310

310

HABITAT-USE, REPRODUCTIVE SUCCESS, AND SURVIVAL OF FEMALE LESSER PRAIRIE CHICKENS IN TWO YEARS OF CONTRASTING WEATHER

BY

STEVEN SCOT MERCHANT, B.S.

A Thesis submitted to the Graduate School

in partial fulfillment of the requirements

for the Degree

Master of Science

Major Subject: Wildlife Science

New Mexico State University

Las Cruces, New Mexico

May 1982

"Habitat-Use, Reproductive Success, and Survival of Female Lesser Prairie Chickens in Two Years of Contrasting Weather," a thesis prepared by Steven Scot Merchant in partial fulfillment of the requirements for the degree, Master of Science, has been approved and accepted by the following:

William H. Matchett
Dean of the Graduate School

Charles Davis
Chairman of the Examining Committee

April 1, 1982
Date

Committee in charge:

Dr. Charles A. Davis, Chairman

Dr. Reldon F. Beck

Dr. Jerry Holechek

Dr. Raul Valdez

ACKNOWLEDGMENTS

I would like to sincerely thank Dr. Charles A. Davis for his guidance, advice, and patience throughout my course of study. I also thank Drs. R. F. Beck, J. Holechek, and R. Valdez for their critical comments.

The New Mexico Department of Game and Fish should be thanked for funding the project and for providing permits, equipment, and personnel. Bitter Lake National Wildlife Refuge also generously donated the use of trapping equipment.

I would like to extend my thanks to the following persons who not only helped with trapping prairie chickens, but who also provided amiable companionship: Roxy Ahlborn, Kathy Cheap, Ross Hier, James Rietzel, Alan Spitznagel, Bruce Sterling, David Still, Thomas Thompson, Mike Wisdom, and John Wondzell. I would especially like to thank David L. Wilson and Gary G. Ahlborn for their friendship, assistance, and data sharing.

Finally, I would like to thank my family for their continual understanding and support.

VITA

April 7, 1957 - Born at Elkhart, Indiana

1975 - Received high school diploma, Elkhart Central High School, Elkhart

1979 - Received Bachelor of Science degree in Forestry, Wildlife Ecology Option, Michigan Technological University, Houghton, Michigan

PROFESSIONAL AND HONORARY SOCIETIES

The Wildlife Society

Prairie Grouse Technical Council

PUBLICATIONS

Merchant, S. S. 1981. A possible hunting relationship between two raptor species. Raptor Research. Submitted.

ABSTRACT

HABITAT-USE, REPRODUCTIVE SUCCESS, AND SURVIVAL
OF FEMALE LESSER PRAIRIE CHICKENS IN TWO
YEARS OF CONTRASTING WEATHER

BY

STEVEN SCOT MERCHANT, B.S.

Master of Science in Wildlife Science
New Mexico State University
Las Cruces, New Mexico, 1982
Dr. Charles A. Davis, Chairman

Spring and summer habitat-use, home ranges, reproductive success, and survival of female lesser prairie chickens (Tympanuchus pallidicinctus) in Roosevelt and Lea counties, New Mexico, are contrasted between 1979 and 1980. In 1979, weather was near optimal for prairie chicken reproduction and survival, whereas in 1980, drought conditions existed. Effects of these conditions are discussed.

Eight habitat types were delineated in the study area: 3 types in the shinnery oak (Quercus havardii)-grassland

(Shinnery Oak-Bluestem, Sandhills, and Shinnery Oak-Midgrass), 4 disturbed types (Reverted Cropland, Weeping Lovegrass, Fallow, and Cultivated), and a Shortgrass type.

Most habitat-use by prairie chickens in spring and summer occurred in the 3 shinnery oak-grassland types. Sandhills and Shinnery Oak-Bluestem were preferred habitat types during prenesting, nesting, and postnesting periods. In 1980, when drought conditions prevailed, use of Shinnery Oak-Bluestem (good and excellent range condition classes) was higher than in 1979, while use of Shinnery Oak-Midgrass (poor and fair range condition classes) was lower. The Sandhill type (fair and good range condition classes) was used less in 1980 than in 1979, but it remained the most preferred type. The use of disturbed types was higher during the drought conditions of 1980, but they still were not preferred types.

Home ranges were larger in 1980 during the prenesting, postnesting, and overall spring-summer period. The increased size of home ranges in 1980 was attributed to effects of the drought.

All indices to reproductive success were lower for 1980 than for 1979. These included the percent of females nesting, percent of females renesting, percent of successful nests, number of brood observations, and mean brood size. The lower reproductive success in 1980 was attributed to direct and indirect influences of the drought.

Spring and summer survival of females was lower in 1980, probably due to increased vulnerability to predators, which was associated with the stressful drought conditions. Mammals, mostly coyotes, were the major predators of prairie chickens during both 1979 and 1980.

Spring lek counts reflected the previous year's nesting success and survival. The number of occupied leks apparently is a better index to population levels than is the mean number of males per lek.

TABLE OF CONTENTS

Page

LIST OF TABLES

Table Page

LIST OF FIGURES

INTRODUCTION

New Mexico supports the only stable, nonthreatened population of lesser prairie chickens (Tympanuchus pallidicinctus)[1] in existence today (Crawford 1980), but the species remains relatively unknown within the state. Studies by Frary (1957) and Davis et al. (1979) have provided some information on the habitat needs of lesser prairie chickens in New Mexico, but a better understanding of their habitat-use is still needed. Specifically, the plasticity of habitat needs, including home ranges, must be known. Habitat requirements in optimal years may be different from habitat requirements in drought years. Periodic droughts are common throughout the range of the lesser prairie chicken; and, if viable populations are to be maintained, management practices must supply the species' needs during these drought periods.

Factors which diminish grassland, which prairie chickens depend on, probably exert their greatest pressure on populations by limiting reproduction (Svedarsky 1969). Despite this, reproductive data for lesser prairie chickens are few. Davis et al. (1979) reported the fate of 36 nests discovered in Chaves County, New Mexico, but yearly differences in nesting success were not discussed. Campbell (1972) reported the percentage of young prairie chickens in hunters'

---

[1]Common and scientific names of birds follow the American Ornithologists' Union (1976).

bags from 10 years of New Mexico hunts, and only commented that variation in the percent of young birds may have been due to the effects of weather on breeding success. If populations are to be correctly managed, especially if they are to provide huntable surpluses, changes in yearly reproduction must be known.

This report evolved from a project funded by the New Mexico Department of Game and Fish and the New Mexico State University Agricultural Experiment Station. The objective was to gather the information needed to develop management practices which could enhance prairie chicken populations in New Mexico. Overall results were reported by Davis et al. (1982). The specific objectives of my part of the study were to 1) compare differences in spring and summer habitat-use, home ranges, survival, and reproduction between the 2 years of the study, and 2) discuss how the contrasting weather conditions in the 2 years may have influenced the above results. Data were collected mostly during spring and summer of 1979 and 1980. Limited data were collected during spring 1981.

STUDY AREA

The study area consists of 14,510 ha occupied mostly by shinnery oak-grassland, located approximately 65 km south of Portales, New Mexico, with the community of Milnesand at its northwestern corner. The area is bordered on the north by NM Highway 262, and on the west by NM Highway 18 (Fig. 1). The Milnesand Prairie Chicken Restoration Area, a 3,108 ha parcel of land administered by the New Mexico Department of Game and Fish, is centrally located within the study area. The remaining portion of the study area is in private ownership.

Climate of the area is semiarid, with an average annual precipitation rate of 38.4 cm (U.S. Dept. Com. 1980). Typically, 75 percent of the precipitation occurs from April through September, principally in the form of thundershowers. Monthly mean temperatures at Crossroads, located 4 km south of the study area, range from 3.6°C in January to 24.6°C in July. Extended periods with temperatures exceeding 35°C are common from June through August. Freezing nighttime temperatures occur from November through February.

Cattle grazing, as well as the exploration and development of oil and gas, occurs throughout the study area. Dryland farming is also practiced in the area; sorghum and winter wheat are the major crops. Recreational hunting is an important land-use practice, especially on the state-owned land.

Eight habitat types are delineated within the study area (Fig. 2). Generally, variation among habitat types is due to past land-use practices, as well as soil differences. A brief description and the percent of each habitat type in the study area are given below. More detailed descriptions of the vegetation of the 4 habitats most essential to prairie chickens (Ahlborn 1980) are presented in Tables 1-4.

Shinnery Oak-Bluestem (21.14%): Homogeneous shinnery oak (*Quercus havardii*)[2] cover, interspersed with little bluestem (*Schizachyrium scoparius*) and sand bluestem (*Andropogon hallii*), is the most obvious characteristic of this habitat type. This type is generally in the good and excellent range condition classes (Ross and Bailey 1967). Soils are fine sands, and the topography is level.

Shinnery Oak-Midgrass (25.46%): Homogeneous shinnery oak cover and the conspicuous lack of bluestems are characteristic of this type. Three-awns (*Aristida* spp.), dropseeds (*Sporobolus* spp.), and gramas (*Bouteloua* spp.) are the dominant grasses. Soils and topography are the same as in the Shinnery Oak-Bluestem type; therefore, vegetative differences in these 2 habitat types are attributed

[2]Common and scientific plant names follow Correll and Johnston (1970).

Table 1. Percent basal cover[a] of vegetation in 4 habitat types. Mean and standard error values reported. Sample size in parentheses.

	Vegetation type			
Categories	Shinnery Oak-Bluestem (170)	Sandhills (120)	Shinnery Oak-Midgrass (100)	Reverted Cropland (220)
Vegetation	10.9 ± 0.8	2.8 ± 0.5	6.8 ± 0.7	7.2 ± 0.6
Rank	1	4	3	2
Bare	50.2 ± 1.8	57.5 ± 2.2	58.5 ± 2.3	59.9 ± 1.9
Rank	4	3	2	1
Litter	38.9 ± 1.7	39.0 ± 2.2	34.7 ± 2.1	32.2 ± 1.8
Rank	2	1	3	4

[a]From Ahlborn (1980), from line-point transects (Heady et al. 1959).

