1960	24	4	26.7
	1961	20	14	58.3
Bessey Area	1962	10	–	–
	1963	18	7	70.0
	1964	16	14	77.8
	1965	22	15	93.8
	1966	21	15	68.2

means were compared using a paired t-test, which indicated no significant difference ($P<0.05$). However, variance in counts within grounds and seasons was high resulting in a low power of test.

Permanence of courtship grounds.—The total number of courtship grounds found during the study far exceeded the number active in any one year. Although the numbers of active grounds located on an area fluctuated from year to year, no trends in numbers of grounds were apparent during years when the study areas were searched completely by an investigator familiar with the areas. Each spring, some of the courtship sites used the previous spring were no longer attended, and some sites not used the previous spring were in use. The rates of "turnover" in use of courtship sites located on the three study areas are summarized in Table 8. On the Loup County and Swan Lake areas, an average of 43 percent of courtship grounds active one year were used the following year. An average of 78 percent of grounds active during a spring on the Bessey area were observed active the following spring. The causes of changes in use of courtship grounds were found to be related to changes in land use and will be discussed in greater detail later. It was concluded that the apparent difference in rate of turnover in use of grounds between the Loup County and Swan Lake areas and the Bessey area probably resulted from (1) a greater effort to determine the status of grounds used during previous years on the Bessey area than on the other areas and/or (2) a more stable pattern of land use on the Bessey area.

According to Edminster (1954:140), most dancing grounds are used only a few years because of habitat changes. In contrast, Ammann (1957:141) found that 7 out of 10 grounds found on Drummond Island were used every year for 10 years. In South Dakota, Hillman and Jackson (1973) reported that 41 percent of the grounds studied remained active 5 years or longer, with 21 percent active 10 years or longer. On the Bessey area several grounds were used each year throughout the study (8 years) and several were found to be active each year from 1962 through 1973 (12 years).

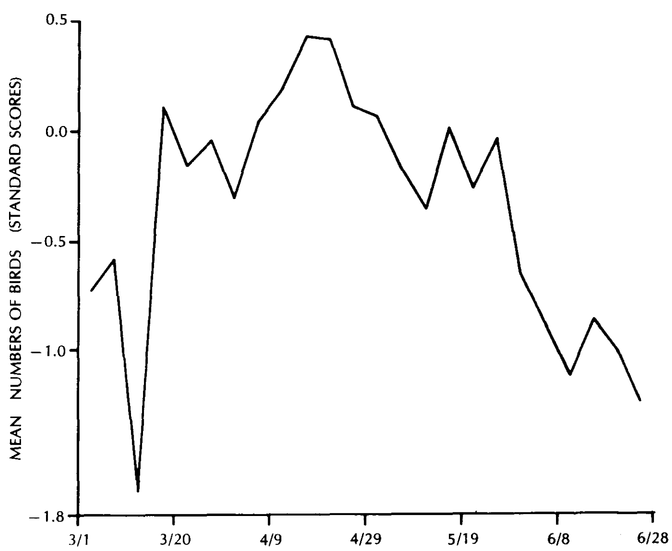


Figure 7. Mean numbers of sharp-tailed grouse (standard scores) counted on dancing grounds on the Bessey Area during mornings in spring, 1962 through 1966, 1968 and 1969, as a function of time of year. Plotted values are means over 5-day intervals.

Influence of weather on courtship activity.—The relationship of time of morning and time of spring to numbers of sharp-tailed grouse observed on dancing grounds during spring, 1962 through 1966, was studied using data from 449 counts (Figures 7 and 8). Examination of these figures indicated that average attendance on dancing grounds was highest during mid-April (seasonal) and before sunrise (daily). The joint relationship between attendance and time of spring and time of morning were studied using multiple linear regression. The model fitted was a second-order polynomial with all terms included. The dependent variable was the number of birds

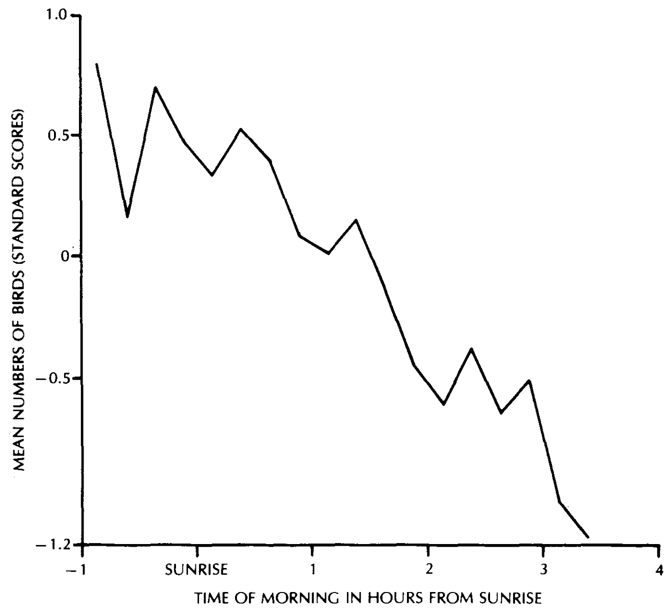


Figure 8. Mean numbers of sharp-tailed grouse (standard scores) counted on dancing grounds on the Bessey Area during spring, 1962 through 1966 as a function of time of morning. Plotted values are means over 15-minute intervals.

(standard score) counted on a ground during one morning observation. The independent variables were time of spring in days starting March 1, and time of morning in minutes from one hour before sunrise. Observations were made from March 3 through June 27 and from 52 minutes before sunrise to 4 hours, 5 minutes after sunrise. Results of the regression analysis are presented in Table 9. The variance accounted for by regression was significant ($P<0.05$). The percent of variance accounted for by regression (multiple − R^2) was 26.2, which suggested that a considerable amount of variance (73.8%) was not accounted for by regression. Although variance explained by regression was significant, the predictive potential of the equation was poor. The expected relationship between numbers of birds (standard score), time of spring and time of day is illustrated graphically in Figure 9 by the isometric plot of the response surface based on the equation formed from the regression coefficients in Table 9. Examination of the coefficients (Table 9) and the response surface (Figure 9) indicates the expected number of birds decreases in a nearly linear fashion from one hour before sunrise. The significant interaction between the effects of time of spring and time of morning ($P<0.05$), as indicated by the time of spring X time of morning standard partial regression coefficient, is also reflected by the plot. The decline in expected numbers of birds during a morning was greater early and late in the courtship season than during mid-season. In other words, birds are more likely to remain on a ground later in the morning during the most active part of the courtship season. No observations were made in the morning before birds arrived on display grounds which usually occurred about one hour before sunrise. Arrival was usually well-synchronized and was assumed to be in response to increasing light intensity prior to sunrise. The equation based on regression, therefore, was only applicable to the period following arrival of birds on the grounds. It is also noted that a second-degree polynomial, as used in the analysis, allows a fit to data following a smooth "rounded curve" and is not sensitive to unsymmetrical and sharply curved relationships. However, it was felt that the model used approximated observed relationships well in present data. The optimum value for expected numbers of birds was found by setting time of morning equal to 0.0 (one hour before sunrise) and by setting the first differential of the remaining terms of the regression equation equal to 0.0. This gave an optimum at day of spring = 34 (April 3). The apparent difference between the predicted optimum and that suggested by examination of Figure 7 was probably due to lack of fit of the polynomial curve.

Table 9. Results of multiple linear regression of numbers of sharptailed grouse (standard score) counted on dancing grounds on day of season and time of morning. Analysis was based on 449 counts during spring, 1962 through 1966, on grounds on and adjacent to the Bessey area.

Dependent Variable:
Number of birds (standard score)

Independent Variables:	Regression Coefficient (b)	Normalized Regression Coefficient (Beta)	F[1]
Day of season (days from Feb. 28)	0.02396	0.51525	5.387
Time of morning (minutes from 1 hr. before sunrise)	−0.00694	−0.41268	3.183
Day of season²	−0.00035	−0.91123	26.320
Time of morning²	−0.00002	−0.29797	2.769
Day of season x time of morning	0.00009	0.36516	5.216
Constant term	0.56668		

Multiple— $R^2 = 0.26232$

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F
Regression	5	103.686	20.737	31.506[2]
Residual	443	291.576	0.658	

[1] $(b/\text{Std. error of } b)^2$ with 1 and 443 d.f.; tabulated F (P = 0.05, 1 and 443 d.f.) = 3.86
[2] Tabulated F (P = 0.05, 5 and 443 d.f.) = 2.23

As noted, it was not always possible to determine the sex of birds observed on courtship grounds. From 1959-67, observers attempted to determine the maximum number of males on each ground each spring. This was usually accomplished during the peak of the courtship season. However, sex often could not be determined earlier and later in the season. Therefore, data from those years were insufficient to investigate the relationship between time of spring and attendance of grounds by females. However, during the spring of 1969, several dancing grounds were observed for relatively long periods of time on each of several mornings during the courtship season. Attendance by females on these dancing grounds is expressed in terms of females per male and presented graphically in Figure 10. The peak in female attendance corresponded to the peak in numbers of total birds for 1962 through 1966 (Figure 6). During that period, sex was determined during 85 counts in spring on the Bessey area. The average ratio of females to males per count was 0.7:1. Also, the attendance of females on a ground varied greatly from morning to morning. The maximum number of females seen during a count was 21 sharptail hens on the morning of April 22, 1964 on Ground 21; eight male sharptails were present.

Initiation of sharptail courtship display activity in spring and fall and diurnal periodicity of display are assumed to correspond to increasing day length and diurnal fluctuations in light intensity (Marshall and Jensen 1937:96-97). Spring activity usually reaches a peak sometime in April or May, depending on latitude. In the present study, the peak oc-

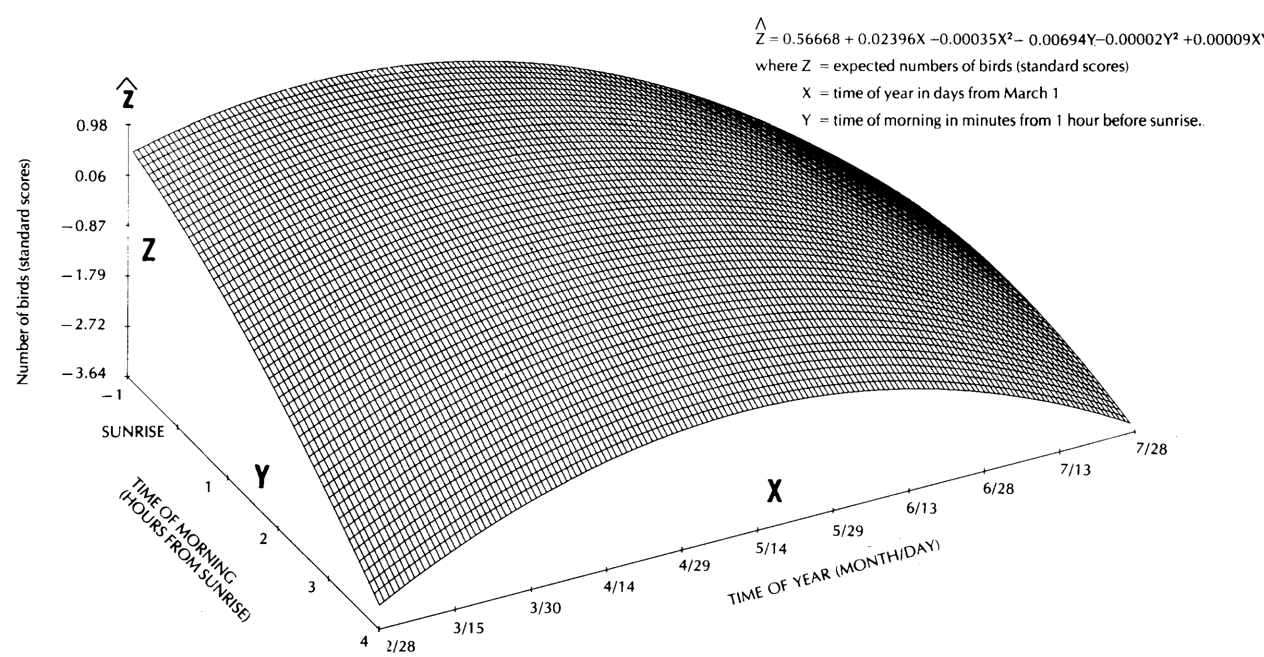


Figure 9. Isometric plot of expected numbers of sharp-tailed grouse (standard scores) on a dancing ground as a function of time of spring and time of morning. Expected values computed using a second degree polynomial in two independent variables (time of spring and time of morning), Coefficients were determined by multiple linear regression using data collected during springs, 1962 through 1966, on the Bessey Area.

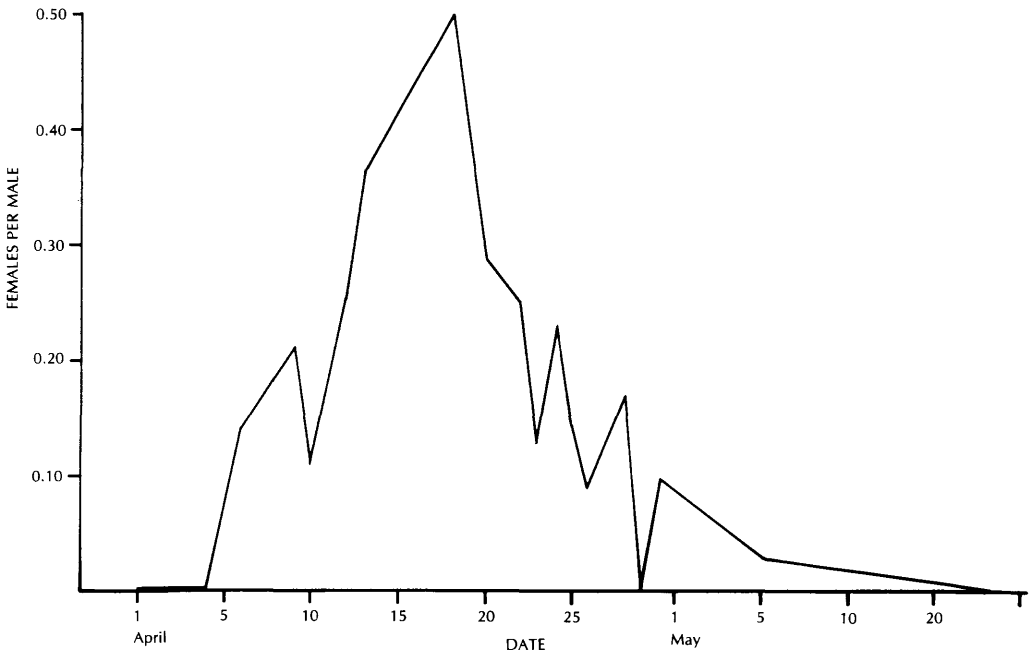


Figure 10. Distribution of female sharp-tailed grouse attendance on dancing grounds during spring, 1969.

curred in mid-April. In Saskatchewan, Folker (1964:10) reported that sharptail dancing activity reached a maximum during the first two weeks in May, 1958, on his study area. He also attributed the decline in display activity in late May and June to a decline in sexual motivation. In the present study, the relationship of attendance on grounds to time of spring followed a second-order polynomial curve. Field experience indicated that the spring activity peak on the Bessey area varied slightly from year to year, occurring earlier in years having more clear days in early spring and later when cloudy or inclement weather prevailed.

In the present study, limited data suggested that the peak in attendance of female sharptails on dancing grounds in spring is more pronounced than that of males. The most reported data on attendance of female prairie grouse on courtship grounds was on greater prairie chickens in Wisconsin (Hamerstrom and Hamerstrom 1973:12-24). In that study, peaks in attendance of hens varied approximately two weeks between early and late years. In addition, it was noted that "hens are much less regular and predictable in their presence on a booming ground than cocks even within a given morning." Also, peaks in attendance of hens were very pronounced, although usually discontinuous, and seemed to be confined to a period of about one week.

Sexes were not distinguished in the study of attendance by sharptails on dancing grounds on the Bessey area using regression analysis. Since attendance by males was expected to reach a plateau, the presence of hens may account for the observed peak. There may also have been a peak in attendance by non-territory holding males during the seasonal peak in courtship activity. Robel *et al.* (1970:301) found that juvenile male prairie chickens in Kansas visited display grounds less as the booming season progressed.

On the Bessey area, total numbers of sharptails on grounds during mornings in spring declined in a nearly linear fashion as the morning progressed. The rate of decline was related to time of season, with attendance and display activity maintained longer during the seasonal peak in activity.

From observations of dancing grounds throughout the entire morning courtship period, it was found that males were first to arrive on the ground between one hour and one-half hour before sunrise depending on cloud cover and other weather conditions. Arrival of males was usually well-synchronized, with most "regulars" (those holding territories) arriving within a few minutes of one another. The most intense display activity usually occurred about sunrise, with attendance of females usually greatest from just before sunrise to about one hour after sunrise. The presence of non-territory holding cocks often coincided with that of females. These males sometimes displayed at the edge of a ground in poorly defined territories and were often chased by more dominant cocks. As the morning progressed, display activity became less intense, with increasingly longer periods of inactivity. Unless disturbed, the most dominant cocks were normally last to leave the ground, at about 3 hours after sunrise. In some cases, two or three males remained on the ground for more than 30 minutes after all other birds had left, each seemingly attempting to leave several times, only to be stimulated by the presence of the others into renewed defense of his territory. Finally, after some kind of unknown agreement (or simply fatigue) the two competitors would walk off the ground, often together.

Regression analysis was used to evaluate the joint relationship between sharptail numbers (standard score) and values of several weather variables during spring counts on the Bessey area. Analysis was based on

Table 10. Descriptive statistics of variables used in regression analysis of the relation between numbers of birds on dancing grounds in spring and weather. Number of birds was the dependent variable. Number of cases = 161.

VARIABLE NAME	MEAN	MINIMUM	MAXIMUM	RANGE
Number of birds[1]	0.0	−2.457	2.548	5.005
Day of spring	52.3	32.0	101.0	69.0
Temperature (°F)	43.6	30.0	61.0	31.0
Relative humidity (%)	79.6	48.0	100.0	52.0
Wind (MPH)	6.5	0.0	15.0	15.0
Cloud Cover (%)	49.2	1.0	100.0	99.0

[1]Standard score.

Table 11. Results of multiple linear regression analysis of numbers of sharp-tailed grouse (standard score) counted on dancing grounds on several weather variables. Analysis was based on 161 counts during spring, 1968 and 1969, on six grounds on and adjacent to the Bessey area.

Dependent Variable:
Number of birds (standard score)

Independent Variables:	Regression Coefficient (b)	Normalized Regression Coefficient (Beta)	F[1]
Day of season (days from Feb. 28)	−0.13817	−2.55937	4.606
Temperature (°F)	0.45270	3.22814	4.442
Relative humidity (percent)	0.18199	2.54620	5.658
Cloud cover (percent)	0.01259	0.53535	0.335
Wind (miles per hour)	−0.96733	−4.05576	23.994
Day of season²	−0.00135	−3.23584	29.685
Temperature²	−0.00709	−4.48992	7.640
Relative humidity²	−0.00089	−1.92491	5.837
Cloud cover²	−0.00005	−0.23356	0.306
Wind²	−0.01053	−0.65748	1.759
Day of season x temperature	0.00433	4.88337	10.753
Day of season x relative humidity	0.00085	1.49001	1.598
Day of season x cloud cover	0.00019	0.47568	0.483
Day of season x wind	0.00095	0.24999	0.163
Temperature x relative humidity	−0.00222	−1.87893	2.063
Temperature x cloud cover	0.00013	0.24547	0.067
Temperature x wind	0.01873	3.89167	11.554
Relative humidity x cloud cover	−0.00026	−0.98879	2.720
Relative humidity x wind	0.00252	0.89578	1.429
Cloud cover x wind	−0.00021	−0.09169	0.069
Constant term	−9.47141		

multiple−R^2 = 0.51583

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F
Regression	20	75.829	3.791	7.457[2]
Residual	140	71.175	0.508	

[1](Beta/Std. error of Beta)² with 1 and 140 d.f., tabulated F (P = .05, 1 and 140 d.f.) = 3.91
[2]Tabulated F (P = .05, 20 and 140 d.f.) = 1.64

161 cases from the springs of 1968 and 1969. Descriptive statistics of variables analyzed are presented in Table 10. A second-order polynomial model was fitted. Since there was no previous knowledge of relationships between variables, all possible second-order terms were included (Draper and Smith 1966:130). Time of spring in days, starting March 1, was also included to account for relationships between variables and time of season because previous analyses demonstrated that attendance was related to time of season.

Results of the regression analysis are summarized in Table 11. Variance accounted for by regression was significant ($P<0.05$). The percentage of variance accounted for by regression was 51.5, nearly double that accounted for by time of spring and time of morning alone in the previous analysis. Significant terms in equation were the first and second-order terms of time of spring, temperature, and relative humidity ($P<0.05$). The first order term of wind was significant ($P<0.05$), as were the products (interactions) of time of spring and temperature, and temperature and wind ($P<0.05$).

Examination ot the coefficients of the first and second order terms of temperature indicated a convex, curved relationship between temperature and the dependent variable. However, the significance of the interaction between temperature and day of season suggested that the effect of temperature was dependent on time of season. The effects of temperature at different times of season were simulated by a simple computer program written in Calctran (Dewar 1970). The program utilized the regression coefficients from Table 11 and gave expected values of numbers of birds over a range of values for one variable, assuming the others constant. Simulation based on regression was limited to ranges of variables actually measured and used in the determination of the regression equation. Raw scores of numbers of birds were computed from standard scores using the mean and standard deviation from Ground 26 during 1969. Figure 11 illustrates the results of simulating effects of temperature on expected numbers of birds, assuming constant values of relative humidity, cloud cover, and wind. Values of relative humidity, cloud cover, and wind were assumed to be 80 percent, 1 percent and 0 mph respectively. Under these conditions, effects of temperature depended on time of spring, with the optimum expected numbers of birds at 30°F, 34°F, and 38°F for April 1, April 15 and May 1 respectively. The optimum at April 1 was actually at less than 30°F, but no observations were made below that temperature. Results of other simulations not presented indicated that optimum temperatures were higher with increased wind velocity.

Both terms of relative humidity were significant with no significant interactions with other variables. Measured values of relative humidity ranged from 48 to 100 percent (Table 10). Assuming day of spring, temperature, cloud cover, and wind to be constant at April 15, 40°F, 50 percent and 5 mph respectively, optimum relative humidity was approximately 74 percent with higher and lower values being somewhat less desirable. However, within the ranges of relative humidity actually measured, simulation indicated that numbers of birds would be expected to vary less than two, assuming other variables remained constant at values stated.

The first-order term of wind was also significant. However, the second-order term of that variable was not significant, indicating a nearly linear relationship. The significance of the term representing interaction of temperature and wind suggested that effects of wind and temperature were interrelated. This relationship was also studied by simulation and indicated that expected numbers of birds decreased as wind increased

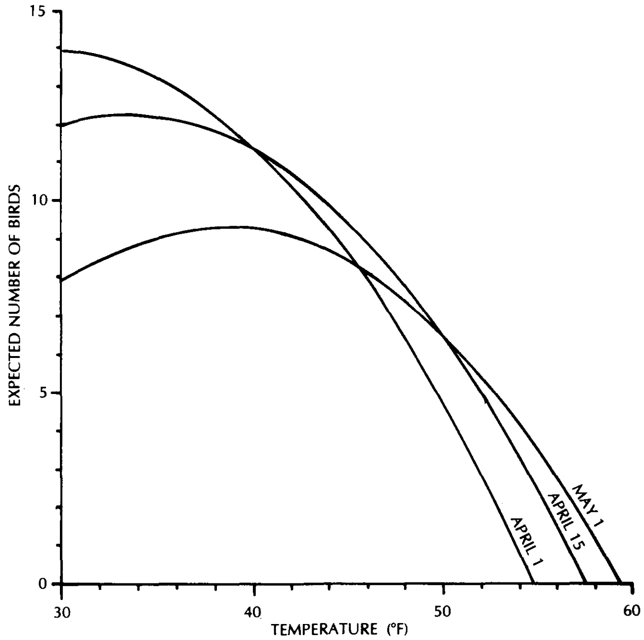


Figure 11. Expected numbers of sharp-tailed grouse present on a dancing ground in relation to temperature on three different dates. Values were computed using the regression equation from Table 10 and assuming relative humidity, wind and cloud cover to be 80%, 0 m.p.h., and 1% respectively. Actual values of numbers of birds based on data from ground 26 in 1969 (Mean = 8.5, standard deviation = 2.989).

when temperature was low (Figure 12). However, numbers of birds also decreased at higher temperatures in combination with low wind velocities. A possible explanation for these phenomena was that, while unusually warm mornings were normally windy, a calm, warm morning was often associated with changes in weather, particularly an approaching storm. Experience indicated that attendance and courtship activity usually decreased under such conditions.

Precipitation during counts in 1968 and 1969 was recorded as absent, light, medium, or heavy. Since this variable was not measured continuously, it was not used in the regression analysis. However, precipitation had an obvious effect on attendance and courtship activity. In 1968, light rain occurred on three of the nine mornings when counts were made, and it rained heavily one morning. During mornings with light rain, display activity decreased and fewer birds were present. On the morning of heavy rain, which was accompanied by thunder and hail, there were birds on only one of six grounds counted, and they may have roosted on or adjacent to the ground the night before. In 1969, light rain occurred one morning, but the number of birds on five grounds was not appreciably less than on other mornings.

Several authors have referred to the influence of weather on courtship activity of prairie grouse. However, most references to effects of weather on courtship activity have been subjective. Edminster (1954:152) summarized previous findings on sharp-tailed grouse by stating: "The dancing-ground activity varies with the weather as well as with the season. Cold, crisp, clear, quiet days are most conducive to energetic displays, but warm, windy, rainy, or stormy weather noticeably suppresses the birds' courtship activity." In Saskatchewan, Folker (1964:10) observed sharptails dancing during high winds and concluded that wind velocity did not affect dancing behavior. Lumsden (1965:39) reported that attendance of sharptail hens was highest when it was calm and clear, and lowest during windy mornings with precipitation. Robel (1964:708) found that booming activity of male prairie chickens in Kansas was greater when temperatures were below 12°C to 16°C (54°F to 61°F) and decreased as temperature rose above 18°C to 20°C (64°F to 68°F). Hamerstrom and Hamerstrom (1973:7, 15) found that prairie chicken booming activity in Wisconsin was most intense on clear, still and frosty mornings with the best temperature range 25°F-40°F. They attributed daily irregularities in hen attendance during the peak of the courtship season to variations in weather.

Dancing ground counts as a census method.—Counts of birds attending courtship grounds in spring have long been used as a basis for estimating densities or trends in densities of prairie grouse. The method of locating courtship grounds was described by Grange (1948) and was utilized as early as 1929 in Wisconsin. The procedure involved driving along roads in the survey area in early morning during the active part of the courtship season and stopping at regular intervals to listen for display activity. The direction and estimated distance to each ground heard was recorded and plotted on a map. When a ground could be heard from more than one listening point, triangulation was used to assist in determining its location. During subsequent mornings, grounds previously heard were located and the birds counted. Most investigators have recommended that numbers of cocks and hens be determined when possible. Two or more counts per ground per season have also been recommended to offset variations in attendance due to weather or other factors. Since females were not regular in attendance on grounds, comparisons of numbers of birds from year-to-year or between areas, using dancing ground counts, have usually been based on numbers of males. This technique or variations of it are the most common methods for determining distribution and estimating numbers or trends in numbers of prairie grouse throughout their inhabited range.

Nebraska initiated systematic courtship ground surveys in 1955. These surveys have been conducted each spring on approximately 20 automobile routes distributed throughout the prairie grouse range in the state. Each route covered 20 miles, with listening stops designated at one-mile intervals. It has been assumed that displaying sharp-tailed grouse could be heard up to 0.5 miles; therefore the area effectively sampled on each route has been 15.71 square miles. Counts have been conducted once annually on each route.

Several investigators have attested to the validity of dancing and booming ground counts for measuring spring population densities. Lehmann (1941:47-48) employed booming ground counts to measure abundance of Attwater's prairie chicken and compared count data to that obtained from other enumeration methods. He concluded that booming ground counts were "the most rapid and economical of all known census techniques." In studies of the prairie chicken in Missouri, Schwartz (1944)

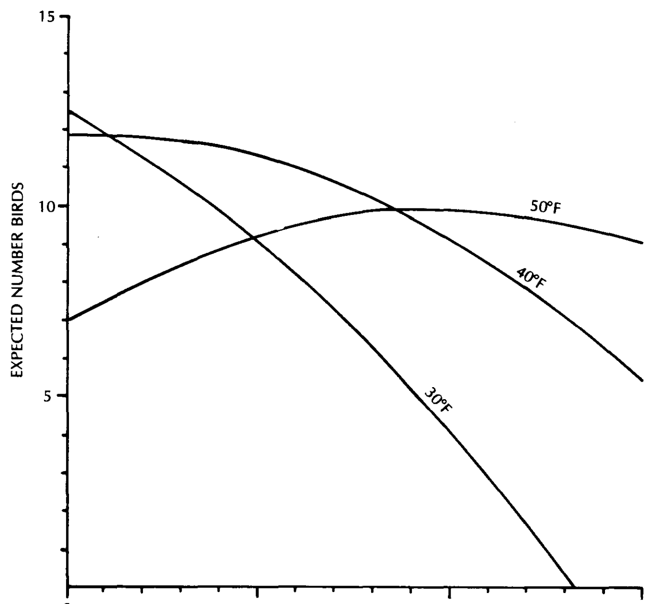


Figure 12. Expected numbers of sharp-tailed grouse present on a dancing ground in relation to wind at three different temperatures. Values were computed using the regression equation from Table 10 and assuming the day of season to be 45 (April 14) and the relative humidity and cloud cover to be constant at 80 percent, and 50% respectively. Actual values of numbers of birds based on data from ground 26 in 1969 with a mean of 8.5 birds, and a standard deviation of 2.989.

found that the numbers of cocks on booming grounds fluctuated with the spring population level. In studies of the Columbian sharp-tailed grouse in Utah, Hart *et al.* (1950:68) concluded that "the average number of grouse per dancing ground at the peak of the season together with the number of dancing grounds being used gives a population index figure, which in turn indicates the population trend when compared to results obtained from similar surveys in previous years." In Wisconsin, Hamerstrom and Hamerstrom (1973:7) found that some male prairie chickens were "regular" in attendance on booming grounds while other males were not. They concluded that comparisons made using booming ground count data should be based on the numbers of "regulars". They also found that it was necessary to make at least three counts on a ground during the peak of the booming season to accurately determine the number of regulars. Some investigators have found spring courtship ground counts useful for predicting abundance of grouse the subsequent fall. Ammann (1957:138) found that, in addition to data on actual numbers and trends in numbers of sharptails in Michigan, spring dancing ground counts provided information for making recommendations for the hunting season.

Use of data from dancing ground surveys to measure numbers or changes in numbers of sharptails has been based on the assumption that one or some combination of the variables measured (i.e., numbers of grounds, numbers of males, etc.) were directly related to population size. According to Hamerstrom and Hamerstrom (1973:9) the validity of this assumption has not been proven for prairie chickens because no valid measure of abundance has been available to use as a standard. The same can be said for sharp-tailed grouse. However, several studies (Grange 1948, Hamerstrom and Hamerstrom 1973, and Kirsch *et al.* 1973) have shown that pronounced and continuing declines in prairie grouse populations in an area have been accompanied by declines in numbers of courtship grounds and total numbers of displaying males. Kirsch and Miller (1973) also found that the average numbers of males per dancing ground remained constant, even though the number of grounds and total numbers of male sharptails declined markedly on their North Dakota study areas.

An examination of the function of lekking behavior seemed to provide insight into the possible relationship between spring population levels and densities of dancing grounds and/or numbers of birds in attendance. Wynne-Edwards (1962:215-216) proposed that communal nuptial behavior in grouse served to regulate population size by limiting breeding. He suggested that there was an upper limit on density of courtship grounds and the numbers of males per ground, and that when the capacity of a display ground was reached, additional males were turned away as surplus. It was further suggested that the number of females fertilized might be limited because only a few dominant males on each ground copulated.

Findings of some recent research tend to support these concepts. Studying black grouse movements by radio telemetry in Scotland, Robel (1969:762) found that males were segregated into lekking and non-lekking groups and only 30 to 40 percent of the males on this study area attended the lek. He found that the non-lekking birds were more mobile and raised a question as to whether the non-lekking birds formed a reservoir for the lekking birds. He concluded that counts of male black grouse on leks may be a poor index to sizes of populations. In studies of movements of greater prairie chickens in Kansas, Robel *et al.* (1970) observed extensive spring, inter-booming ground movements by juvenile males that tried frequently and unsuccessfully to establish territories on booming grounds. A few adult males, which were not territory-holders, were also observed moving from ground to ground during the booming season. Ammann (1957:140) observed single sharptail males or groups of two or three males displaying at odd locations. He observed such occurrences more frequently during years of "considerable expansion" in population size. Hamerstrom and Hamerstrom (1973:7) termed single male greater prairie chickens which displayed apart from regular booming grounds "territorial males" and referred to such behavior by several birds as "casual display."

In the present study, male sharptails exhibiting such behavior were termed "transient males" because they were seldom seen displaying at the same location more than a few times during the courtship season. It was concluded that transient males observed on the Bessey area were cocks which could not establish territories on permanent dancing grounds. Therefore, they represented surplus breeding stock. It was also considered likely that such males periodically visited permanent dancing grounds during the courtship season, thus contributing to fluctuations in numbers of males observed on individual grounds from morning to morning. Ammann (1957:140) also attributed such fluctuations to visits by non-territory-holding males. There appeared to be a minimum distance between dancing grounds on the Bessey area, which led to the conclusion that there may have been an upper limit on numbers of dancing grounds that the area would support.

If the conclusions of the preceding discussion are correct, the expected relationship between spring population densities of sharp-tailed grouse and densities of dancing grounds or numbers of displaying males

would be as follows: During years of an increasing population the number of dancing grounds increases as the number of males exceeds the capacity of existing grounds. New grounds are used by only a few males at first, with the number of males in attendance increasing each year until the capacity of the ground is reached. This process continues until the upper limit on numbers of dancing grounds and the number of males per ground in the area is reached or until some other factor limits further expansion. In a declining population the reverse takes place.

In an area with numbers of dancing grounds and males per ground at capacity, additional increases in the population result in a surplus of males unable to establish and maintain territories on existing dancing grounds, and presumably unable to participate in breeding. Thus, small fluctuations in population size at this level would not be reflected in either numbers of dancing grounds or numbers of males regularly attending grounds in the area.

However, in an area where an increase in population is limited at a level corresponding to the capacity for numbers of dancing grounds, but below the capacity of those dancing grounds for numbers of males, relatively small changes in population levels are reflected in fluctuations in the total number of males regularly attending grounds on the area. When the population in an area is limited at a level below the capacity of that area for dancing grounds, fluctuations in population are reflected in changes both in the number of dancing grounds and in the number of males regularly attending grounds on the area. Also, the capacity for numbers of dancing grounds in an area may change due to alterations in habitat, resulting in subsequent changes in the locations and/or numbers of grounds. Such changes may not necessarily reflect changes in population size, at least initially.

It was the conclusion of this study that the relation between sharp-tailed grouse population size and density of dancing grounds and numbers of males in attendance is dynamic and depends on the status of the population. Therefore, knowledge of the status of the population in an area would be a necessary prerequisite to use of a dancing ground survey for measuring changes in population size. Changes in spring population levels could theoretically be measured at certain population levels by counts of numbers of displaying males on grounds. However, variations in attendance due to changes in weather, time of day, and time of season would require a sound statistical design and adequate replication for valid conclusions to be drawn.

Such sampling would require considerably more effort than is currently expended on statewide dancing ground surveys in Nebraska and other states. A decision of whether such increased effort is justified should be based on the objective of the survey. In Nebraska, as well as other states, a primary objective of dancing ground surveys is to provide information on population levels to be used in formulating fall hunting season regulations. Use of measures of spring populations, assuming such measures are valid, for estimating fall population levels is questionable for prairie grouse, as well as other upland game species because of the variability of success in reproduction. From investigations of greater prairie chickens in Kansas, Baker (1953:60-61) concluded: "Considering potential losses, among young birds, caused by adverse weather, spring censuses are not sufficient bases for fixing regulations."

It is suggested that the primary value of spring dancing ground surveys in developing hunting season regulations is to determine if a spring population is present in an area and whether a pronounced decline or increase in population size is occurring. This would provide a basis for deciding whether an area should be open to hunting. The use of spring dancing ground counts as a basis for setting the length of the hunting season or the bag and possession limits does not appear to be justified. The value of counts of numbers of grouse on dancing grounds does not appear to justify the effort and cost.

It may be possible to obtain valid estimates of dancing ground densities using a modification of audio-census methods currently used for locating dancing grounds. This would require knowledge of the audibility of displaying birds to distance from the transect, the rate at which audible sounds are emitted, and the effects of time of day, time of season, and weather on both audibility and rate of sound production. Assuming the above relationships are known, an appropriate audio-census method, with corresponding estimates of densities and variances of estimates, could be developed.

III. PRODUCTION

After the April peak in activity on courtship grounds, female attendance declines abruptly, corresponding to initiation of nesting. Attendance of males also declines, but at a slower rate. Hens accomplish the tasks of nest selection, incubation, and brooding of young without aid from the cocks. Males are not usually found on grounds after mid-June, and apparently spend the summer loafing and feeding individually or in small flocks.

As with other upland game species, success of production is the main factor determining prairie grouse population levels in the subsequent fall. Success of production depends primarily on the number of nests hatched and the survival of young during the first few weeks after hatching. Therefore, predictions of fall population levels should be based on measurement of summer populations after most young are four to five weeks old. Since prairie grouse do not concentrate during summer, production is difficult to estimate. In the present study, factors determining success of reproduction and methods of measuring summer population levels of prairie grouse were investigated.

Methods

Data were gathered on prairie grouse nests on the Loup County and Swan Lake areas from 1959 through 1961 and on the Bessey area from 1962 through 1966. Methods used to locate nests included: Searching along line transects, in plots, and in suitable habitat; offering a reward for locations of nests found on the study areas by non-project personnel; and incidental observation.

Twenty-five nest searching plots were established on the Loup County and Swan Lake areas in 1960, and two plots were established on the Bessey area in 1962. Each plot was .25 miles by .25 miles in size (40 acres). Locations of plots on the Loup County and Swan Lake areas were determined by random selection from the 36 sections on each area. Then, one 40-acre plot was selected from the 16 in each of the chosen sections. The two plots on the Bessey area were also selected randomly.

Swan Lake and Loup County plots were searched systematically by teams of observers walking abreast along parallel transects crossing each plot. Plot transects were spaced 22 yards apart in 1960 and 21 yards in 1961. Search teams included two to six men in 1960 and three to eight men in 1961. In 1960, team members walked six feet apart, and it was assumed that all nests within three feet on either side of an observer's path were located. In 1961, members walked 12 feet apart and dragged a rope between them. Searching of plots was conducted during June in 1960 and from May 8 through 17 in 1961. The two plots on the Bessey area were searched in 1962 by two men walking eight feet apart. It was assumed that each observer located all nests within four feet on either side of his line of travel. The entire areas of each plot were covered systematically between May 23 and July 13. Nest searching was also conducted along line transects on the Bessey area in 1962 and 1963. Line transects were laid out systematically north and south or east and west. In 1962, two men searched 60 miles of transect together and one man searched 13 miles of transect. In 1963, two men searched 43 miles of transects together. It was assumed that all nests within four feet of the line of travel of an observer were located, resulting in effective coverage of about one acre per man per mile walked or approximately 133 acres in 1962 and 86 acres in 1963.

The method of searching "suitable habitat" was used on the Loup County and Swan Lake areas in 1959, 1960, and 1963. "Suitability" of habitat was determined subjectively by the investigator and was defined as native prairie in high-range condition with adequate residual grass cover for nest concealment. Such areas were usually searched by a man walking with a bird dog. In 1959, a flushing device was constructed by tying burlap bags on a frame made of bamboo poles. The device was pulled across vegetation by a man on a horse and covered a width of about 50 feet. It was used for about nine hours.

