KANSAS

PRAIRIE CHICKENS

KANSAS FISH AND GAME COMMISSION

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INTRODUCTION

Three species of prairie grouse, plains sharp-tailed *(Pedioecetes phasianellus jamesii)*, lesser prairie chicken *(Tympanuchus pallidicinctus)*, and greater prairie chicken *(Tympanuchus cupido pinnatus)*, historically found suitable habitat in Kansas.

The plains sharp-tailed grouse originally occupied the northwest one-fourth of Kansas; however, they were eliminated from this region due primarily to the destruction of brush habitat (Aldrich 1963). By 1932, sharp-tailed grouse were no longer found in Kansas (Bent 1932). During the early 1950's, sharp-tailed grouse were spreading from Nebraska into extreme northwest Kansas (Baker 1953); however, no authenticated report of sharp-tails has since been noted.

The lesser prairie chicken probably always inhabited the southwestern quarter of the state, but according to Schwilling (1955) no distinction was made between the lesser and greater prairie chicken until 1885. He indicated that these birds were abundant until about 1929 or 1930, but were virtually eliminated during the ensuing drought period. Thereafter, the population began to slowly recover, primarily in the sandsage grassland areas south of the Arkansas and Cimarron rivers. Center-pivot irrigation was introduced to Kansas in the 1960's and soon threatened destruction of the sandsage habitat, where most lesser prairie chickens are found in Kansas (Waddell 1977).

The greater prairie chicken was probably the most common of all the prairie grouse in Kansas. Since settlement, the land-use changes from grassland to cropland have influenced prairie chicken populations and range. Greater prairie chicken populations initially increased, but later dwindled as land conversion continued. The Flint Hills of east-central Kansas now remains their stronghold, with smaller populations to the east and west.

These changes in land-use and prairie chicken populations have been documented by Baker (1953) and Bent (1932), but specific habitat needs and population data were unknown. In 1962, the Kansas Fish and Game Commission initiated investigations to develop and evaluate survey techniques for monitoring prairie chicken populations throughout their Kansas range. An intensive study was also initiated to obtain information relative to population dynamics, biology and habitat requirements of the greater prairie chicken in the Flint Hills.

HISTORY

The evolution and ecology of the prairie ecosystem was strongly influenced by interactions with herbivores and wildfires. Prairie grouse evolved within this system. Changes in any component of this interaction can have major effects on the whole ecosystem.

Deliberate setting of fires by Indians surely played a part in influencing prairie chicken populations, but before European agriculture, prairie chicken populations probably remained relatively constant.

Historical records of prairie chickens in Kansas are rare. The accounts of early explorers mention little of the bird. This may indicate that they did not occur in substantial numbers. Pike did not note the prairie chicken in his account of travels across Kansas in the autumn of 1806 (Coues 1895:357-459). While observing prairie chickens twice in Missouri, Tixier never mentioned seeing them during his travels in 1840 to an Osage Indian Village probably located in southeast Kansas (McDermott 1940:102-132). Even more significant was the fact that part of his party survived for two days on upland sandpipers *(Bartramia longicauda)* during their stay on the prairie. Had prairie chickens been available, they no doubt would have also been used as food.

Territorial and state laws governing the harvest and use of prairie chickens in Kansas probably present the most complete records available (Wood 1974). These laws, though initially unscientific, reveal a general concern for the population.

In 1861, the last territorial legislature imposed the first hunting season for prairie chickens in Kansas (2 November to 31 March). No limits or methods of taking birds were stated. However, Leavenworth County landowners were allowed to take the birds year-round if hunting on their own land. This could indicate a greater abundance of birds or favoritism toward the landowner in extreme northeast Kansas. The season never actually occurred because in the same year the formation of the first Kansas state legislature resulted in game law changes. The new legislature apparently gave county governments authority over seasons. As a result, the season opened on 2 September rather than 2 November, statewide. The law provided that the season could be closed in any county if a minimum of 20 citizens of that county petitioned for closure. There is no evidence that any county exercised this option.

The law remained unchanged until 1865, when the legislature removed state protection of the prairie chicken, but left open the option to counties to close hunting in their own jurisdictions. Again, there is no record of any counties doing so. No governmental body provided enforcement of the laws affecting prairie chickens.

With further settlement of Kansas in the late 1860's and 1870's, agriculture activity increased, and the prairie chicken population responded. Farming made range expansion possible due to new winter food supplies. Early farming efforts seemingly provided excellent habitat. Koch (1863:163) indicated that prairie chicken numbers increased within three years after settlement. In an ornithological survey in 1872, J. A. Allen noted that the prairie chicken was rare, but was advancing westward every year. Prairie chickens were first seen in the vicinity of Fort Hays around 1870 and were apparently fast becoming common.

During the late 1800s, new settlements were being established in western Kansas, and the accompanying agriculture helped move the prairie chicken west. Cooke (1900) reported that prairie chickens first nested in Colorado in approximately 1899.

Kansas laws were liberalized during the 1870's suggesting increased prairie chicken numbers. Nets and traps were illegal in 1868, but by 1876, landowners could use them to catch the birds on their own property. In 1877, prairie chickens could be taken by anyone, anyplace, by any means. However, commercial shipment of any game animal out of the state was illegal.

A similar expansion in prairie chicken range and numbers was noted in many of the central plains states. In Minnesota, prairie chickens existed during the period of early exploration. However, prior to 1850, prairie chickens entered the state from the east and south and spread rapidly westward and northward following settlement (Partch 1973). Greater prairie chicken in Iowa increased in number from the time of early settlement (Stempel and Rodgers 1961). Prairie chickens were not present in the Dakota Territory prior to 1870, but by 1873, they were the most common grouse species south of Yankton, and were spreading northward (Johnson 1964).

Prairie chickens were heavily used as food by many settlers. Johnson (1964) stated that between 1885 and 1894, many ate prairie chickens rather than kill their own domestic birds. Virtually no game laws were enforced during the late 1800's and early 1900's. As prairie chickens disappeared in the eastern United States, market hunting for the species flourished in the plain states. These birds brought $3.50 per dozen at Chicago markets in 1871 (Johnson 1964). The price in New York in the 1870's was about $.20 per pound. One large New York establishment sold 2,400 prairie chickens daily during the 1878 Christmas holiday season.

Concerns for the decline in prairie chickens emerged as early as 1880 in the eastern tallgrass prairie and the early 1890's in the plain states. In Illinois, prairie chickens seemed to decline after 1880 (Yeatter 1943). Iowa also experienced a dramatic rise and fall in their prairie chicken populations (Stempel and Rodgers 1961). Their numbers increased through 1880, but then declined, despite the outlawing of hunting. By 1900, prairie chickens had begun to decline in Minnesota (Partch 1973).

The decline of prairie chicken populations in Kansas was noted as early as 1891, when N. W. Goss reported that the birds were rapidly decreasing in numbers, and that, unless the law protecting them was strictly enforced, especially relative to trapping, prairie chickens would soon be exterminated. During periods of extreme cold and snow cover, hunger overcame fear and chickens were easily trapped. In 1912, Dyche noted that prairie chickens were previously found in great numbers, especially in eastern Kansas, but as of that date they were restricted mainly to counties in the western part of the state. Bunker (1913) noted that, while prairie chickens were fairly common in western Kansas, they were no longer so abundant in some areas.

At some point, agriculture provided an optimum balance of food and cover for prairie chickens, but they rapidly disappeared, once this balance was exceeded. This decline was probably accelerated by subsistence and market hunting and, no doubt, natural population fluctuations occurred. There is no question that the major long-term impact resulted from expansion of cultivation and the subsequent loss of prairie habitat. Unlike most tallgrass prairie regions, the Flint Hills of Kansas escaped heavy cultivation and consequently maintained good prairie chicken populations during the agricultural revolution.

In the early 1900's, public concern for the welfare of prairie chicken populations grew, and many Kansas county commissions closed their counties to hunting. From 1903 through 1905, 20 Kansas counties closed their seasons. All of these were in the western one-half of the state, with 17 in the southwest. In 1907, the Butler County government made prairie chicken hunting illegal for three years. The first statewide daily bag limit on prairie chickens (15 birds) was imposed in 1905 and was lowered to 12 in 1911.

Despite all efforts, prairie chicken numbers continued to decline, suggesting that hunting was not solely responsible. There was no prairie chicken season in Kansas from 1913 through 1916. By 1922, prairie chicken populations had stabilized in the eastern portions of Kansas and were found wherever conditions were favorable. This included the extreme eastern counties, where they were nearly extirpated ten years earlier (Clapp 1922).

During the 1920's, more regulations were established, and market hunting stopped. Season limits of 20 birds and shooting hours of one-half hour before sunrise to sunset were first established in 1921. In addition, only 11 hunting days were allowed from 1921 through 1926. The Kansas Forestry, Fish and Game Commission was established in 1926, further increasing the ability of the state to impose and enforce game laws. The Commission imposed a statewide closed season on prairie chickens in 1927 in hopes of protecting lesser prairie chickens in the southwestern portion of Kansas.

During the early 1930's, populations of prairie chickens fluctuated greatly due to drought conditions (Schwilling 1953, Baker 1953). From 1931 through 1935, the season was only two days in length. The severe drought during the late 1930's may have reduced the hatching rate of prairie chickens (Stempel and Rodgers 1961). Prairie chicken hunting seasons in Kansas were closed from 1936 through 1940 during the height of the drought. It is likely that changes in agriculture and overgrazing that accompanied the drought all but eliminated greater prairie chickens from northwest Kansas and drastically reduced populations elsewhere (Baker 1953).

From 1941 through 1943, short hunting seasons were opened in certain areas of the state. Six southeast counties (Woodson, Allen, Anderson, Linn, Bourbon, and Crawford) were open to hunting in 1941. Greenwood, Franklin, and Wil-

Table 1. Summary of greater prairie chicken season frameworks in Kansas, 1957 through 1983.

Year	Season Length (Days)	Daily Bag	Possession Limit	Remarks
1957	2	2	4	19 Counties
1958	2	2	4	19 Counties
1959	3	2	4	27 Counties
1960	3	2	4	28 Counties
1961	3	2	4	28 Counties
1962	5	2	4	29 Counties
1963	3	2	4	29 Counties
1964	5	2	4	29 Counties
1965	3	2	4	29 Counties
1966	9	2	4	29 Counties
1967	9	2	6	29 Counties
1968	7	2	6	29 Counties
1969	11	2	6	E US Hwy 81 (51 Cos.)
1970	4	2	4	E US Hwy 81 (51 Cos.)
1971	4	2	6	E US Hwy 81 & I-95W (51 Cos.)
1972	18	2	6	E US Hwy 81 & I-35W (51 Cos.)
1973	30	2	6	E US Hwy 81 & I-35W (51 Cos.)
1974	28	2	6	E K-15 (59 Cos.)
1975	9	2	4	Statewide
1976	30	2	6	Statewide
1977	37	2	6	E US Hwy 81, N US Hwy 54
1978	44	2	6	E US Hwy 81
1979	59	2	6	Statewide
1980	61	2	6	Statewide
1981	101	2	6	Statewide
1982	88	2	6	Statewide
1983	89	2	6	Statewide

son were added in 1942 and 1943, while Linn County remained closed.

The season was closed again in 1944 and remained closed through 1950. Hunters were allowed to take two birds during one-day seasons (25 October) in 1951 and 1952. The only areas open to hunting in the state were the counties in or near the Flint Hills.

The season was again closed from 1953 until 1956. In 1956, an attempt to reopen the prairie chicken season failed due to fears that hunting, coupled with drought conditions, would be detrimental to the birds. A season was established in 1957 and in every year since (Table 1).

It can be concluded that European agricultural influence was a positive factor in the expansion of the prairie chicken. Only after man amplified agricultural operations did the prairie chicken suffer. Intensified land use and changes in the prairie plant composition during the late 1800's started the downward trend. Despite efforts to slow the decline, the altered habitat could not support high numbers of prairie chickens. Though populations fluctuated widely during the first half of the 20th century, the population numbers of the 1800's were never repeated. The drought years of the 1930's and 1950's drastically reduced the numbers and range of Kansas prairie chickens. Since then, Kansas prairie chickens have again gradually increased their range and populations.

DISTRIBUTION

Schwilling (1955) believed the original area dominated by lesser prairie chickens was in the southwest one-fourth of the state, roughly south of the Smoky Hill River and east to Harper and Kingman counties. The remainder of Kansas was dominated by greater prairie chickens (Fig. 1).

Baker (1953) studied the distribution of both lesser and greater prairie chickens with help from Kansas game protectors and U.S. Soil Conservation Service personnel (Fig. 2). He reported that greater prairie chicken populations were stable or slightly increasing in the eastern one-third of Kansas, but decreasing in the remnant habitat of the northeast. An abundant population of lesser prairie chicken existed in the southwest quarter of the state prior to 1930, but were nearly eliminated from the state during the dust bowl days of the 30's (Baker 1953, Bent 1932). The lesser prairie chicken population was still low in 1953, but began to show slight increases (Baker 1953).

White (1963) surveyed employees of the Kansas Forestry, Fish and Game Commission and Soil Conservation Service personnel in 1963 to update range and density maps of prairie chickens in Kansas (Fig. 3). He noted that remnant chicken populations in northwest Kansas had nearly disappeared, with only isolated flocks in Cheyenne, Rawlins, and Sherman counties. Populations in the eastern one-third of the state were again listed as stable with some slight in-

Figure 1. Approximate original range dominated by lesser and greater prairie chickens during the pre-settlement period in Kansas (Schwilling 1953).

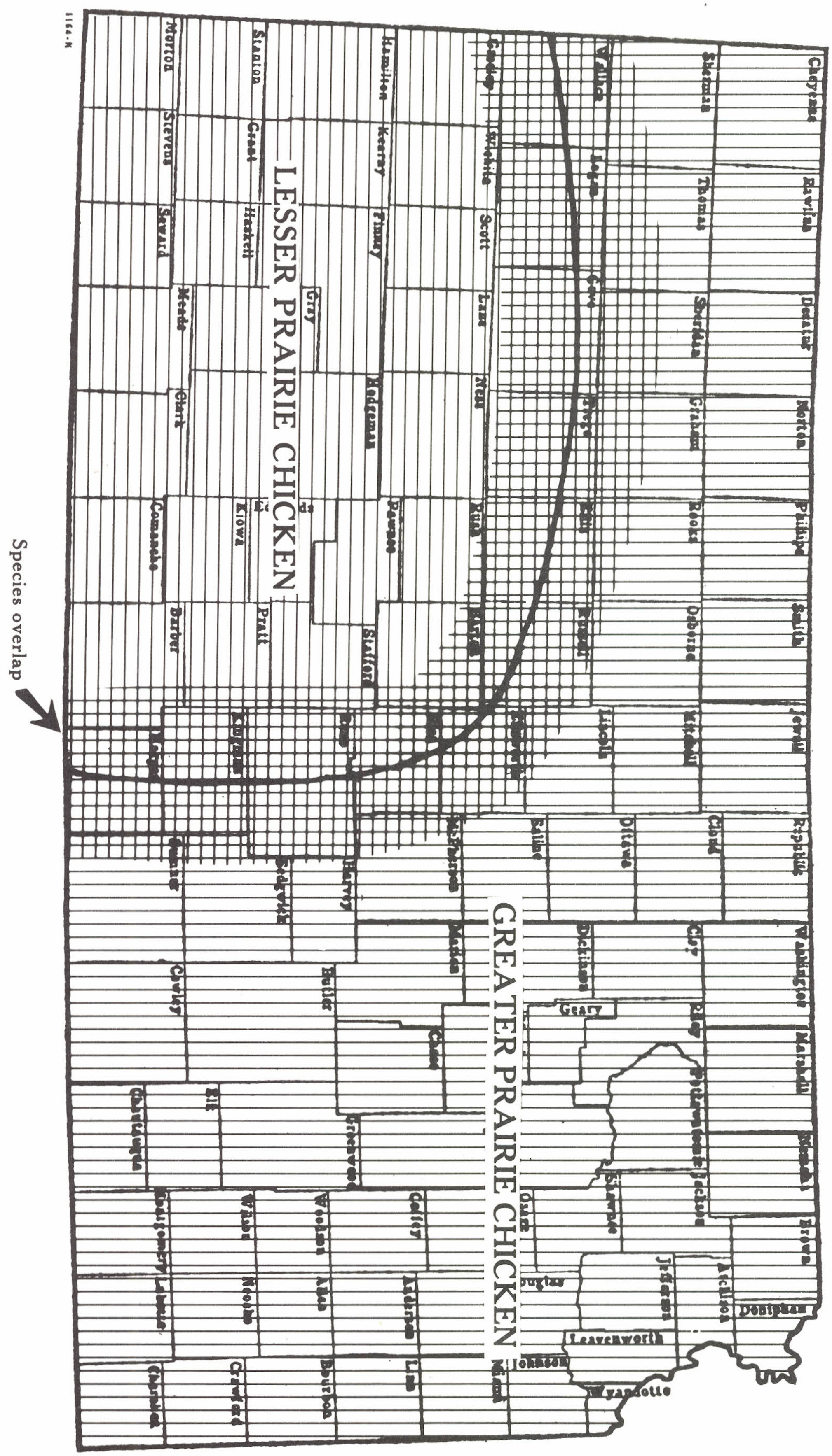
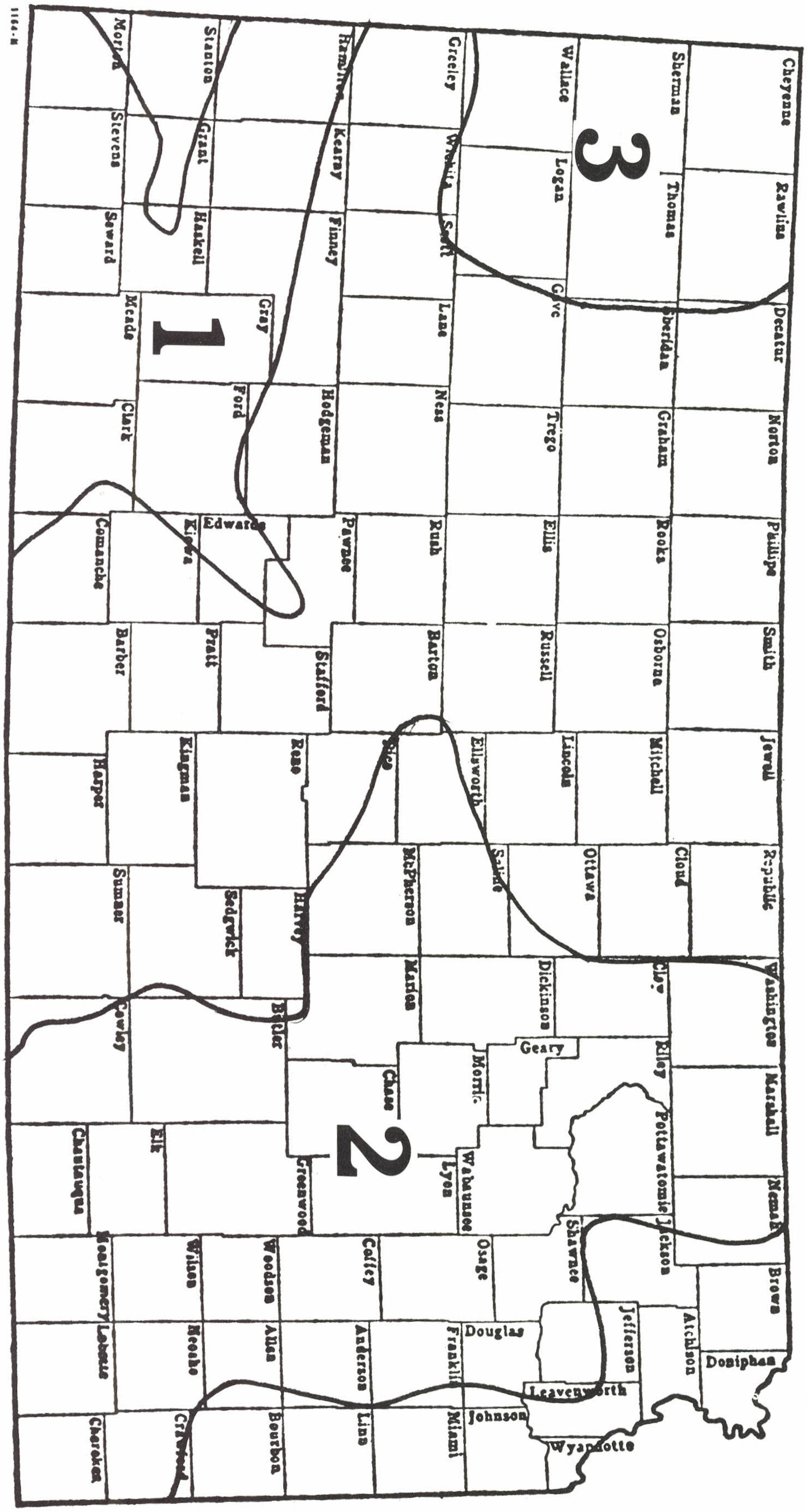


Figure 2. The geographic distribution of prairie chickens in Kansas, 1950 (Baker 1953). (1) Range of the lesser prairie chicken; (2) the chief range of the greater prairie chicken; (3) range wherein scattered flocks of the greater prairie chicken were reported present in 1950.



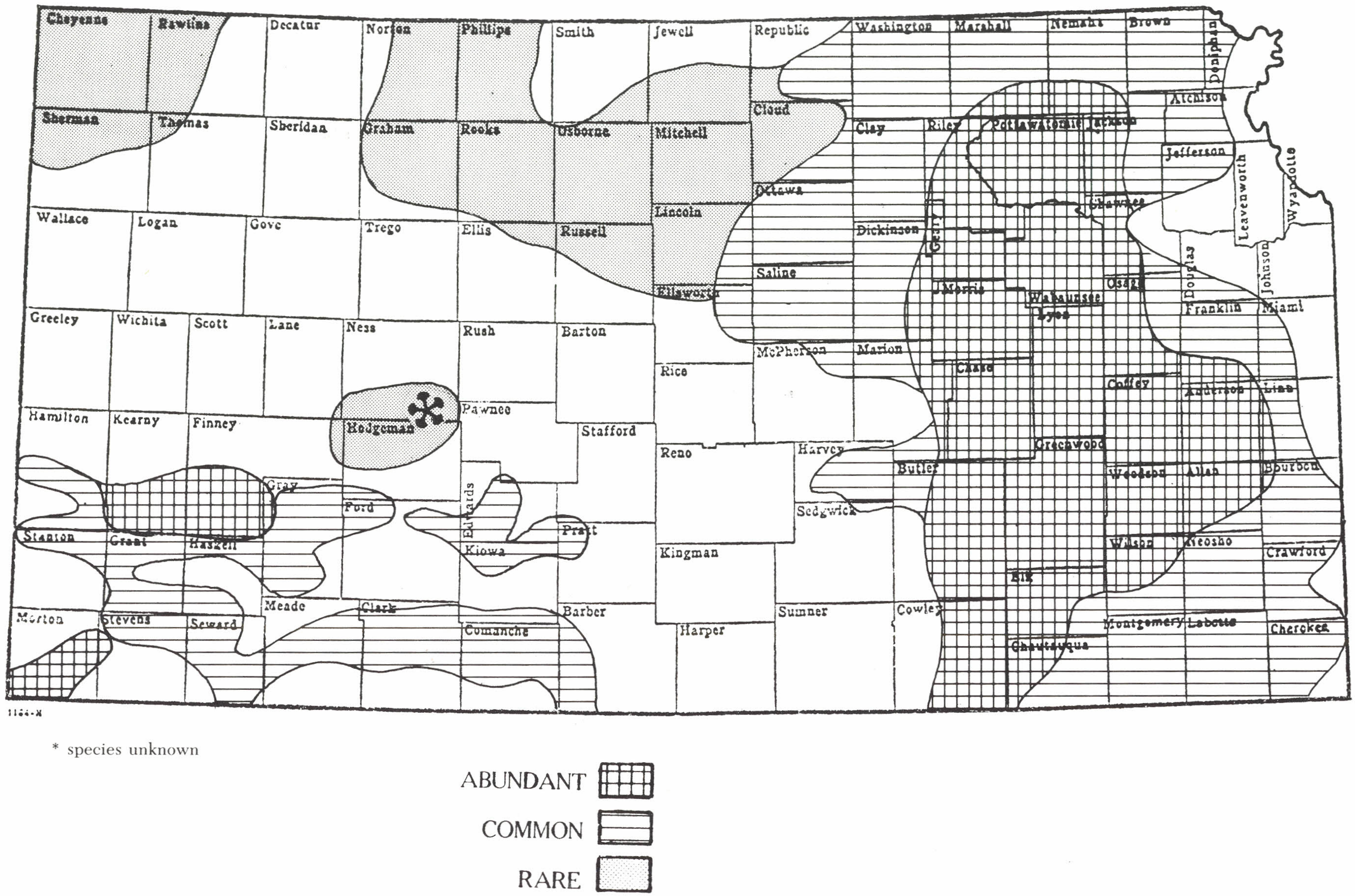


Figure 3. The distribution and relative densities of lesser and greater prairie chickens in Kansas, 1962 (White 1963).

creases. In addition, there was an obvious westward range extension in northern counties, with movement as far west as Norton and Graham counties. Populations in this extended range were still considered very low but they were increasing. White found the population status of the lesser prairie chicken only slightly altered from that reported by Baker in 1953.

In 1980, the Kansas Fish and Game Commission revised the distribution and population densities data. Maps and questionnaires for each county in the state were sent to each district game biologist and state game protector. Graphic representations of seven management regions (Fig. 4) and statewide distribution and densities of prairie chicken were prepared (Fig. 5). Densities were categorized as: 1) *abundant*, where prairie chickens were regularly seen or reported as occurring in the area; 2) *common*, where birds were seen occasionally; 3) *rare*, where birds are known to be present but seldom seen.

Participating employees also answered a questionnaire designed to determine the status of local populations and the reasons for any population change (Table 2). This information was consolidated by management regions (Fig. 4).

Region one (Southwest), in the lesser prairie chicken range, is experiencing the most dramatic change in habitat. Prime sandsage prairie habitat is being converted to cropland through center pivot irrigation systems. This development has not yet drastically reduced the distribution of lesser prairie chickens, but densities are decreasing. Large contiguous populations are disappearing and will continue to do so as long as this conversion continues (Waddell 1977).

Region two (Western Cropland) has shown a considerable increase in distribution and density from 1975 to 1980. This increase was due primarily to naturally occurring fluctuations and better rangeland management. Most local decreases were attributable to urbanization.

Region three (Flint Hills) populations have generally remained stable or increased due to better range management and natural population fluctuations. Local decreases were attributed mainly to conversion of grassland to cropland.

Region four (Eastern Cropland) has remained stable, with certain areas showing increases and others showing decreases. Increases were attributed to better range management and natural population fluctuations, while decreases resulted from overgrazing, conversion of grassland to cropland, and woody invasion.

Region five (Blackjack) has scattered populations and was showing decreases in population distribution as a result of conversion of grassland to cropland and overgrazing of remaining rangeland.

Region six (High Plains) populations fluctuated substantially due to marginal habitat conditions in this area. Populations showed gradual expansion in the northeastern portion of this region. Better rangeland management and natural population fluctuations have enhanced westward movement.

Region seven (Northeast) was classified as having a rare population which was slowly disappearing because of grassland conversion and overgrazing. Any local increases were due mainly to natural causes.

Statewide trends reveal expanded distribution of prairie chickens. This is probably attributed to natural population fluctuations and better management of rangeland.

Table 2. Response (percent) of state game protectors and district biologists to questions pertaining to distribution and populations of prairie chickens in Kansas, 1980.