Table 2. Percent canopy cover[a] of vegetation in 4 habitat types. Mean and standard error values reported. Sample size in parentheses.

Species	Oak-Bluestem (170)	Sandhills (120)	Oak-Midgrass (100)	Reverted Cropland (220)
Grasses				
Little bluestem	5.5 ± 0.6	1.1 ± 0.3	0.5 ± 0.2	2.7 ± 0.3
Sand bluestem	3.7 ± 0.5	0.3 ± 0.2	0.1 ± 0.1	3.2 ± 0.4
Silver bluestem	--	--	--	1.1
Bluestem total	9.2 ± 0.7	1.4 ± 0.3	0.6 ± 0.3	7.0 ± 0.5
Three-awns	2.0 ± 0.4	1.2 ± 0.3	3.3 ± 0.6	4.0 ± 0.4
Dropseeds	0.6 ± 0.2	0.3 ± 0.2	0.3 ± 0.2	1.1 ± 0.2
Gramas	2.0 ± 0.4	0.1 ± 0.1	1.3 ± 0.4	0.3 ± 0.1
Fall witchgrass	0.2	0.1	0.1	0.2
Paspalum	0.5	0.2	0.6	0.2
Lovegrasses	1.6	0.1	1.5	1.6
Others	0.1	0.2	0.2	0.5
Total Grasses	16.2 ± 1.2	3.6 ± 0.6	7.9 ± 1.1	14.9 ± 1.0
Shrubs				
Shinnery oak	17.8 ± 0.6	31.9 ± 1.4	22.9 ± 1.3	8.7 ± 0.6
Snakeweed	0.8	0.1	1.5	1.7
Sand sage	0.4	1.0	--	--
Yucca	0.4		0.3	0.7
Others	--	--	--	--
Total Shrubs	19.4 ± 1.2	33.0 ± 1.7	24.7 ± 1.7	10.1 ± 1.2
Total Forbs	0.8 ± 0.4	0.9 ± 0.3	0.1 ± 0.1	2.0 ± 0.4
Grand Totals	36.4 ± 1.4	38.2 ± 1.8	32.7 ± 1.8	27.0 ± 1.4

[a]From Ahlborn (1980), from line-point transects (Heady et al. 1959).

Table 3. Percent basal composition[a] of vegetation in 4 habitat types. Mean and standard error values reported. Sample size in parentheses.

Species	Oak-Bluestem (170)	Sandhills (120)	Oak-Midgrass (100)	Reverted Cropland (220)
Grasses				
Little bluestem	15.3 ± 0.9	3.8 ± 0.5	3.3 ± 0.6	9.9 ± 0.6
Sand bluestem	9.2 ± 0.7	1.9 ± 0.4	0.5 ± 0.2	8.4 ± 0.6
Silver bluestem	--	--	--	2.4 ± 0.3
Bluestem total	24.5 ± 1.0	5.7 ± 0.7	3.8 ± 0.6	20.7 ± 0.9
Three-awns	7.8 ± 0.6	9.4 ± 0.8	17.0 ± 1.2	16.0 ± 0.8
Dropseeds	6.3 ± 0.6	3.2 ± 0.5	8.9 ± 0.9	8.0 ± 0.6
Gramas	8.6 ± 0.6	6.3 ± 0.7	9.4 ± 0.9	2.0 ± 0.3
Fall witchgrass	3.9 ± 0.5	3.8 ± 0.5	5.4 ± 0.7	1.3 ± 0.2
Paspalum	5.3 ± 0.5	3.2 ± 0.5	7.1 ± 0.8	3.9 ± 0.4
Lovegrasses	5.6 ± 0.6	2.6 ± 0.4	7.6 ± 0.8	9.2 ± 0.9
Others	1.3	1.9	1.6	4.1
Total Grasses	63.3 ± 1.1	36.1 ± 1.4	60.8 ± 1.5	65.2 ± 1.0
Shrubs				
Shinnery oak	22.5 ± 1.0	44.8 ± 1.4	29.1 ± 1.4	13.0 ± 0.7
Snakeweed	2.7 ± 0.4	0.2 ± 0.1	3.8 ± 0.6	2.7 ± 0.4
Sand sage	0.2 ± 0.1	1.8 ± 0.4	--	t
Yucca	0.3 ± 0.1	t	0.1 ± 0.1	0.4 ± 0.1
Others	--	--	--	0.2
Total Shrubs	25.7 ± 1.1	46.8 ± 1.4	33.0 ± 1.5	16.3 ± 0.8
Total Forbs	11.0 ± 0.8	16.6 ± 1.1	6.2 ± 0.8	18.5 ± 0.8

[a]From Ahlborn (1980), from line-point transects (Heady et al. 1959).

Table 4. Height (cm) of canopy cover[a] of vegetation in 4 habitat types. Mean and standard error values reported. Sample size in parentheses.

Species	Oak-Bluestem (123)	Sandhills (113)	Oak-Midgrass (96)	Reverted Cropland (201)
Grasses				
Little bluestem	30.8 ± 1.4	43.2 ± 5.8	22.5 ± 2.9	43.0 ± 3.0
Sand bluestem	32.0 ± 2.6	28.8 ± 6.4	30.0 ± --	42.7 ± 2.5
Silver bluestem	--	--	--	25.2 ± 1.9
Bluestem total	31.3 ± 1.3	39.8 ± 4.8	23.6 ± 2.7	40.0 ± 1.7
Three-awns	32.4 ± 2.5	26.5 ± 3.7	28.4 ± 2.3	33.7 ± 1.7
Dropseeds	26.4 ± 2.9	43.0 ± 7.8	14.7 ± 2.4	32.1 ± 2.5
Gramas	22.2 ± 1.8	10.0 ± --	18.7 ± 3.0	24.0 ± 4.6
Fall witchgrass	13.0 ± 1.0	5.0 ± --	17.0 ± --	11.8 ± 2.1
Paspalum	19.1 ± 1.8	26.3 ± 5.9	17.5 ± 3.8	20.0 ± 3.21
Lovegrasses	21.9 ± 1.7	20.0 ± --	18.6 ± 2.8	29.1 ± 2.6
Others	--	--	--	--
Total Grasses	28.5 ± 0.9	32.9 ± 2.7	22.9 ± 1.4	35.4 ± 1.0
Shrubs				
Shinnery oak	26.4 ± 0.5	34.1 ± 0.6	27.2 ± 0.7	41.0 ± 1.5
Snakeweed	19.2 ± 1.9	25.0 ± --	17.9 ± 1.2	18.8 ± 2.4
Sand sage	39.2 ± 4.0	45.4 ± 2.9	--	--
Yucca	37.2 ± 1.2	--	50.3 ± 6.9	44.3 ± 3.9
Others	--	--	--	--
Total Shrubs	26.6 ± 0.5	34.4 ± 0.6	27.0 ± 0.7	39.7 ± 1.4
Total Forbs	17.5 ± 1.7	31.8 ± 5.3	15.0 ± --	26.8 ± 1.6
Grand Totals	27.2 ± 0.5	34.2 ± 0.6	25.9 ± 0.6	36.4 ± 0.8

[a]From Ahlborn (1980), from line-point transects (Heady et al. 1959).

to cattle grazing (Ahlborn 1980). The Shinnery Oak-Midgrass type is in the poor and fair range condition classes (Ross and Bailey 1967).

Sandhills (6.71%): This type is characterized by rolling dunes formed from wind-blown sand. Shinnery oak is the dominant cover plant, while grass cover is sparse. However, where grasses are present, they occur in tall clumps. Bluestem abundance is intermediate between that of the Shinnery Oak-Bluestem and the Shinnery Oak-Midgrass types. Purple three-awn (*Aristida purpurea*) is the most common grass. The range condition classes (Ross and Bailey 1967) of this type are fair and good.

Reverted Cropland (16.25%): This type includes old fields that have not been plowed recently. The type is characterized by sand hummocks and wind-eroded areas where the sandy, clay-loam subsoil has been exposed. Shinnery oak is found only on the sand hummocks, while the exposed subsoil supports a variety of grasses and forbs. Due to the spotty distribution of topsoil, plant cover is discontinuous.

Shortgrass (12.38%): This type is found on the tighter soils of the study area. Vegetation is composed primarily of shortgrasses, including buffalo grass (*Buchloe dactyloides*), sandbur (*Cenchrus incertus*), and grama grasses. Snakeweed

(Xanthocephalum sarothrae) also is a conspicuous component of this type.

Weeping Lovegrass (8.68%): This type is characterized by leveled pastures seeded to weeping lovegrass (Eragrostis curvula var. ermela). Less commonly, side oats grama (Bouteloua curtipendula) or switchgrass (Panicum virgatum) is combined with the weeping lovegrass.

Fallow Fields (6.25%): This type is characterized by recently abandoned cultivated fields, where invading annuals form the majority of the plant species. Dominant plants include cocklebur (Xanthium saccharatum), sunflower (Helianthus spp.), and four-point evening primrose (Oenothera rhombipetala).

Cultivated (3.13%): This type is present in scattered areas of tight soils found in the study area. Sorghum and, less commonly, winter wheat are grown using dryland techniques.

METHODS

Trapping and Radiotagging

Cannon nets (Dill and Thornsberry 1950) were used to capture 42 female lesser prairie chickens on spring leks (Davis et al. 1980). Solar-powered transmitters (from Wildlife Materials, Inc., Carbondale, IL and Telemetry Systems, Inc., Mekon, WI) were attached to 41 females during the 2 spring trapping periods. The transmitters, each weighing approximately 13 g, were attached using wing loops constructed from flat elastic webbing (Riley 1978). The total package, including transmitter and harness, weighed approximately 18 g.

