CURRENT STATUS AND APPROACHES TO MONITORING POPULATIONS AND HABITATS OF LESSER PRAIRIE CHICKENS IN OKLAHOMA

By

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Scope and Method of Study: Four different topics relating to lesser prairie chickens were addressed during this study. Interviews with State Game Rangers, biologists, and landowners were combined with field observations to determine the current distribution and size of remaining flocks in Oklahoma. Data from 4 long term studies of prairie chickens were examined to evaluate the usefulness of average lek size and total number of leks as indicies to density of displaying males. The responses of lesser prairie chickens to basic habitat components in shinnery oak and sand sagebrush rangelands were examined by comparing densities of displaying males on 8 areas (4,144 ha each) to vegetative parameters using simple linear and multiple regression techniques. Percentage and frequency of grass, brush, forbs and open ground (bare soil or litter) were compared with densities of displaying males. Landsat digital data were used to evaluate lesser prairie chicken habitats in western Oklahoma on the 4 shinnery oak and 3 of the sand sagebrush areas. The Interactive Digital Imagery Manipulation System (IDIMS) at the U. S. Geological Survey's Eros Data Center, Sioux Falls, South Dakota, was used to quantify resource classes on each area.

Findings and Conclusions: The contemporary range of the lesser prairie chicken is comprised of several spatially isolated segments totaling 2,791 km^2, a decline of 55% in 20 years. Sand sagebrush rangeland comprised 68% of the range with shinnery oak rangeland comprising most of the remainder. The spring 1979 population was estimated at 7,500 birds, a decline of 50% in 20 years. Number of leks exhibited a strong, positive correlation with density of males and can provide a useful index to population trends if sampling effort is sufficient to detect all leks on large areas. Percentage brush and densities of males were positively correlated in sand sagebrush rangeland and negatively correlated in shinnery oak rangeland. Management strategies should emphasize brush in sand sagebrush rangeland and grass cover in shinnery oak rangeland. Density of males and Landsat brushland classes were positively correlated in sand sagebrush rangeland and negatively correlated in shinnery oak rangeland. Density of males and Landsat grassland classes were negatively correlated in sand sagebrush rangeland and positively correlated in shinnery oak rangeland. Landsat digital analysis can provide cost-effective monitoring of prairie chicken habitats.

ADVISOR'S APPROVAL Fritz L. Knopf

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CURRENT STATUS AND APPROACHES TO MONITORING

POPULATIONS AND HABITATS OF LESSER

PRAIRIE CHICKENS IN OKLAHOMA

Thesis Approved:

Thesis Adviser

Dean of the Graduate College

PREFACE

The purpose of this study was to provide current information on lesser prairie chickens in Oklahoma for use by the Oklahoma Department of Wildlife Conservation. Techniques to monitor habitat and population trends were also investigated. The research combined original field work with published and unpublished population data.

Financial support was provided by Federal Aid in Wildlife Restoration, P. R. Project Oklahoma W-125-R, Oklahoma Department of Wildlife Conservation, and Oklahoma State University, cooperating.

I wish to express my sincere appreciation to my major adviser, Dr. Fritz L. Knopf, Assistant Professor, Department of Ecology, Fisheries, and Wildlife, for his guidance during the study and assistance in preparing this thesis. I also wish to thank Dr. Paul A. Vohs, Leader, Oklahoma Cooperative Wildlife Research Unit, and Dr. John A. Bissonette, Assistant Leader, Oklahoma Cooperative Wildlife Research Unit, for their suggestions and assistance during the study and for serving as members of my graduate committee. Dr. William Warde, Assistant Professor, Statistics, provided many hours of statistical and computer programming assistance.

A special thanks is extended to Richard D. DeArment, Biologist, Texas Parks and Wildlife, and Verne E. Davison, Biologist, U. S. Soil Conservation Service for the use of their data. I thank the many landowners who provided access to the study areas: Jim Atkins, Leland Barby, Paul Barby, Glen Briles, Rick Brown, C. M. Crawford, Tom

Christner, Francis Davison, Glen Easterwood, Dick Hamilton, Ham Hamilton, and H. Hodges.

Finally, I wish to thank my wife, Beverly, for her support and the long hours in preparing this manuscript.

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CHAPTER I

INTRODUCTION

This thesis comprises 4 manuscripts written in formats suitable for immediate submission to national scientific journals. These manuscripts are presented as chapters in the thesis and each is complete without additional supporting materials. The manuscript "Distribution and status of the lesser prairie chicken in Oklahoma" (Chapter II) was written in the format of THE JOURNAL OF WILDLIFE MANAGEMENT. The manuscript "Number of leks as an index to population trends of prairie chickens" (Chapter III) was written in the format of the WILDLIFE SOCIETY BULLETIN. The manuscript "Lesser prairie chicken densities on shinnery oak and sand sagebrush rangelands in Oklahoma" (Chapter IV) is the principal paper of the thesis and was written in the format of THE JOURNAL OF WILDLIFE MANAGEMENT. The manuscript "Use of Landsat imagery to evaluate lesser prairie chicken habitat in western Oklahoma" (Chapter V) was written in the format of THE JOURNAL OF WILDLIFE MANAGEMENT. The legal description of each study area (Appendix) is provided for future reference.

CHAPTER II

DISTRIBUTION AND STATUS OF THE LESSER PRAIRIE CHICKEN IN OKLAHOMA[1]

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Abstract: The contemporary range, population size, and status of the lesser prairie chicken (*Tympanuchus pallidicinctus*) in western Oklahoma was determined during a 2 1/2 year study initiated in July 1977. The contemporary range is comprised of several spatially isolated segments totaling 2,791 km^2, a decline of 55% in 20 years. Sand sagebrush (*Artemisia filifolia*) rangeland comprises 68% of the range and occurred primarily along the North Canadian (Beaver) River in Texas, Beaver, Harper, and Woodward counties. Shinnery oak (*Quercus havardii*) rangeland comprises most of the remaining range and occurred in Woodward, Ellis, Roger Mills, and Beckham counties. The spring 1979 population was estimated at 7,500 birds; 58% inhabited sand sagebrush rangeland and 40% shinnery oak rangeland. Relic tracts of mixed and shortgrass prairie supported the remainder of the population comprised of a few small remnant flocks. All flocks remaining occur on large blocks

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[1]This paper represents a contribution from Federal Aid in Wildlife Restoration, P. R. Project Oklahoma W-125-R. Cooperators of the Oklahoma Cooperative Wildlife Research Unit include Oklahoma State University, Oklahoma Department of Wildlife Conservation, U. S. Fish and Wildlife Service, and Wildlife Management Institute.

of privately owned rangeland and appear stable in size.

Historically, the lesser prairie chicken (Tympanuchus pallidicinctus) ranged over much of central and western Oklahoma (Copelin 1956, Sutton 1967). Population levels began declining in the early 1900's and have fluctuated dramatically (Davison 1935, 1940, Duck and Fletcher 1944, Copelin 1963). The last thorough survey reporting the population size and distribution of lesser prairie chickens in Oklahoma was conducted by Copelin (1958, 1963). The purpose of this study was to determine the contemporary range, population size, and status of the species in Oklahoma.

STUDY AREA

Lesser prairie chickens were reported by Copelin (1958, 1963) to inhabit parts of Beaver, Beckham, Blaine, Cimarron, Dewey, Ellis, Greer, Harper, Roger Mills, Texas, Woods, and Woodward counties. These counties occur primarily in the Grama-Buffalograss section of the Great Plains Shortgrass Prairie Province with some extension eastward into the Bluestem-Grama Prairie section of the Tall-Grass Prairie Province (Bailey 1976). This study was confined to these counties because interviews with State Game Rangers and biologists indicated a considerable decrease in occupied range since Copelin's (1963) survey.

Within the study area, lesser prairie chicken habitats have traditionally included the Sandsage-Grassland and Shinnery Oak-Grassland game types (Duck and Fletcher 1943). The Sandsage-Grassland game type occurs along the North Canadian (Beaver) River through the length of the Panhandle (Cimarron, Texas, and Beaver counties) and extending into

Harper and Woodward counties. The Shinnery Oak-Grassland game type is prominent in parts of Woodward, Ellis, Roger Mills, and Beckham counties. A few flocks extended into the Shortgrass Highplains and Mixed Grass Eroded Plains game types (Duck and Fletcher 1943) according to Copelin's (1963) survey. Detailed descriptions of the vegetative and life-form composition of lesser prairie chicken habitats in Oklahoma can be found in Copelin (1963), Jones (1963), and Donaldson (1969).

METHODS

A questionnaire was mailed to State Game Rangers and biologists located within or near the last reported range (Copelin 1963) of the lesser prairie chicken. Subsequent interviews with landowners combined with field verification of reported sightings provided the basis for determining current range and distribution of remaining flocks. Flock locations were plotted on county highway maps (8mm = 1km) and area of occupied range was quantified with a Numonics model 1224 electronic digitizer.

Six 16 section (4,144 ha) study areas, 3 in sand sagebrush grassland and 3 in shinnery oak grassland were established to determine density of displaying males within the larger remaining segments of the range of the species in Oklahoma (Cannon and Knopf, ms). During the springs of 1978 and 1979, each study area was searched for active leks along east-west transects approximately 0.8 km apart between daylight and approximately 2 hours after sunrise. The calls made by displaying males on leks were triangulated and plotted on topographic maps (Hamerstrom and Hamerstrom 1973) to aid in the location of active leks. Each lek was censused at least 3 times during April and the first week in May.

The density of displaying males on each study area was used to estimate the population size in adjacent, continuous rangeland. An adult sex ratio of 1:0.78, which is an average ratio from several lesser prairie chicken studies (Taylor and Guthery 1979), was used to estimate total population numbers. While no statistical estimate of population size can be obtained in this manner, the method has been used previously to evaluate prairie chicken populations trends (Duck and Fletcher 1944; DeArment, personal communication). Because intensive study areas were located within good habitats rather than marginal sites, our estimates of population size may be biased upwards.