Nests were also found by offering a reward to non-project personnel for the verified location of a prairie grouse nest. Payment was $1 per nest from 1959 through 1962 and $3 from 1963 through 1966. From 1959 through 1961, the reward was offered to landowners or operators on the Loup County and Swan Lake study areas. Payment was made only for nests on the study areas. In 1962, payment was offered to U.S. Forest Service personnel. Payment was made for a nest located anywhere on the Bessey Division, Nebraska National Forest. From 1963 through 1966, the reward was advertised in a local newspaper, and payment was made for nests located anywhere in Thomas and Blaine counties. Also a few nests were located by project personnel incidental to other field work.

Estimates of nest density were based on data from plots or line transects where the approximate acreage searched was known. Other methods, such as searching suitable habitat, did not allow density estimation because the sizes of the areas searched were not recorded.

If possible, the clutch size and fate of each nest was determined. Dates of hatching were also determined by direct observation of some nests. In addition, hatching dates were estimated for juvenile sharptails examined at hunter check stations in the Bessey Division, Nebraska National Forest, during the falls of 1962 through 1969. The method of aging juvenile grouse was developed in 1960 under Pittman-Robertson Project W-33-R, and has been used in Nebraska since that time. The method is described in Appendix 3. Basically, it allows estimation of age in weeks by comparing the lengths of the seventh and eighth primary wing feathers using an "aging fan." By this method, age can be estimated for birds 11 through 16 weeks old. Older or younger birds cannot be aged to week. Consequently, application of the method is limited by the time of the hunting season and the dates of hatching the previous summer. Hunting seasons in 1962 through 1964 opened during October, and most young grouse were older than 16 weeks by that time. Therefore, those data were not included in estimation of hatching dates. During 1965 through 1969, hunting seasons opened between September 16 and 21, and most young examined during those years could be aged.

Prairie grouse populations on the Loup County and Bessey areas were censused during summers of 1962 through 1966 by walking line transects. Parallel, straight-line transects were established on each area in a semi-random fashion. On the Loup County area, two east-west transects were selected randomly between each pair of east-west section lines. This resulted in 12 transects, each 6 miles long. These were used each year from 1962 through 1966. In 1962, 14 north-south transects were selected in a similar fashion on the Bessey area. These varied in length because of the irregular shape of the study area. They totaled 49.1 miles in length and were used during 1962 and 1963. In 1964, 20 north-south transects were selected on the Bessey area. Two or three north-south transects were selected randomly between each pair of north-south section lines. They totaled 72 miles in length and were used from 1964 through 1966. In addition to transects on the Bessey area proper, several others of undefined length were run each year adjacent to the area. Transect sampling on or adjacent to the Bessey area was limited to the prairie portion of the area; plantations were excluded.

Transects were walked in the morning by one man or one man with a flushing-type dog. The dog ranged unconstrained within approximately 50 yards of the observer. Use of the dog was documented on data forms. When a grouse or flock of grouse was flushed, the perpendicular distance from the point of flushing to the transect was estimated. Adult birds accompanying a brood were distinguished from those not associated with a brood. For convenience, adults will be referred to as "brooding adults" and "non-brooding adults." Numbers of adults in each flock and young in each brood were recorded. No attempt was made to estimate age of young grouse flushed along transects.

The method used to estimate densities of prairie grouse from line transect data was described by Gates, *et al.* (1968). This method requires that the perpendicular or right-angle distance from the transect to the point of flushing be known for each bird flushed. The method is based on assumption of the following relation:

$$P = e^{-\lambda y}$$

Where P is the probability of flushing a bird, e is the base of the natural logarithm (2.71828...), y is the right-angle distance of the bird from the transect and λ is a constant specific to a particular species, cover type, etc. In other words, the probability of flushing a bird decreases in an exponential fashion as the right-angle distance to the bird increases. The constant λ appropriate for a given species is estimated from actual data by:

$$\hat{\lambda} = \frac{\frac{n-1}{n}}{\sum_{i=1} y_i} \qquad (2)$$

Where n is the number of birds flushed, y_i is right-angle distance from the transect to the point of flushing for the ith bird and $\sum_{i=1}^{n} y_i$ is the sum of the right angle distances. The probability of flushing a bird in an area of size A, when the sum of transect lengths is L, is given by:

$$\hat{p} = 2L/A\hat{\lambda}c, \qquad (3)$$

where c is a conversion constant for units. In this study L and A were expressed in miles and square miles respectively, and right-angle flushing distance (y) was expressed in feet, therefore c = 5280. The estimated population $(\hat{N})$ in an area is then given by:

$$\hat{N} = n/\hat{p} \qquad (4)$$

and the density $\hat{D} = \hat{N}/A$. The variance (v) and standard deviation (s) of N are estimated by:

$$v(\hat{N}) = \frac{n}{\hat{p}^2}\left[\hat{q} + \frac{n}{n-2}\right] \qquad (5)$$

$$s(\hat{N}) = \sqrt{v(\hat{N})} \qquad (6)$$

where $\hat{q} = 1 - \hat{p}$. The standard deviation of density is s (D) = s (N)/A.

The above method is based on several assumptions in addition to those already mentioned. These include: (1) birds are randomly distributed over the sample area, (2) birds behave (flush) independently, and (3) the system is static, that is, the birds do not run from the observer before flushing, etc. For a complete discussion of assumptions, see Gates *et al.* (1968). Some of the assumptions of the method were evaluated for prairie grouse observed during this study.

Data were gathered on grouse flushed along line transects on both Loup County and Bessey. However, numbers of broods flushed annually on the Loup County area were considered insufficient to estimate annual density on that area. Prairie chickens were uncommon on the Bessey area, and none were flushed along line transects there. Therefore, estimates of densities were limited to sharp-tailed grouse on the Bessey area. However, all data on sharp-tailed grouse flushed along line transects on Loup County, Bessey, and adjacent to the Bessey area were used to evaluate the applicability of the density estimation method for sharp-tailed grouse in the Nebraska Sand Hills.

When prairie grouse broods were located incidental to other field work, the number and approximate age of young were recorded. Age of young was estimated as < 1/4, 1/4, 1/2, 3/4,> 3/4 grown.

Results and Discussion

Nest density.—Numbers of nests located on all study areas are listed in Table 12. Estimates of nest density were based on results of searching plots and along line transects. During 1960, 21 of the 40-acre plots on the Loup County and Swan Lake areas were searched, resulting in effective coverage of 249.3 acres in which two nests were found. In 1961, two nests were found in 20 plots on the Loup County and Swan Lake areas. The area effectively searched was 510.1 acres. In 1962, the two 40-acre plots on the Bessey area were searched completely, and two nests were found. Nest densities based on the above were 5.1, 2.5, and 16.0 nests per square mile respectively. Although observations were considered insufficient to allow comparison of densities between areas or years, the density estimated for 1961 on the Loup County and Swan Lake areas may have been low due to the assumption that the estimated area effectively searched was increased (approximately doubled from 1960) by spacing observers further apart and by dragging a rope. On the Bessey area, 133 and 86 acres were effectively searched for nests along line transects in 1962 and 1963 respectively and none were found. This was not surprising, considering the relatively small area searched in relation to expected densities.

Various techniques for locating prairie grouse nests have been reported. Baker (1953:24) used a flushing bar 30 feet in length, mounted on the front of a truck, to locate greater prairie chicken nests in Kansas. Lengths of steel pipe suspended from the flushing bar served as a drag. A longer flushing bar (46 feet) was also used on a tractor. Using this device 160 acres were censused in six hours. Copelin (1963:32) reported using a similar device to locate nesting lesser prairie chicken hens in Oklahoma. More recently Higgins, *et al.* (1969) used a cable-chain flush-

Table 12. Numbers of prairie grouse nests found on the Loup County, Swan Lake, and Bessey areas 1959 through 1966.

Searching Method	1959	1960	1961	1962	1963	1964	1965	1966	Totals
	Year								
Suitable Habitat	4	0	0	–	–	–	–	–	4
Plot	–	2	2	2	–	–	–	–	6
Transact	–	–	–	0	0	–	–	–	0
Reward	23	4	4	0	1	23	15	8	78
Random	0	1	0	1	3	2	3	3	13
Totals	27	7	6	3	4	25	18	11	101

ing device, dragged between two vehicles, to successfully locate waterfowl and upland game bird nests in North Dakota. Terrain has limited the use of flushing devices on vehicles in some areas. Twedt (pers. comm.) found that some sharptail nesting habitat in South Dakota was not accessible for searching using a truck-mounted flushing device.

Because of the dune topography and loose sandy soil of the Sand Hills, nest searching with vehicles and flushing devices was not employed in this study. However, it is my opinion such methods could be used successfully in areas of gentle terrain. Use of a flushing device dragged behind a horse was too limited to allow evaluation. The efficiency of locating nests by dragging a rope between observers was not determined. It was assumed that an observer on foot could locate essentially all nests within four feet of his line of travel. However, Folker (1964:16) found that the flushing distance of incubating hen sharptails in Saskatchewan was two feet. Assuming all nests can be located within four feet on either side of an observer's path, the sampling rate is about one acre per mile. Using this method, however, the manpower necessary and cost of sampling would probably be prohibitive for areas large enough to allow statistically meaningful comparisons of nest densities between areas or years.

Estimates of densities of prairie grouse nests made during this study were based on a total of six nests. The repeatability of the estimates was not determined; therefore, statistical reliability was not known. Only one of the six nests was successful. Few investigators have reported estimates of nest densities for prairie grouse. Baker (1953:25) found 16 prairie chicken nests in 610 acres in Kansas. However, he was apparently only searching habitat considered suitable for nesting. Concentrations of nests have been found in areas of suitable nesting cover. Schwartz (1945), studying prairie chickens in Missouri, found seven nests in 15 acres of sweet clover. Jones (1963:771, 772) found no lesser prairie chicken nests on 272 acres of potential nesting cover, but located nine greater prairie chicken nests on 254 acres of suitable nesting cover on his study areas in Oklahoma.

Because nests are difficult to find, the use of nest density estimates are not recommended for measuring productivity of sharp-tailed grouse in the Nebraska Sand Hills.

Methods of locating nests other than searching plots and line transects did not allow density estimation. Although searching only suitable or potential nesting habitat should have increased the efficiency of locating nests, considerable effort was still required. In 1959, it took 101.5 hours to locate four nests or approximately 25 man-hours per nest. No nests were found using this method in 1960 and 1961, although effort was not recorded. The most effective method of locating nests was offering a reward. A total of 78 nests was located in this way during the study. In addition, 13 nests were located incidental to other field work. Data were gathered on 101 grouse nests, 68 sharp-tailed grouse, 31 prairie chicken, and 2 unknown species.

Clutch size and nest success.—Clutch size was determined for 43 nests (Table 13). The mean clutch size for 28 sharptail nests was 11.6 eggs, and the mean for 15 prairie chicken nests was 11.8. The difference between means was not significant ($P<0.05$). These clutch sizes were similar to those reported by other investigators. Edminster (1954:142, 174) reported the typical sharptail clutch to be 12, with prairie chickens usually laying 11 to 12 eggs.

Fate was determined for 56 sharptail and 29 prairie chicken nests (Table 14). Fifty-five percent of the sharptail nests and 50 percent of the prairie chicken nests were successful (one or more eggs hatched). These results agreed with those from other studies. Edminister (1954:159) summarized data from several studies and concluded that about 50 percent of nests of sharptails and prairie chickens can be expected to hatch. Analyzing data from several studies, Ammann (1957:99) found 44 percent nest success for both species.

Twenty-eight sharptail nests and 15 prairie chicken nests which were successful were examined to determine the numbers of eggs which hatched. Eleven (39.3 percent) of the sharptail nests and seven (47 percent) of the prairie chicken nests contained eggs which did not hatch. Twenty-five (8 percent) of 324 eggs in the sharptail nests, and 30 (17 percent) of 177 eggs in the prairie chicken nests did not hatch. Of the 55 eggs from both species which did not hatch, fertility of 27 was determined. Of those nine (33 percent) were infertile, and the remaining 18 contained dead embryos. Assuming the above data are representative of prairie grouse in the Nebraska Sand Hills, about 89 percent of eggs in successful nests would be expected to hatch; about 4 percent would be expected to be infertile, and 7 percent fertile, but fail to develop beyond the embryo stage. According to Edminster (1954:159), 11 of 12 eggs (92 percent) in an average sharptail nest would be expected to hatch. Folker (1964:22) examined 52 eggs in four sharptail nests in Saskatchewan of which all were fertile, but five (10 percent) failed to develop.

Predators were the primary cause of nest destruction, causing destruction of 39 percent of the sharptail nests and 31 percent of the prairie chicken nests. While species of predators involved were not determined,

Table 13. Mean clutch sizes for successful nests of sharp-tailed grouse and prairie chickens. Nests were located during the period 1959 through 1966.

Species	Clutch Size: Number of Nests	Mean	S.E.[1]
Sharp-tailed Grouse	28	11.57	0.57
Prairie Chicken	15[2]	11.80	0.83
Combined Species	43	11.65	0.46

[1]Standard error (standard deviation of mean).

[2]Does not include 1 successful prairie chicken nest of unknown clutch size.

Table 14. Fate of prairie grouse nests located during the period 1959 through 1966.[1]

Fate	Prairie Chicken		Sharp-Tailed Grouse		Combined Species	
	Number of Nests	Percent of Total	Number of Nests	Percent of Total	Number of Nests	Percent of Total
Successful	16	55.2	28	50.0	44	51.8
Unsuccessful:						
Predation	9	31.0	22	39.3	31	36.5
Trampled by livestock	2	6.9	0	0	2	2.3
Crushed by vehicle	0	0	1	1.8	1	1.2
Destroyed by mower	1	3.5	3	5.3	4	4.7
Destroyed by unknown agent	1	3.5	2	3.6	3	3.5
Sub-total (unsuccessful)	13	44.9	28	50.0	41	48.2
Total	29	100.1	56	100.0	85	100.0

[1]Does not include 2 nests of unknown species of prairie grouse; 2 prairie chicken nests from which eggs were collected; 7 sharp-tail nests from which eggs were collected; and 5 sharp-tail nests of unknown fate.

raccoon *(Procyon lotor)*, striped skunks *(Mephitis mephitis)*, coyotes *(Canis latrans)*, badgers *(Taxidea taxus)*, bullsnakes *(Pituophis sayi)* and thirteen-lined ground squirrels *(Citellus tridecemlineatus)* were common on the study areas and were thought to be the main causes of predation. Mowing caused abandonment of about five percent of nests of both species of grouse. Two nests were abandoned after being trampled by livestock.

Edminster (1954:159) also reported predation to be the major cause of nest destruction in several studies he reviewed. He concluded, however, that predation was not a limiting factor in prairie grouse populations. Studying sharp-tailed grouse in Canada, Cartwright (1944) concluded that nest predation may reduce the chance of poor production resulting from inclement weather. Destruction of a nest late in incubation or loss of a brood does not allow a hen to renest. Young are particularly vulnerable to mortality at and just following hatching. Therefore, the time just before to just after hatching is the most critical period in production. If most nests hatch during a short time period, which corresponds to inclement weather, mass destruction of nests or loss of young may result. However, a brief period of adverse weather would likely result in poor production only when hatching is well synchronized. Predation of nests during egg-laying or early incubation would result in renesting, thus staggering the hatching date and reducing the risk of serious loss due to adverse weather.

Nesting chronology. — Hatching dates were determined for 21 sharptail nests and estimated for juvenile sharptails shot by hunters on the Bessey Division, Nebraska National Forest, during the 1965-1969 hunting season (Figure 13). Dates of hatching were similar for both nest and harvest data, as well as between years within the harvest data. Fifty-two percent of the nests hatched during the second week in June, while 56 percent of the juveniles hatched during the second and third weeks in June. The accuracy of the aging technique was not known. Boddicker (no date) examined weight and primary feather characteristics as indicators of age in sharptails in South Dakota and found that primary aging techniques aged 77 percent of young correctly to the nearest week.

Hatching dates observed and calculated in the present study suggested a high degree of synchronization in hatching. There was no evidence of a second peak in frequencies, which would have been expected if renesting commonly occurred. This suggests that pronounced losses of production could result from relatively short periods of inclement weather.

According to Edminster (1954:143), the date of hatching varies with latitude and weather, with birds in the latitude of Wisconsin and Michigan hatching from mid to late June. The peak of hatching of sharptails in Utah occurs during late May and early June (Hart, *et al.* 1950:24). Hillman and Jackson (1973:16) reported that the hatching peak in South Dakota occurs from the last week in May through the first week in June. The difference between the reported hatching peak in South Dakota and that noted in the present study may be due to differences in aging techniques. Despite differences in reported hatching dates, findings of the present study and those of other studies reviewed suggest that hatching within years and geographical areas is well synchronized in sharp-tailed grouse.

Although the extent of renesting was not determined in the present study, Janson (1956:9) reported renesting in sharptails in South Dakota. Christenson (1971:44) found that seven of nine radio-monitored sharptail hens renested after their first nests were destroyed. Christenson (1971) also found that renesting attempts were more successful than initial attempts which he attributed to increased nesting cover as the season progressed.

Summer densities of adults and broods. — Data gathered on sharp-tailed grouse flushed along line transects on the Bessey area during the summers of 1962 through 1966 are summarized in Table 15. A total of 314.2 miles was walked on the Bessey area this period. Sharptails flushed included 114 non-brooding adults, 113 young in 20 broods, and 21 brooding adults. An average of one non-brooding adult was flushed for each 2.8 miles walked, and an average of one brood was flushed for every 15.0 miles walked. In addition, 76 non-brooding adults, 53 young in 11 broods, and 16 brooding adults were flushed along transects adjacent to the Bessey area and on the Loup County area.

On the Bessey area, 63.1 miles were walked by an observer with a dog, and 251.1 miles were walked without a dog. The effects of the dog on numbers of non-brooding adults and broods flushed were tested by chi-square. Observed numbers of adults and broods with the dog present and absent were compared to numbers expected assuming a constant rate of flushing per mile walked. Effects of the dog on the flushing rate for non-brooding adults and broods was not significant ($P<0.05$). A t-test was used to determine the effects of the presence of a dog on the means of right-angle distances of flushing for non-brooding adults and broods. It was also non-significant ($P<0.05$). Therefore, it was concluded that use of the dog had no measurable effect on flushing sharp-tailed grouse along line transects and use of the dog was disregarded in further analysis of data and estimates of densities.

The method of estimating densities from line transect data used in this study assumes that the probability of flushing a bird decreases as the right-angle distance from the transect increases according to equation (1). This assumption was tested for sharp-tailed grouse using right-angle flushing distances for 190 non-brooding adults flushed along transects on the Loup County and Bessey areas and adjacent to the Bessey area. Observed numbers of birds flushed in intervals of 30 feet from the transect were compared to expected numbers in each interval (Figure 14). The expected numbers of birds (b_i) in each interval (i) from the transect were determined by multiplying the total number of birds flushed (n) in all intervals by the fraction (r_i) of the area under the curve of equation (3) correspond-

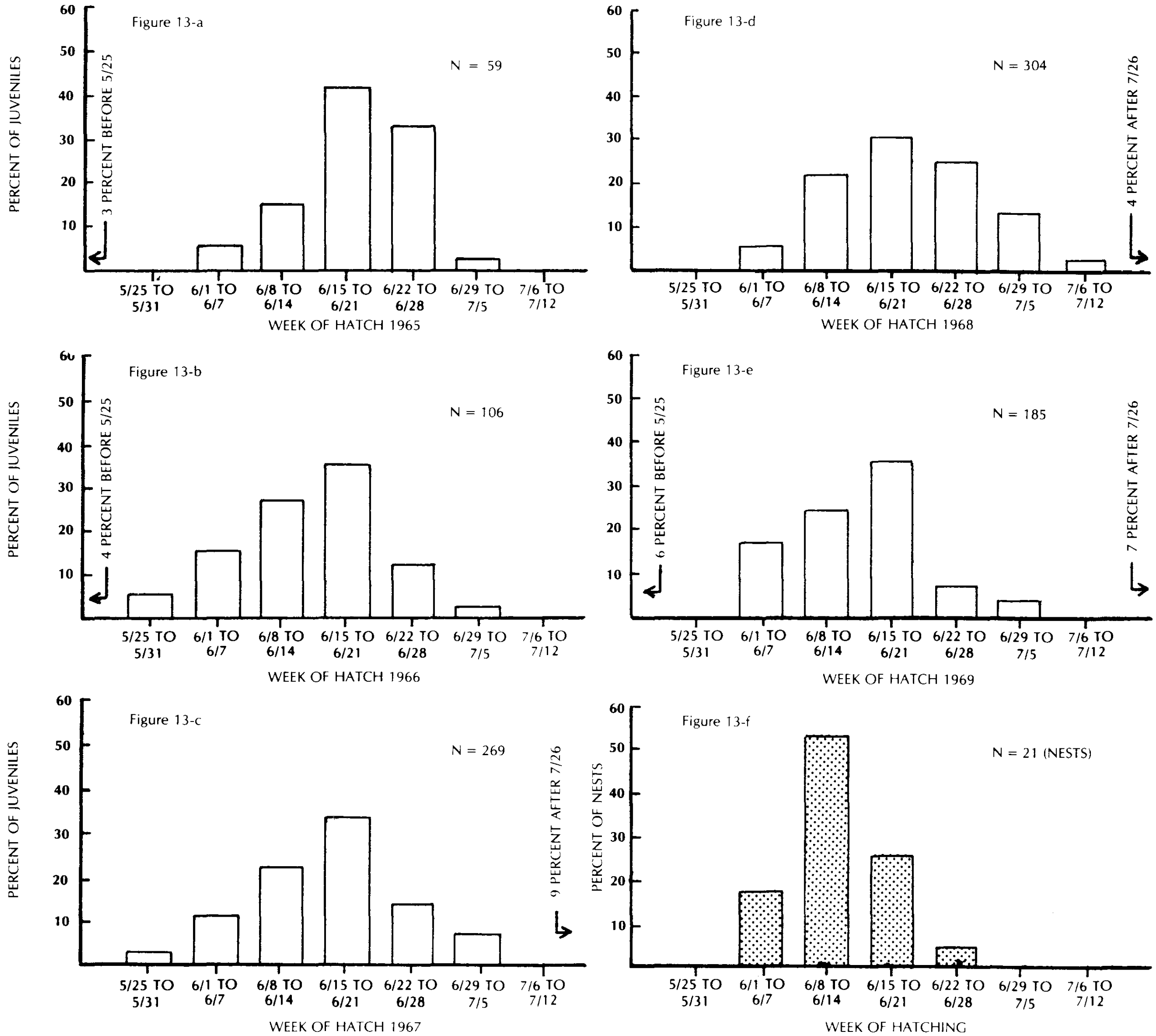


Figure 13. Percentages of juvenile sharp-tailed grouse by calculated weeks of hatching (a through e) and sharptail nests by actual weeks of hatching (f). Figure 13-a through 13-e based on juveniles examined at hunter check stations; figure 13-f based on 21 sharp-tailed grouse nests located between 1959 and 1966.

Table 15. Summary of data on sharp-tailed grouse flushed during summer along transects on the Bessey area.

Year	Miles of Transect	No. of Birds Flushed: Adults (no brood)	No. of Birds Flushed: Adults with Broods	No. of Birds Flushed: Young	Mean Right-Angle Flushing Distance: Adults (no brood)	Mean Right-Angle Flushing Distance: Adults with Broods	Mean Right-Angle Flushing Distance: Young	λ [1]: Adults (no brood)	λ [1]: Adults with Broods	λ [1]: Young	Probability (p) [1]: Adults (no brood)	Probability (p) [1]: Adults with Broods	Probability (p) [1]: Young
1962	49.1	27	6	27	65.4	88.5	52.1	.0147	.0094	.0185	.0530	.0830	.0423
1963	49.1	26	2	19	134.3	111.0	112.7	.0072	.0045	.0084	.1091	.1735	.0930
1964	72.0	19	2	13	72.5	10.0	10.0	.0131	.1000	.0923	.0877	.0115	.0124
1965	72.0	23	9	43	121.7	45.8	27.1	.0079	.0194	.0361	.1458	.0590	.0318
1966	72.0	19	2	11	56.8	28.0	22.9	.0167	.0179	.0397	.0687	.0642	.0289

[1]Deviation explained in text.

ing to each interval. Expected numbers of birds (b_i) in each interval (i) of width (w) starting at d_i were obtained by:

$$b_i = n r_i \qquad (7)$$

Where:

$$r_i = \left[\int_{y=d_i}^{y=d_i+w} e^{-\lambda y}\cdot dy - \int_{y=0}^{y=d_i} e^{-\lambda y}\cdot dy\right] \Big/ \left[\int_{y=0}^{y=\infty} e^{-\lambda y}\cdot dy\right],$$

Which reduces to:

$$r_i = e^{-\lambda d_i} - e^{-\lambda(d_i+w)} \qquad (8)$$

The width of the intervals (w) was arbitrarily set at 30 feet, and the computed value of λ for the 190 non-brooding adults was 0.0110. For example, to obtain the expected number of grouse (b) flushed between 60 and 90 feet (w = 30 feet), with n = 190, and $\lambda = 0.0110$,

$$r = e^{-0.011(60)} - e^{0.011(90)} = 0.145$$

$$b = (190)(0.145) = 27.6$$

Deviations of observed from expected numbers of grouse flushed in each interval were tested by chi-square and found significant ($P<0.05$), indicating a significant departure of observed values from the negative exponential distribution. However, examination of Figure 14 suggested that deviations of observed from expected values were inconsistent and did not result from the observed values following another distribution. Further examination revealed that bias existed in estimating right-angle distances, resulting in certain distances being estimated more often than was expected. Bias seemed to increase as the right-angle distance increased. For example, the distance 200 feet was estimated frequently, resulting in an unusual number of grouse estimated as flushing in the interval 180 to 210 feet. Observed frequencies were smoothed using a 3-point moving average. Deviations of smoothed observed frequencies from expected values were tested by chi-square and found not significant ($P<0.05$). Therefore, it was concluded that deviations of observed values from expected values were primarily caused by bias in estimating the right-angle flushing distances and that the probabilities of flushing sharp-tailed grouse at specified right-angle distances were approximated by the negative exponential distribution. Although numbers of broods flushed were not considered adequate to test the assumption of the negative exponential distribution, it was assumed to be valid for broods also.

Another assumption of equations (4) and (5) was that birds flushed independently. Data were not collected on the distances between birds flushed along transects as required to test independence of flushing. However, adults were found in flocks and young in broods. The average number of non-brooding adults per flock was 1.9 with about 36 percent flushed as singles, 20 percent as doubles, and 9 percent as triples. Broods averaged 5.4 young, with each brood accompanied by one or more adults. Since grouse in broods and flocks usually flushed together, flushing of individual birds could not be considered independent. Gates (1969) used computer simulation to study the effect of pairing of birds on estimates of density and variance from equations (4) and (5). He found that estimates of density remained unbiased, but variance increased with pairing.

Mean right-angle flushing distances and probabilities of flushing for adult and juvenile sharptails flushed along transects on the Bessey area are presented in Table 15. Annual estimates of summer densities, based on line transect data, are presented in Table 16. Estimates of summer densities ranged from 19.0 to 69.9 sharptails per square mile. Estimated densities of non-brooding adults ranged from 6.6 to 21.4 per square mile, with standard deviations from 27.6 to 33.0 percent of the corresponding density estimates. Estimated numbers of young sharptails per section varied from 8.6 to 56.9, with standard deviations ranging from 21.6 to 45.0 percent of the estimates. However, estimates of variance were probably low because of dependence in flushing individual birds.

Based on the above estimates of variance, the amount of sampling necessary to detect a certain percentage change in densities of juveniles between years, if such a change occurs, was estimated using the method described by Cochran and Cox (1957:20). It was assumed that an estimate of density was based on walking 72.0 miles of transect on a sample area approximately the size of the Bessey area, that the transect(s) was located at random within the sample area, and that the sample area was located randomly within the area in which changes in density were to be studied. It was also assumed that the unit standard deviation of a set of estimates was 45 percent of the mean estimate (the maximum estimated standard deviation of estimates of young on the Bessey area). Given a probability of 80 percent of detecting a 50 percent change in density of juveniles, if such a change occurred, and a 5 percent significance level, the number of estimates required annually would be approximately 15 or 72 miles on each of 15 sample areas each year. This estimate of sample size assumes a completely random design. However, since densities are likely to differ over the range, a randomized block design would be preferred. Comparison between two years in such a design would then reduce to a paired t-test. The sampling effort necessary to detect a certain level of change is determined by variance. Since estimates of variance in this study were based on a model which assumes independent flushing, they were suspect. It is recommended that esti-

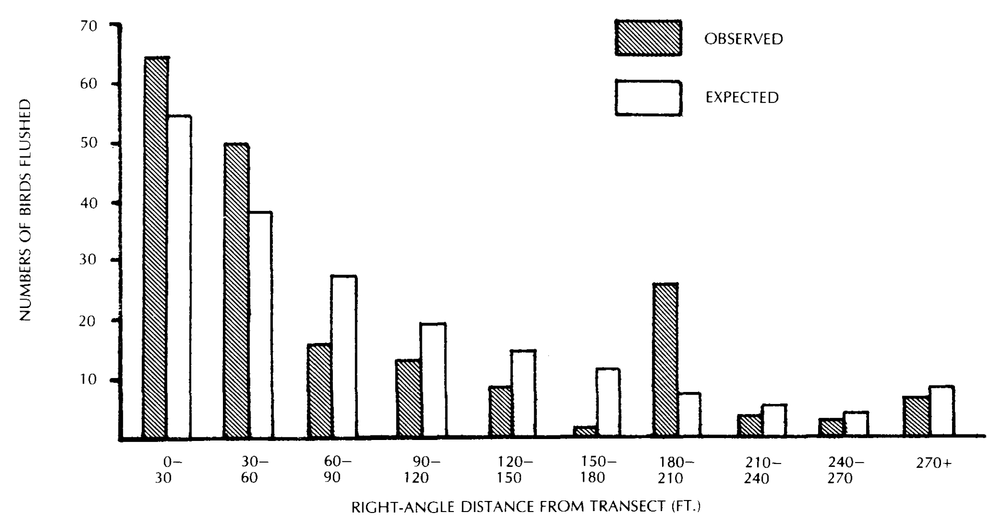


Figure 14. Observed and expected numbers of adult sharp-tailed grouse (not associated with broods) flushed at 30-foot intervals of right-angle distance from the transect. (expected frequencies based on x = 0.011; deviation explained in text)

Table 16. Estimates of summer densities of sharp-tailed grouse on the Bessey area.

Year	Estimated Density (birds/mile²) ± Standard Deviation: Adults (no brood)	Adults with Broods	Young	Total Estimated Density (birds/mile²)
1962	21.4 ± 5.9	3.0 ± 1.9	26.8 ± 7.4	51.2
1963	10.0 ± 2.8	0.5 – [1]	8.6 ± 2.8	19.0
1964	9.1 ± 3.0	7.3 –	44.0 ± 18.0	60.4
1965	6.6 ± 1.9	6.4 ± 3.2	56.9 ± 12.3	69.9
1966	11.6 ± 3.8	1.3 –	16.0 ± 7.2	28.9

[1]Number of birds flushed insufficient to compute variance

mates of variance be obtained from actual counts or by computer simulation of a representative system.

An alternative procedure for measuring production, using line transect data, would be to estimate densities of broods rather than total juveniles. Although independence of flushing cannot be assumed for individuals in broods, it could probably be assumed for individual broods, thus satisfying that assumption of the model.

Most investigators have experienced difficulty in assessing population levels of prairie grouse during summer. Of sharptails in Colorado, Rogers (1969:32) stated: "The summer or brood season proved to be the poorest time for obtaining distribution and density information." Because of the characteristically low densities of prairie grouse in most areas, efforts to locate birds during summer have often been directed to searching of "suitable" habitat. Studying lesser prairie chickens in Oklahoma, Copelin (1963:36) was able to find 28 broods in two summers by driving 900 miles in shinnery. Twenty-seven of the broods were in oak motts. Such counts, however, make estimates of density and changes in density difficult to measure. In Michigan, Ammann (1957:157, 158) recommended that late summer counts be made with the aid of dogs by searching potential cover or by systematically searching predetermined areas. The latter method would presumably allow estimates of density.

It is my opinion that use of trained dogs could reduce the cost of estimating densities of sharptails during summer. However, a model appropriate for estimating densities would have to be developed because models such as the one used in the present study assume a certain relationship between probability of flushing a bird and the distance of the bird from the observer or transect. It is unlikely that the same relationship would hold with the use of dogs. Overton and Davis (1969:424) described a method of determining density of quail from a strip census using dogs, but they found that variation between dogs resulted in several complications in application of the technique. Investigators in some states have attempted to census broods on automobile transects. In South Dakota brood counts along 20-mile automobile transects were initiated in 1947, but were found ineffective and discontinued in 1959 (Hillman and Jackson 1973:35). Rogers (1969:33) concluded that useful sharptail brood data could not be obtained from automobile transects in Colorado.

Most efforts to determine changes in densities of prairie grouse during summer have been based on so-called "indices". In Nebraska, for example, rural mail carriers with delivery routes in the grouse range, count numbers of prairie grouse seen on specified dates while driving their routes. However, juveniles are not distinguished from adults. These data are expressed as a ratio of birds to miles driven. Game and Parks Commission personnel also record ages and sizes of all broods seen incidental to other work. However, the relationships between such measures and population levels are not known. It is likely that factors such as differences between observers and observability of birds may contribute as much to variance in rural mail carrier counts as changes in the populations themselves, thus limiting the value of such counts for determining changes in population levels. Before any measure of population levels is used, it is necessary to determine the relationship of the measure to the population and the statistical reliability of the technique. Similarly, measures presently in use should be evaluated and discontinued if they cannot be shown reliable.

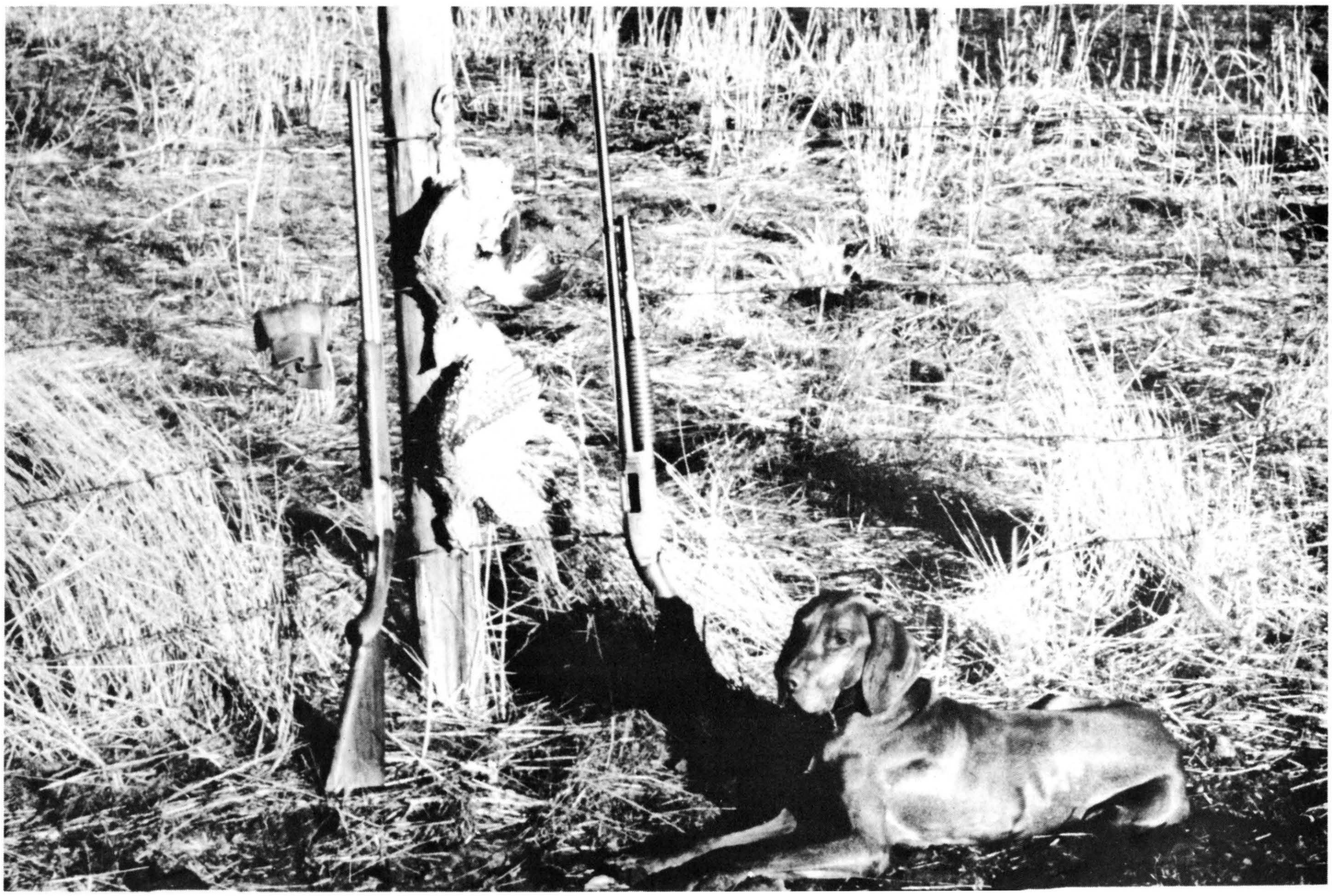
It is my opinion that efforts to measure annual production of prairie grouse in the Nebraska Sand Hills should be dictated by the need for such information. At present, the primary justification for obtaining such information is for consideration in establishing annual hunting regulations. However, it is likely that production is usually not uniform over the area open to hunting and that regulations based on production would therefore need to be area-specific. Administration of such regulations would probably not be feasible. Ordinarily, hunting regulations vary little from year to year, with the daily bag fluctuating from two to three grouse. It is unlikely that such changes in regulations have any appreciable effect on prairie grouse populations. Consequently, the effort necessary to obtain statistically reliable estimates of annual changes in summer populations of prairie grouse in the Nebraska Sand Hills is not justified for use in determining hunting regulations. However, findings of this study indicate that reliable estimates of summer densities and changes in densities of sharp-tailed grouse can be obtained using line-transect methods and appropriate sampling designs, assuming the need for such measures is sufficient to justify the effort and cost.

Brood size. – During the course of this study, young were counted in 164 sharptail and 63 prairie chicken broods. Mean brood sizes for estimated age classes are presented in Table 17. Mean brood sizes for all age classes were 6.1 for sharp-tailed grouse and 6.3 for prairie chickens. The expected decrease in mean brood size with increasing age was not evident in either species. A probable explanation was that older young observed together may have come from two or more broods. It was also possible that counts of young in older broods were more likely to be complete than those in younger broods.

Table 17: Sizes of sharp-tailed and prairie chicken broods by age classes of broods.

	BROOD SIZE					
	Sharp-tailed Grouse			Prairie Chicken		
Age	N	Mean	S.E.[1]	N	Mean	S.E.
<1/4	14	7.00	1.06	1	9.00	–
1/4	23	4.48	0.54	8	5.63	0.87
1/2	53	6.34	0.51	12	5.17	1.16
3/4	62	6.00	0.39	33	6.67	0.68
<3/4	12	7.92	1.13	9	6.78	0.78
All Ages	164	6.12	0.27	63	6.30	0.45

[1]Standard error (standard deviation of mean).



IV. HARVEST

Methods

Prairie grouse harvest data were gathered on Nebraska National Forest, Bessey Division, during hunting seasons of 1962 through 1973. Hunting season dates and bag limits in Nebraska for those years are presented in Appendix 4. Primary access to the Forest was through the main entrance on Nebraska Highway 2 about two miles west of the Village of Halsey. Many hunters used the camping facilities available near the main entrance. A second access road (Gaston Road) was completed late in the 1965 hunting season (Figure 6). Other access to the Forest consisted of sand trails across private land and received relatively little use by hunters.

Harvest data were obtained at check stations at the main and Gaston Road entrances and through questionnaires given hunters when check stations were not operative. The schedules for operation of check stations and use of questionnaires which varied from year to year, are presented in Appendix 5. Although information requested from hunters interviewed at check stations varied slightly between years, the following questions are representative of those asked each party:

How many grouse were bagged?
How many grouse were hit but not retrieved?
How many hunters in the party?
What time afield?
How many hours actually spent hunting?
What is your residence?