Radiotracking

Birds were radiotracked using a truck-mounted whip antenna and a hand-held yagi antenna in conjunction with a portable radio receiver (Wildlife Materials, Inc.). Radio contact was first obtained by using the nondirectional whip antenna. The hand-held yagi antenna was then used to determine more precise locations. Radio locations were taken from points (2 or more) recognizable on 1:7920 scale aerial photographs, usually from within 500 m of the bird. Fixed-wing aircraft (New Mexico Department of Game and Fish; and Lautterbach Flying Service, Portales, NM) were used on 6 occasions to contact birds that could not be located by the above method. For each radio contact with a bird, date, time, and habitat type were recorded in a notebook. Locations were mapped on aerial photo overlays.

Due to the large size of the study area, the number of radio-tagged birds, and imposed gasoline limits, birds were not radio-located daily. However, birds were located every second or third day.

Radiotelemetry was used to find 25 of the 26 nests discovered during the study.

Reproductive Periods

Radiotelemetry data were stratified into 3 major reproductive periods: the prenesting, nesting, and postnesting periods. The overall prenesting period extended from 31 March to 21 May. The prenesting period of an individual female was considered to extend from the date of her capture to the date she began egg-laying. For nonnesting females, a prenesting period was calculated by adding the mean number of prenesting days (from nesting females) to the date of capture for the nonnesting female.

The overall nesting period included egg-laying and incubation periods, and extended from 27 April to 6 July. For a nonnesting female, a "nesting" period was calculated by adding the mean number of nesting days (from known nesting females) to the end of the non-nesting female's calculated prenesting period.

The postnesting period followed the nesting period. This reproductive period was stratified into postnest brood (females with broods) and postnest nonbrood (broodless females). The postnesting period and the total spring-summer seasonal period ended when broods began to disperse and birds began to visit fall leks. This occurred on 15 August in 1979 and 20 August in 1980.

Preference Indices and Habitat Availability

Habitat-preference indices were calculated separately for prenesting, nesting, and postnesting periods. As a first step in developing a preference index, it was necessary to determine the percent availability (% of study area) for each habitat type. The method used was a modification of that of Robel et al. (1970). I assumed that a given habitat type was not prairie chicken habitat in a season when no birds were found using it. Therefore, only those types utilized by chickens in that season were considered when computing the percent availability for each type. Percent availability for a type was calculated by dividing the total area of a habitat type within the study area by the total area of all of the habitat types within the study area which were actually utilized during the period (Table 5). Only habitat types actually used during the period were considered in constructing a preference index for 2 reasons. First, data from this study and others (cited by Davis et al. 1979) indicate that female lesser prairie chickens are very mobile. Therefore, it appeared that all habitat types and all

Table 5. Percent availability figures[a] used to calculate preference indices.

Habitat type	Reproductive period		
	Prenesting	Nesting	Postnesting
Shinnery Oak-Bluestem	30.39	27.02	24.13
Shinnery Oak-Midgrass	36.60	32.54	29.06
Sandhills	9.65	8.58	7.66
Reverted Cropland	23.36	20.77	18.55
Weeping Lovegrass	NU[b]	11.09	9.90
Fallow	NU	NU	7.13
Cultivated	NU	NU	3.57
Shortgrass	NU	NU	NU

[a]Percent of all available habitat represented by the type.

[b]Indicates this habitat type was not used during the period, in either year. It was therefore considered nonhabitat, thus not available, and was not used in calculating preference indices.

parts of the study area were accessible. So, it seemed obvious that unused types were not truly prairie chicken habitat. Secondly, although it was important to know which habitat types within the study area were not utilized during a given period, it was clear that including those habitat types in the preference-index calculation would cause a positive bias in preference-index values for all of the utilized types.

Home Ranges

Home ranges were calculated for each reproductive period and for the entire spring-summer period. For any given reproductive period, a minimum of 4 radio locations was needed to delineate a home range. A total spring-summer range was determined only for birds that were radiotracked from their dates of capture to within 1 week of the end of the period. If a bird was lost for over 2 weeks, a total seasonal range was not determined. A compensating polar planimeter was used to measure home ranges by the minimum area method (Mohr 1947). Student *t* tests (McClave and Dietrich 1979:292) were used to compare home-range sizes statistically.

Reproductive Success

The percent of captured females that initiated a nest was used as a general index of prenesting survival and nesting. Nesting success was determined for all 26 nests discovered during the study by using guidelines suggested by Rearden (1951) and Davis et al.

(1979). Numbers of broods, including those discovered while conducting census transects (Ahlborn 1980), were used as an indicator of the results of total hatching success combined with brood survival to midsummer. Age ratios calculated from birds captured on fall leks (trapping technique was the same as for spring) were used as a general indicator of reproductive success.

Spring Lek Counts

Leks were found by systematically driving all existing roads in the study area, stopping to listen for audible lekking activity (gobbling, cackling, etc.) at 2-km intervals. In addition, each existing "oil pad" (hard-surfaced drilling site) in the study area was checked for lek use. Where roads were farther than 2 km apart, the search was continued by walking between the roads and listening for lekking activity. Males were counted on leks from 15 March to 15 May, between 1 hour before and 2 hours after sunrise.

WEATHER

Weather was near average in 1979 with respect to overall temperature and precipitation, but in 1980 temperature generally was above average and precipitation below average (Figs. 3 and 4). Moisture conditions were even worse during much of 1980 than these general data indicate, because the drought actually began in fall 1979. Only 17 percent of the average precipitation occurred from September through December of that year, and only 33 percent of the average occurred from January through July of 1980.

Comparisons for selected seasons emphasize further the contrast between 1979 and 1980 conditions. April and May (spring) weather was near average in 1979, but was relatively cool and dry in 1980 (Table 6). June through August (summer) weather was relatively cool and moist in 1979, but hot and dry in 1980 (Table 7). Weather during the first 10 days after the estimated mean hatching date for lesser prairie chicken nests also illustrates the hot, dry conditions of 1980 (Table 8).

The drought of late 1979 and 1980 had a pronounced influence on the vegetation within the study area. Field observations indicated that early spring forbs were much less abundant in 1980 than in 1979. Forbs also remained scarce throughout the summer of 1980. Campbell et al. (1973), working approximately 115 km south of the present study area, found a strong positive correlation between

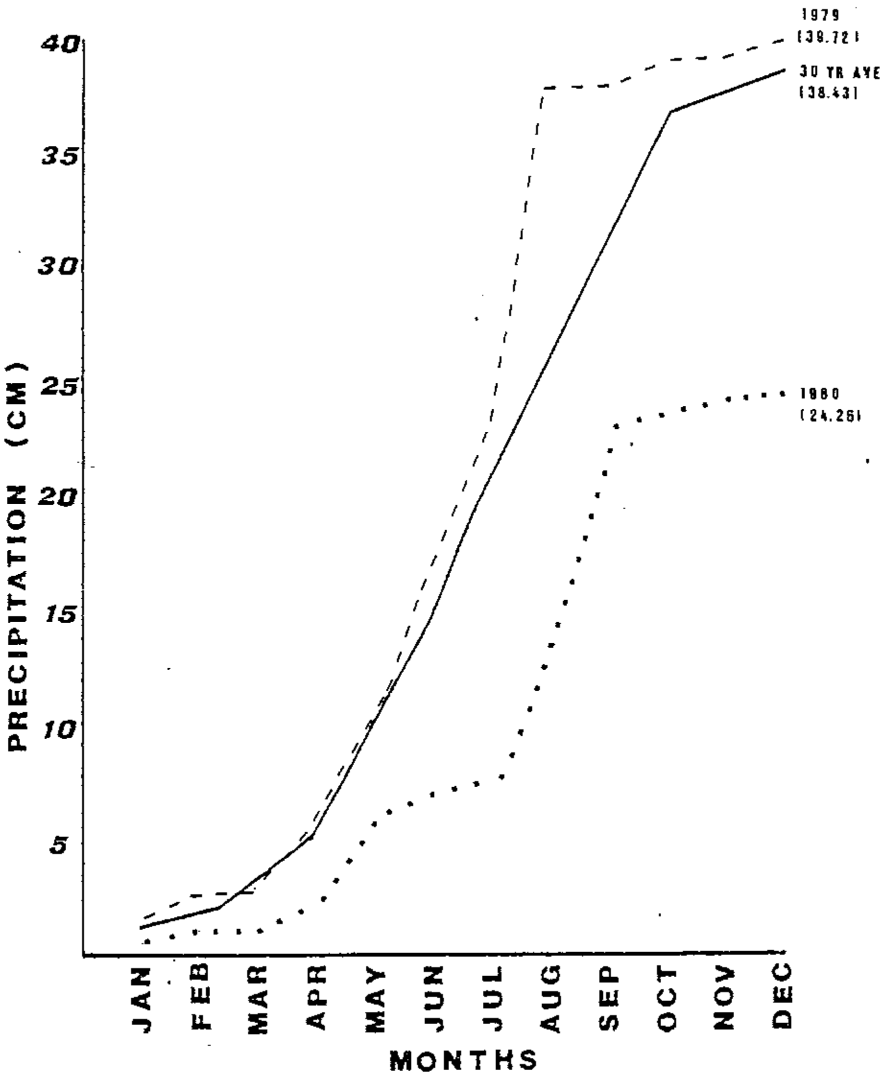

Fig. 3. Cumulative annual precipitation at Crossroads, New Mexico, 1979-80 (U.S. Dept. Com. 1979, 1980).