RESULTS

The contemporary range of the lesser prairie chicken in western Oklahoma (Fig. 1) is comprised of several spatially isolated segments totaling 2,791 km^2 (Table 1). The predominant vegetative associations are Sand-Sage Grasslands (68%) and Shinnery Oak-Grasslands (32%). Occupied Sand-Sage Grassland range occurs primarily along the North Canadian River in eastern Texas, Beaver, Harper, and northern Woodward counties. Occupied Shinnery Oak-Grassland range occurs in scattered tracts across southern Woodward, Ellis, and Roger Mills counties. Approximately 5% of the range estimate for Sand-Sage Grassland includes Shortgrass High Plains infested by sand sagebrush.

Our estimates of the number of lesser prairie chickens in Oklahoma in 1979 was approximately 7,500 birds, up 3% from the 1978 estimate (Table 2). Sand-Sage Grassland supported 58% of the population, and Shinnery Oak-Grassland 40%. Remnant flocks inhabiting relic tracts of Mixed Grass Eroded Plains and Shortgrass High Plains comprised approximately 2% of the population.

Fig. 1. Distribution of the lesser prairie chicken in western Oklahoma.

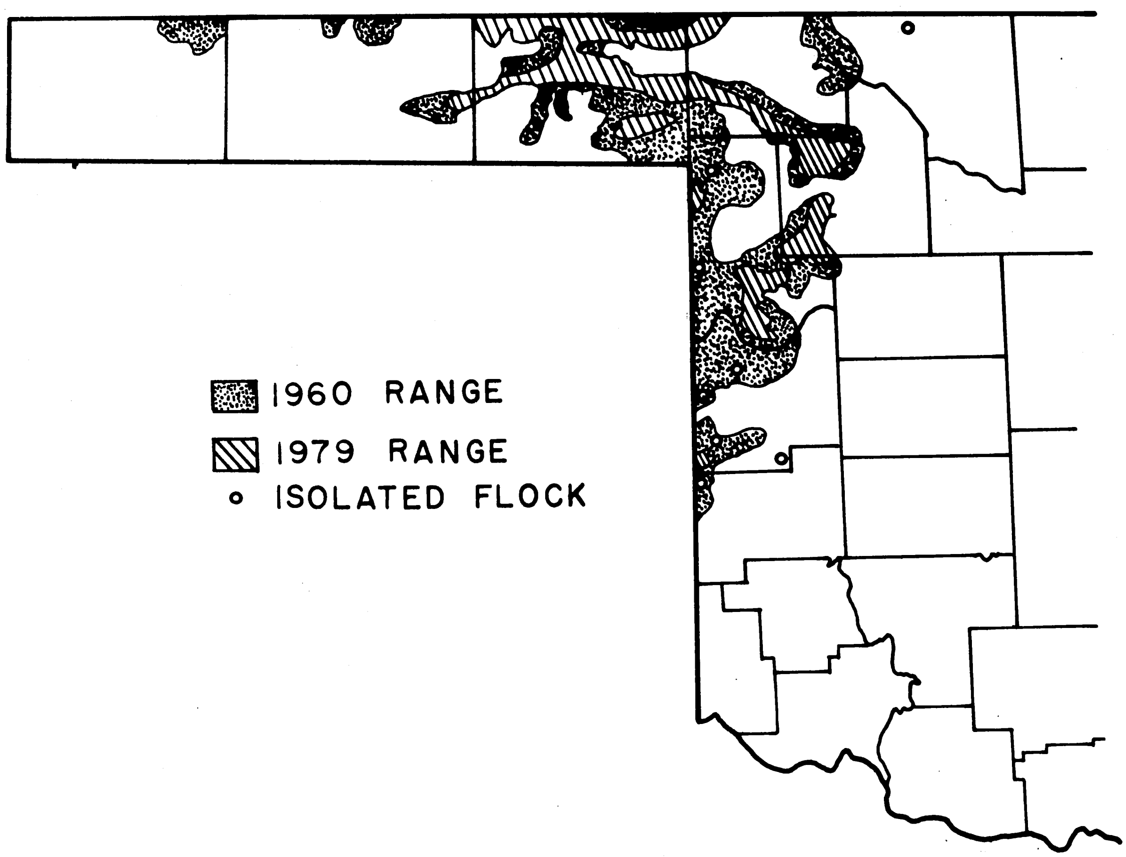
1960 RANGE
1979 RANGE
ISOLATED FLOCK

Table 1. Comparison of the historical and contemporary (1979) range of the lesser prairie chicken in Oklahoma.

County	1944 occupied range (km^2)[a]	1960 occupied range (km^2)[b]	1979 occupied range (km^2)	Percentage change (1960 to 1979)
Beaver	1,803	1,515	1,182	- 21
Beckham	720	41	3	- 93
Blaine	0	10	0	-100
Cimarron	998	86	0	-100
Dewey	303	10	0	-100
Ellis	1,736	2,169	461	- 79
Greer	207	10	0	-100
Harper	715	368	350	- 5
Roger Mills	1,373	956	106	- 89
Texas	332	78	59	- 24
Woods	461	249	5	- 98
Woodward	1,495	733	625	- 15
Total	10,143	6,225	2,791	

[a]From Duck and Fletcher (1944).

[b]From Copelin (1963).

Table 2. Estimated numbers of the lesser prairie chicken in western Oklahoma.

County	Game Ranger and biologist survey	1944 Survey[a]	1978 Estimate	1979 Estimate	Percentage change 1944-1979
Beaver	2,000	445	3,408	3,492	+685
Beckham	20	228	25	20	- 91
Cimarron	0	50	0	0	-100
Dewey	0	268	0	0	-100
Ellis	3,000	7,500	1,046	1,681	- 78
Harper	500	855	735	542	- 37
Roger Mills	300	2,560	200	210	- 92
Texas	800	-	89	132	-
Woods	20	50	20	40	- 20
Woodward	2,500	2,950	1,752	1,410	- 52
Total	9,140	14,906	7,275	7,527	

[a]Duck and Fletcher (1944)

DISCUSSION

The range of the lesser prairie chicken in Oklahoma has decreased approximately 55% since the study of Copelin (1963), and nearly 72% since the mid 1940's (Duck and Fletcher 1944). The majority of the remaining range, lies within Roger Mills, Ellis, Woodward, Harper, and Beaver counties (Fig. 1). Prairie chicken range within the Shinnery Oak-Grasslands of Ellis and Roger Mills counties has declined to a small fraction of historical levels. Occupied Sand-Sage Grassland range in Woodward, Harper, and Beaver counties has also decreased, but only slightly in comparison. Small pockets of occupied range have disappeared in Blaine, Cimarron, Dewey, and Greer counties since Copelin's (1963) survey, while isolated populations persist in eastern Texas, northern Woods, and northwestern Beckham counties.

The current population estimate of 7,500 birds represents a decline of 50% from Copelin's (1963) spring 1960 estimate of 15,000 birds. The majority of the present population inhabitats parts of Beaver, Harper, Woodward, and Ellis counties (Table 2). Population size relative to Copelin's (1963) survey appears to have seriously declined in Ellis and Roger Mills counties, closely paralleling the loss in occupied range. Historical population estimates (Duck and Fletcher 1944) for the counties listed by Copelin (1963) also reflect this decline, with the exception of Beaver County. Duck and Fletcher's (1944) population estimate for Beaver County (Table 2) appears unrealistic when historical range estimates (Table 1) and flock locations (Copelin 1958, 1963) are considered.

Copelin (1963) expected an anticipated increase in rangeland acreage following his studies to have a favorable effect on lesser prairie chicken distribution in the 5 counties where the birds were most abundant. Since his survey, rangeland acreage in Beaver, Harper, Ellis, Woodward, and Roger Mills counties has increased an average of 12% (USDA, SCS 1962, 1976). The actual change in rangeland acreage included a decrease of 4% in Roger Mills county to an increase of 40% in Ellis county. The observed decreases in population numbers and distribution, especially in Ellis county, suggest that overgrazing or other land-use practices have adversely affected remaining flocks and compensated gains in rangeland acreage.

Within the current range, shinnery oak rangeland supports higher prairie chicken densities than sand sagebrush rangelands. These results agree with Copelin's (1963) earlier observations. However, sand sagebrush rangeland appears to be a more stable habitat in Oklahoma since it is unsuited for row crop farming (Allgood et al. 1962) and proper stocking rates of cattle are necessarily low to support successful grazing operations (E. C. Snook, State Range Conservationist).

Although shinnery oak rangeland soils are subject to wind erosion, row cropping is possible in certain areas if minimum tillage techniques are employed (Cole et al. 1966). Shinnery oak rangeland supporting prairie chickens occurs on large ranches where conversion to row cropping has been absent or minimal, and cattle grazing intensities are moderate by choice. Even though shinnery oak rangeland soils can withstand row cropping and overgrazing somewhat better than sand sagebrush rangeland soils (Allgood et al. 1962, Cole et al. 1966, Snook, personal communication), shinnery oak rangelands supporting prairie chickens in Woodward, Ellis, and Roger Mills counties may be lost in the future if grazing intensity significantly increases.

All major remaining flocks occur on large blocks of privately owned native rangeland. The complete absence of stable breeding populations on adjacent, smaller landholdings suggests that associated land-use practices are incompatible with the habitat requirements of the species. The future status of lesser prairie chickens in Oklahoma will reflect the practices of individual landowners, since only a few scattered flocks remain on public lands. Current populations, although widely scattered and isolated, should remain stable provided that the large ranches remain intact and are managed within proper grazing guidelines.