1. Have you seen or had reports of prairie chickens in this county in the past six months?

Survey	Region 1			Region 2			Region 3			Region 4			Region 5			Region 6			Region 7			Statewide
	SGP	DB	TOT	SGP	DB	TOT	SGP	DB	TOT	SGP	DB	TOT	SGP	DB	TOT	SGP	DB	TOT	SGP	DB	TOT	TOT
YES	90	62	77	83	82	83	100	91	95	81	92	86	77	75	77	46	46	46	28	0	17	64
NO	10	38	23	17	18	17		9	5	19	8	14	23	25	23	54	54	54	72	100	83	36

2. If any, what species do you have in the county? Greater P.C.; Lesser P.C.; Both; Uncertain.

Survey	Region 1			Region 2			Region 3			Region 4			Region 5			Region 6			Region 7			Statewide
	SGP	DB	TOT	SGP	DB	TOT	SGP	DB	TOT	SGP	DB	TOT	SGP	DB	TOT	SGP	DB	TOT	SGP	DB	TOT	TOT
LPC	95	94	95													8	10	9				21
GPC				100	100	100	100	100	100	100	100	100	100	100	100	71	90	81	100	100	100	74
BOTH																						
UNC	5	6	5													21		10				5

3. If present, has the population distribution increased, decreased, or remained the same over the past five years?

Survey	Region 1			Region 2			Region 3			Region 4			Region 5			Region 6			Region 7			Statewide
	SGP	DB	TOT	SGP	DB	TOT	SGP	DB	TOT	SGP	DB	TOT	SGP	DB	TOT	SGP	DB	TOT	SGP	DB	TOT	TOT
INC	38	25	33	80	63	73	33	10	21	46	18	34	22	25	23	39	67	48		0	0	39
DEC	18	33	24	10	13	11	0	30	16		55	23	45	50	46	39	33	37		80	57	29
SAME	44	42	43	10	24	16	67	60	63	54	27	43	33	25	31	22	0	15	100	20	43	32

SGP—State Game Protector
DB—District Biologist
TOT—Totals

4. If the population has decreased indicate reason(s) below:
   A. Land conversion from grassland to cropland.
   B. Overgrazing of pastures.
   C. Invasions of grassland by trees and shrubs.
   D. Urban sprawl.
   E. Natural causes.
   F. Other

Survey	Region 1			Region 2			Region 3			Region 4			Region 5			Region 6			Region 7			Statewide
	SGP	DB	TOT	SGP	DB	TOT	SGP	DB	TOT	SGP	DB	TOT	SGP	DB	TOT	SGP	DB	TOT	SGP	DB	TOT	TOT
A.	80	100	89		50	33	100	43	56		28	28	57	40	50	14	60	42	50	45	45	45
B.	20		11					29	22		33	33	14	40	25	29	40	35	50	30	36	28
C.								14	11		28	28		20	8							9
D.				100	50	67		14	11		11	11								13	9	8
E.													29		17					12	9	4
F.																57		23				5

5. If the population has increased indicate reason(s) below:
   A. Conversion of cropland to grassland.
   B. Better grassland management.
   C. Natural causes.
   D. Other

Survey	Region 1			Region 2			Region 3			Region 4			Region 5			Region 6			Region 7			Statewide
	SGP	DB	TOT	SGP	DB	TOT	SGP	DB	TOT	SGP	DB	TOT	SGP	DB	TOT	SGP	DB	TOT	SGP	DB	TOT	TOT
A.																	9	5				2
B.	38	50	42	40	43	41	33	59	50	22	57	38	50	50	50	25	30	28	31		31	36
C.	37	50	42	60	43	53	67	41	50	67	43	56	50	50	50	40	26	33	50		50	43
D.	25		16		14	6				11		6				35	35	34	19		19	19

SGP—State Game Protector
DB—District Biologist
TOT—Totals

EVALUATION OF PRAIRIE CHICKEN POPULATION AND HARVEST SURVEYS

Prior to 1957, no prairie chicken population or harvest trend data were collected in Kansas. That year began a survey to collect data on harvest by using a mailed hunter questionnaire. Field interviews with hunters provided an additional source of hunter performance data in 1961. Additional surveys were initiated in 1962 to provide estimates of annual change in statewide population densities.

METHODS

Rural Mail Carrier Survey

Rural mail carriers cooperated by making a five-day game count during the last full calendar week in January, April, July, and in mid-October. Carriers were asked to report prairie chickens seen, dates of the count, length of route, and counties traveled. The index derived was the number of prairie chickens seen per 100 miles traveled (pc/100 mi), (Tables 3, 4, 5, and 6).

Booming Ground Routes

Eleven booming ground routes were estab-

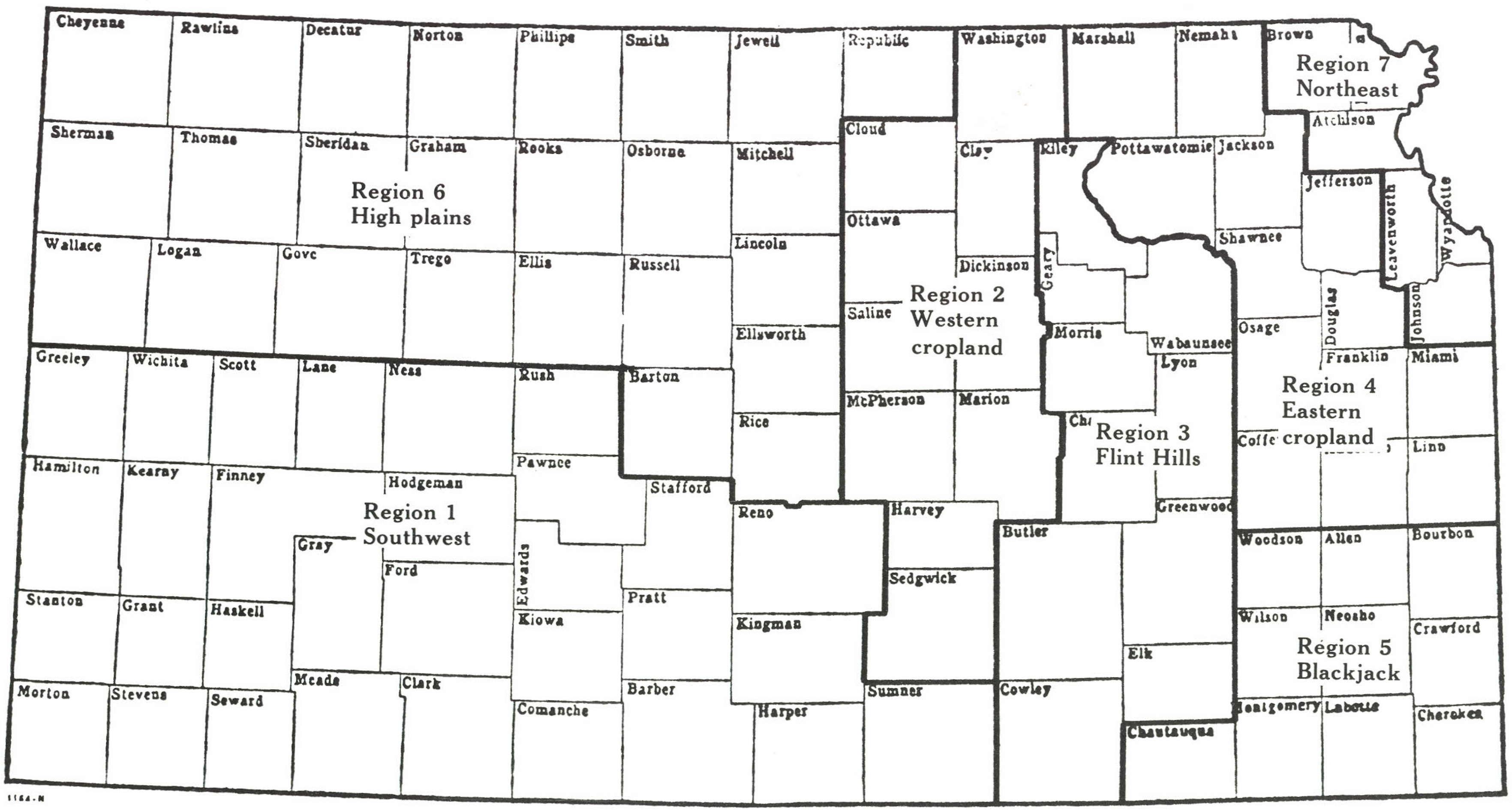


Figure 4. Management regions for prairie chickens in Kansas.

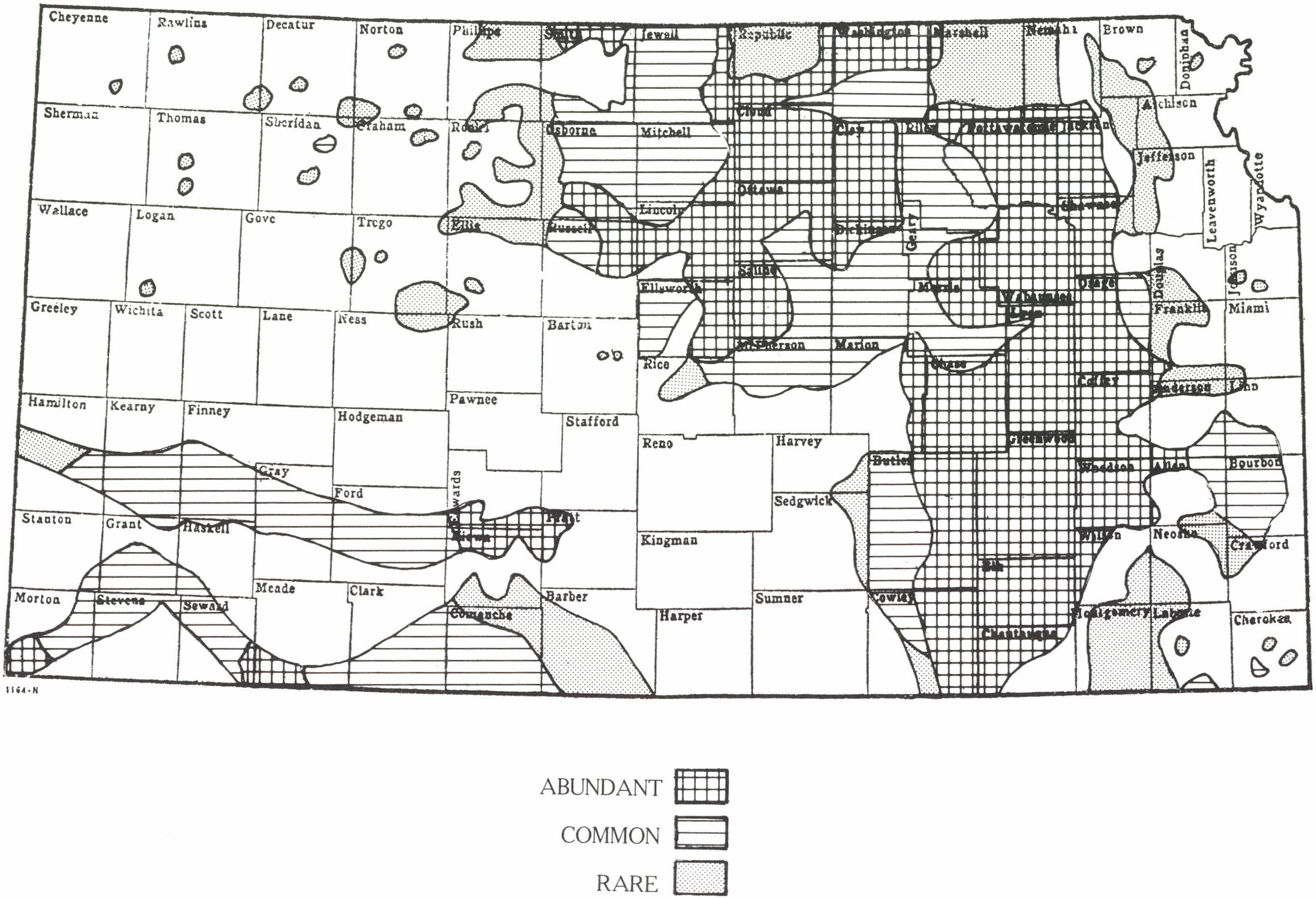


Figure 5. Statewide distribution and density map of prairie chickens in Kansas during 1980.

Table 3. Greater prairie chicken population indices from the January RMCS in Kansas, 1963-1980.

Year	Regions*				
	Region 2 W. Crop	Region 3 Flint Hills	Region 4 E. Crop	Region 5 Blackjack	Rangewide
Prairie Chickens/100 miles:					
1963	0.71	4.58	2.00	0.47	1.89
1964	0.36	2.36	1.45	0.99	1.28
1965	0.99	4.21	0.70	0.22	1.38
1966	3.86	7.69	1.37	1.52	3.24
1967	0.90	8.31	2.41	3.05	3.46
1968	0.78	2.68	0.57	0.61	1.05
1969	0.90	8.68	1.17	0.84	2.54
1970	0.47	3.05	0.52	0.26	0.96
1971	0.33	1.55	0.18	0.11	0.50
1972	0.53	3.05	0.40	0.53	1.03
1973	0.73	3.00	0.70	0.19	1.09
1974	0.31	1.38	0.37	0.12	0.43
1975	0.11	1.99	0.03	0.07	0.49
1976	0.25	2.65	0.27	0.23	0.80
1977	0.56	4.08	0.20	0.01	1.08
1978	1.68	8.23	0.53	0.13	2.36
1979	2.50	15.33	1.22	0.37	4.21
1980	0.76	4.23	0.24	0.08	1.25

* For regional designations refer to figure 4.

Table 4. Greater prairie chicken population indices from the April RMCS in Kansas, 1963-1979.

Year	Regions*				
	Region 2 W. Crop	Region 3 Flint Hills	Region 4 E. Crop	Region 5 Blackjack	Rangewide
Prairie Chickens/100 miles:					
1963	0.16	0.58	0.37	0.26	0.34
1964	0.15	0.68	0.62	0.18	0.41
1965	0.16	0.84	0.38	0.37	0.43
1966	0.06	0.73	0.28	0.22	0.31
1967	0.18	1.35	0.33	0.22	0.39
1968	0.20	0.57	0.10	0.13	0.22
1969	0.12	0.74	0.14	0.17	0.25
1970	0.25	0.57	0.27	0.12	0.29
1971	0.09	0.62	0.09	0.16	0.21
1972	0.13	1.14	0.13	0.14	0.36
1973	0.03	0.56	0.26	0.03	0.22
1974	0.32	0.78	0.14	0.07	0.31
1975	0.05	1.33	0.04	0.02	0.33
1976	0.06	0.56	0.06	0.00	0.16
1977	0.07	0.40	0.11	0.02	0.15
1978	0.18	0.88	0.14	0.04	0.29
1979	0.16	0.84	0.21	0.01	0.27

* For regional designations refer to figure 4.

Table 5. Greater prairie chicken population indices from the July RMCS in Kansas, 1963-1979.

Year	Regions*				
	Region 2 W. Crop	Region 3 Flint Hills	Region 4 E. Crop	Region 5 Blackjack	Rangewide
Prairie Chickens/100 miles:					
1963	0.01	0.62	0.43	0.15	0.30
1964	0.01	0.51	0.27	0.13	0.22
1965	0.18	0.17	0.27	0.09	0.18
1966	0.11	0.48	0.23	0.10	0.22
1967	0.10	0.27	0.17	0.11	0.16
1968	0.02	0.25	0.15	0.08	0.12
1969	0.05	0.32	0.22	0.33	0.23
1970	0.02	0.44	0.10	0.01	0.12
1971	0.01	0.38	0.01	0.02	0.08
1972	0.08	0.55	0.08	0.04	0.17
1973	0.13	0.15	0.02	0.03	0.06
1974	0.14	0.42	0.01	0.01	0.13
1975	0.02	0.55	0.02	0.00	0.14
1976	0.08	0.51	0.02	0.03	0.14
1977	0.03	0.60	0.02	0.01	0.15
1978	0.28	0.43	0.09	0.00	0.19
1979	0.04	0.55	0.17	0.01	0.19

* For regional designations refer to figure 4.

Table 6. Greater prairie chicken population indices from the October RMCS in Kansas, 1966-1979.

Year	Regions*				
	Region 2 W. Crop	Region 3 Flint Hills	Region 4 E. Crop	Region 5 Blackjack	Rangewide
Prairie Chickens/100 miles:					
1966	0.41	3.28	0.62	0.50	1.10
1967	0.35	1.97	0.51	0.62	0.78
1968	0.61	2.70	0.94	0.39	1.09
1969	0.34	2.62	0.59	0.10	1.82
1970	0.94	2.43	0.34	0.21	1.16
1971	0.36	2.04	0.22	0.21	0.64
1972	0.30	1.92	0.41	0.82	0.82
1973	0.27	1.30	0.16	0.01	0.39
1974	0.23	2.48	0.17	0.01	0.68
1975	0.42	0.93	0.24	0.02	0.38
1976	0.59	1.32	0.04	0.06	0.46
1977	0.41	1.69	0.16	0.11	0.55
1978	0.96	3.01	0.13	0.17	1.00
1979	0.96	3.34	0.55	0.17	1.14

* For regional designations refer to figure 4.

lished in 1963, with additional routes established in 1965, 1969, and 1978. The same 11 routes were used each year from 1963 through 1980. Each route was ten miles long, and booming grounds within one mile of either side (20 mi^2) of the route were counted. The survey began 40 minutes before sunrise, with three-minute listening stops at each one-mile interval. The approximate location of each booming ground was directionally recorded, and after the final listening stop, observers retraced the route to locate and count all males and all prairie chickens on each booming ground. Booming ground counts were discontinued one and one-half hours after sunrise or if winds exceeded 12 mph. Several mornings were sometimes necessary for completion of some routes. The index derived was prairie chickens per square mile (pc/mi^2), (Table 7).

Summer Brood Count

Throughout the greater prairie chicken range, brood observations were recorded by State Game Protectors and Soil Conservation Service personnel during their routine activities, from 1963 through 1967. The survey extended for an eight-week period beginning on the last Monday in June. The number of adults, number of young, and week of observation were recorded. Indices calculated were juvenile per adult (ju/ad), and prairie chickens seen per man-week of observation (pc/week), (Table 8).

Hunter Check Station

During the opening weekend of each hunting season from 1963 through 1967, voluntary hunter check stations were established on major highways throughout the primary range of the greater prairie chicken. Information collected included county hunted, number of hunters in each group, hours hunted, and number of prairie chickens bagged. Birds were sexed by examining the outer two tail feathers (Edminster 1954), and classified as juveniles or adults by examining primaries nine and ten (Ammann 1944). Indices obtained included prairie chickens bagged per hunter (pc/hunter), prairie chickens bagged per gun-hour (pc/gun hr), and combination of sex and age ratio data (Tables 9 and 10).

Hunter Field Bag Check

State Game Protectors contacted hunters in the field to obtain bag check data. Information recorded included county hunted, number of prairie chickens bagged, number of hunters, hours hunted, and date hunted. Indices calculated included prairie chickens bagged per gun-hour (pc/gun hr), and prairie chickens bagged per hunter (pc/hunter), (Table 11).

Wing-Tail Feather Envelopes

From 1963 through 1967, 2,000 postage-paid envelopes were distributed annually to prairie chicken hunters in the field for the purpose of collecting wing and tail feathers. Instructions were provided for proper removal of these feathers. The techniques used and indices generated for both age and sex were calculated the same as from hunter check station data (Tables 12 and 13).

Small Game Harvest Survey

Estimates of statewide prairie chicken harvest and harvest rates were obtained by mailing questionnaires to five percent of the previous years' resident hunting license buyers. Normally, over forty percent of the hunters on the mailing list returned usable data which amounted to two percent or more of the current year's hunting license holders. Indices obtained were season-kill per hunter, total harvest, and birds per hunter-day (Table 14).

Statistical Analysis

One-way, two-way, and three-way analysis of variance (ANOVA) tests (sometimes with a measure of interactions), were performed on different indices among time (year) and space (region) groupings of the sample data.

Survey indices expected to be related were submitted to correlation tests to determine the degree and direction of the relationships. Linear regressions with confidence belts were constructed for pairs of index values yielding a large correlation coefficient. The same tests were applied to indices which were indicators of population parameters.

Table 7. Greater prairie chicken population indices from booming ground survey (pc/mi^2) in Kansas, 1963-1979.

Year	Regions*				
	Region 2 W. Crop	Region 3 Flint Hills	Region 4 E. Crop	Region 5 Blackjack	Rangewide
1963	No data	10.1	3.2	10.2	9.0
1964	No data	7.1	7.1	10.6	7.6
1965	No data	8.8	6.3	3.3	7.1
1966	No data	11.2	7.6	5.3	8.9
1967	No data	10.4	7.4	7.2	7.7
1968	No data	7.1	6.2	7.6	6.9
1969	9.4	8.9	10.1	5.3	8.6
1970	7.1	9.1	5.7	3.8	7.2
1971	7.8	5.9	3.9	2.5	5.3
1972	9.1	6.3	3.1	.5	5.3
1973	9.7	6.0	3.2	1.2	5.4
1974	8.7	6.5	5.1	4.6	6.0
1975	8.2	7.3	8.3	4.6	7.0
1976	14.9	8.0	8.3	4.8	8.1
1977	No data	8.6	7.7	5.3	8.3
1978	13.4	9.9	9.7	7.9	10.5
1979	13.3	7.9	13.3	13.0	11.0

* For regional designations refer to figure 4.

Table 8. Greater prairie chicken population indices from summer brood count surveys in Kansas, 1964-1970.

Year	Regions*				
	Region 2 W. Crop	Region 3 Flint Hills	Region 4 E. Crop	Region 5 Blackjack	Rangewide
Juvenile/Adult:					
1964	3.15	4.60	3.37	2.64	3.63
1965	1.00	3.03	1.97	2.76	2.50
1966	1.20	2.66	2.50	2.67	2.41
1967	2.16	1.91	4.25	2.39	2.34
1968	3.00	2.56	3.85	1.75	2.70
1969	2.11	2.83	0.80	1.84	2.14
1970	2.75	1.24	0.52	0.79	0.94
Prairie Chickens/Man-week of Observation:					
1964	2.22	5.08	2.01	3.47	3.24
1965	0.46	3.83	1.90	0.74	1.97
1966	1.57	5.50	1.80	1.25	2.83
1967	1.09	3.19	1.75	1.09	1.78
1968	0.30	1.76	0.99	0.58	0.99
1969	0.48	1.43	0.27	0.94	0.82
1970	0.38	0.99	0.72	0.83	0.73

* For regional designations refer to figure 4.

Table 9. Greater prairie chicken hunter performance and age ratio indices from data collected at check stations in Kansas, 1963-1967.

Year	Regions*				
	Region 2 W. Crop	Region 3 Flint Hills	Region 4 E. Crop	Region 5 Blackjack	Rangewide
Juvenile/Adult:					
1963	No data	1.73	1.81	2.13	1.82
1964	No data	1.84	1.25	No data	1.45
1965	No data	2.04	1.92	2.30	2.00
1966	No data	1.62	2.10	No data	1.79
1967	No data	1.74	0.61	1.16	1.22
Average	No data	1.79	1.53	1.86	----
Juvenile/Adult Female:					
1963	No data	1.73	1.81	2.13	1.82
1964	No data	3.04	2.84	No data	2.92
1965	No data	3.36	4.02	5.75	3.81
1966	No data	2.83	3.75	No data	3.39
1967	No data	3.48	1.66	1.75	2.70
Average	No data	2.88	2.81	3.21	----
Prairie Chicken/Hunter:					
1963	No data	0.45	0.52	0.48	0.48
1964	0.37	0.39	0.39	0.31	0.38
1965	No data	0.39	0.45	0.47	0.42
1966	No data	0.39	0.50	0.25	0.41
1967	No data	0.56	0.26	0.41	0.42
Average	No data	0.44	0.42	0.38	----
Prairie Chicken/Gun Hour:					
1963	No data	0.15	0.11	0.11	0.13
1964	0.08	0.07	0.08	0.06	0.07
1965	No data	0.09	0.10	0.13	0.10
1966	No data	0.12	0.14	0.05	0.12
1967	No data	0.19	0.08	0.14	0.14
Average	No data	0.12	0.10	0.10	----

* For regional designations refer to figure 4.

Table 10. Greater prairie chicken sex ratios in hunters bag from check station collections in Kansas, 1963-1967.

Years	Index					
	*JuF/100adf	JuM/100f	AdM/100f	AdM/100adf	M/100f	JuM/100juf
1963	61	67	32	82	99	112
1964	55	76	45	100	121	138
1965	50	90	36	90	126	150
1966	57	75	45	104	120	132
1967	56	63	53	120	116	112
Average	57	74	42	99	116	128

* ju = juvenile
ad = adult
m = male
f = female

Table 11. Greater prairie chicken hunter performance indices from the random bag-check survey in Kansas, 1964-1970.

Year	Regions*				
	Region 2 W. Crop	Region 3 Flint Hills	Region 4 E. Crop	Region 5 Blackjack	Rangewide
Prairie Chickens/Gun Hour:					
1964	0.08	0.13	0.05	0.07	0.09
1965	0.12	0.12	0.11	0.05	0.10
1966	0.12	0.14	0.09	0.12	0.12
1967	0.07	0.10	0.07	0.09	0.09
1968	0.14	0.18	0.09	0.34	0.17
1969	0.07	0.12	0.09	0.09	0.08
1970	0.11	0.08	0.04	0.05	0.07
Average	0.10	0.12	0.08	0.12	----
Prairie Chicken/Hunter:					
1964	0.26	0.37	0.20	0.28	0.31
1965	0.38	0.34	0.32	0.17	0.32
1966	0.42	0.41	0.29	0.39	0.38
1967	0.33	0.29	0.40	0.29	0.31
1968	0.29	0.45	0.31	0.82	0.41
1969	0.24	0.31	0.25	0.28	0.29
1970	0.38	0.21	0.11	0.16	0.19
Average	0.33	0.34	0.27	0.34	----

* For regional designations refer to figure 4.

Table 12. Greater prairie chicken age ratio in the hunters bag from wing-tail collections in Kansas, 1963-1970.

Year	Regions*				
	Region 2 W. Crop	Region 3 Flint Hills	Region 4 E. Crop	Region 5 Blackjack	Rangewide
Juvenile/Adult:					
1963	1.23	1.88	2.95	2.62	2.06
1964	No data	1.97	1.25	2.57	1.87
1965	No data	2.07	1.49	3.00	2.00
1966	No data	0.91	1.28	1.30	1.06
1967	No data	1.47	0.58	0.80	0.97
1968	No data	1.84	2.15	1.80	1.93
1969	No data	2.24	0.53	1.40	1.43
1970	0.89	1.89	1.17	0.44	1.14
Average	----	1.78	1.75	1.74	----

* For regional designations refer to figure 4.

Table 13. Greater prairie chicken sex ratios in the hunters bag from wing-tail collections in Kansas, 1963-1970.

Years	Index					
	*juf/100adf	jum/100f	adm/100f	adm/100adf	m/100f	jum/100juf
1963	57	84	38	88	123	148
1964	63	76	31	83	108	122
1965	67	72	27	80	99	108
1966	44	69	50	90	119	156
1967	54	49	58	126	107	91
1968	66	70	37	113	107	105
1969	54	79	38	85	117	145
1970	43	69	54	94	122	161
Average	56	71	42	94	112	129

*ju = juvenile
ad = adult
m = male
f = female

Table 14. Estimated annual greater prairie chicken hunting activity in Kansas, 1957-1979.

Year	% Hunting Species	Est. Total Hunters	Days Hunted	Avg. Daily Bag	Season Kill	Est. Statewide Kill	% Change
1957	16.00	30,300	1.32	0.59	0.78	24,000	
1958	22.59	51,900	1.13	1.26	1.45	75,000	+212
1959	27.86	64,100	1.52	0.94	1.42	91,000	+ 21
1960	25.71	57,500	1.45	0.51	0.74	43,000	— 53
1961	19.46	40,000	1.50	0.64	0.96	38,000	— 12
* *							
1962	20.37	39,200	1.59	0.60	0.95	37,000	
1963	20.58	37,100	1.57	0.65	1.02	38,000	+ 3
1964	25.49	44,500	1.73	0.50	0.87	39,000	+ 3
1965	23.49	41,500	1.56	0.65	1.01	42,000	+ 8
1966	26.67	52,700	1.84	0.69	1.27	67,000	+ 60
1967	22.20	45,100	1.79	0.53	0.94	42,000	— 37
1968	19.94	39,500	1.80	0.63	1.13	45,000	+ 7
1969	23.34	48,600	2.08	0.46	0.95	46,000	+ 2
1970	16.38	35,300	1.62	0.33	0.53	19,000	— 59
1971	15.81	32,100	1.65	0.60	0.98	32,000	+ 68
1972	16.07	34,000	1.96	0.54	1.06	36,000	+ 13
1973	8.69	18,700	2.45	0.29	0.71	13,000	— 64
1974	9.54	20,200	2.75	0.33	0.91	18,000	+ 38
1975	8.57	17,100	3.16	0.29	0.92	16,000	— 11
1976	10.76	21,800	2.75	0.44	1.19	26,000	+ 63
1977	11.11	22,800	2.92	0.59	1.71	39,000	+ 50
1978	15.88	34,100	3.12	0.50	1.49	51,000	+ 31
1979	15.88	36,100	3.02	0.71	2.45	88,000	+ 74

* Total hunter figures prior to 1962 not adjusted to compensate for inactive resident hunters.

Results

Analysis of data in 1972 resulted in several surveys being dropped (Summer Brood Counts, Hunter Check Station, Hunter Field Bag Check, and Wing-tail Envelope Distribution), while others were retained (all RMCS, Booming Ground Survey, Mail Questionnaire Harvest Survey).

One-way and two-way ANOVA indicated significant differences ($P<.05$) in prairie chicken populations between counties. This information resulted in grouping counties with similar populations into management units (Fig. 4).

Spring Surveys

Two-way ANOVA of the April RMCS data from 1963 through 1966, revealed significant differences between regions ($P<.01$), but variation was nonsignificant ($P>.05$) among years of the survey.

ANOVA tests of booming ground data from 1963 through 1971 indicated no significant differences among years or regions for the index pc/mi^2 of route. The index booming grounds per route showed a significant difference ($P<.01$) among regions, but no significant difference among years. No significant correlations between the April RMCS (pc/100 mi) and booming ground (pc/mi^2) indices were found on either regional or rangewide basis. For years 1963 through 1980, the coefficient of variation for the booming ground (pc/mi^2) ranged from twenty percent in the Flint Hills to fifty-six percent in the Blackjack regions.

Booming ground counts and their importance as good, annual population trend estimaters is suspect. However, a continual increase or decrease in the number of grounds and birds on grounds may be indicative of changes in population size and structure. Further discussion of booming grounds will be made in another section.

Summer Surveys

ANOVA tests using the July RMCS (pc/100 mi) from 1963 through 1966, revealed significant differences among regions ($P<.05$), but variance among years of the survey and interactions between years and regions were nonsignificant ($P>.05$). The coefficient of variation was 37 percent for the entire range with regions varying from 34 to 114 percent.