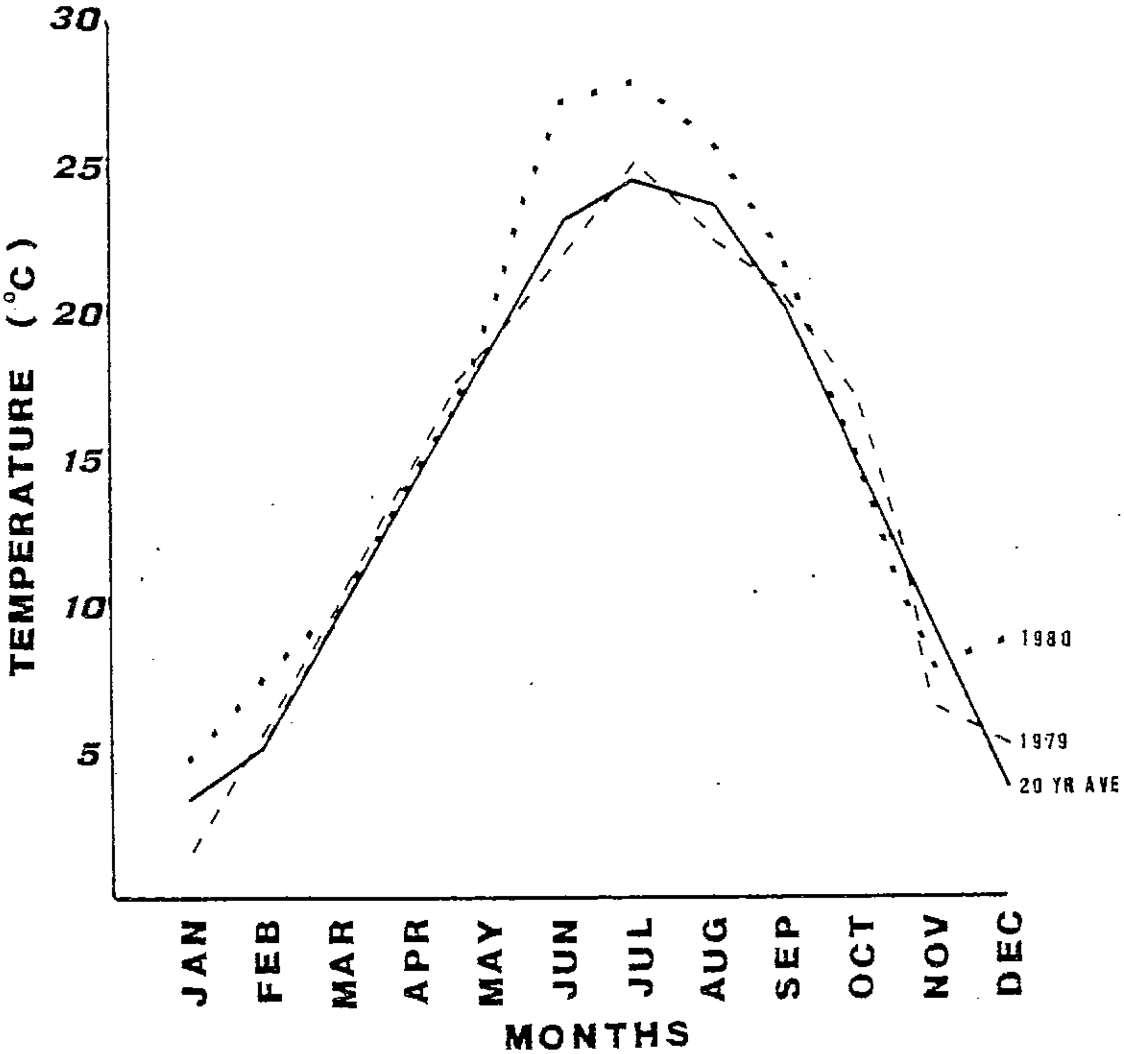

Fig. 4. Monthly temperature averages at Crossroads, New Mexico, 1979-80 (U.S. Dept. Com. 1979, 1980).

Table 6. Summarized temperature and precipitation data from April and May, 1979 versus 1980, at Crossroads, New Mexico (U.S. Dept. Com. 1979, 1980).

Year	No. days with min. temp. $\leq 0°C$	No. days with max. temp. $\geq 32°C$	No. rainy days <1.26 cm (≤ 0.50 in.)[a]	No. rainy days 1.27–2.53 cm (0.51–0.99 in.)	No. rainy days ≥ 2.54 cm (≥ 1.00 in.)	Total rainfall (cm)	Mean temperature (°C)
1979	4	4	3	1	1	6.35 (-0.13)[b]	17.0
1980	10	4	8	1	1	4.90 (-1.58)	16.4

[a] Data originally presented in English units.

[b] Deviation in cm from the 30-year mean.

Table 7. Summarized temperature and precipitation data for June through August, 1979 and 1980, at Crossroads, New Mexico (U.S. Dept. Com. 1979, 1980).

Year	No. days with max. temp. ≥32°C	No. days with max. temp. ≥37°C	No. rainy days <1.26 cm (≤0.50 in.)[a]	1.27-2.53 cm (0.51-0.99 in.)	≥2.54 cm (≥1.00 in.)	Total rainfall (cm)	Mean temperature (°C)
1979	45	4	13	7	2	28.0 (+11.3)[b]	23.5
1980	82	38	8	0	1	7.8 (- 8.9)	26.8

[a]Data originally presented in English units.

[b]Deviation in cm from the 30-year mean.

Table 8. Temperature and precipitation data for the first 10 days following the estimated mean hatching date[a] (U.S. Dept. Com. 1979, 1980).

Year	Dates	Mean max. temp. and range (°C)	Mean min. temp. and range (°C)	Rainfall (cm)	Max. daily rainfall (cm)
1979	5-15 June	30.0 24.4-36.7	11.6 7.8-15.5	2.7	1.3
1980	16-26 June	38.8 35.0-41.1	18.3 16.1-20.6	T[b]	T

[a]Determined from radiotagged females. In 1980, when no successful nests were found, the mean hatching date was calculated by adding 37 days to the mean egg-laying date: 11 for egg-laying and 26 for incubation (Svedarsky 1969, for greater prairie chickens).

[b]Less than 0.2 cm.

precipitation and forb availability. The shortage of rainfall beginning in September 1979 no doubt caused the lower forb abundance.

Shinnery oak was affected by the drought. Spring catkin- and leaf-emergence typically occurs within the first week of April in eastern New Mexico (C. A. Davis, New Mexico State University, Las Cruces, pers. comm.), but in 1980 it was delayed until the last week of April. This delay apparently was in response to the low spring soil moisture. Also, the drought effects became so severe in July 1980 that some shinnery oak plants began to drop their leaves prematurely.

Bluestem grasses were also noticeably affected by the drought conditions of late 1979 and 1980. Virtually no new growth was observed in little bluestem and sand bluestem during the 1980 growing season.

The apparent effects of the drought on lesser prairie chickens, via their effects on habitat-use, home ranges, reproduction, and survival, are discussed in the following sections.

HABITAT-USE

The use of a habitat by prairie chickens is a reflection of its ability to provide life-sustaining resources for the species. The supply of these resources, including food, water, and cover, is influenced by several factors, including weather. Therefore, changes in yearly habitat-use may be attributable, at least in part, to changes in weather conditions. Since contrasting weather conditions were evident between the 2 years of the study (Figs. 3 and 4), yearly habitat-use differences were investigated under the premise that differences in weather were responsible for differences in habitat-use.

Habitat-use was independent of the year ($\chi^2 = 2.896$, $P < 0.25$, Table 9) for the prenesting period. Possibly, the effects of the drought in 1980 were less significant during this period as compared to later in the summer and therefore did not significantly influence habitat-use.

For the nesting period, general habitat-use was dependent on the year ($\chi^2 = 10.336$, $P < 0.05$, Table 10). Examination of individual chi-square values suggests that the increased use of Reverted Cropland and Weeping Lovegrass in 1980 was responsible for the difference in habitat-use.

The small sample of nest sites precludes statistical comparisons of habitat-use between years for nest sites, but some differences were apparent. Use of the Sandhills and Shinnery Oak-Bluestem

Table 9. Chi-square test of independence[a] for yearly habitat-use during the prenesting period.

Habitat type	1979		1980		Totals	χ^2 (1 df)
	Observed[b]	Expected	Observed	Expected		
Shinnery Oak-Bluestem	19	20.80	71	69.20	90	0.203
Sandhills	13	10.63	33	35.37	46	0.687
Shinnery Oak-Midgrass	8	10.86	39	36.14	47	0.979
Reverted Cropland	9	6.70	20	22.30	29	1.027
Totals	49	49	163	163	212	2.896 ns[c] (3 df)

[a]From Steel and Torrie (1960:366).

[b]The number of radio locations during the period.

[c]Not significant, $P < 0.25$.

Table 10. Chi-square test of independence[a] for yearly habitat-use during the nesting period.

Habitat type	1979 Observed[b]	1979 Expected	1980 Observed	1980 Expected	Totals	χ^2 (1 df)
Shinnery Oak-Bluestem	81	71.69	56	65.31	137	2.536
Sandhills	25	29.83	32	27.17	57	1.639
Shinnery Oak-Midgrass	39	39.77	37	36.23	76	0.031
Reverted Cropland / Weeping Lovegrass[c]	1	4.71	8	4.29	9	6.130**[d]
Totals	146	146	133	133	279	10.336** (3 df)

[a]From Steel and Torrie (1960:366).

[b]The number of radio locations during the period.

[c]Values combined because of the low number of expected locations.

[d]Significant at $P < 0.05$.

types for nest sites was not greatly dissimilar for the 2 years (Table 11). However, 33 percent (5) of the 1979 nests occurred in the Shinnery Oak-Midgrass type, but only 18 percent (2) of the 1980 nests occurred in this type (Table 11). One nest was found in Reverted Cropland and one in Weeping Lovegrass in 1980, whereas no nests were observed in these 2 types in 1979 (Table 11).