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CHAPTER III

NUMBER OF LEKS AS AN INDEX TO POPULATION TRENDS OF PRAIRIE CHICKENS[1]

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Abstract: Data from 4 long term studies of lesser prairie chickens (*Tympanuchus pallidicinctus*) and greater prairie chickens (*T. cupido*) were examined to evaluate the usefulness of average lek size and total number of leks as indicies of displaying male density. Average lek size exhibited relatively low correlations with displaying male densities for both greater (r = 0.75) and lesser (r = 0.28, 0.37, 0.80) prairie chickens. Number of leks exhibited strong, positive correlations with density of displaying males for both greater (r = 0.94) and lesser (r = 0.96, 0.87, 0.81) prairie chickens.

Prairie chickens and sharp-tailed grouse (*Pediocetes phasianellus*) congregate at lek sites (booming, gobbling, dancing, or display grounds) each spring. Annual population estimates traditionally are based upon counts of males displaying at leks (e.g., Schwartz 1945, Baker 1953,

[1]This paper represents a contribution from Federal Aid in Wildlife Restoration, P. R. Project Oklahoma W-125-R. Cooperators of the Oklahoma Cooperative Wildlife Research Unit include Oklahoma State University, Oklahoma Department of Wildlife Conservation, U. S. Fish and Wildlife Service, and Wildlife Management Institute.

Hamerstrom and Hamerstrom 1973). The use of male densities to monitor annual population trends is based on the assumption that the number of displaying males is related to total population size (Schwartz 1945, Grange 1948, Hart et al. 1973). However, Sisson (1976) concluded that any census of displaying males is unrealistic when the cost of annual surveys are considered. While favoring continuation of annual counts of displaying males, Hamerstrom and Hamerstrom (1973) also believe that most management needs can be met with a reconnaissance type of annual count over large habitat units.

Two reconnaissance techniques have been proposed to monitor grouse population trends: average lek size and total number of leks. The former has shown little promise as an indicator (Kirsch et al. 1973) while the latter was proposed by Sisson (1976) and may, at least, casually, provide meaningful information (DeArment, personal communication). In this paper we examine the relationship between these techniques and census data for displaying males accumulated during 4 long-term studies of prairie chickens. We thank V. E. Davison and R. DeArment for permission to use their unpublished data. W. E. Warde provided statistical advice.

METHODS

Data on lek and total numbers of displaying males were obtained from 3 long-term studies of lesser prairie chickens. Counts for 14 years were obtained for a 4,144 ha shinnery oak (<u>Quercus havardii</u>) rangeland tract in Ellis County, Oklahoma. These counts were conducted intermittently from 1932-1975 (Davison 1940 and personal communication, Copelin 1963), and during 1978 and 1979 by the authors. Annual counts of males totaling 46 years were obtained for areas in west Texas (Jackson and DeArment 1963, DeArment personal communiction). One area (2,655 ha) was shinnery oak rangeland in Wheeler County, Texas. The second area was a large tract (40,000 ha) of sand sagebrush (Artemisia fillifolia) rangeland located in Hemphill County, Texas. The data from the Texas areas represent annual counts conducted almost every year since 1952. Data from each of these 3 studies of lesser prairie chickens were collected in a similar, consistent manner from the 3rd week in April to the 1st week in May each spring. Land-use practices on the 3 areas remained unchanged throughout the reported periods.

Besides the lesser prairie chicken data, lek and displaying male counts for greater prairie chickens in Portage County, Wisconsin (Hamerstrom and Hamerstrom 1973) were analyzed. The data represent 22 years of counts conducted on the 18,000 ha Portage County Prairie Chicken Management Area.

For each of the 4 areas, the density of displaying males each year was correlated using simple linear regression techniques with (1) the average size of all leks on the area, and (2) the total number of leks.

RESULTS

For lesser prairie chickens, density of displaying males exhibited a strong, positive correlation with number of leks on the shinnery oak rangelands of Ellis County, Oklahoma and Wheeler County, Texas (r = 0.96, 0.87; Fig. 1a, b). Density of displaying males and number of leks were also positively correlated on the sand sagebrush rangeland area in Hemphill County, Texas (r = 0.81; Fig. 1c), although the relationship was weaker. Average lek size was not correlated with density of males on the shinnery oak rangeland areas (r = 0.28, 0.37; Fig. 2a, b). However, the 2 parameters were weakly ($\underline{r}$ = 0.80), but significantly ($\underline{P}$ < 0.01), correlated on the sand sagebrush area in Hemphill County, Texas (Fig. 2c).

For the greater prairie chicken in Portage County, Wisconsin, density of displaying males exhibited a strong, positive correlation, ($\underline{r}$ = 0.94) with number of leks (Fig. 3a). Average lek size and density of displaying males were weakly correlated ($\underline{r}$ = 0.75; Fig. 3b).

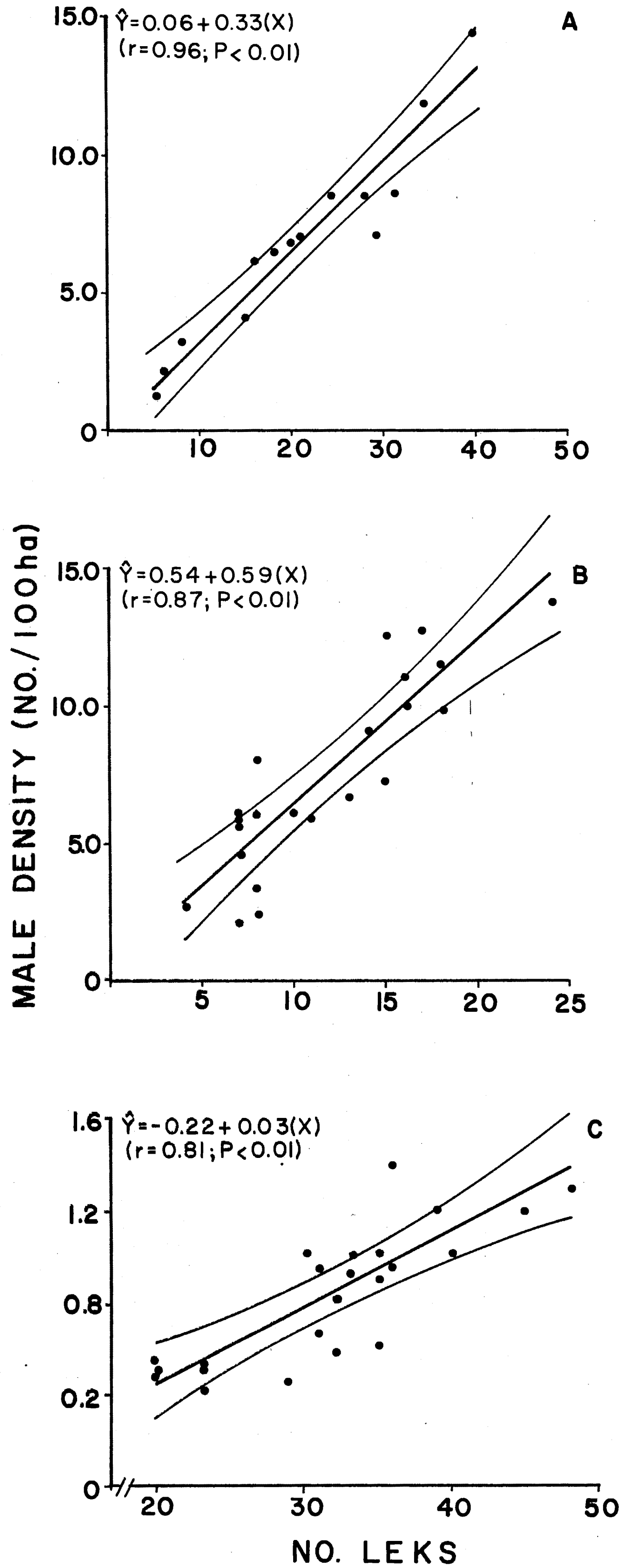
Hamerstrom and Hamerstrom (1973) distinguished between regularly used (dominant) and infrequently used (temporary) lek sites. Dominant lek sites are used daily by displaying males, whereas temporary leks appear less frequently. The complete enumeration of temporary leks appears to increase the correlation between density of displaying males and number of leks. Regression analysis of number of dominant leks and density of displaying males for the Portage County, Wisconsin area (Hamerstrom and Hamerstrom 1973:23) revealed a slightly lower correlation ($\underline{r}$ = 0.91; $\underline{P}$ < 0.005) than data including the temporary leks ($\underline{r}$ = 0.94, $\underline{P}$ < 0.005; Fig. 3b).

Variability in average lek size increases as density of displaying males increase. Average lek size exhibited a relatively high degree of variability on the Ellis County, Oklahoma (C. V. = 53.2) and the Wheeler County, Texas (C. V. = 44.9) areas. Both areas have been at relatively high population densities (Fig. 2a, b) in the past. In contrast, average lek size was less variable on the Hemphill County, Texas (C. V. = 23.9) and Portage County, Wisconsin (C. V. = 35.8) areas. Both areas have been at relatively low population densities (Figs. 2a, 3b) throughout the reported census periods.

DISCUSSION

Density of displaying males provides only a relative index to

Fig. 1. Relationship between density of displaying males of lesser prairie chickens and number of leks on shinnery oak rangelands in (A) Ellis County, Oklahoma and (B) Wheeler County, Texas, and sand sagebrush in (C) Hemphill County, Texas.



15.0
10.0
5.0
0
10
20
30
40
50
Ŷ=0.06+0.33(X)
(r=0.96; P< 0.01)
A
MALE DENSITY (NO./100ha)
15.0
10.0
5.0
0
5
10
15
20
25
Ŷ=0.54+0.59(X)
(r=0.87; P<0.01)
B
1.6
1.2
0.8
0.2
0
20
30
40
50
Ŷ=-0.22+0.03(X)
(r=0.81; P<0.01)
C
NO. LEKS

Fig. 2. Relationship between density of displaying males of lesser prairie chickens and average lek size on shinnery oak rangelands in (A) Ellis County, Oklahoma and (B) Wheeler County, Texas, and sand sagebrush rangeland in (C) Hemphill County, Texas.