One-way ANOVA testing of summer brood count (ju/ad) data indicated there were no significant differences ($P>.05$) among weeks or among counties, but there were significant differences ($P<.01$) between years 1963, 1964, and 1965. Using the index ju/ad, a two-way ANOVA test was performed, using years and regions; the results showed a significant difference ($P<.01$) among regions and among years. Two-way ANOVA for pc/week and ju/ad resulted in a significant difference among years ($P<.01$) and regions ($P<.01$) for each index. Correlation tests were performed using annual rangewide values for July RMCS and Summer Brood Counts. The results showed no significant correlation between the two during the seven-year testing period. The number of prairie chicken observed during the summer survey periods was very low. This low count may have affected the accuracy of the data and could have given exaggerated information on population trends.

Fall Surveys

Biological data (ju/adf, adm/100adf, juf/100adf, jum/100f, adm/100f, and m/100f) collected at check stations from 1963 to 1967 were submitted to ANOVA tests. One-way tests indicated that there were no significant differences among counties or years at the $P>.05$ level; except ju/adf and adm/100adf showed significant difference ($P<.05$) among counties. In the two-way analysis, there was no significant difference ($P>.05$) among check stations or years, and no significant interaction ($P>.05$) between years and check stations.

Hunter success data collected at check stations were submitted to two-way ANOVA tests. The indices pc/hour, pc/hunter, and cripples lost/pc bagged each showed significant differences among years ($P<.01$), with no significant differences among regions and no interaction between years and regions ($P>.05$).

Hunter success data (pc/hunter, gun hours/hunter, and pc/hour) from the hunter field bag-check were submitted to one-way ANOVA tests. ANOVA testing indicated a significant difference among counties ($P<.01$) and years ($P<.01$) for the indices. ANOVA tests were not performed on sex and age ratios gathered from wing-tail envelopes.

Two-way ANOVA testing using October RMCS data (pc/100 mi) for 1966 through 1970 indicated a significant difference among regions ($P<.01$), but no significant difference among survey years ($P>.05$). The coefficient of variation for the October RMCS rangewide (1966-1979) was 46 percent, with a regional variation of 35 to 51 percent.

Correlation tests were run using combinations of meaningful fall indices. Rangewide values of hunter field bag-check data (pc/hunter and pc/hour) indicated a significant positive relationship ($r = .870$, $df = 5$, $P<.05$). The pc/hunter (field bag-check) data significantly correlated with the mail survey indices pc/day ($r = .894$, $df = 5$, $P<.01$), total harvest ($r = .794$, $df = 5$, $P<.05$), and season kill/hunter ($r = .935$, $df = 5$, $P<.01$). The index pc/hour (field bag-check) was also significantly correlated with the mail survey indices pc/day ($r = .699$, $df = 5$, $P<.10$) and season kill/hunter ($r = .696$, $df = 5$, $P<.10$).

Correlations between the October RMCS and hunter mail survey for the years 1966 through 1978 showed no significant relationship ($P>.10$) rangewide. October RMCS rangewide has a coefficient of variation of 46 percent, while the mail survey total harvest varied 41 percent and average daily bag varied 26 percent.

Test results indicate that the hunter field bag-check and mail survey provided comparable data. These two surveys spanned the entire hunting season, and, thus, were an indication of overall hunter performance. Check-station data represented only the opening weekend and was not comparable to hunter surveys, as shown by the poor relationship between this survey and the hunter field bag-check and mail surveys. However, this does not reflect negatively on the accuracy of the check-station survey for the period measured.

The premise that harvest reflects population size holds true for pheasants and quail in Kansas. With prairie chickens, however, indications are that, due to hunting methods used (pass shooting in fields), hunter performance and total harvest are more closely related to factors that influence chicken use of grain fields. Such conditions include weather and food availability in the rangeland as well as population size.

Winter Survey

Two-way ANOVA testing of the 1963 to 1971 January RMCS data (pc/100 mi) indicated a significant difference among years ($P<.05$) and regions ($P<.01$). The regional differences are generally true because of different habitat types and conditions. Differences in years are likely to be related to population change as well as climatic conditions and food availability.

Correlation of Spring-Fall Surveys

There was a significant correlation between the pc/mi^2 (booming ground data) and the total harvest (mail survey), ($r = .728$, df = 14, $P<.001$), but no correlation with the pc/day (mail survey) (Fig. 6).

Correlation of Spring-Summer Surveys

Correlation testing of annual rangewide values for the indices pc/mi^2 from the booming ground survey and pc/100 mi from the July RMCS yielded an r of 0.63, df = 15, $P<.01$ (Fig. 7). No significant relationships were found between the booming ground counts and the summer brood counts. Similarly, the April RMCS showed no relationship to brood counts or July RMCS.

The significant positive relationship between booming ground counts and subsequent July RMCS indicates that a summer population is directly related to size of the spring population. It is generally accepted that weather and habitat conditions during production influences the size of the summer population. In addition, a high coefficient of variation for both surveys suggests that the correlation may be the result of chance.

Correlation to Winter-Spring Surveys

Annual rangewide values of pc/100 mi (January RMCS) and pc/mi^2 (booming ground survey) were significantly correlated ($r = .732$, df = 15, $P<.01$), (Fig. 8). Both surveys are suspect as population trend indicators, but for the years the surveys were tested there were parallel consistencies. No significant correlation existed between rangewide values for the January RMCS and April RMCS.

There were no significant relationships between population surveys and mail surveys, wing-tail envelopes or hunter field bag-checks.

One can speculate that the reason for this nonrelationship is: (1) summer population indices are not indicative of hunter performance and

Figure 6. Regression tests between prairie chicken/mi^2 (booming ground data) and total harvest (mail survey) in Kansas.

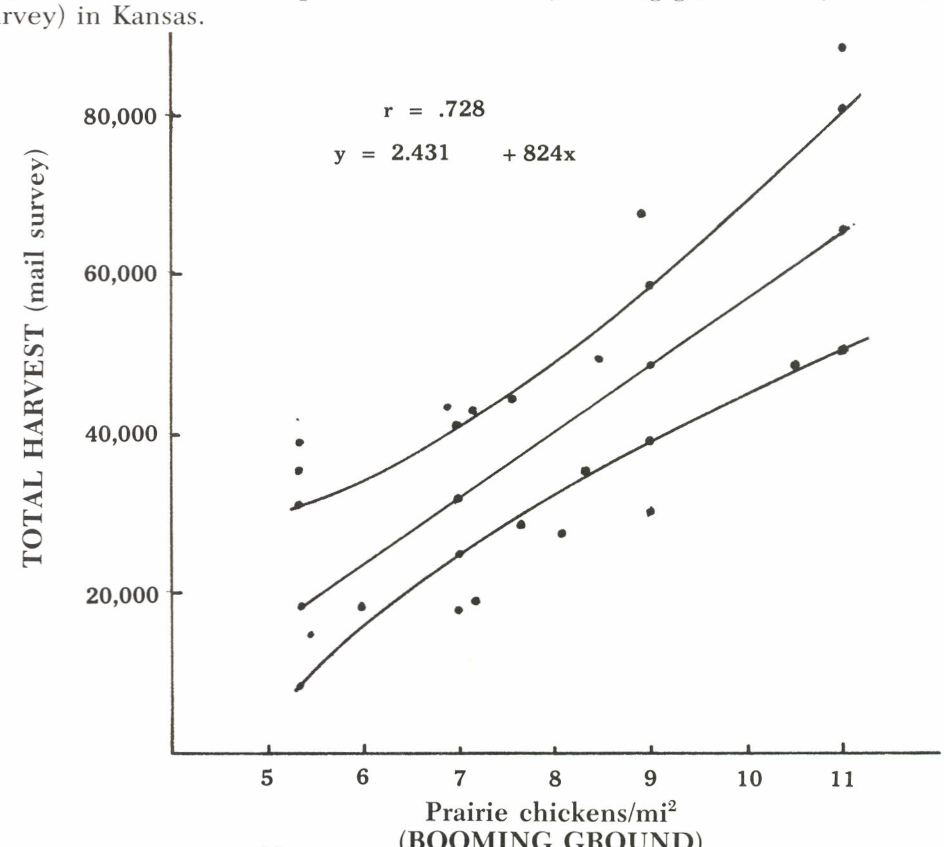


Figure 7. Regression tests between prairie chickens/mi^2 (booming ground data) and prairie chickens/100 mi (July RMCS) in Kansas.

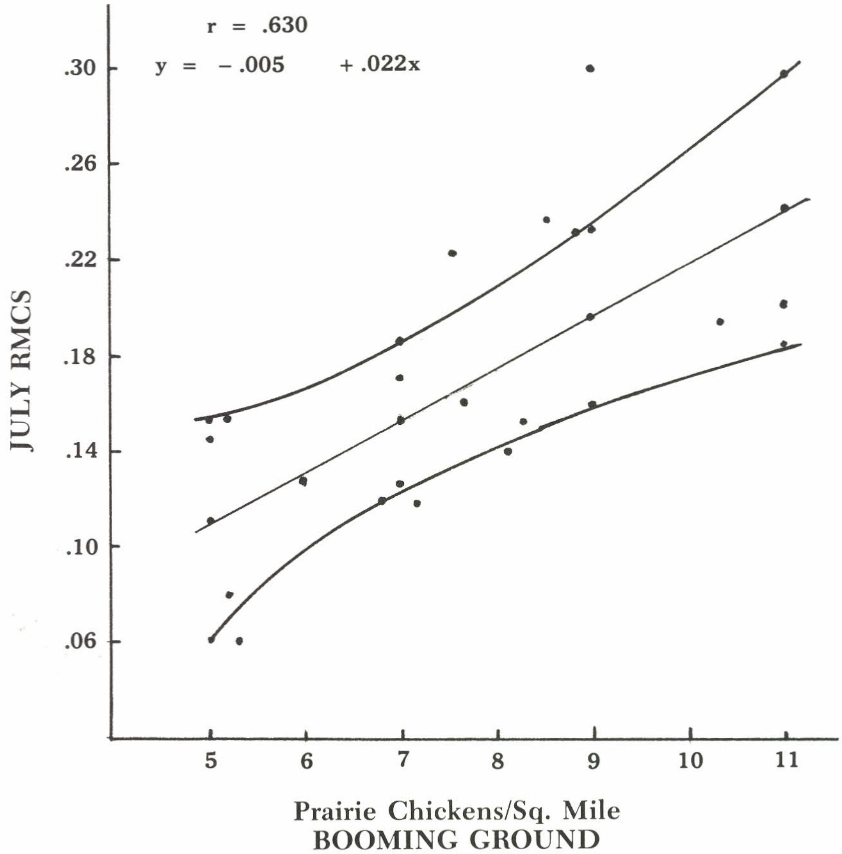
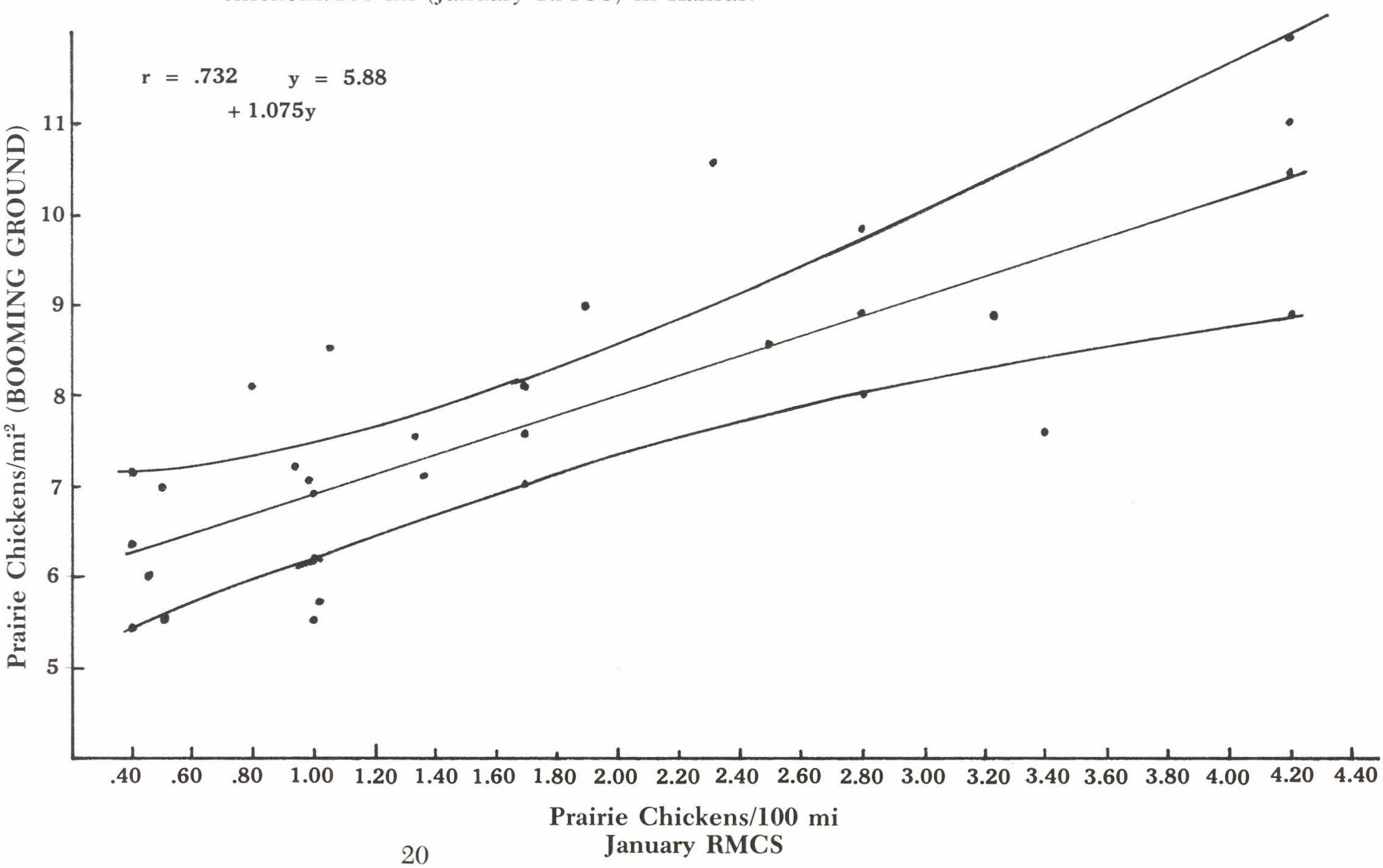


Figure 8. Regression tests between prairie chickens/mi^2 (booming ground data) and prairie chickens/100 mi (January RMCS) in Kansas.



harvest; (2) harvest data is not a true indicator of fall population size; or (3) the surveys are not capable of measuring population trends.

Correlation of Fall-Winter Surveys

Statewide values indicated that total harvest (mail survey) was significantly correlated with the January RMCS, pc/100 mi, ($r = .514$, $df = 16$, $P<.05$), (Fig. 9). The October RMCS (pc/100 mi) and January RMCS (pc/100 mi) showed no correlation.

Correlation of Fall-Spring Surveys

A nonsignificant positive relationship occurred in annual statewide values between October RMCS (pc/100 mi) and the following April RMCS (pc/100 mi), ($r = .531$, $df = 3$, $P>.05$).

A negative relationship existed between total harvest (harvest survey) and spring booming ground counts (pc/mi^2), ($r = -.4657$, $df = 15$, $P<.10$).

October and April RMCS indicate a relationship from fall to the following spring, but the negative correlation between the total harvest and pc/mi^2 is unexplainable.

Discussion and Recommendations

Results of statistical testing of surveys has raised several questions: 1) What is the effect of weather and habitat conditions on population? 2) Is there a relationship between birds produced and birds harvested? 3) Is harvest limited by something other than population size, or do we simply lack a reliable production survey? 4) Are prairie chicken winter mortality rates relatively stable from year to year? 5) Are our surveys precise enough to detect annual population trends?

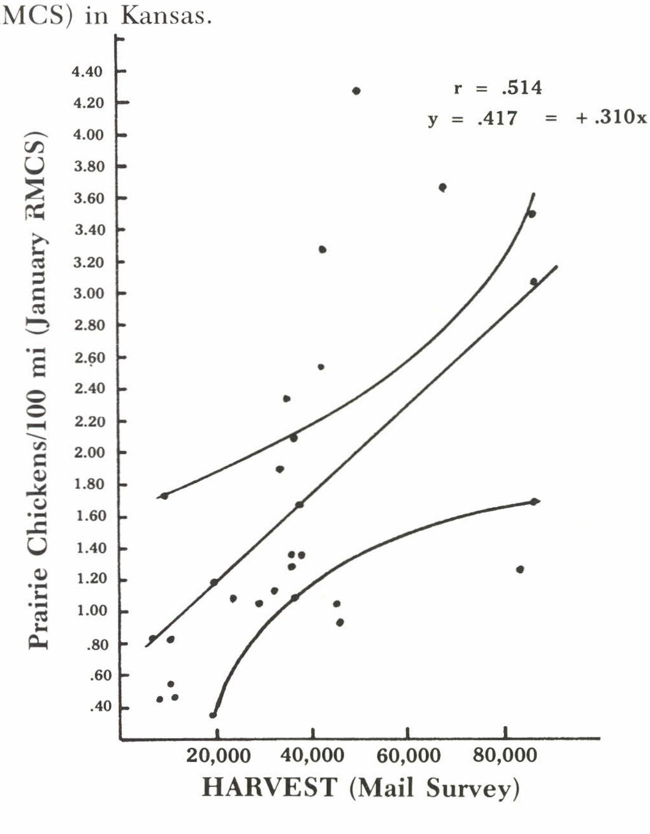
Kansas prairie chicken populations may show relatively little annual variation. There are very clear differences between regions, as habitat quality and quantity vary regionally. Regions on the periphery of the major chicken range appear to have undergone gradual habitat change, but this has not resulted in significant changes in the population size. Kansas' prairie chicken surveys, however, may not be sufficiently sensitive to measure small annual changes in populations.

It appears that statewide populations have shown slight increases since the surveys began. Additional increases or at least a stable trend can be assumed if present habitat conditions are maintained. Factors that may contribute to a decline include plowing the tallgrass prairie, extensive annual burning, poor timing of burn, overgrazing, year-round grazing, and changes in prairie plant composition. Higher populations could be attained by improved rangeland management, particularly in areas of intensive grazing and burning.

The RMCS and booming ground survey will be retained to provide an indicator of prairie chicken populations and distribution. The small-game harvest survey will retain prairie chicken questions, since it does provide an index to harvest and hunter performance trends, despite an unclear relationship to population size.

To better manage prairie chicken populations, it is imperative to have an understanding of factors which limit those populations. It is also critical that reliable surveys be developed and maintained to monitor population trends. By conducting population surveys and investigating limiting factors, a reliable indicator of population fluctuations should become evident and the limiting factors with which management must be concerned can be described.

Figure 9. Regression tests between total harvest (mail survey) and the following prairie chickens/100 mi (January RMCS) in Kansas.



EXTERNAL SEX & AGE CHARACTERISTICS OF THE GREATER PRAIRIE CHICKEN

Most studies of sex and age criteria for prairie chickens have been conducted during the fall hunting season when the birds are readily available from sportsmen. Captive birds have also been used in several projects in an attempt to accurately age young birds. Baker (1953) studied the primary molt of young from one week to twelve weeks of age. Because the molt progressed in a regular manner, he was able to construct a chart showing progress of molt by weeks.

Young prairie chickens retain primaries nine and ten in the post-juvenile molt, while adults lose all primaries during the post-nuptial molt. Ammann (1944) found that during the fall, the ninth and tenth primaries of immature birds showed a worn and faded appearance in contrast to primaries one through eight. In adults, all primaries were rounded at the tips, unfaded, and unworn. Schwilling (personal communication) developed a wing gauge for determining the age of juvenile prairie chickens up to 17 weeks by comparing the lengths of primaries seven and eight. Bursa measurements are also used in separating young from adults.

In 1967, the Kansas Fish and Game Commission collected specific parts from prairie chickens at hunter check stations during the opening weekend. The depth of the bursa of Fabricius was measured in millimeters and sex was determined by gonadal inspection. The tail, head, and both wings were collected and retained with bursal measurements, for future inspection. Bursa depth was compared to wear and coloration on the ninth and tenth primaries for 217 prairie chickens. It was assumed that the ninth and tenth primaries were true indicators of age (Ammann 1944). Comparisons indicated that a bursa depth of ten millimeters or less indicates an adult with 88 percent confidence (SE = 0.032), whereas 95 percent (SE = 0.020) of the measurements over ten millimeters were from juveniles. Since both techniques produce similar results, either technique can be used with reasonable accuracy during the fall hunting season.

When examination of gonads is not possible, sex can usually be determined from plumage. Adult males have longer pinnae and larger orange colored air sacs and eyebrows than females. During fall hunting seasons, juvenile males and females appear similar in these characteristics. Edminister (1954) indicated that the absence of barring in the outer tail feathers characterized male birds and barring of all tail feathers indicated females. Henderson et al. (1967) found that individual male's crown feathers were uniformly dark with a buff colored edge whereas female's crown feathers were cross-barred with alternating light and dark bands. They found that sexing by tail feathers was 91.7 percent accurate, and sexing by crown feathers was 85.3 percent accurate.

In 1967, tail feathers characteristics and crown markings were compared with gonad inspections for 181 prairie chickens. For 99 percent of the birds, the combination of tail feathers and crown markings served as a true indicator of sex.

Obtaining wing and tail feathers via hunter envelopes can lead to some problems with these techniques. In most cases, parts from more than one prairie chicken were placed in an envelope and mailed in. Approximately 30 percent of the envelopes received were discarded due to problems such as missing wings or tail feathers, plucked wing feathers, or failure to place a rubber band on the wing and tail feathers of individual birds.

In 1967, a study was conducted to find a method to sex prairie chickens by wing characteristics alone, thus eliminating these problems. Wing plumage coloration and markings were examined; however, this method showed little value due to high individual variation.

Calamus diameters of each primary were measured as a possible means of determining sex and age. The overlap between all sex and age classes were too great for this method to be valuable. Baker (1953) indicated the mean length of primary eight was different between males and females, but variation in length was too great to permit accurate separation of sexes. He also found that incomplete growth of the eighth primary during the early fall hunting season can further increase variation.

In a further attempt to identify sex by wing feather characteristics, 482 samples of sexed (248 males and 234 females) and aged prairie chickens were collected from hunters during the 1965 and 1966 hunting season. Total lengths were measured on all primaries, secondaries and the alula. All feather lengths showed excessive overlap between sexes, except primaries nine and six. Measurements of primary nine indicated that an average of 83.5 percent (males = 89.9 percent, females = 75.8 percent) of the birds could be sexed using a dividing point of 166 millimeters (>166 = males, <166 = females). Measurements of primary six appeared better for identifying sex. Approximately 89.9 percent of the birds were sexed accurately by assigning those primaries of under 186 millimeters to females and those over 186 millimeters to males. The greatest overlap occurred between juvenile males and adult females.

Further testing of this technique involved five observers, each of which measured 150 sixth-primary feathers evenly divided into sex and age cohorts. The observers were able to identify sex with an overall accuracy of 89.4 percent, ranging from 87.3 to 92 percent.

This technique is reasonably accurate in determining the sex of prairie chickens taken during the early part of Kansas' hunting season. When possible, other methods of sexing (tail and crown markings) should be used, since these are more reliable. However, when only the wing is available, the length of the sixth primary as a sexing technique is particularly valuable.

Weights

Schwartz (1945) and Gross (1930) both indicated the female was smaller than the male. In his analysis of 192 hunter-killed prairie chickens, Baker (1953) found that the average weights of each sex and age class were significantly different from each other, with adult males averaging 975.4 grams, juvenile males 926.4 grams, adult females 834.9 grams, and juvenile females 777.9 grams. Blus (1965) weighed 62 prairie chickens in Nebraska during the winter trapping period and found mean weights of males were considerably greater than those of females. There were no striking weight differences between age groups within sex. Nebraska prairie chickens averaged 1029 grams, 1025 grams, 863 grams, and 867 grams for adult and juvenile males, and adult and juvenile females, respectively.

Weights of 654 prairie chickens were taken during opening weekends (usually the first full weekend in November) of the 1965, 1966, and 1967 hunting seasons. Adult males averaged 955 grams (N = 133, range 826-1126), and adult females 807 grams (N = 125, range 702-950). Juvenile males averaged 917 grams (N = 236, range 713-1053), and juvenile females averaged 788 grams (N = 160, range 619-932). Mean weights of each sex and age class were significantly different ($P<.05$) with the juvenile prairie chickens not having attained full weight by November.

Of 57 prairie chickens trapped during January and February 1979, 13 adult males averaged 973 grams (range 840-1049), 17 adult females weighed a mean of 799 grams (range 760-860), 11 juvenile males weighed a mean of 973 grams (range 900-1080), and 16 juvenile females average 774 grams (range 660-840). It is apparent that similar sexes between adults and young are nearly the same in weight, but there still is a difference between sexes. The birds trapped during that winter showed basically the same weights as prairie chickens during fall hunting seasons. This is important because the winter of 1978 to 1979 produced record snowfall and near-record cold. This suggests that prairie chickens are quite capable of maintaining body weights, even during severe winters.

INTENSIVE STUDY

A two-phase intensive study of the greater prairie chicken was carried out in Chase County, the center of the Flint Hills region of eastcentral Kansas. The economy of the county was closely tied to livestock grazing, and 82 percent of the land was tallgrass prairie (Neill 1974).

The first Phase was conducted from 1963 to 1968 to investigate population structure, habits, and movements of prairie chickens on two different ecosystems. Each study area was 16 square miles, with one, the "grassland study area" comprising more than 95 percent native tallgrass prairie within a vast area of grassland. The other study area, "agricultural study area", was comprised of 67.5 percent native grassland intermingled with cool-season grass and cultivated crops.

Phase two of the investigation was conducted from 1974 to 1978 to study available and utilized habitats, its effects on population trends, and to examine possible population monitoring techniques.

The study area "grassland-cropland" was nine square miles in size, utilizing three sections of the agricultural study area and six square miles of adjoining grassland.

Grassland Study Area

The grassland study area was composed of native rangeland with only 0.5 percent cropland (Fig. 10). Sharpe's Creek Road is the only improved road, although several pasture access trails cross the area. The soils are of the Florence-Labette and Clime-Sogn associations (Neill 1974). Both types were gently to strongly sloping with dark soils and numerous limestone outcrops (Fig. 11).

Vegetation

The dominant grass species of the grassland study area are those representing true tallgrass prairie: big bluestem *(Andropogon gerardi)*, little bluestem *(Andropogon scoparius)*, indiangrass *(Sorghastrum nutans)*, and switchgrass *(Panicum virgatum)*. Common forb species in this grass complex are leadplant *(Amorpha canescens)*, blacksampson *(Echinacea angustifolia)*, western ironweed *(Vernonia baldwini)*, broomweed *(Gutierrezia dracunculoides)*, sunflower *(Helianthus* spp.), and goldenrod *(Solidago* spp.).

The topography and soil composition permit very little cultivation, accounting for the retention of large permanent native pastures on 95.5 percent of the study area. The rolling ridges slope to many treeless creeks which eventually empty into Sharpe's Creek and its larger tributaries. These major creeks are permanent sources of water and are fed by springs. Approximately 220 acres of riparian vegetation occurred along these waterways. Twelve stock ponds on the area provided additional permanent sources of water.

Most landowners do not reside on the land. Many cattle are owned by out-of-state ranchers who graze the area about five months (May to October), depending on seasonal pasture conditions and price trends. Animals were taken off grass as early as July or as late as the end of September or early October. Most of the pastures were in good to excellent condition. In most years, pastures are burned in April to remove previous years' vegetation and to induce early growth.

Figure 10. Cover map of Grassland Study area, Chase County, Kansas.

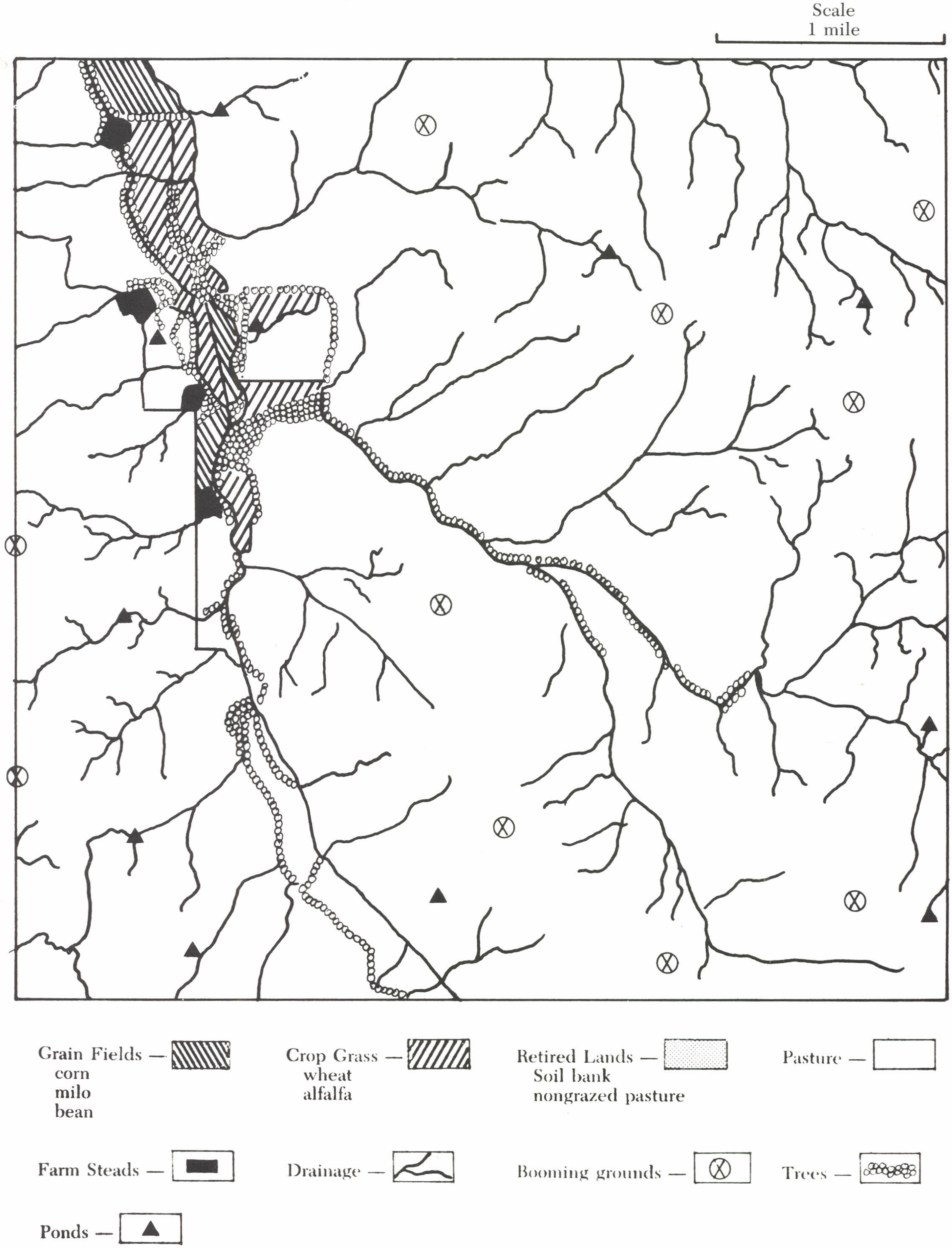


Figure 11. Two aspects of the grassland study area in the Flint Hills of Chase County, Kansas.