These data for the nesting period suggest that the higher use of Reverted Cropland and Weeping Lovegrass in 1980 may have occurred at the expense of Shinnery Oak-Midgrass use. The lack of bluestem grasses in the Shinnery Oak-Midgrass type (sampled in 1979, Tables 1-4) indicates that it has been the most heavily grazed of the 3 shinnery oak-grassland types which have not been cultivated or mechanically disturbed (Sandhills, Shinnery Oak-Bluestem, Shinnery Oak-Midgrass). The drought conditions of 1980 must have further reduced the relatively low forage production in this type, thereby reducing its use during the nesting period. Tall grasses (primarily bluestems) are preferred nesting cover for lesser prairie chickens in eastern New Mexico (Davis et al. 1979). Possibly, females found Shinnery Oak-Midgrass less attractive for nest sites in 1980 because of the further reduction of tall grasses and, instead, searched out areas such as Weeping Lovegrass where tall grasses were abundant. Forbs were most abundant in the Reverted Cropland type, and this may have influenced its use during the nesting period of 1980, when forb availability was low throughout the shinnery oak grassland. It should be noted that, although the use of the Shinnery Oak-Midgrass

Table 11. Preference indices of relative use of habitat types for nest site placement, 1979 and 1980.

Habitat type	1979			1980		
	Observed no. nests per habitat type	Expected no. nests per habitat type[a]	Preference index[b]	Observed no. nests per habitat type	Expected no. nests per habitat type	Preference index
Shinnery Oak-Bluestem	8	4.04	1.98	5	2.96	1.69
Sandhills	2	1.21	1.65	2	0.89	2.23
Shinnery Oak-Midgrass	5	4.90	1.02	2	3.60	0.55
Reverted Cropland	0	3.12	0.00	1	2.28	0.44
Weeping Lovegrass	0	1.67	0.00	1	1.23	0.81
Fallow	NU[c]			NU		
Cultivated	NU			NU		
Shortgrass	NU			NU		

[a]Expected number of nests per type was calculated by multiplying the total number of nests by the percentage of available area occupied by that type.

[b]Number of nests per type (Observed) divided by the Expected number of nests.

[c]Indicates no use in either year; therefore, it was not considered available habitat and was not used in calculating preference indices.

type for nest sites decreased in 1980, this type was still used to a greater extent than was Reverted Cropland or Weeping Lovegrass.

Habitat-use for the postnesting period was strongly dependent on the year ($\chi^2 = 37.902$, $P < 0.005$, Table 12). Habitat-use by females with broods in 1979 was not significantly different from that of broodless females in the same year ($\chi^2 = 1.9836$, $P < 0.75$); therefore, yearly differences in habitat-use were not attributed to the fact that all 1980 hens were broodless.

Temperatures reached their maximum, while rainfall continued low, during the postnesting period of 1980. Yearly differences in habitat-use were more significant for the postnesting period than for other periods (Tables 9-12), strongly suggesting that such differences were weather-influenced. Examination of individual chi-square values (Table 12) suggests that the increased use of Shinnery Oak-Bluestem, decreased use of Sandhills and Shinnery Oak-Midgrass, and increased use of disturbed types (Reverted Cropland, Weeping Lovegrass, Fallow, and Cultivated) in 1980 all contributed to habitat-use being dependent on the year. A likely causative interaction between weather, livestock forage, and habitat-use is described below.

In the semiarid Great Plains, decreased plant cover associated with high stocking rates is a major reason for low water intake rates (Rhoades et al. 1964). Since production of forage (which is also prairie chicken cover and food) is dependent on soil moisture, lightly grazed sites (which perforce absorb precipitation more

Table 12. Chi-square test of independence[a] for yearly habitat-use during the postnesting period.

Habitat type	1979 Observed[b]	1979 Expected	1980 Observed	1980 Expected	Totals	χ^2 (1 df)
Shinnery Oak-Bluestem	43	60.98	189	171.02	232	7.191**[c]
Sandhills	46	30.75	71	86.24	117	10.260**
Shinnery Oak-Midgrass	38	25.49	59	71.51	97	8.328**
Reverted Cropland	1	6.04	22	16.95	23	5.703**
Weeping Lovegrass, Fallow, Cultivated[d]	0	4.73	18	13.27	18	6.416**
Totals	128	128	359	359	487	37.898** (4 df)

[a]From Steel and Torrie (1960:366).

[b]The number of radio locations during the period.

[c]Significant at $P < 0.05$.

[d]Values combined because of the low number of expected locations.

effectively) may be more effective than heavily grazed sites in producing plant growth in years of light rainfall (Rhoades et al. 1964). It appears logical, then, that within the 3 types of shinnery oak-grassland, prairie chicken-use of lightly grazed habitats would increase during drought periods, while the use of more heavily grazed habitats would decrease. This is what occurred during the postnesting period, as prairie chicken-use of Shinnery Oak-Bluestem (least grazed, as indicated by range condition classification) increased in 1980, while use of Shinnery Oak-Midgrass (heavily grazed) decreased (Table 13). The lower use of Sandhills in 1980 (good and fair range classes, Table 13) may have been due to the degradation of vegetation in the type because of drought, which may have been more severe than degradation of vegetation within the Shinnery Oak-Bluestem type because of differences in amounts of total plant cover in the 2 types.

The use of disturbed types (Reverted Cropland, Fallow, and Cultivated) was higher during the droughty summer of 1980, as compared to 1979 (Table 13). Possibly, the use of these types was higher in 1980 because of the foraging behavior of some females. Even in the best habitats within the shinnery oak-grassland, forb and insect production appeared relatively low due to drought. However, forbs appeared abundant in the Fallow, Cultivated, and Reverted Cropland types. Possibly, some females were attracted to these areas because of high forb, and consequent high insect, density. Davis et al. (1982) have documented the dependence of

Table 13. Habitat preference indices[a] for the prenesting, nesting, and postnesting periods, calculated from 979 locations of 41 female lesser prairie chickens.

Habitat type	Prenesting 1979	Prenesting 1980	Nesting**b 1979	Nesting**b 1980	Postnesting** 1979	Postnesting** 1980
Shinnery Oak-Bluestem	1.28	1.43	2.05	1.56	1.39	2.18*c
Sandhills	2.75	2.10	2.00	2.80	4.69	2.57*
Shinnery Oak-Midgrass	0.45	0.65	0.82	0.85	1.02	0.56*
Reverted Cropland	0.79	0.53	0.03	0.22]d*	0.04	0.34*
Weeping Lovegrass	NU[e]	NU	0.00	0.14]	0.00	0.11]
Fallow	NU	NU	NU	NU	0.00	0.43]*
Cultivated	NU	NU	NU	NU	0.00	0.23]
Shortgrass	NU	NU	NU	NU	NU	NU

[a]Observed number of locations divided by the expected number of locations (calculated from Table 6).

[b]Indicates that habitat use was dependent on the year ($P < 0.05$), using chi-square contingency tables (Steel and Torrie 1960:366).

[c]Indicates that individual chi-square values for habitat types are significant ($P < 0.05$).

[d]The habitat types contained in the brackets were combined in the chi-square analysis because of their low expected values.

[e]Indicates no use in either year and therefore was not considered available habitat and was not used in the preference-index calculations or chi-square analyses.

prairie chickens in the study area on insects as a food source. Females in 1979 apparently found adequate forage within the shinnery oak-grassland, where cover was superior, making it unnecessary to venture into disturbed types where cover was marginal.

It is apparent that in times of drought, prairie chickens rely heavily on lightly grazed habitat types. In optimal years, such as 1979 (Ahlborn 1980:20), more heavily grazed habitats, such as Shinnery Oak-Midgrass, can support substantial numbers of prairie chickens. However, in dry years, these types are of less value to prairie chickens. Small disturbed sites within the shinnery oak-grassland may provide additional forage to some female prairie chickens, especially when forb production is low on the native range.

HOME RANGES

The term "home range," as applied here, represents the area of use for a given period. Prenesting, postnesting, and total spring-summer home ranges were largest in 1980 (Table 14). Home ranges for nesting females during the nesting period were larger in 1979, but this was due to renesting (Table 14).

Within a home range, a species' food, cover, and reproductive requirements are met. External influences affect these requirements; thus, they can affect home-range sizes. Stenger (1958) demonstrated an inverse relationship between ovenbird (Seiurus aurocapillus) territory size and food abundance. Territories within habitats where insects were more dense were smaller than territories in habitats where insect density was lower. It is logical, then, that environmental factors, such as drought, which affect food abundance can affect home ranges as well as territories. In fact, McNab (1963) noted that, for mammals, home-range area may vary according to the direct and indirect influences of weather and climate. He noted that water deficiencies or poor soil conditions could increase home-range size through their effects on the distribution and abundance of plants.

Prenesting home ranges in 1980 probably were affected by food abundance. Campbell et al. (1973) studied scaled quail (Callipepla squamata) in southern Lea County, New Mexico, only 115 km south of the present study area. They found a strong, positive correlation

Table 14. Summary of home-range data for female lesser prairie chickens, measured in hectares. Mean and standard error values presented. Sample size in parentheses.

Reproductive period	1979	1980	Probability of yearly difference[a]
Prenesting	62.7 ± 13.9 (8)	121.8 ± 23.2 (18)	0.119
Nesting			
Single-nesting birds[b]	11.7 ± 3.0 (7)	8.5 ± 1.4 (11)	0.180
All birds[c]	14.2 ± 2.5 (10)	8.5 ± 1.4 (11)	0.056
Postnesting	66.4 ± 4.9 (7)	240.0 ± 73.9 (9)	0.059
Total spring-summer	174.4 ± 31.4 (7)	463.8 ± 118.6 (8)	0.045

[a]Level of significance determined by Student's *t* test (McClave and Dietrich 1979:292).

[b]Includes only the females which initiated a single nest.

[c]Included 3 birds that renested in 1979, none in 1980.

between rainfall and forb abundance in their study area. The low rainfall in late 1979 and 1980 must have adversely affected forb abundance, as well. Since the majority of the prairie chicken spring diet is forbs (Davis et al. 1982), a low density of forbs could cause birds to forage longer and travel farther to meet their nutritional requirements. Shinnery oak catkins are also an important spring food item (Davis et al. 1982), and are normally available by the first of April (C. A. Davis, New Mexico State University, Las Cruces, pers. comm.). However, in 1980, this abundant food source did not become available until late April, and this may have caused prairie chickens to increase their foraging activities, thus enlarging their home ranges.