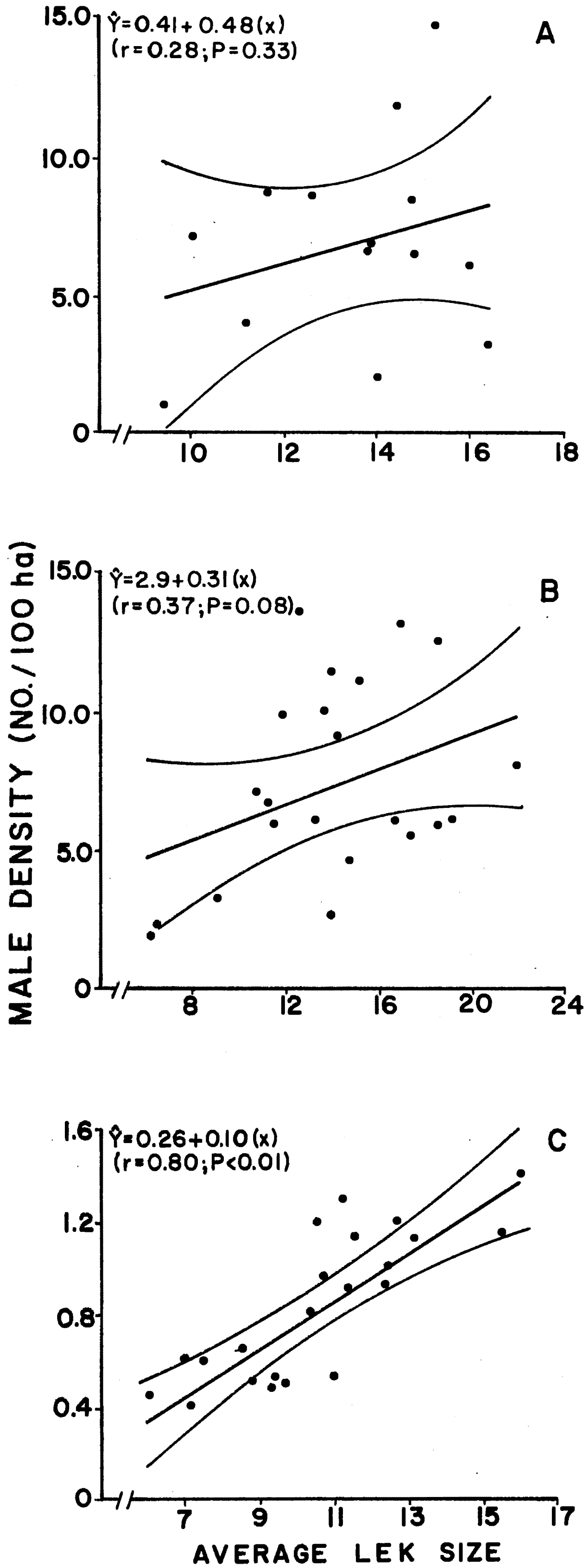
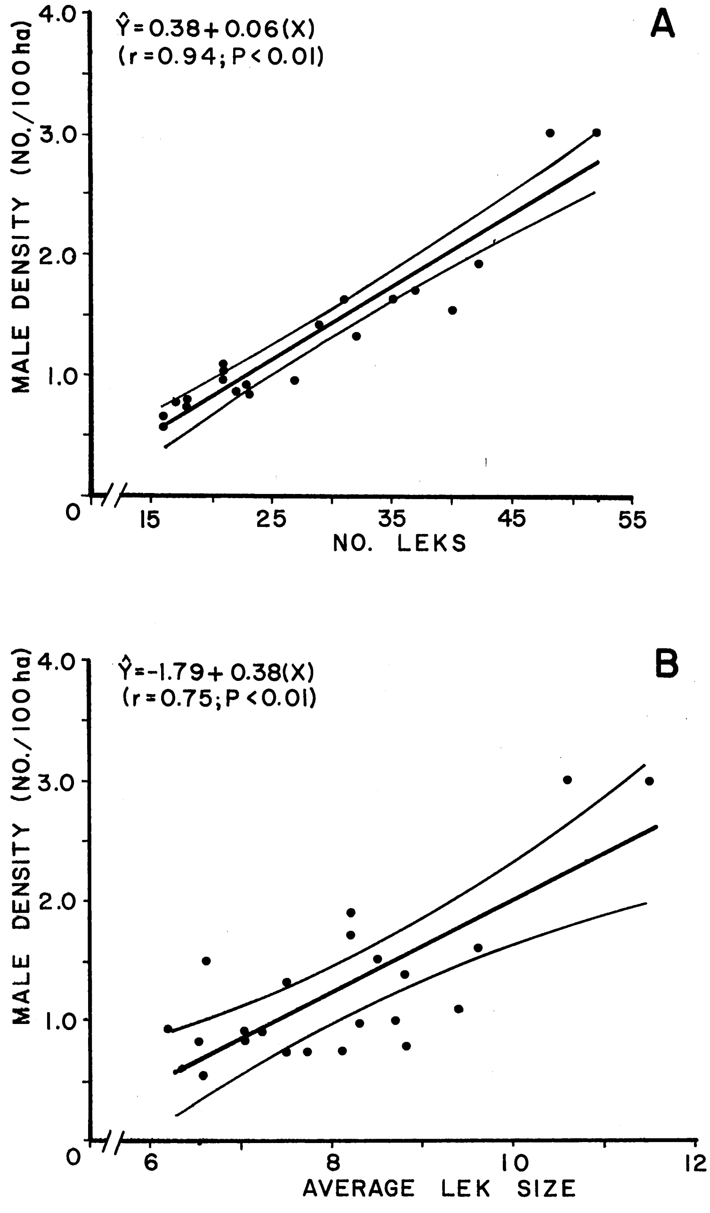

15.0
Ŷ=0.41+0.48(x)
(r=0.28;P=0.33)
A
10.0
5.0
0
10
12
14
16
18
MALE DENSITY (NO./100 ha)
15.0
Ŷ=2.9+0.31(x)
(r=0.37;P=0.08)
B
10.0
5.0
0
8
12
16
20
24
1.6
Ŷ=0.26+0.10(x)
(r=0.80;P<0.01)
C
1.2
0.8
0.4
0
7
9
11
13
15
17
AVERAGE LEK SIZE

Fig. 3. Relationship between density of displaying males of greater prairie chickens and (A) number of leks, and (B) average lek size in Portage County, Wisconsin.


A
Ŷ = 0.38 + 0.06(X)
(r = 0.94; P < 0.01)
MALE DENSITY (NO./100 ha)
4.0
3.0
2.0
1.0
0
15
25
35
45
55
NO. LEKS
B
Ŷ = -1.79 + 0.38(X)
(r = 0.75; P < 0.01)
MALE DENSITY (NO./100 ha)
4.0
3.0
2.0
1.0
0
6
8
10
12
AVERAGE LEK SIZE

population size because no reliable technique exists for surveying prairie chickens (Hamerstrom and Hamerstrom 1973). The use of male density as an index to population size is reasonable because apparent declines in prairie grouse populations have been accompanied by declines in densities of displaying males and number of active leks (Hamerstrom and Hamerstrom 1973, Kirsch et al. 1973).

Our analyses indicate that on large areas a linear relationship exists between density of displaying males and the number of active leks for both lesser and greater prairie chickens. The relationship was evident in both historically high (Fig. 1a, b) and low (Fig. 3a) density populations. For large management areas, the number of leks appears to be a reliable index to total numbers of displaying males.

Failure to census all active leks may affect the relationship between density of displaying males and number of leks. The weaker correlation between densities of displaying males and numbers of leks on the Hemphill County, Texas area (Fig. 1c) suggests that a low sampling effort (DeArment, personal communication) may have missed the temporary leks. Because of their infrequent appearance, 2 or more surveys may be required to locate all temporary leks.

The increased variability in average lek size at higher population densities may be attributed to a greater number of small, temporary leks. The number of temporary leks on the low-density area in Wisconsin increased as density of displaying males increased (Hamerstrom and Hamerstrom 1973:23). Thus, greater numbers of the small, temporary leks may have caused average lek size to decline as densities of displaying males and number of leks increased. This may explain the weaker relationship observed between average lek size and the density of displaying males.

MANAGEMENT RECOMMENDATIONS

Provided sampling effort is sufficient to detect both dominant and temporary leks during the peak of display activity each spring, the number of leks appears to provide a useful index to the density of displaying males, for both lesser and greater prairie chickens. Visual confirmation of lek presence along survey routes or in habitat units should provide a rapid, reliable, and economical indicator of density of displaying males. However, we believe that survey areas (habitat units) must encompass at least the minimum recommended management unit of 2,100 ha (Kirsch 1974), with areas approaching 4,200 ha or larger being preferable (Davison 1940).

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CHAPTER IV

LESSER PRAIRIE CHICKEN DENSITIES ON SHINNERY OAK AND SAND SAGEBRUSH RANGELANDS IN OKLAHOMA[1]

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Abstract: Percentage and frequency of grass, brush, forbs, and open ground on 8 separate 4,144 ha study areas, 4 in shinnery oak (*Quercus havardii*) and 4 in sand sagebrush (*Artemisia filifolia*) rangeland, were compared with density of displaying males of lesser prairie chickens (*Tympanuchus pallidicinctus*) on each area for spring 1978 and 1979. In sand sagebrush rangeland, density of displaying males was positively correlated with percentage and frequency of brush (r = 0.83, 0.90) and negatively correlated with percentage and frequency of grass (r = -0.88, -0.80). In shinnery oak rangeland, density of displaying males was negatively correlated with percentage and frequency of brush (r = -0.81, -0.87) and positively correlated with percentage and frequency of grass (r = 0.90, 0.70). The differential responses of lesser prairie chickens to vegetative components of the 2 rangeland types suggest that different

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[1]This paper represents a contribution from Federal Aid in Wildlife Restoration, P. R. Project Oklahoma W-125-R. Cooperators of the Oklahoma Cooperative Wildlife Research Unit include Oklahoma State University, Oklahoma Department of Wildlife Conservation, U. S. Fish and Wildlife Service, and Wildlife Management Institute.

management strategies are needed for each rangeland type.