Agricultural Study Area

The agricultural study area differs from the grassland study area in that more of the total acreage was in cropland (Fig. 12). Much of the area was cross fenced with graded roads on most section lines. Two small, intermittent creeks meander through the western half of the study area. Generally, the land is owned and operated by resident ranchers.

The soils are of the Irwin-Labette association consisting mainly of deep clay soils developed over limestone or shale on gently sloping uplands. The range sites were made up primarily of loamy upland (33 percent), clay pan (25 percent), and clay upland (36 percent), (Neill 1974).

Clay pan and clay upland range sites were generally under cultivation. Both sites were upland types and are level to moderately sloping. These soils yielded fair crops, but respond to fertilization (Fig. 13).

Vegetation

Approximately 67.5 percent of the area was native grass pasture comprised mainly of tallgrass prairie. Because of overgrazing, many increasers (i.e., sideoats grama *(Bouteloua curtipendula)*, blue and hairy grama *(B. gracilis* and *B. hirsuta)*, buffalograss *(Buchloe dactyloides)* and invaders (i.e., prairie-three awn *(Aristida oligantha)*, windmill grass *(Chloris verticillata)*, western ironweed, ragweed *(Ambrosia* spp.), and broomweed were present in varying frequencies. Another 15.7 percent of the study area was dominated primarily by Japanese brome *(Bromus japonicus)*. The moderately grazed brome pastures were slowly being invaded by native plants. The remainder of the study area was composed of row crops (5.7 percent), wheat (4.9 percent), unpastured grasses (5.5 percent), and smaller amounts of alfalfa *(Medicago sativa)*, and alfalfa-brome mixture.

Some transient summer grazing occurs, but cow-calf operations with year-round grazing were prevalent. Pastures averaged only one-half section and were generally overgrazed where year-round grazing occurs.

Annual burning occurred on only a small portion of the area and most pastures were not burned during the study. With year-round grazing and haying practices, there was little duff left to support a fire.

The ratio of cropland to pasture on the area has remained relatively constant with some conversion of cropland to pasture.

Grassland-Cropland Study Area

Approximately six percent of the study area was in cultivated crops, consisting mainly of grain sorghum, wheat, and alfalfa. Grasslands made up the remainder of the area, of which 89 percent was native tallgrass prairie and 11 percent was domestic cool season grasses. Pasture sizes ranged from 80 to 1,280 acres with the larger pastures in native grass (Fig. 14). Three percent of the study area was used for hay, 17 percent was year-round cow-calf grazing, and approximately 75 percent was summer grazing for yearling steers.

The area has two soil associations, Labette-Irwin and Florence-Labette, both described above. All the soil types, range sites, land-use capacities, and percentage of each according to Neill (1974) are presented in Table 15. A list of the most common vegetation found in the grassland is in Table 16. Common and scientific names follow Anderson and Owensby (1969).

Methods

Vegetative Analysis

Vegetative transects were randomly selected on five of the major soil types which comprised 71 percent of the study area. Four transects were established on Labette-Sogn soil type, three on Labette-Dwight soil types, three on Irwin silty clay loam, one on Labette silty clay loam, and two on Dwight silt loam.

A visual obstruction measurement (Robel 1970) was used to measure the average density and height of grassland vegetation at 100 points along 200 meter transects. Measurements were recorded by counting the lowest decimeter or half-decimeter mark visible on a one-inch-by-four-foot round wooden dowel with alternating decimeters painted white or black with the midpoint of each decimeter marked with a narrow red stripe. The pole was placed vertically in the vegetation and observations were made from a distance four horizontal meters at a height of one meter above the ground (Fig. 15). These measurements were taken annually during the first part of May and again in late July or early August.

A modified vegetative step point (Owensby 1973) was used during the project to study vegetative composition and basal cover (Fig. 16). The investigator placed one leg of the point frame at his toe after each step along the transect. The point frame was then leaned forward until point contact was made on plant or bare soil. Species recorded were those whose bases were contacted by the point, or, if no basal hit occurred, the species nearest the point forward (180 degree arc). Basal hit or miss information was used for basal cover estimates. Previous years' vegetation (duff) was also recorded. This technique was used once annually during late July and early August, with 250 points recorded on each of the 13 transects (Fig. 14).

For comparative purposes, habitats utilized by prairie chicken were also measured. Twenty points were measured in each of the four cardinal directions from activity sites (areas where birds were observed and/or flushed) for a total of 80 points per site. Other data collected at the activity site included date, section, time, temperature, wind speed and direction, cloud cover, percent and exposure of slope, distance to nearest edge, distance to water, range site, number of birds by age (where possible), and whether or not the site had been burned.

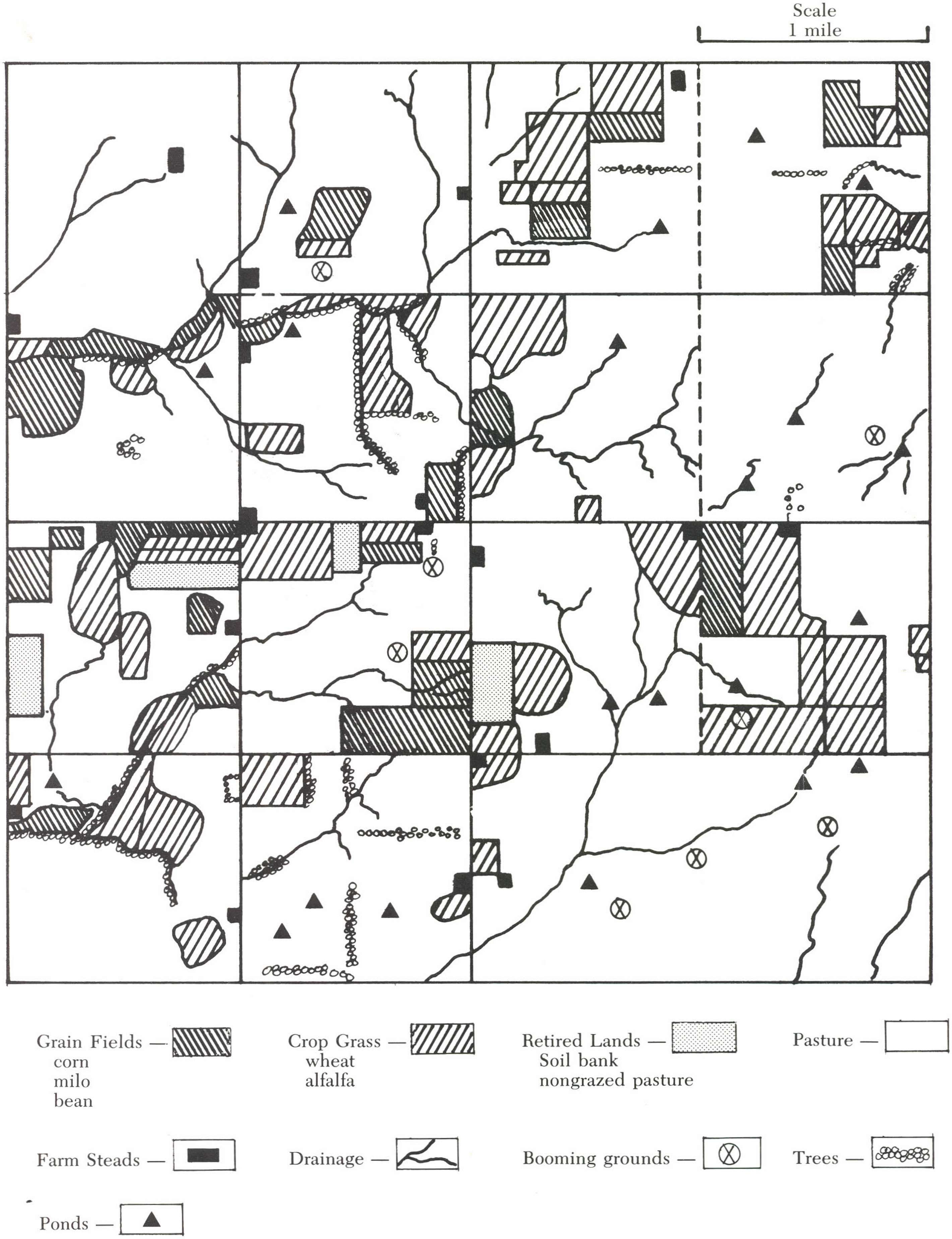


Figure 12. Cover map of agricultural study area, Chase County, Kansas.

Figure 13. Two aspects of the agricultural study area in Chase County, Kansas.

Figure 14. Grassland-cropland study area, Chase County, Kansas.

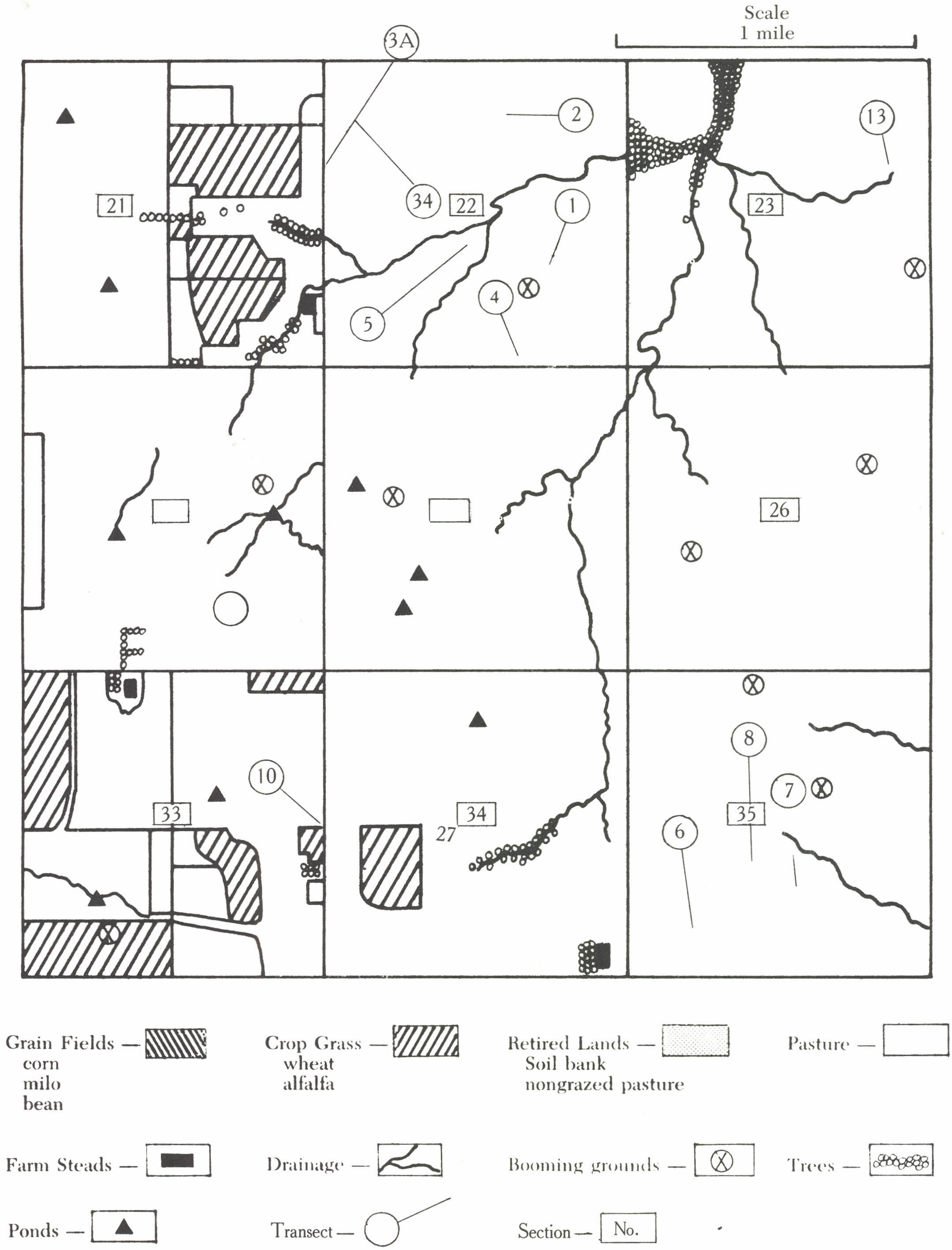


Table 15. Soils on the prairie chicken study area in Chase County, Kansas.

Soil Type	Range Site	L.C.D.[a]	Percent on Study Area
Irwin Silty Clay Loam (1-4% Slope)	Clay pan	IV[b] e[c]	6%
Tully Silty Clay Loam (4-7% Slope)	Loamy upland	III e	4%
Tully Silty Clay Loam (3-7% Slope)	Loamy upland	III e	4%
Labette-Sogn Complex	Loamy upland—60% Shallow—40%	VI e	35%
Irwin Silty Clay Loam (1-4% Slope)	Clay upland	III e	9%
Irwin Silty Clay Loam (0-1% Slope)	Clay upland	II s	3%
Dwight Silt Loam (1-4% Slope)	Clay pan	IV e	6%
Labette Silty Clay Loam Shallow (1-4% Slope)	Loamy upland	III e	7%
Labette-Dwight-Complex (1-4% Slope)	Loamy upland-50%	III e	14%
Dwight-Silty Loam (0-1% Slope)	Clay pan-50%	IV s	1%
Labette Silty Clay Loam Shallow (4-7% Slope)	Loamy upland	IV e	1%
Lady Smith Silty Clay Loam (1-3% Slope)	Clay upland	III e	1%
Alluvial Land	Loamy lowland	VI w	3%
Labette Silty Clay (1-4% Slope)	Loamy upland	IV e	1%
Labette Silty Clay Loam (4-7% Slope)	Loamy upland	VI e	1%
Labette Silty Clay Loam Shallow (0-1% Slope)	Loamy upland	II e	1%
Florence Soil	Flint Ridge—25% Loamy upland—75%	V e	2%
Reading Silt Loam	Loamy lowland	I	1%
Volin Silt Loamy Clayey Substratum	Loamy lowland	I	1%
Tully Silty Clay Loam (1-4% Slope)	Loamy upland	II e	2%
Lady Smith Silty Clay Loam (1-3% Slope)	Clay pan	III e	1%
Clime-Sogn Complex	Shallow	VI e	1%

[a]L.C.D. = Land Use Capacity
[b]I = Land in good condition
II = Bottom land normally
III = Upland cropland not eroded
IV = Upland cropland eroded
V = Rocky soils
VI = Severe erosion on rocky soils
[c]e = erosion
s = fertility problem
w = wet

Table 16. Common vegetation on the grassland portions of the Chase County prairie chicken study areas in Kansas.

Grasses

Big bluestem—*Andropogon gerardi*
Blue grama—*Bouteloua gracilis*
Buffalograss—*Buchloe dactyloides*
Hairy grama—*Bouteloua hirsuta*
Indiangrass—*Sorghastrum nutrans*
Japanese brome—*Bromus japonicus*
Kentucky bluegrass—*Poa pratensis*
Little bluestem—*Andropogon scoparius*
Prairie threeawn—*Aristida oligantha*
Prairie dropseed—*Sporobalus heterolepis*
Scribner panicum—*Panicum scribnerianum*
Sideoats grama—*Bouteloua curtipendula*
Smooth brome—*Bromus inermis*
Switchgrass—*Panicum virgatum*
Tumblegrass—*Schedonnardus paniculatus*
Western wheatgrass—*Agropyron smithii*
Windmillgrass—*Chloris verticillata*

Forbs

Broomweed—*Gutierrezia dracunculoides*
Ironweed—*Vernonia baldwini*
Louisiana sagewort—*Artemisia ludoviciana*
Many-flowered scurfpea—*Psoralea tenuiflora*
Missouri goldenrod—*Solidago missouriensis*
Western ragweed—*Ambrosia psilostachya*
Heath aster—*Aster erocoides*
Leadplant—*Amorpha canescens*
Dotted gayfeather—*Liatris punctata*
Plains coreopsis—*Coreopsis tinctoria*
Western yarrow—*Achillea millefolium*
Daisy fleabane—*Erigeron stigosus*
Slim aster—*Aster exilis*
Blacksampson—*Echinacea augustifolia*
Serrateleaf eveningprimrose—*Oenothera serrulata*
Purple prairieclover—*Petalostemon purpureum*
Pitcher sage—*Salvia azurea*
Slimleaf scurfpea—*Psoralea linearifolia*
Blue wildindigo—*Baptisa minor*
Plains wildindigo—*Baptisa leucophaea*
Field pussytoe—*Antennaria neglecta*
Plaintian—*Plantago* spp.

Shrubs

Jersey tea—*Ceanothus americanus*
Prairie rose—*Rosa setigera*
Aromatic sumac—*Rhus aromatica*
Smooth sumac—*Rhus glabra*
Buckbrush—*Symphoricarpos orbiculatus*
Osageorange—*Maclura pomifera*

Sedge

Sedge—*Carex* spp.

Figure 15. Visual obstruction technique used to measure height and density of vegetation at prairie chicken activity areas and along transects on the grassland-cropland study area in Chase County, Kansas, 1975-1978.

Figure 16. A modified vegetative step point measuring device used to determine vegetative composition and basal cover at prairie chicken activity areas and along transects on the grassland-cropland study area in Chase County, Kansas, 1975-1978.

Cover Map

The study area was cover mapped in late August. In addition, the pattern of grassland burning was mapped each spring. The number and kind of livestock were also recorded annually in each pasture.

Weather Stations

Two weather stations were located at opposite sides of the study area. Each was equipped with a Belford constant recording seven day hydrothermograph that recorded temperature and humidity. An official U.S. Weather Service rain gauge was also set up at each station (Fig. 17).

Population Surveys

From 1964 to 1968, Phase I study areas were searched to find all display grounds (booming grounds). Display grounds were located during the spring by listening for the call of booming males from one-half hour before sunrise to one hour after sunrise. Once located, an attempt was made to count and identify the sex of all prairie chickens on the ground. Two counts per ground were made during the peak display period.

During Phase II, population counts were made from June 1974 to December 1978. All spring booming grounds on the nine-section study area were counted twice a week from February to the termination of spring activities in June. Generally, only flush counts were made, but when possible, sex ratios were recorded. Fall counts were conducted similarly from mid-September through November. Each April, 80 visual obstruction counts were made on each booming ground.

Intensive observations of prairie chickens were conducted weekly from February through May on pre-selected booming grounds during both Phase I and II of the study. Observations were made from a blind during the entire morning display period.

Date, temperature, wind speed and direction, and cloud cover were recorded during each observation period. Throughout each period, information was collected on the number of males and females on the display ground at ten-minute intervals.

During Phase II of the study, all roads on the study areas were traversed in vehicle (approximately 14 miles) on each observation day throughout the year. Counts were begun one-half hour before sunrise at a single starting point. Data recorded were date, time start and finish, temperature, wind speed and direction, cloud cover, number of miles driven, number of prairie chickens seen, and their activities. These data were converted to prairie chickens seen per mile driven.

Following auto counts, a four-mile transect within one of the nine sections on the study area was walked by an observer with two dogs. During all months, if possible, each section was walked at least twice. Starting time after sunrise was the same, within an hour, between days and years. Data collected were date, time of start and finish, temperature, wind speed and direction, cloud cover, number of miles walked, and number of prairie chickens seen and their activities. This information was converted to prairie chickens seen per mile walked.

When prairie chickens were observed on both walking and driving surveys, the activity site was mapped and vegetatively sampled.

During Phase I, brood counts were conducted from mid-June through late August. The study areas were traversed by vehicle and randomly on foot with one dog to obtain sight observations of broods. Efforts to count broods were generally confined to morning and evening. Recorded information included the number of hours and date of search, the number of young, number of broods, estimated age of broods, and the number of adults with or without broods. The population index was observation time per bird.

Hunting Surveys

During the hunting seasons from 1963 to 1967, hunters using the study areas were interviewed to determine hunting success, and sex and age of harvested birds. Envelopes with instructions for wing and tail feather collection and an attached questionnaire were distributed to all landowners and lessees on each study area prior to the hunting season. Landowner cooperators were asked to provide envelopes to hunters on their land. Envelope drop boxes were erected at convenient locations throughout the study areas.

Fall and Winter Surveys

Fall and winter population surveys were conducted during Phase II of the study by driving roads and walking the study area as described earlier. Grassland habitats utilized by chickens were measured when a flock exceeded nine birds. Prairie chickens using feed fields were counted both to determine use and population trends from October through February from 1975 through 1977.

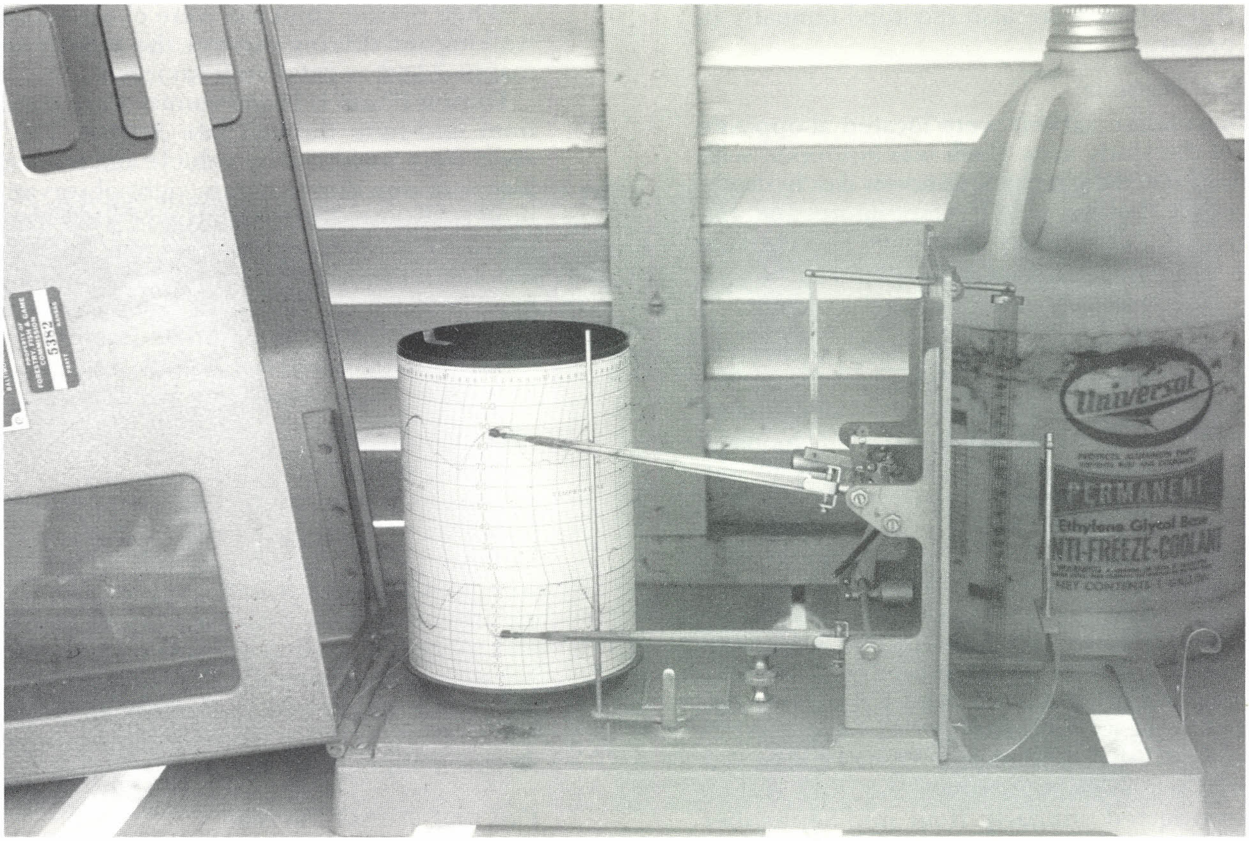
Habits and movements of prairie chickens were noted throughout the study. Most information was gathered by continuous observations during flock movements, display activity, and by observation of marked birds.

Trapping and Marking

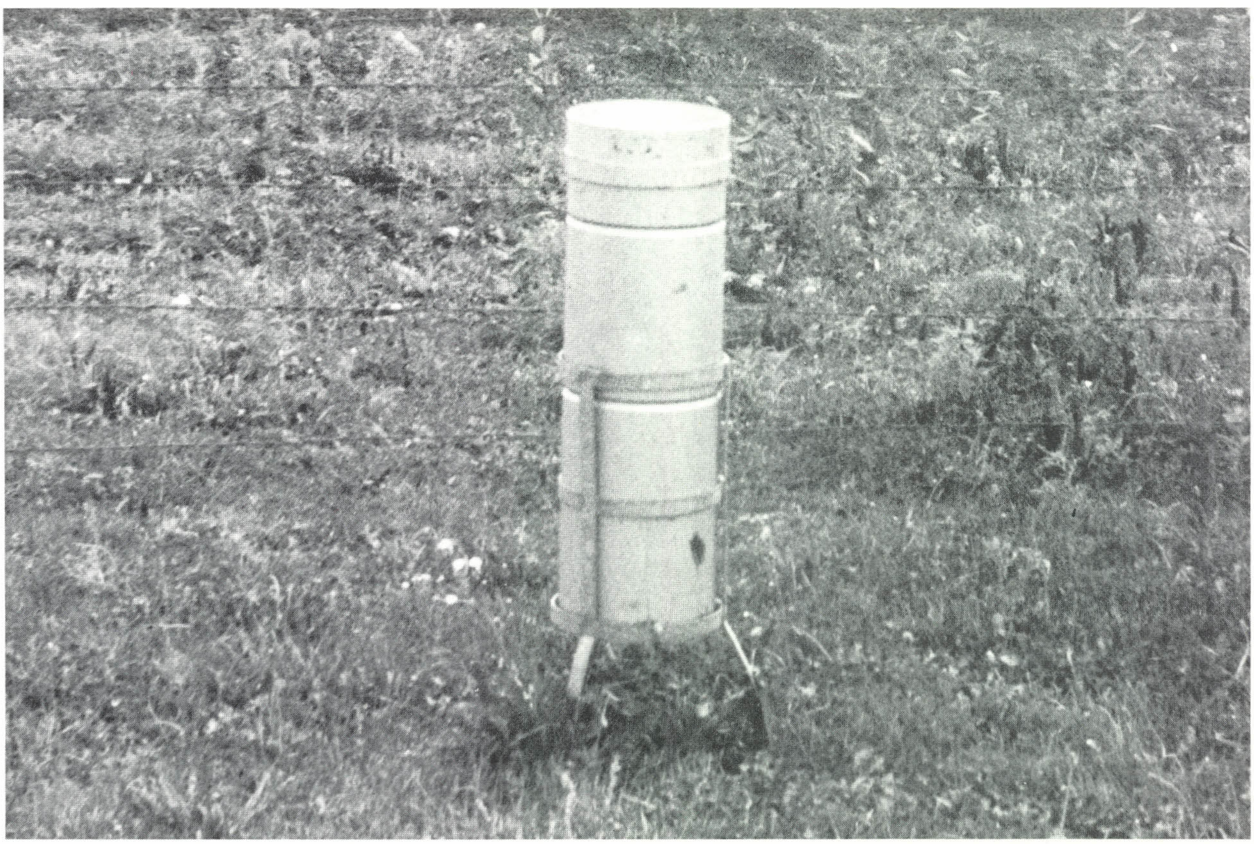
Following the hunting season, trapping sites were prebaited with corn, sorghum, soybeans, or a combination of these.