On days when check stations were not manned in 1962 through 1969, signs were posted requesting each party of grouse hunters entering the forest to pick up, complete, and return a questionnaire on their hunting activity that day (Figure 15). Special boxes were provided to dispense and collect questionnaires (Figure 16). In addition to the main and Gaston Road entrances, questionnaire pickup and deposit boxes were placed at entrances to the Forest via trails 276 and 277. The questionnaire consisted of a 6 X 10-inch envelope with questions printed on the outside (Figure 17). Questions on the envelope were equivalent to those asked hunters who were interviewed at check stations. Pickup and deposit boxes were checked frequently to make certain blank questionnaires were available and to collect completed ones.

With the conclusion of research on Bessey in 1969, the Terrestrial Wildlife Division assumed responsibility for operating the check station at the Forest. Since then, the Bessey check station has been operated on the first weekend of each season; questionnaires are no longer used.

Sex of grouse was determined during seasons 1962 through 1964 by examination of the color pattern of the central tail feathers, as described by Snyder (1935:46) and Manweller (1939). From 1965 through 1969, sex was determined by examining both the central tail feathers and crest feathers (Henderson, *et al.* 1967). In addition, some birds were sexed internally each year.

Grouse were aged by examining the outer primary feathers. Juveniles could be distinguished from adults, since they do not molt the ninth and tenth primaries during their first fall. In addition, juvenile age in weeks was estimated by the use of the wing fan described previously (Appendix 3).

To allow sex determination of grouse reported by questionnaire, hunters were asked to include central tail feathers (1962 through 1967) and crest feathers (1965 through 1967) in the questionnaire envelope for each bird shot. A packet of small coin envelopes was provided in each questionnaire envelope for tail and crest feathers. Respondents were asked to place the tail and crest feathers for each bird in a separate coin envelope. Hunters responding by questionnaire were also requested to place one wing in the envelope for each grouse bagged to allow age determination.

During the 1964 through 1967 hunting seasons, some grouse examined at check stations were weighed to the nearest gram.

The following were computed for the years 1962 through 1969:

$$\widehat{UH} = (QNR)(APS)$$
$$\widehat{UB} = (\widehat{UH})(AB)$$
$$\widehat{TH} = RH + \widehat{UH}$$
$$\widehat{TB} = RB + \widehat{UB}$$
$$\widehat{TC} = (TB)(RC)/RB$$
$$\hat{H} = \widehat{TB} + \widehat{TC}$$

$$\hat{C} = \frac{TC}{\hat{H}} 100$$

$\widehat{UH}$ = estimated number of hunter days not reported
$\widehat{UB}$ = estimated unreported number of birds bagged
QNR = number of questionnaires picked up but not returned
APS = average party size
AB = average reported number of birds bagged per hunter day
$\widehat{TH}$ = estimated total number of hunter days
$\widehat{TB}$ = estimated total number of birds bagged
RB = reported number of birds bagged
$\widehat{TC}$ = estimated total number of birds lost to crippling
RC = reported number of birds hit but not retrieved and assumed dead
$\hat{H}$ = estimated total number of birds killed as a result of hunting
$\hat{C}$ = estimated number of birds lost to crippling as a percent of the estimated total number of birds killed as a result of hunting

Estimates of annual mortality due to hunting were compared to corresponding estimates of densities during the preceding spring and summer, 1962 through 1966, in an effort to determine the portion of the population removed by hunting annually. Harvest data collected on the first weekend of each hunting season, 1962 through 1973, were analyzed to determine if a trend in grouse hunting pressure could be verified statistically. Factors affecting the numbers of birds bagged annually were also studied. Changes in ratios of juveniles to adults in the hunter's bag, as the season progressed, were analyzed to determine if juveniles were subject to differential mortality. Statistical analyses were done by computer using APL (Iverson 1962), OMNITAB (Chamberlain and Jowett 1970), and SAS (Barr and Goodnight 1972).

During the 1971 season, a portion of the study area was closed to motorized vehicles (Figure 18), primarily in response to hunters who objected to the use of off-road vehicles. Use of the closed area by hunters and the distance hunters penetrated into the area when limited to travel by foot or horseback were examined. An adjacent area, approximately the same size as the closed area was arbitrarily selected as a control. The control area was open to use of motorized vehicles. An aerial survey of hunters on the closed and control areas was conducted on the mornings of the first two days of the hunting season (September 18 and 19). Surveys were begun at 8:00 a.m. on September 18 and 9:00 a.m. on September 19. Observations were made by the pilot and one observer in a Champion Citibria. Transects were flown at approximately one-half to three-fourths mile intervals at an altitude of about 600 feet. The location of each hunter observed was recorded on a map of the Forest with a scale of one inch per mile. Numbers and distribution of hunters on the closed and control areas were compared.

In this report the term "hunter day" is defined as one hunter afield for any length of time on one day. "Gun hour" refers to one hunter afield for one hour.

Results

Questionnaire return.—Hunters entered the Forest primarily through the main and Gaston Road entrances, with most hunters using the main entrance exclusively (Figure 6). Hunters usually drove into the prairie on Road 203, the Natick, or the Gaston Road, parked their vehicle, and hunted within about one mile of their vehicle. Since there are few distinctive landmarks, many hunters preferred to hunt within sight of a road or along fence lines to avoid getting lost. Because of access, the most heavily hunted part of the Forest was west of a line running north and south along the eastern edge of the plantations, approximately 85 square miles. Within that area, most hunting occurred within one mile of a major road in the prairie (Road 203, Gaston and Natick roads) or an area of about 55 square miles.

Those few hunters, who entered the Forest east of the main entrance, were rarely contacted during the study. However, such use was assumed negligible compared to that on the monitored area. During days when check stations were operated, it was estimated that more than 90 percent of the grouse hunting activity on the forest was accounted for. The amount of hunting activity accounted for when checking stations were not operated was not known. However, during seasons 1962 through 1969 (when questionnaire envelopes were used), 38 to 50 percent of the questionnaires picked up when checking stations were not operated were returned. The number of parties failing to pick up questionnaires voluntarily was not known, but was believed to be low. Some questionnaires returned were only partially completed. The number of incomplete questionnaires averaged approximately 30 percent of those returned each year. However, most incomplete questionnaires provided some usable information. Although most hunters could be relied on to remove one wing from each grouse shot and place it in the questionnaire envelope, many failed to include the proper tail and crest feathers for sex identification. In several cases, more than one wing from one or more of the birds bagged were included in the envelopes making analysis of data difficult.

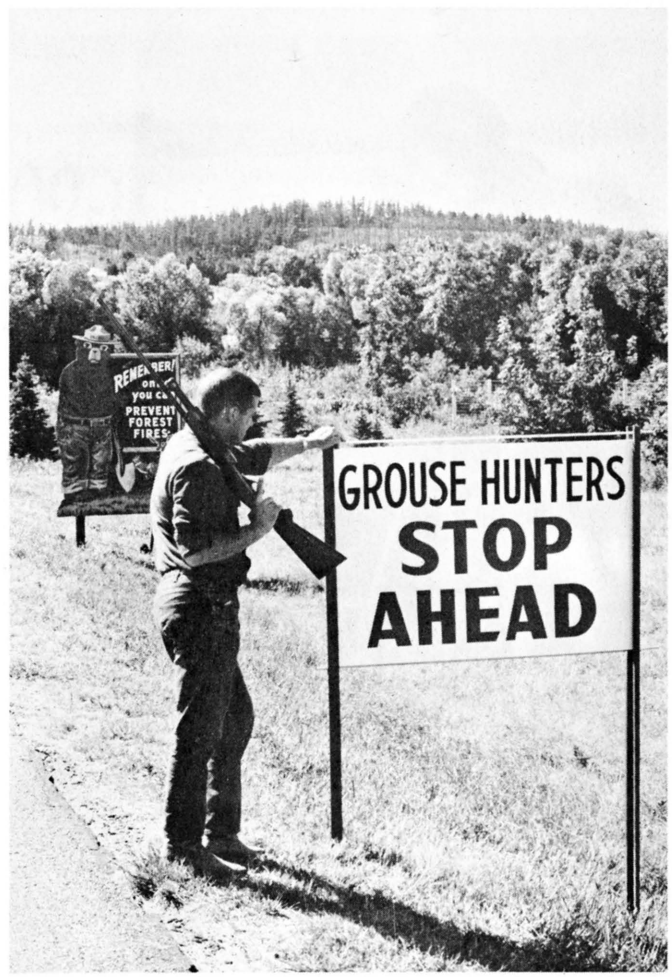


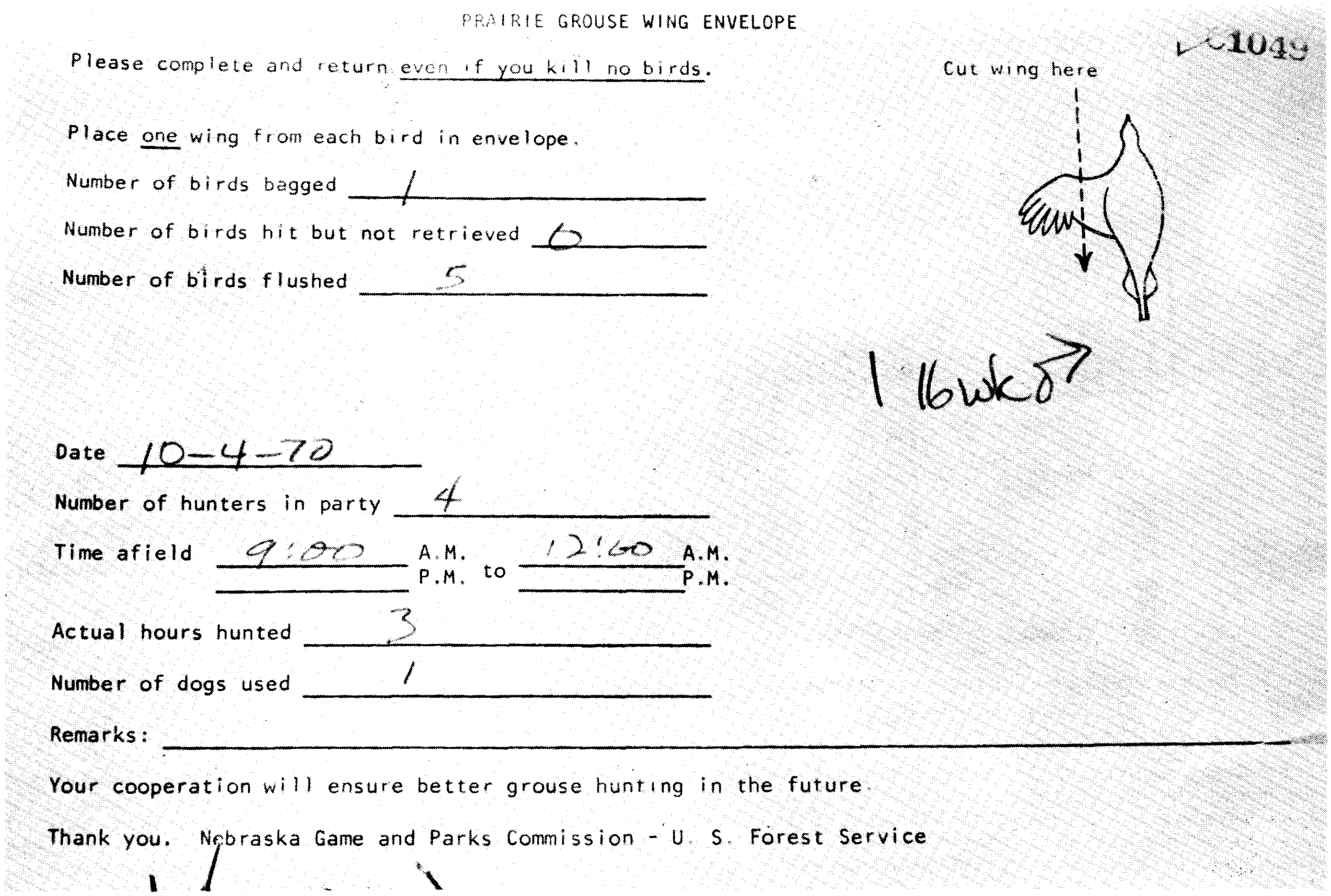
Figure 15. Sign notifying grouse hunters of check station at main entrance to forest.

Residence of hunters.—Hunters interviewed at check stations on the Forest, 1964 through 1968, were asked their county of residence if Nebraskans or state of residence if nonresidents. Since identities of individual hunters were not maintained, residence was determined on a hunter-day basis. During the five-year period, residence was determined for 2,495 hunter-days' effort of which 84.9 percent was from residents and 15.1 percent from non-residents. Nonresidents came from 21 states with Kansas, Missouri, and Iowa hunters contributing 42.0, 19.9, and 10.9 percent respectively of nonresident hunter-days. Hunter-days attributed to residents of various Nebraska counties are shown in Figure 19. Residents of Lancaster County in southeastern Nebraska were responsible for the most hunter days (14.1 percent) for any single county. Residents of Thomas County, which includes most of the Forest, ranked second with 10.0 percent of the effort. With the exception of Thomas County residents, most hunters came from counties having larger cities and towns, and presumably lived in urban or suburban areas. Hunters from the cities of Lincoln (Lancaster County) and Omaha (Douglas County) had to drive about 235 and 300 miles respectively to reach the Forest.

Mortality of grouse caused by hunting.—Reported and estimated harvest of prairie grouse on Bessey Division, Nebraska National Forest, for the hunting seasons 1962 through 1969 are presented in Table 18. The estimated total number of grouse killed as a result of hunting varied from 302 to 1,460 annually. Estimates of total kill assumed that all parties were contacted at a check station or picked up a questionnaire and that those not returning questionnaires were as successful as those who did. It is likely that neither assumption was correct but that errors in one may have counteracted errors in the other. Estimated numbers of grouse hit but not retrieved (and assumed dead) varied from approximately 8 to 13 percent of the estimated kill annually. The latter percentages were based on reported numbers of birds hit, but not retrieved, and may have been low due to the possible reluctance of some hunters to report actual numbers of birds they hit but did not retrieve. Assuming the area hunted was 85 square miles, hunters killed an estimated average of 5.7 grouse per square mile in 1962 through 1966.

Based on summer transect censuses for the same period on the Bessey study area (Table 16), the estimated density of grouse averaged 46 birds per square mile during late summer. Therefore, an estimated average of 12 percent of the total preseason population was killed by hunters each year, assuming that summer densities on the study area were representative of the forest as a whole and that no mortality occurred between the time of summer counts and the subsequent hunting seasons. Summer population estimates were not available for 1967 through 1969. However, assuming the same average summer density (46 grouse per square mile), the estimated kill of 1,460 grouse during the 1968 season would have represented a harvest of 37 percent of the preseason population.

Other investigators have also attempted to determine the impact of hunting on prairie grouse populations. Grange (1948:63) estimated that hunting was responsible for a 24-percent reduction of the preseason sharptail population in Wisconsin in 1941. Edminster (1954:159), summarizing work of several investigators, estimated that hunting reduced fall populations of sharp-tailed grouse up to 25 percent and that total fall and winter losses were likely to be approximately 50 percent. Ammann (1957:129) studied effects of hunting on sharptails on Drummond Island in Michigan and estimated mortality from hunting at 40 percent of the preseason population. He concluded that sharptail populations could withstand 40 to 50 percent reduction annually from hunting, except during years of population decline, when harvest should be reduced. Based on extensive band return data on sharptails in South Dakota, Robel, *et al.* (1972:96) estimated minimal mortality of grouse from hunting at 20.5 and 21.8 percent respectively on two study areas.


PRAIRIE GROUSE WING ENVELOPE

1049

Please complete and return even if you kill no birds.

Cut wing here

Place one wing from each bird in envelope.

Number of birds bagged 1

Number of birds hit but not retrieved 0

Number of birds flushed 5

1 16wk ♂

Date 10-4-70

Number of hunters in party 4

Time afield 9:00 A.M. P.M. to 12:00 A.M. P.M.

Actual hours hunted 3

Number of dogs used 1

Remarks:

Your cooperation will ensure better grouse hunting in the future.

Thank you. Nebraska Game and Parks Commission - U. S. Forest Service

Figure 17. Hunter questionnaire envelope.

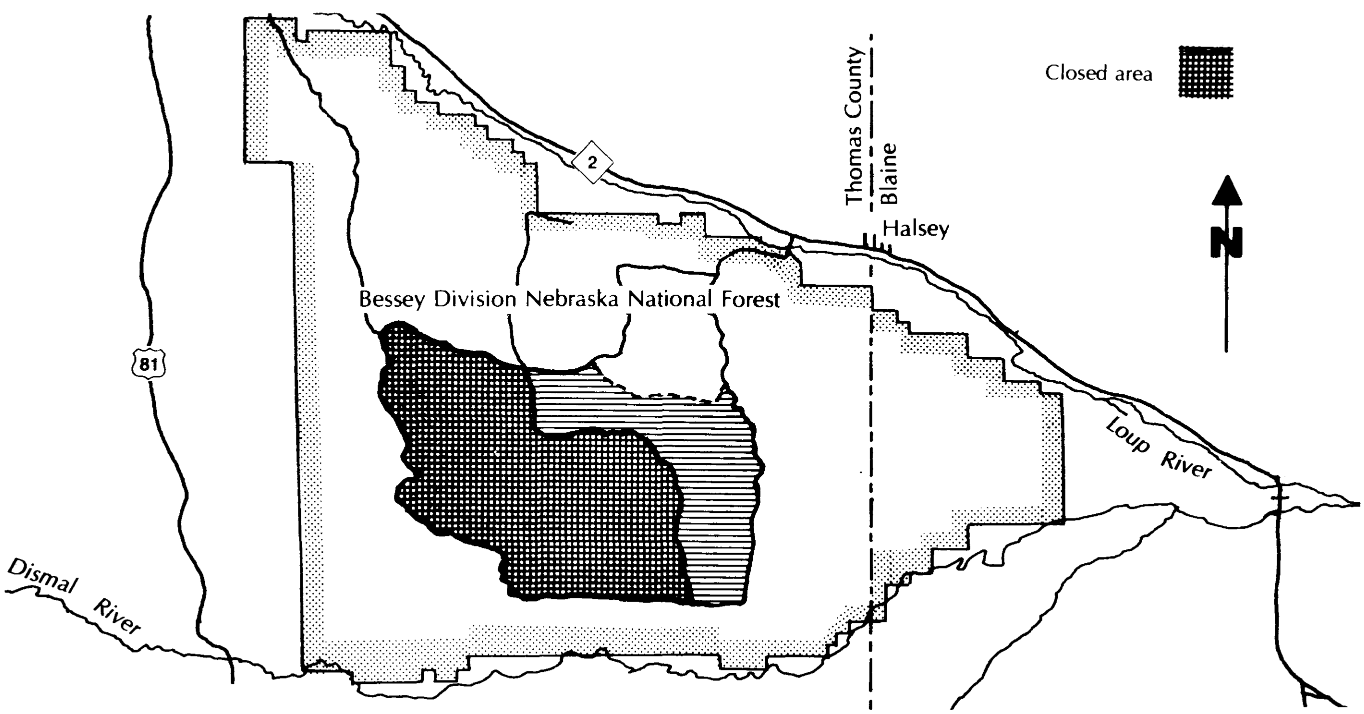


Figure 18. Area closed to motorized vehicles.

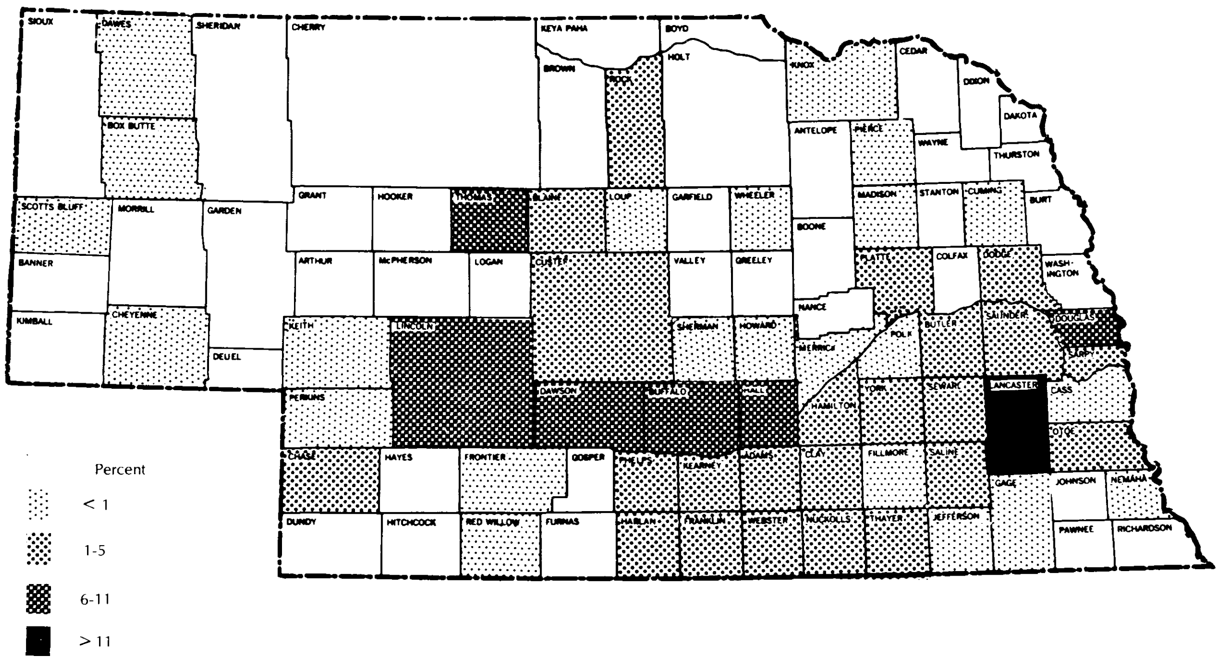


Figure 19. Origin of hunting effort (percent of hunter days) by county for Nebraska residents who hunted grouse on the forest during the 1964-68 seasons.

It is an accepted principle in game management that hunting mortality substitutes for some of the natural mortality which would otherwise occur. Hamerstrom and Hamerstrom (1973:36) estimated mortality of prairie chickens in hunted and non-hunted populations in Wisconsin, however, and concluded that hunting increased mortality by about 25 percent.

Considering the observed rate of increase in hunting pressure, there seems to be justification for concern over the future impact of hunting on prairie grouse on the Forest. Most of the range of the prairie grouse in Nebraska is in private ownership. Hunting pressure on private land is regulated by the landowners and is generally light. Public land open to hunting of prairie grouse includes the Bessey Division of the Nebraska National Forest, Samuel McKelvy National Forest, Valentine National Wildlife Refuge, Crescent Lake National Wildlife Refuge, and several state-owned areas of limited size. Federal lands open to public hunting total approximately 440 square miles or about 2.4 percent of the prairie grouse range in the state. As a result, hunting pressure on public lands is relatively high and can be expected to increase. Bessey Division is unique among federal lands because it is closer to the more densely populated portion of the state and has superior camping facilities. If hunting pressure continues to increase on the Forest, special regulations may be necessary to prevent over-harvest of prairie grouse.

Assuming a minimum preseason population of 20 grouse per square mile, a maximum harvest of 10 grouse per square mile (50 percent) is recommended. With present access roads, the area effectively hunted is approximately 85 square miles. Thus, the maximum recommended annual harvest would be 850 grouse. A larger harvest could be allowed during years of higher than normal production. However, accurate measures of production are not presently available, so the recommended maximum harvest should not be exceeded. Harvest is, to some extent, limited by density of grouse, regardless of relatively large increases in hunting pressure. For example, 580 man-days of effort and a harvest of 706 grouse

Table 18. Reported and estimated harvest of prairie grouse on Nebraska National Forest, Bessey Division, 1962 through 1969.

	Number of Questionnaires[1]		Reported Data[2]				Season Estimates				
Year	Total	Returned	Parties	Hunters	Bag	Crips	Hunters	Bag	Crips	Total Kill	Estimated % Cripple Loss
1962	145	132	132	350	304	38	384	334	42	376	11
1963	179	161	161	398	386	48	443	430	54	484	11
1964	238	219	219	588	628	54	639	683	59	742	8
1965	182	160	160	442	237	28	503	270	32	302	11
1966	216	157	157	422	326	53	581	449	73	522	14
1967	312	154	154	438	472	59	887	956	120	1,076	11
1968	562	347	347	983	787	114	1,592	1,275	185	1,460	13
1969	400	259	259	722	471	55	1,115	727	85	812	10
TOTALS	2,234	1,589	1,589	4,343	3,611	449	6,144	5,124	650	5,774	11

[1]Includes incomplete questionnaires

[2]Based on checking station interviews and completed questionnaires

Table 19. Selected prairie grouse harvest data reported at checking stations during the first weekend of each hunting season, 1962 through 1973, on Nebraska National Forest, Bessey Division, and statewide.

	Nebraska National Forest, Bessey Division				Statewide
Year	Hunter-Days	Grouse Bagged	Gun-Hours Per Bird	Age Ratio[1]	Age Ratio[1]
1962	140	148	3.86	1.05	1.29
1963	166	153	3.62	1.87	2.28
1964	304	307	4.33	1.01	1.80
1965	158	91	6.71	0.96	2.10
1966	219	183	5.27	1.56	2.11
1967	277	363	3.28	1.95	1.81
1968	561	542	4.30	0.99	1.81
1969	518	375	5.72	0.85	1.64
1970	443	332	5.95	1.41	1.80
1971	362	360	4.26	2.09	2.49
1972	580	706	3.41	2.70	2.83
1973	655	416	7.23	0.86	1.23
TOTALS	4,383	3,976	—	—	—
MEANS	365.25	331.33	4.83	1.44	1.93

[1]Juveniles/Adult

were reported on the first weekend of the 1972 season (Table 19). Although effort increased 13 percent to 655 man-days during the first weekend of the 1973 season, only 416 grouse were reported harvested, representing a decrease of 41 percent in harvest. Hunters in 1973 reported hunting 7.23 hours to bag one bird. It is likely that the effort required to bag a bird in 1973 would discourage many hunters from further effort.

Seasonal distribution of hunting effort and harvest.—The seasonal distribution of hunting effort and harvest of prairie grouse on the Bessey area were determined from 1962 through 1965, when check stations were operated each weekend (Figure 20). The season those years varied from 23 to 44 days. Since the season usually opened and closed on a weekend, the last "week" in Figure 20 actually represents the last weekend or two days of the season. An average of 52 percent of the effort and 51 percent of the reported harvest occurred during the first week of the season. Averages of 73 percent of the effort and 71 percent of the harvest were accounted for by the end of the second week of the season. In general, effort and bag declined as the season progressed. Examination of the distribution of effort and harvest in 1965, when the season included seven weekends, suggested that hunting pressure on the forest essentially ceases after six weekends of open season. An estimated average of 83 percent of the effort and 78 percent of the harvest occurred on weekends. Similar distributions of effort and harvest have been noted in other states (Ammann 1957:116, Hillman and Jackson 1973:39, and Grange 1941:63).

Factors influencing harvest.—Harvest data from the Nebraska National Forest was analyzed to determine if factors underlying the annual variation in harvest could be identified. To maximize sample size, harvest data from 1962 through 1973 were utilized. However, data were only collected on opening weekend in 1970 through 1973. Therefore, analysis was limited to first weekend data. It was assumed that first-weekend data were representative of the entire season. This assumption was considered reasonable since more than 50 percent of the effort and harvest occurred during the first week of the season. Weekend harvest data used in subsequent analyses are presented in Table 19.

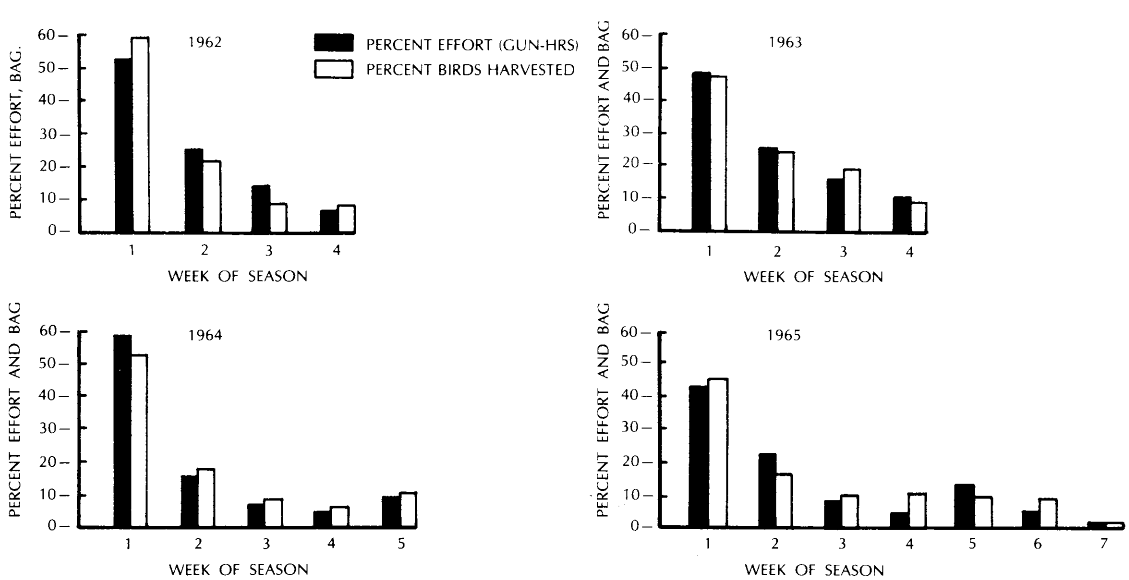


Figure 20. Seasonal distribution of effort and harvest of prairie grouse on Nebraska National Forest, Bessey Division, 1962 through 1965.

The following hypothesis was tested: Annual effort expressed in man-days was a linear function of year as 1 (1963) through 11 (1973) and success the previous season expressed as the ratio of total gun-hours to total birds bagged. The hypothesis was tested by multiple linear regression (Table 20). The regression sum of squares was significant ($P<0.05$), with 93.3 percent of the variance in effort accounted for by regression. Each of the independent variables were significantly related to effort ($P<0.05$). The regression coefficients (b) for years indicated effort increased an average of about 45 man-days per year. The coefficient for success the previous year was negative indicating low success (high gun-hours per bird) one season had a negative influence on effort the following year.

A second hypothesis was tested in the same manner: Annual harvest, expressed in grouse bagged, was a linear function of effort, expressed in hunter days, bag limit, opening date of the season, expressed in days from September 15, and the ratio of juveniles to adults in the bag. Results of that analysis are presented in Table 21. The reduction in sum of squares due to regression was again significant ($P<0.05$) with 90.1 percent of the variance in harvest accounted for. The effects of effort and juveniles per adult were significant ($P<0.05$), while bag limit and opening date had no significant influence on harvest. These results are not consistent with those of other investigators (Grange 1941:70, Ammann 1957:117, and Hillman and Jackson 1973:39) who found that harvest was greater during earlier seasons because of increased wariness of birds later in fall. Examination of b values indicated that an increase of 1.0 in the juvenile per adult ratio was accompanied by an average increase of 129.9 grouse bagged on the first weekend, assuming other variables remained constant. Similarily, an increase of 100 hunter days resulted in an average increase in the first weekend harvest of 76.9 grouse.

Assuming the age ratio in the hunters' bag on the first weekend of the season was indicative of production and survival of young, results of the foregoing analysis suggested that total harvest was primarily a function of the effort (hunter days) and success of reproduction the previous summer. Thus, hunter success, measured in terms of birds bagged per hunter, was primarily a function of the ratio of juveniles to adults. The observed relation between harvest and age ratio may have been due to increased numbers of birds resulting from higher reproductive success, or greater vulnerability of juveniles to hunting, or both.

The change in ratios of juveniles to adults as the season progressed was analyzed by a method described by Eberhardt and Blouch (1955) to test for differential vulnerability of juveniles. The method is based on the principle that if juveniles are more vulnerable than adults, then the age ratio (juveniles per adult) would be expected to decrease in an exponential manner as the season progressed. The test involved regressing the log of the age ratio during consecutive time intervals on the corresponding cumulative hunting effort. Data from the Forest for 1967 and 1968 were selected because age ratio data were available for the entire season those years. Each year's data were divided into five or six consecutive time periods with a minimum of 20 birds in each. Numbers of birds in each period were used as weights in the regression analysis. The slopes of the resulting regression lines were not significantly different than 0.0 ($P<0.05$) and the null hypothesis of no differential vulnerability was accepted. Ammann (1957:91) also studied changes in age ratios as the hunting season progressed and found no statistical evidence of differential vulnerability in Michigan sharptails.

Based on results of analysis of sharptail harvest data in this study, it was concluded that the observed relation between age ratio and harvest resulted from a positive relation between grouse density and age ratio in the hunter's bag and that harvest was primarily a function of hunting effort and abundance of grouse.

Relation of harvest to spring and summer population.—The relationships between spring and summer measures of density of prairie grouse on the Bessey area and harvest in subsequent falls were investigated for the years 1962 through 1966 when such data were available. However, the resulting sample size (5 years) was of questionable size for analysis. The average number of gun-hours required to bag a grouse each season was used as a measure of fall abundance. Simple linear correlations of gun-hours per bird in fall with estimated densities of male grouse the previous spring (Table 6) and with estimated densities of grouse the previous summer (Table 16) were not significant ($P<0.05$). Because of the small sample size and variation associated with measurements used, the above tests were not considered conclusive. For example, it is likely that harvest was affected by production, as indicated in previous analyses, but that variance known to be associated with estimates of summer population densities (Table 16) may have precluded detection of relationships with such small sample sizes.

Sex and age composition of the harvest.—Sex and age ratios for sharp-tailed grouse bagged on the forest, 1962 through 1969, are presented in Table 22. For comparison, corresponding data for the state as a whole are also included. Data from the forest were gathered throughout each hunting season, while statewide data was gathered only during the first weekend of each season. The overall age ratio on the forest was 1.23 juveniles per adult. However, the age ratio differed between sexes, with 1.96 juveniles per adult in males and 1.04 juveniles per adult in females. The apparent dependency of age ratio on sex for 2,334 grouse examined on the forest was tested by Chi-square and found significant ($P<0.05$). Juvenile males and adult females were found in greater numbers in the hunter's bag than was expected. The sex ratio of grouse bagged on the forest differed significantly from 1:1 within age groups and for ages combined ($P<0.05$) with females more numerous than males. Dependency of age ratios on sex in statewide data was also significant ($P<0.05$), although not as pronounced as on the forest. Statewide males significantly outnumbered females in juveniles ($P<0.05$). In contrast to the Forest, sex ratios of

Table 20. Results of multiple linear regression analysis of effort (man-days) of prairie grouse hunters on year and the previous year's success (hours/birds) for the first weekend of each hunting season, 1963 through 1973, on Nebraska National Forest, Bessey Division.

Dependent Variable:
Effort (man-days)

Independent Variables	Regression Coefficient (b)	Normalized Regression Coefficient (Beta)	F^1
Year	45.41332	0.85719	45.64848
Hours/Bird (Previous Season)	−65.52473	−0.42390	11.16348
Constant Term	415.31640		

Multiple−r^2 = 0.93364

ANALYSIS OF VARIANCE

Source	Degress of Freedom	Sum of Squares	Mean Square	F^2
Regression	2	269128.178	134564.089	27.171
Residual	8	39620.004	4952.501	

[1](b/Std. error of b)^2 with 1 and 8 d.f.; tabulated F = 5.32, (P = .05, 1 and 8 d.f.)
[2]Tabulated F = 4.46, (P = .05, 2 and 8 d.f.)

Table 21. Results of multiple linear regression analysis of harvest (numbers of birds) on effort, age ratio, bag limit, and season opening for the first weekend of each hunting season 1962 through 1973, on Nebraska National Forest, Bessey Division.

Dependent Variable:
Harvest (number of grouse reported bagged)

Independent Variables	Regression Coefficient (b)	Normalized Regression Coefficient (Beta)	F[1]
Effort (Hunter-days)	0.76885	0.79397	35.21912
Age ratio (juveniles/adult)	129.87301	0.44033	11.17638
Bag limit	63.07457	0.17628	1.74862
Season opening (days from Sept. 15)	−0.12679	−0.00576	0.00188
Constant term	−156.63713		

Multiple-r^2 = 0.90093

ANALYSIS OF VARIANCE

Source	Degress of Freedom	Sum of Squares	Mean Square	F[2]
Regression	4	307600.78714	76900.19679	15.91483
Residual	7	33823.87952	4831.98279	

[1]$(b/\text{Std. error of } b)^2$ with 1 and 7 d.f.; tabulated F = 5.59 (P = .05, 1 and 9 d.f.)
[2]Tabulated F = 4.12 (P = .05, 4 and 7 d.f.)

adults harvested statewide did not differ significantly from 1:1 ($P<0.05$).

Annual age ratios in sharp-tailed grouse harvested on the forest during the first weekend of each season 1962 through 1973 were compared to corresponding statewide measurements (Table 19). Means of annual ratios of juveniles per adult were 1.44 on the Forest and 1.93 statewide. The difference between means was significant ($P<0.05$). Annual age ratios from the Forest and statewide were positively correlated ($P<0.05$, r = 0.81 with 10 d.f.). Assuming age ratios reflect success of reproduction, it was concluded that reproductive success of grouse on the Forest fluctuated with, but was consistently lower than, reproductive success statewide.

In Michigan, males consistently outnumbered females in sharp-tailed grouse shot by hunters (Ammann 1957:93). In North Dakota, the average annual ratio of male to female sharptails in the hunter's bag varied from 0.87 to 1.27 and averaged 1.06 for the period 1964 through 1972 (Kobriger 1973:6). Sex ratios of sharptails shot in South Dakota from 1964 through 1971 varied from 0.86 to 1.13 males per female annually and averaged 0.98 (Roth 1972). The average sex ratios in North and South Dakota were similar to those observed statewide in Nebraska (1.03). Sex ratios for sharp-tailed grouse examined at check stations in the present study appeared atypical when compared with those statewide in Nebraska and with those observed in other states. The reason for this difference was not determined.

Fall weights.—During the hunting seasons of 1964 through 1967, 193 sharp-tailed grouse from the Forest were weighed to the nearest gram. Only those birds which had not been dressed were weighed. Mean weights for each sex and age class are summarized in Table 23. Males and females averaged 860.0 and 744.6 grams respectively. The difference between means was significant ($P<0.05$) with males averaging 115.4 grams heavier than females. Adults averaged 22.4 grams heavier than juveniles, the difference also being significant ($P<0.05$).

Weight difference between sexes is characteristic of prairie grouse. Manweiler (1939) proposed a method of sexing live sharptails using a combination of the rectrix pattern and weight. Although the difference in

Table 22. Sex and age composition of sharp-tailed grouse harvested on Nebraska National Forest, Bessey Division, and statewide in Nebraska, 1962 through 1969.

Year	Male		Female		Unknown Sex		Grand Total	Juvenile/Adult	Male/Female
	Adult	Juvenile	Adult	Juvenile	Adult	Juvenile			
NEBRASKA NATIONAL FOREST, BESSEY DIVISION[1]									
1962	36	60	78	91	5	7	277	1.33	0.57
1963	35	87	71	120	13	31	357	2.00	0.64
1964	66	150	132	153	18	23	542	1.51	0.76
1965	28	47	86	47	4	7	219	0.86	0.56
1966	45	84	80	60	11	20	300	1.21	0.92
1967	51	106	99	117	53	121	547	1.69	0.73
1968	40	58	75	72	296	245	786	0.91	0.67
1969	20	36	59	45	146	117	423	0.88	0.54
All Years	321	628	680	705	546	571	3,451	1.23	0.69
STATE WIDE — NEBRASKA[2]									
1962-69	680	1,301	730	1,201	—	—	3,912	1.77	1.03

[1]Only grouse of known age included; data collected throughout hunting season.
[2]Only grouse of known sex and age included; data collected on the first weekend of the hunting season only.

Table 23. Weights of sharp-tailed grouse examined at hunter checking stations on Nebraska National Forest, Bessey Division, 1964 through 1967.

Sex and Age	n	Mean	Range	S.E.[1]
Male	96	860.00	700-989	5.916
Adult	37	882.57	700-989	11.156
Juvenile	59	845.85	740-955	6.051
Female	97	744.55	626-898	5.531
Adult	45	759.23	685-898	7.192
Juvenile	52	731.85	626-807	5.542
Total	193	801.97	626-989	4.779
Adult	82	814.88	685-989	6.891
Juvenile	111	792.45	626-955	6.136

[1]Standard error (standard deviation of mean).

mean weights of adults and juveniles was significant, the considerable overlap in weights between age groups would limit use of weight as a criterion for age determination.