The contemporary range of the lesser prairie chicken is restricted to scattered tracts of shinnery oak or sand sagebrush rangelands (Taylor and Guthery 1979) in Oklahoma, Kansas, Texas, Colorado, and New Mexico. Uncertainity over optimum, or even tolerable, limits of shinnery oak and/or sand sagebrush densities in prairie chicken habitats has resulted in conflicting management strategies (Copelin 1963, Jackson and DeArment 1963, Jones 1963, Donaldson 1969). Jackson and DeArment (1963) blamed herbicidal treatments of brush for a drastic population decline experienced in Texas during the 1950's and recommended protection of shinnery oak and sand sagebrush from herbicidal applications. Alternatively, Donaldson (1969) challenged the rationale behind the protection of brush after finding lesser prairie chickens preferred areas where densities of brush were decreased, creating an interspersed (Hamerstrom et al. 1957) brush-grassland habitat. Donaldson (1969) concluded that the common element between sand sagebrush and shinnery oak rangeland was a proper interspersion of open and partially closed canopy consisting of brush, grass, and forbs.

Life-form classification (DuRietz 1931) of vegetation has been used to describe habitats selected by individual birds (Jones 1963, Donaldson 1969) but has shown little promise in discriminating among habitats supporting different population densities (Crawford and Bolen 1976). Because the area required by individual birds for essential activities (i.e., feeding, mating, nesting, and brood rearing) constitutes thousands of hectares (Copelin 1963, Jones 1963), we might expect habitat features influencing flocks of prairie chickens to operate on a similar scale.

The purpose of this study was to evaluate the effect of basic habitat composition and land-use practices on lesser prairie chicken populations as reflected by densities of displaying males. Several spatially isolated flocks inhabiting scattered tracts of sand sagebrush and shinnery oak rangeland in western Oklahoma were investigated.

STUDY AREA

The contemporary range of the lesser prairie chicken in Oklahoma (Cannon and Knopf, ms) lies within the Grama-Buffalograss section of the Great Plains Prairie Province (Bailey 1976). Remaining flocks occur principally within Duck and Fletcher's (1943) Sand-Sage Grassland and Shinnery Oak-Grassland game types, with only small, scattered flocks ranging into the Shortgrass Highplains and Mixed Grass Eroded Plains game types.

Eight 16 section (4,144 ha) study areas representing 4 of Duck and Fletcher's (1943) game types were selected for investigation. The 8 areas were centered on large ranches in Beaver, Beckham, Ellis, Harper, Roger Mills, Woodward, and Woods counties. Four study areas were within the Shinnery Oak-Grassland game type and contained shinnery oak rangeland. Four additional areas were classed as sand sagebrush rangeland, but included combinations of Sand-Sage Grassland, Shortgrass Highplains, and Mixed-Grass Eroded Plains game types. Sand sagebrush had recently invaded these areas of Shortgrass Highplains and Mixed-Grass Eroded Plains from adjacent Sand-Sage Grassland. The Sand-Sage Grassland game type originally (Duck and Fletcher 1943) formed a narrow, irregular strip along major streams.

METHODS

Study areas were selected relative to probable population sizes as determined by a preliminary survey of State Game Rangers, biologists, and landowners. We chose areas containing either a relatively low-or high-density population, with a minimum of 60% of the area being rangeland. Density of displaying males was determined for each study area. During spring of 1978 and 1979, each area was searched for leks (from initial daylight to 2 hours after sunrise) along east-west transects approximately 0.8 km apart. Vocalizations made by displaying males were triangulated and plotted on topographic maps (Hamerstrom and Hamerstrom 1973) to aid in locating leks. Beginning 1 March, total numbers of males at each lek were counted at least 3 times, with the last count occurring between 20 April and 10 May.

The line-interception method (Canfield 1941) was used to describe vegetation. Percentage grass, brush, forbs, and open ground (bare soil or litter) were derived from measurements to the nearest centimeter along 30 20-m transects located on the central 4 sections (1,036 ha) of each study area. The frequency of grass, brush, forbs, and open ground was also determined for 2-m intervals along each transect. An index of residual cover, regardless of its form, was obtained from visual-obstruction measurements (to the nearest 5 cm) on a density pole (Robel et al. 1970) along each transect at 2-m intervals. Variability (mean variance) in residual cover was derived from the visual-obstruction measurements. The fall-winter agricultural components of each study area were recorded on ASCS aerial photographs. The area of each crop type was quantified with a numonics model 1224 electronic digitizer.

All vegetative measurements were obtained during March (before spring green-up) each year to minimize the effects of new vegetation. The vegetative data were regarded as a representative sample of the rangeland component of each study area because rangeland condition was fairly uniform across each area due to individual land-holdings often encompassing entire study areas and transect lines were randomly located.

Land-use and vegetative parameters were compared to density of displaying males using simple linear and multiple regression techniques that selected the set of variables, up to a maximum of 3, that best explained variability in density of displaying males. Each year's data were tested separately, and then combined if analysis of covariance failed to reject homogeneity of regression. The data also were tested with the rangeland types combined and separated.

RESULTS

All habitat data for 1978 and 1979 (Table 1) were lumped after analysis of covariance indicated no significant differences due to slope or year for each variable. Analysis of the lumped data for shinnery oak and sand sagebrush rangeland types failed to identify any vegetative or land-use parameters that could explain the variation in density of displaying males.

Data for the shinnery oak and sand sagebrush rangeland areas were separated, and subsequent analyses revealed different relationships between these brushlands and densities of males (Figs. 1, 2). In sand sagebrush rangeland, density of displaying males was positively correlated with percentage brush and negatively correlated with percentage grass (Table 2). In contrast, density of displaying males in shinnery oak rangeland was negatively correlated with percentage brush

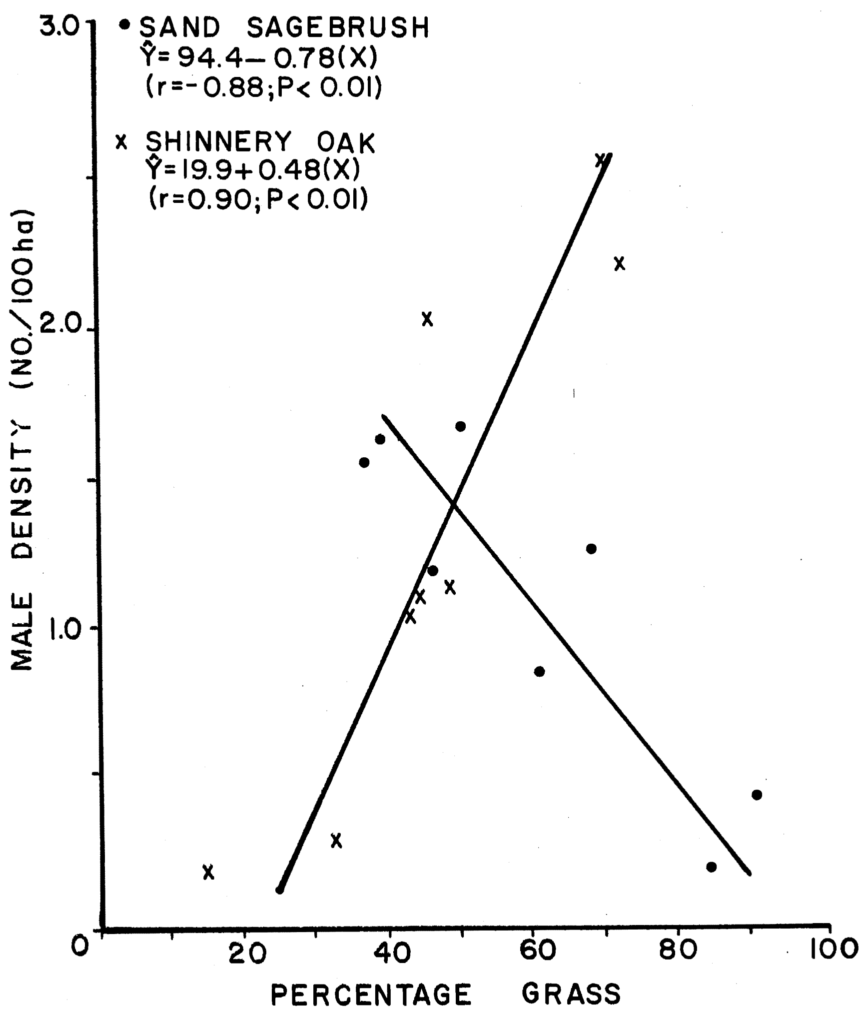
Table 1. Comparison of density of displaying males with vegetative and land-use parameters for 1978 and 1979. Rangeland descriptors were derived from 30 20-m transects on each area. Study areas 1-4 are sand sagebrush sites, while 5-8 are shinnery oak sites.