Nesting home ranges were significantly larger in 1979 (Table 14), but only because no females renested in 1980, resulting in reduced home ranges. There were no significant differences in home-range size between years for single-nesting females (those which did not renest).

Postnesting home ranges in 1979 were not significantly different between brood and broodless females (67.7 ha vs. 63.9 ha); therefore, it was assumed that the lack of brooding females in 1980 was not the cause of the increased home-range sizes in 1980. Temperatures following nesting were extreme in 1980 (Tables 6 and 7), and this must have caused an increased water loss in prairie chickens, causing them to forage more widely for succulent insects and forbs, which were low in density due to drought. Only one female was known to drink free-standing water in 1980, and none were known to drink in 1979. Therefore, female prairie chickens must have had to increase their foraging time and area in order to compensate for any water loss. Southwood and Cross (1969) demonstrated that for partridge (Perdix perdix) in Britain, distances broods needed to walk to obtain adequate food were inversely proportional to arthropod (mostly insect) density. Copelin (1963) observed that in dry years, lesser prairie chicken broods in western Oklahoma were more mobile, indicating that they also used larger areas.

Total spring-summer home ranges clearly demonstrate that 1980 home ranges were larger (Table 14). Data from previous studies cited above give strong support for the idea that the hot, dry conditions of 1980 were either directly or indirectly responsible for the increase in home-range areas. From a management point of view, more important than the actual cause of the increased home-range sizes is the recognition of the necessity to compensate for the larger home ranges. If sound populations are to be maintained, management areas must be large enough to fulfill a population's needs, even during drought.

REPRODUCTIVE SUCCESS

Chronology of Reproduction

All aspects of breeding, starting with the onset of lekking, were delayed in 1980. In 1979, male prairie chickens were observed on spring leks beginning on 31 January, but in 1980 none were observed on leks until 22 February. Large flocks were observed in grain fields through March 1980, indicating that prairie chickens were still mostly in winter habitat, whereas no large flocks had been observed in grain fields during March 1979.

Abundance of forbs (the main spring food of lesser prairie chickens, Davis et al. 1982) in and around grain fields may provide a triggering mechanism which stimulates birds to move from wintering areas back into the shinnery oak-grassland. As prairie chickens incorporate more forbs into their late winter diet in response to increased forb availability around grain fields, they may become stimulated into breeding condition and return to leks in the shinnery oak-grassland, by which time forbs have become abundant there, also. The dry fall-winter of 1979-80 no doubt resulted in lowered soil moisture in the late winter and early spring, which, in turn, would have delayed emergence of spring forbs and consequent initiation of breeding condition and return of prairie chickens to breeding habitat.

A delay in egg production in 1980 was indicated by a delay in the peak period of copulation, since (I assume) readiness to copulation is related to the progress in egg development. The peak copulation period for lesser prairie chickens in eastern New Mexico usually is in the first 2 weeks of April (Davis et al. 1980). Field observations indicated that the peak copulation period in 1979 did occur in the first 2 weeks in April. However, the first observed copulation in 1980 did not occur until 20 April, and the peak copulation period was the last 2 weeks of April. Further, the delay in egg production in 1980 was shown directly by the mean date for initiation of egg-laying by radiotagged females being delayed by 11 days in 1980 (Table 15). This apparently delayed the mean nest destruction date, which also was later in 1980 (Table 15).

The delay in egg production which occurred in 1980 probably was due to the same factor(s) that delayed the onset of lekking. The condition of the food source in early spring and the female's resulting physiological condition certainly could affect egg production. It has been demonstrated that for the confamilial red grouse (Lagopus lagopus) in Scotland, the amount of green heather (Calluna vulgaris) present in early spring affects egg-laying dates (Jenkins et al. 1967). Similarly, the delayed growth of early spring forbs in eastern New Mexico could well affect egg-laying dates in the lesser prairie chicken. The delay in egg production in 1980 could have been caused in part, also, by the delayed emergence of shinnery oak catkins, which provide a major part of the spring diet in the

Table 15. Nesting chronology for radiotagged, female lesser prairie chickens.

Year	Capture date	Egg-laying date[a]		Nest destruction date		Hatching date	
		1st nest	2nd nest	1st nest	2nd nest	1st nest	2nd nest
1979	$\overline{X}$ = 10 Apr	$\overline{X}$ = 29 Apr	$\overline{X}$ = 25 May	$\overline{X}$ = 19 May	$\overline{X}$ = 26 Jun	$\overline{X}$ = 5 Jun	$\overline{X}$ = 27 Jun
	2 Apr-19 Apr[b]	20 Apr- 4 May	13 May-3 Jun	14 May-28 May		1 Jun-7 Jun	17 Jun-7 Jul
	(16)[c]	(11)	(3)	(5)	(1)	(5)	(2)
1980	$\overline{X}$ = 10 Apr	$\overline{X}$ = 10 May		$\overline{X}$ = 28 May			
	31 Mar-25 Apr	3 May-22 May		24 May- 6 Jun			
	(25)	(11)		(11)			

[a]Date on which first egg was laid.

[b]Range of dates.

[c]Number of females.

present study (Davis et al. 1982). These catkins usually are available in early April in eastern New Mexico, but their emergence was delayed until late April in 1981 (C. A. Davis, New Mexico State University, Las Cruces, *pers. comm.*).

Number of Nesting Females

There was a considerably higher incidence of nesting attempts in 1979 than in 1980 (Table 16). Probably, this difference was caused by many females being in lowered physiological condition in 1980 because of the low food abundance (or quality) associated with low rainfall, as described previously.

All living radiotagged females (which were in radio contact) that lost their first clutch of eggs renested in 1979, but no known renesting occurred in 1980. High summer temperatures (Table 7) may have been the cause of the lack of renesting in 1980. Wilson (1949) noted that for domestic fowl, egg-laying decreased at temperatures above 26.5°C, and some females ceased egg-laying after temperatures exceeded 38°C. Although lesser prairie chickens have evolved with high summer temperatures, temperatures during 1980 may have exceeded some critical point that prevented egg production.

Nesting Success

Differences in the nesting success of radiotagged females between the 2 years are evident. Sixty-four percent of the radiotagged females hatched young in 1979, but no radiotagged females

Table 16. Nesting statistics for radiotagged, female lesser prairie chickens.

Year	Percent females[a] known to nest	Percent known non-nesters	Clutch size		No. eggs hatched		Percent females[b] renesting	Percent nesting females hatching young	Percent nesting females producing an independent brood[c]
			1st nest	2nd nest	1st nest	2nd nest			
1979	92	8	$\overline{X}$ = 10.1	$\overline{X}$ = 10.7	$\overline{X}$ = 6.8	$\overline{X}$ = 9.5	100	64	27
	(11)[d]	(1)	9–12[e]	10–11	3–9	8–11	(3)	(7)	(3)
			(10)	(3)	(5)	(2)			
1980	73	27	$\overline{X}$ = 9.5	–	–	–	0	0	0
	(11)	(4)	8–11						
			(11)						

[a]In 1979, 2 other radiotagged females were lost to predators prior to nesting, 1 dropped the transmitter, and 1 was lost from radio contact. In 1980, 5 were lost to predators prior to nesting, 1 dropped the transmitter, and 4 were lost from radio contact.

[b]The percent of all living radiotagged females that renested after loss of their first clutch of eggs.

[c]An independent brood was considered a brood that began to mix with other groups of prairie chickens, both adult and young, and began to separate from the brooding female.

[d]Number of females.

[e]Range of values.

hatched young in 1980 (Table 16). Fifty percent of the nests initiated by radiotagged females hatched at least one egg in 1979, compared to none in 1980.

The weather conditions during spring and/or summer 1980 may have affected nesting success through one or more mechanisms. The lack of winter and spring rains during 1979/80 obviously reduced forb densities in the study area, thereby perhaps reducing the physiological condition of some females sufficiently that they produced few eggs or none. Miller et al. (1966) demonstrated that for red grouse in Scotland, breeding success (including hatching rates) was related to the amount of food available to adults in winter and spring. Keindeigh (1934) noted that for passerine birds, nest attentiveness decreased with increasingly high temperatures. Perhaps female lesser prairie chickens were less attentive at their nests due to high temperatures or the need to search for food. Since prairie chicken nests appear more cryptic when the female is present on the nest, nests are more vulnerable to predation and sun when the female is absent. Hot, dry weather also is known to reduce the hatchability of pheasant eggs (Yeatter 1950), and Gerstell (1936) has noted the importance of high humidity in the artificial incubation of game bird eggs. It can be suggested, then, that the hot and dry conditions of 1980 affected lesser prairie chicken egg hatchability as well.

Brood Abundance and Brood Size

Indices of brood abundance for nonradiotagged birds also indicate yearly differences in reproductive success. Both the frequency and total number of brood encounters for 1979 were over 2 times as high as for 1980 (Table 17). Further, average brood size was more than twice as large in 1979 as in 1980 (Table 17).

The early posthatching period has been recognized as a critical period in chick survival for greater prairie chickens (Shelford and Yeatter 1955), and Edminister (1947) concluded that inclement weather was the most critical mortality factor for ruffed grouse (*Bonasa umbellus*) chicks. Data from Table 8 clearly illustrate that weather in eastern New Mexico is harsh in terms of its potential effects on broods. The weather for the first 10 days following the mean hatching date of prairie chickens was particularly harsh in 1980 (Table 8). This harsh weather, especially the daily high temperatures, may have resulted in high chick mortality in 1980. Extreme temperatures and the lack of rain may have caused higher chick mortality in 1980 as a direct result of heat stress and water loss, or indirectly by making chicks more susceptible to other mortality factors. Chick survival may also be related to the physiological condition of adult females before nesting. Jenkins et al. (1967) observed that red grouse chick survival, as well as clutch size and egg hatchability, was related to the food resource in April. If female lesser prairie chickens were in a poor

Table 17. Indices of reproductive success for lesser prairie chickens, excluding radiotagged females.