Closure to off-road vehicles.—Response of grouse hunters to closure of part of the forest to off-road travel by motorized vehicles during the 1971 hunting season was studied by determining the distribution of hunters over the closed area and an adjacent open area by aerial surveys on the first two days of the season. The open and closed areas surveyed were approximately 23 square miles each with similar access. A total of 121 hunters was seen on the two areas during the two survey periods, of which 77 (64 percent) were using the closed area. It was not known whether this difference in hunter use was a result of the closure since no comparable data were available for a period when both areas were open to motorized vehicles. However, based on experience during previous hunting seasons, the density of hunters probably was not greatly affected by the closure. Numbers of hunters observed more than 1/2 mile from the nearest road were determined for each area. Of 77 hunters seen on the closed area, 44 (57 percent) were more than 1/2 mile from the nearest road; 39 percent of 44 hunters observed on the open area were more than 1/2 mile from the nearest road. The dependency of proportions of hunters observed more than 1/2 mile from the nearest road on whether they were in the open or closed area was tested by Chi-square and was not significant ($P<0.05$).

Although the vehicle closure had no discernible effects on hunter use or distribution as viewed during aerial flights, the value or success of such management cannot be properly assessed by such measures alone During years prior to the closure, numerous hunters contacted at check stations or by questionnaire opposed use of off-road vehicles for hunting. The primary basis for objection was the disturbance caused by use of such vehicles. Another cause for concern over use of such vehicles was potential disturbance of vegetative cover, particularly on steep grades. The loose sandy soil of steeper slopes is particularly susceptible to such disturbance.

V. TRAPPING AND MOVEMENTS

Methods

Prairie grouse were trapped and marked during 1958 through 1961 on the Loup County and Swan Lake areas. Both species of grouse on these areas formed feeding flocks varying in size from a few to over 50 birds during late fall and winter. Such flocks usually ranged over an area of 1 to 2 square miles. During periods of snow cover, flocks could be attracted by bait such as corn or small grains. Winter trap sites were established on the Loup County and Swan Lake areas at several locations where feeding flocks were observed (Appendix 6, Figures 21 & 22).

During 1962, most field work was transferred to the Bessey area. However, no regular feeding flocks could be located there. To allow continuation of trapping and marking work, trap sites were established along the Middle Loup River near the Bessey area, where feeding flocks of sharp-tailed grouse and prairie chickens had been observed (Appendix 6, Figure 23). Although most trapping and marking was conducted during winter, limited effort was made to capture grouse on display grounds during spring and to capture nesting hens during summer.

Traps used to capture feeding birds during winter included walk-in pen, tip-top, cannon net, and clap traps (Table 24). Walk-in pen traps were constructed in various shapes from circular to rectangular and in several sizes. The most effective design for walk-in traps was a rectangular trap with sides made of 2 x 4-inch or 1 x 2-inch mesh welded wire on a 2 x 2-inch wood frame. Cotton netting was used for the tops. Rectangular walk-in traps ranged in size from 18 to 36 inches high, from 4 to 16 feet wide, and from 5 to 31 feet long. Entrances were made at ground level. Funnels made of hardware cloth or one-way gates were used at entrances to prevent exit from the traps. Bait was placed inside the traps. Tip-top traps had four sides 18 inches wide and 3 feet high constructed of welded wire and covered with sorghum stalks. The tops of the tip-top traps were made of tempered hardwood with an entrance covered by a treadle. Birds lured to the top of the trap by bait (usually corn) could step on the treadle and fall into the trap below. Cannon-net traps were also used over bait during winter and early spring. A clap trap similar to that described by McClure (1966:61) was used during winter, 1959. It was baited with ear corn and was designed to capture a single bird.

Limited effort was made to capture grouse on display grounds during the springs of 1963 and 1966 on the Bessey area. Methods included a cannon-net and a clap trap (Table 24). A dead female grouse mounted in a precopulatory position was used in an effort to attract male grouse into a clap trap. Although males were attracted to the trap, no birds were caught because of malfunction of the trap mechanism. A dip-net with a 5-foot handle was used to capture nesting hens during summers, 1959, 1960, 1964 and 1965.

Site locations for winter trapping were determined in late fall after feeding flocks formed. Each trap site was pre-baited from November through January with 2 to 15 bushels of ear corn and small grains to establish use of the area by grouse. Traps were usually placed on the sites without tops in January or early February, depending on weather. Trapping was begun after the grouse had become accustomed to the traps, usually in January or February. Baiting continued throughout trapping. Winter trapping was conducted during morning and evening feeding periods. Tops were removed from the traps at night. The daily schedule usually involved activating the traps (putting the tops on) in early morning and returning to check the traps at mid-day. Any captured birds were removed, processed, and released. The same procedure was repeated in late afternoon and evening.

All birds were banded with aluminum leg bands on initial capture. In addition, other marking methods were used to allow visual identification. Plastic back tags were used from 1959 through 1963. These tags were constructed after those described by Blank and Ash (1956) with exception of a modified harness. During 1959 through 1961, the harness

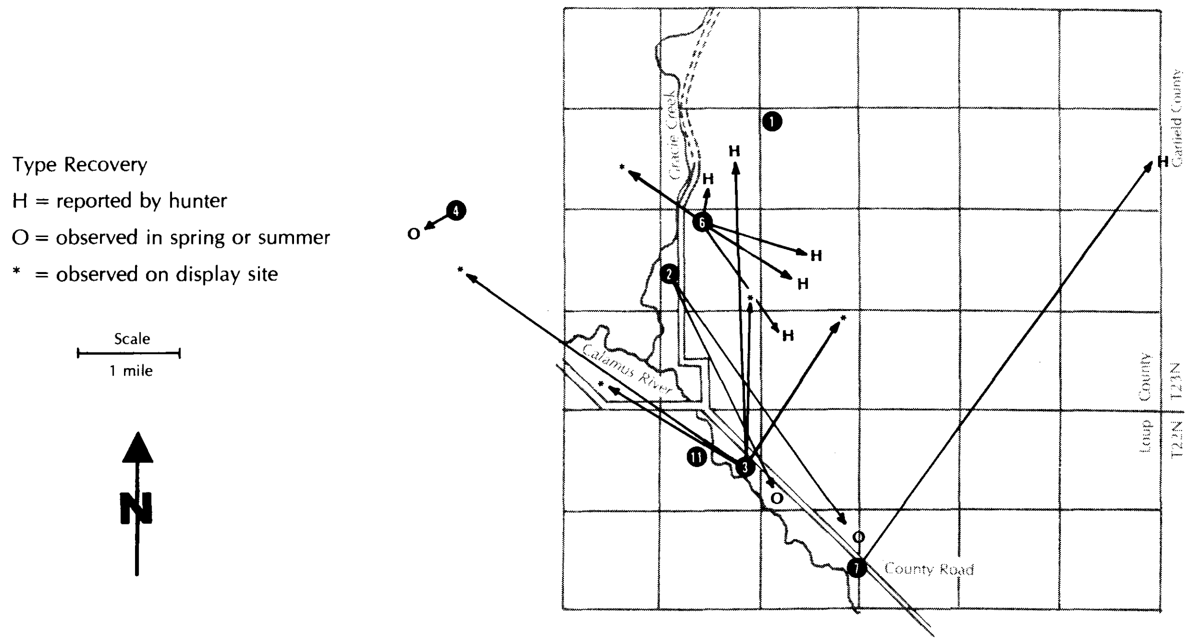


Figure 21. Locations of trapsites and movements of marked prairie grouse on the Loup County Area.

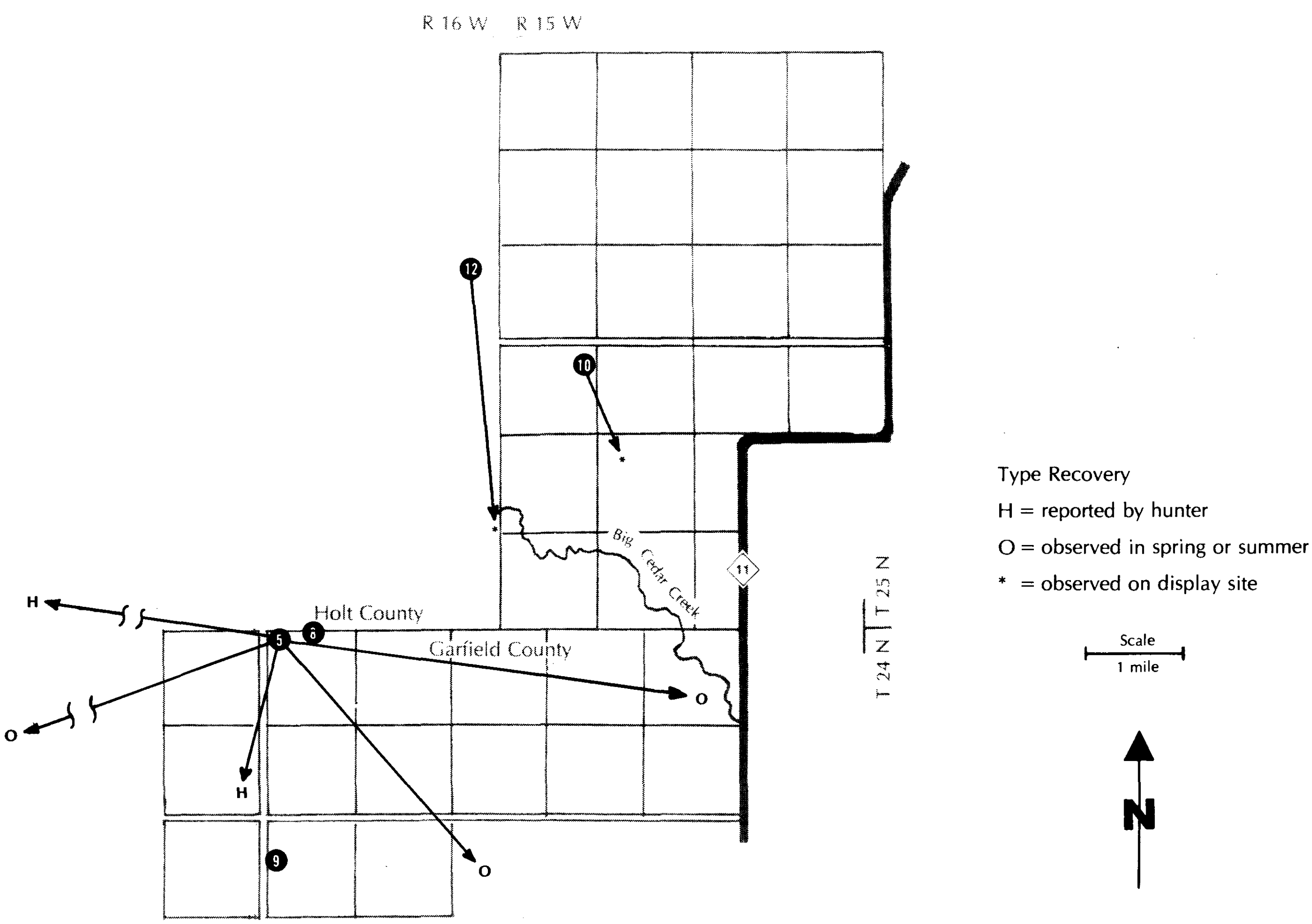


Figure 22. Location of trapsites and movements of marked prairie grouse on the Swan Lake Area.

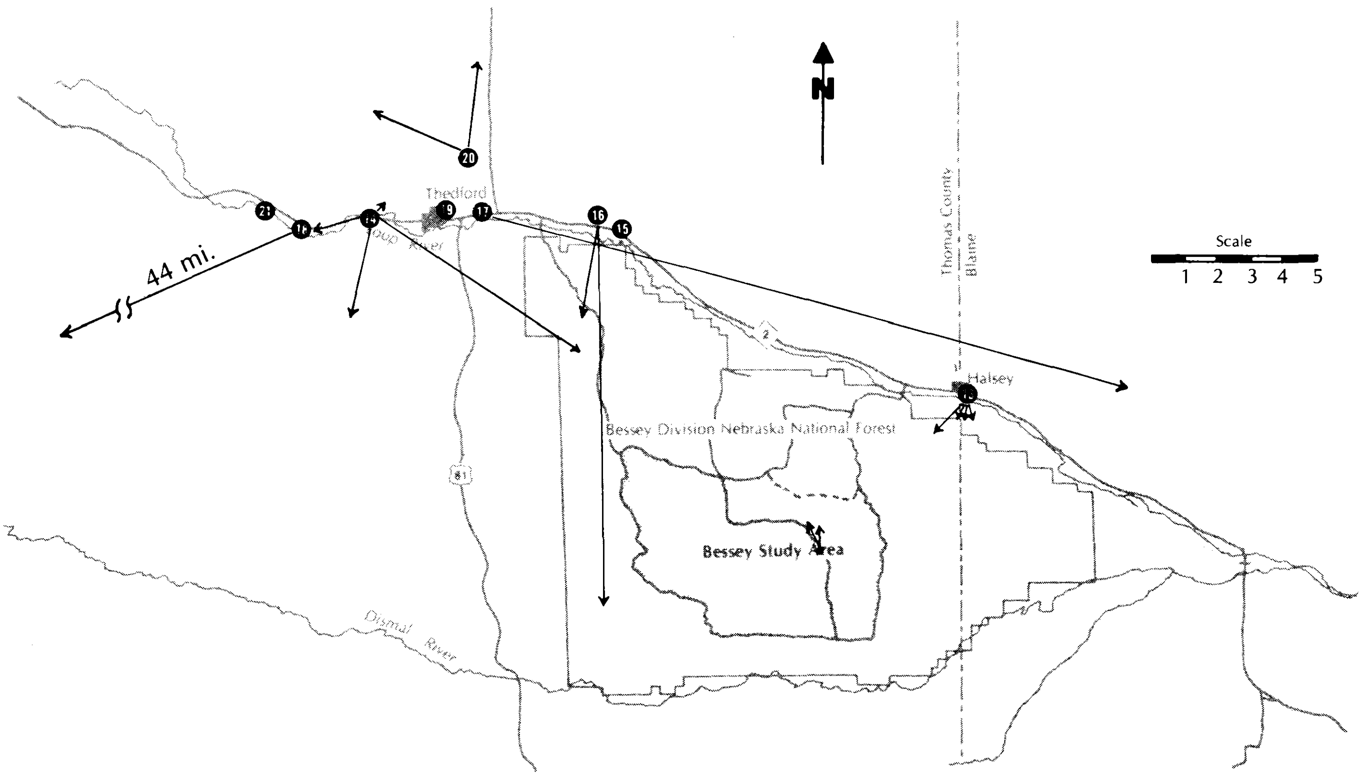


Figure 23. Locations of trapsites and movements of marked grouse shot and reported by hunters on and near the Bessey Area.

was made of braided nylon formed into a loop, which was slipped over the wings. A numbered plastic tag, 2 inches wide and 6½ inches long, was stapled to the harness. In 1959, plastic tags broke or tore easily after being attached to the bird. Thereafter, a cloth-backed plastic was used for tags. It was thought that back tag harnesses increased mortality. Therefore, back tag harnesses were modified in subsequent years with flat nylon-reinforced elastic replacing the braided nylon.

During 1964 through 1966, DuPont aniline dye was applied to the underside of the tail to mark some birds. Different colors (red, yellow, purple, and blue-green) were used at each trap site to allow determination of movements of birds subsequent to marking. Plastic poultry bands or bandettes were used to mark birds in 1966 only. Red, yellow, green, or blue bandettes were placed on right and left legs with different color combinations representing different trap sites.

Results

Evaluation of capture and marking techniques.—Numbers of prairie grouse initially captured by year and trapping method are presented in Table 24. Most trapping was conducted during winter when grouse formed feeding flocks and could be attracted by bait. Several techniques for capturing prairie grouse during winter were tried in 1959 and 1960. The baited rectangular walk-in pen trap with funnel type entrances was the most effective method tested and was used exclusively for winter trapping in subsequent years. Other investigators (Klett 1957, Henderson and Jackson 1965, Jackson 1967, Horak 1966, Hillman and Jackson 1973, and Hamerstrom and Hamerstrom 1973) also found baited walk-in pen traps effective for capturing prairie grouse during winter.

Winter trapping was successful only in areas where grouse were accustomed to feeding on grain. Grain was made available at several locations on the Bessey area but was completely ignored by grouse. Agricultural crops were absent on the area, and it was concluded that grouse (primarily sharptails) on the area had adequate natural foods and were not accustomed to utilizing agricultural crops. These results also suggested that wintering populations on the Bessey area were distinct from those along the Middle Loup River where agricultural crops were commonly utilized for food during winter.

Efficiency of walk-in pen traps was determined in 1965 and 1966 (Table 25). The average number of grouse caught per trap was 4.2 in mornings and 4.1 during afternoons. This was similar to results of Klett (1957:17) who reported trapping an average of 7.5 sharptails per day in walk-in pen traps in North Dakota.

Few grouse were known to die from trapping and handling. Two grouse died as a result of handling, and ten grouse were killed in traps by wild predators or domestic dogs or cats. One grouse was killed during cannon-net trapping by a cannon projectile, and one bird died when it flew into a wire fence after release.

Numbers of prairie grouse by year of capture and marking technique are presented in Table 26. In addition to aluminum leg bands used on each bird, several types of markers were used to allow visual identification in the field. Plastic back tags used from 1959 through 1963 were not used after 1963 because the harness was observed to impair the flight of some birds and was thought to increase mortality. Jackson (1967:27) also reported increased mortality of sharptails resulting from back tags and found that use of such tags was opposed by some landowners and sportsmen. Pepper (1972:11) found that the harnesss of back tags he used on sharp-tailed grouse hindered flight. Jackson (1967) and Pepper (1972) found poncho and jess-type neck collars were effective markers and apparently had no adverse affects.

Dye was used to mark 233 prairie grouse from 1964 through 1966. Although dye was not as durable as other external markers, there was no evidence of adverse effects from the dye. The dye remained visible for three to four months when applied in winter.

Colored, plastic poultry bandettes were used on 119 grouse, often in combination with dye, during 1966 only. The bandettes apparently had no adverse effects on grouse; however, few birds were subsequently identified in the field by means of bandettes. Jackson (1967:30) found that colored plastic bands were the most effective of several markers he used.

Table 24. Numbers of prairie grouse captured and banded each year by method of capture.

	CAPTURE METHODS					
Year	Baited Pen[1] Trap (Jan.-Mar.)	Cannon Net[2] (Jan.-May)	Clap Trap[3] (Jan.-April)	Dip Net (June)	Spot-light (July-Aug.)	Totals
1959	131	21	0[5]	1	–	153
1960	303	–[4]	–	2	–	305
1961	61	–	–	–	–	61
1963	71	2	–	–	–	73
1964	148	–	–	1	–	149
1965	263	–	–	3	–	266
1966	67	3	0	–	0	70
TOTALS	1,044	26	0	7	0	1,077

[1]Includes walk-in pen trap, clover leaf trap, tip-top trap.
[2]Used over bait (Jan.-Feb.) and on display grounds (April-May).
[3]Used with bait (Jan.-March) and with mounted female decoy on display grounds (April).
[4]"–" indicates method not used.
[5]"0" indicates method used but no birds captured.

Species, sex and age.—Numbers of prairie grouse captured and marked during the study are presented by species, sex, and age in Table 27. Birds captured and marked included 736 sharp-tailed grouse, 328 prairie chickens, and 13 sharptail-prairie chicken hybrids. Males outnumbered females nearly two to one in sharptails and more than five to one in prairie chickens. Klett (1957:19) also concluded that the sex and age composition of trapped sharptails was not representative of the population and suggested that sex and age composition may have differed between wintering flocks. Hamerstrom and Hamerstrom (1973:27) concluded that the sex and age composition of prairie chickens trapped during winter in Wisconsin was not representative of the population. In the present study, it was concluded that deviant sex ratios in the trapped population may have resulted from differences in feeding behavior between sexes and/or selectivity of trapping methods for certain sex and age groups.

Survival.—Of 946 prairie grouse trapped and marked from 1959 through 1960 and from 1963 through 1965, 119 (12.6 percent) were recaptured during subsequent years (Table 28). However, the rate of recapture was dependent partially on trap locations from year to year and the number of years a particular trap site was in use. It was also found that the range of some feeding flocks was often relatively limited. For example, distinct groups of sharptails were observed at trap sites 15 and 16 (Figure 23), which were approximately 0.5 miles apart. Many prairie grouse were found to winter in the same area year after year; thus, the rate of recapture depended to some extent on how many years a trap site was used (Appendix 6). The number of birds captured at a trap site one winter and recaptured at the same or a nearby site the following winter ranged from 13 to 40 percent.

Of 43 sharptails banded and released at trap site 14 during winter 1963-1964, 17 (40 percent) were recaptured the following winter. However, of 23 prairie chickens captured at trap site 13 in 1963-1964, only 3 (13 percent) were recaptured the following winter. The flock near trap site 13, however, failed to develop a regular feeding schedule during 1964-1965. Of 143 sharp-tailed grouse trapped at sites 14, 16, and 17 in 1963-1964, 35 (25 percent) were recaptured in 1964-1965. Five (12 percent) of 43 sharptails banded at trap site 14 in 1962-1963 were recaptured two years later. During 1964-1965, 184 sharp-tailed grouse were captured at trap sites, 14, 16, 18, 19, and 20. Of those, 39 (21 percent) were recaptured at the same sites in 1965-1966. Of 35 prairie chickens trapped and released at trap sites 18 and 19 in 1964-1965, 10 (29 percent) were recaptured in 1965-1966. Survival rates indicated by these recapture data should be considered minimal because some prairie grouse undoubtedly moved to different wintering areas after banding.

Numbers of prairie grouse banded and subsequently recovered dead are presented in Table 29. Of 1,077 prairie grouse banded, 41 (3.8 percent) were recovered dead. This included 23 sharp-tailed grouse and 5 prairie chickens reported shot by hunters, and 10 sharptails and 3 prairie chickens found dead from other causes.

Although data presented in Tables 28 and 29 were not considered sufficient to calculate life tables, an annual mortality rate of 69.4 percent was computed from data in Table 29 (Hickey 1952:10-11). However, survival information from banding data in this report pertained only to prairie grouse which had survived to their first winter if captured as juveniles or to subsequent winters if captured as adults. Thus, mortality of juveniles from hatching to approximately eight months of age could not be determined.

Frequencies of banded prairie grouse recovered dead by estimated age at death are presented in Table 30. Age was determined by assuming that birds captured as adults had hatched in June two summers prior to capture and that grouse captured as juveniles had hatched in June the previous summer. The limited data suggested that grouse on the study areas frequently survived more than 2 years but few birds exceeded 4 years of age.

Based on hunter band return data on sharp-tailed grouse banded in winter in South Dakota, Robel *et al.* (1972:95) estimated annual mortality at 79.5 and 70.6 percent respectively on two study areas. Hamerstrom

Table 25. Trapping effort and numbers of prairie grouse captured using baited walk-in pen traps during winters, 1965 and 1966.

	Trapping Effort		Number of Birds Captured					
			A.M.			P.M.		
Year	AM	PM	Total	Mean	Range	Total	Mean	Range
1965	92	109	359	3.9	0-19	517	4.7	0-18
1966	42	43	208	5.0	0-15	105	2.4	0-18
TOTALS	134	152	567	4.2	0-19	622	4.1	0-18

Table 26. Number of prairie grouse marked by method.

MARKER USED	NUMBER OF PRAIRIE GROUSE MARKED[1] 1959	1960	1961	1963	1964	1965	1966	Totals
				— SHARP-TAILED GROUSE —				
Aluminum leg band	57	192	51	49	138	199	50	736
Plastic back tag	52	147		2				201
Dye					93	107	2	202
Plastic bandettes							89	89
				— PRAIRIE CHICKEN —				
Aluminum leg band	96	107	10	23	10	63	19	328
Plastic back tag	87	83	2	2				174
Dye					6	25		31
Plastic bandettes							29	29
				— HYBRID —				
Aluminum leg band		6		1	1	4	1	13
Plastic back tag		3						3
Plastic bandettes							1	1

[1]All grouse were banded with aluminum leg bands when first captured; other markers were used in addition to aluminum leg bands and were sometimes applied on birds originally captured in previous years.

and Hamerstrom (1973) estimated annual mortality of a population of prairie chickens in Wisconsin to be 79 and 66 percent for two cohorts subjected to hunting. They estimated the annual mortality of cohorts not subjected to hunting to be 52 percent.

Numbers by sex in banded sharptails were compared to numbers by sex in sharptails bagged and reported by hunters to determine if mortality due to hunting was dependent on sex. Of 730 sharptails banded and released, 453 were males and 277 were females. Of 23 banded sharptails reported bagged by hunters, 10 were males and 13 were females. The above data was analyzed by chi-square and there was no significant dependency of mortality on sex ($P<0.05$).

Movements.—Movements of 61 sharptails, 23 prairie chickens, and one hybrid were observed. Some marked birds were observed more than once. Therefore, 100 observations were made on the 85 grouse. The following types of movements were identified: (1) winter trap sites to other winter trap sites within years; (2) winter trap sites to other locations within the same winter; (3) winter trap sites to spring locations; (4) spring display ground trap sites to other display grounds; (5) winter trap sites to summer locations; (6) nest sites to other locations during summer; (7) winter trap sites to fall locations; (8) spring display ground trap sites to fall locations; (9) brood sites to fall locations, and (10) winter trap sites to other winter trap sites during subsequent years. During win-

Table 27. Sex age of prairie grouse trapped and banded on the Loup County and Swan Lake study areas, 1959 through 1961, and on or near the Nebraska National Forest study area, 1963 through 1966.

NUMBERS OF GROUSE

Age	Species	Sex: Male	Female	Unknown	Total
ADULT	Sharptail	142	115	0	257
	Prairie chicken	105	20	0	125
	Hybrid	3	0	0	3
	Combined species	250	135	0	385
JUVENILE	Sharptail	279	146	4	429
	Prairie chicken	145	28	0	173
	Hybrid	7	3	0	10
	Combined species	431	177	4	612
UNKNOWN	Sharptail	32	16	2	50
	Prairie chicken	28	2	0	30
	Hybrid	0	0	0	0
	Combined species	60	18	2	80
TOTAL	Sharptail	453	277	6	736
	Prairie chicken	278	50	0	328
	Hybrid	10	3	0	13
	Combined species	741	330	6	1,077

Table 28. Years of banding and recapture for 119 prairie grouse recaptured during years subsequent to banding.

NUMBERS OF GROUSE

Year Banded	Total Banded	Year Recaptured 1960	1961	1963	1964	1965	1966	Totals
1959	153	2						2
1960	305		1					1
1961	61							
1963	73				20	6		26
1964	149					37	4	41
1965	266						49	49
1966	70							
TOTALS	1,077	2	1		20	43	53	119

ter trapping, individual grouse were often captured more than once at the same or a nearby trap. In some cases, more than one trap was used in an area within the range of one feeding flock. In such cases, the traps in one area were treated as a single trap site. Therefore, movements of one-half mile or less between winter traps or trap sites are not reported as movements. Movements of 40 grouse for which the direction and distance moved were known are presented in Figures 21, 22, 23 and 24. All movements are presented in Appendix 7.

A total of 23 movements made by 17 sharptails and 2 prairie chickens from one winter trap site to another the same winter were observed. Sharptails moved an average of 2.1 miles with a maximum of 3.7 miles and a minimum of 1.6 miles. The prairie chickens moved 2.4 miles each. Such movements were dependent on locations of trap sites and do not necessarily represent the nature of winter movements. Recaptures were commonly made at the same or a nearby trap. It was concluded that winter feeding flocks tended to remain in an area of a few square miles. This conclusion is supported by observations of feeding flocks on the Swan Lake and Loup County areas in 1959, 1960, and 1961. Areas used by feeding flocks on those areas were usually less than one mile in radius. Two sharptails and one prairie chicken found dead the same winter as trapped moved 0.3, 1.5 and 0.3 miles respectively. One of the sharptails was killed by a domestic cat. The cause of death of the other birds was unknown.

Movements from winter trap sites to locations in spring were observed for 14 sharptails, 10 prairie chickens and 1 hybrid. Six of the sharptails and six prairie chickens were observed on display grounds. The average distance moved was 1.4 miles for sharptails, with a maximum of 2 miles and a minimum of 1 mile; prairie chickens moved an average of 2.5 miles with a maximum of 3.5 miles and minimum of 0.1 mile. The hybrid was observed on a display ground 0.1 mile from the trap site. Five sharptails and three prairie chickens moved from the winter trap sites to locations the following spring other than display sites. The sharptails moved an average of 7.3 miles with a maximum of 30.3 miles and a minimum of 0.1 mile; the prairie chickens moved 4.0, 2.2, and 2.5 miles respectively. Three sharptails and one prairie chicken were found dead of unknown causes the spring following banding in winter. The latter had moved 0.1, 1.0, 0.5 and 1.0 miles respectively. One sharptail was found dead at the trap site the second spring after banding.

Kobriger (1965:788) found that sharptails in the Sand Hills moved an average of 0.9 miles from winter trap sites to spring dancing grounds and that most birds moved to the dancing ground nearest the site where they were banded. Henderson and Jackson (1965:10) found that sharptails in South Dakota moved less than one mile from wintering sites to dancing grounds in spring. Jackson (1967:38) reported that sharptails in South Dakota moved less than two miles from winter trap sites to dancing grounds.

Two marked grouse, a prairie chicken and a hybrid, were observed after moving from one display ground to another. Each bird moved 1.2 miles.

Three sharptails and one prairie chicken were found dead the summer following winter banding. Two of the sharptails drowned in a windmill tank. Causes of death of the remaining birds were not known. Movements of the sharptails were 1.5, 0.7, and 0.7 miles respectively. The prairie chicken had moved 1 mile.

One sharptail and two prairie chicken hens captured and marked on their nests were later observed. The sharptail hen was killed at the nest site by a predator. Both prairie chicken hens were observed with broods subsequent to marking (Figure 24). One hen was marked on June 1 and observed one-half mile northeast of the nest site on August 12. The other hen was marked on June 12 and observed with brood on July 29, August 3, 4, 18, 19, and 20. Movements were 1.2, 0.6, 0.3, 0.6, 0.3, and 0.1 miles respectively from the previous point of sighting. The maxi-

Table 29. Years of banding and recovery for 41 prairie grouse reported dead subsequent to banding.

NUMBERS OF GROUSE

Year Banded	Number Banded	Year Recovered 1959	1960	1961	1963	1964	1965	1966	Total Recoveries
1959	153	3							3
1960	305		8		1				9
1961	61			3		1			4
1963	73				6	2			8
1964	149					4	1	1	6
1965	266						6	2	8
1966	70							3	3
TOTALS	1,077	3	8	3	7	7	7	6	41

mum distance this hen was observed from her nest site was 1.2 miles.

Christenson (1971:36) used radio telemetry to determine movements of sharptails in North Dakota. He found that broods generally stayed within one mile of the nest site and that the weekly home range of broods varied from 20 to 130 acres. Robel *et al.* (1970:294-295) determined monthly ranges of greater prairie chickens in Kansas, using radio telemetry. Average ranges of females were 479, 473, and 326 acres during June, July, and August respectively. Corresponding mean daily movements were 423, 417, and 465 yards.

Movements were observed for 20 sharptails and 4 prairie chickens trapped and marked in winter and reported as bagged by hunters during a subsequent fall hunting season. Thirteen sharptails were taken the season following banding. Average movement was 6.4 miles, with a maximum of 44.0 miles and a minimum of 0.0 miles. Five sharptails were bagged the second season after banding. Their movements ranged from 0.0 to 12.0 miles, with an average of 5.0 miles. Two sharptails were bagged the fourth season following banding, with one moving 3.0 miles and the other 0.5 miles from the trap site. The four prairie chickens were taken the season following banding. Their movements were 15.0, 2.0, 0.4, and 0.4 miles. From these data, it was concluded that dispersal did not increase with time. The longest movement recorded during the study was by an adult female sharptail, banded in January 1966. It was bagged by a hunter 44 miles southwest of the trap site during October 1966.

Klett (1957:29) reported that 74 percent of the sharptails banded during winter in North Dakota and recovered from hunters during fall were shot within 1.5 miles of the trap site. Robel *et al.* (1972:95) reported movements of 576 sharp-tailed grouse banded during winter and shot during subsequent fall hunting seasons in South Dakota. Approximately 42 percent of recoveries were within 0.5 miles of the banding site. However, recoveries 20 miles or more from the site where banded were not uncommon.

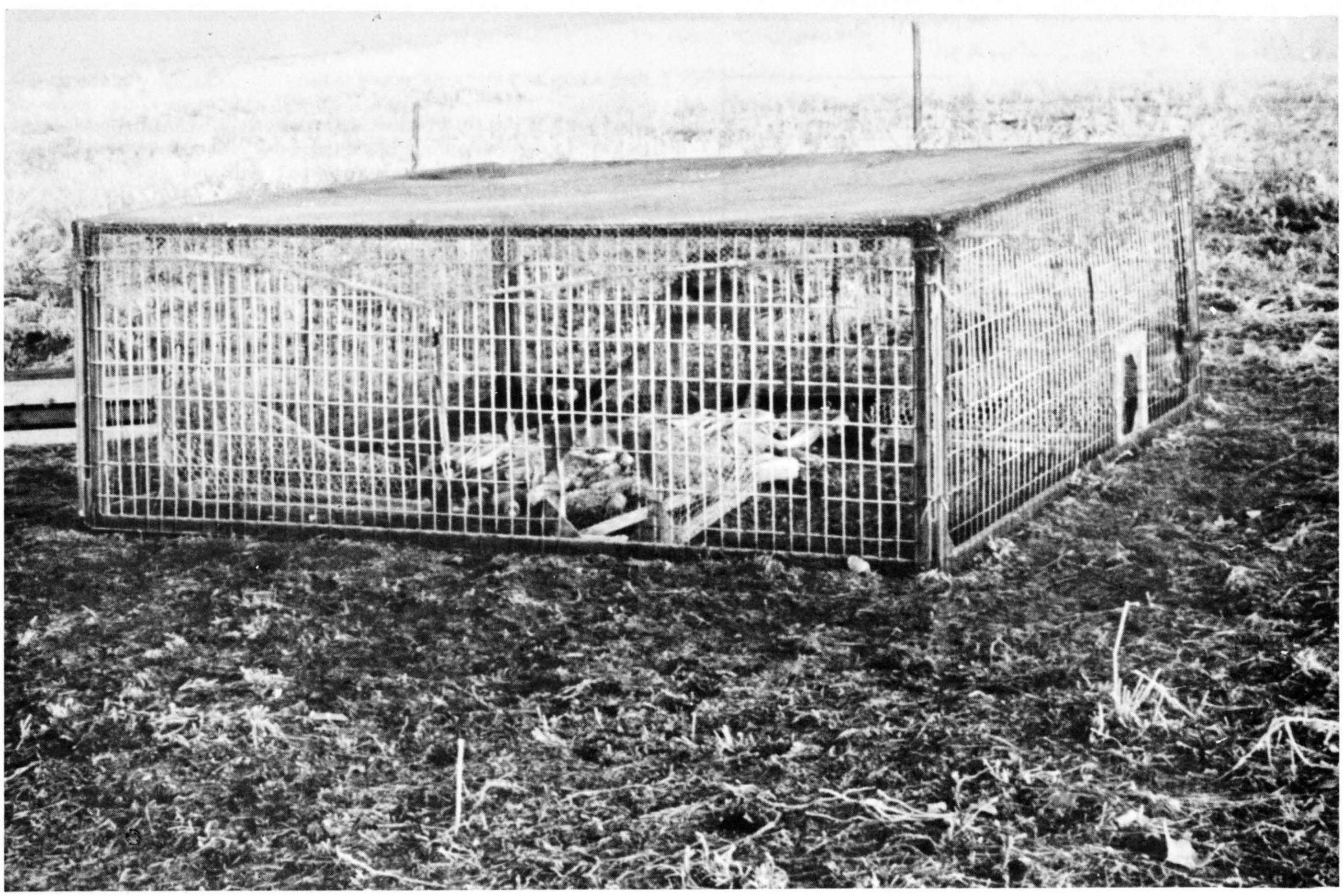
Independent effects of sex and age on movements of 20 sharptails (7 males and 13 females) were tested. Mean movement was 1.3 miles and 8.1 miles for males and females respectively. However, difference between means was not significant ($P<0.05$). Of the 20 sharptails, 19 were of known age and included 11 trapped as juveniles and 8 trapped as adults. Mean movement for the juveniles was 4.9 miles and 6.9 miles for the adults. The latter difference was also not significant ($P<0.05$).

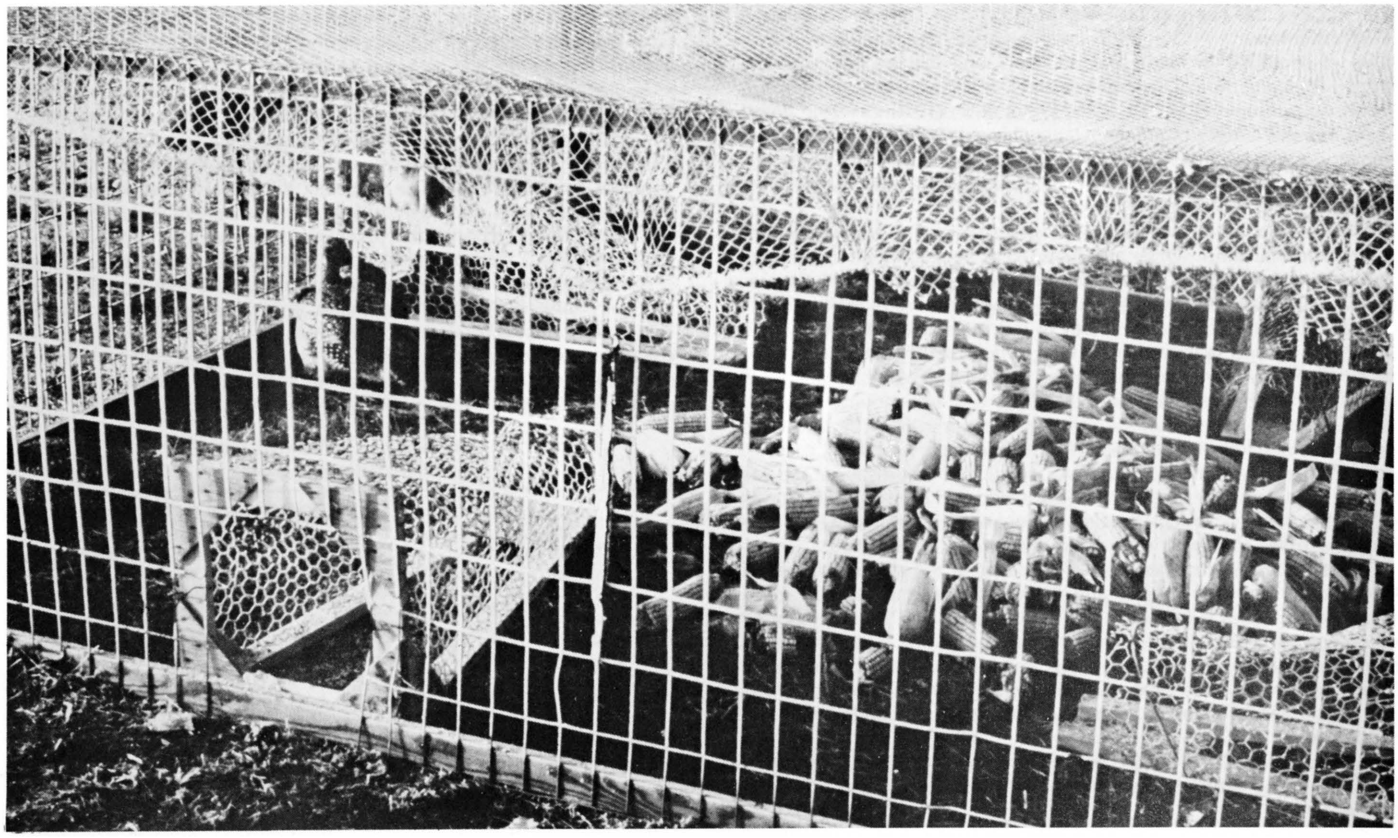
Although the above tests showed no statistical significance between mean movements of different sex and age groups, the power of the tests may not have been adequate to detect differences present because of small sample sizes and high variance in movement distances. Robel *et al.* (1972:95-97) reported that juvenile female sharptails had significantly greater ($P<0.01$) dispersal tendencies from winter to fall than all other sex and age groups on one study area. In addition, females moved significantly farther ($P<0.01$) than males on another study area. Copelin (1963:46), studying lesser prairie chickens in Oklahoma, concluded that dispersal was greatest during the first year of life and that hens usually moved farther than cocks. Hamerstrom and Hamerstrom (1973:27) reported that juvenile greater prairie chickens in Wisconsin moved more

Table 30. Frequencies of banded prairie grouse by estimated age at death.[1]

AGE AT DEATH	FREQUENCY OF DEATHS
0-1	7
1-2	16
2-3	14
3-4	2
4-5	1
5-6	1
TOTAL	41

[1]Method of estimating age described in text.