Study area	Males km^2	Rangeland percentage				Rangeland frequency				Residual cover		Percentage agriculture
		Grass	Brush	Forbs	Open	Grass	Brush	Forbs	Open	Index	Variability	
1978												
1	0.84	60.7	6.6	2.0	30.7	0.99	0.35	0.40	0.96	4.15	35.0	22
2	1.62	38.4	23.7	6.3	31.6	0.95	0.68	0.65	0.92	7.30	93.9	2
3	0.19	83.7	1.1	2.2	13.0	1.0	0.05	0.61	0.72	4.98	17.5	1
4	1.18	45.6	14.2	4.0	36.2	0.95	0.51	0.77	0.95	5.48	72.3	1
5	2.53	70.7	5.3	1.1	22.9	1.0	0.51	0.17	0.88	7.00	54.1	12
6	1.13	47.4	11.0	4.8	36.8	0.97	0.79	0.70	0.92	4.72	36.0	0
7	1.06	43.0	7.2	2.2	47.6	0.99	0.72	0.67	0.95	5.63	49.2	18
8	0.29	31.2	32.3	1.2	35.3	0.82	0.84	0.26	0.87	5.21	29.1	5

Table 1. (Continued)

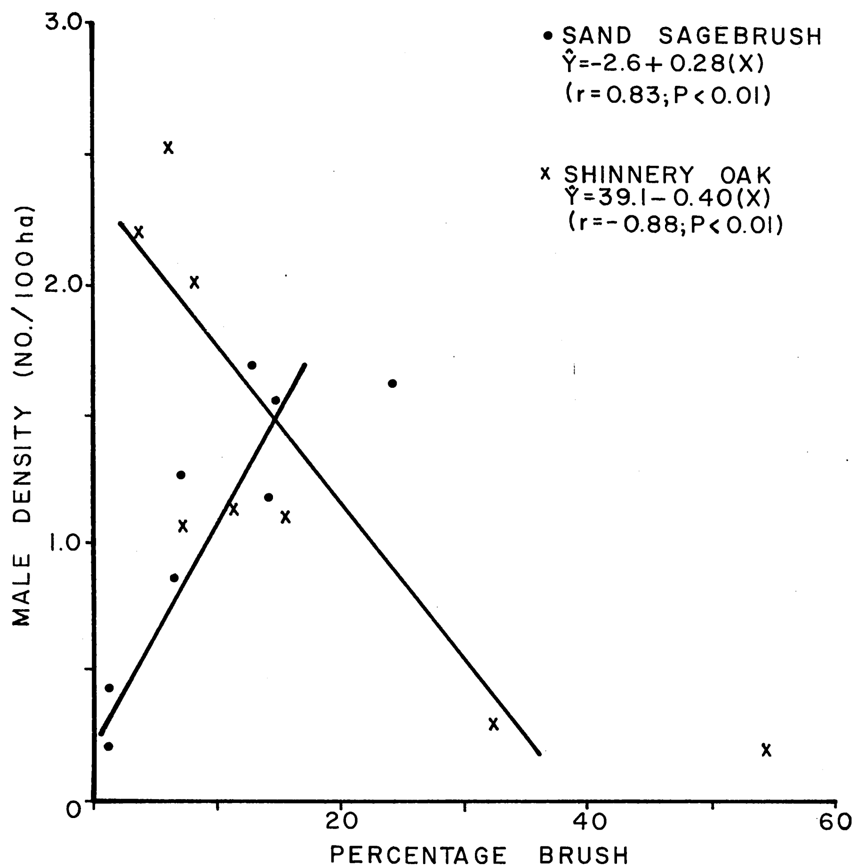
Study Area	Males km^2	Rangeland percentage				Rangeland frequency				Residual cover		Percentage agriculture
		Grass	Brush	Forbs	Open	Grass	Brush	Forbs	Open	Index	Variability	
1979												
1	1.25	67.7	7.0	1.1	24.1	0.99	0.38	0.11	0.72	2.6	19.5	22
2	1.67	49.9	11.5	1.7	36.9	0.91	0.42	0.40	0.75	3.1	38.9	3
3	0.43	90.5	1.0	0.8	7.7	1.00	0.06	0.28	0.37	2.2	8.2	1
4	1.54	36.9	14.5	1.8	46.8	0.90	0.55	0.50	0.88	2.0	19.7	0
5	2.20	72.0	3.0	0.9	24.1	0.99	0.44	0.36	0.82	4.7	35.7	12
6	2.03	44.9	8.0	1.3	45.7	0.96	0.73	0.63	0.97	3.9	27.2	0
7	1.11	44.0	15.3	2.0	38.6	0.92	0.68	0.65	0.90	5.6	37.5	32
8	0.19	14.8	54.7	0.1	30.3	0.47	0.94	0.05	0.59	2.0	11.1	14

Fig. 1. Relationship between density of displaying males and percentage grass on shinnery oak and sand sagebrush rangeland.



3.0
2.0
1.0
0
• SAND SAGEBRUSH
Ŷ= 94.4 – 0.78(X)
(r=-0.88; P< 0.01)
x SHINNERY OAK
Ŷ= 19.9 + 0.48(X)
(r=0.90; P< 0.01)
MALE DENSITY (NO./100ha)
20
40
60
80
100
PERCENTAGE GRASS

Fig. 2. Relationship between density of displaying males and percentage brush on shinnery oak and sand sagebrush rangeland.



3.0
2.0
1.0
0
20
40
60
MALE DENSITY (NO./100 ha)
PERCENTAGE BRUSH
• SAND SAGEBRUSH
Ŷ=-2.6+0.28(X)
(r=0.83; P<0.01)
x SHINNERY OAK
Ŷ=39.1-0.40(X)
(r=-0.88; P<0.01)

Table 2. Simple correlation coefficients and probability levels for density of displaying males and vegetative parameters in shinnery oak and sand sagebrush rangelands.

Parameter	Correlation coefficient	P ≥ r
Shinnery Oak Rangeland (n = 8)		
Brush (%)	-0.81	0.02
Grass (%)	0.90	<0.01
Open ground (%)	-0.30	0.48
Open ground frequency	0.43	0.28
Brush frequency	-0.87	<0.01
Grass frequency	0.70	0.05
Forbs (%)	-0.08	0.95
Forbs frequency	0.13	0.76
Agriculture	-0.40	0.32
Residual cover	0.48	0.23
Residual cover variability	0.58	0.13

Table 2. (Continued)

Parameter	Correlation coefficient	P ≥ r
Sand Sagebrush Rangeland (n = 8)		
Brush (%)	0.83	<0.01
Grass (%)	-0.88	<0.01
Open ground (%)	0.83	<0.01
Open ground frequency	0.51	0.02
Brush frequency	0.90	<0.01
Grass frequency	-0.80	0.02
Forbs (%)	0.38	0.35
Forb frequency	0.06	0.88
Agriculture (%)	0.07	0.87
Residual cover	0.06	0.88
Residual cover variability	0.52	0.18

and positively correlated with percentage grass. Percentage open ground (bare soil or litter) and density of displaying males were positively correlated in sand sagebrush rangeland, but were not significantly correlated in shinnery oak rangeland. Frequency of open ground and density of displaying males were weakly correlated in both rangeland types. Percentage open ground increased with percentage brush ($\underline{r}$ = 0.72; $\underline{P}$ = 0.05) in sand sagebrush rangeland, but exhibited no apparent relationship in shinnery oak rangeland ($\underline{r}$ = -0.10; $\underline{P}$ = 0.81).

Brush frequency and density of displaying males were positively correlated in sand sagebrush rangeland and negatively correlated in shinnery oak rangeland. Grass frequency showed an opposite relationship with density of displaying males in the 2 rangeland types, respectively. Density of displaying males showed no relationships with percentage forbs, forb frequency, or percentage agriculture in the sand sagebrush and shinnery oak rangelands.

Residual cover was not correlated with density of displaying males in sand sagebrush or shinnery oak rangeland. However, analysis of each year's data separately suggested that residual cover may influence density of displaying males. In shinnery oak rangeland density of displaying males and residual cover exhibited a positive relationship in 1978 ($\underline{r}$ = 0.82; $\underline{P}$ = 0.18) and 1979 ($\underline{r}$ = 0.58; $\underline{P}$ = 0.42). Likewise, in sand sagebrush rangeland, the 2 parameters exhibited a positive relationship in 1978 ($\underline{r}$ = 0.52; $\underline{P}$ = 0.28) and 1979 ($\underline{r}$ = 0.85; $\underline{P}$ = 0.14).

Variability in residual cover was also not correlated with density of displaying males in sand sagebrush or shinnery oak rangeland. As with residual cover, separate analysis of each year's data revealed significant or near significant relationships between density of displaying males and variability in residual cover. In sand sagebrush rangeland, density of displaying males and variability in residual cover were positively correlated in 1978 ($\underline{r}$ = 0.97; $\underline{P}$ = 0.03) and 1979 ($\underline{r}$ = 0.93; $\underline{P}$ = 0.07). Variability in residual cover and density of displaying males in shinnery oak rangeland were also positively correlated in 1978 ($\underline{r}$ = 0.84; $\underline{P}$ = 0.16) and 1979 ($\underline{r}$ = 0.70; $\underline{P}$ = 0.30).

DISCUSSION

Copelin (1963) noted that lesser prairie chickens do not occur in prairie grassland or in low density forests, and described preferred habitat as low-to-high-density shrub savannahs, where most shrubs are less than 1-meter. Our analyses indicate that lesser prairie chickens respond to the basic vegetative components of sand sagebrush and shinnery oak rangeland differently, suggesting different management strategies for each rangeland type.

The positive correlation between density of displaying males and sand sagebrush suggests that residual cover in sand sagebrush rangeland is provided largely by the sagebrush. Nesting studies (Jones 1963, Sell 1979) indicate that sand sagebrush provides important nesting and brood rearing cover, especially where tall grasses have been reduced or eliminated by overgrazing. The positive relationships between density of displaying males and percentage open ground, and percentage brush and percentage open ground suggests that overgrazing has forced prairie chickens to rely heavily on sand sagebrush for cover.

Although they will use dense stands of shinnery oak (Taylor 1978, Sell 1979), our analyses indicate that in this rangeland type lesser prairie chickens prefer areas where the bulk of the residual cover is provided by perennial mid- and tall-grass species. The positive correlation of density of displaying males with percentage grass indicates a distinct preference for grassland by prairie chickens despite the considerable cover provided by extensive stands of shinnery oak. Nesting studies (Copelin 1963, Riley 1978) also indicate the lesser prairie chickens prefer shinnery oak rangeland habitats predominated by mid- and tall-grass species.

Measurements of residual cover exhibited no clear relationship with density of displaying males in either rangeland type. However, the results for each year suggest that residual cover influences chicken densities on a year-to-year basis. The measurement of residual cover is likely more sensitive to changes in grazing and precipitation patterns than percentage and frequency of grass, brush, and open ground.