Year	Brood encounters[a] (no./linear km)	Total brood[b] observations	Mean no. and 95% C.I. of chicks/brood	Fall age ratio of trapped birds (no. young:adult)	Weight (gm) of young males at fall trapping
1979	0.13	25	7.8 ± 1.6	3.00:1	696 ± 16.9
	(191)[c]		(17)[d]	(24)	(15)
1980	0.06	13	3.5 ± 2.5	0.44:1	641 ± 60.4
	(206)		(4)	(13)	(4)

[a]Brood or brood sign per linear km of census transect.

[b]Broods or brood sign observed from brood census transects.

[c]Number of km of census transect.

[d]Number of observations.

physiological state in early 1980, nests that were successful may have contained smaller clutches, produced fewer hatched eggs, and resulted in lower chick survival. Any combination of these factors could explain the smaller brood sizes that were observed in 1980.

Fall Age Ratios and Bird Weights

The age ratio (no. young per adult) for prairie chickens captured on fall leks was 7 times higher in 1979 than in 1980 (Table 17). Weight of young males also was greater in 1979 (Table 17).

The high age ratio in 1979 indicates high rates of hatching success and/or chick survival, and the low age ratio in 1980 reflects poor hatching success and/or chick survival. The weight difference in young males, although not significant ($P < 0.20$), suggests that young birds were in better condition (or further developed) in 1979. This, in turn, could have affected survival of the young birds in the following fall and winter.

MORTALITY AND SURVIVAL OF FEMALES

The spring-summer survival rate for adult female prairie chickens was nearly 50 percent less in 1980 than in 1979 (Table 18). Also, 2 females died (apparently killed by predators) in late August 1980, shortly after the end of the spring-summer period; this further reduced the 1980 survival rate to 24 percent. In contrast, no females were known to be taken by predators during late August of 1979.

During the spring-summer period, for both years combined, 12 radiotagged females were known to be consumed (and apparently had been killed) by predators. Mammalian predators, principally coyotes (*Canis latrans*),[3] were believed responsible for 11 of these. The remaining female was killed by an avian predator. Suspected avian predators included great horned owls (*Bubo virginianus*) and prairie falcons (*Falco mexicanus*).

Radiotagged females experienced a high spring-summer mortality rate in both years. Svedarsky (1979) noted a high summer mortality rate in female greater prairie chickens (*T. cupido*), and speculated that vulnerability of females increased due to 1) dissolution of winter flocks causing a reduction in predator detection capability; 2) nest establishment and incubation activities; 3) weakened

---

[3]Common and scientific names of mammals follow Findley et al. (1975).

Table 18. Minimum[a] spring-summer survival rates of female lesser prairie chickens radiotagged in early spring.

Year	Number of females radiotagged	Number of females known alive after spring-summer	Minimum female survival rate
1979	16	9	56.25%
1980	25	8	32.00%

[a]These survival rates are considered minimal because some lost birds may have actually been alive, and radiotagged females may have been more susceptible to predation.

physical condition due to incubation; 4) the need to forage actively while off the nest; and 5) greater attractiveness to predators during brooding. Campbell (1972) observed that the annual mortality rate of female lesser prairie chickens in eastern New Mexico was higher than that of adult males. He attributed the higher mortality rate of females to the hazards of egg-laying, incubation, and brooding.

The low spring-summer survival rate for females in 1980 probably was a reflection of the severe weather conditions causing increased mortality in females through several mechanisms. High temperatures and lack of water may have weakened females to a point of increased vulnerability to predators. Weight data (from Davis et al. 1982) indicated that yearling male prairie chickens weighed 6 percent less in the summer of 1980 than in 1979. This suggests that males, and possibly females, were in a weakened condition during 1980. Increased foraging time and increased home ranges resulting from food or water shortages may have increased the probability of females encountering predators, and foraging in habitats where forbs and insects were available but cover was marginal (Fallow and Cultivated habitat types) may have increased vulnerability to predation.

EFFECTS OF REPRODUCTION AND SURVIVAL ON NUMBERS

Annual population indices of prairie grouse have traditionally been based on spring lek counts (Cannon and Knopf 1981). The largest number of occupied leks and the largest total number of males in the study area occurred in spring 1980 (Table 19). These numbers reflect the excellent reproduction of 1979 and survival during fall-winter of 1979/80. The weather during summer of 1979 was considered near optimal for nesting and brooding (Ahlborn 1980: 20), and the 1980 spring lek counts reflect this fact. Following the poor reproduction and survival of 1980 (apparently weather-induced), the total number of occupied leks, total number of males, and mean number of males per lek were lower in spring 1981 (Table 19). Spring lek counts on Bureau of Land Management land, approximately 55 km southwest of the present study area, in 1981 resulted in the lowest mean number of males per lek in the 11 years since counts began; the number of occupied leks also was low (C. A. Davis, New Mexico State University, Las Cruces, *pers. comm.*). These findings indicate that low reproduction and survival in lesser prairie chickens were widespread in New Mexico during the drought of 1980.

Cannon and Knopf (1981), using data from Ellis County, Oklahome, found a strong correlation between the number of occupied leks per area and population density, but a poor correlation between the average number of males per lek and population density. Data from

Table 19. Comparison of population indices to the total number of males found on spring leks in the study area.

Unit of measure	Year 1979	Year 1980	Year 1981
Total number of males	195[a]	296 (55)[b]	192 (-35)
Density (males/km^2)	1.34	2.04 (55)	1.32 (-35)
Number of occupied leks	18	28 (56)	23 (-18)
Mean number of males per lek	10.3	10.6 (3)	8.4 (-21)

[a]Lek number 24 was active, but no counts of males were made, so it was assigned 10 males, the mean number of males per lek for that year.

[b]Percent increase or decrease from the previous year.

the 3 years of lek counts in the present study area are presented in Table 19. The number of occupied leks appears to be the best index to population density, at least in years of increase. A 55 percent increase in the total number of males found on leks throughout the study area in 1980 was accompanied by a 56 percent increase in the number of leks occupied, yet the mean number of males per lek increased only 3 percent (Table 19). Apparently young birds quickly establish new leks in years of increase, making the total number of occupied leks a good population index, whereas the mean number of males per lek may not change significantly.

The total number of males in the study area decreased by 35 percent in 1981, while the number of occupied leks decreased by 18 percent and the mean number of males per lek decreased by 21 percent (Table 19). The mean number of males per lek was a slightly better index to the total study area population in 1981, possibly because males are slow to abandon leks with which they are familiar.

CONCLUSIONS

Yearly differences in habitat-use which were attributed to contrasting weather conditions were not major. Shinnery Oak-Bluestem and Sandhills were preferred prenesting, nesting, and postnesting habitat types in both 1979 and 1980. However, data from this study suggest that during periods of drought, high-quality habitats (Shinnery Oak-Bluestem and some Sandhills) within the shinnery oak-grassland receive relatively more use, while lower-quality habitats (Shinnery Oak-Midgrass and some Sandhills) receive less use. In years of favorable weather (1979), substantial numbers of prairie chickens utilize the heavily grazed Shinnery Oak-Midgrass type, but in poor years (1980) this type is used less. In contrast, Shinnery Oak-Bluestem, the type closest to climax vegetation, received its highest use during the severest part of the drought. Disturbed types (Reverted Cropland, Weeping Lovegrass, Fallow, and Cultivated) were used relatively more during drought conditions, but they were never preferred types. This increased use probably was due to low abundance of forbs and insects throughout the nondisturbed shinnery oak-grassland.

Home ranges of female lesser prairie chickens were larger throughout the spring-summer period during drought conditions (1980) than during the presumably normal or optimal conditions (1979). This probably was in response to a decreased supply of food and/or water.

Parameters of reproductive success varied greatly between 1979 and 1980. The percent of females nesting, percent of females renesting, number of successful nests, number of broods observed, and mean brood size all were smaller in 1980. The lower reproductive success in 1980 was attributed to the drought of that year. Therefore, weather appears to be a limiting factor in lesser prairie chicken populations which acts through reproductive success.

Female mortality was high during both years of the study, and this high spring-summer mortality was attributed to the hazards of nesting and brooding. Mammals, thought to be mostly coyotes, were the major predators of prairie chickens. Survival was lower in 1980, and this was attributed to increased vulnerability to predators, associated with the drought of that year.

Spring lek counts reflected the previous year's nesting success and survival. Following the favorable reproduction and survival of 1979, 1980 spring lek counts revealed an increase in the number of occupied leks, mean number of males per lek, and total number of males in the study area. Following the low reproduction and survival (apparently weather-induced) of 1980, the total number of occupied leks, mean number of males per lek, and total number of males in the study area were lower in 1981.

It is apparent that the fate of prairie chicken populations is determined by the quality of the habitat. Prairie chickens prefer quality, near-climax habitat types, such as Shinnery Oak-Bluestem with or without Sandhills, while they avoid or at least do not

CONCLUSIONS

Yearly differences in habitat-use which were attributed to contrasting weather conditions were not major. Shinnery Oak-Bluestem and Sandhills were preferred prenesting, nesting, and postnesting habitat types in both 1979 and 1980. However, data from this study suggest that during periods of drought, high-quality habitats (Shinnery Oak-Bluestem and some Sandhills) within the shinnery oak-grassland receive relatively more use, while lower-quality habitats (Shinnery Oak-Midgrass and some Sandhills) receive less use. In years of favorable weather (1979), substantial numbers of prairie chickens utilize the heavily grazed Shinnery Oak-Midgrass type, but in poor years (1980) this type is used less. In contrast, Shinnery Oak-Bluestem, the type closest to climax vegetation, received its highest use during the severest part of the drought. Disturbed types (Reverted Cropland, Weeping Lovegrass, Fallow, and Cultivated) were used relatively more during drought conditions, but they were never preferred types. This increased use probably was due to low abundance of forbs and insects throughout the nondisturbed shinnery oak-grassland.