Two walk-in, "funnel-type" traps were used; one designed after Hammerstrom (1942) and the other, a variation of the cloverleaf type trap. One trap was rectangular, measuring six feet by twelve feet and made with one-inch mesh chicken wire supported by steel posts at each corner. The top was two-inch mesh fish seine. Funnels were 15 inches long with an outer end opening of ten inches by eight inches which narrowed to five and one-half by four and one-half inches at the inner opening. These were inserted, off center, on opposite sides of the trap. The second type of walk-in trap was made of four by two-inch mesh welded wire and was smaller (4 x 4 x 2 feet), but with similar funnels. This trap

Figure 17. Weather measuring devices used on the grassland-cropland study area in Chase County, Kansas, 1975-1978.



Hydrothermograph for a 7 day constant recording of temperature and humidity.



was self-supporting and easier to handle.

A third, more mobile trap was designed using a rectangular shape and an entrance similar to the cloverleaf trap. This trap was made of welded wire and measured four by three by three feet. It was also covered with two-inch fish seine. Each of the four corners of the trap were connected with hog rings, which acted as hinges, permitting folding. Ends of the trap were vertically cut in half and reconnected with hog rings to facilitate folding, making an approximate four-inch, funnel-type opening similar to the cloverleaf trap (Fig. 18).

Nineteen prairie chickens were trapped with walk-in traps during the winter of 1964 through fall of 1965 with no apparent difference in efficiency for one trap over the other.

Rocket nets were used during spring and fall booming ground activities and occasionally at bait stations throughout the winter flocking period. Generally, two nets (60 x 60 ft., with two inch mesh) were placed opposing each other and fired by rockets (Fig. 19). Birds captured this way struggled continuously and often lost or broke feathers. To quiet the birds, burlap bags were quickly placed over each bird. This eliminated much feather loss. A total of 58 birds were trapped in this way; 35 on booming grounds and 23 in feed fields.

A mist net measuring 60 x 12 feet with a four-inch mesh was used primarily on booming grounds, and once in a feed field. The technique was first used in the manner suggested by Low (1957); suspended one foot off the ground by two vertical poles. It was hoped that birds would become entangled when the bottom edge of the net was lower to the ground. Six birds were harassed into the mist net by a vehicle. One bird was captured in a similar manner on a feeding site.

Walk-in traps used during winter were cost-effective, since constant surveillance of traps was not necessary. Construction cost of each trap was low. A disadvantage was that fewer prairie chickens were caught per trap-day than with the rocket net. Prairie chickens were sometimes captured in walk-ins during mid-day and remained in the trap for several hours. Coyotes *(Canis latrans)* and hawks may harass these birds and have been known to enter a trap and kill captured chickens.

Rocket nets captured the majority of birds, but this equipment is expensive. Many man-hours were used, since two men were needed to set and observe the net until the chickens were in proper position. It was most effective during fall and spring booming ground periods, and during winter flocking.

Figure 18. Funnel-type, fold-down, walk-in, prairie chicken trap used during phase 1 of the study in Chase County, Kansas, 1964-1968.

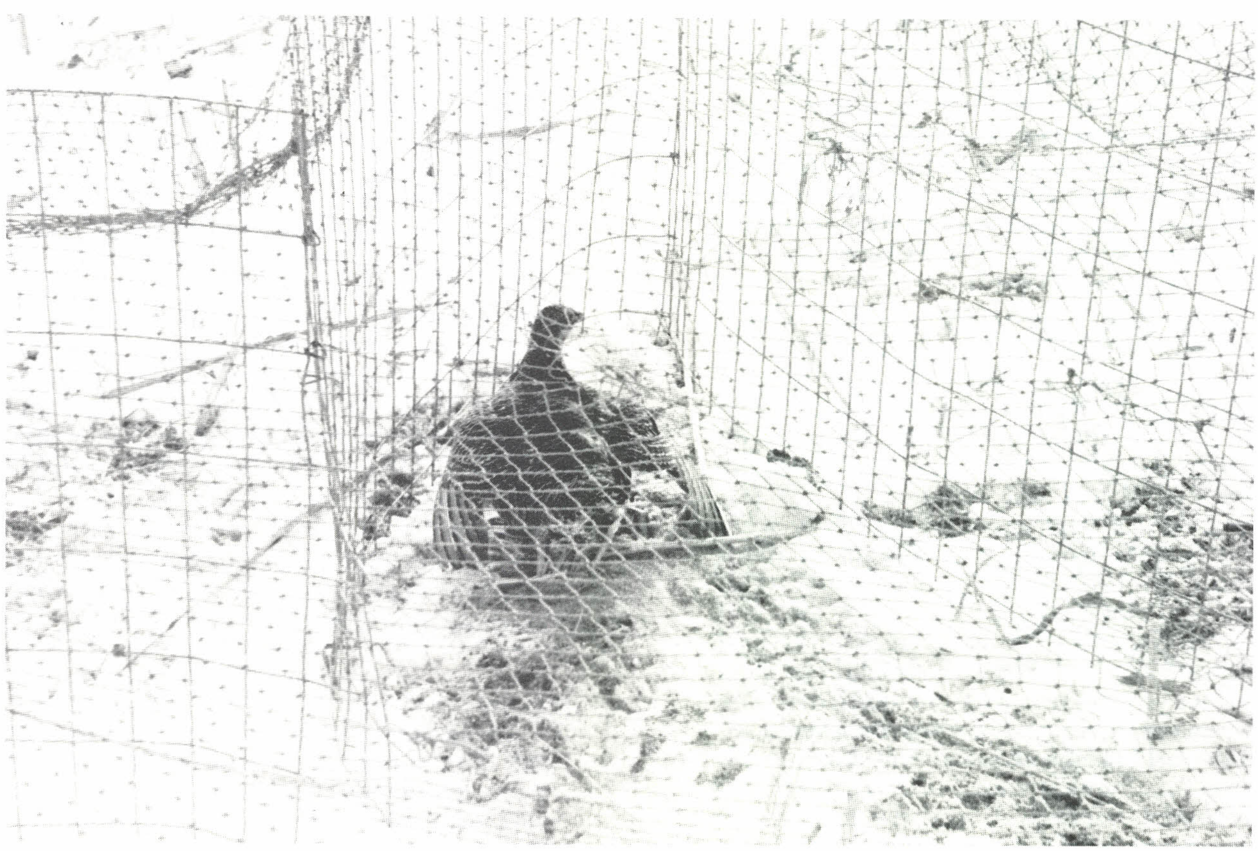


Figure 19. Opposing rocket nets used to capture prairie chickens during phase 1 of the study in Chase County, Kansas, 1964-1968.

Mist netting has several advantages over rocket nets on booming grounds (Silvy and Robel 1968): (1) fewer recaptures, (2) less disturbance of display grounds, and (3) lower acquisition and operational costs. However, the mist net seldom captures more than one bird at a time. Both nets were adversely affected by strong winds.

Eighty-one prairie chickens were trapped from the spring of 1964 to the fall of 1965. Of these, 50 were trapped on the agricultural study area, ten of which were captured on booming grounds. Thirty-one birds trapped on grasslands were all caught on booming grounds.

All birds were aged when possible, sexed, marked, and released at the point of capture. Aluminum, number 14, butt-end bands bearing the address of the Kansas Fish and Game Commission and identification numbers were placed on the right leg of each bird. A colored celluloid, numbered band was also attached to each leg. Wing markers of plasticized nylon fabric were attached to both patagia with aluminum rivets (Knowlton, Michael, and Glazener 1964), (Fig. 20). One tag color designated the study area and another the trap site. The wing tag was the best field identification marker, since it could be seen at a distance of 100 yards with the naked eye. The marker was durable and known to remain attached to one bird for at least four years.

Food Habits

Prairie chicken droppings were collected from 1965 to 1968 on each study area. Each dropping was labeled with the date and location of collection. A total of 91 droppings were collected on the grassland area and 66 on the agricultural area. In addition, 20 crops and gizzards were collected on the agricultural study area during the 1969 hunting season. Gizzards were labeled and placed in formalin.

Collected samples were grouped by dates into four segments, each representing a season of the year (March-May, June-August, September-November, and December-February). An effort was made to collect 20 samples in each segment from both study areas; however, only 14 samples were collected on the agricultural study area during the winter segment.

Each sample was washed, strained, and dried before being divided into cultivated and noncultivated vegetation, insects, and other animal materials. Seeds in the sample were classified to species.

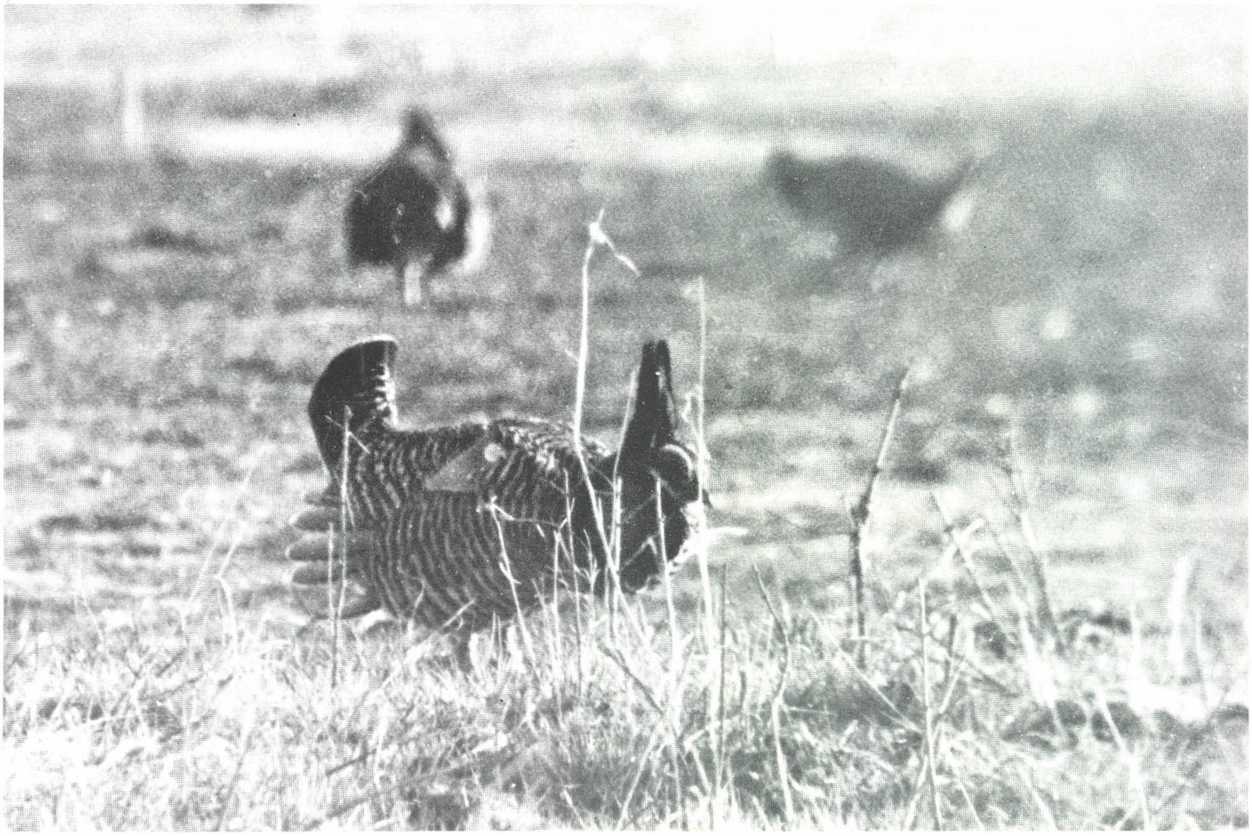
Analysis

Data collected during the study were analyzed with the Statistical Analysis System (SAS, SAS Institute Inc. 1982).

Results

The greater prairie chicken is a species that can only survive in grasslands. Management of those grasslands along with cropland interspersion is important and dictates population density. In Kansas, greater prairie chickens inhabit areas from mid-grass prairie in the northcentral part of

Figure 20. Marked prairie chicken with plasticized nylon Patigia wing markers during phase 1 of the study in Chase County, Kansas, 1964-1968.



the state to tame grass areas in the southeast. However, greatest numbers are found in native tallgrass prairies of the Flint Hills.

Booming Grounds

Two major peaks of booming ground use occur in April and October (Fig. 21). The majority of grounds used are traditional. Ranchers have indicated that some grounds have been in use for 40 years or more.

Males appear on the ground everyday from first light until about two hours after sunrise. Early in the spring, all their energies are focused on establishing small territories on the booming ground. This is accomplished via vocal and visual intimidation displays. Later in the spring, activities are expanded to courtship of females arriving on the ground. Resonating booming calls of the male prairie chickens can be heard for a mile or more on a calm day. Booming ground display and courtship behavior of the greater prairie chicken has been described extensively (Breckenridge 1929; Schwartz 1945; Hammerstrom and Hammerstrom 1960 and 1973; and Robel 1965). Evening displays are similar to morning activities, but less intense.

Throughout the study, 22 different booming grounds were located on study areas (Figs. 10, 12, and 14). Physical characteristics of these grounds are summarized in Table 17.

Leks were divided into two categories: those less than three-quarters of a mile from cultivated lands, and those further away. Grounds were normally found on the highest point of land for one-quarter mile (Fig. 22). In areas of high relief, chickens selected only ridges for display sites. The 16 booming grounds on rangeland averaged over one mile from land of higher or similar elevation. Mean distance between grounds was not different ($P > .10$) between categories one (0.66 mi.) and two (0.80 mi.), and averaged about three-quarters of a mile overall. Of the six grounds located within three-quarters of a mile of croplands, two were located on wheat and four on grassland. Wheat field display areas were generally abandoned earlier than grassland leks in spring due to wheat growth. Only one of two wheat sites lasted the duration of the study, and it was usually abandoned when wheat growth reached a height of 15 to 20 inches, sometimes as early as mid-April. Early abandonment has the potential of adversely affecting a population that is influenced by this ground, particularly during times of late nesting or renesting attempts. On areas where wheat is less than five percent of total land use, the potential effect on the population is minimal, but in areas where wheat is more common, the potential for booming grounds in wheat is higher and may have some effect on production.

The remaining 20 grounds were on some type of grassland. Grounds were located on droughty sites (clay pan and loamy upland) and generally on ridgetops where soils produce short, scattered vegetation. Forty percent of booming grounds on grasslands were located on nearly bare ground

Figure 21. Typical booming prairie chicken in Chase County, Kansas.

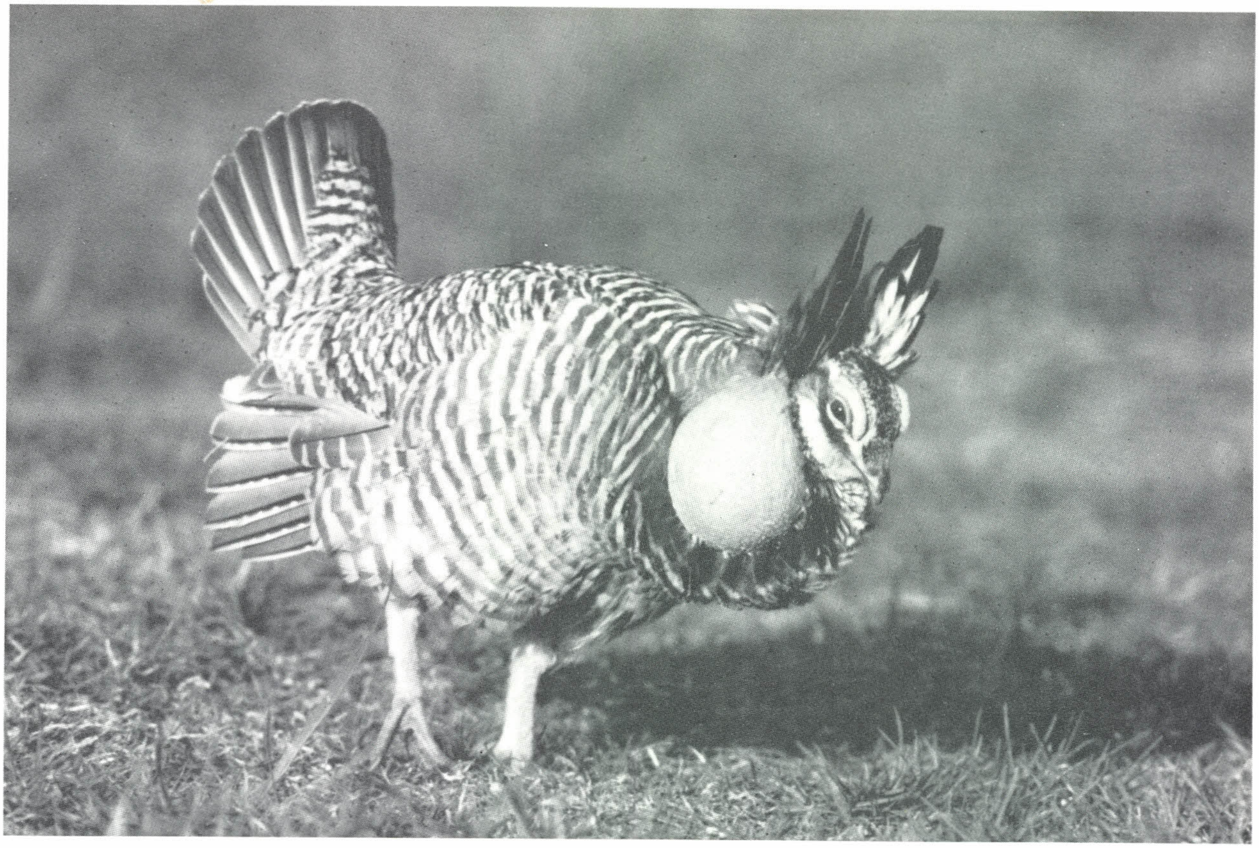


Figure 22. Typical booming ground located in elevated short grass area in the Flint Hills of Chase County, Kansas.

Table 17. Physical characteristics of 22 booming grounds on the study areas in Chase County, Kansas.

Grounds Within ¾ Mile of Cultivation	Range Site	Nearest Higher Point (Miles)	Cropland	Grassland	Distance to Nearest Ground (Miles)	Known Duration of Ground (Years)
1	Clay pan	¼	Wheat		1½	2
2	Loamy upland	½		Saltlick	½	4
3	Clay pan	¼		P-3 awn domestic grass	¼	4
4	Clay pan	¼		Brome domestic grass	⅝	14+
5	Clay pan	⅛	Wheat		⅝	14+
6	Clay pan	¼		Native	½	14+
		about ¼			⅔	
Grounds Further Than ¾ Mile of Cropland						
7	Shallow	½		Saltlick	1	5+
8	Loamy upland	1½		Overgrazed native grass	⅞	4+
9	Loamy upland	2		Saltlick	⅞	4+
10	Clay pan	¾		Saltlick	¾	5+
11	Clay pan	½		Trail	¾	5+
12	Loamy upland	4		Native ridgetop cherty soil	¾	4+
13	Loamy upland	½		Native ridgetop cherty soil	⅜	4+
14	Shallow	½		Ridgetop	1⅛	4+
15	Loamy upland	1		Saltlick	⅞	5+
16	Shallow	2		Ridgetop cherty soil	1¼	2+
17	Clay pan	½		Ridgetop chertysoil	1	4+
18	Clay pan	½		Ridgetop cherty soil	½	4+
19	Loamy upland	1		Ridgetop cherty soil	1	4+
20	Loamy upland	1		Ridgetop cherty soil	1	3+
21	Loamy upland	¾		Trail and Ridgetop	½	3+
22	Loamy upland	¾		Rocky soil	¾	1+
		about 1 1/10			over 8/10	

+ = still existing after study ended.

area created by saltlick or worn trails, which suggests that bare or near-bare areas are preferred. During the years 1976, 1977, and 1978, visual obstruction readings were taken on six booming grounds located in grassland in grassland areas. In 1978, the majority of the study areas, including all six booming grounds, were burned. This drastic change in habitat su·rounding, and including, the ground had no apparent effort on displaying males. There was no difference (p>.10) in the density reading between 1976 and 1977 when extensive burning did not occur. Sixty-three percent of the 800 readings showed a vegetation height-density of less than 0.5 decimeters, 31 percent were between 0.5 and 1.0 decimeters, three percent were between 1.0 and 1.5 decimeters, and the remaining three percent exceeded 1.5 decimeters. Jones (1963b) found that mean vegetation height on booming grounds was 1.5 decimeters in Oklahoma. Anderson (1969) showed that cocks preferred cover six inches or less for booming and that mowing or burning had little effect on lek use if the vegetation was initially less than six inches. He also indicated that tall escape cover near the ground benefitted the stability of the ground. No indication of this was found in this study. Schwartz (1945) indicated that height and density of cover exert some influence upon ground location, although they were located in the same general area every year.

Two main reasons for leks being located on elevated sites are: (1) greater visibility and audibility, and (2) poor soil and eroded range sites that produce sparse, short vegetation.

In major grassland areas where habitat is relatively stable, booming ground locations and numbers remain constant. With diversified grassland management such as rotational grazing, grounds are less stable and often move as habitat changes. If pastures are overgrazed or otherwise mismanaged, prairie chicken populations will decline and eventually disappear.

Territories

Prairie chicken booming ground activities were observed on Diamond-tail number 10 lek between 14 March and 30 June, 1966. The ground was located on a saltlick approximately one-half acre in size near the top of a ridge on the grassland study area. Because the area was used constantly by cattle during summer, little vegetation was present on the saltlick.

Two males on the ground were trapped and marked; one during the spring of 1964 and the other in the spring of 1965. The bird marked in 1964 was found dead 100 yards from the ground on 26 March, 1966. The remaining marked bird came to the ground every observation day and occupied the same area on the ground until 30 June 1965, when no birds appeared on the ground. Other males on the ground were not individually marked, but certain areas (territories) were occupied on the ground each observation day, presumably by the same male. Individual male territories were marked and mapped (Fig. 23).

Numerous disputes occurred between males occupying adjacent territories; commonly in a zone between the territories. Fighting generally occurred along this strip, but rival males met more frequently at certain spots. Although each male seemed to know his territory boundaries, no physically definable boundary was apparent. Hammerstrom and Hammerstrom (1960) indicated that neighboring cocks spar more often at certain spots along their common territorial boundaries. Robel (1965) showed that there is an outermost tertiary area which overlaps with neighboring territories, a secondary area which is only occasionally entered by neighboring chickens, and an inner-most primary area which adjacent chickens never enter. Lumsden (1965) stated that each territory of sharp-tailed grouse has a nucleus in which a male is clearly dominant. As the distance from this nucleus increases, dominance decreases. In summary, each male established on a ground has a discrete territory which he dominates; however, there exists a buffer zone between neighboring territories where males meet to contest territorial dominance. A territory is defended by display postures, movements and calling. Disputes which result in contact fighting occurred most frequently early in the booming season during territorial establishment.

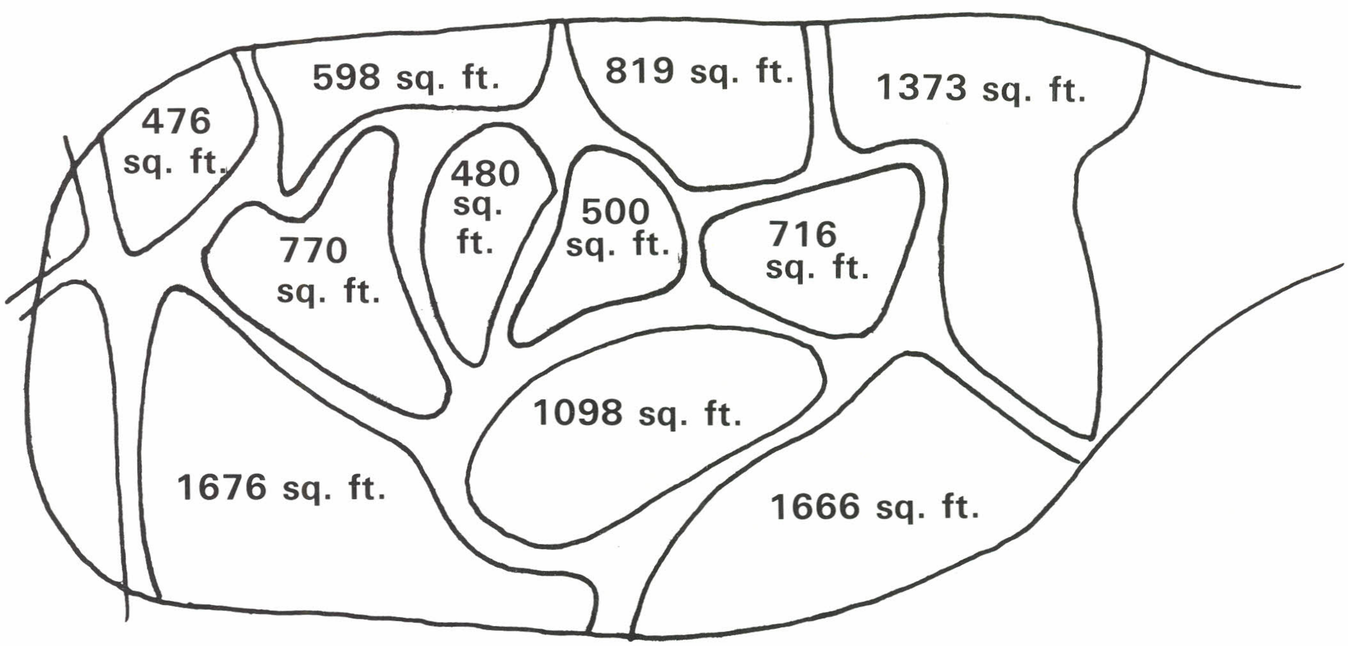
The size of a territory, activity of the male in his territory, and the specific habitat of the booming ground appear to be independent of the number of males present on the ground. A question that arises is why the number of territorial males on a lek remains nearly constant from year to year when "nonterritorial" males are available to establish additional territories on the booming grounds? On most booming grounds, there appears to be ample area for more territories. A possibility is that "nonterritorial" males have a mating function off the ground as well as being available to fill vacated territories on established grounds should they occur.

Displays and Calls

Displays and calls of prairie chickens on booming grounds have been extensively investigated and described by Schwartz (1945), and Hammerstrom and Hammerstrom (1960). In this paper, only the most notable displays and calls will be discussed.

The "booming" call of the male prairie chicken is the one most commonly heard on the lek and is

Figure 23. The size and location of territories on Diamond-Tail #10 booming ground in Chase County, Kansas, 1965.



responsible for the name "booming ground." On a calm morning, this call can be heard for at least one mile. It primarily serves to advertise the ground's location, but is also used for territorial defense and courtship displays.

Booming occurs most frequently when males first arrive on the ground in the morning. Booming activity was most intense in April and decreased steadily in intensity and duration during May and June. When females were on the ground, the rate of booming appears to double.

Prairie chicken copulation was never observed on Diamond-tail ground number 10 during 17 days of observation. Females would generally walk through the ground from one territory to another. Males in the vicinity of a female would display all around her, but particularly in front of her. Neighboring males occasionally crossed territorial lines to court. Females appeared disinterested, and, at times, picked up green vegetation. Some chasing behavior was observed between hens, suggesting a social hierarchy structure in females.

Populations

During Phase I of the study, the number of males present were recorded on numerous grounds, particularly Diamond-tail number 10 and Thompson number 5. In 1966, the number of males reached a high of 19 during mid-March and ranged from 12 to 15 during most of April on Diamond-tail number 10. The number of males visiting this ground declined steadily during May and June until no more activity was noted on 30 June. Large numbers of males establishing territories in early spring were also observed on the Thompson number 5 booming ground. In early March, 34 males were attempting to establish territories on this lek, but only 20 males occupied territories by April. Robel (1970) showed that the male population on booming grounds decreased a mean of 3.3 birds for each two-week period after 1 March.

Numbers of males with established territories on Diamond-tail number 10 varied only slightly between 1965 (15), 1966 (14), and 1967 (16). Other grounds observed during Phase I of the study on the grassland study area were similar. Data from the agricultural study area revealed that some grounds increased in size, while others decreased, with occasional complete loss of males. Changes in land use may have affected these booming ground fluctuations.

Aside from variation in habitat and weather conditions, annual and daily fluctuations in numbers of males on booming grounds is caused by inconsistent attendance by nonterritorial males. On Diamond-tail number 10 it was common for one to five nonterritorial males to visit. Hammerstrom and Hammerstrom (1960, 1973) also noted this, particularly during high population years. Robel (1970), using radio-telemetry, identified movement from one lek to another by juvenile males. He also indicated from counts on three booming grounds that the number of regular territorial males was constant from one year to the next, and that the number of "incidental males" varied with total population.

Hen visitation to Diamond-tail number 10 was erratic, with no more than three hens visiting the grounds on any morning. Eleven hen visits were recorded during 17 mornings.

Female visitation was recorded on 36 mornings during Phase II of the study. Females visited as early as 9 March and as late as 21 May. Of 45 females observed, 67 percent were seen during the last week of March and the first week of April. Thirteen percent were seen before this period, and 20 percent were observed later.

Schwartz (1945) stated that hen visitation during the latter part of March was infrequent but suddenly increased for approximately a week to a constant maximum during the peak copulation period about the first week in April. Robel (1970) reported that females appeared on the lek in flocks of six to twelve during late March and early April, however, groups of only one to six females visited the ground during mid-April. Hammerstrom and Hammerstrom (1973) indicated that territories are not fully organized until early April in Wisconsin. They stated that hen visitation built up to a peak by the third or early fourth week in April. A second lower peak comes about mid-May, which presumably represents late-nesting or renesting hens.

In this study, if the number of females visiting the ground indicates peak mating, then this activity was greatest during the first week of April. Females coming to the ground in late May may have indicated renesting.