Variability in residual cover influences chicken densities on a yearly basis, especially in sand sagebrush rangeland. The positive correlation of density of displaying males with variability in residual cover suggests that under present rangeland conditions, prairie chickens prefer sand sagebrush rangelands with a high degree of interspersion. Shinnery oak rangelands with lightly to moderately grazed grasslands and a minimal amount of shinnery oak brush also appear to provide an interspersion pattern that prairie chickens prefer. The results support Donalson's (1969) conclusion that an interspersion of grass, brush, and forbs enables lesser prairie chickens to inhabit both shinnery oak and sand sagebrush rangelands.

Percentage and frequency of forbs were not significantly correlated with density of displaying males. However, weedy vegetation is an important habitat component for prairie chickens (Copelin 1963, Jones 1963) and comprised up to 6% of each study area. Brood ranges typically consist of lower successional portions of available habitat with a high percentage of forbs (Copelin 1963, Jones 1963, Taylor 1978, Sell 1979), that attract an abundant supply of insects.

The initially positive, than increasingly negative effects of agriculture on lesser prairie chickens are well documented (Duck and Fletcher 1944, Copelin 1963, Jackson and DeArment 1963, Crawford and Bolen 1976). Our results indicate that percentage agriculture and grain sorghum production apparently had neither a simple, nor singular, influence over density of displaying males in either the shinnery oak or sandsage rangeland type. Although the presence of some agriculture on our study areas probably influenced population numbers, we believe that this influence was masked by the prairie chicken's sensitivity to changes in rangeland quality.

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CHAPTER V

USE OF LANDSAT IMAGERY TO EVALUATE LESSER PRAIRIE CHICKEN HABITAT IN WESTERN OKLAHOMA[1]

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Abstract: Landsat digital data were used to evaluate lesser prairie chicken (*Tympanuchus pallidicinctus*) habitats in western Oklahoma. Seven study areas, 4 in shinnery oak (*Quercus havardii*) rangeland, and 3 in sand sagebrush (*Artemisia filifolia*) rangeland were analyzed using the Interactive Digital Imagery Manipulation System (IDIMS) at the U. S. Geological Survey's Eros Data Center, Sioux Falls, South Dakota. In shinnery oak rangeland, density of displaying males was positively correlated with grassland classes and negatively correlated with brushland classes. In sand sagebrush rangeland, density of males was negatively correlated with grassland classes and positively correlated with brushland classes. The relationships between density of males and Landsat resource classes closely parallel relationships found between

[1]This paper represents a contribution from Federal Aid in Wildlife Restoration, P. R. Project Oklahoma W-125-R. Cooperators of the Oklahoma Cooperative Wildlife Research Unit include Oklahoma State University, Oklahoma Department of Wildlife Conservation, U. S. Fish and Wildlife Service, and Wildlife Management Institute.

density of males and field measurements of percentage grass and brush. Analysis of Landsat digital data is a cost-effective habitat monitoring tool for large areas, provided adequate ground truthing is obtained and the imagery is geometrically corrected to facilitate accurate location of ground truth data within a scene.

Dramatic declines have occurred in the range and population size of the lesser prairie chicken in western Oklahoma over the last 20 years (Copelin 1963, Cannon and Knopf, ms). The contemporary range of 2,791 km^2 (Cannon and Knopf, ms) is comprised of several spatially isolated segments of shinnery oak and sand sagebrush rangeland. Prairie chickens are highly dependent upon extensive areas of high quality residual cover in each rangeland type, and are sensitive to overgrazing and agriculture in excess of 35-40% (Copelin 1963, Jones 1963, Donaldson 1969, Crawford and Bolen 1976, Cannon and Knopf, ms). The scattered distribution of remaining flocks and their dependence on specific habitats have created a need for cost-effective monitoring of changes in remaining habitat.

Analysis of Landsat digital data was proposed as an alternative to manual interpretation of aerial photography and intensive field studies. Flight dates of photography can vary considerably whereas Landsat imagery for an area is repeated every 9 days and machine processing can provide land-use information for large areas in a matter of days. Intensive field studies to monitor vegetation changes and subsequent effects on prairie chickens are costly and time consuming, especially for widely scattered habitat segments. Landsat imagery has shown considerable promise as a means to economically evaluate and monitor changes in terrestrial habitats of wildlife populations (Brabander 1974, Frye et al.

1979, Katibah and Graves 1979, Parker 1979). The purpose of this study was to evaluate the ability of Landsat imagery to detect vegetative parameters biologically important (Copelin 1963, Jones 1963, Donaldson 1969, Cannon and Knopf, ms) to prairie chickens. Digital processing and technical assistance were provided by the U.S. Geological Survey's EROS Data Center (USGS-EDC) Sioux Falls, South Dakota.

STUDY AREA

The contemporary range of the lesser prairie chicken in Oklahoma (Cannon and Knopf, ms) lies within the Grama-Buffalograss section of the Great Plains Prairie Province (Bailey 1976). Remaining flocks are confined principally to Duck and Fletcher's (1943) Sand-Sage Grassland and Shinnery Oak-Grassland game types, with only small, scattered flocks ranging into the Shortgrass Highplains and Mixed Grass Eroded Plains game types.

Seven 16-section (4,144 ha) study areas, 4 in shinnery oak rangeland and 3 in sand sagebrush rangeland, were selected for investigation (Cannon and Knopf, ms). The 7 study areas were centered on large ranches in Beaver, Beckham, Ellis, Harper, Roger Mills, and Woodward counties.

METHODS

A computer compatible tape (CCT) of a Landsat scene (Path 31, Row 35) dated 4 October 1978 was used for the digital analysis of the 4 shinnery oak rangeland areas. For the 3 sand sagebrush areas, digital analysis was performed with a CCT of a Landsat scene (Path 32, Row 34) dated 14 October 1978. Imagery dates in the fall were selected to facilitate discrimination of grassland, brushland (green canopy), and sorghum, a readily used food item by prairie chickens during the winter.

The specific imagery dates (4, 14 October 1978) were determined by the availability of cloud-free scenes before a killing frost (approximately 1 November 1978).

Color-infrared aerial photographs (1::120,000) acquired by the National Aeronautics and Space Administration (NASA) 19 August 1972 and 5 June 1975 were used to aid in locating each study area within the Landsat scene. Black and white aerial photographs (1::40,000) acquired 1973-74 by the Agricultural Stabilization and Conservation Service (ASCS) were used to record detailed land cover patterns (e.g., grazing intensity, brush type and density, agriculture) on each study area. Vegetation data from line-transects (Cannon and Knopf, ms) were used in conjunction with the aerial photographs in the training phase of the digital classification.

The 4 shinnery oak rangeland areas were analyzed separately from the 3 sand sagebrush areas to avoid anticipated spectral overlap. Each study area was centered within a block (120 lines x 170 samples) of picture elements (pixels) to facilitate digital analysis. Landsat digital data were analyzed using an interactive analysis procedure (Rhode 1978) on the Interactive Digital Imagery Manipulation System (IDIMS) at the USGS-EDC. A stratified sampling procedure (Fleming et al. 1975) was used to select training areas within each block of pixels. Training areas were selected to include representative samples of the various resource classes identifible from ground truth data (field investigation). An unsupervised clustering algorithm (ISOCLS) was used to group training area pixels into homogeneous groups and to generate a statistics file (Rhode 1978, Pettinger 1979, Rhode et al. 1979).

The spectral clusters generated by the clustering algorithm (ISOCLS) were evaluated through the use of a video display screen. Single clusters and/or groups of clusters were color coded to faciliate pattern recognition and comparison with annotated aerial photogrphs. The cluster groups were assigned to resource classes based on groud truth data. The final set of spectral clusters and corresponding training statistics for each rangeland type were used to classify the remainder of each block of pixels. The training statistics file was used by a maximum likelihood classification algorithm (CLASFY) to create a 1-band classified image of each study area (Pettinger 1979, Rhode et al. 1979).

A 16-section (4,144 ha) digital mask was applied to each classified block of pixels to isolate the actual study area. The number of pixels in each land-use class were recorded as percentages and compared with 1979 density of displaying males on each study area (Cannon and Knopf, ms) using simple linear regression techniques.

RESULTS

The sand sagebrush rangeland training areas comprised 21.2% (13,000 pixels) of the 3 study areas. The shinnery oak rangeland training areas comprised 15.3% (12,500 pixels) of the 4 study areas. The 1st unsupervised clustering (ISOCLS) of training data for each rangeland type resulted in considerable spectral overlap based on ground truth data. On sand sagebrush rangeland, plowed ground was confused with sand sagebrush, sorghum/sudan stubble, and degraded lovegrass (*Eragrostis curvula*) pasture. The clustering algorithm (ISOCLS) parameters were refined and the classification repeated after concluding that the clustering algorithm parameters were not detecting known differences in vegetative cover on the areas (Table 1). Before repeating the cluster

Table 1. ISOCLS Algorithm Parameters specified for the first and second clustering of training area digital data and number of clusters generated.

Parameter	ISOCLS nomenclature	Normal range	Sand sagebrush rangeland Specified values Trial 1	Trial 2	Shinnery oak rangeland Specified values Trial 1	Trial 2
Maximum no. of iterations	ISTOP	15-30	20	20	20	20
Minimum no. of pixels/ cluster	NMIN	15-30	25	20	25	20
Minimum combining distance of Landsat relative radiance values	DLMIN	2.5-4.0	3.0	1.5	3.0	1.5
Maximum standard deviation of Landsat relative radiance values	STDMAX	1.0-3.0	2.5	1.8	2.5	1.8
Maximum no. clusters	MAXCLS	30-60	50	50	50	50
No. clusters generated			27[a]	43	27	50

[a] 11 classes were masked and combined with the 43 classes generated in Trial 2.

analysis for the sand sagebrush areas, 11 correctly classified sorghum/ sudan clusters were masked (Pettinger 1979) and combined with the results of the 2nd clustering.