Home ranges of female lesser prairie chickens were larger throughout the spring-summer period during drought conditions (1980) than during the presumably normal or optimal conditions (1979). This probably was in response to a decreased supply of food and/or water.

prefer lower-quality habitats, such as Shinnery Oak-Midgrass and disturbed habitat types. It must be assumed, then, that there is a selective advantage in occupying the quality habitats, especially during drought. If more of these quality habitats can be provided through proper management practices, then drought effects, such as low reproduction and survival, probably can be lessened.

Wisdom (1980) demonstrated that nesting success of lesser prairie chickens in eastern New Mexico was enhanced by the presence of tall, wide clumps of sand bluestem, which are found in a few near-climax areas in the shinnery oak-grassland, while areas devoid of sand bluestem were not highly conducive to nesting success. In this study area, sand bluestem is scarce and usually not vigorous, and little bluestem apparently serves as an acceptable substitute. Management efforts should therefore be directed towards maintaining areas of quality, near-climax vegetation, and improving areas devoid of bluestem grasses (lower-quality habitats). Disturbed types, even though their use may increase during periods of drought, are never preferred. Since these types are common throughout the shinnery oak-grassland, increasing the amounts of disturbed habitat types (even grain fields) can only be considered detrimental to prairie chickens.

Since grazing has been determined to be a predominant cause of shinnery oak-grassland deterioration (Duck and Fletcher 1944, Hammerstrom and Hammerstrom 1961, Jackson and De Arment 1963), an obvious method of improving lesser-quality habitats is to reduce grazing pressure. Control of shinnery oak also may be a viable method of range improvement. Actual techniques of improving shinnery oak-grasslands for the benefit of prairie chickens are discussed by Davis et al. (1979, 1982), Pettit (1979), Sell (1979), Ahlborn (1980), Doerr (1980), and Wisdom (1980).

Since prairie chickens home ranges are larger during periods of drought, management recommendations concerning a minimum management area should consider this fact. Areas must be large enough to support viable populations, even during critical drought periods.

Lek counts also have management implications. In considering the time and money saved by counting only occupied leks and not individual birds, the total number of occupied leks per unit area appears to be a better index to population levels, even though in years of population decrease the mean number of males per lek may be a slightly (but not necessarily significantly) better index.

LITERATURE CITED

Ahlborn, G. G. 1980. Brood-rearing habitat and fall-winter movements of lesser prairie chickens in eastern New Mexico. M.S. Thesis. New Mexico State Univ., Las Cruces. 73pp.

American Ornithologists' Union. 1976. Thirty-third supplement to the American Ornithologists' Union check-list of North American birds. Auk 93:875-879.

Campbell, H. 1972. A population study of lesser prairie chickens in New Mexico. J. Wildl. Manage. 36:689-699.

Campbell, H., D. K. Martin, P. E. Ferkovich, and B. K. Harris. 1973. Effects of hunting and some other environmental factors on scaled quail in New Mexico. Wildl. Monogr. 34. 49pp.

Cannon, R. W., and F. L. Knopf. 1981. Lek numbers as a trend index to prairie grouse populations. J. Wildl. Manage. 45:776-778.

Copelin, F. F. 1963. The lesser prairie chicken in Oklahoma. Oklahoma Wildl. Conserv. Dept. Tech. Bull. 6. 58pp.

Correll, D. S., and M. C. Johnston. 1970. Manual of the vascular plants of Texas. Texas Res. Found., Renner. 1881pp.

Crawford, J. A. 1980. Status, problems, and research needs of the lesser prairie chicken. Pp. 1-7 in Proceedings of the prairie grouse symposium. Oklahoma State Univ., Stillwater. 89pp.

Davis, C. A., G. G. Ahlborn, S. S. Merchant, and D. L. Wilson. 1982. Final report: Prairie chicken habitat evaluation. New Mexico Dept. Game and Fish. In prep.

________, T. Z. Riley, J. F. Schwarz, H. R. Suminski, and M. J. Wisdom. 1980. Livetrapping female prairie chickens on spring leks. Pp. 64-67 in Proceedings of the prairie grouse symposium. Oklahoma State Univ., Stillwater. 89pp.

________, ________, R. A. Smith, H. R. Suminski, and M. J. Wisdom. 1979. Final report: Habitat evaluation of lesser prairie chickens in eastern Chaves County, New Mexico. New Mexico State Univ., Agric. Expt. Stn., Las Cruces. Mimeo. 143pp.

Dill, H. H., and W. H. Thornsberry. 1950. A cannon-projected net trap for capturing waterfowl. J. Wildl. Manage. 14:132-137.

Mohr, C. O. 1947. Table of equivalent populations of North American small mammals. Am. Midl. Nat. 37:223-249.

Pettit, R. D. 1979. Effects of picloram and tebuthiuron pellets on sand shinnery oak communities. J. Range Manage. 32:196-200.

Rearden, J. D. 1951. Identification of waterfowl nest predators. J. Wildl. Manage. 15:386-395.

Rhoades, E. D., L. F. Locke, H. M. Taylor, and E. H. McIlvain. 1964. Water intake on a sandy range as affected by 20 years of differential cattle stocking rates. J. Range Manage. 17:185-190.

Riley, T. Z. 1978. Nesting and brood-rearing habitat of lesser prairie chickens in southeastern New Mexico. M.S. Thesis. New Mexico State Univ., Las Cruces. 60pp.

Robel, R. J., J. N. Briggs, J. J. Cebula, N. J. Silvy, C. E. Viers, and P. G. Watt. 1970. Greater prairie chicken ranges, movements, and habitat usage in Kansas. J. Wildl. Manage. 34:286-305.

Ross, J. W., and O. F. Bailey. 1967. Soil survey of Roosevelt County, New Mexico. U.S. Dept of Agric., Soil Conserv. Serv., Washington, D.C. 73pp.

Sell, D. L. 1979. Spring and summer movements and habitat use by lesser prairie chicken females in Yoakum County, Texas. M.S. Thesis. Texas Tech. Univ., Lubbock. 41pp.

Shelford, V. E., and R. E. Yeatter. 1955. Some suggested relations of prairie chicken abundance to physical factors, especially rainfall and solar radiation. J. Wildl. Manage. 19:233-242.

Southwood, T. R. E., and D. J. Cross. 1969. The ecology of the partridge. III. Breeding success and the abundance of insects in natural habitats. J. Anim. Ecol. 38:497-509.

Steel, R. G. D., and J. H. Torrie. 1960. Principles and procedures of statistics with special reference to the biological sciences. McGraw-Hill Book Co., New York. 481pp.

Stenger, J. 1958. Food habitats and available food of ovenbirds in relation to territory size. Auk 75:335-346.

Svedarsky, W. D. 1969. Spring and summer ecology of female greater prairie chickens in northwestern Minnesota. Ph.D. Dissertation. Univ. of South Dakota, Grant Forks. 166pp.

Mohr, C. O. 1947. Table of equivalent populations of North American small mammals. Am. Midl. Nat. 37:223-249.

Pettit, R. D. 1979. Effects of picloram and tebuthiuron pellets on sand shinnery oak communities. J. Range Manage. 32:196-200.

Rearden, J. D. 1951. Identification of waterfowl nest predators. J. Wildl. Manage. 15:386-395.

Rhoades, E. D., L. F. Locke, H. M. Taylor, and E. H. McIlvain. 1964. Water intake on a sandy range as affected by 20 years of differential cattle stocking rates. J. Range Manage. 17:185-190.

Riley, T. Z. 1978. Nesting and brood-rearing habitat of lesser prairie chickens in southeastern New Mexico. M.S. Thesis. New Mexico State Univ., Las Cruces. 60pp.

Robel, R. J., J. N. Briggs, J. J. Cebula, N. J. Silvy, C. E. Viers, and P. G. Watt. 1970. Greater prairie chicken ranges, movements, and habitat usage in Kansas. J. Wildl. Manage. 34:286-305.

Ross, J. W., and O. F. Bailey. 1967. Soil survey of Roosevelt County, New Mexico. U.S. Dept of Agric., Soil Conserv. Serv., Washington, D.C. 73pp.

Sell, D. L. 1979. Spring and summer movements and habitat use by lesser prairie chicken females in Yoakum County, Texas. M.S. Thesis. Texas Tech. Univ., Lubbock. 41pp.

Shelford, V. E., and R. E. Yeatter. 1955. Some suggested relations of prairie chicken abundance to physical factors, especially rainfall and solar radiation. J. Wildl. Manage. 19:233-242.

Southwood, T. R. E., and D. J. Cross. 1969. The ecology of the partridge. III. Breeding success and the abundance of insects in natural habitats. J. Anim. Ecol. 38:497-509.

Steel, R. G. D., and J. H. Torrie. 1960. Principles and procedures of statistics with special reference to the biological sciences. McGraw-Hill Book Co., New York. 481pp.

Stenger, J. 1958. Food habitats and available food of ovenbirds in relation to territory size. Auk 75:335-346.

Svedarsky, W. D. 1969. Spring and summer ecology of female greater prairie chickens in northwestern Minnesota. Ph.D. Dissertation. Univ. of South Dakota, Grant Forks. 166pp.

U.S. Department of Commerce. 1979. Monthly summarized station and divisional data. Climatological Data: New Mexico 83(1-2).

________. 1980. Monthly summarized station and divisional data. Climatological Data: New Mexico 84(1-2).

Wilson, W. O. 1949. High environmental temperatures as affecting the reaction of laying hens to iodized casein. Poult. Sci. 28(4):581-592.

Wisdom, M. J. 1980. Nesting habitat of lesser prairie chickens in eastern New Mexico. M.S. Thesis. New Mexico State Univ., Las Cruces. 38pp.

Yeatter, R. E. 1950. Effects of different preincubation temperatures on the hatchability of pheasant eggs. Science 112:529-530.