During Phase II, in February of years 1975 through 1978, booming grounds were checked on 84 occasions. Prairie chickens were present on 59 (70 percent) of those visits. Leks were occupied on 97 (96 percent) of the 101 visits in March, 107 (99 percent) of the 108 visits in April, 76 (94 percent) of the 81 visits in May, and 65 (64 percent) of the 102 visits in June. During the peak activity period of March, April, and May, birds were present during 280 (96 percent) of the 290 checks. Avian or mammalian predators may account for the bird absences at certain times. During months of less intense activity, bird absence may be attributable to wet conditions, wind, cold, as well as hot weather, and lack of interest.

Grounds 5, 6, 17, 18, and 19 were active over the four-year study. Number nine was active only during 1975 and ground seven during 1978 only. Lek 21 was active during 1976, 1977, and 1978. Ground 20 was not active until April 1976 and was active thereafter. Ground location from year to year remained static, but numbers increased from six in 1975 to eight in 1978. The number of "incidental males" on grounds varied with the total population.

During Phase II of the study, two aspects of booming ground population fluctuations were studied. The first part involved counting birds that were flushed from booming grounds semiweekly during March through June in the years 1975 through 1978. A total of seven booming grounds were counted, of which five were active during the entire study while only two were active during the last three years; and in 1978, an additional ground was initiated.

Information was analyzed for individual grounds and between grounds. Data indicated that there was no consistency in the fluctuating number of birds using particular grounds, compared to the number of birds using another ground during each month sampled. The fluctuations could be attributed to nonterritorial males moving between grounds, females on the grounds, weather conditions, and establishment of new grounds.

Assuming that a constant percent of the total population consistently uses booming grounds, some stay on one ground, others move from one ground to another, a total of all birds flushed on all grounds during each month for different years would give an annual trend in population. Figure 24 shows this population fluctuation, with lower numbers in 1975 and 1977, and the higher counts in 1976 and 1978.

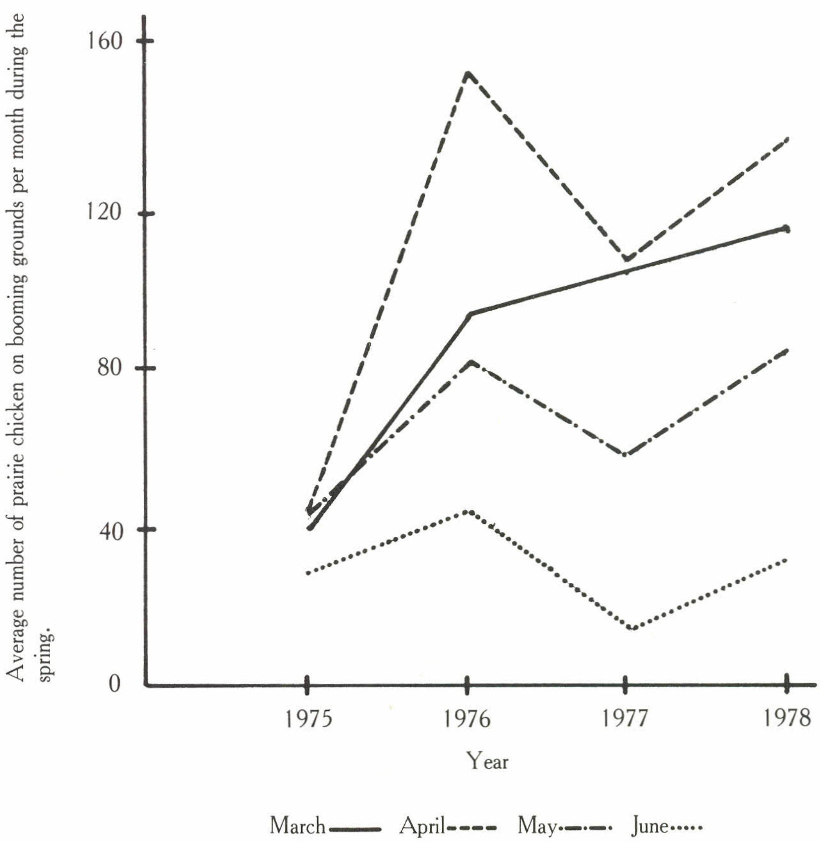
The second part of the booming ground study was conducted at leks five and six, and was designed to evaluate fluctuations in the number and sex ratio of chickens on the grounds during booming activities. Males and females on the ground were counted at ten-minute intervals one morning each week from mid-February to mid-May.

Birds were present on the grounds during 98 percent (368 of 372) of the counts. Both males and females were present in 20 percent of all observations. Both sexes were present during 0, 10, 26, and 21 percent of the observations in February, March, April, and May, respectively. When both sexes were present, females accounted for 8, 14, and 12 percent of the birds present in March, April, and May, respectively.

Variance in the number of birds on grounds was analyzed between grounds, years, and months. These estimates of variance for males indicate that 81 percent of the variance is caused by year to year changes, ten percent due to difference in grounds, nine percent due to random error in census techniques, and there was no variances due to months. Although a low average number of females were observed, they showed a 50 percent variance due to years, 28 percent due to grounds, 22 percent due to random error in the sampling technique, and no difference occurred because of different months. Flush counts were also made on the grounds, and an estimate of variance for the total number of birds was made, indicating 78 percent of the variance was because of year to year changes and 13 percent because of differences due to months.

Coefficients of variation in the number of males, females, and total flush counts were calculated. These statistics indicate the mean

Figure 24. Spring booming ground populations on the grassland-cropland study area by year and month in Chase County, Kansas, 1975-1978.



number of females on grounds must change approximately 174 percent to show significant ($P<.10$) change in abundance of hen prairie chickens. However, a 23 percent change in the male count or flush count would be significant ($P<.10$). Obviously, male or flush counts are superior to hen counts as population indices. Booming ground counts give a general indication of long-term trends or prairie chicken populations; however, they are suspect on an annual basis. Greater precision can be obtained by increasing the number of grounds counted and by making more counts per lek.

Because the territorial male population is relatively constant on each ground, nonterritorial male visits will reflect changes in that population. When populations of nonterritorial males are high in number and they are harassed from permanent leks, temporary satellite booming grounds are often established. Large fluctuations in number of males using these grounds are common. When populations are low, temporary leks disappear, and nonterritorial male disturbance on permanent grounds decreases. If the number of males declines to the point that permanent grounds disappear, it is likely that habitat changes rather than normal fluctuations are responsible. Consequently, counts which show trends towards reduced numbers of grounds and fewer males per ground are clear warnings that habitat management is needed.

Habitat Management

Preferred booming ground sites are located on elevated, droughty areas, such as hilltops or ridges with short vegetation (less than two inches); often the tallest point for at least a quarter mile. However, booming grounds can be found on level land or sites lower than nearby terrain if surrounding nesting habitat is suitable. Booming grounds are typically less than five acres in size and are used perennially.

Permanent booming grounds can be economically established by developing a saltlick along a ridge where cattle will trample and overuse the vegetation. Since prairie chicken activity on stable leks occurs during all but two months of the year (July and August), maintaining the ground year around is important. Ideally, booming grounds are located in areas where at least 60 percent of the surrounding habitat is good to excellent range condition grassland and no less than one-half section in size. In this section, booming grounds normally are no closer than one-half mile apart.

If grassland is limited, booming grounds occur on plowed fields. However, at least 80 acres of nesting cover in well-managed grassland should be within one-third mile. When grassland is limited and interspersed with cropland, booming grounds may occur as close as one-quarter mile apart. With the diversification of grassland management and crop rotation on these grassland/cropland areas, the number and location of booming grounds is less stable and often move as the habitat changes. If pastures are overgrazed or otherwise mismanaged, booming grounds and prairie chicken populations will decline and may eventually disappear.

Burning can cause drastic changes in habitat during spring mating season. Burning has little long-term effect on displaying males, but may force females to shift to other grounds near unburned grassland to find suitable nesting habitat. Burning is necessary to maintain tallgrass prairie, but should be done only every three to four years on a rotation basis; that is, burning from one-third to one-fourth of an area annually. Generally, burning is best for wildlife and range management if it is done in mid-April, about the same time as nest initiation. This will result in some nest loss, but hens will renest. A proper burning regime will benefit grasslands as well as prairie chicken populations.

NESTING

During the entire study, 20 nests were located. Two methods were employed to locate nests: Searching the study area on foot with a dog yielded 13 nests, and advertisements in the local newspaper asking residents to report nest locations yielded seven nests.

Seven nests had been destroyed, three had hatched before they were found, and ten nests were active when found. Of the ten active nests, seven were destroyed (possibly aided by human interference), and three hatched. Because of human interference and low sample size, nest success was not estimated. Information gathered from other studies (Baker 1953; Hammerstrom and Hammerstrom 1939; Yeatter 1943; Blus and Walker 1966; and Sisson 1976) found that approximately 50 percent of prairie chicken nests were successful. Robel (1970) found only a 26 percent hatching success on his study area.

Clutch Size and Hatching

The average number of eggs in 13 nests was 10.7, ranging from seven to 13 eggs. Hammerstrom and Hammerstrom (1939) reported average clutch size of 12.0 and Gross (1930) found a mean of 11.5 in Wisconsin. Blus and Walker (1966) and Sisson (1976) reported clutch sizes of 13.3 and 11.8, respectively, in Nebraska.

Four of the six successful nests hatched during or before the first week in June and the sixth nest hatched during the third week of June. In 1966, during Phase I of the study, when a brood was observed, its age was estimated to the nearest week, following Baker (1953), up to ten weeks of age. Chicks more than ten weeks old were classified as 10+. After 15 weeks, the young could not be readily distinguished from adults. Age estimates obtained from 21 broods suggested that peak hatch occurred during late May and early June in 1966. Robel (1970) found that the critical nest initiation period was comparatively short, late April into early May. Nests initiated before May 1 experienced greater success than nests begun later. Schwartz (1945) indicated the last of May and early June were peak hatching dates in Missouri. Gross (1930) and Hammerstrom and

Hammerstrom (1939) in Wisconsin, Blus and Walker (1966) and Sisson (1976) in Nebraska, all indicated the first three weeks in June are peak hatch periods.

Nest Location

Prairie chickens prefer to locate their nests on well-drained upland sites. Generally, nests are located on north or west exposures with slopes of less than 20 degrees. The average distance from a nest to a booming ground is one-third mile. Stock ponds were generally less than one tenth of a mile from nest sites. Jones (1963b) noted that all nests located in Oklahoma were within one quarter mile of available water.

All 20 nests were within 20 yards of some type of edge (a visible change in habitat such as a trail, fence row, creek, or any noticeable vegetation change). The average distance to edge was 6.1 yards, and several nests were on the edge of plowed fields or graveled roads. All nests were in the open with no trees or shrubs nearby. Yeatter (1943) mentioned that nests were frequently found close to small trees, along field margins, or near streams.

Vegetation

Vegetation surrounding the nest must be dense enough to provide concealment from ground and avian predators, but sufficiently open for easy access to and from the site. Fifteen of 20 nests were located in native bluestem pastures, two in cool season grass pastures, two in alfalfa fields, and one on a wheat field edge. This suggests vegetational structure is more important than species in nesting habitat.

During Phase I of the study, 15 nests were located in vegetation with a mean height of 2.9 decimeters (12 inches), and an average maximum height of 5.05 decimeters (20 inches) within a meter of the site. During Phase II of the study, habitats surrounding four nests were measured by the visual obstruction method. Average visual obstruction within 40 meters of the nest site is two decimeters (eight inches) and ranged from one-half decimeter (two inches) to 7.5 decimeters (30 inches). Blus and Walker (1966) obtained measurements of vegetation, which ranged from 3.7 inches to nine inches and averaged five inches. Jones (1963b) found heights of vegetation ranging from 9 inches to 28 inches and averaging about 18 inches. Determination of vegetation at nest sites indicated that 81 percent were grasses, 12 percent forbs and seven percent sedges. Ground cover is composed of 18 percent live vegetation, 54 percent duff, and 28 percent bare ground. Residual vegetation was important in construction and concealment of all nest sites. No nests were found on recent burn sites. Nests are built in small ground depressions either natural or scratched by the hen. Although residual vegetation is critical, there appears to be an upper limit of accumulated duff that is tolerated at prairie chicken nest sites. In well-managed pastures, this limit is usually reached after three or four growing seasons. Again, this points out the importance of burning. Habitat surrounding the nest should be two decimeters (eight inches) tall and occupy approximately 15 percent of the area in large expanses of rangeland. A minimum of 80 acres of good nesting habitat should be within one-third mile of a booming ground.

To provide prime nesting conditions for prairie chickens, two management techniques should be implemented: 1) moderate to light grazing will maintain the proper height and density of vegetation and create edge; and 2) burning every third or fourth years will prevent excessive duff accumulation.

Ideally, one-third to one-fourth of the range would be control burned every year. Since cattle prefer recently burned areas, entire grazing units should be burned. Burning large pastures often leaves a number of overgrazed or naturally shortgrass areas unburned which, while hens may use them, are usually low quality for nest sites. Predators may concentrate their hunting and feeding activities on these sites. Where a complete burn occurs on large adjoined grazing units, prairie chickens will move and/or be adversely affected due to a lack of nesting habitat. These situations can be altered by preventing scattered grazing units (at least 800 acres) from burning through back-firing.

Quality of nesting cover is of primary importance; however, the quantity and dispersion of this cover is also important. When the quality and quantity of habitat is limited by intensive agricultural use, overgrazing, or extensive annual burning, nesting hens are forced to concentrate in smaller areas. Due to overcrowding, they become susceptible to increased predation and nest desertion. The end result may be lower production and reduced population levels.

Weather plays an important role in annual nesting success also. Heavy rains and cool weather in the spring can cause nest destruction and desertion.

BROOD

During the study, 249 broods were located. Broods are defined as newly hatched young remaining with the hen until disbanding of the family unit into flocks.

The hatching process was observed for 12 young prairie chickens as follows:

Upon arrival at the nest (3:30 p.m., 20 June 1966), seven chicks had already hatched, three were outside of the nest and four were active in the nest. The remaining five eggs were cracked, but not pipped. During the observations, the hen did not move more than five feet from the nest. At 4:30 p.m., the eighth chicken hatched and the ninth had pipped a large hole in the egg. By 6:30 p.m., all chicks had hatched, though the last hatched chick remained in the nest with wet down. Several chicks were moving freely around the area of the nest and picking at food items. The nest was checked at 9:00 a.m. the following morning and no sign of chicks or hen was noted within 30 yards of the nest site. Schwartz (1945) indicated that less than 24 hours is required for a chick to emerge from the egg after pipping, although from eight to twenty-four hours may be required for all birds to emerge and leave the nest. He also stated that the first few days are spent in close proximity to the nest.

Clutch Size and Survival

Very little information was gathered between hatching and the time the chicks were three weeks old. Mortality of chicks appeared to be greatest during this early, secretive period. The average number of chicks hatching per successful nest was 10.7 birds. Observations made on 249 broods during 1963, 1965-1967, 1974-1975, and 1978 indicate that the average brood size in June was 6.9, 6.7 in July, and 7.1 in August. This suggests that about three young per brood are lost during the first three weeks of life, with little mortality thereafter. Sisson (1976) reported an average number of young prairie chickens per brood was 6.3 in a sample of 63 broods.

Activities

During Phase II, a systematic search for broods was made in each section. Broods were located throughout the study area, but there was a tendency for the birds to concentrate near cultivated or disturbed areas, such as cropland and/or domestic grass plantings (Fig. 25). This is shown by the fact that Japanese brome is one of the most common species encountered in point count surveys. Large native pasture area did support prairie chicken broods but not in high numbers. From brood sightings shown in Figure 25, it is clear that booming ground locations have little relation to brood location. The majority of grounds (six) are located in large native pastures away from any cultivation, while only three grounds are located near some type of disturbed lands.

Broods are most active during cooler parts of the day, when young are in search of food. Insect populations are higher in diverse habitats, which may partially explain why young concentrate around disturbed areas. During mid-day, broods generally were found loafing in the shade of tall grasses or forbs. It appears that broods range over only about 160 acres during their first eight to ten weeks of life. Concentrations, or flocking, occurs anytime after the young are 11 weeks of age. After the first week in August, flocks of 25 to 50 young chickens are common. However, in some years, flocking may be postponed until September or even early October.

Adult females begin their annual molt late, after the young are independent. Adult males begin molting soon after booming ground activities end. Males generally isolate themselves or remain in small groups during this time. Baker (1953) indicated that males molted soon after the breeding season ended and that the molt period for females without broods corresponded closely with males.

Populations

During the brood-rearing period (June, July, August, and September), prairie chickens were systematically counted while driving and walking set patterns throughout the study area. ANOVA tests were performed on both data sets for prairie chickens seen per mile (pc/mile) compared between years, months, section, temperature, wind speed, and cloud cover.

Numbers of prairie chickens seen from both data sets showed similar trends in 1975, 1976, and 1977, but the opposite trend occurred in 1978 (Fig. 26). While driving, the highest pc/mile index was in 1978 and was significantly different ($P<.10$) from all other years. The least number of birds seen was a year earlier in 1977, which is different ($P<.10$) from 1978 and 1976, but similar ($P>.10$) to 1975.

Walking showed the least number of pc/mile in 1978, with the highest in 1976. These two years were significantly different ($P<.10$), the remaining years were similar ($P>.10$) to all years. Habitat conditions in 1976 and 1978 were similar. These conditions would suggest similar population response and information for the two years from each survey, but the opposite occurred with no apparent explanation.

The pc/mile driving and walking showed a significant ($P<.10$) increase as months progressed June-September (Fig. 27). This increase was expected because of recruitment and higher visibility of young as they mature.

Prairie chicken populations, particularly broods seen, were lowest in sections of total native grassland (sections 26, 34, 35, 22), and significantly ($P<.10$) higher on sections where cool-season grass and some cultivation occurred (sections 21, 23, 27, 38, and 33).

Difference's in temperature, wind speed, and cloud cover had little effect on observability or flushes of prairie chickens.

Habitat Usage and Availability

During 1966 and 1967, brood searching was done on the agricultural study area. Of 58 broods observed, 17 (29 percent) were found in alfalfa or alfalfa-brome fields (five percent of the area), 21 (36 percent) in pastures (78 percent of the area), 17 (29 percent) along roadsides (2.5 percent of the area), two (three percent) in wheat fallow (five percent of the area), and one (two percent) in a sorghum field (six percent of the area). Twenty-eight (48 percent) were found on clay upland range sites, and 16 (27 percent) were found on clay pan range sites, which comprise 36 percent and 25 percent of the study area, respectively. These two range sites were often available for cultivation as both were upland types and level to moderately sloping. Twelve (21 percent) were found on upland range sites (33 percent of the area) which were sloping and usually pastured grasslands.

During Phase II of the study (1974 through 1978), 106 broods were located; 100 (94.3 percent) were located in pastures (94.1 percent of the study area), three (2.8 percent) in alfalfa (1.5

Figure 25. Grassland-cropland study area with major brood location, Chase County, Kansas, 1975-1978.

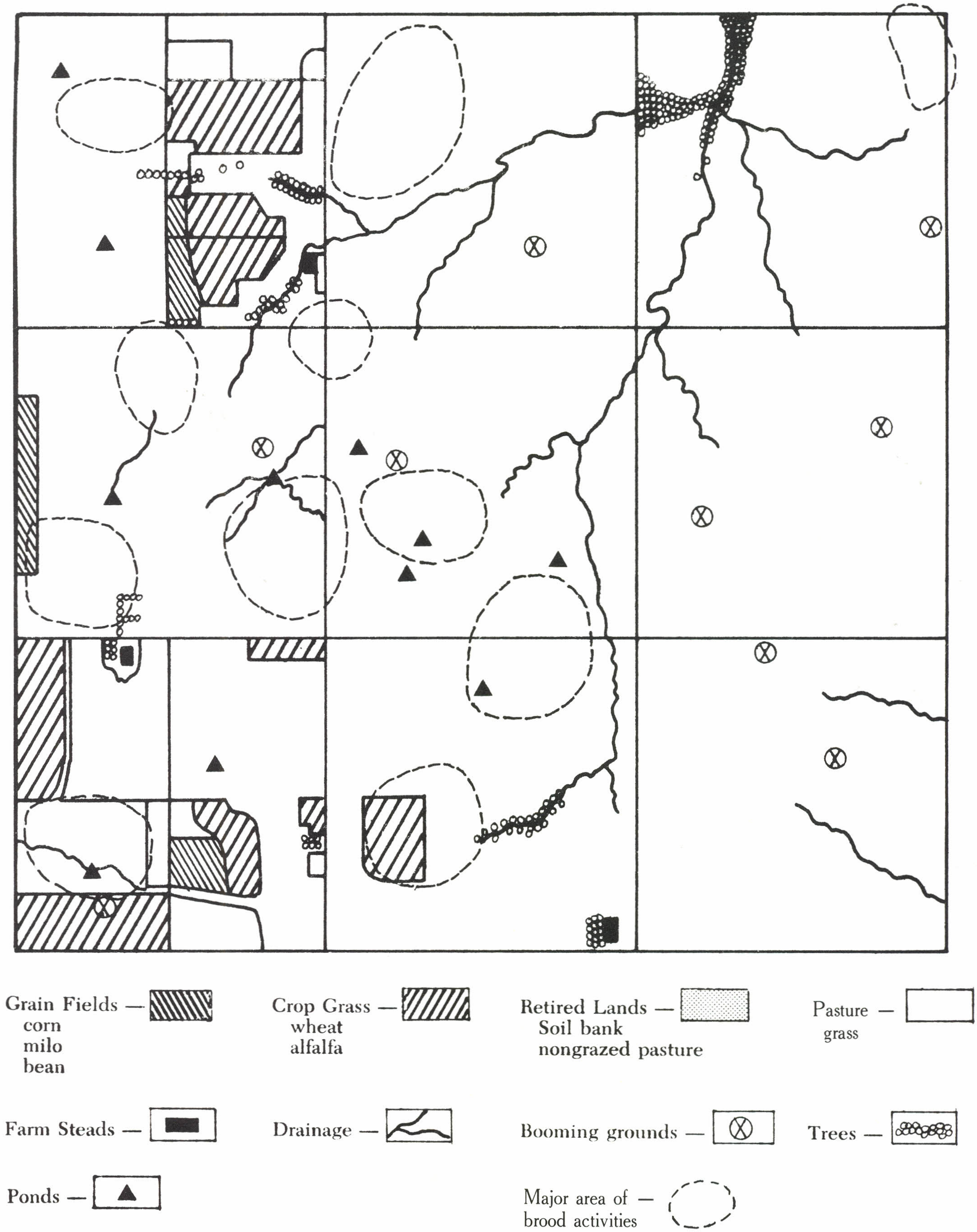


Figure 26. Annual trends of prairie chicken summer populations (pc/mi) from data collected while walking and driving on the grassland-cropland study area, Chase County, Kansas, 1975-1978.

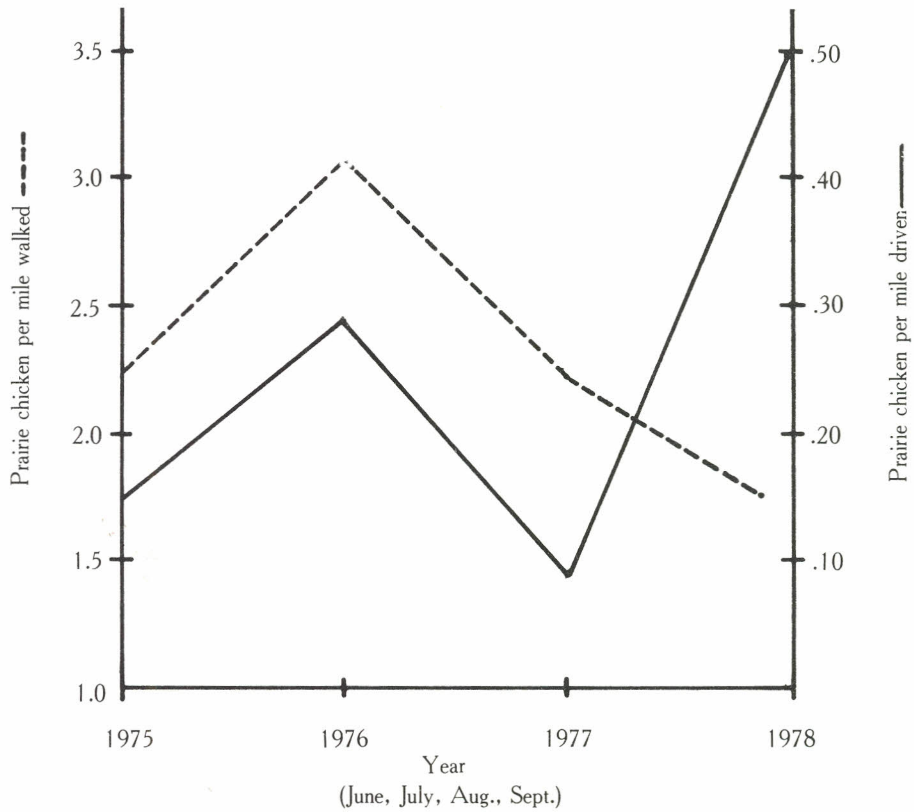
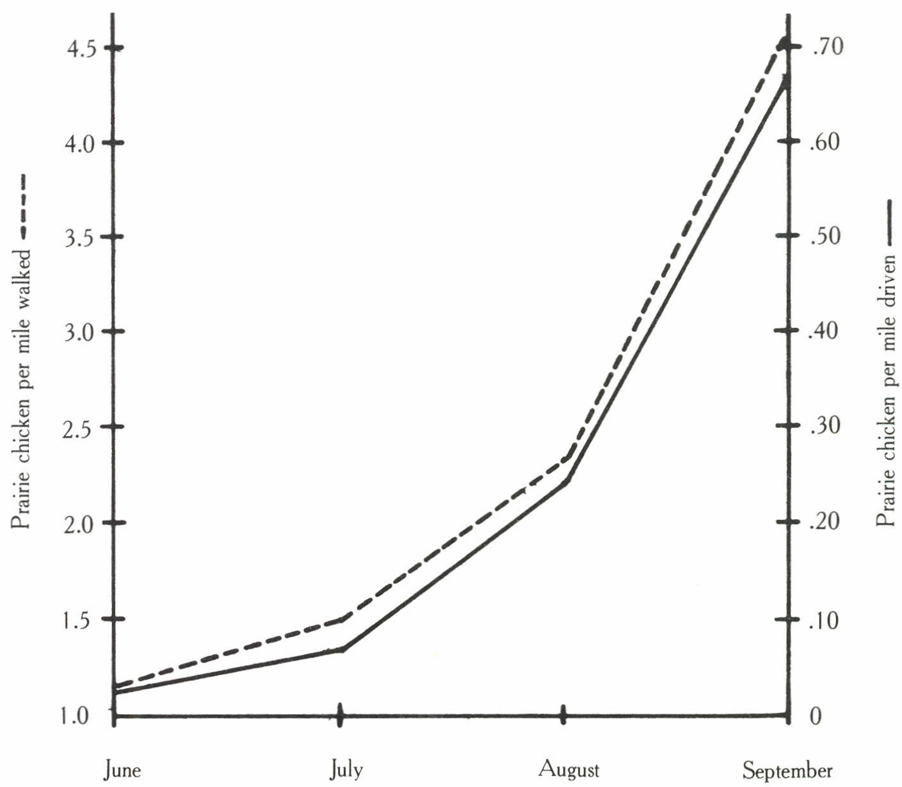


Figure 27. Prairie chickens (pc/mi) observed while walking and driving during the summer on the grassland-cropland study area, Chase County, Kansas, 1975-1978.



percent of the study area), and three (2.8 percent) in wheat (2.9 percent of the study area). Seventy-eight brood observations during Phase II indicated that ten (12.8 percent) were on clay pan range sites and 19 (24.4 percent) were on clay upland, which makes up 13.7 percent and 13.2 percent of the area, respectively. Six (7.6 percent) were observed on clay pan-loamy upland range site, which comprises 13.9 percent of the study area. Thirty-three broods (42.3 percent) were found on loamy, upland shallow range sites (34.2 percent of the study area), three broods (3.8 percent) on loamy upland range sites (18.2 percent of the study area), and seven broods (8.7 percent) on loamy upland range sites (4.0 percent of the study area).

Broods appear to prefer habitat associated with clay upland, loamy upland, and shallow range sites.

Prairie chicken broods were observed 22 percent of the time on west facing slopes, six percent northwest, 20 percent north, 12 percent northeast, 16 percent east, four percent southeast, seven percent south, five percent southwest, and six percent of the time birds were seen on flat terrain. During brood rearing there was generally a ten to fifteen mile-per-hour wind blowing out of the south-southwest. There is no apparent preference for particular parts of the slopes, with 19 percent of the broods on bottom land, 23 percent on the lower one-fourth of the slope, 17 percent in the middle, 19 percent on the upper one-fourth, and 22 percent on the top of the hill.

Prairie chickens obtain moisture from eating insects or dew on vegetation thereby negating the importance of surface water. Streams and numerous stock ponds are located throughout the study area, but one-third of the birds observed were located over 1,000 yards from any of these potential watering sources. Broods tended to be found in areas that were easy to walk through, but with sufficient vegetation to provide security. About 37 percent of the broods were located along or within five yards of an edge (discernible change in vegetation) and two-thirds of the broods were within 60 yards of an edge.

Grassland is generally preferred by prairie chickens, but there is a tendency for major brood activities to be associated with lands formerly or presently cultivated.