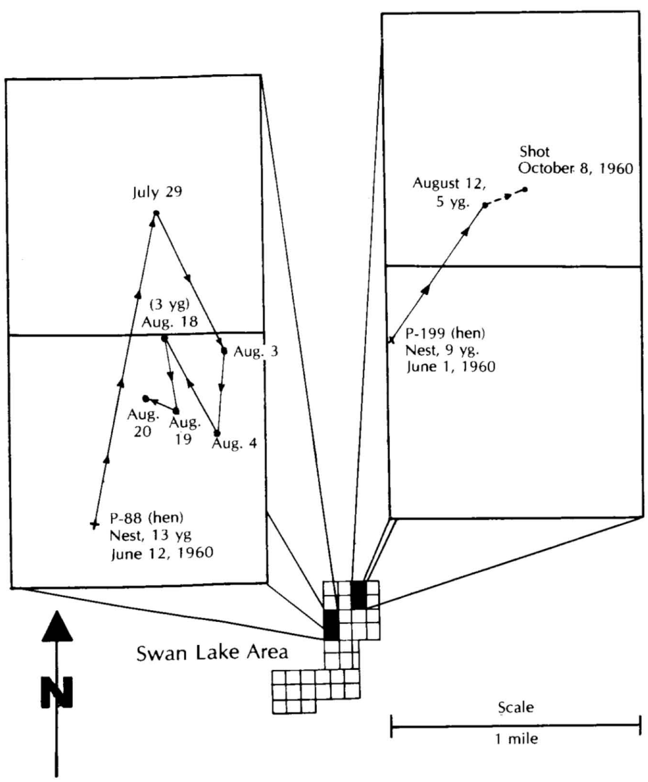


Figure 24. Movements of two prairie chickens trapped and marked at their nests on the Swan Lake Area, 1960.

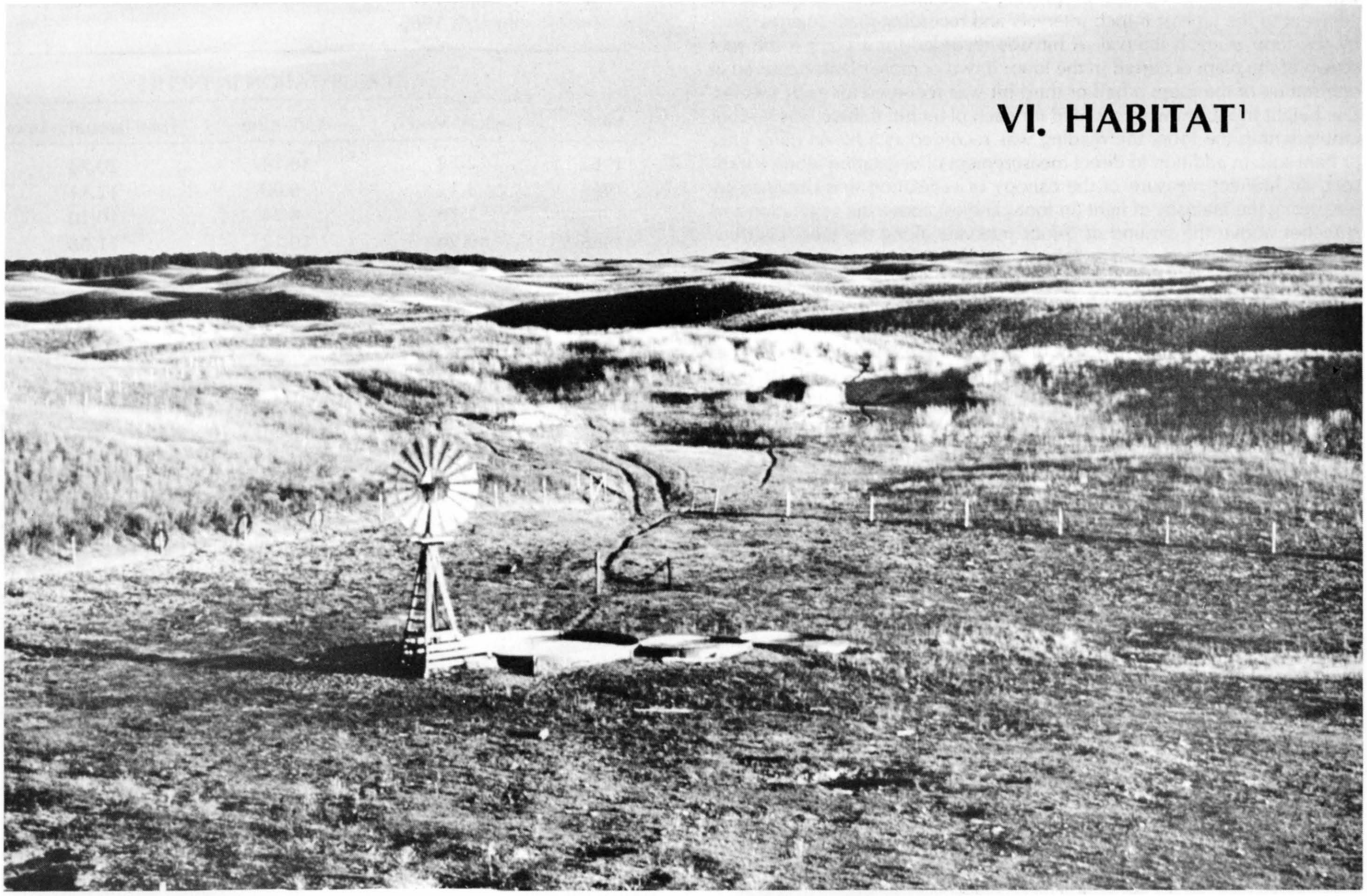
than adults and that hens moved farther than cocks. They attributed differences in movements between sex and age groups to the degree of attachment to display grounds, with adult males having the greatest attachment to booming grounds and being the most conservative in movement. Such an explanation is consistent with findings of the present study and other studies cited.

Three sharptails trapped and marked on display grounds were reported bagged by hunters the following fall. These birds were shot 0.6, 0.8, and 0.0 miles from the location where they were marked and released.

One female prairie chicken which had been trapped and marked on the nest and observed with a brood in late summer was reported bagged by a hunter that fall in the same area where she was observed with the brood. She had moved 0.5 miles from the nest.

Six sharptails trapped and marked in winter were recaptured during subsequent winters at different trap sites. Distance moved ranged from 2.0 to 8.0 miles with a mean of 3.2 miles. However, most recaptures were made at the same trap site suggesting that individual prairie grouse in the Sand Hills tend to winter in the same areas year after year.

Results of the present study and those of other studies citied suggest that although prairie grouse are capable of extended movements, most birds are relatively sedentary, ranging less than 3.0 miles during a year. There was no evidence that dispersal of individual birds increased with time. Both males and females seemed to be attached to a particular area with males showing a strong attachment for a particular display site.



VI. HABITAT[1]

Methods

Habitat used by sharp-tailed grouse on the Bessey area was studied from 1963 through 1966 and from 1968 through 1970. Habitat was classified as used for courtship, nesting, brooding, loafing, feeding, and roosting. Courtship habitat consisted of spring courtship or dancing grounds. Nesting habitat included sites where occupied or unoccupied nests were located, while brooding sites referred to locations where broods were observed. Loafing, feeding, and roosting habitat corresponded to sites used by adult sharptails for those activities. During 1963 through 1966, characteristics of habitat preferred by sharp-tailed grouse for each activity category were studied. Additional research was conducted on characteristics of courtship grounds during 1968 through 1970.

Habitat preference was investigated during 1963 through 1966 by: (1) measurement of habitat available on the study area; (2) measurement of habitat used by grouse for each activity, and (3) comparison of habitat used to habitat available.

Habitat available on the Bessey area was described by measuring the topography, microclimate, and vegetation of representative sites. Topography characteristic of the study area was determined by finding the relative proportion of the study area in ridge, valley, north slope, and south slope. This was accomplished by random selection of 200 points on aerial photos of the study area, and classifying each point into a topographic category. The microclimate characteristic of each of four topographic sites was measured during June, July, and August of 1965. Sampling stations were located on a ridge top, the adjacent valley to the south, and the north and south facing slopes of the valley. Stations on slopes were placed near the mid-point of each slope. Temperature and relative humidity were measured with Bendix recording hygrothermographs, placed in shelters on the ground at each sampling station. Hygrothermographs were serviced weekly to replace charts, and instruments were rotated between sampling stations to minimize instrument bias. Accuracy of each instrument was checked weekly, using a Bendix hand-aspirated psychrometer and a thermometer. Evaporation rates were measured with Livingston atmometers placed approximately 24 inches above the soil surface. Atmometers were serviced at approximately three-day intervals, and the amount of water added was recorded. Wind was measured with Bendix totalizing anemometers, placed approximately 24 inches above ground. Because only two anemometers were available, one was placed at the ridge-top station and the other was rotated between the other locations at five-day intervals. All measurements were expressed as a percentage of the ridge-top measurement. Vegetation characteristics of the study area were estimated by sampling at each of 20 control sites each month, June through August, in 1963.

Habitat used by sharp-tailed grouse was measured during 1963 through 1966. Topography and vegetation were measured at each activity site as soon as possible after the activity was observed to minimize the effects of changes in vegetation resulting from seasonal growth. However, since nests were usually located one to several weeks after initiation of nesting, some changes in vegetation had undoubtedly occurred between nest initiation and measurement.

Most activity sites studied were located on the Bessey area. However, difficulty in finding some types of activity sites, particularly nesting, required that sites located near the study area on the forest or on private rangeland also be included in the study.

Vegetation at control and activity sites was measured from 1963 through 1966, with a combination of quadrat and line transect methods. The transect technique was adapted from that described by Parker and Harris (1959) and the U.S. Forest Service (1954). At each control and activity site, a 50-foot steel tape was stretched across the ground with the center of the tape at the control or activity site. The tape was placed approximately parallel to the prevailing topographic contour. Vegetation

[1]Results in this section are based to a large extent on data gathered by Walker (1966) and Twedt (1974).

was sampled along the tape by placing a 3/4-inch loop on the ground adjacent to the tape at 6-inch intervals and recording plant species "hit" by the loop at each interval. A hit was recorded for a plant if the root crown of the plant occurred in the loop; if two or more plants occurred in one setting of the loop, a half or third hit was recorded for each species. The height in inches was recorded for each plant hit. If there was no root crown within the loop, the reading was recorded as a hit on plant litter or bare soil. In addition to direct measurement of vegetation along a transect, an indirect measure of the canopy of vegetation was obtained by measuring the intensity of light (in foot-candles) above the vegetation and 4 inches above the ground at 5-foot intervals along the tape. Light intensity was measured with a Sekonic Model S photographic exposure meter. The percent light intercepted by the vegetation was then determined for each of the 10 readings. A set of readings along the tape transect was referred to as a "transect sample". With exception of control sites, which were sampled monthly, only one sample was taken at each site.

Direct measurements of vegetation from each transect sample were summarized by summing hits and computing mean heights for each growth category (current and residual), and within growth categories by species, and life-form. Current growth consisted of vegetative growth that occurred during the season when the measurement was made, while residual growth referred to standing vegetation from previous seasons. Life-form categories used were (1) grass or grasslike, (2) forb, and (3) shrub or tree (woody cover). A forage density index was calculated for each transect sample by summing hits on plants classed as forage species (U.S. Soil Conservation Service 1958). The mean of percent light intercepted readings was also calculated for each sample.

Vegetation was also measured within a quadrat at each control and activity size. The quadrat was 100 feet by 100 feet and was centered on the site with one side approximately parallel to the transect. Within the quadrat at each site the percent dry weight of each plant species present was estimated visually. The percent range condition of the site was determined using dry-weight estimates by a method described by Dyksterhuis (1949). With this method, range condition is computed on the relative dry weight of each species and the response of each species to grazing. In general, plant species characteristic of the climax vegetation of a site are more desirable for forage than plants of early successional stages. Desirable plant species or "decreasers" decrease under grazing, while less desirable species or "increasers" increase in response to grazing. Plants which have no value as forage are referred to as "undesirables". Therefore, lightly grazed or unused pastures are normally at a later stage in succession and have a higher range condition than pastures which have a history of more intense livestock use.

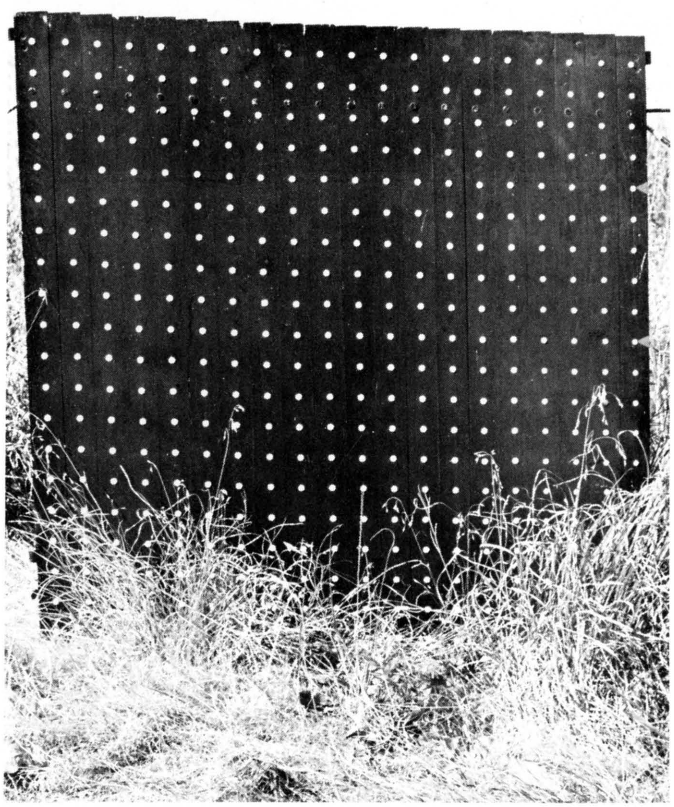


Table 31. Precipitation on the Bessey area for selected periods, 1962 through 1966.

	PRECIPITATION IN INCHES		
Year	January-March	April-June	Total (January-June)
1962	2.59	18.14	20.73
1963	3.11	9.00	12.11
1964	1.76	8.34	10.10
1965	0.96	10.12	11.08
1966	1.65	6.76	8.41
Long-term Average	2.32	8.64	10.96

Transect and quadrat measurements of vegetation at nest sites were supplemented by a list of plant species occurring in the canopy of each nest.

Characteristics of habitat preferred by sharp-tailed grouse for each activity category were investigated by comparing the habitat used for each activity with habitat available on the study area on the basis of (1) topography, (2) plant species composition from transect and quadrat measurements, (3) transect data on density, height and canopy of vegetation, and forage density, and (4) percent dry weight of woody vegetation and percent range condition from quadrat measurements.

The expected use of each topographic site category was determined from random sampling of aerial photographs. Observed use of topography was compared to expected use using chi-square to determine topographic site preferences.

Characteristics of vegetation preferred by grouse for each activity were also investigated by comparing activity sites to control sites. Comparisons of vegetation between sites were based on species composition along transects and measurements from transects and quadrats. Species composition was expressed in terms of the percent frequency of occurrence, percent composition, and importance index. Percent frequency of occurrence of a species referred to the percent of transect samples that the species occurred on. Percent composition of a species referred to the number of hits on that species as a percent of the hits on all species. The importance index of a species was computed by summing the percent frequency and percent composition. Statistical analyses of vegetation data were limited to measurement data.

To avoid bias resulting from seasonal growth of vegetation, statistical analyses were based on measurements which were least affected by such bias or by restricting the comparisons to specific time periods. Restriction of comparisons to specific time periods limited the activities which could be analyzed because control measurements were only made during June through August. The t-test was used for comparison of activity and control sites on the basis of individual measurement variables. Computation of t was based on the pooled or separate variance estimates depending on the homogeneity of variances.

Activity and control sites were also compared on the basis of vegetation measurements using multiple discriminant analysis. Objectives of discriminant analysis were (1) to test the hypothesis that activity sites were no different than control sites with respect to the variables measured and (2) to determine which variables, if any, contributed to discrimination between activity and control sites. Discriminant analysis was conducted within one-month time periods which limited analyses to (1) nest sites and control sites measured in June, (2) brood sites and control sites measured in July, and (3) loafing sites and control sites measured in July. Variables used in the analysis included: hits on residual grass, hits on all residual vegetation, hits on current grass growth, hits on all current growth, mean height of all growth, mean percent light intercepted, hits on bare soil, hits on litter, forage density index, percent dry weight of woody vegetation, and percent range condition. In addition to the original measurements for each variable, the squared values of each variable (second order terms) were also included to account for possible nonlinear relationships.

Discriminant analysis was performed by the BMD07M computer program (Dixon 1971:214a-214t). In each analysis the program performed a test of the equality of group means using a set of variables selected in a stepwise manner. Classification functions were generated based on the selected variables. These functions were then used to classify each sample into one of the two groups (activity or control) based on values of the variables associated with that sample. To test the discriminating power of the classification functions, samples from each activity group analyzed were randomly split into two subgroups, one of which was used to develop classification functions and the other to test the accuracy of the functions.

During the springs of 1969 and 1970 the vegetation and topography associated with each of eight sharptail courtship grounds were described. The courtship grounds studied were 1, 13, 23, 26, 27, 33, 34, and A26 (Figure 6), which were considered representative of the characteristics of grounds on the Bessey area. Six of the eight grounds were adjacent to windmills. Displaying male grouse were observed in order to determine the boundary of the display area and the approximate center of activity on each ground. Vegetation was sampled along straight transect lines which passed through the center of each ground. The number of transect lines on a ground depended on its size and shape. A primary transect was laid out along the longest axis of each ground. In addition, at least one secondary transect was laid out approximately perpendicular to the primary transect with the intersection at the center of the ground. One or two additional secondary transects were used on grounds that were considerably longer than they were wide. Each transect extended 30 meters beyond the edge of the display area into an area referred to as the display perimeter. Because of the predominantly northwest to southeast orientation of dune ridges and valleys, transects were usually oriented approximately northwest to southeast and northeast to southwest. Vegetation was sampled at 5-meter intervals along transects within the display area and at 10-meter intervals along transects within the display perimeter.

A photographic technique similar to methods described by Kobriger (1965) and Jones (1968) was used to sample vegetation on courtship grounds in this part of the study. A sample consisted of a strip of vegetation 0.1 meters in width photographed against a 1-meter by 1-meter flat black surface called a "cover-board" (Figure 25). The cover-board consisted of 20 vertical strips of plywood, 5 centimeters wide and 1 meter long joined tongue-and-groove to allow it to conform to a slope. White reference dots (thumbtacks) were placed on the board in a grid with rows and columns spaced 5 centimeters apart. In order to photograph only the vegetation within 0.1 meter of the cover-board, a piece of sheet metal was used to flatten other vegetation. In some cases, where large clumps of grasses or shrubs could not be flattened, vegetation was removed. Photographs were taken with a hand-held 35 mm single-lens reflex camera using Ektachrome color transparency film. The number of samples (photographs) at each courtship ground varied with the number and lengths of transects. The color transparency of each sample was projected on a screen and the location of each reference dot obscured or "hit" by vegetation was recorded. Values calculated for each sample included the total number of hits, number of vertical dot columns with hits (columns hit), and the means of the highest hits in each column (average column height).

Topography within a 210-meter radius of the center of each courtship ground was measured along the primary and one secondary transect line. Vertical changes in elevation from the center of each ground were

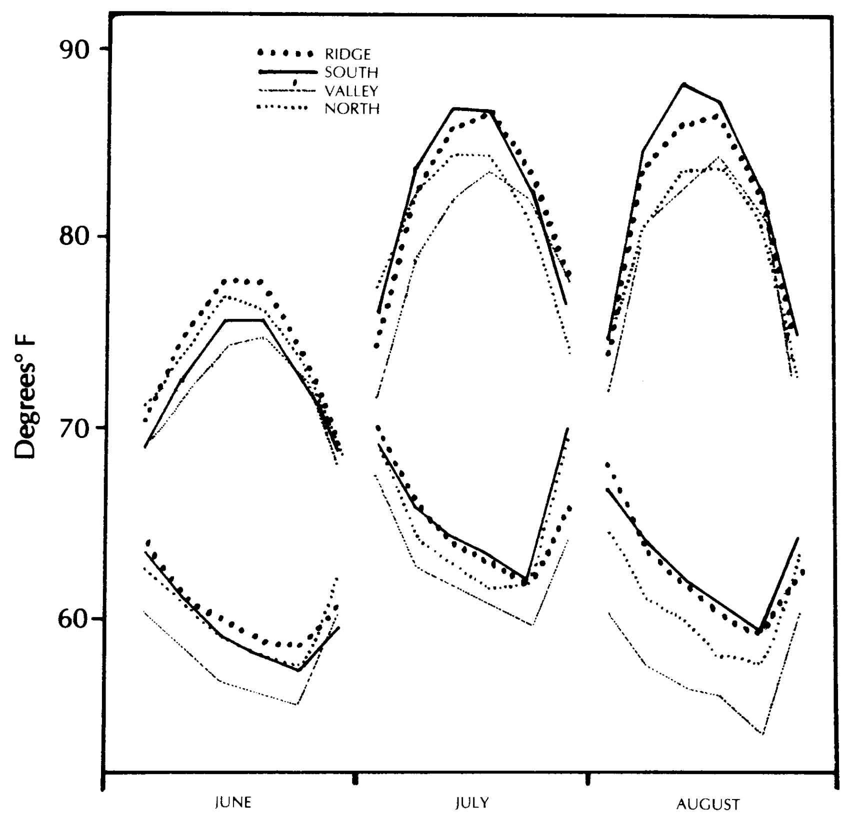


Figure 26. Summary of monthly temperature means at 2-hour intervals at four climatological stations. Upper series of four lines indicate time period between 10:00 A.M. and 8:00 P.M. Lower series of lines are for the time period occurring from 10:00 P.M. until 8:00 A.M.

measured along transect lines at 15-meter intervals to a distance of 210 meters from ground center. Thus, 56 elevation readings were taken at each courtship ground (14 in each of four directions).

Vegetation data from photographic sampling on courtship grounds during 1969 and 1970 were analyzed using the multiple linear regression procedure of SPSS (Nie, *et al.* 1970:174-195). Data resulting from measurement of topography at courtship grounds during 1969 and 1970 were subjected to linear regression analysis using OMNITAB (Chamberlain and Jowett 1970).

Results and Discussion

Climatological factors.—Precipitation is an important factor influencing growth of vegetation in the Sand Hills. The normal annual precipitation at the weather station on the Forest was 19.89 inches, based on the period 1931 through 1960, (U.S. Department of Commerce 1966). The primary period of vegetation growth is during spring and early summer. Precipitation data recorded at the Forest from January through June for the years 1962 through 1966 are presented in Table 31. Precipitation during January through June deviated from 89.1 percent above (1962) to 23.3 percent below (1966) the long-term average.

Comparative data on temperature, wind, relative humidity, and evaporation on four topographic sites for the months of June, July, and August, 1965, are presented in Figures 26 through 29. The highest average temperature and the greatest daily temperature ranges occurred during August (Figure 26). During July and August average temperature readings were higher on the ridge and south slope than on the valley floor or north slope. Throughout the summer the valley site remained coolest of the four sites. During August, maximum temperatures on the north-facing and valley site were similar, averaging 2 to 4 degrees F cooler than the ridge or south slope.

Summer winds in the Sand Hills are predominantly southerly. For this reason and because of the northwest and southeast orientation of the dunes and valleys on the Bessey area, wind velocities would be expected to be greatest on south slopes and ridge-tops, with north slopes and valley sites most protected. These relationships are confirmed by data presented in Figure 27. Average wind velocity was highest on the ridge-top, decreasing on the south slope, valley, and north slope in that order.

Mean relative humidity was lowest on the ridge-top and south slope (Figure 28). The mean minimum relative humidity was highest on the north slope throughout the summer.

Differences in evaporation between topographic sites were related to temperature, wind, and relative humidity (Figure 29). Mean evaporation rates were highest on the ridge-top and south slope where temperature and wind tended to be highest and relative humidity lowest. Evaporation rates were also measured in shrub stands on north and south slopes. Evaporation rates in shrub stands were less than half those of the ridge-top and south slope.

Available habitat.—The relative proportion of the Bessey area in each topographic site category (ridge-top, valley, north slope, and south slope) was determined by examination of points located at random on

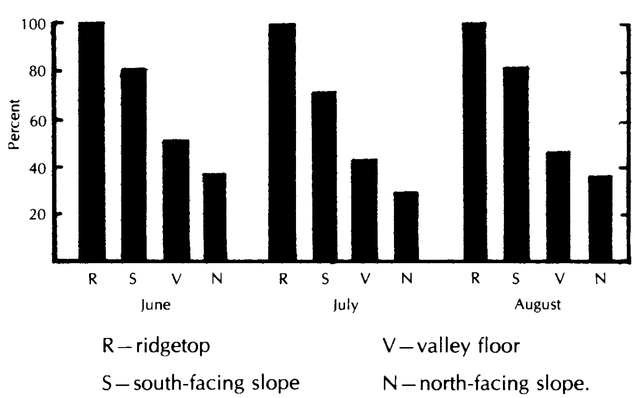


Figure 27. Relative wind movement at four climatological stations.

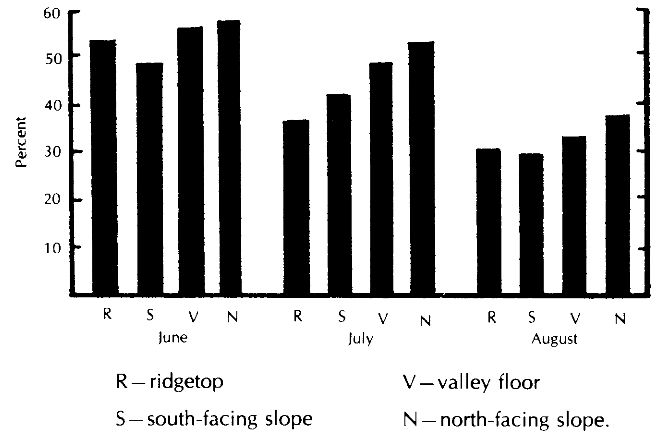


Figure 28. Mean monthly relative humidity minimum at four climatological stations.

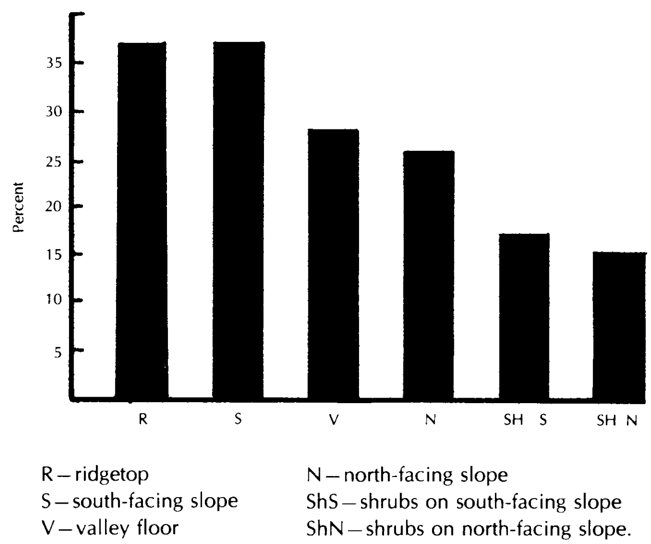


Figure 29. Daily evaporation means on several climatological stations.

aerial photos (Table 36). The data indicated that the area located at random was approximately 35 percent ridge-top, 38 percent valley, 11 percent north slope and 17 percent south slope. Control sites, used for analysis of vegetation were also selected randomly. Of the 20 sites, 6 were on ridge-tops, 7 in valleys, 5 on north slopes, and 2 on south slopes. The chi-square test was used to compare frequencies of topographic distribution of control sites to the expected distribution based on random sampling on photographs. Deviations of observed from expected values were not significant ($P<0.05$) suggesting that the relative proportions of area in each topographic site category were in agreement in the two sources of data. Range sites on the study area corresponded to topography. Ridge-tops and steep slopes were usually classified as choppy sands sites. Gentle slopes and most valleys were sands sites, while sandy sites occurred in restricted areas in larger valleys.

Characteristics of vegetation for each topographic site were determined from data gathered on transect and quadrat samples at control sites during summer (June, July and August) 1963. Important plant species encountered as residual growth, and current growth along transects are presented in Tables 32 and 33 respectively. The 10 most important species having indexes of 20 or more are listed for each topographic site category.

Species encountered as residual growth were similar on the four range sites, consisting primarily of grasses (Table 32). Little bluestem *(Andropogon scoparius),* prairie sandreed *(Calamovilfa longifolia),* sand

Table 32. Important plant species encountered as residual growth on control transects on each of four topographic sites during summer on the Bessey area.

Species	PERCENT Occurrence	Composition	Importance Index
RIDGE			
Andropogon scoparius	88.9	57.1	146.0
Calamovilfa longifolia	33.3	10.7	44.0
Sporobolus cryptandrus	22.2	6.0	28.2
Eragrostis trichodes	16.7	8.3	25.0
Carex spp.	16.7	4.8	21.5
VALLEY			
Andropogon scoparius	38.1	25.4	63.5
Sporobolus cryptandrus	23.8	11.9	35.7
Calamovilfa longifolia	19.0	10.2	29.2
Amorpha canescens	14.3	11.9	26.2
Eragrostis trichodes	14.3	6.8	21.1
NORTH SLOPE			
Andropogon scoparius	53.3	39.4	92.7
Calamovilfa longifolia	40.0	15.2	55.2
Sporobolus cryptandrus	33.3	9.1	42.4
Eragrostis trichodes	26.7	12.1	38.8
Panicum virgatum	20.0	7.6	27.6
SOUTH SLOPE			
Andropogon hallii	83.3	41.7	125.0
Andropogon scoparius	66.7	16.7	83.4
Rosa spp.	50.0	16.7	66.7
Calamovilfa longifolia	33.3	12.5	45.8
Eragrostis trichodes	16.7	4.2	20.9
Panicum scribnerianum	16.7	4.2	20.9
Stipa comata	16.7	4.2	20.9

dropseed *(Sporobolus cryptandrus)*, and sand lovegrass *(Eragrostis trichodes)* ranked most important on ridge-top, valley, and north slope sites while sand bluestem *(Andropogon hallii)*, little bluestem, rose *(Rosa spp.)*, and prairie sandreed dominated south slopes. Grasses or grass-like plants also dominated current growth on control sites on all topographic sites. The abundant sedge *(Carex spp.)* was the most important current growth in all four site categories. Species encountered as residual growth were also important as current growth. In addition, Junegrass *(Koeleria cristata)*, needle and thread *(Stipa comata)* and Scribner panic *(Panicum scribnerianum)* were also important. Western ragweed *(Ambrosia psilostachya)* was important on valley and south slope sites. South slopes differed from other sites in the greater importance of sand bluestem.

Means of measurement variables for each topographic site category from transect and quadrat samples at control sites are presented in Tables 34 and 35. Means of selected measurement variables within topographic sites were compared using Duncan's Multiple Range Test. Variables selected were total hits on residual growth, total hits on current growth, mean height of current growth, hits on all growth, height of all growth, mean percent light intercepted, hits on litter, hits on bare soil, forage density index, percent range condition, and percent dry weight of woody vegetation. Tests were based on July measurements. Of the above mea-

Table 33. Important plant species encountered as current season growth on control transects on each of four topographic sites during summer on the Bessey area.

Species	PERCENT Occurrence	Composition	Importance Index
RIDGE			
Carex spp.	100.0	19.3	119.3
Andropogon scoparius	100.0	14.1	114.1
Calamovilfa longifolia	100.0	12.7	112.7
Sporobolus cryptandrus	83.3	7.1	90.4
Koeleria cristata	77.8	5.3	83.1
Andropogon hallii	66.7	3.2	69.9
Eragrostis trichodes	44.4	3.4	47.8
Panicum scribnerianum	44.4	2.2	46.6
Unknown grass	44.4	1.4	45.8
Bouteloua gracilis	22.2	6.7	28.9

(continued)

Table 33. (continued)

Species	PERCENT Occurrence	Composition	Importance Index
	VALLEY		
Carex spp.	100.0	34.6	134.6
Calamovilfa longifolia	95.2	7.8	103.0
Sporobolus cryptandrus	85.7	12.1	97.8
Panicum scribnerianum	71.4	3.8	75.2
Stipa comata	42.9	8.9	51.8
Ambrosia psilostachya	47.6	2.6	50.2
Eragrostis trichodes	42.9	6.9	49.8
Andropogon scoparius	42.9	3.6	46.5
Andropogon hallii	33.3	2.0	35.3
Plantago purshii	33.3	1.9	35.2
	NORTH SLOPE		
Carex spp.	100.0	18.1	118.1
Calamovilfa longifolia	93.3	13.8	107.1
Andropogon scoparius	73.3	14.1	87.4
Eragrostis trichodes	66.7	9.0	75.7
Sporobolus cryptandrus	66.7	3.9	70.6
Panicum scribnerianum	60.0	3.5	63.5
Andropogon hallii	60.0	3.1	63.1
Stipa comata	53.3	8.1	61.4
Koeleria cristata	53.3	2.6	55.9
Rosa spp.	46.7	1.8	48.5
	SOUTH SLOPE		
Carex spp.	100.0	34.8	134.8
Andropogon hallii	100.0	20.6	120.6
Eragrostis trichodes	83.3	7.4	90.7
Andropogon scoparius	83.3	5.9	89.2
Calamovilfa longifolia	83.3	5.4	88.7
Sporobolus cryptandrus	83.3	5.4	88.7
Ambrosia psilostachya	66.7	2.5	69.2
Stipa comata	50.0	9.8	59.8
Rosa spp.	50.0	3.9	53.9
Panicum scribnerianum	33.3	1.5	34.8

surements, only two differed significantly between topographic sites. The mean height of current growth was significantly greater on north and south slopes than on ridges, and mean height of all growth was greater on north slopes than on ridges.

Differences in vegetation between topographic sites is to be expected in grazed pastures in the Sand Hills. Such differences result from differences in soil conditions and differential use by livestock. Because valleys are more accessible, they are usually grazed more intensely than slopes and ridges which often results in lower forage production and range condition in valley sites. Vegetation data from transects on control sites indicated that height of vegetation was greatest on slopes and least on ridge-tops. However, topographic sites appeared similar with respect to other variables. Sample sizes within topographic site categories were low, particularly for the south slope (n = 2), which limited the power of tests and the ability to detect a real difference if it occurred. The fact that grazing was generally well-regulated, minimizing over-use, may have contributed to the apparent similarity of vegetation on different topographic sites on the Forest. Finally, differences in vegetation on different topographic sites may have existed which were not measured by the variables analyzed.

Habitat used by sharp-tailed grouse.—Characteristics of 251 sites where sharp-tailed grouse were observed displaying, nesting, brooding, loafing, feeding, or roosting were examined. The numbers of sites by activity and month are presented in Appendix 8. Most measurements of activity sites were made during spring and summer.

Topography.—Use of topographic sites for each activity was compared to sites available to determine the importance of topography in habitat selection. Frequencies of sharp-tailed grouse activity sites by topographic site category are presented in Table 41. Approximate proportions of the Bessey area in each category are entered under "random" in Table 36 and were used to compute expected frequencies for each activity category. Expected values were then compared to observed values by chi-square (Table 37). Actual use of topographic sites deviated significantly from expected use in each activity ($P<0.05$) with the nature of the deviation differing between activities.

Courtship sites occurred more frequently than expected on ridge-top exposures. Two-thirds of the 39 courtship sites studied were located on ridge-tops. Ridges used for courtship were usually low to medium height with gentle slopes. Examination of these data suggested that ridge-tops were preferred for courtship sites. Although only 11 percent of the study area consisted of north slope, 71 percent of all nest sites occurred there. Most of the remaining nests (24 percent) were found on south facing slopes. Brooding, loafing, and roosting sites also occurred more frequently than expected on north slopes, while ridges were apparently avoided. Feeding grouse were observed more often than expected on south slopes and in valleys.

Intensive study of eight courtship grounds in 1968 through 1970 produced additional data on the relationship of courtship sites to topography. The vertical change in elevation from the center of each ground was measured along four transect lines oriented approximately northwest-southeast and northeast-southwest. A total of 14 readings were taken at 15-meter intervals in each direction. Data for the eight courtship grounds and the four directions were pooled and the mean elevation change calculated for each 15-meter interval. The means and their 95 percent confidence intervals were plotted as a function of distance from the center of the ground in Figure 30. These results complement previous data, which indicated that the center of a ground tends to be higher in elevation than the surrounding area out to a distance of approximately 90 meters where the average elevation change was −2.76 meters (−9.06 feet). Elevation changes from 15 meters to 90 meters from the center of the ground were regressed on distance from ground center. The slope of the regression line was negative and differed significantly from 0.0 ($P<0.05$) confirming the conclusion previously stated that courtship grounds studied were elevated above the surrounding terrain.

The role of topography in selection of courtship sites by prairie grouse has been addressed by several investigators. Marshall and Jensen (1937:96) reported that all sharptail courtship grounds they studied in Utah were on the tops of ridges or knolls. Baumgartner (1939:487) re-

Table 34. Measurements of vegetation on transects on control sites on the Bessey area made during June, July and August, 1963.

Variable	Combined Sites (20)[1] N[1]	Mean ± S.E.	Ridge (6) N	Mean ± S.E.	Valley (7) N	Mean ± S.E.	North Slope (5) N	Mean ± S.E.	South Slope (2) N	Mean±S.E.
Hits on residual growth:										
Grass	60	3.40±0.40	18	4.56±0.80	21	2.10±0.44	15	3.87±0.96	6	3.33±0.99
Forb	60	0.12±0.05	18	0.06±0.06	21	0.29±0.12	15	0.00 –	6	0.00 –
Shrub	60	0.30±0.09	18	0.06±0.06	21	0.43±0.21	15	0.27±0.15	6	0.67±0.33
Total Mean	60	3.82±0.41	18	4.67±0.81	21	2.81±0.54	15	4.13±0.99	6	4.00±0.86
Height[2] of residual growth:										
Grass	53	11.72±0.82	17	10.70±1.11	16	12.46±1.99	14	11.96±1.45	6	12.12±2.28
Forb	6	12.42±2.88	1	12.00 –	5	12.50±3.53	0	– –	0	– –
Shrub	11	8.64±1.40	1	5.00	4	7.75±0.99	3	13.00±4.36	3	6.67±0.88
Total	55	11.56±0.78	17	10.57±1.09	18	11.92±1.76	14	12.22±1.50	6	11.75±1.96
Hits on current growth:										
Grass	60	34.38±1.49	18	38.61±2.23	21	35.62±3.43	15	29.00±1.20	6	30.83±2.83
Forb	60	1.87±0.27	18	0.89±0.21	21	3.10±0.61	15	1.40±0.31	6	1.67±0.67
Shrub	60	1.37±0.24	18	0.50±0.12	21	1.38±0.50	15	2.33±0.45	6	1.50±0.72
Total Mean	60	37.62±1.44	18	40.00±2.27	21	40.10±3.31	15	32.73±1.23	6	34.00±2.76
Height[2] of current growth:										
Grass	60	6.82±0.27	18	5.39±0.41	21	6.62±0.46	15	8.19±0.34	6	8.32±0.55
Forb	43	6.22±0.68	11	4.80±1.24	17	7.02±1.03	11	6.73±1.67	4	5.33±1.51
Shrub	35	9.70±1.05	9	9.26±3.19	10	10.54±1.71	13	8.89±1.35	3	11.73±1.14
Total	60	6.88±0.27	18	5.42±0.42	21	6.79±0.48	15	8.20±0.34	6	8.30±0.64
Hits on all growth: Mean	60	41.38±1.38	18	44.67±1.85	21	42.91±3.11	15	36.67±1.71	6	38.00±3.43
Hits on litter	60	56.05±1.36	18	51.56±2.28	21	55.48±2.81	15	61.07±1.84	6	59.00±2.44
Hits on bare soil	60	5.73±0.75	18	8.00±1.63	21	4.38±1.05	15	5.00±1.59	6	5.50±1.06
Height[2] of all growth: Mean	60	7.31±0.28	18	5.97±0.50	21	7.16±0.52	15	8.62±0.35	6	8.62±0.40
Percent light intercepted	60	21.68±1.61	18	15.80±2.12	21	20.32±3.06	15	27.42±3.21	6	29.73±2.60
Forage density index	60	32.92±1.30	18	36.50±1.98	21	33.48±3.01	15	28.60±1.33	6	31.00±1.83

[1]Number in parentheses refers to number of sites; each site was sampled once each month; therefore N refers to the number of samples on which the respective mean was based. In the case of height, means were based only on samples where plants were recorded.