Comparison with ground truthing revealed that the 2nd unsupervised clustering generated a better classification, especially for the rangeland component of the training areas. However, maximum-likelihood classification (CLASFY) of the 7 study areas (120 x 170 pixel blocks) revealed additional confusion between rangeland and agriculture. The additional confusion was the result of variability in soil type and growth stage of crops not included in the training areas. Due to machine processing time constraints, selection of additional training areas and subsequent clustering were not performed. Instead, the agricultural component of each study area was stratified (Pettinger 1979) and confused rangeland/agriculture pixels within the agricultural strata were changed to the correct classification.

The final classification resulted in 8 land-use classes on the sand sagebrush rangeland areas (Table 2) and 8 land-use classes on the shinnery oak rangeland areas (Table 3). The rangeland classes for each rangeland type were characterized with vegetation data from line-transects (Table 4).

In shinnery oak rangeland, density of displaying males was positively correlated with percentage (total) grassland (Table 5). Percentage (total) brushland, bare soil, and agriculture were negatively correlated with density of males in shinnery oak rangeland. In sand sagebrush rangeland, percentage brushland was positively correlated with density of males. Percentage bare soil, grassland, and agriculture were negatively correlated with density of males.

Table 2. Landsat classification of study areas categorized as sand sagebrush rangeland in Texas, Beaver, and Woodward counties, Oklahoma, 14 October 1978.

Landsat classes	Area 1[a] No. pixels	Area 1[a] Percentage area	Area 2 No. pixels	Area 2 Percentage area	Area 4 No. pixels	Area 4 Percentage area
Bare soil/sand	1,074	12.1	176	1.8	70	0.7
Grassland-low cover	623	7.0	125	1.3	32	0.3
Shortgrass prairie/pasture	2,478	28.0	2,066	21.6	915	9.6
Sandsage brushland low density	135	1.5	3,272	34.1	4,172	43.7
Sandsage brushland high density	3,229	36.5	3,783	39.5	3,548	37.2
Riparian	1	<0.1	12	0.1	778	8.2
Sudan	24	0.3	122	1.3	13	0.1
Sorghum	1,296	14.6	32	0.3	10	0.1
Total	8,860		9,588		9,538	

[a]1 pixel equals 0.45 ha

Table 3. Landsat classification of study areas categorized as shinnery oak rangeland in Woodward, Ellis, Roger Mills, and Beckham counties, Oklahoma, 4 October 1978.

Landsat classes	Area 5[a]		Area 6		Area 7		Area 8	
	No. pixels	Percentage area	No. pixels	Percentage area	No. pixels	Percentage area	No. pixels	Percentage area
Bare soil	835	9.2	421	4.5	2,389	26.9	1,326	13.6
Grassland-low cover	2,431	26.7	3,367	36.2	1,309	14.8	2,177	22.2
Grassland-high cover	4,069	44.7	3,462	37.2	1,733	19.6	1,108	11.3
Shinnery oak brushland high density	102	1.1	84	0.9	659	7.4	2,386	24.3
Shinnery oak brushland low density	924	10.2	1,836	19.7	1,535	17.3	2,061	21.1
Mixed agriculture: lovegrass, sudan, alfalfa, and marsh	379	4.1	37	0.4	189	2.1	31	0.3
Agriculture: sorghum and sudan	24	0.3	6	0.1	146	1.7	252	2.6
Mixed agriculture: poor lovegrass, sorghum and sudan stubble	334	3.7	93	1.0	905	10.2	447	4.6
Total	9,098		9,306		8,865		9,788	

[a]1 pixel equals 0.45 ha

Table 4. Comparison of ground truth data with Landsat rangeland classes in western Oklahoma.

Landsat class	Percentage Grass	Brush	Open	Residual cover index
<u>Sand Sagebrush Rangeland</u>				
Grassland - sparse cover	50-100	0-1	0-50	0-0.5
Shortgrass prairie/pasture	75-100	0-1	0-25	0.5-3.5
Sandsage brushland - low density	30-80	1-10	10-40	0-3.5
Sandsage brushland - high density	25-70	11-55	25-55	1.0-8.0
<u>Shinnery Oak Rangeland</u>				
Grassland - low cover	25-75	<5	25-75	0-3.5
Grassland - high cover	50-90	<5	25-40	3.5-10.5
Shinnery oak brushland - low density	40-80	5-25	5-55	1.0-13.0
Shinnery oak brushland-high density	0-40	25-75	25-60	2.0-13.5

Table 5. Relationships between density of males and Landsat resource classes. Relationships between density of males and percentage grass and brush from line transects are provided for comparison.

Resource class	Line intercept		Landsat	
	r	P	r	P
Shinnery Oak Rangeland (n = 4)				
Bare soil			-0.49	0.51
Grassland	0.89	0.11	0.91	0.08
Brushland	-0.95	0.05	-0.95	0.05
Agriculture			-0.36	0.64
Sand Sagebrush Rangeland (n = 3)				
Bare soil			-0.93	0.24
Grassland	-0.75	0.46	-0.67	0.53
Brushland	0.76	0.45	0.91	0.27
Agriculture			-0.93	0.24

DISCUSSION

Landsat imagery has only recently been applied by field personnel to resource and wildlife related problems (Colwell et al. 1978, Adams 1979, Frye et al. 1979, Katibah and Graves 1979). The limited application of Landsat imagery in the past is the result of limited access to machine processing systems. The results of this study indicate Landsat imagery can provide cost-effective analysis of diverse terrestrial habitats.

Landsat digital analysis can detect 2 - 3 levels of grazing intensity and brush density in shinnery oak and sand sagebrush rangeland. Adequate ground truthing is essential to detecting these subtle differences in rangeland quality. Geometrically correlating the ground truth data with the classified scenes was difficult but field patterns of agriculture, and contrasting grazing intensities along fences and brush density provided sufficient detail to accurately locate the majority of the ground truth data. Future analyses of expansive rangeland tracts to quantify habitat quality should include geometric correction (Pettinger 1979). Landsat data geometrically corrected to overlay standardized maps will insure accurate correlation of ground truth data with spectral clusters and greatly increase the discrimination capabilities of the machine-processing system.

Sand sagebrush and shinnery oak rangelands require different managemant strategies for prairie chicken survival (Donaldson 1969, Cannon and Knopf, ms). High quality habitat is characterized by a predominance of residual cover of grasses in shinnery oak rangelands and brush cover in sand sagebrush rangelands. The positive correlation (Table 5) between density of males and grassland classes in shinnery oak rangeland and brushland classes in sand sagebrush rangeland closely parallels similar relationships (Table 5) found with field sampling technique (Cannon and Knopf, ms). Although the sample size of the correlation is small, the results indicate that Landsat digital analysis can detect and quantify habitat parameters important to prairie chicken survival.

The detrimental effects of excessive agriculture on prairie chicken survival has been documented (Crawford and Bolen 1976). However, the negative correlation between density of males and agriculture (Table 5) in sand sagebrush rangeland was not considered indicative of excessive agriculture since percentage agriculture was relatively small (Table 2). The comparatively higher percentages of agriculture on the shinnery oak areas (Table 3) did not exhibit a clear relationship with density of males (Table 5). Although agriculture probably influenced population size, prairie chicken numbers were considered to be largely influenced by rangeland quality (Cannon and Knopf, ms) because the agricultural component of each study area was within tolerance limits of the birds (Crawford and Bolen 1976).

A single Landsat data set can provide only limited information for some land-use practices within an area. The problem encountered in accurately classifying agriculture adjacent to rangeland was the result of variable crop management by individual landowners. Accurate classification of all land-use classes would have required multi-seasonal Landsat coverage of the study areas; the expense was considered excessive for this study. However, the single date coverage generated rangeland classes closely approximating ground truth data on each area. The generalized agricultural classes were acceptable because separation of rangeland and agriculture was possible. Loss of additional rangeland will almost certainly be detrimental to remaining flocks of prairie chickens (Crawford and Bolen 1976, Cannon and Knopf, ms), and timely detection of further losses of habitat is crucial to survival of birds in isolated flocks.

The widely scattered distribution of remaining prairie chicken flocks renders intensive monitoring of habitat in the field impractical at a time when such information is most urgently needed. Landsat digital analysis can detect habitat quality parameters to which prairie chickens are sensitive and can monitor changes on a seasonal basis. With adequate ground truthing, Landsat imagery can provide useful habitat information during critical survival periods of prairie chickens. Excluding the collection of ground truth data, the analysis (machine processing and CCT's) cost 2.3 ¢ per hectare.

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APPENDIX

LEGAL DESCRIPTIONS OF THE STUDY AREAS

Table 1. Legal descriptions of the study areas.

Area	County	Location
Sand Sagebrush Rangeland		
1	Texas	S 13-16, 21-28, 33-36, T 3 N, R 19 E
2	Beaver	E 3/4 S 36, T 5 N, R 25 E W 1/4 S 34, S 31-33, T 5 N, R 26 E S 3-10, 15-18, T 4 N, R 26 E
3	Woods	S 15-22, 27-34, T 29 N, R 18 W
4	Harper	S 9-16, 21-28, T 25 N, R 23 W
Shinnery Oak Rangeland		
5	Ellis Woodward	S 1-3, 9-15, 22-24, T 20 N, R 23 W S 6, 7, 18, 19, T 20 N, R 22 W
6	Ellis	S 25, 36, T 18 N, R 24 W S 1, 12, T 17 N, R 24 W S 28-33, T 18 N, R 23 W S 4-9, T 17 N, R 23 W
7	Roger Mills	E 1/4 S 31, W 3/4 S 35, S 32-34, T 13 N, R 26 W S 3-10, 15-18, T 12 N, R 26 W
8	Beckham	S 28-33, T 11 N, R 26 W S 4-9, T 10 N, R 26 W
	Wheeler (Texas)	Area bounded by points: 14SMQ0719 14SMG0713 14SMG0919 14SMQ0913

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