Ground cover at brood observation sites was 49.4 percent duff, 32.7 percent bare ground, and 18.4 percent live plants. There was no difference ($P>.10$) in any category between years and months.

Vegetative types were pooled into three categories: grass (72.9 percent), forbs (17.6 percent), and carex (6.3 percent). Again, there were no significant differences ($P>.10$) within categories between years and months.

A lack of differences between months and between years suggests either that vegetation on the study area did not change significantly, broods selected vegetation as described, or that the sampling technique was not sensitive enough to pick up a change.

Thirteen species of grass and 12 species of forbs were individually analyzed for differences between years and the four summer months. Because most of these species show little significant difference ($P>.10$) in the year and month category, an index was established by using the average over the years for the summer months.

Density of vegetation is probably as important in prairie chicken brood habitat as any other component. Broods prefer habitat they can walk through, see over, hide in, and feed from.

Visual obstruction measurements were tested, resulting in only minor differences between years and months for each density reading. Because of these similarities, an index was established using average summed over years for the summer months (Table 18).

Vegetation from 1.5 to 2.0 decimeters (six to eight inches) in height can conceal a prairie chicken. The average overall height of vegetation recorded during Phase I was three decimeters (12 inches) with a maximum height of seven decimeters (26 inches). During Phase II, the average vegetation height was 1.5 decimeters (six inches), with a maximum of 5.5 decimeters (22 inches).

Vegetative species analysis and visual obstruction readings were performed on available habitats for the differences and similarities by years (combining transects) and grazing units (combining five years) on all data collected. Grazing units are similar range sites combined from each pasture. Information tested was mean-percent-duff (previous year vegetation), bare ground, hits (live vegetation), grass, forbs and carex, and major plant species.

There were significant differences in the mean percent duff ($P<.10$) with the least amount of duff found in 1974 and 1978, and the most in 1975, 1976, and 1977. These data are somewhat determined by the amount of burning the previous spring.

The trend for bare ground occurrence is the reverse of that for duff measurements. Percentage of bare ground increases when burning frequency is increased. The years 1974 and 1978 were high years and different ($P<.10$) from 1976 and 1977, which were low.

In 1974, 1975, and 1978 hits were significantly higher ($P<.10$) from 1976 and 1977. Burning could have affected this reading by promoting new growth.

Grazing units were mostly similar ($P>.10$), and the few differences ($P<.10$) showed no consistent pattern in the amount of duff, bare ground, and hits.

Percent grass remained the same ($P>.10$) for the first four years on the study, but in 1978, the percentage of grass hits was significantly lower ($P<.10$).

Forb trends for years were similar to grass, except 1978 levels were higher than the other four years. This change in the forb-grass ratio was caused by extensive burning during the spring and drought conditions during the grazing season.

Table 18. Comparison of densities between prairie chicken brood location and transect by a preference index on the grassland-cropland study area, Chase County, Kansas, 1975-1978.

	Brood Locations ($\bar{X}$ % Occurrence)	May Transects ($\bar{X}$ % Occurrence)	Preference Index (Brood/May)	July/Aug. Transects ($\bar{X}$ % Occurrence)	Preference Index (Brood/Aug.)
Density 1 (0 dm)[1]	2.8		.09	.02*	140.0
Density 2 (.5 dm)	14.3	22.1*	.65	11.6	1.23
Density 3 (1 dm)	20.5	19.2	1.07	22.5	.91
Density 4 (1.5 dm)	12.9	5.4*	2.38	13.3	.97
Density 5 (2 dm)	18.8	2.1*	8.95	17.1	1.10
Density 6 (2.5 dm)	9.7	.2*	48.5	8.7	1.11
Density 7 (3.0 dm)	6.2	.05*	124.0	5.1	1.22
Density 8 (3.5 dm)	2.4			1.7	1.41
Density 9 (4.0 dm)	2.4			1.0*	2.40
Density 10 (4.5 dm)	.9			.1*	9.00

[1] Sample size of 97 flock counts and 58 transect counts.
[2] 29% of the Density 1 reading was burned pasture.
* Significantly different from brood data (P<.10).

Carex percentages were similar (P>.10) between all years. Grazing units showed no differences (P>.10) in the ratio of grass, forbs, and carex. When differences (P<.10) occur, high and low groupings represented similar range sites, indicating that such range sites produce like vegetation with some variation due to grazing pressure.

The 25 major species of vegetation contacted along transects were tested for analysis of variance between years and grazing units. Data indicated that most species remained consistent throughout the study. Minor variances that occurred were shifts in plant numbers, with very little change in species composition. Because of the versatility and hardiness of grassland plant species, only a major change in weather condition and/or land management could affect plant composition. During this study, none of these changes occurred. No distinct difference was seen between grazing units. When differences occurred, it appears that grazing had more affect on grass species present than range site differences. This apparent similarity in vegetative types along each transect made it possible to combine yearly data and grazing unit data into an index of average percent occurrence for each species (Table 19).

Information was also gathered by taking 100 visual obstruction readings (density) along each transect. Combining transects into grazing units was done similarly to vegetative counts. Readings were tested for ANOVA from areas of no vegetation to a density of four decimeters. Density readings were taken in both May and August. May readings also had a "burned" category in addition to no vegetation.

Considerable burning occurred during two years of the study, 1975 and 1978. These two years are significantly different (P<.10) from 1976 and 1977.

All transects in grazing units were burned at least once during the study, but grazing units in section 35 were burned most often.

Density one reading was a "no" vegetation category and when combined with May burning accounted for 29.7 percent of the area. Other visual obstruction measurements taken during May were also influenced by burning. Burning occurred when enough duff was available to carry a fire. In 1975 and 1978, most transects were burned. Vegetation on remaining transects was low in density and short, with not enough fuel to carry a fire. In 1976 and 1977, burning was minimal because the majority of vegetation was one-half to one decimeter in height. Average visual obstruction measurements were computed by combining years and grazing units. This value gave an average index to the availability of vegetation density during the four-year study (Table 18).

The majority of August visual obstruction (density) readings were between one-half decimeter (two inches) and two decimeters (eight inches). This range gave a wide range of habitat densities available to prairie chicken.

Data tested for years indicated that density one vegetation (no vegetation) was uncommon on all transects. Also, data indicated that 1978's vegetation was significantly (P<.10) less dense than in other years. The other years, 1975, 1976, and 1977, were similar (P>.10) in the distribution of density readings.

Grazing units are generally similar (P>.10) in density. As in the May readings, an average visual obstruction measurement was obtained to indicate the availability of different densities of vegetation on the study area (Table 18).

Performing ANOVA tests on the two visual obstruction data sets during May and August indicates there is a significant difference (P<.10) for all readings between these months each year.

Generally, visual obstruction tests (density) yield a significantly (P<.10) higher reading in August than in May. This is to be expected in August, during the peak or shortly after the peak, of growing season. Shorter vegetation is indi-

Table 19. Comparison of types of vegetation between prairie chicken brood location and transect by a preference index on the grassland-cropland study area, Chase County, Kansas, 1975-1978.

Variable	Brood Locations N	Brood Locations $\bar{X}$ % Occurrence	Transects N	Transects $\bar{X}$ % Occurrence	Index[1]
Hit	69	18.43	58	18.20	1.01
B. Ground*	69	32.70	58	39.07	.84
Duff*	69	49.40	58	35.72	1.38
Grass*	90	72.88	58	78.83	.92
Forbs*	90	17.55	58	11.69	1.50
Carex*	90	6.31	58	9.16	.69
J. Brome*	97	18.40	58	.58	31.72
B. Bluestem*	97	6.68	58	13.50	.49
L. Bluestem*	97	6.64	58	18.32	.36
P. 3-Awn*	97	3.40	58	1.24	2.74
Dropseed	97	7.06	58	8.48	.83
Sideoats*	97	5.46	58	8.23	.66
Bluegrass*	97	1.96	58	.38	5.16
Switchgrass	97	.77	58	.61	1.26
Indiangrass	97	1.06	58	1.08	.98
Blue grama*	97	1.33	58	3.64	.37
Hairy grama*	97	3.51	58	9.03	.39
Buffalograss	97	.14	58	.41	.34
Scrib Panicum	97	.39	58	.27	1.44
Scurfpea*	97	.22	58	.66	.33
Sagewort	97	.95	58	1.81	.52
Ironweed	97	.74	58	1.29	.57
Goldrod	97	.39	58	.77	.51
Ragweed	97	2.78	58	3.38	.82
H. Aster*	97	1.02	58	4.01	.25
Leadplant*	97	.03	58	1.24	.02
Pussytoe*	97	.25	58	2.30	.11
Gayfeather	97	.32	58	.20	1.61
Plantago	97	.59	58	.66	.89
Broomweed	97	.34	58	.32	1.06
P. Coropsis	97	.37	58	.67	.55

* Means are significantly different (P<.10).

[1] Preference indices >1.0 indicate selectivity.
Preference indices <1.0 indicate avoidance or non-selectivity.

cated just after burning before the grazing season.

Table 19 compares vegetative species utilized by prairie chicken broods to the species of vegetation available along random transects. A student's t-test was performed between like vegetation in each data set to indicate if the differences are significant at the ten percent level. A habitat index (Robel 1970) was determined by dividing the percent of species occurrence at brood locations by the percent of species occurrence of that habitat characteristic available on the study area. This was used to detect relative usage of each habitat type. A habitat index greater than 1.0 indicates usage greater than that expected, if no preference was exhibited by the brood. A value less than 1.0 reflects avoidance, or at least less usage than would be expected if the broods were using all habitat types in direct proportion to their abundance.

Results indicate that broods selected areas that have some duff and bare ground. Live vegetation encountered at brood locations was similar to that along the transect. Broods also selected areas of high forb content along with abundant lower grass and carex.

There is a significant (P<.10) tendency for broods to select domestic or cool-season grass over native, warm-season grass. These domestic grasses are generally in poor condition and next to or combined with disturbed lands. The low fertility of the soil, lack of artificial fertilization, occasional burning, haying, and summer grazing make for low quality cool-season pasture sought by prairie chicken broods. In addition, these areas are adjacent to cultivated crops or native prairie. These types of pastures make up about nine percent of the study area.

Early burning in native pastures would stimulate a higher forb count, simulating more closely the type of vegetation broods choose.

Table 18 compares the visual obstruction (density) measurements along transects for both May and August to the readings taken on brood location sites. The analysis was made by using student's t-test and preference index similar to what was used in plant species comparisons. May brood information suggested an avoidance of areas which had little or no vegetation and preferences for vegetation 1.5 decimeter or greater in height. Significant difference ($P<.10$) comparing July/August vegetation to brood counts indicated that broods select areas with no vegetation or vegetation over 4.0 decimeters. The density of vegetation on the summer transect and what broods used was not significantly different ($P<.10$) for heights of .5 to 3.5 decimeters.

Cover Types

Each year during Phase II (1974 through 1978), all sections of the study areas were cover mapped. Six percent of the study area was in cultivated crops and nine percent in domestic, cool-season grasses. Most cultivation was in the western three sections. The remaining 85 percent was dominated by native tallgrass prairie.

Grain sorghum made up an average of 1.67 percent on the study area. This number ranged from 3.41 percent in 1974 to .59 percent in 1978. Wheat replaced grain sorghum loss, showing an increase from 1974 to 1978. Acreages of alfalfa, domestic cool-season grasses and native grasses remained stable throughout the study. Burning is a major influence on the study area. The amount of burning varies considerably, depending on the amount of previous year's vegetation present prior to the growing season. Some spring burning occurred annually on the study area, ranging from a low 1.45 percent in 1976 to a high 65.2 percent in 1978, with 13.0 percent burned in 1975 and 2.89 percent in 1977. An average of 33 percent of large native grass areas were burned annually, while at western sections of the area, where cool-season grasses and cultivated crops are common, an average of only eight percent was burned.

Pastures utilized by yearling steers from May through September were generally on native grass and made up about 75 percent of the study area. These pastures were generally in good condition and were stocked at a rate of four acres per steer. Some pastures were intensively used throughout the year, and overgrazing was common. Seventeen percent of the study area was cow-calf pastures and was stocked at a rate of 8.3 acres per cow-calf.

Sections 21 and 33 were the most diverse, with sections 27, 28, and 34 having some diversity through the presence of both tame and native grasses. Sections 22, 23, 26, and 35 were the most monotypic, having only native summer-grazed pastures.

A "step-wise" method (SAS Users Guide, 1982) of data comparison and analysis was performed on numerous independent variables and their response variables. This information was exploratory and identified those habitat types that cause possible variability in prairie chicken numbers.

According to this procedure, approximately 34 percent of the variability in the number of birds (birds/mile walked) was caused by milo, alfalfa, and cool-season pastures grazed during the summer months. Approximately 43 percent of the variability in the number of young seen per mile walked was caused by milo, grazed pastures, native hayed grass, and burned pastures.

Weather

During Phase II, weather stations were installed on the north and south edge of the study area. Each station recorded daily temperatures and precipitation. ANOVA tests were performed between both weather stations and found that there was no significant variance between the two data sets.

Average maximum temperature (80.56°F) during the period April through September was less than normal (83.3°F) as recorded by the U.S. Weather Service in Cottonwood Falls, Kansas for years 1905 through 1960 (Neill 1974). Average minimum temperature for the summer was 58.5 degrees Farenheit, near the weather service average. Summer precipitation (April through September) averaged 4.13 inches per month, slightly above the 3.81 inch long-term average.

Most precipitation was recorded during 1975 and 1977, with 19.07 and 22.14 inches, respectively. In 1977, rains were evenly distributed throughout the growing season. Rains stimulated good vegetation growth, leaving residual materials in the spring of 1978, which resulted in more than normal burning. In 1975, heavy rains occurred in June, none in July, and average precipitation in May and August, resulting in near normal vegetation growth. Rainfall in 1976 and 1978 was low and totaled only 8.00 and 11.07 inches, respectively, for the growing season. During these two years, overgrazing was common and vegetative growth was poor.

A step-wise procedure was used to define any relationship between summer bird populations and weather information. Weather information included mean temperature, mean precipitation, and total precipitation at the time of the survey. These data were analyzed for direct effects and back dated for indirect effects of the weather on prairie chicken numbers.

These tests showed no cause-effect relationship, and no pattern was established. During the four years of the study, weather patterns did show changes, particularly in precipitation, but apparently not drastic enough to cause changes in populations directly, or indirectly by vegetative change. A long-term study of extremes in weather conditions and the effects it has on prairie chicken populations is necessary to better understand weather-related population fluctuations.

Habitat Management

Hens and broods leave the nest vicinity as soon as young are dry, and move to vegetation sufficiently sparse for young to easily move about, but dense enough to provide shade and shelter from predators.

During the cooler part of the day, young prefer areas near openings such as trails, field edges, overgrazed areas, and cattle rubs. They remain close to taller vegetation for escape cover. Areas of over-utilization and disturbed areas near cultivated fields allow easy movement and permit young to avoid morning and evening dew.

Moderate grazing provides increased plant diversity, paths, and small areas of sparse cover, which permit easy movements. This variability also increases insect populations. Burning every three or four years is a necessary management tool for maintenance of brood habitat on native range as well as for maintaining good to excellent range condition.

Broods make heavy use of cropland-grassland borders. Edges of row crops, alfalfa fields, or go-back areas provide excellent prairie chicken brood habitat. High insect populations and overhead vegetative canopy with little residual ground cover are the enticements of these fields. On the study area, cool-season pastures were a major type of vegetation used by broods.

FALL AND WINTER ACTIVITIES AND HABITAT

Booming Ground

The display of male prairie chickens during the fall is much less intense than in the spring.

During Phase I, all booming grounds which were active in the fall had been occupied during the preceding spring, but some of the spring leks were not used in the fall. On the grassland study area, 80 percent of the spring grounds were occupied in the fall; however, on the agricultural study area only 25 percent of the spring grounds were occupied in the fall.

Prairie chickens begin to appear on booming grounds for their fall display activities during the third week of September. Peak fall booming ground activity and attendance occurs during the first three weeks in October. After the first week in November, the number of birds visiting grounds declines; however, some continue to visit the lek daily until periods of severe weather interrupt display activities. Prairie chickens irregularly visit leks during December, January, and February. On several occasions when the temperature was between 25 and 35 degrees Farenheit, on a heavy overcast day, birds would not appear on the grounds; but when temperatures were low (approximately 15°F) and skies clear, birds would be on the grounds. Baker (1953) and Hammerstrom and Hammerstrom (1939) indicated that a combination of light and temperature affected fall activity on booming grounds.

During Phase I, 20 visits were made to Thompson's number five booming ground on the agricultural study area to observe fall display activities. The number of birds using this ground in the fall was several times greater than in the spring. No more than 20 to 25 prairie chickens used this ground during the spring, however, as many as 123 were counted in the fall, with an average of 70 birds annually. Because the birds were in the midst of molt, it was impossible to get an accurate sex and age ratio from field observations. Two cannon-net trapping attempts during October yielded seven male prairie chickens, of which six were juveniles.

As in spring, birds visited the ground both morning and evening. In the morning, small flocks arrived before sunrise and stayed for several hours. In late afternoon, birds arrived an hour to an hour-and-a-half before sunset. The evening display was less intense than the morning. Birds on the ground generally loafed or fed, but occasionally became active, with subdued booming displays. At dusk, birds flew to night roosts in adjacent pastures.

Throughout the display periods, small flocks of chickens moved between booming grounds and feeding areas. Despite this continuous movement to and from the lek, there appeared to be a nucleus of birds that stayed on the ground. These birds appeared to have established territories and did most of the chasing, booming, and displaying. Display was similar to that of spring booming, but less intense.

During Phase II, all permanent grounds were occupied in both spring and fall. There was a large, inconsistent, fluctuation in the number of birds on leks between spring and fall, with some the number on grounds increasing, some decreasing, and others remaining unchanged.

During Phase II, grounds 5, 6, 18, 19, and 17 were active only for the four-year study. Number nine was active only during 1975, and ground seven only during 1978, while leks 20 and 21 were active during 1976, 1977, and 1978. Prairie chickens were present on the leks during 76 percent (26 of 35) of the September visits, 83 percent (106 of 127) in October, 73 percent (65 of 89) in November, and 37 percent (13 of 35) in December.

A flush count of birds from active booming grounds was made during each visit. This count was made semi-weekly during the period October through November in years 1975 through 1978. Although there were significant differences between grounds and between years ($P<.05$), there was no correlation between booming grounds ($P>.10$) during this two month period. Fluctuations could be attributed to male movement between grounds, to feeding areas, weather conditions, and lack of interest.

If a constant proportion of the total population uses booming grounds during the fall, a count of all birds flushed on all grounds during each month for different years should give an annual population trend. Figure 28 shows fall counts indicating that the population trend in the fall of 1975 was high and so was the following spring of 1976. The remaining years also showed parallel trends.

Flock Movements

Although feeding flocks were observed as early as late July, 33 observations of feeding flock movements were recorded during the winters of years 1965 through 1968. Daily movements to feeding fields occurred prior to daytime loafing and again before night roosting. The average distance a flock flew to feed was 1.4 miles, ranging from one-eight to two miles. From 1965 to 1968, 22 complete movements to and from the Odle and Blosser field complex were observed. These two feed fields were located in the northeast corner of Phase I agricultural study area. One field contained 27 acres of soybeans and the other 48 acres of grain sorghum. The two fields were separated by a county road. During the springs of 1967 and 1968, the sorghum field was not planted and became overgrown with annual weeds. Birds did not use the field during this period, but the soybean field was still utilized by feeding prairie chickens.

Figure 29 indicates the location of the prairie chicken's loafing and roosting areas in relation to feeding fields. Areas "A" and "B" were used in all three years by two and sometimes three flocks of chickens. Area "A" was situated on a ridge top in a large, moderately-grazed (summer only) pasture located approximately one mile from the sorghum field. The area was used for a nighttime roosting area and for daytime loafing activities. Vegetation at the site was sparce, but surrounded by taller vegetation. Vegetation was thin enough for chickens to move through, but dense enough to provide shelter. Jones (1963a) also indicated that winter night roosts were located in small pockets of short vegetation within areas of taller vegetation. Area "B" was primarily a daytime loafing site situated in a lowland area approximately half a mile from the fields. The average visual obstruction height of grassland vegetation utilized by prairie chickens during the fall and winter was 1.5 decimeter (six inches). Jones (1963a) indicated that prairie chickens select a large variety of vegetational configurations for loafing. Mohler (1952) reported that typical loafing and roosting cover consisted of stands of mixed grasses with numerous stems over two feet and understory of fallen, tangled grasses covering the ground to a depth of eight inches or more. This was not evident in the study. Area "C" was occupied only during the fall of 1965 and was used for both day loafing and night roosting. The site was situated on a ridge top approximately three quarters of a mile from the sorghum field. Habitat at this location was similar to that at Area "A". Area "D" appeared to be an occasional daytime loafing site and was used only for a short time after the morning feeding and before the night roosting period.

Home range used by these birds during fall and winter appeared to be approximately one square mile. Robel (1970) showed that mean daily movements of adult male prairie chickens were 697 yards in November, 592 yards in December, 735 yards in January, and 1,121 yards in February. Juveniles follow patterns similar to adult males. Baker (1953) reported that a flock covered approximately one square mile during the two years of his observation. Mohler (1952) found the home range of winter flocks to be approximately three square miles in Nebraska. Schwartz (1945) also reported that the area traversed in one day by a flock of chickens is often less than one square mile, depending on the availability of food and roosting cover.

Remaining movement observations were recorded at feeding sites. Flights to and from feeding sites average 0.8 mile each direction, and ranged from one-fourth to two miles. Generally, the habitat utilized was similar to that described above. Mohler (1963) stated that prairie chickens preferred wintering areas where grain fields were situated adjacent to extensive grasslands, thus providing adjacent food and roosting cover. This was also found to be true in the current study.

Baker (1953) followed several flocks during the fall and winter of his study and noted that the daily routine began at the roosting area on an unmowed slope. Chickens first moved to a booming ground and then to feed fields. After feeding, they moved to loafing areas at or near roosting areas. In the evening, feeding areas and occasionally booming grounds were again visited before the birds went to night roosts.

From 28 recorded observations of marked birds, it was determined that feeding areas are used year after year by the same flocks of chickens. For two years, birds trapped in one feed field used feeding areas within one mile of the trap site.

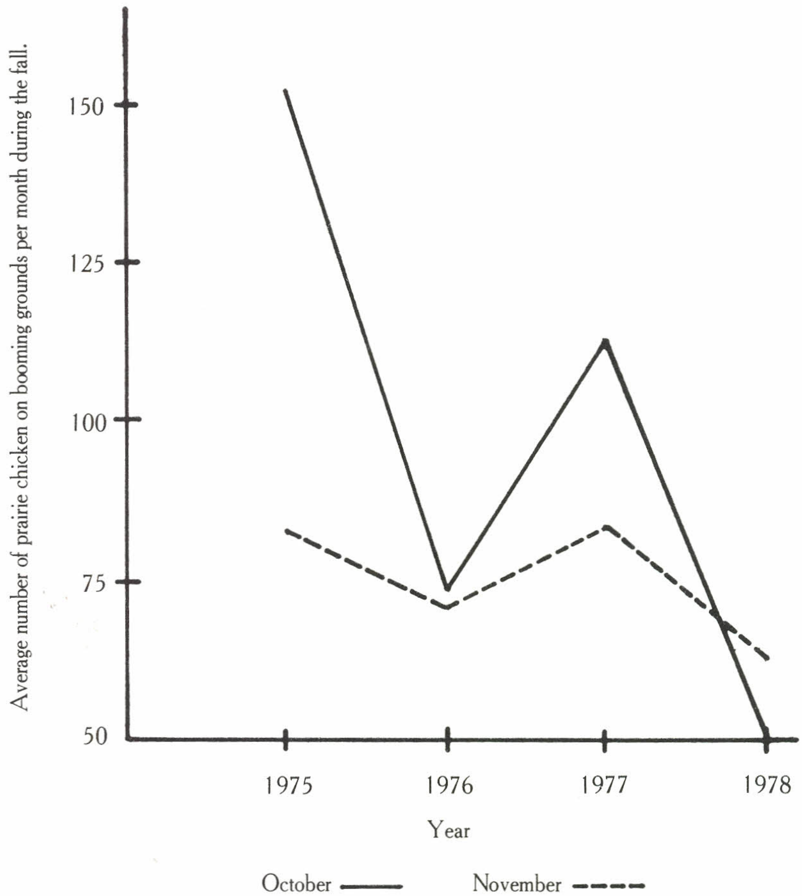
Feeding Activities

During the period November through February, 114 visits to the study area were made to observe feeding activities of prairie chickens. Prairie chickens were present at traditional feeding fields during 65 percent of the visits. Prairie chickens were feeding in the fields during 90 percent of the observation periods in November, 58 percent in December, 63 percent in January, and 47 percent in February. There was a significant difference ($P<0.10$) among months in the number of birds and flocks coming to feeding fields. November and December had a higher daily average observation of numbers (33.6) and flocks (1.6) than in either January or February, with 10.0 and 0.4, mean birds and flocks, respectively. Opportunity for feed field hunting is potentially greater during earlier months.

Temperature, wind speed, and cloud cover played no significant role ($P>.10$) in the number of prairie chickens or flocks coming to feeding areas.

Snow cover also had very little effect on prairie chicken utilization of feeding areas. In Kansas, extreme cold less than 20 degrees Fahrenheit and total snow cover is unusual for more than five consecutive days. Cold periods (20 degrees Fahrenheit or less) and snow (five inches or more) that completely cover available food in grasslands can force prairie chickens to come to feeding fields in increased numbers to obtain more readily available, high nutritional foods, such as soybeans and corn. A prolonged cold spell with sub-freezing temperatures and snow 5 to 15 inches in depth existed during all of January and until mid-February of 1979. Birds fed

Figure 28. Fall booming ground populations by month and year on the grassland-cropland study area, Chase County, Kansas, 1975-1978.



almost entirely in cultivated fields, particularly on soybeans, during this period. Schwartz (1945) indicated that during periods of severe weather, prairie chickens would come together to form large flocks. When milder weather returned, these flocks broke into smaller units.

Several flocks utilized the same feeding fields, but did not associate with each other until stress from snow cover occurs, when flocks sometimes join and fly to roost as one large unit.

During mild weather conditions, flocks came to feeding fields in the morning approximately 57 minutes after sunrise and fed for an average of an hour. During evening feeding periods, birds arrived about one hour before sunset and fed for an average of one-half hour. Prairie chickens are continuous daylight feeders but also loaf in pastures.

During mild winters, food in the grasslands can sustain chickens. Crop fields are used because of their easy accessibility and an abundance of highly nutritional foods. In addition, a feeding tradition is established which has survival value should heavy snow cover render native foods unavailable.

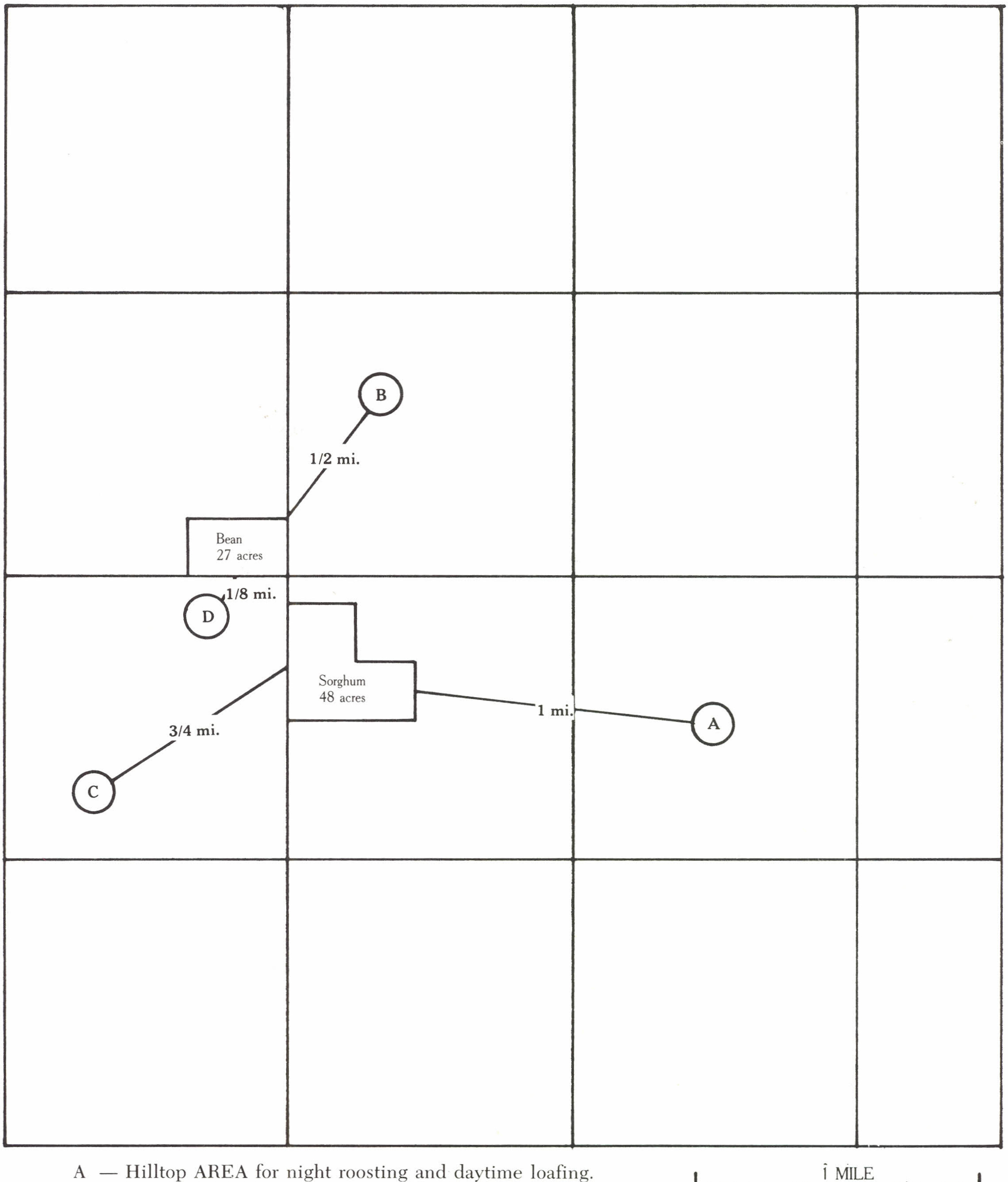
Significant differences ($P<.10$) occurred between years in the total number of birds and total flocks observed using feeding fields. These changes occurred because weather conditions, prairie chicken populations, and changes in land-use patterns by local ranchers shifted feeding locations. The greatest mean number of birds per flock (47.5) and mean flocks per observation day (2.3) coming to feed fields were recorded in 1966, 1977, and 1978. They were significantly different ($P<.10$) from 1965, 1967, 1974, 1975, and 1976 in the birds per flock (8.7) and flocks observed (.6).