[2]In inches.

Table 35. Percent weight of woody vegetation and percent range condition based on data from quadrats[1] at control sites during July, 1963.

Topographic Site	N	VARIABLE Percent Weight of Woody Vegetation	Percent Range Condition
		—Mean±S.E.—	—Mean±S.E.—
Ridge	6	3.67±1.02	80.33±2.94
Valley	7	7.14±2.49	73.57±8.32
North Slope	5	13.60±7.70	82.20±8.27
South Slope	2	8.00±7.00	88.00±7.00
Sites Combined	20	7.80±2.21	79.20±3.65

[1]Quadrats were 100 feet by 100 feet square placed with the approximate center at the control site.

ported similar findings for sharptails in Michigan and referred to courtship grounds as "dancing hills." Of 85 prairie chicken booming grounds studied in Michigan by Douglass (1942:172), 32 were on a knoll or hill and the remainder were on level ground. Also investigating prairie grouse in Michigan, Ammann (1957:138) stated: "Both species of prairie grouse show a decided preference for knolls, ridges, or slight elevations when selecting their dancing grounds." He also noted that where other sites were used for courtship, there were no suitable elevated sites available (Ammann 1957:139). In Colorado, Rogers (1969:23) reported that all plains sharp-tailed grouse dancing grounds studied were on ridges or knolls and that when other prominences were present they were at least 500 feet from the display site.

Ammann (1957:139) observed that the distribution of sharptail cocks on a courtship ground was related to the topography of the ground, with displaying cocks dispersed over a larger area on grounds located on level terrain than on grounds located on a small hill. This relationship was investigated in the present study by comparing the average areas of the territories held by individual cocks on two courtship grounds representing the extremes in topography. Courtship Ground 26 was located on a medium hill nearly symmetrical in shape, while Ground 33 was located along a low ridge (Figure 6). The area used for display on Ground 26 was approximately circular, covering about 0.32 acres. Ground 33 occupied about 0.75 acres and was approximately 270 feet long by 130 feet wide. A maximum of 15 cocks used Ground 26 in 1969, giving an average area of 923 square feet per bird. The 30 cocks on Ground 33 averaged 1,093 square feet per bird. Since numbers of males fluctuated on a ground from day to day, the densities of cocks were considered similar on the two grounds.

With exception of courtship, the relation of topography to habitat selection by prairie grouse is poorly documented, possibly because landform is not a dominant physical feature in most areas where prairie grouse have been intensively studied. In contrast, topography is a dominant physical feature of the Nebraska Sand Hills. Ammann (1957:58) observed that sharptails in Michigan attained maximum population levels on "moderately rolling" terrain. Brown (1966:5-6) found that the extent of "brokenness" of terrain was positively related to suitability of habitat for sharp-tailed grouse in Montana, when other factors were also considered. In the present study, microclimate was found to differ between topographic sites during the summer. Since prevailing summer winds in the Sand Hills are from the south, north slopes tend to be cooler and more mesic. Selection of north slopes for nesting, brooding, and loafing may have been influenced by microclimate. West (1961:4) suggested that humidity may be positively related to nest success of prairie grouse. North slopes could be expected to provide high humidity, as well as protection from dessicating wind and direct exposure to the sun at midday during summer.

Vegetation.—Important plant species encountered on vegetation transects at sharptail activity sites are listed in Tables 38 through 43; plant species recorded in the canopies of nest sites are presented in Table 44. Examination of data in Table 38 indicated that species encountered as residual growth on 39 courtship grounds were typical of those encountered on control sites. However, density of residual vegetation on courtship grounds was low compared to control sites (Table 32). Little bluestem, for example, occurred as residual growth on 88.9 percent of ridge-top control samples and on only 15.6 percent of courtship ground samples. Although data on current vegetation were not available from control sites for early spring for comparison with courtship ground data, forbs appeared to be more prevalent on courtship sites than would be expected on ridges in general.

Transect data indicated that residual vegetation at 41 nest sites (Table 39) was similar to north slope control sites but was present in higher densities than at the control sites (Table 32). Sand lovegrass, *(Eragrostis trichodes)* a preferred forage species characteristic of climax stands, was found in 26.7 percent of north slope control samples and in 46.3 percent of nest samples. Species recorded as current growth at nest sites were similar to those encountered on control sites. In addition to transect data, plant species dominating the canopies of 46 nests were recorded (Table 44). The growing seasons of canopy species were not specified. The species occurring most frequently in nest canopies were sand lovegrass, little bluestem, and prairie sandreed, which corresponded to transect data (Table 39). Plant species recorded at brooding, loafing, feeding, and roosting sites (Table 40 through 43) appeared similar to species recorded at control sites.

Frequencies of occurrence of shrub and tree species encountered on control and activity sites are presented in Table 45. Woody species occurring most frequently on control sites were rose, leadplant amorpha

Table 36. Frequencies of sharp-tailed grouse activity sites by topographic exposure category.

	Random[1]		ACTIVITY Display		Nesting		Brooding		Loafing		Feeding		Roosting	
Topographic Site	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Ridge	70	35.0	26	66.7	2	4.9	8	12.7	6	8.2	1	3.6	0	0.0
Valley	76	38.0	6	15.4	0	0.0	16	25.4	4	5.5	13	46.4	0	0.0
North Slope	21	10.5	2	5.1	29	70.7	27	42.9	48	65.8	3	10.7	4	57.1
South Slope	33	16.5	5	12.8	10	24.4	12	19.0	15	20.5	11	39.3	3	42.9
TOTALS	200	100.0	39	100.0	41	100.0	63	100.0	73	100.0	28	100.0	7	100.0

[1]Method of sampling explained in text.

Table 37. Chi-square analysis of topographic exposure data from sharp-tailed grouse activity sites.

Physiographic Exposure	ACTIVITY[1] Courtship	Nesting	Brooding	Loafing	Feeding
Ridge					
Observed	26	2	8	6	1
Expected[2]	13.65	14.35	22.05	25.55	9.80
Valley					
Observed	6	0	16	4	13
Expected	14.82	15.58	23.94	27.74	10.64
North Slope					
Observed	2	29	27	48	3
Expected	4.10	4.31	6.62	7.67	2.94
South Slope					
Observed	5	10	12	15	11
Expected	6.44	6.77	10.40	12.05	4.62
Chi-square[3]	17.81	169.42	74.65	248.25	17.23

[1]Roosting excluded because of inadequate sample size.

[2]Expected values based on proportions derived from random sampling on aerial photos.

[3]Chi-square (P = 0.05, with 3 degrees of freedom) = 7.81

(*Amorpha canescens*), Louisiana sagewort (*Artemisia ludoviciana*), small soapweed (*Yucca glauca*), sandcherry (*Prunus besseyi*), and inland ceanothus (*Ceanothus ovatus*). In general, occurrence of woody species was similar on activity and control sites.

Measurement data from transect and quadrat samples at activity sites are presented in Tables 46 through 49. Vegetation preferences of sharp-tailed grouse were investigated by comparing data from each activity to appropriate control site data.

Courtship sites sampled in April, May, and June were compared to control sites sampled in June on the basis of hits on all residual growth, mean height of residual growth, mean percent light intercepted, hits on bare soil, and percent range condition. Means of all variables compared were significantly less ($P<0.05$) on courtship sites than on control sites confirming field observations that courtship sites usually support shorter and less dense vegetation than found on surrounding terrain.

Additional data were obtained on structure and density of vegetation on courtship sites from analysis of cover-board photograph data from eight grounds on the Bessey area. Data from the eight grounds were pooled for analysis. The actively used portions of the grounds were compared with the ground perimeters on the basis of the means of total hits, columns hit, and average column height, using one-way analysis of variance. The three means were each significantly greater for the ground perimeters than for the active display areas ($P<0.05$). These results indicated that the area of active courtship display of sharp-tailed grouse

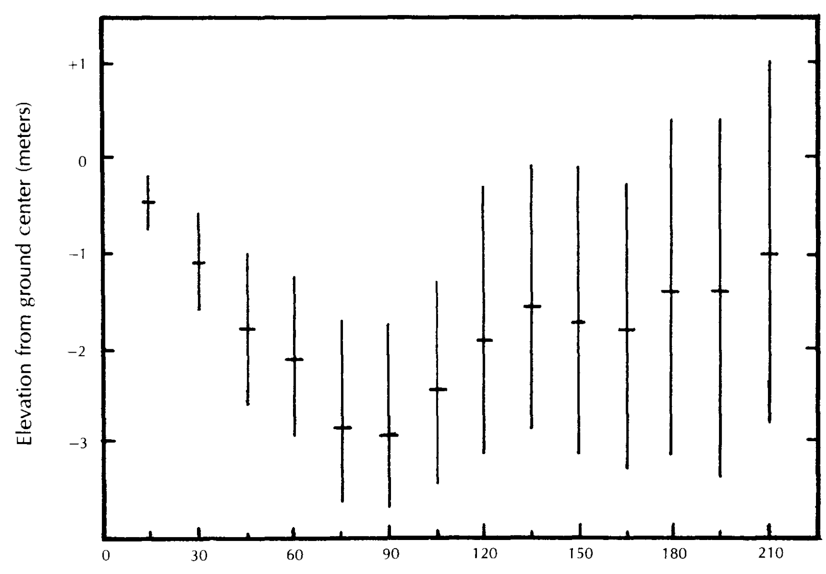


Figure 30. Dancing ground elevations at selected distances from ground center. All directions pooled. Mean elevations and 95 percent confidence intervals are indicated.

Table 38. Important plant species encountered on transects on 39 sharp-tailed grouse courtship grounds on or near the Bessey area.

Species	Percent Occurrence	Percent Composition	Importance Index
RESIDUAL GROWTH			
Calamovilfa longifolia	29.7	25.2	54.9
Ambrosia psilostachya	26.6	15.8	42.4
Andropogon scoparius	15.6	17.3	32.9
Sporobolus crytandrus	15.6	9.4	25.0
CURRENT GROWTH			
Carex spp.	78.1	18.5	96.6
Sporobolus cryptandrus	59.4	8.5	67.8
Unknown forbs	45.3	11.1	56.4
Bouteloua hirsuta	32.8	12.1	44.9
Calamovilfa longifolia	37.5	4.6	42.1
Ambrosia psilostachya	32.8	2.2	35.0
Plantago purshii	26.6	7.5	34.1
Festuca octoflora	25.0	4.9	29.9
Lepidium densiflorum	25.0	4.1	29.1
Koeleria cristata	26.6	1.6	28.2

males supported shorter and less dense vegetation than the area immediately surrounding the display area. However, interpretation of these results was complicated by the presence of a windmill and livestock watering tank within a few hundred feet of six of the eight grounds. Since use by cattle is concentrated around windmills, vegetation density in the vicinity of an established windmill generally bears a positive relationship to distance from the windmill. To test the hypothesis that vegetation height and density was positively related to the distance from the center of the courtship site independent of the effects of location of the windmill, data for each of the three variables (number of hits, columns hit, and average column height) were regressed on the second order polynomial of the distances of the sample from the approximate center of the courtship site and from the windmill. The regressions of numbers of hits and numbers of columns with hits were significant, while regression of average column height was not significant ($P<0.05$). Results of regression analyses of numbers of hits and numbers of columns with hits are presented in Table 50. Examination of the regression of numbers of hits indicated that first order terms of the independent variables (distance to ground center and distance to the windmill) were each positively and significantly related to vegetation density ($P<0.05$). The second order terms and interaction (distance to ground center x distance to windmill) were not significant, indicating that the relationships between independent variables and the dependent variable were essentially linear and independent. Both the first and second order terms of the independent variables were significantly related to the dependent variable (columns hit) while the interaction term was not significant ($P<0.05$). Examination of the regression coefficients indicated that columns hit per cover-board reading increased with increased distance from the center of the ground and windmill but that the rate of increase declined as indicated by negative b values for the second order terms.

Based on analysis of vegetation coverboard data it was concluded that sharp-tailed grouse selected courtship sites in areas in which the mean height and density of vegetation were lower than typical of the surrounding terrain. It was further concluded that, in the case of courtship grounds near windmills, the density of vegetation on a specific site increased with distance from the center of the display site independent of a general

Table 39. Important plant species encountered on transects at 41 sharp-tailed grouse nest sites on or near the Bessey area.

Species	Percent Occurrence	Percent Composition	Importance Index
RESIDUAL GROWTH			
Andropogon scoparius	70.7	41.1	111.8
Calamovilfa longifolia	51.2	15.3	66.5
Eragrostis trichodes	46.3	15.7	62.1
Sporobolus cryptandrus	34.2	10.9	45.1
CURRENT GROWTH			
Calamovilfa longifolia	87.8	12.9	100.7
Carex spp.	82.9	15.5	98.4
Andropogon scoparius	80.5	16.8	97.3
Eragrostis trichodes	75.6	12.7	88.3
Sporobolus cryptandrus	68.3	6.5	74.8
Andropogon hallii	46.3	4.3	50.7
Bouteloua hirsuta	43.9	5.0	48.9
Ambrosia psilostachya	43.9	3.1	47.0
Stipa comata	39.0	3.1	42.2
Panicum scribnerianum	24.4	2.0	26.3

Table 40. Important plant species encountered on transects at 63 sharp-tailed grouse brood sites on or near the Bessey area.

Species	Percent Occurrence	Percent Composition	Importance Index
RESIDUAL GROWTH			
Andropogon scoparius	31.8	30.3	62.0
Calamovilfa longifolia	19.1	13.2	32.2
Eragrostis trichodes	17.5	13.8	31.3
CURRENT GROWTH			
Carex spp.	90.5	20.0	110.5
Calamovilfa longifolia	69.8	10.5	80.4
Sporobolus cryptandrus	47.6	5.7	53.3
Andropogon scoparius	47.6	5.5	53.1
Stipa comata	39.7	9.0	48.7
Eragrostis trichodes	41.3	6.3	47.6
Ambrosia psilostachya	39.7	2.7	42.4
Panicum scribnerianum	38.1	3.1	41.2
Amorpha canescens	33.3	3.3	36.6
Panicum virgatum	30.2	2.3	32.5

increase in density of vegetation with increased distance from the windmill.

Of 36 courtship grounds located on or immediately adjacent to the Bessey area, 28 (78 percent) were located within 0.25 mile of a windmill (Figure 6). Most of the remaining grounds were located in areas of localized overuse by livestock. An exception was Ground 18 located in the natural area which was not grazed. However, Ground 18 was only used one spring during the study. Based on analysis of vegetation measurement data from courtship sites, it was concluded that concentration of livestock use on the study area created vegetative cover favorable for courtship behavior of sharp-tailed grouse. The most common causes of concentration of livestock on the study area were windmills and their associated water tanks which were distributed in a relatively uniform manner over the area at about one per square mile during the study (Figure 6). Therefore, it was also concluded that the common association of courtship grounds and windmills on the Bessey area was a result of the indirect effect of the placement of the windmill on vegetation through concentration of livestock.

The influence of height and density of vegetation on selection of courtship sites by prairie grouse has been reported by several authors. Marshall and Jensen (1937:96) referred to cover on courtship grounds as the "most exacting requirement" of the sharptail in Utah. All grounds they studied were in a weed-grass cover type which was apparently the shortest cover type available. Baumgartner (1939:487) stated, "all of the known dancing grounds in Michigan have been located on open knolls or grassy ridges with or without a sparse growth of small trees and shrubs." Douglass (1942:172) reported similar findings for prairie chickens in Michigan. Kobriger (1965:794-795) found that vegetation on courtship grounds was less dense than on the areas adjacent to grounds in the Nebraska Sand Hills.

The permanence of prairie grouse courtship grounds was discussed previously. On the Bessey area, an average of 22 percent of courtship sites used during a spring were not used the following spring (Table 8). Several groups of displaying sharptail cocks were observed to move from one site to another during the study.

Factors related to shifts in the locations of four courtship grounds were documented (refer to Figure 6). Ground 3 was located during spring 1962. Cocks were displaying on a long, low ridge north of Road 203. In late spring, 1964, conifer seedlings were planted in rows through the courtship site. Males were observed displaying among the seedlings the following two springs. However, the numbers of males using the site

Table 41. Important plant species encountered on transects at 73 sharp-tailed grouse loafing sites on or near the Bessey area.

Species	Percent Occurrence	Percent Composition	Importance Index
RESIDUAL GROWTH			
Andropogon scoparius	56.2	48.3	104.5
Eragrostis trichodes	28.8	10.4	39.2
Calamovilfa longifolia	16.4	5.7	22.1
CURRENT GROWTH			
Carex spp.	87.7	20.6	108.3
Andropogon scoparius	71.2	14.8	86.1
Calamovilfa longifolia	63.0	8.1	71.2
Eragrostis trichodes	61.6	8.7	70.3
Sporobolus cryptandrus	50.7	6.3	57.0
Stipa comata	42.5	5.1	47.6
Andropogon hallii	39.7	2.8	42.5
Panicum scribnerianum	37.0	3.8	40.8
Ambrosia psilostachya	37.0	2.2	39.2
Rosa spp.	34.3	2.1	36.3

Table 42. Important plant species encountered on transects at 28 sharp-tailed grouse feeding sites on or near the Bessey area.

Species	Percent Occurrence	Percent Composition	Importance Index
	RESIDUAL GROWTH		
Carex spp.	46.4	35.6	82.1
Sporobolus cryptandrus	39.3	7.3	46.6
Andropogon scoparius	21.4	7.6	29.0
Calamovilfa longifolia	21.4	5.3	26.7
Stipa comata	21.4	3.6	25.1
Panicum virgatum	17.9	3.6	21.5
Medicago sativa	10.7	9.2	20.0
	CURRENT GROWTH		
Panicum scribnerianum	57.1	10.9	68.1
Carex spp.	50.0	14.4	64.4
Sporobolus cryptandrus	46.4	11.1	57.6
Stipa comata	32.1	5.7	37.8
Andropogon scoparius	28.6	4.3	32.8
Calamovilfa longifolia	25.0	3.2	28.2
Eragrostis trichodes	25.0	3.2	28.2
Unknown forb	21.4	4.5	25.9
Ambrosia psilostachya	21.4	3.9	25.3
Andropogon hallii	17.9	2.4	20.3

decreased. In spring of 1967 and thereafter, the site was not used for display. However, Ground A26 was established during spring, 1967, and use continued to present (spring, 1974). Presumably, surviving males from Ground 3 in 1966 were among cocks establishing Ground A26 in 1967.

Ground 15 was located in spring, 1963, near an abandoned windmill site. The windmill had been moved approximately .25 miles west in 1962. In spring, 1964, males using Ground 15 were observed to shift location of display to a site near the new windmill (Ground 23). The shift apparently took place gradually with use alternating between sites during the transition. From spring, 1965, through spring, 1971, Ground 23 remained active, while display activity was no longer observed on Ground 15.

Ground 16 was found in the spring of 1963 near an abandoned windmill site. The windmill and water tank had been moved to a new location approximately .25 miles west the year before. Numbers of displaying males using Ground 16 declined in the spring of 1964. In spring, 1965, males were observed displaying near the relocated windmill (Ground 26) as well as Ground 16. From 1966 to present (spring, 1974), display activity was observed on Ground 26 while no activity was observed on Ground 16.

Ground 17 was first located in the spring of 1963 at an abandoned windmill site. The windmill and water tank had been moved to a new location approximately 0.5 miles northwest in 1961. Display activity was observed on the site each spring, from 1963 through 1966. In the fall of 1966, display activity was first noted near the new windmill site (Ground 33). The following spring all display activity had shifted to Ground 33, which has also remained active until present (spring 1974).

In the Sand Hills, continued overuse by livestock near windmills usually results in complete removal of vegetative cover, and in areas of

Table 43. Important plant species encountered on transects at 7 sharp-tailed grouse roosting sites on or near the Bessey area.

Species	Percent Occurrence	Percent Composition	Importance Index
	RESIDUAL GROWTH		
Andropogon scoparius	85.7	43.4	129.1
Eragrostis trichodes	71.4	17.0	88.4
Calamovilfa longifolia	42.9	13.2	56.1
Andropogon hallii	42.9	5.7	48.5
Rosa spp.	28.6	9.4	38.0
Panicum virgatum	14.3	9.4	23.7
	CURRENT GROWTH		
Andropogon scoparius	85.7	31.1	116.8
Eragrostis trichodes	71.4	20.0	91.4
Carex spp.	71.4	13.3	84.8
Calamovilfa longifolia	71.4	8.2	79.6
Koeleria cristata	42.9	2.2	45.1
Rosa spp.	42.9	2.2	45.1
Bouteloua hirsuta	28.6	5.2	33.8
Andropogon hallii	28.6	2.2	30.8
Paspalum stramineum	28.6	1.5	30.1
Panicum scribnerianum	28.6	1.5	30.1

Table 44. Frequencies of occurrence of plant species in the canopies of 46 sharp-tailed grouse nests located on or near the Bessey area.

Plant Name[1]	OCCURRENCE Frequency	Percent
Eragrostis trichodes	26	56.5
Andropogon scoparius	24	52.2
Calamovilfa longifolia	18	39.1
Rosa spp.	6	13.0
Panicum virgatum	4	8.7
Amorpha canescens	4	8.7
Andropogon hallii	3	6.5
Stipa comata	3	6.5
Yucca glauca	3	6.5
Medicago sativa	3	6.5

[1]Those plants occurring less than 5 percent excluded.

Table 45. Percent occurrences of woody plant species in quadrats[1] at control sites and at sharp-tailed grouse activity sites on the Bessey area.

Species	PERCENT OCCURRENCE Courtship (39)[2]	Nesting (41)	Brooding (63)	Loafing (73)	Feeding (28)	Roosting (7)	Control (20)[3]
Amorpha canescens	46.9	24.4	54.0	53.4	46.4	14.3	55.0
Artemesia filifolia	0.0	0.0	0.0	0.0	7.1	0.0	0.0
Artemesia glauca	4.7	2.4	1.6	2.7	0.0	0.0	0.0
Artemesia ludoviciana	9.4	29.3	46.0	35.6	42.9	28.6	55.0
Ceanothus ovatus	0.0	31.7	11.1	24.7	7.1	28.6	20.0
Prunus americana	0.0	0.0	4.8	1.4	0.0	28.6	5.0
Prunus besseyi	4.7	26.8	30.2	46.6	7.1	0.0	25.0
Prunus virginiana	0.0	4.9	3.2	16.4	3.6	0.0	5.0
Rhus radicans	0.0	4.9	4.8	24.7	3.6	0.0	5.0
Rhus trilobata	0.0	0.0	0.0	1.4	0.0	0.0	0.0
Ribes spp.	0.0	0.0	0.0	1.4	0.0	0.0	0.0
Rosa spp.	39.1	70.7	76.2	82.2	57.1	85.7	75.0
Salix spp.	0.0	0.0	0.0	12.3	0.0	0.0	0.0
Symphoricarpos occidentalis	0.0	0.0	1.6	4.1	3.6	0.0	5.0
Yucca glauca	21.9	46.3	30.2	37.0	32.1	57.1	40.0

[1]Quadrats were 100 feet by 100 feet square placed with the approximate center at the activity site.
[2]Sample size.
[3]From July samples.

Table 46. Densities of plants in each life-form category at sharp-tailed grouse activity sites based on numbers of hits on transects.

Activity	N	Mean Number of Hits ± S.E. Grass	Forb	Shrub	Total
		RESIDUAL GROWTH			
Display	39	1.51 ± 0.37	0.59 ± 0.13	0.10 ± 0.06	2.21 ± 0.41
Nesting	41	5.54 ± 0.55	0.02 ± 0.02	0.02 ± 0.02	5.59 ± 0.55
Brooding	63	2.02 ± 0.29	0.11 ± 0.04	0.32 ± 0.07	2.44 ± 0.31
Loafing	73	3.62 ± 0.49	0.07 ± 0.03	0.40 ± 0.08	4.08 ± 0.49
Feeding	28	8.39 ± 1.88	1.79 ± 0.86	0.64 ± 0.26	10.82 ± 2.01
Roosting	7	6.71 ± 0.99	0.00	0.86 ± 0.55	7.57 ± 1.17
		CURRENT GROWTH			
Display	39	15.85 ± 2.09	7.72 ± 2.00	0.13 ± 0.07	23.69 ± 2.67
Nesting	41	19.05 ± 0.90	2.98 ± 0.62	0.49 ± 0.12	22.51 ± 1.04
Brooding	63	19.73 ± 1.25	3.56 ± 0.51	1.51 ± 0.19	24.79 ± 1.34
Loafing	73	17.93 ± 0.91	2.66 ± 0.28	1.82 ± 0.22	22.41 ± 1.02
Feeding	28	14.32 ± 2.90	2.89 ± 0.70	0.43 ± 0.17	17.64 ± 3.21
Roosting	7	17 43 ± 4.12	1.29 ± 0.47	0.57 ± 0.30	19.29 ± 4.32

Table 47. Height of vegetation in each life-form category at sharp-tailed grouse activity sites based on transect data.

	GRASS		FORB		SHRUB		TOTAL	
Activity	N	Mean ± S.E.	N	Mean ± S.E.	N	Mean ± S.E.	N	Mean ± S.E.
				RESIDUAL GROWTH				
Display	22	4.06 ± 0.38	16	5.36 ± 0.49	3	3.33 ± 0.33	27	4.58 ± 0.36
Nesting	40	8.28 ± 0.46	1	4.00	1	6.00	40	8.26 ± 0.46
Brooding	44	8.84 ± 0.73	7	8.14 ± 1.33	16	14.25 ± 5.54	49	10.80 ± 1.89
Loafing	57	9.38 ± 0.62	5	7.40 ± 0.60	22	10.85 ± 1.78	64	9.64 ± 0.31
Feeding	22	4.27 ± 0.48	10	4.51 ± 0.93	8	8.41 ± 1.46	22	4.94 ± 0.51
Roosting	7	11.16 ± 1.94	0		3	7.33 ± 1.33	7	10.49 ± 1.49
				CURRENT GROWTH				
Display	33	1.91 ± 0.13	31	1.32 ± 0.10	4	5.13 ± 1.74	37	1.66 ± 0.09
Nesting	41	5.81 ± 0.27	33	3.16 ± 0.35	14	9.37 ± 1.66	41	5.58 ± 0.28
Brooding	62	7.34 ± 0.30	50	7.12 ± 0.70	41	12.38 ± 2.46	63	8.31 ± 0.70
Loafing	72	7.57 ± 0.27	60	6.13 ± 0.47	52	10.92 ± 1.04	72	7.89 ± 0.33
Feeding	27	2.74 ± 0.34	17	2.65 ± 0.41	7	5.21 ± 0.97	27	2.73 ± 0.34
Roosting	6	8.52 ± 0.78	4	4.45 ± 1.13	3	9.17 ± 1.42	6	8.23 ± 0.81

loose sandy soils, blowouts result from wind erosion. Because of the difficulty of maintaining a water tank in the presence of blowing sand, windmills are usually moved when a blowout starts to develop. Windmills are also moved because of well failure. In the absence of use by cattle, plant succession begins on the disturbed area of an abandoned windmill site. Vegetative cover is often slow to establish because of difficulty in stabilizing blowing sand. Invading plants characteristic of early successional stages often create a rank growth of tall vegetation that renders the site unsuitable for courtship display.

It was concluded that shifts in locations of display grounds observed on the Bessey area resulted from changes in land use which in turn caused changes in vegetative cover. Ammann (1957:59), studying prairie grouse in Michigan, suggested that neither heavily vegetated areas nor entirely bare areas were suitable for courtship sites and that low, matted or sparse vegetation was preferred. These findings were confirmed in the present study. Abandonment of grounds 3 and 16 resulted from increased density and/or height of vegetation, and abandonment of grounds 15 and 17 apparently occurred when all vegetative cover had been removed and blowout conditions prevailed.

Vegetation preferences of sharp-tailed grouse for nesting, brooding, and loafing were investigated using multiple discriminant analysis of transect and quadrat data gathered at activity and control sites, 1963 through 1966. Results of discriminant analysis of nest and control sites are presented in Table 51. Of 22 variables used in the analysis, 8 were selected by the program to perform the discriminant analysis. The approximate F value is significant ($P<0.05$) indicating that nest sites differed from control sites with respect to the vegetation measures selected by the program. Prior to analysis of nest and control data, nest cases were randomly split into two sets referred to as "nest" and "validation" sub-groups. The nest sub-group, comprised of 20 nests, was used in the

Table 48. Summary data from transects at sharp-tailed grouse activity sites on the Bessey area.

	Number of Hits										
	All Standing Vegetation[1]		Litter	Bare Soil	Height of All Vegetation[1]		Percent Light Intercepted		Forage Density Index		
Activity	N	Mean ± S.E.	Mean ± S.E.	Mean ± S.E.	N		N	Mean ± S.E.	N	Mean ± S.E.
Display	39	25.90 ± 2.58	43.72 ± 2.96	31.46 ± 3.90	38	2.08 ± 0.12	39	0.31 ± 0.16	63	14.82 ± 1.94
Nesting	41	28.10 ± 1.25	65.76 ± 1.63	9.73 ± 1.46	41	6.07 ± 0.26	41	15.92 ± 1.85	40	19.00 ± 0.84
Brooding	63	27.24 ± 1.37	63.86 ± 1.66	10.41 ± 1.76	63	8.62 ± 0.94	63	32.12 ± 2.15	63	19.29 ± 1.18
Loafing	73	26.49 ± 1.00	66.10 ± 1.54	10.11 ± 1.20	73	8.23 ± 0.33	73	35.97 ± 2.20	72	18.88 ± 0.80
Feeding	28	28.46 ± 2.50	58.82 ± 3.17	11.39 ± 2.18	28	3.87 ± 0.36	28	7.04 ± 2.02	24	14.25 ± 2.64
Roosting	7	26.86 ± 4.18	71.86 ± 3.30	5.86 ± 1.44	7	9.58 ± 1.37	7	30.86 ± 3.59	6	21.17 ± 3.43

[1]Life-form and growing season categories pooled.

Table 49. Percent weight of woody vegetation and percent range condition in quadrats[1] at sharp-tailed grouse activity sites on or near the Bessey area.

	Percent Weight of Woody Vegetation		Percent Range Condition	
Activity	N	Mean ± S.E.	N	Mean ± S.E.
Courtship	39	2.03 ± 0.38	39	43.08 ± 4.16
Nesting	41	7.10 ± 1.20	41	81.73 ± 1.79
Brooding	63	15.78 ± 2.14	62	65.65 ± 2.92
Loafing	73	22.63 ± 2.24	72	75.85 ± 1.85
Feeding	28	7.14 ± 1.56	25	58.40 ± 3.38
Roosting	8	8.71 ± 2.75	7	87.00 ± 2.91

Table 50. Results of multiple linear regression analysis of vegetation coverboard photo data from sharp-tailed grouse courtship grounds on the Bessey area.

Dependent Variable

Number of hits (total number of reference dots obscured by vegetation)

Independent Variables	Regression Coefficient (b)	Normalized Regression Coefficient (Beta)	F[1]
Distance to ground center	0.34803	0.51417	5.339
Distance to windmill	0.17473	0.49462	4.155
(Distance to ground center)^2	−0.00243	−0.29139	2.629
(Distance to windmill)^2	−0.00081	−0.39560	2.448
Distance to ground center X Distance to windmill	0.00027	−0.04335	0.049
Constant Term	3.97858		
Multiple — r^2 = 0.11361			

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F
Regression	5	4860.878	972.175	6.305[2]
Residual	246	37925.260	154.167	

Dependent Variable

Columns hit (Number of vertical reference dot columns in which one or more dots were obscured by vegetation)

Independent Variables	Regression Coefficient (b)	Normalized Regression Coefficient (Beta)	F[1]
Distance to ground center	0.20987	0.77151	13.060
Distance to windmill	0.11235	0.79138	11.556
(Distance to ground center)^2	−0.00122	−0.36317	4.437
(Distance to windmill)^2	−0.00043	−0.51997	4.594
Distance to ground center X Distance to windmill	−0.00041	−0.16333	0.760
Constant Term	2.29658		
Multiple — r^2 = 0.18410			

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Mean Square	F
Regression	5	1272.176	254.435	11.101[2]
Residual	246	5632.152	22.919	

[1](b/Std. error of b)^2 with 1 and 246 d.f.; tabulated F (P = 0.05, 1 and 246 d.f.) = 3.89

[2]Tabulated F (P = 0.05, 5 and 246 d.f.) = 2.26

discriminant analysis. The program used classification functions developed on the basis of the nest sub-group and control group to "reclassify" each case. Thus, the validation sub-group provided a test of the accuracy of classification functions. The results of classification are also presented in Table 51. Of the nest sub-group and the control group, 38 out of 40 cases were classified correctly. Of the 15 nest cases in the validation group, all were classified correctly as nests.

Influences of individual variables in discriminating between nest and control sites were indicated by their "F-to-remove" values. Variables with the largest F-to-remove values contributed most to discrimination. Variables which contributed most to discrimination between nest and control sites were the squared values of mean height of all growth, hits on all current growth, and hits on current grass. Means of first order terms of each of these variables were significantly higher at control sites than at nest sites in June ($P<0.05$). Mean percent light intercepted was also greater at control than nest sites ($P<0.05$), indicating that nests had less canopy than expected in the area at large. The second order term of hits on litter was also selected in the analysis. Although important in discrimination, mean percent dry weight of woody vegetation did not differ significantly between nest and control sites. Forage density was significantly lower at nest sites than at control sites ($P<0.05$). The mean number of hits on litter was significantly greater at nest than at control sites ($P<0.05$)

Although examination of individual variables may prove helpful in interpreting results of discriminant analysis, the value of the procedure lies in detecting differences based on the joint action of several variables.

Based on the above analysis, it was concluded that nesting grouse preferred sites having relatively open canopy and sparse current growth, with accumulation of plant litter. Since nest sites analyzed were measured in June, avoidance of dense current growth probably indicated avoidance of cool season grasses and forbs, as well as a preference for residual cover of warm season grasses. Selection of warm season grasses was indicated by species dominating canopies of nests (Table 44). Grasses provide little canopy which may explain the importance of canopy in discrimination. Accumulation of litter on a site can only occur if livestock use is very light or excluded entirely. Hormay (1970:17) cited accumulation of plant litter between plants as important in preventing soil erosion and improving soil fertility. He suggested that pastures must be rested from grazing to allow litter to accumulate. Analysis of control site vegetation data indicated no significant differences in litter between topographic site categories. However, field observations suggested that litter accumulation was usually greater on relatively steep north slopes because of a more mesic microclimate and a lower accessibility to livestock. Increased accumulation of litter on north slopes may have contributed to preference of such sites for nesting.

Christenson (1971:20-26) measured vegetation at 22 sharp-tailed

Table 51. Results of multiple discriminant analysis of nesting and control sites based on vegetation data.

	Means		Classification Function Coefficients		
Variables	Control	Nesting	Control	Nesting	F-to-Remove
(Hits on current grass)^2	1441.25	481.30	−0.04545	−0.03105	9.20
(Hits on all current growth)^2	1729.70	649.85	0.04186	0.02686	11.38
(Mean height of all growth)^2	54.84	35.10	0.17099	0.06250	12.24
Mean percent light intercepted	21.40	14.30	0.38647	0.15308	6.58
(Hits on litter)^2	2906.35	3950.55	0.00424	0.00549	2.15
Forage density index	34.00	21.20	1.35837	1.05550	2.19
Percent weight of woody vegetation	8.10	7.45	−0.45614	−0.01981	5.29
(Percent weight of woody vegetation)^2	194.00	120.85	0.00292	−0.00382	2.60
			CONSTANTS		
			−41.05647	−26.26772	

U − Statistic = 0.24742 degrees of freedom = 8, 1, 38
Approximate F = 11.78654* degrees of freedom = 8, 31

Classification Matrix

Group	Number Classified into Group: Control	Nesting
Control	19	1
Nesting	1	19
Validation	0	15

*Significant ($P < 0.05$)

Table 52. Results of multiple discriminant analysis ot brooding and control sites based on vegetation data.

	Means		Classification Functional Coefficients		
Variables	Control	Brooding	Control	Brooding	F-to-Remove
Hits on residual grass	3.45	2.15	−5.53740	−0.97666	15.78
Hits on all residual growth	3.85	2.50	6.32870	1.35191	18.87
Hits on current grass	34.10	18.50	2.38952	1.66611	12.42
(Mean height of all growth)^2	59.79	66.19	0.20385	0.10681	10.87
Mean percent light intercepted	20.00	39.19	−0.17422	0.09640	15.51
(Forage density index)^2	1181.00	456.70	−0.02530	−0.01937	3.43
Percentweight of woody vegetation	7.80	15.85	−0.04075	0.23508	1.82
(Percent weight of woody vegetation)^2	153.40	452.15	0.00733	−0.00014	3.23
			CONSTANTS		
			−34.28485	−19.98230	

U − Statistic = 0.23547 degrees of freedom = 8, 1, 38
Approximate F = 12.58151* degrees of freedom = 8, 31

Classification Matrix

Group	Number Classified Into Group: Control	Brooding
Control	18	2
Brooding	1	19
Validation	7	12

*Significant ($P < 0.05$)

grouse nest sites in North Dakota and found that species of plants associated with nests varied, but that height of cover was consistent among nests. He concluded that uniform stands of vegetation at least 12-inches high or patches of vegetation at least 14 inches high were necessary for nesting. Christenson (1971:46) recommended that regulation of grazing to maintain uniform stands of vegetation at least 12-inches high might substantially increase grouse populations. Pepper (1972:24) concluded that sharp-tailed grouse in Saskatchewan selected nest sites on the basis of foliar density and that vegetation at the nest site often differed from vegetation within a few feet of the nest.

Discriminant analysis of brood and control sites was based on data from 39 brood sites and the 20 control sites measured in July (Table 52). Nineteen brood cases were randomly selected as the validation subgroup. Eight of the 22 variables used in the analysis were selected for discrimination. Brood sites differed significantly from control sites with reference to selected variables ($P<0.05$). Although 37 of the 40 brood and control cases used in the analysis were classified correctly, only 12 (63 percent) of the 19 cases in the validation group were classified correctly as brood sites. Results of classification suggested that brood sites differed less from control sites than did nest sites.

Examination of individual variables indicated that hits on all residual growth, hits on residual grass, mean percent light intercepted, and the second order term of mean height of all growth contributed most to discrimination. Hits on all residual growth, hits on residual grass, and hits on current grass averaged lower on brood sites than on control sites ($P<0.05$), suggesting that brooding grouse selected sites with relatively less residual cover and grass than average on the study area. In contrast to nest sites, however, the mean percent light intercepted was greater at brood sites than at control sites ($P<0.05$). Greater canopy at brood sites was attributed to greater densities of forbs and greater amounts of woody vegetation at brood sites. Means of hits on current forb growth and percent dry weight of woody vegetation were greater at brood sites than at control sites ($P<0.05$). Based on discriminant analysis of brood and control sites, it was concluded that brooding sharp-tailed grouse preferred sites with relatively dense canopies resulting from a greater abundance of forbs and woody cover.

Ammann (1957:61) reported that sharp-tailed grouse broods in Michigan usually selected sites with some overhead cover near. Hamerstrom (1963:800) studied habitat used by sharptail broods in Wisconsin and concluded that grassland interspersed with shrubs was preferred. Kobriger (1965:796) observed sharp-tailed grouse broods using mowed meadows in the Sand Hills. He found that broods fed there during early morning and later afternoon-evening and used taller vegetation which provided shade during mid-day. Similar findings were reported by Pepper (1972:31), who found that sharptail broods in Saskatchewan utilized sparser cover during early morning and evening and heavier cover such as trees and shrubs during mid-day. Pepper (1972:30, 34) also found that natural vegetation used by sharptail broods was ungrazed or lightly grazed and that broods preferred a higher density of forbs and lower density of grasses than nesting hens.

Results of discriminant analysis of loafing and control sites are presented in Table 53. Analysis was based on data from 43 loafing sites and the 20 control sites measured in July. Of the loafing cases, 20 were used in the analysis while the remaining 23 were used for validation. Ten of the 22 variables were selected by the program. As with nesting and brooding, loafing sites differed significantly from control sites with respect to variables selected ($P<0.05$). Thirty-nine of the 40 cases used in the analysis were classified correctly, with 16 (70 percent) of the 23 validation cases classified correctly as loafing sites.

Examination of variables selected for the analysis indicated that the first and second order terms of hits on current grass, first and second order terms of percent weight of woody vegetation, mean height of all growth and mean percent light intercepted ranked most important in distinguishing between loafing and control groups. Tests between group means of individual variables indicated that hits on current grass averaged less at loafing than at control sites while means of percent weight of woody vegetation, mean height of all growth, and mean percent light intercepted were higher at loafing sites. The second order term of bare soil also ranked relatively high in importance with incidence of bare soil greater at loafing than at control sites ($P<0.05$).

Means of variables indicated that percent dry weight of woody vegetation averaged more than three times greater at loafing sites than at control sites, while mean percent light intercepted averaged more than twice as much at loafing sites as at control sites. Based on discriminant analysis of loafing and control sites, if was concluded that loafing sharptails preferred sites with a relatively dense canopy, provided by woody vegetation, and a relatively open understory, characterized by the absence of dense stands of grass. Data in Table 36 indicated that loafing sharptails preferred north slopes. North slope sites having relatively dense vegetative canopy and open understories would be expected to provide maximum protection from direct solar radiation and strong southerly winds during midday in summer.

Because of limited sample size, vegetation data from feeding sites were not subjected to discriminant analysis. However, vegetation data from eight feeding sites measured in July were compared with July measurements on the 20 control sites. Comparison was made on the basis of differences between means for individual variables. Densities of residual and current growth of grasses, overall height of vegetation, and percent range condition were lower on feeding than on control sites ($P<0.05$). However, the mean of hits on current forb growth was higher on feeding than on control sites ($P<0.05$). These results suggested that feeding sharptails selected sites with vegetation in earlier stages of succession.

Vegetation was sampled at seven roosting sites. However, numbers of samples within any given month were not considered sufficient to allow statistical comparisons between roosting and control site data (Appendix 8). All roosting sites measured occurred on relatively steep slopes. Field observations indicated sharptails usually roosted on sites dominated by grasses, often interspersed with woody vegetation.

Summary of Habitat Preferences

Findings on habitat preferences of sharp-tailed grouse during spring and summer are summarized below:

- Sharptails preferred tops of low to medium hills or ridges with short, sparse vegetation for courtship sites. Changes in land use on a courtship site, resulting in taller, denser vegetation, caused abandonment of the site within two to five years;
- Nesting grouse preferred north slopes dominated by residual cover of warm season grasses with an accumulation of plant litter;
- Sites selected for brooding had relatively dense canopies resulting from presence of forbs and shrubs;
- Loafing sharptails preferred north slopes with relatively dense canopies of woody vegetation and open understories;
- Sharptails selected sites having vegetation in earlier stages of succession for feeding. Such sites were characterized by relatively dense forb cover and sparse grass cover.
- Slopes dominated by grasses interspersed with woody vegetation were preferred for roosting.

Recent studies of habitat selection by birds indicated that selection is based on the "physiognomy" or apparent characteristics of habitat such as land form or height and density of vegetation (Hilden 1965). Results of the present study, as well as other studies cited, support this concept. Throughout the greater part of its range, the sharp-tailed grouse is considered an inhabitant of the ecotone between forest and prairie, and woody vegetation in the form of shrubs and trees is considered an essential component of its habitat (Grange 1949:238). According to Edminster (1954:145), the sharptail uses successional stages that precede and follow brushland to a limited degree, but "...the one indispensible cover type is brush of some suitable kind." In such areas, the height, density, form, and spatial distribution of vegetation appear to play the dominant role in determining the physiognomy of habitat. Grange (1949:237) described the components of habitat of sharp-tailed grouse in Wisconsin in terms of the life form and spatial distribution of plants. In the Nebraska Sand Hills, land form or topography plays a dominant role in determining the physiognomy of the habitat. Topography not only influences the microclimate near the ground, but also has an effect on vegetation. Grazing, which has a dominant influence on plant succession in the Sand Hills, is also affected by topography through the influence of topography on accessibility to livestock. Based on findings of the present study it was concluded that selection of habitat by sharp-tailed grouse in the Nebraska Sand Hills is a function of the physiognomy of habitat determined primarily by landform and vegetation. It was also evident that sharptails selected sites differing in physiognomy for different activities,

Table 53. Results of multiple discriminant analysis of loafing and control sites based on vegetation data.

Variables	Means		Classification Function Coefficients		F-to-Remove
	Control	Loafing	Control	Loafing	
Hits on current grass	34.10	17.85	0.71390	−0.07508	5.26
(Hits on current grass)^2	1297.30	355.05	0.11122	0.12393	10.36
Mean height of all growth	7.40	8.33	−4.14643	−5.46084	6.95
Mean percent light intercepted	20.00	40.44	1.47579	1.63422	5.21
(Hits on bare soil)^2	60.55	191.95	0.25676	0.27459	4.73
Hits on litter	57.45	65.75	7.97417	8.33814	2.77
Percent range condition	79.20	74.55	36.39514	37.72960	3.31
(Percent range condition)^2	6525.90	5717.15	−0.24333	−0.25161	2.80
Percent weight of woody vegetation	7.80	26.10	2.36526	2.87024	7.00
(Percent weight of woody vegetation)^2	153.40	910.80	−0.02778	−0.03414	4.94
			CONSTANTS		
			976.04541	−1042.22339	

U − Statistic = 0.24622   degrees of freedom = 9, 1, 38
Approximate F = 10.20471*   degrees of freedom = 9, 30

Classification Matrix

Group	Number Classified into Group	
	Control	Loafing
Control	20	0
Loafing	1	19
Validation	7	16

*Significant ($P < 0.05$)

indicating the need for diversity in physiognomy of habitat. While sites used for some activities such as courtship and feeding were characterized by overuse by livestock, grouse selected lightly used or unused sites for nesting and loafing. Woody cover is often selectively used by livestock during hot weather even under light to moderate stocking rates. Brush stands heavily used by livestock become unsuitable for use by sharptails for loafing cover during summer.

Range Management Recommendations

According to Burzlaff (1961:4) the goals of range management are:

1. Keep the range covered with good forage plants.
2. Maintain range feed reserve.
3. Increase livestock and wildlife products.
4. Reduce and control the flow of water from rangelands.
5. Control soil erosion on range watersheds.

In practice, however, the primary objective of range management in the Sand Hills is to attain the maximum sustained yield of livestock pfoducts from the range. Livestock production is determined by the quantity and quality of forage. According to Burzlaff (1962:13) range in excellent condition is the most productive; therefore, the highest sustained yields of livestock can be expected on range in excellent condition. Although increased livestock production may result initially from overstocking range in good or excellent condition, range condition and productivity will decrease and long-term yields will be lower. Therefore, one of the most important tools of range management for livestock is the regulation of stocking rates to maintain high range condition. An accepted standard for proper range utilization is removal of no more than 40 to 50 percent by weight of current forage production annually (Soil Conservation Service, 1967). However, control over utilization of forage cannot be achieved by regulation of stocking rates alone. According to Hormay (1970:15) livestock graze selectively by plant species and areas, consistently preferring the more accessible areas and most palatable plant species. This behavior results in an uneven pattern of use. Therefore, to achieve better utilization of forage, while maintaining high range condition, it is necessary to control the distribution of livestock on the range.

Methods commonly used to control distribution of grazing include fencing, distribution of water and salt, and rotation of use between pastures. Uniform distribution of grazing is desirable from a livestock production viewpoint. This has led to the development of "planned grazing systems." A planned grazing system has been defined as "one in which two or more grazing units are alternately rested from grazing in a planned sequence over a period of years. The rest period may be throughout the year or during all or part of the growing season. It is a system also known as High Intensity-Low Frequency—HILF." (Soil Conservation Service, 1973). In general, planned grazing systems in the Sand Hills require relatively small pastures (640 acres or less). As the number of pastures in a system increase, the period of time livestock are in a given pasture shortens and the density of animals increases, thus forcing more uniform utilization of plant species and areas.

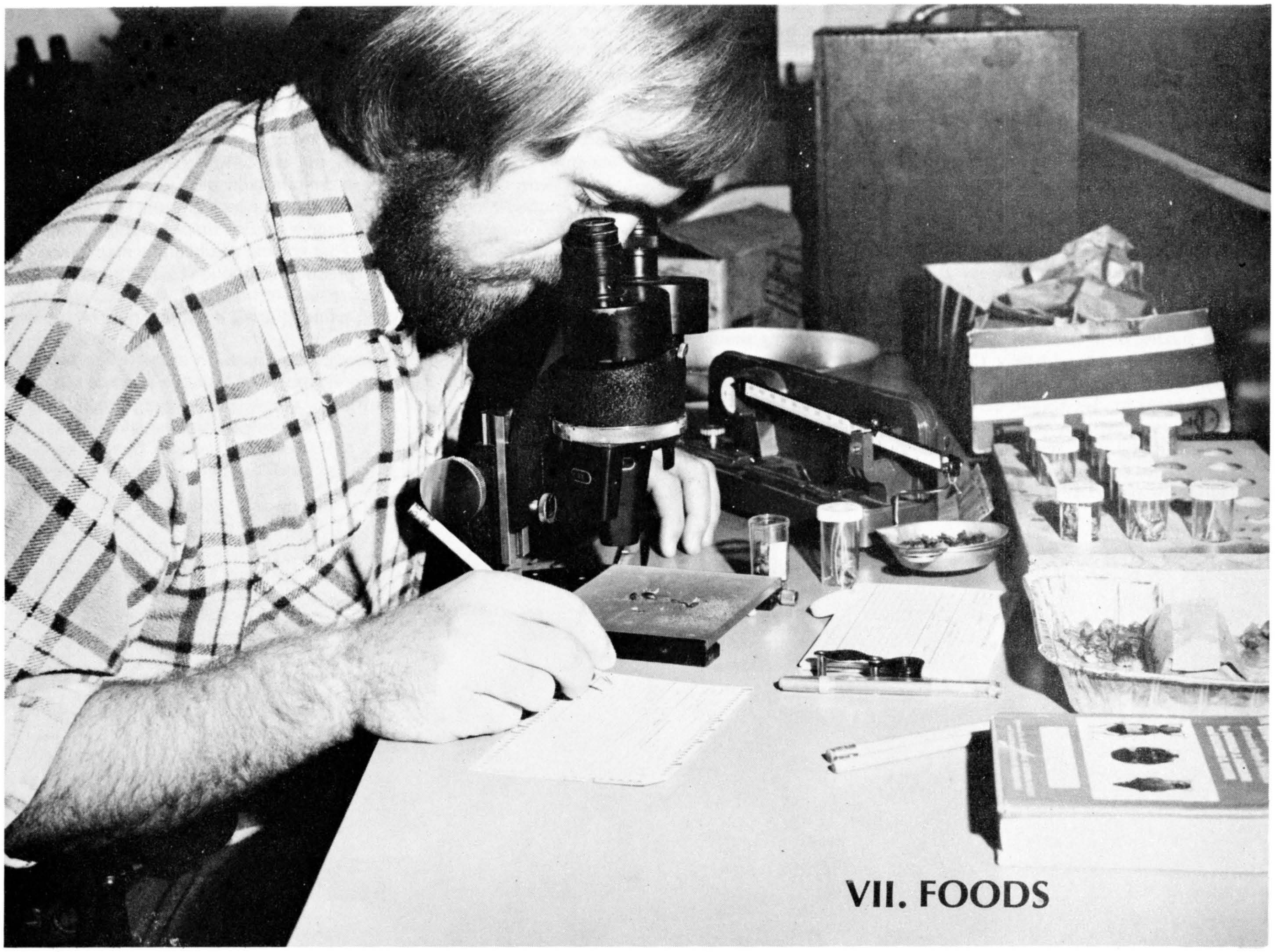
Characteristics of grassland necessary for maintaining high sharptailed grouse populations differ from those considered desirable from a livestock production viewpoint. Research on habitat requirements of sharptails in the Sand Hills indicated that grouse require different topographic sites and successional stages of vegetation for different activities. Nesting grouse select sites having dense stands of climax grass species interspersed with some forbs and low shrubs or half-shrubs. Most nesting hens selected sites on north-facing slopes, whereas sites in earlier successional stages on more level terrain were selected for feeding by both adults and hens with broods. However, loafing adults and broods selected sites having more shrubby cover. Courtship sites were usually located in overused areas near watering facilities. Availability of habitat required for successful nesting and brood-rearing is considered one of the most important factors limiting sharp-tailed grouse in the Sand Hills. Overstocking of range with livestock results in loss of climax vegetation necessary for successful nesting. Shrubby cover needed by broods for protection from weather extremes also deteriorates under excessive grazing pressure. Maximum carrying capacity for sharp-tailed grouse on Sand Hills range can best be achieved by maintaining an interspersion of sites having different range condition classes.

While high utilization grazing systems may be desirable from a livestock production viewpoint, they result in loss of habitat diversity and interspersion required by sharp-tailed grouse. The preference of nesting grouse for sites having climax vegetation indicates that maintenance of high range condition is desirable for grouse. Grazing systems utilizing relatively small pastures (less than 640 acres) and/or more than two pastures in rotation should be avoided. From a grouse production viewpoint, selective grazing of livestock is desirable. In general, grazing should be regulated to allow approximately 15 percent of a pasture to remain unused during a season. Experience indicates that a two-pasture system grazing livestock in one pasture during the first half of the season and in the other pasture the remainder of the season is a desirable compromise. Rotation should be on a last-out, first-in basis and pastures should be at least 1,280 acres (2 square miles) in size.

During the period 1969 to 1971 a six-pasture rotation using pastures averaging approximately 640 acres in size was used on the Bessey area. The six-pasture system was found to be less desirable for livestock production and range recovery than the two or three pasture systems in use on the balance of the Forest. The six-pasture system was subsequently discontinued. The diversity of vegetation resulting from selective grazing by livestock and wild herbivores would be expected to contribute to the long-term stability and productivity of the system. This concept should be carefully considered in evaluating the long-term impact of intensive grazing systems designed to achieve uniform utilization.

Another range management practice which is expected to be beneficial to sharptail populations is winter grazing on pastures dominated by the choppy sands range site. Winter grazing would allow maintenance of high range condition and would reduce destruction of shrubby vegetation. Since livestock on winter pasture require supplementary feed and attention during inclement weather, winter grazing is feasible only on pastures near ranch headquarters.

Woody vegetation frequently deteriorates in areas where livestock are concentrated. In such areas it would be desirable to fence out some woody stands to provide cover for grouse. Badly overgrazed stands of chokecherry and plum on the Forest, have shown remarkable recovery within a few years after being protected from livestock by fencing. Such stands are also utilized by other wildlife species, notably deer and passerine birds.



VII. FOODS

Methods

Crop contents of sharp-tailed grouse and prairie chickens were gathered from 1963 through 1968. Most crops were removed from grouse shot by hunters during the fall. Crop contents were air-dried at approximately 70°C for 24 to 48 hours. Dried food items were then identified as to genera, if plant, or family, if animal. Plant material was further classified as vegetative or reproductive and animal material as larval or adult. Material in each food category was weighed to the nearest 0.01 gram. Data were summarized by computer and the t-test was used to test differences between means.

Results

Numbers of crops collected by species of prairie grouse, season, and county are presented in Appendix 9. Of 576 crops collected, 474 were from sharp-tailed grouse and 102 from prairie chickens. Most sharptail crops were collected on the Forest in Thomas County, while most prairie chicken samples were collected in Brown, Holt, and Rock counties. A total of 508 (88 percent) of the crops were collected during fall of which 507 were removed from grouse bagged by hunters. Crops not obtained from hunters were removed from birds collected by project personnel or found dead due to natural or accidental mortality. Crops were removed from 47 grouse killed by automobiles and four grouse killed by predators. The remaining grouse were collected or suffered other accidental mortality. Numbers of crops collected by season, grouse species, sex, and age are presented in Appendix 10. Of 474 sharptail crops, 35 (7 percent) were empty, while 18 (18 percent) of 102 prairie chicken crops had no contents (Appendix 11).

Mean weights of crop contents by grouse species within seasons are presented in Table 54. Seasonal means for sharptails indicated that the average weight of crop contents was greatest during winter (18.4 grams) and lowest during summer (2.6 grams). Sample sizes were insufficient for comparison of seasonal means of prairie chickens. Weight of crop contents would be expected to vary with time of day, since grouse feed primarily during early morning and late afternoon. The time of day when death occurred may have been influenced by the type of mortality. Therefore, observed differences in seasonal means of weights of crop contents may have been biased by the type of mortality which varied between seasons.

During fall the mean weight of crop contents of sharptails (4.83 grams) was significantly greater ($P<0.05$) than the mean for prairie chickens (2.58). The cause of this difference was not determined.

Weight of crop contents is broken down by general food categories for sharp-tailed grouse during spring, summer, fall, and winter in Table 55 and for prairie chickens during fall in Table 56. Most foods taken by sharptails during spring were plants (99.5 percent by weight) with vegetative and reproductive parts taken in approximately equal amounts. During summer, nearly half of crop contents (42 percent by weight) were animal material, primarily made up of adult insects. Both vegetative and reproductive plant material were also ingested. During fall, the diet of sharptails shifted back to plant material (83 percent by weight) and, in contrast to spring and summer, most plant material was reproductive (seeds, fruits, etc.). Adult animal material was eaten in fall but in lesser

Table 54. Weights of food contents in crops of 437 sharp-tailed grouse and 84 prairie chickens by season of collection.[1]

Season	Species	Number of Crops	Weight of Crop Contents (grams) Mean	S.E.[2] of Mean
Spring	Sharptail	18	12.49	2.93
	Prairie chicken	3	11.32	6.54
Summer	Sharptail	16	2.58	0.64
	Prairie chicken	3	1.56	0.90
Fall	Sharptail	382	4.83	0.25
	Prairie chicken	77	2.58	0.29
Winter	Sharptail	21	18.35	4.01
	Prairie chicken	1	23.61	—
All-Seasons	Sharptail	437	5.71	0.27
	Prairie chicken	84	3.10	0.34

[1]Grouse with empty crops and/or unknown season excluded.
[2]Standard error (standard deviation of mean).

amounts than during summer. In winter, crop contents were made up almost entirely of plant material (99.7 percent by weight). Contents of crops of prairie chickens from fall were similar to those of sharptails in relative weights of general food types except that animal material made up a larger proportion of the contents of prairie chickens crops.

The seasonal use of plant and animal foods by sharp-tailed grouse is presented graphically in Figure 31. Since numbers of crops varied among seasons, data within seasons were weighted in preparing Figure 31. Plant material dominated adult crops throughout the year with use of animal material essentially restricted to summer and fall when insects were available. The apparent greater use of animal foods during fall than during summer may have resulted from a small and possibly unrepresentative sample of summer crops. Animal food dominated the crops of young sharptails during summer (79 percent by weight) and continued to be important in fall (21 percent). Winter and spring use of animal foods by young grouse was similar to that of adults.

In sharptail crops from spring, 30 genera of plants and 5 families of animals were identified (Appendix 12). Foods used most frequently during spring were rose hips *(Rosa)*, sage or sagewort *(Artemisia)*, and golderod *(Solidago)*. Relatively large amounts of corn *(Zea)* were found in the crops of three grouse which had been feeding in agricultural land. Grasshoppers *(Locustidae)* were the most frequent animal food identified in spring crops.

The composition of foods taken by sharptails during summer (Appendix 13) differed considerably from spring. Sixteen genera of plants and 18 families of animals were identified. Plant foods eaten most frequently also differed from spring, with gromwell *(Lithospermum)*, smartweed *(Polygonum)* and dandelion *(Taraxacum)* occurring most frequently. Dandelion made up 38 percent of the weight of crop contents. Grasshoppers again dominated animal material, accounting for 32 percent of the weight of spring crop contents.

Fall foods of sharptails included 56 genera of plants and 33 families of animals (Appendix 14). The greater numbers of taxonomic categories of foods identified in fall than during other seasons probably resulted partially from the greater number of fall crops examined. Of plants, rose hips, sunflower *(Helianthus)*, plum *(Prunus)* and sumac *(Rhus)* occurred most frequently and accounted for 73.4 percent of the total weight of crop contents. Grasshoppers continued to dominate animal foods in fall, making up 13.7 percent of the total weight of crop contents.

In the winter, sharp-tailed grouse consumed similar plants as in fall, with little animal food taken (Appendix 15). Rose hips accounted for 31.5 percent of the weight of all winter food. Three sharptails were collected

Table 55. Percent weight composition of pooled crop contents by food type for sharp-tailed grouse.

	Spring (March-May)	Summer (June-August)	Fall (September-November)	Winter (November-February)
Plant				
Vegetative	43.13	32.14	3.12	30.78
Reproductive	56.40	24.80	79.95	68.91
Total Plant	99.53	56.94	83.07	99.69
Animal				
Adult	0.44	41.76	15.20	0.31
Larvae	0.00	0.02	1.36	0.00
Total Animal	0.44	41.78	16.56	0.31
Grit	0.03	0.05	0.37	0.00
Unknown	0.00	1.23	0.00	0.00
Number of crops	18	16	382	21

while feeding on eastern redcedar *(Juniperus)* during mid-winter when snowcover was on the ground. Their crop contents averaged 16.2 grams and consisted entirely of redcedar fruit.

Swenk and Selko (1938) described food eaten by sharp-tailed grouse during fall in western Nebraska. They found that vegetation made up over 99 percent of food volume, which differed from results of the present study in which 17 percent of the weight of crop contents in fall was made up of animal material (Table 55). Kobriger (1965) described foods of sharp-tailed grouse on Valentine National Wildlife Refuge in the Nebraska Sand Hills. In contrast to the Forest, where most of the food data in the present study were gathered, Valentine Refuge is characterized by large sub-irrigated meadows supporting different vegetation than that found on the upland prairie of the Forest. Clovers *(Trifolium)* were the most important plant food of adults and young sharptails during summer on the Valentine Refuge, while grasshoppers, ants *(Formicidae),* and beetles *(Coleoptera)* were most important among insects. During the fall, rose and clovers ranked highest in importance among sharptail foods on the refuge. The importance of clover among foods of sharptails on the refuge probably reflected greater abundance of clover which is common in subirrigated meadows. Kobriger (1965:797) also reported that animal food made up 60 percent of the volume of crop contents of sharptails up to 7 weeks old, which agreed with results of this study (Figure 31). Renhowe (1968) found that sharp-tailed grouse in western South Dakota preferred dandelion in spring; rose hips, wolfberry *(Symphoricarpos),* and clovers during summer; and cultivated crops during fall and winter.

Fall foods of prairie chickens (Appendix 16) were similar to those of sharptails, with rose the most important among plant material and grasshoppers dominating animal material. Greater importance of *Polygonum* in crops of prairie chickens than in sharptails probably resulted from greater use of sub-irrigated meadows by prairie chickens.

Table 56. Percent weight composition of pooled crop contents by food type for 77 prairie chickens during fall (September through November).

Food Type	Percent Weight
Plant	
Vegetative	15.10
Reproductive	47.42
Total Plant	62.52
Animal	
Adult	30.77
Larvae	6.22
Total Animal	36.99
Grit	0.07
Unknown	0.42
Total Contents	100.00

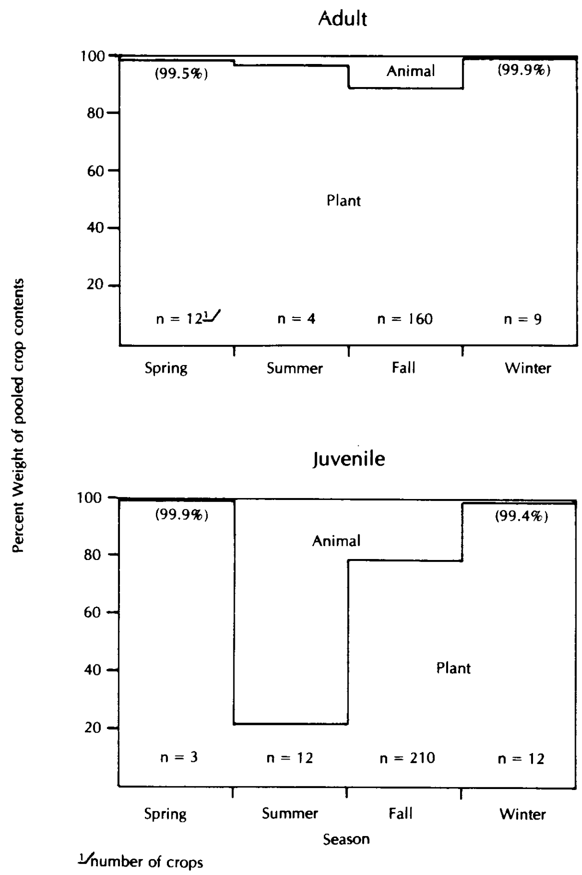


Figure 31. Relative percent by weight of animal and plant foods in crops of adult and juvenile sharp-tailed grouse by season.

Food preferences of sharp-tailed grouse and prairie chickens were not determined in the present study because of a lack of suitable data on availability. However, based on measurements of vegetation reported previously, food habits of prairie grouse seemed to be primarily determined by availability. For example, rose hips ranked most important among foods eaten by sharp-tailed grouse on an annual basis and rose was the most common woody species on random vegetation quadrats on the Bessey area (Table 45). Grasshoppers were the most important animal food consumed and were also common on the study area.

Based on results of this study it was concluded that food suitable for sharp-tailed grouse was readily available on the Bessey area and that food was not a factor limiting the carrying capacity for grouse on the area.

APPENDIX

Appendix 1. List of plants occurring on or near the Bessey area.

Achillea lanulosa	western yarrow
Agoseris spp.	agoseris
Agropyron smithii	western wheatgrass
A. trachycalum	slender wheatgrass
A. cristatum	crested wheatgrass
Agrostis hiemalis	winter bent
Allium nuttallii	nuttail onion
Amaranthus retroflexus	redroot pigweed
A. blitoides	prostrate pigweed
A. hybridus	slim pigweed
Ambrosia psilostachya	western ragweed
A. artemisifolia	common ragweed
Amelanchier spp.	serviceberry
Amorpha canescens	leadplant amorpha
A. fruticosa	indigobush amorpha
A. nana	dwarfindigo amorpha
Andropogon gerardi	big bluestem
A. hallii	sand bluestem
A. scoparius	little bluestem
Anemone cylindrica	candle anemone
Antennaria spp.	pussytoes
Apocynum sibiricum	prairie dogbane
Arenaria spp.	sandwort
Argemone intermedia	intermediate pricklepoppy
Aristida fendleriana	fendler threeawn
A. longiseta	red threeawn
A. oligantha	prairie threeawn
Artemisia filifolia	sand sagebrush
A. glauca	green sagewort
A. ludoviciana	Louisiana sagewort
Asclepias arenaria	sand milkweed
A. stenophylla	narrowleaf milkweed
A. verticillata	easternwhorled milkweed
Aster ericoides	heath aster
A. pauciflorus	fewhead aster
Astragalus bisulcatus	twogroved milkvetch
A. crassicarpus	groundplum milkvetch
A. drummondii	drummond milkvetch
A. flexuosus	pliant milkvetch
A. goniatus	nickleaf milkvetch
A. gracilis	slender milkvetch
A. missouriensis	Missouri milkvetch
A. mollissimus	woolly milkvetch
A. pectinatus	tineleaved milkvetch
A. purshii	pursh milkvetch
A. racemosus	alkali milkvetch
A. striatus	prairie loco
A. tenellus	looseflower milkvetch
Beckmannia syzigachne	American sloughgrass
Bouteloua curtipendula	sideoats grama
B. gracilis	blue grama
B. hirsuta	hairy grama
Bromus ciliatus	fringed brome
B. commutatus	hairy brome
B. japonicus	Japanese brome
B. secalinus	chess brome
B. tectorum	cheatgrass brome
Buchloe dactyloides	common buffalograss
Calamogrostis canadensis	bluejoint reedgrass
C. inexpansa	northern reedgrass
Calamovilfa gigantea	big sandreed
C. longifolia	prairie sandreed
Campanula spp.	bellflower
Carex spp.	sedge
Ceanothus ovatus	inland ceanothus
Cenchrus pauciflorus	mat sandbur
Chaenactis spp.	dustymaiden
Chamaecrista fasciculata	showy partridgepea
Chenopodium leptophyllum	narrowleaf goosefoot
C. album	lambsquarters goosefoot
Chloris verticillata	tumble windmillgrass
Chrysopsis villosa	hairy goldenaster
Cirsium spp.	thistle
Cleome serrulata	rockymountain beeplant
Comandra spp.	bastardtoadflax
Commelina virginica	Virginia dayflower
Coryphantha vivipara	purple ballcactus
Croton texensis	Texas croton
Cryptantha spp.	cryptantha
Cycloloma atriplicifolium	tumble ringwing
Cyperus spp.	flatsedge
Dalea enneandra	slender dalea
Delphinium spp.	larkspur
Digitaria sanguinalis	crabgrass
Distichlis stricta	inland saltgrass
Draba spp.	draba
Echinochloa crusgalli	barnyardgrass
Eleocharis spp.	spikesedge
Elymus canadensis	Canada wildrye
E. macounii	macoun wildrye
Equisetum spp.	horsetail
Eragrostis cilianensis	stink lovegrass
E. spectabilis	purple lovegrass
E. trichodes	sand lovegrass
Erigeron canadensis	horseweed fleabane
E. strigosus	daisy fleabane
E. pumilus	low fleabane
Eriogonum annuum	annual eriogonum
Euphorbia missurica	Missouri spurge
E. serpens	serpent euphorbia
Festuca octoflora	sixweeks fescue
Froehlichia floridana	Florida snakecotton

Appendix 1. (continued)

Gentiana puberla	downy gentian
Gilia longiflora	whiteflower gilia
Glyceria grandis	American mannagrass
Glycyrrhiza lepidota	American licorice
Grindelia squarrosa	curlycup gumweed
Haplopappus spinulosus	ironplant goldenweed
Hedeoma hispida	rough falsepennyroyal
Helianthus annuus	common sunflower
H. laetiflorus	showy sunflower
H. petiolaris	prairie sunflower
H. rigidus	stiff sunflower
Hordeum jubatum	foxtail barley
H. pusillum	little barley
Hymenopappus tenuifolius	woollywhite hymenopappus
Iva spp.	sumpweed
Juncus spp.	rush
Kochia spp.	summercypress
Koeleria cristata	prairie junegrass
Kuhnia eupatorioides	false prairieboneset
Lappula spp.	stickseed
Lathyrus incanus	hoary peavine
L. ornatus	showy peavine
Lepidium densiflorum	prairie pepperweed
L. perfoliatum	clasping pepperweed
Lespedeza capitata	roundhead lespedeza
Lesquerella ludoviciana	foothill bladderpod
Liatris punctata	dotted gayfeather
L. squarrosa	scaled gayfeather
Linaria spp.	toadflax
Linum spp.	flax
Lithospermum incisum	narrowleaf gromwell
L. canescens	hoary gromwell
Lobelia siphilitica	bigblue lobelia
Lotus americanus	Spanishclover deervetch
L. purshianus	pursh deervetch
Lupinus argenteus	silvery lupine
Lupinus plattensis	Nebraska lupine
L. pusillus	rusty lupine
Lygodesmia juncea	rush skeletonplant
L. rostrata	beaked skeletonplant
Malvastrum coccineum	scarlet globemallow
Medicago lupulina	black medic
M. sativa	alfalfa medic
Melilotus alba	white sweetclover
Mentha longifolia	horse mint
Mentzelia nuda	bractless mentzelia
Mirabilis linearis	narrowleaf fouroclock
Monarda pectinata	pony beebalm
Muhlenbergia cuspidata	stoneyhills muhly
M. pungens	sandhill muhly
M. racemosa	green muhly
M. richardsonis	mat muhly
Munroa squarrosa	falsebuffalograss
Oenothera biennis	yellow eveningprimrose
O. serrulata	serrateleaf eveningprimrose
O. rhombipetala	diamond eveningprimrose
O. strigosa	rough sundrops
Opuntia fragilis	brittle pricklypear
O. humifusa	spreading pricklypear
Oryzopsis hymenoides	Indian ricegrass
Oxalis stricta	commonyellow woodsorrel
Oxytropis lambertii	lambert loco
O. sericea	silky loco
Panicum capillare	witchgrass panic
P. obtusum	vinemesquite panic
P. scribnerianum	scribner panic
P. virgatum	switchgrass panic
P. wilcoxianum	wilcox panic
Paspalum stramineum	sand paspalm
Penstemon albidus	white penstemon
P. angustifolius	narrowleaf penstemon
P. glaber	sawsepal penstemon
P. grandiflorus	shell-leaf penstemon
Petalostemum candidum	white prairieclover
P. purpureum	purple prairieclover
P. villosum	silky prairieclover
Astragalus ceramicus	painted milkvetch
Phalaris canariensis	common canarygrass
Phragmites communis	common reed
Physalis heterophylla	clammy groundcherry
P. lanceolata	lanceleaf groundcherry
Plantago patagonica	woolly plantain
Poa arida	plains bluegrass
P. canbyi	canby bluegrass
P. compressa	Canada bluegrass
P. pratensis	Kentucky bluegrass
Polygonum aviculare	prostrate knotweed
P. erectum	erect knotweed
P. persicaria	spottedthumb knotweed
Populus deltoides	eastern poplar
Potentilla arguta	white cinquefoil
Prunus americana	American plum
Prunus besseyi	bessey cherry (western sandcherry)
P. virginiana	common chokecherry
Psoralea argophylla	silverleaf scurfpea
P. esculenta	common breadroot scurfpea
P. lanceolata	lemon scurfpea
P. tenuiflora	slimflower scurfpea
Purshia tridentata	antelope bitterbrush
Ratibida spp.	prairieconeflower
Redfieldia flexuosa	common blowoutgrass
Rhus radicans	poisoning sumac
R. trilobata	skunkbush sumac
Ribes spp.	currant
Rosa spp.	rose
Rumex venosus	veiny dock
Rumex crispus	curly dock
Salix humilis	prairie willow
S. interior	sandbar willow
Senecio plattensis	prairie groundsel

Appendix 1. (continued)

Salsola kali	common russianthistle
Schedonnardus paniculatus	common thumblegrass
Scirpus spp.	bulrush
Setaria lutescens	yellow bristlegrass
S. viridis	green bristlegrass
Sisyrinchium campestre	prairie blueeyedgrass
Sitanion hystrix	bottlebrush squirreltail
Smilacina stellata	starry falsesolomonseal
Solanum nigrum	black nightshade
S. triflorum	cutleaf nightshade
Solidago missouriensis	Missouri goldenrod
S. serotina	smooth goldenrod
Sophora sericea	silky sophora
Sorghastrum nutans	yellow indiangrass
Spartina gracilis	alkali cordgrass
S. pectinata	prairie cordgrass
Specularia perfoliata	clasping venuslookingglass
Sporobolus airoides	alkali sacaton
S. asper	tall dropseed
S. cryptandrus	sand dropseed
S. heterolepis	prairie dropseed
S. vaginiflorus	poverty dropseed
Stipa comata	needleandthread
S. spartea	porcupine needlegrass
S. viridula	green needlegrass
Strophostyles leiosperma	littleflower mealybean
Symphoricarpos occidentalis	western snowberry
Talinum parviflorum	flameflower
Taraxacum officinale	common dandelion
Thelesperma gracilis	slender greenthread
Thermopsis rhombilfolia	prairie thermopsis
Thlaspi spp.	pennycress
Tradescantia occidentalis	prairie spiderwort
Tragopogon pratensis	meadow salsify
Tribulus spp.	puncture vine
Trifolium pratense	red clover
T. repens	white clover
Triplasis purpurea	purple sandgrass
Urtica spp.	nettle
Verbascum thapsus	flannel mullein
Verbena stricta	woolly verbena
Vicia americana	American vetch
Vicia sparsifolia	stiffleaf vetch
Xanthium spp.	cockleburr
Yucca glauca	small soapweed

Appendix 2. Computation of standard normal deviates (standard scores).

$$\text{standard score} = Z_{ijk} = \frac{\overline{X}_{ijk}-X_{jk}}{S_{jk}}$$

$i = 1, 2, \ldots, n$
$j = 1, 2, \ldots, g$
$k = 1, 2, \ldots, y$

where

$$\overline{X}_{jk} = \frac{i = 1 \quad X_{ijk}}{n}$$

and

$$S_{jk} = \sqrt{\frac{\sum_{1=1}^{n} (X_{ijk} - \overline{X}_{jk})^2}{n-1}}$$

and where: n = number of counts on a ground within a year
g = number of grounds
k = number of years
X_{ijk} = raw score for the i^{th} observation on the j^{th} ground in the kth year
$\overline{X}_{jk}$ = the arithmetic mean of raw scores $i = 1, 2, \ldots, n$ on the jth ground in the kth year
S_{jk} = the standard deviation of raw scores on the j^{th} ground in the kth year

Example calculation

Assume numbers of birds observed on a dancing ground during five mornings were: 5, 7, 4, 8, 8

$$\text{Mean} = \overline{X} = \frac{\sum_{i=1}^{5} X_i}{n} = 32/5 = 6.4$$

$$\text{Standard deviation} = S = \sqrt{\frac{\sum_{i=1}^{5} (X_i - 6.4)^2}{4}} = 1.817$$

Standard score = $Z_{i=1} = (5 - 6.4)/1.817 = -0.771$
$Z_{j=2} = (7-6.4)/1.817 = 0.330$
etc.

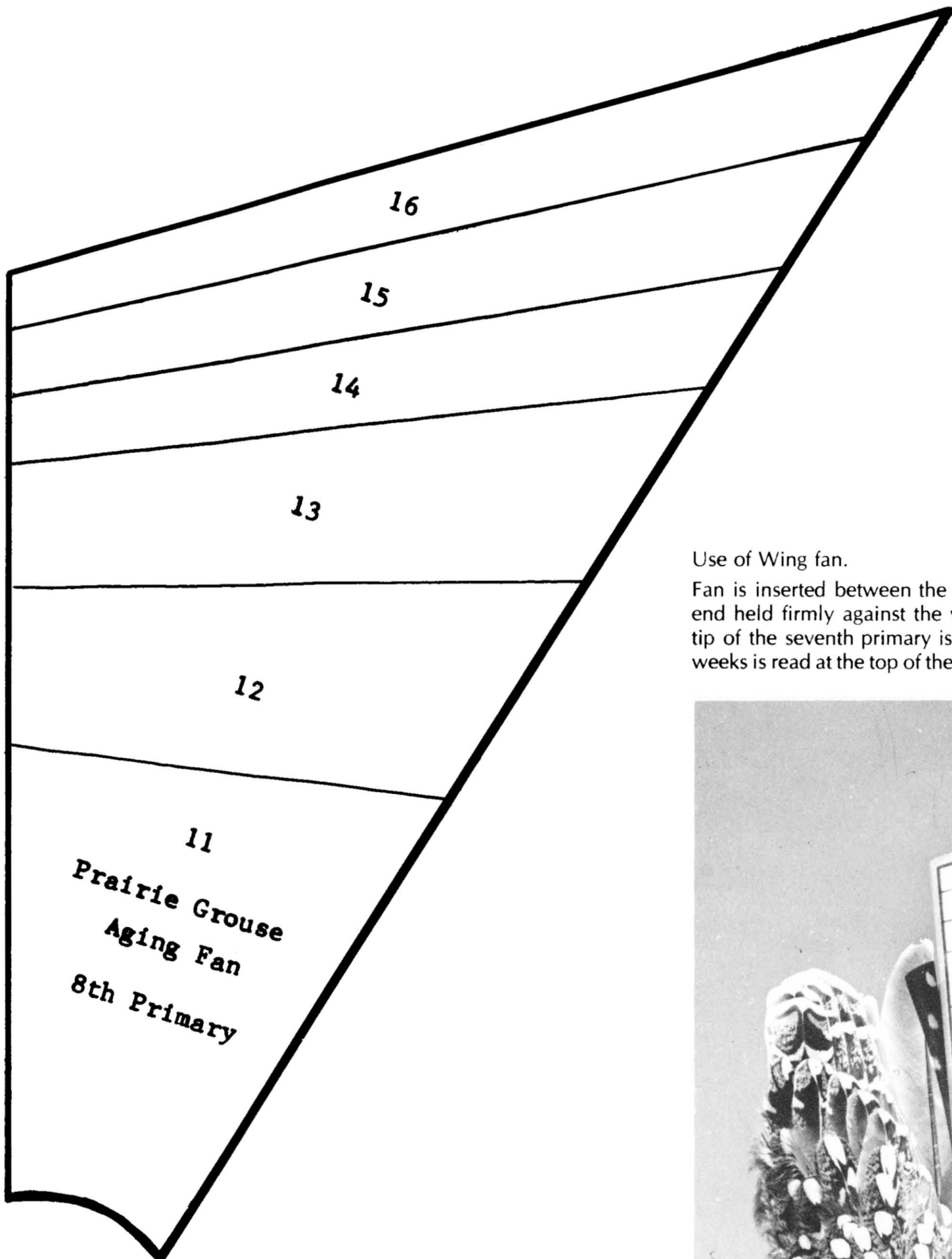
Standard scores characteristically have a mean of 0.0 and a variance of 1.0. Computation of a raw score from a standard score requires that the associated mean and standard deviation are known. Thus, to find the raw scores from the standard scores calculated above:

Raw score = $X_i = S \bullet Z_i + \overline{X}$

$X_{i=1} = 1.817 \bullet (-0.771) + 6.4 = 5.0$

$X_{j=2} = 1.817 \bullet (0.330) + 6.4 = 7.0$

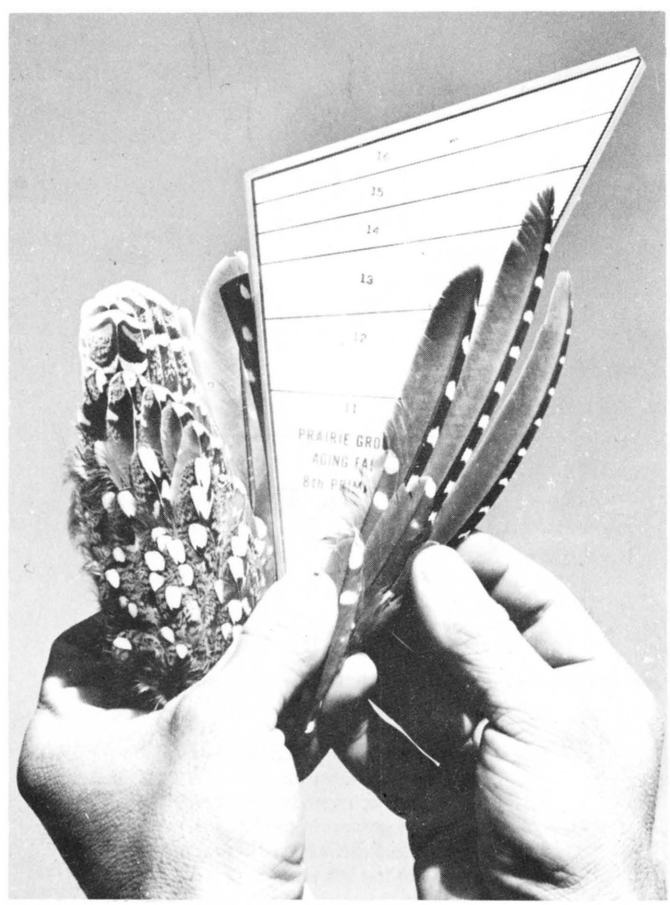
Use of prairie grouse wing fan to age young-of-the-year prairie grouse during fall.



Wing fan actual size.

Use of Wing fan.

Fan is inserted between the seventh and eighth primaries with the small end held firmly against the wing. The fan is then rotated until the distal tip of the seventh primary is even with the top of the fan and the age in weeks is read at the top of the eighth primary.



Appendix 4. Nebraska prairie grouse hunting regulations, 1962 through 1973.

Year	Season Dates (inclusive)		Length of Season (Days)	Bag Limits	
	Open	Closed		Daily	Possession
1962	Oct. 6	Oct. 28	23	2	4
1963	Oct. 5	Oct. 31	27	2	4
1964	Oct. 3	Nov. 11	30	3	6
1965	Sept. 18	Oct. 31	44	2	6
1966	Sept. 17	Oct. 31	45	2	6
1967	Sept. 16	Nov. 5	51	3	9
1968	Sept. 21	Nov. 17	58	3	9
1969	Sept. 20	Oct. 31	42	2	4
1970	Oct. 3	Nov. 15	44	2	6
1971	Sept. 18	Oct. 17	30	2	6
1972	Sept. 16	Oct. 15	30	2	6
1073	Sept. 22	Nov. 4	44	3	6

Appendix 5. Schedules for collection of prairie grouse harvest data on Nebraska National Forest. Bessey Division, 1962 through 1973.

Year	Operation of Check Station	Questionnaires Used?
1962	Each weekend at main entrance	Yes
1963	Each weekend at main entrance	Yes
1964	Each weekend at main entrance	Yes
1965	Each weekend at main entrance	Yes
1966	First weekend at main and Gaston Road entrance;	Yes
	second weekend at main entrance	Yes
1967	First weekend at main and Gaston Road entrance; second and third weekends at main entrance	Yes
1968	First and second weekends at main and Gaston Road entrance	Yes
1969	First weekend at main and Gaston Road entrances	Yes
1970	First weekend at main entrance	No
1971	First weekend at main entrance	No
1972	First weekend at main entrance	No
1973	First weekend at main entrance	No

Appendix 6. Locations and years for 21 active prairie grouse winter trap sites on the Loup County and Swan Lake study areas and in the vicinity of the Bessey study area.

Trap site Number	Study Area	County	Legal Description	Ranch Name	Years Active						
					1959	1960	1961	1963	1964	1965	1966
1	Loup Co.	Loup	NW¼ Sec. 21, T23N, R17W,	Johnson	X	–	–	–	–	–	–
2	Loup Co.	Loup	SW¼ Sec. 29, T23N, R17W,	Reed	X	–	–	–	–	–	–
3	Loup Co.	Loup	SE¼ Sec. 5, T22N, R17W,	Jensen	X	X	–	–	–	–	–
4	Loup Co.	Loup	NE¼ Sec. 26, T23N, R18W,	Wallace	X	–	–	–	–	–	–
5	Swan Lake	Garfield	NW¼ Sec. 3, T24N, R16W,	Maring	X	X	–	–	–	–	–
6	Loup Co.	Loup	NW¼ Sec. 29, T23N, R17W,	Schrup	–	X	X	–	–	–	–
7	Loup Co.	Loup	SE¼ Sec. 9, T22N, R17W,	Scherzberg	–	X	–	–	–	–	–
8	Swan Lake	Garfield	NW¼ Sec. 3, T24N, R16W,	Ackles	–	X	–	–	–	–	–
9	Swan Lake	Garfield	NW¼ Sec. 15, T24N, R16W,	Barthel (South)	–	X	–	–	–	–	–
10	Swan Lake	Holt	NE¼ Sec. 19, T25N, R15W,	Barthel (North)	–	X	–	–	–	–	–
11	Loup Co.	Loup	Sec. 5, T22N, R17W,	Hetfield	–	–	X	–	–	–	–
12	Swan Lake	Holt	NE¼ Sec. 13, T25N, R16W,	De Groff	–	–	X	–	–	–	–
13	Neb. Nat. Forest	Blaine	SW¼ Sec. 6, T22N, R25W,	Sautter	–	–	–	X	X	–	–
14	Neb. Nat. Forest	Thomas	NW¼ Sec. 7, T23N, R28W,	Robinson	–	–	–	X	X	X	X
15	Neb. Nat. Forest	Thomas	SW¼ Sec. 8, T23N, R27W,	Weil No. 1	–	–	–	–	X	–	–
16	Neb. Nat. Forest	Thomas	NW¼ Sec. 8, T23N, R27W,	Weil No. 2	–	–	–	–	X	X	X

(continued)

Trap site Number	Study Area	County	Legal Description	Ranch Name	Years Active 1959	1960	1961	1963	1964	1965	1966
17	Neb. Nat. Forest	Thomas	NE¼ Sec. 10, T23N, R28W,	Weise	–	–	–	–	X	X	–
18	Neb. Nat. Forest	Thomas	SW¼ Sec. 11, T23N, R29W,	Warren	–	–	–	–	–	X	X
19	Neb. Nat. Forest	Thomas	North½ Sec. 9, T23N, R28W,	Johnston	–	–	–	–	–	X	X
20	Neb. Nat. Forest	Thomas	NW¼ Sec. 34, T24N, R28W,	Peters	–	–	–	–	–	X	X
21	Neb. Nat. Forest	Thomas	NE¼ Sec. 9, T23N, R29W,	Hempkin	–	–	–	–	–	X	–

Appendix 7. Movement data on individual prairie grouse. The following abbreviations are used: Species—PC (prairie chicken), ST (sharp-tailed grouse), HB (prairie chicken and sharptail hybrid); Sex—M (male), F (female), U (unknown); Age, A (adult), J (juvenile), U (unknown); type of recovery, R (recapture), H (reported by hunter), O (observed by external marker), D (found dead); Study area—NNF (Nebraska National Forest), LC (Loup County), SL (Swan Lake).

Band Number	Location Marked: Study Area	Trapsite Number	Species	Sex	Age When Marked	Date: Marked or Previously Recovered	Recovered	Elapsed Time: Years	Days	Type of Recovery	Movement: Distance in Miles	Direction
S-78	LC	6	ST	F	A	1-8-60	1-14-60		6	D	0.3	S-SE
S-94	LC	6	ST	M	J	1-9-60	1-16-60		7	D	1.5	S-SW
S-1508	NNF	18	ST	M	A	1-20-66	1-21-66		1	R	2.0	E-NE
						1-21-66	1-28-66		7	R	2.0	W-SW
P-100	LC	3	PC	M	J	1-21-60	1-26-60		5	D	0.3	N-NE
S-1853	NNF	18	ST	M	J	1-20-65	2-1-65		12	R	2.0	E-NE
S-1869	NNF	18	ST	M	A	2-4-65	2-5-65		1	R	2.0	E-NE
						2-5-65	3-12-65		35	R	2.0	W-SW
S-370	NNF	14	ST	F	A	2-1-65	2-6-65		5	R	2.0	W-SW
						2-6-65	2-25-65		19	R	2.0	E-NE
S-1528	NNF	14	ST	M	A	1-28-66	2-12-66		15	R	2.0	E-NE
S-110	LC	6	ST	M	A	1-11-60	2-13-60		33	R	2.5	S-SE
S-1513	NNF	14	ST	M	A	1-28-66	2-19-66		22	R	2.0	E-NE
S-1854	NNF	18	ST	M	J	1-20-65	2-22-65		33	R	1.6	W-NW
						2-26-65	3-9-65		11	R	1.6	E-SE
S-1823	NNF	18	ST	M	J	1-13-65	2-23-65		41	R	1.6	W-NW
P-131	SL	5	PC	F	J	2-16-60	2-23-60		7	R	2.4	S-SW
S-1	LC	4	ST	M	J	2-14-59	2-27-59		13	R	2.5	E-SE
P-130	SL	5	PC	M	J	2-16-60	3-4-60		16	R	2.4	S-SW
S-1976	NNF	19	ST	M	A	2-17-66	3-8-66		19	R	2.2	N-NE
Unknown	NNF	19	PC	U	U	Winter-65	3-10-65		Unknown	O	4.0	Unknown
S-5	LC	4	ST	M	J	2-14-59	3-11-59		25	O	0.3	W-SW
S-1933	NNF	14	ST	M	A	2-6-65	3-12-65		14	D	0.1	Unknown
P-101	LC	3	PC	M	J	1-21-60	3-15-60		53	D	1.0	E-NE
S-1801	NNF	18	ST	F	J	3-13-65	3-16-65		3	R	2.0	E-NE
S-1818	NNF	18	ST	M	A	1-21-65	3-17-65		55	R	2.0	E-NE
P-239	NNF	18	ST	F	A	1-19-65	3-17-65		57	R	2.0	E-NE
S-1942	NNF	19	ST	M	J	3-13-65	3-23-65		10	R	2.2	N-NE
S-1541	NNF	19	ST	F	A	2-20-66	3-24-66		32	R	2.2	N-NE
S-1946	NNF	17	ST	M	J	3-15-65	3-25-65		10	R	3.7	E-NE
S-25	LC	2	ST	M	J	2-26-59	3-25-59		27	O	3.3	S-SE
S-115	LC	3	ST	M	J	1-11-60	4-7-60		86	O	0.1	NW
S-33	LC	2	ST	M	J	2-27-59	3-23-59		25	P	2.5	S-SE
P-104	LC	3	PC	M	A	1-21-60	4-8-60		77	O	0.1	W-NW
						4-8-60	5-1-60		23	O	1.2	W-NW
P-108	LC	3	HB	M	A	1-25-60	4-8-60		73	O	0.1	W-NW

(continued)

						4-8-60	5-1-60		23	O	1.2	W-NW
P-109	LC	3	PC	M	J	1-26-60	4-8-60		72	O	3.5	W-NW
Unknown	NNF	19	PC	U	U	Winter-65	4-9-65		Unknown	O	2.2	Unknown
S-63	LC	3	ST	M	U	1-5-60	4-10-60		95	O	1.5	N-NE
S-99	LC	3	ST	M	J	1-9-60	4-10-60		91	O	1.5	N-NE
S-105	LC	6	ST	M	A	1-11-60	4-12-60		91	O	1.0	W-NW
S-214	SL	9	ST	F	A	2-25-60	4-15-60		49	D	1.0	S-SW
Unknown	NNF	14	ST	M	U	Winter-65	4-19-65		Unknown	O	1.1	Unknown
Unknown	NNF	18	ST	M	U	Winter-65	4-19-65		Unknown	O	2.0	Unknown
Unknown	NNF	19	PC	M	U	Winter-65	4-19-65		Unknown	O	2.8	Unknown
Unknown	NNF	19	PC	M	U	Winter-65	4-19-65		Unknown	O	2.8	Unknown
P-229	NNF	19	PC	M	A	2-18-66	4-21-66		62	O	2.8	Unknown
Unknown	NNF	19	PC	M	U	Winter-66	4-21-66		Unknown	O	2.8	Unknown
S-56	SL	5	ST	F	J	3-5-59	4-29-59		45	O	30.3	W-SW
S-381	NNF	15	ST	M	J	1-27-64	5-9-64		103	D	0.5	W-SW
P-208	SL	12	PC	M	A	3-15-61	5-10-61		56	O	2.5	S-SE
S-201	SL	10	ST	M	J	2-17-60	5-19-60		91	O	1.0	S-SE
P-274	NNF	15	ST	M	A	3-25-64	6-1-64		97	D	1.5	E-NE
S-86	LC	6	ST	M	J	1-8-60	6-5-60		148	D	0.7	S-SE
P-19	SL	5	PC	M	J	3-4-59	6-18-59		106	D	1.0	SE
S-1511	NNF	16	ST	M	A	1-19-66	6-20-66		152	D	0.7	Unknown
S-2000	NNF	Nest	ST	F	J	6-17-65	6-26-65		9	D	0.0	
P-199	SL	Nest	PC	F	A	6-1-60	8-12-60		72	O	0.5	N-NE
P-88	SL	Nest	PC	F	A	6-12-59	7-29-59		48	O	1.2	N-NE
P-88	SL	Nest	PC	F	A	7-29-59	8-3-59		5	O	0.6	S-SE
						8-3-59	8-4-59		1	O	0.3	S-SW
						8-4-59	8-18-59		14	O	0.6	N-NW
						8-18-59	8-19-59		1	O	0.3	S-SE
						8-19-59	8-20-59		1	O	0.1	W-NW
S-192	LC	3	ST	F	J	2-15-60	10-5-63	3	232	H	3.0	N-NW
S-232	LC	7	ST	M	U	3-21-60	10-13-60		206	H	0.5	N-NE
S-275	LC	6	ST	F	A	2-7-61	10-28-64	3	254	H	0.5	N-NW
S-276	LC	6	ST	F	J	2-7-61	10-7-61		242	H	1.0	W-SW
S-279	LC	6	ST	M	J	2-7-61	10-14-61		249	H	1.0	W-SW
S-284	LC	6	ST	F	J	2-7-61	10-7-61		242	H	1.0	S-SW
P-81	SL	5	PC	M	J	3-5-59	10-5-59		214	H	15.0	W-NW
P-85	SL	5	PC	M	J	3-5-59	10-4-59		213	H	2.0	S-SW
P-199	SL	Nest	PC	F	A	8-12-60	10-8-60		57	H	0.0	
S-309	NNF	13	ST	F	A	2-3-63	10-5-63		244	H	1.7	S-SW
S-372	NNF	13	ST	M	A	3-12-63	10-5-63		207	H	0.4	S-SW
S-376	NNF	Display gr.	ST	M	A	4-24-63	10-5-63		164	H	0.6	N-NW
S-377	NNF	Display gr.	ST	M	A	4-24-63	10-22-63		183	H	0.8	N-NW
S-322	NNF	14	ST	M	A	2-9-63	10-15-64	1	249	H	0.0	
S-423	NNF	14	ST	M	J	1-30-64	10-21-64		265	H	0.0	
S-429	NNF	14	ST	M	J	1-31-64	10-8-64		251	H	0.3	N-NE
S-333	NNF	14	ST	F	A	2-19-63	10-31-64	1	255	H	2.0	W-SW
S-1997	NNF	20	ST	M	J	4-7-65	9-18-65		164	H	2.1	N-NE
S-1972	NNF	20	ST	F	A	3-24-65	9-18-65		178	H	3.4	W-NW
S-1841	NNF	17	ST	F	J	1-17-65	10-23-65		279	H	20.6	E-SE
S-1828	NNF	14	ST	F	A	1-13-65	10-7-65		267	H	3.0	S
P-245	NNF	14	ST	F	J	2-5-64	10-17-65	1	254	H	9.0	E-SE
S-1551	NNF	Display gr.	ST	M	J	5-13-66	10-7-66		146	H	0.0	
S-1524	NNF	18	ST	F	A	1-20-66	10-16-66		270	H	44.0	S-SW

Band Number	Location Marked: Study Area	Location Marked: Trapsite Number	Species	Sex	Age When Marked	Date: Marked or Previously Recovered	Date: Recovered	Elapsed Time: Years	Elapsed Time: Days	Type of Recovery	Movement: Distance in Miles	Movement: Direction
S-1882	NNF	16	ST	F	J	2-20-65	9-17-66	1	208	H	12.0	S
S-1907	NNF	16	ST	F	J	2-22-65	10-4-66	1	223	H	3.4	S-SW
S-315	NNF	13	PC	M	A	2-7-63	10-5-63		240	H	0.4	S-SW
S-366	NNF	13	PC	M	A	3-3-63	10-5-63		216	H	0.4	S-SW
S-51	LC	2	ST	M	A	2-27-59	1-16-60		323	R	2.8	N-NE
P-239	NNF	14	ST	F	A	2-3-64	1-12-65		343	R	2.0	W-SW
P-247	NNF	14	ST	M	A	2-10-64	2-4-65		359	R	2.0	W-SW
S-469	NNF	17	ST	F	A	1-25-65	3-8-66	1	42	R	2.1	N-NW
S-1869	NNF	18	ST	M	A	3-12-65	1-19-66		313	R	8.0	E-NE
S-1976	NNF	20	ST	M	A	3-26-65	2-17-66		328	R	2.2	S-SW
S-498	NNF	16	ST	M	J	3-25-64	5-13-66	2	48	D	0.0	

Appendix 8. Frequencies of transect-quadrat vegetation samples by activity and month.

Activity	NUMBER OF SAMPLES: January	February	April	May	June	July	August	September	October	Totals
Control					20	20	20			60
Courtship			17	20	2					39
Nesting				2	35	4				41
Brooding					7	39	17			63
Loafing	1	1		1	11	43	13	3		73
Feeding	8				2	8		2	8	28
Roosting		1			1	1	2	2		7
TOTALS	9	2	17	23	78	115	52	7	8	311

Appendix 9. Numbers of crops of sharp-tailed grouse and prairie chicken by season[1] and county of collection.

County	SHARP-TAILED GROUSE: Spring	Summer	Fall	Winter	Unknown	Totals	PRAIRIE CHICKEN: Spring	Summer	Fall	Winter	Unknown	Totals
Blaine	2	1	9			12			6			6
Brown	1	1	28			30			16			16
Cherry		1	15	3		19						0
Custer	2	1	4			7						0
Dawes		1				1						0
Gage						0			1			1
Garfield			5	2		7			7			7
Holt			7			7	2	1	9			12
Hooker		1		1		2						0
Keya Paha	1		1			2			1			1
Lincoln						0			1			1
Logan		2	6			8			4			4
Loup	1	1		3		5			2			2
McPherson			2			2			5			5
Rock	1	3	48	1	1	54	1	2	30			33
Sheridan		1	2			3						0
Thomas	11	6	261	11	1	290			6	1		7
Wheeler			21			21			6			6
Unknown			4			4			1			1
TOTALS	19	19	413	21	2	474	3	3	95	1		102

[1]Spring = March, April, May
Summer = June, July, August
Fall = September, October, November
Winter = December, January, February

Appendix 10. Numbers of crops of sharp-tailed grouse and prairie chicken by sex, age and season of collection.

Species	Sex	Age	Spring	Summer	Fall	Winter	Unknown	Totals
			SEASON					
Sharp-tail		Juvenile	2	5	111	4	1	123
	Male	Adult	7	1	76	7	1	92
		Unknown	1		4			5
		Sub-Totals	10	6	191	11	2	220
	Female	Juvenile	1	6	114	8		129
		Adult	4	4	97	2		107
		Unknown	1		2			3
		Sub-Totals	6	10	213	10	0	239
	Unknown	Juvenile		3	3			6
		Adult	2					2
		Unknown	1		6			7
		Sub-Totals	3	3	9	0	0	15
	TOTALS		19	19	413	21	2	474
Prairie Chicken	Male	Juvenile		1	36			37
		Adult		1	12	1		14
		Unknown			1			1
		Sub-Totals	0	2	49	1	0	52
	Female	Juvenile			25			25
		Adult	3		16			19
		Unknown			1			1
		Sub-Totals	3	0	42	0	0	45
	Unknown	Juvenile		1	3			4
		Adult						
		Unknown			1			1
		Sub-Totals	0	1	4	0	0	5
	TOTALS		3	3	95	1	0	102
	GRAND TOTALS		22	22	508	22	2	576

Appendix 11. Numbers of crops of sharp-tailed grouse and prairie chickens by season and presence of contents.

Crops	Spring	Summer	Fall	Winter	Unknown	Totals
	SEASON					
SHARP-TAIL						
With contents	18	16	382	21	2	439
Empty	1	3	31	0	0	35
Total	19	19	413	21	2	474
PRAIRIE CHICKEN						
With contents	3	3	77	1	0	84
Empty	0	0	18	0	0	18
Total	3	3	95	1	0	102

Appendix 12. Frequencies of occurrence and weights of foods identified in crops of 18 sharp-tailed grouse collected during spring.

	Frequency		Weight in Grams		
Food Name	Actual	Percent	Mean	Total	Percent
		—PLANT—			
Rosa	9	50.0	7.36	66.23	28.9
Artemisia	6	33.3	4.56	27.37	12.0
Solidago	6	33.3	4.47	26.84	11.7
Carex	4	22.2	0.63	2.53	1.1
Eriogonum	4	22.2	0.04	0.15	0.1
Medicago	4	22.2	3.59	14.35	6.3
Poa	3	16.7	0.20	0.60	0.3
Zea	3	16.7	12.51	37.52	16.4
Equisetum	2	11.1	0.01	0.02	0.0
Juniperus	2	11.1	0.56	1.12	0.5
Lepidium	2	11.1	0.16	0.31	0.1
Tragopogon	2	11.1	0.89	1.77	0.8
Trifolium	2	11.1	0.25	0.50	0.2
Amaranthus	1	5.5	0.16	0.16	0.1
Ambrosia	1	5.5	0.02	0.02	0.0
Antennaria	1	5.5	0.11	0.11	0.1
Euphorbia	1	5.5	0.01	0.01	0.0
Helianthus	1	5.5	0.05	0.05	0.0
Hymenopappus	1	5.5	0.11	0.11	0.1
Lithospermum	1	5.5	0.01	0.01	0.0
Opuntia	1	5.5	0.33	0.33	0.1
Paspalum	1	5.5	0.01	0.01	0.0
Penstemon	1	5.5	0.79	0.79	0.3
Populus	1	5.5	7.74	7.74	3.4
Prunus	1	5.5	0.04	0.04	0.0
Psoralea	1	5.5	1.64	1.64	0.7
Salix	1	5.5	1.51	1.51	0.6
Sorghum	1	5.5	3.70	3.70	1.6
Stipa	1	5.5	0.01	0.01	0.0
Triticum	1	5.5	8.41	8.41	3.7
Unknown plant	26	—	0.92	23.81	10.4
TOTAL PLANT	92	—	—	227.77	99.5
		—ANIMAL—			
Locustidae	4	22.2	0.20	0.80	0.4
Tettigoniidae	2	11.1	0.06	0.12	0.1
Chrysomelidae	1	5.5	0.05	0.05	0.0
Cicadellidae	1	5.5	0.01	0.01	0.0
Formicidae	1	5.5	0.02	0.02	0.0
Unknown Insect	1	5.5	0.01	0.01	0.0
TOTAL INSECT	10	—	—	1.01	0.5
		—GRIT—			
Grit	2	11.1	0.04	0.08	0.0
TOTAL FOOD & GRIT	104			228.86	100.0

Appendix 13. Frequencies of occurrence and weights of foods identified in crops of 16 sharp-tailed grouse collected during summer.

Food Name	Frequency Actual	Frequency Percent	Weight in Grams Mean	Weight in Grams Total	Weight in Grams Percent
		–PLANT–			
Lithospermum	4	25.0	0.03	0.11	0.3
Polygonum	3	18.8	0.23	0.69	1.7
Taraxacum	3	18.8	5.26	15.79	38.0
Physalis	2	12.5	1.01	2.03	4.9
Rosa	2	12.5	0.03	0.05	0.1
Tragopogon	1	6.3	0.17	0.17	0.4
Amaranthus	1	6.3	0.32	0.32	0.8
Cenchrus	1	6.3	0.01	0.01	0.0
Trifolium	1	6.3	1.00	1.00	2.4
Erigeron	1	6.3	0.07	0.07	0.2
Euphorbia	1	6.3	0.23	0.23	0.6
Hordeum	1	6.3	0.38	0.38	0.9
Lepidium	1	6.3	0.01	0.01	0.0
Paspalum	1	6.3	0.01	0.01	0.0
Psoralea	1	6.3	0.29	0.29	0.7
Solidago	1	6.3	0.07	0.07	0.2
Unknown plant	26	–	0.12	3.09	7.4
TOTAL PLANT	51	–	–	24.32	58.6
		–ANIMAL–			
Locustidae	11	68.8	1.21	13.27	32.0
Chrysomelidae	7	43.8	0.23	1.58	3.8
Formicidae	7	43.8	0.01	0.08	0.2
Tettigoniidae	5	31.3	0.12	0.62	1.5
Tenebrionidae	4	25.0	0.16	0.64	1.5
Cicadellidae	3	18.75	0.04	0.13	0.3
Pentatomidae	3	18.75	0.06	0.19	0.5
Scutelleridae	2	12.5	0.01	0.02	0.1
Vespidae	2	12.5	0.05	0.11	0.3
Arachnida	1	6.3	0.01	0.01	0.0
Braconidae	1	6.3	0.01	0.01	0.0
Carabidae	1	6.3	0.17	0.17	0.4
Cicindelidae	1	6.3	0.08	0.08	0.2
Curculionidae	1	6.3	0.01	0.01	0.0
Gryllidae	1	6.3	0.05	0.05	0.1
Miridae	1	6.3	0.01	0.01	0.0
Myrmeleontidae	1	6.3	0.06	0.06	0.2
Nabidae	1	6.3	0.01	0.01	0.0
Unknown insect	3	18.75	0.04	0.11	0.3
TOTAL ANIMAL	56	–	–	17.16	41.4
		–GRIT–			
Grit	2	12.5	0.01	0.02	0.1
TOTAL FOOD & GRIT	109	–	–	41.50	100.0

Appendix 14. Frequency of occurrence and weights of foods identified in crops of 382 sharp-tailed grouse collected during fall.

	Frequency		Weight in Grams		
Food Name	Actual	Percent	Mean	Total	Percent
		–PLANT–			
Rosa	256	67.0	3.65	934.14	50.5
Helianthus	69	18.1	1.24	85.77	4.6
Prunus	65	17.0	2.77	180.12	9.7
Rhus	50	13.1	2.95	159.35	8.6
Euphorbia	48	12.6	0.09	4.32	0.2
Solidago	48	12.6	0.21	9.94	0.5
Erigeron	45	11.8	0.15	6.84	0.4
Lygodesmia	38	10.0	0.19	7.03	0.4
Trifolium	33	8.6	0.70	23.20	1.3
Ambrosia	25	6.5	0.06	1.53	0.1
Panicum	22	5.8	0.04	0.86	0.0
Symphoricarpos	21	5.5	0.58	12.20	0.7
Physalis	19	5.0	0.52	9.82	0.5
Polygonum	19	5.0	0.19	3.53	0.2
Cyperus	17	4.4	0.06	0.94	0.1
Taraxacum	13	3.4	0.33	4.24	0.2
Artemisia	8	2.1	0.06	0.49	0.0
Salix	6	1.6	0.04	0.22	0.0
Elaeagnus	5	1.3	7.54	37.72	2.0
Eragrostis	5	1.3	0.01	0.08	0.0
Juniperus	4	1.5	0.26	1.04	0.1
Petalostemum	4	1.5	0.03	0.10	0.0
Astragalus	3	0.8	0.01	0.02	0.0
Vicia	3	0.8	0.30	0.89	0.0
Andropogon	2	0.5	0.02	0.03	0.0
Antennaria	2	0.5	0.02	0.04	0.0
Avena	2	0.5	2.17	4.35	0.2
Carex	2	0.5	0.03	0.05	0.0
Lepidium	2	0.5	0.03	0.05	0.0
Medicago	2	0.5	0.55	1.10	0.1
Hordeum	2	0.5	0.17	0.34	0.0
Melilotus	2	0.5	0.08	0.16	0.0
Poa	2	0.5	0.12	0.24	0.0
Ribes	2	0.5	0.33	0.66	0.0
Triticum	2	0.5	2.36	4.72	0.3
Vitis	2	0.5	12.36	24.72	1.3
Amorpha	1	0.3	0.14	0.14	0.0
Bouteloua	1	0.3	0.03	0.03	0.0
Buchloe	1	0.3	0.01	0.01	0.0
Celtis	1	0.3	0.27	0.27	0.0
Commelina	1	0.3	0.03	0.03	0.0
Crataegus	1	0.3	0.20	0.20	0.0
Eriogonum	1	0.3	0.04	0.04	0.0
Linum	1	0.3	0.02	0.02	0.0
Lithospermum	1	0.3	0.01	0.01	0.0

(continued)

Malva	1	0.3	0.08	0.08	0.0
Paspalum	1	0.3	0.01	0.01	0.0
Pinus	1	0.3	0.01	0.01	0.0
Redfieldia	1	0.3	0.01	0.01	0.0
Rumex	1	0.3	0.84	0.84	0.0
Setaria	1	0.3	0.08	0.08	0.0
Haplopappus	1	0.3	0.01	0.01	0.0
Sisyrinchium	1	0.3	0.08	0.08	0.0
Sorghastrum	1	0.3	0.01	0.01	0.0
Sporobolus	1	0.3	0.01	0.01	0.0
Verbena	1	0.3	0.13	0.13	0.0
Unknown Plant	289	–	0.14	40.58	2.2
TOTAL PLANT	1,159	–	1.35	1,563.45	84.6
		– ANIMAL –			
Locustidae	224	58.6	1.13	252.90	13.7
Carabidae	66	17.3	0.09	6.20	0.3
Cicadellidae	53	13.9	0.03	1.38	0.1
Pentatomidae	52	13.6	0.06	3.12	0.2
Tettigoniidae	37	9.7	0.12	4.51	0.2
Gryllidae	36	9.4	0.09	3.38	0.2
Scutelleridae	34	8.9	0.03	0.92	0.0
Chrysomelidae	28	7.3	0.02	0.53	0.0
Formicidae	27	7.1	0.04	1.03	0.1
Coccinellidae	19	5.0	0.02	0.44	0.0
Tenebrionidae	12	3.1	0.05	0.60	0.0
Membracidae	7	1.8	0.02	0.13	0.0
Miridae	7	1.8	0.01	0.08	0.0
Arachnida	5	1.3	0.01	0.07	0.0
Coreidae	5	1.3	0.01	0.07	0.0
Noctuidae	5	1.3	0.04	0.18	0.0
Pieridae	3	0.8	0.05	0.14	0.0
Scarabaeidae	3	0.8	0.03	0.08	0.0
Agrionidae	2	0.5	0.07	0.13	0.0
Cercopidae	2	0.5	0.03	0.07	0.0
Cicindelidae	2	0.5	0.04	0.07	0.0
Pentostomidae	2	0.5	0.01	0.02	0.0
Cicadidae	1	0.3	0.01	0.01	0.0
Coengaionidae	1	0.3	0.06	0.06	0.0
Corizidae	1	0.3	0.01	0.01	0.0
Curculionidae	1	0.3	0.01	0.01	0.0
Dermestidae	1	0.3	0.04	0.04	0.0
Endomychidae	1	0.3	0.01	0.01	0.0
Ichneumonidae	1	0.3	0.01	0.01	0.0
Myrmeleontidae	1	0.3	0.06	0.06	0.0
Sphecidae	1	0.3	0.06	0.06	0.0
Tabanidae	1	0.3	0.07	0.07	0.0
Vespidae	1	0.3	0.02	0.02	0.0
Unknown Insect	19	–	0.08	1.50	0.1
TOTAL ANIMAL	661	–	0.42	277.91	15.0
		– GRIT –			
Grit	57	14.9	0.12	6.73	0.4
TOTAL FOOD & GRIT	1,877	–	0.98	1,848.09	

Appendix 15. Frequencies of occurrence and weights of foods identified in crops of 21 sharp-tailed grouse collected during winter.

	Frequencies		Weight in Grams		
Food Name	Actual	Percent	Mean	Total	Percent
		—PLANT—			
Rosa	14	66.7	9.51	133.07	31.5
Prunus	9	42.9	1.50	13.52	3.2
Solidago	8	38.1	4.36	34.84	8.2
Rhus	6	28.6	5.08	30.45	7.2
Trifolium	5	23.8	6.21	31.04	7.3
Antennaria	4	19.1	0.92	3.68	0.9
Artemisia	4	19.1	2.44	9.75	2.3
Erigeron	4	19.1	0.31	1.25	0.3
Euphorbia	4	19.1	0.09	0.37	0.1
Helianthus	4	19.1	0.27	1.07	0.3+
Panicum	4	19.1	0.02	0.09	0.0
Salix	4	19.1	0.15	0.59	0.1
Juniperus	3	14.3	16.24	48.73	11.5
Medicago	3	14.3	3.14	9.43	2.2
Populus	3	14.3	1.99	5.97	1.4
Stipa	3	14.3	5.82	17.45	4.1
Eriogonum	2	9.5	0.21	0.41	0.1
Oenothera	2	9.5	3.43	6.86	1.6
Pinus	2	9.5	4.13	8.25	2.0
Symphoricarpos	2	9.5	8.72	17.43	4.1
Zea	1	4.8	20.85	20.85	4.9
Andropogon	1	4.8	0.01	0.01	0.0
Hordeum	1	4.8	0.01	0.01	0.0
Polygonum	1	4.8	0.08	0.08	0.0
Unknown plant	24	—	1.11	26.57	6.3
TOTAL PLANT	118	—	—	421.77	99.7
		—ANIMAL—			
Locustidae	6	28.6	0.19	1.16	0.3
Carabidae	1	4.8	0.01	0.01	0.0
Cicadellidae	1	4.8	0.02	0.02	0.0
Coccinellidae	1	4.8	0.02	0.02	0.0
TOTAL ANIMAL	9	—	—	1.21	0.3
TOTAL FOOD	127	—	—	422.98	100.0

Appendix 16. Frequencies of occurrence and weights of foods identified in crops of 77 prairie chickens collected during fall.

	Frequency		Weight in Grams		
Food Name	Actual	Percent	Mean	Total	Percent
		—PLANT—			
Rosa	28	36.4	2.13	59.67	27.8
Polygonum	19	24.7	0.17	3.31	1.6
Linum	13	16.9	0.09	1.21	0.6
Trifolium	13	16.9	0.76	9.91	4.6
Euphorbia	10	13.0	1.27	12.68	5.9
Ambrosia	8	10.4	0.03	0.26	0.1
Taraxacum	7	9.1	0.18	12.39	5.8
Vicia	7	9.1	0.93	6.51	3.0
Helianthus	7	9.1	1.09	7.66	3.6
Cyperus	4	5.2	0.07	0.29	0.1
Lithospermum	4	5.2	0.12	0.48	0.2
Lygodesmia	4	5.2	0.28	1.13	0.5
Andropogon	3	3.9	0.01	0.02	0.0

(continued)

Chenopodium	3	3.9	0.01	0.04	0.0
Erigeron	3	3.9	0.02	0.05	0.0
Medicago	3	3.9	0.75	2.26	1.1
Panicum	3	3.9	0.02	0.06	0.0
Paspalum	3	3.9	0.02	0.05	0.0
Physalis	3	3.9	0.16	0.48	0.2
Solidago	3	3.9	0.21	0.63	0.3
Zea	3	3.9	3.41	10.24	4.8
Carex	2	2.6	0.01	0.01	0.0
Lactuca	2	2.6	0.08	0.16	0.1
Eragrostis	1	1.3	0.01	0.01	0.0
Lespedeza	1	1.3	0.85	0.85	0.4
Lotus	1	1.3	0.27	0.27	0.1
Oxalis	1	1.3	0.01	0.01	0.0
Poa	1	1.3	0.01	0.01	0.0
Prunus	1	1.3	0.03	0.03	0.0
Rhus	1	1.3	0.01	0.01	0.0
Sorghastrum	1	1.3	0.01	.01	0.0
Stipa	1	1.3	0.01	.01	0.0
Unknown forb	1	1.3	0.33	.33	0.2
Astragalus	1	1.3	0.01	.01	0.0
Yucca	1	1.3	0.77	.77	0.4
Unknown Plant	74	–	0.27	19.59	9.1
TOTAL PLANT	241	–	–	151.41	70.5
		–ANIMAL–			
Locustidae	43	55.8	1.31	56.33	26.2
Carabidae	17	22.1	0.04	0.66	0.3
Cicadellidae	15	19.5	0.02	0.34	0.2
Pentatomidae	15	19.5	0.05	0.72	0.3
Gryllidae	11	14.3	0.19	2.10	1.0
Tettigoniidae	11	14.3	0.08	0.87	0.4
Scutelleridae	10	13.0	0.03	0.33	0.2
Coccinellidae	7	9.1	0.01	0.09	0.0
Formicidae	7	9.1	0.04	0.26	0.1
Chrysomelidae	6	7.8	0.03	0.16	0.1
Arachnida	1	1.3	0.01	0.01	0.0
Asilidae	1	1.3	0.06	0.06	0.0
Cercopidae	1	1.3	0.01	0.01	0.0
Corizidae	1	1.3	0.02	0.02	0.0
Ichneumonidae	1	1.3	0.01	0.01	0.0
Miridae	1	1.3	0.01	0.01	0.0
Noctuidae	1	1.3	0.02	0.02	0.0
Phasmatidae	1	1.3	0.04	0.04	0.0
Pieridae	1	1.3	0.01	0.01	0.0
Pyrrhocoridae	1	1.3	0.04	0.04	0.0
Scoliidae	1	1.3	0.01	0.01	0.0
Tenebrionidae	1	1.3	0.11	0.11	0.1
Trichoptera	1	1.3	1.01	1.01	0.5
Unknown Insect	7	9.1	0.02	0.02	0.0
TOTAL ANIMAL	162	–	–	63.24	29.4
		–GRIT–			
Grit	15	19.5	0.01	0.14	0.1
TOTAL FOOD & GRIT	418	–	–	214.79	100.0

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