Due to substantial variation, no statistical difference ($P>.10$) occurred for the number of feeding chickens between the ten consistently observed feeding fields.

Habitat Usage and Availability

During Phase II, 423 observations of prairie chicken locations were recorded from September to March. These observations were primarily associated with loafing and roosting activity. Generally, birds were found on the leeward side of a hill, with 60 percent of the observations being made on the north, northwest, or east slopes, while the prevailing winds (57 percent of the time) were from the south and southwest. About 90 percent of these observations were on slopes of less than ten degrees. There was no significant difference in the birds' location along the slope; however, they tended to prefer ridge tops, particularly on warm, calm days. Eighty-five percent

Figure 29. Blosser-Odle feed field complex with flock locations on the agricultural study area, Chase County, Kansas, 1964-1968.



A — Hilltop AREA for night roosting and daytime loafing.
B — Lowland AREA used as daytime loafing.
C — Hilltop AREA used as daytime loafing.

of sightings were within 30 yards of a discernible habitat edge. Open water did not appear important to loafing or roosting prairie chickens, since the mean distance to water was 225 yards. There were two occasions when flocks were flushed from edges of ponds and one time were observed on a frozen pond pecking at the ice.

Although loafing sites were widespread, the majority of birds found in sections 21, 28, and 33, were nearest to cultivated sites (Fig. 30). Lower numbers were found as distance from disturbed land increased. There was no preference shown toward selection of one soil over another, with prairie chicken occurrence being nearly proportional to the availability of various soil types.

When flocks of ten or more prairie chickens were flushed from pastures during the October through March period, vegetation and visual obstruction samples were taken at the site. An ANOVA test indicated little difference ($P<.10$) between months and years in the type of habitat utilized by prairie chickens; thus month and year data were combined into a fall-winter category and a mean determined for all samples. This similarity in habitat used was expected, since vegetation form was constant during the dormant season. Flocks used similar locations during the majority of the fall-winter period. Thus, several vegetative samples were taken within the same area.

Ground cover at flock observation sites was 9.9 percent live plants, 26.4 percent bare ground, and 45.3 percent duff. Vegetative types were pooled into three major categories: grass (82.5 percent), forbs (12.5 percent), and carex (4.6 percent).

A student's t-test was used to determine similarities and differences at the ten percent probability level by comparing vegetation utilized by prairie chicken flocks to the species of vegetation found along random transects (Table 20). A preference index (Robel 1970) was again used between the two data sets to estimate habitat use. An index value of greater than 1.0 indicates preferred use by a flock and a value of less than 1.0 reflects avoidance of a certain plant species or habitat type.

Data indicate that use of duff increased while the number of live plant hits decreased significantly. This can be expected because of dormant vegetation during the fall-winter period. This information also indicates a significant ($P<.10$) preference toward grasses and forbs, and an avoidance of carex. Carex is more common in wetter soils at lower elevation. Prairie chickens use ridges or hilltops most often away from carex habitats.

A student's t-test comparing vegetative species indicates there was a significant ($P<.10$) tendency for wintering flocks to search out cool-season vegetation. Pastures dominated by cool-season grasses occurred on only nine percent of the study area. These areas were mostly of low quality 'go-back' fields near cultivation. The nearness of cultivated fields and the late fall and early spring greenery produced by cool-season grasses was attractive as prairie chicken food. In addition, mismanagement of brome and bluegrass fields yields a clump form of vegetation, which is attractive to prairie chickens.

Prairie three-awn was common on go-back lands and was dominant on one particular field. This field was used by a flock during the entire study. Vegetative measurements were taken on several occasions, resulting in nearly 100 percent prairie three-awn. These readings coupled with occurrences in other fields showed a significantly ($P<.10$) high preference for three-awn. Lespedeza was also a preferred species because of the browse provided.

Visual obstruction readings (density) indicated that 70 percent of readings occurred between .5 decimeter (two inches) and 1.5 decimeters (six inches). The remaining readings showed decreasing importance as the vegetation increased in height. The tallest vegetation was 4.0 decimeters (16 inches), and it occurred on three of the 19 samples and only two percent of the readings.

Cover Types

Cover types available on the study area during Phase II of the project were discussed earlier under the Brood Habitat Usage and Availability section.

A "stepwise" analysis was performed to explore relationships between cover types and the number of prairie chickens flushed. After looking at all variables, it was determined that both milo and native grazed pasture were significant cover types and caused 17 percent of the variability in number of prairie chickens flushed. Because approximately 80 percent of the study is native grazed grass, it is understandable that this would cause some variation. Winter grains, such as milo, only make up 1.67 percent of the study area, but have a definite effect on the flush index, indicating that small amounts of such grains are important to fall-winter populations. These populations would decrease in an area with no grains, but may increase with an increase in grains produced.

Weather Conditions

Climatic conditions measured from October to March for the duration of the study were near "normal" compared to data compiled from the U.S. Weather Service records (Neill 1974). The average maximum temperature on the study area was 50.48 degrees Fahrenheit, slightly below the ten-year normal of 53.48 degrees Fahrenheit, and the average minimum temperature was 29.78 degrees Fahrenheit, slightly higher than the ten-year normal of 29.17 degrees Fahrenheit. The average fall-winter precipitation on the study area was 1.91 inches, with the ten-year normal being 1.52 inches. During Phase II of the study, snow fall never exceeded four inches and never lasted more than seven days.

A stepwise analysis comparing fall-winter population data to weather conditions at the time of survey for direct effects and back-dating for indirect effects was performed. The information showed no cause-effect relationship and no pattern was established.

Figure 30. Grassland-cropland study area major fall and winter prairie chicken flock locations, Chase County, Kansas, 1975-1978.

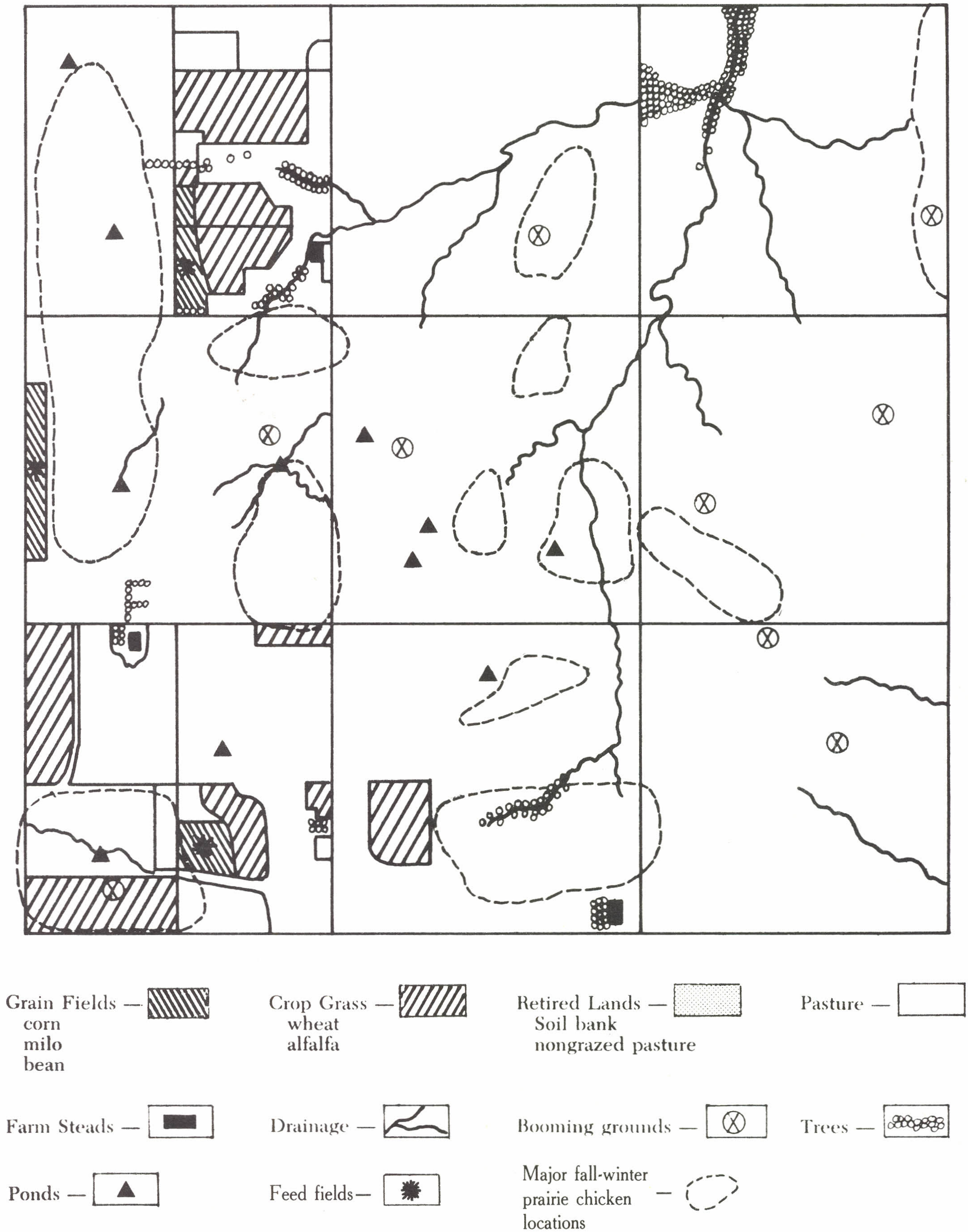


Table 20. Comparison of types of vegetation between prairie chicken flock location and transect by a preference index on the grassland-cropland study area, Chase County, Kansas, 1975-1978.

Variable	Flock Locations N	Flock Locations $\overline{X}$ % Occurrence	Transects N	Transects $\overline{X}$ % Occurrence	Preference Index[1]
Hit*	16	9.94	58	18.20	.55
B. Ground	16	26.37	58	39.07	.67
Duff*	16	45.31	58	35.72	1.27
Grass*	19	82.53	58	78.83	1.05
Forbs*	19	12.47	58	11.69	1.07
Carex	19	4.58	58	9.16	.50
J. Brome*	19	9.28	58	.58	16.00*
B. Bluestem	19	3.93	58	13.50	.29*
L. Bluestem*	19	13.62	58	18.32	.74*
P. 3-Awn*	19	16.02	58	1.24	12.90*
Dropseed	19	5.10	58	8.48	.60*
Sideoats*	19	4.21	58	8.23	.51*
Bluegrass*	19	7.14	58	.38	18.79*
Switchgrass	19	.40	58	.61	.66*
Indiangrass*	19	2.33	58	1.08	2.15*
Blue grama	19	1.59	58	3.64	.44*
Hairy grama*	19	2.59	58	9.03	.29*
Sagewort*	19	.33	58	1.81	.18
Goldrod	19	.47	58	.77	.61
Ragweed*	19	1.00	58	3.38	.30
Pussytoe*	19	1.85	58	2.30	.80
Lespedeza*	19	1.45	58	.13	11.15
Plantago	19	.73	58	.66	1.11
Broomweed*	19	.66	58	.31	2.13

* Means are significantly different (P<.10).

[1] Preference indices >.10 indicate selectivity.
Preference indices <1.0 indicate avoidance or non-selectivity.

Population

A total of 2,732 prairie chickens were flushed from loafing or roosting areas. Thirty-three percent of the flushes were of a single bird, 34 percent were flocks of two to five birds, 24 percent contained six to 15 birds, seven percent had 16 to 50 birds, and only two percent were flocks of 50 or more. Prairie chickens were found in smaller scattered flocks during mild weather, with flock size increasing as inclement weather persisted.

During the fall-winter flocking period, prairie chickens were systematically counted while driving and walking set patterns throughout the study area. ANOVA tests were performed, using both driving and walking data for the index; "prairie chickens seen per mile." Comparisons were made between years, months, sections, temperature, windspeed, and cloud cover.

The number of prairie chickens seen per mile from both data sets showed similar trends from 1974 through 1975 and 1975 through 1976, but the remaining years indicated opposite trends, with a continual decrease for walking and an increase for driving (Fig. 31). While driving, the lowest count was during 1974 and 1975. This count was significantly (P<.10) lower than all other years. The fall-winter years of 1975 to 1976 and 1977 to 1978 showed slight increases for the three years, but were not significantly different (P>.10) from each other.

The test for prairie chickens seen per mile walking showed the least number of birds seen in 1974 and 1975 and the most seen in 1975 and 1976 and were significantly different (P<.10) from each other. Years 1976 through 1977 and 1977 through 1978 show slight decreases from peak count years, but were similar (P<.10) to all years.

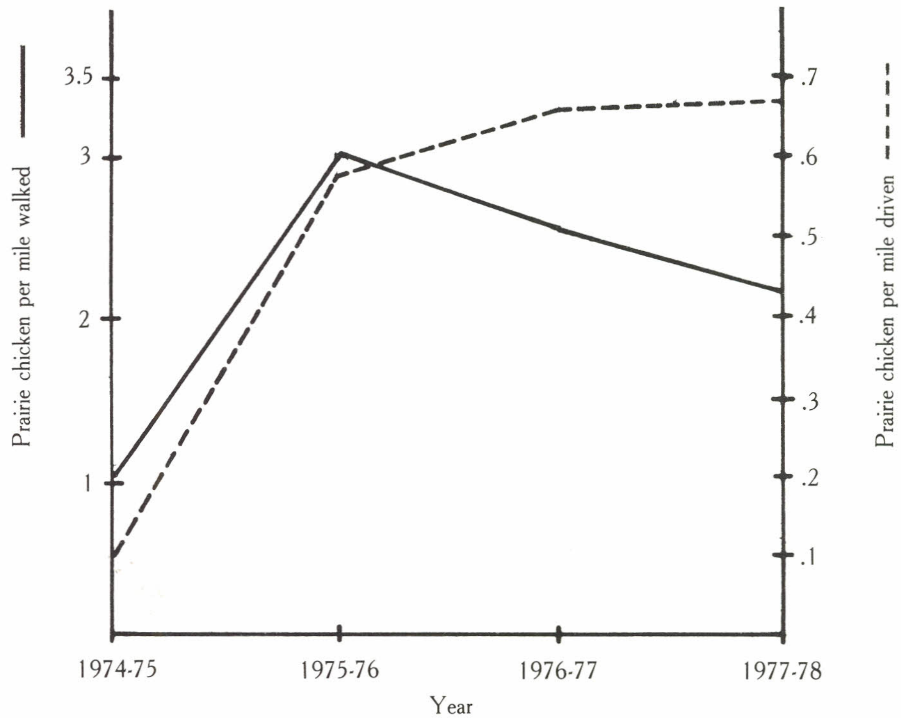
Differences in temperature, wind speed, and cloud cover had no significant (P<.10) effect on the number of prairie chickens flushed.

Hunting

Prairie chicken hunting season began on the first Saturday in November during the study period. Hunters built blinds in or on the edge of grain fields used by prairie chickens and near flight paths to feed fields. During mid-day, while birds were loafing, hunters walked pastures attempting to flush chickens.

Game bag data was collected during five (1963-1967) hunting seasons on the agricultural

Figure 31. Fall and winter flocking population trends from walking and driving (pc/mile) on the grassland-cropland study area, Chase County, Kansas, 1975-1978.



study area. There was little hunting activity on the grassland study area so no bag data was gathered. During opening weekend of each season, at least two biologists patrolled the area, contacting hunters. Most contacts were made after morning and evening hunts and through wing-and-tail feather envelope distribution.

Success

Hunting season length varied from three days (1963-1965) to 14 days in 1967. Opening weekend hunter success is reported in Table 21. Hunter success is expressed in birds harvested per hour of effort and birds bagged per hunter.

Lowest hunting success occurred in 1964, when only 0.10 birds were harvested per hour of effort, 40 percent below the five-year mean (0.14). Only 0.23 birds were bagged per hunter, 36 percent below the five-year mean. In 1967, there were only 0.10 birds bagged per hour of effort, but birds per hunter (0.33) was only 18 percent below the five-year mean due to increased hunting effort. The best hunting success for the five-year period was in 1966, when 103 birds were bagged during 521 hours of effort, yielding 0.20 birds per hour of effort, 43 percent above the five-year mean. The remaining two years (1963 and 1965) produced identical indices of 0.14 birds per hour of effort, which equals the five-year mean and 0.37 birds per hunter, three percent above the average. Baker (1953) reported 0.376 and 0.128 birds were harvested per hour of effort in 1950 and in 1951, respectively.

Effects of Weather on Success

Temperatures during October and November prior to the hunting seasons of 1963 through 1965 were obtained from the U.S. Weather Bureau records in Cottonwood Falls, Kansas. Temperatures below freezing (30°F) occurred only twice (27°F and 25°F) during 1964 prior to the hunting season, when hunting success was lowest. No freezing temperatures were recorded before the hunting season in 1965 and 1967. In 1966, when the hunting success was the best, six days had lows below freezing (12°F and 16°F were recorded on November 2 and 3, two days before the hunting season). During both days of the opening weekend in the low year of 1964 and in the high of 1966, fog was prevalent until mid-morning.

Temperatures recorded during the years 1964, 1965, and 1967 were probably insufficient to kill insects and vegetation. Thus, the food supply in pastures was still plentiful and prairie chickens did not shift feeding habits to grain fields. In 1966, freezing temperatures prior to the hunting season killed vegetation and insects, increasing the energetic drain on prairie chickens. Consequently, they began using grain fields and thereby became vulnerable to feed-field hunting.

Sex and Age

In 1965 and 1966, a total of 150 and 140 wing-and-tail feather envelopes were distributed to landowners, leasees, and hunters on the study area. Only 30 were returned with a total of 43 samples in 1965 and five envelopes with 14

Table 21. Hunter success for prairie chickens on the agricultural study area, Chase County, Kansas, 1963-1967.

Indices	1963 $\bar{X}$	% ch. from 5 year	1964 $\bar{X}$	% ch. from 1963	% ch. from 5 year	1965 $\bar{X}$	% ch. from 1964	% ch. from 5 year	1966 $\bar{X}$	% ch. from 1965	% ch. from 5 year	1967 $\bar{X}$	% ch. from 1966	% ch. from 5 year	5 year $\bar{X}$
No. Hunters	226.0	+4	298.0	+31	+37	188.0	—37	—13	203.0	+8	—6	169.0	—17	—22	216.3
No. of Gun Hours	598.5	+6	673.5	+18	+19	494.5	—27	—12	521.0	—5	—8	538.0	+3	—5	565.1
No. of Birds Bagged	84.0	+10	69.0	—18	—9	70.0	+1	—8	103.0	+47	+35	55.0	—47	—28	76.2
Birds/Gun Hour	0.14	0	0.10	—29	—40	0.14	+40	0	0.20	+43	+43	0.10	—50	—29	.14
Birds/Hunter	0.37	+3	0.23	—38	—36	0.37	+61	+3	0.51	+38	+42	0.33	—35	—8	.36

samples in 1966. This data, combined with the bag-check data, yielded a total of 418 prairie chickens sexed and aged during the study (Table 22).

The five-year average age ratios were 2.0 young per adult and 4.1 young per adult female. The average sex ratio for the five-year period was 113 males per 100 females, with 119 young males per 100 young females and 105 adult males per 100 adult females. In 1964, when hunting success was lowest, the age ratio (1.6 young/adult) and the sex ratio (1:1) were also low.

Despite the fact that the 1965 hunting success was only slightly better than the five-year average, biological data showed the highest young-per-adult ratios (2.7). The sex ratio favored males, with 149 males per 100 females, 26 percent above the five-year average.

Hunting success and biological data show little relationship from one year to another. Production dictates population size, but for the birds to be available to hunters, weather, tradition, and land use have a great deal to do with prairie chicken vulnerability.

Table 22. Population structure of harvested prairie chickens on the agricultural study area, Chase County, Kansas, 1963-1967.

Indices	1963 $\bar{X}$	% ch. from 5 year	1964 $\bar{X}$	% ch. from 1963	% ch. from 5 year	1965 $\bar{X}$	% ch. from 1964	% ch. from 5 year	1966 $\bar{X}$	% ch. from 1965	% ch. from 5 year	1967 $\bar{X}$	% ch. from 1966	% ch. from 5 year	5 year $\bar{X}$
Total Young	50.0		42.0			82.0			75.0			26.0			
Total Adults	28.0		26.0			30.0			41.0			14.0			
Adult Females	13.0		16.0			13.0			17.0			8.0			
Adult Males	14.0		10.0			17.0			25.0			6.0			
Young Females	25.0		18.0			32.0			35.0			13.0			
Young Males	25.0		24.0			50.0			40.0			12.0			
Total Females	38.0		34.0			45.0			52.0			21.0			
Total Males	39.0		34.0			67.0			65.0			18.0			
Yng./Ad. Fem.	3.8	—7	2.6	—32	—37	6.3	+143	+54	4.4	—29	+7	3.2	—27	—22	4.1
Yng./Adult	1.8	—10	1.6	—11	—20	2.7	+69	+42	1.8	—33	—10	1.9	+6	—5	2.0
Ad. Male/100 Females	108.0	+3	62.0	—43	—41	131.0	+111	+22	147.0	+12	+40	75.0	—49	—29	105.0
Yng. Male/100 Females	100.0	—19	133.0	+33	+12	156.0	+17	+30	114.0	—27	—4	92.0	—19	—23	119.0
Total Male/ 100 Fem.	103.0	—9	100.0	—3	—12	149.0	+49	+26	125.0	—16	+11	86.0	—31	—24	113.0

Food Habits

Food items consumed by greater prairie chickens have been studied in Kansas, Missouri, and Oklahoma. Baker (1953) analyzed 65 droppings, 29 crops, and 20 gizzards which showed that, in eastern Kansas, 60 to 70 percent of foods consumed by greater prairie chickens during the winter were cultivated crops. Insects and weed seeds composed approximately five percent, and leaves, forbs, and grasses accounted for the remainder. Jones (1963a) reported that winter foods of prairie chickens consisted primarily of sorghum and Korean lespedeza, but corn seeds and leaves of wheat and Japanese brome were also eaten throughout the winter.

As spring progressed into and through summer, there was increased use of grass blades, native forb seeds, and insects. Throughout the fall, western ragweed was a staple food, along with insects, particularly beetles *(Coleoptera)* and grasshoppers *Orthoptera)*. Corn and sorghum were also used near the end of the fall period.

In Missouri, Schwartz (1945) found that the diets of prairie chickens from September through April consist mostly of plant matter. During the remaining months, animal matter constituted up to 40 percent of the diet. He also reported that uncultivated plants were not commonly eaten and insects occur in the diet only as traces in winter and spring. Korschgen (1962) examined 5,040 prairie chicken droppings from throughout the Missouri range and found items from 161 different plants and 30 insect species. He indicated that agricultural crops regularly comprised more than 50 percent and as much as 90 percent of the monthly diet and averaged about 75 percent of all foods. Wild food items important were common ragweed *(Ambrosia artemisifolia)* and lanceleaf ragweed *(A. bidentata)*. Plants such as sedges, wild rose (*Rosa* spp.), tickseed *(Coreopsis grandiflora)*, buttercup *(Ranunculus fascicularis)*, and serinia *(Serinia oppositifolia)* served as supplements for short periods, but were not staples.

Throughout Phase I, 21 gizzards and 136 usable droppings were collected. All the gizzards and 45 droppings were collected on the agricultural study area. On the grassland study area, 91 droppings were collected. Table 23 gives frequency of occurrence of foods eaten by prairie chickens on both study areas.

Table 23. Frequency of occurrence of food eaten by prairie chickens on the grassland and agricultural study areas in Chase County, Kansas, 1966-1968.

Season [1]	Spring		Summer		Fall		Winter	
Study Area [2]	GSA	ASA	GSA	ASA	GSA	ASA	GSA	ASA
N = Sample Size	22	21	20	24	24	27	25	14
Non-cultivated seed								
Pigweed (*Amaranthus* spp.)	0	5	0	0	4	11	8	21
Lespedeza	0	0	0	0	0	26	4	36
Coralberry (*Symphoricarpos* sp.)	0	0	0	0	4	29	12	50
Flower-of-the-Hour *(Hibiscus trionum)*	0	0	0	0	0	11	0	7
Smartweed	0	0	10	0	25	69	4	0
Dandelion	0	0	0	0	0	3	0	0
Ragweed	0	0	0	0	0	15	0	0
Bristelgrass (*Setaria* spp.)	0	0	5	0	0	0	0	0
Unk. native	50	25	65	25	96	81	80	50
Total native seeds	50	30	75	25	100	97	92	79
Cultivated seed								
Sorghum	0	5	0	0	0	29	4	72
Black Ambur Cane (Sorghum)	0	5	0	0	0	0	0	0
Wheat	0	0	0	0	0	3	0	0
Millet	0	0	0	4	0	0	0	0
Alfalfa	0	0	15	4	0	0	0	0
Corn	0	0	0	0	0	3	0	0
Total cultivated seeds	0	10	15	4	0	40	4	92
Miscellaneous								
Buds	0	0	0	0	0	0	0	7
Woody Stems	0	0	0	0	0	0	0	14
Green leafy material	95	100	90	92	21	89	88	64
Dry leafy material	54	10	80	18	63	18	56	36
Insects	46	55	100	96	79	54	52	21

[1] Spring (March, April, May) — Summer (June, July, Aug.) — Fall (Sept., Oct., Nov.) — Winter (Dec., Jan., Feb.)

[2] GSA = Grassland Study Area — ASA = Agricultural Study Area

On the agricultural study area, chickens utilize cultivated crops as a food source from the time they start flocking in the fall until flocking activities break up during spring. On numerous occasions in late summer and fall, chickens are seen feeding in wheat and alfalfa fields. During the winter months, two daily trips are often made to cropfields to feed. Use of grains and other cultivated crops during the winter may be due to availability and not because of necessity for prairie chicken survival. During daytime loafing periods, when prairie chickens are not resting, they generally mill around, searching for available foods in the pastures. On two occasions, when snow cover made food in pastures and grain fields less available, prairie chickens were seen budding in cottonwood trees *(Populus deltoides)*.

On the agricultural study area, noncultivated vegetation occurred most frequently in the prairie chickens' diet. Nevertheless, 40 percent of the fall and 92 percent of the winter diet contained cultivated grain seeds. Sorghum was the major row crop and was utilized as an important source of food.

On the grassland study area, only five percent of droppings collected contained evidence of cultivated crops. Of those, three summer samples contained alfalfa seeds and one winter sample contained sorghum.

Throughout the winter, green vegetation is available at the base of cool-season grasses. Leafy materials, either green or dry, occurred in the majority of all samples on both study areas. Insects occurred in diets most frequently during summer, but were common throughout the year. Comparison of food habits on the two study areas reveal that prairie chickens are not dependent on cultivated crops, but they will use them when available.

Habitat Management

Habitat used for fall and winter day loafing and night roosting activities are similar to that required for nesting and brood cover. Generally, prairie chickens utilize rangeland habitat consisting of bunch grasses which provide areas of sparce vegetation surrounded by taller grasses.

Feeding fields can be a valuable management tool as a source of high nutrition foods and an area where hunters can pass shoot as the prairie chickens fly to feed.

Ideally, feeding fields should be in open areas with a minimum size of 15 acres. Large fields containing a variety of row crops with strips of green winter wheat will receive the most use. Prairie chickens apparently prefer soybeans, but, corn or sorghum are highly valued. Winter wheat is also used for food as a source of green vegetation. Feeding fields should be close to large pastures, which provide good loafing and roosting sites.

SUMMARY AND CONCLUSIONS

Distribution

The lesser prairie chicken range is in the southwest quarter of the state, roughly extending south of the Smoky Hill River and east to Harper and Kingman counties. The remainder of Kansas prairie chicken range is dominated by the greater prairie chicken.

Statewide, greater prairie chicken trends are toward expanded distribution. This is probably attributed to natural population fluctuations and better management of rangeland. In Kansas, the greater prairie chicken inhabits diverse areas from mid-grass prairie, found in the northcentral part of the state, to seeded, tame-grass areas in the southeast, but their stronghold is the native tallgrass prairies of the Flint Hills.

Within the lesser prairie chicken range, prime sandsage grassland habitat is being converted to cropland by installation of center-pivot irrigation systems. This development has not yet drastically reduced the distribution of lesser prairie chickens, but densities are decreasing. Large, contiguous populations are disappearing and will continue to do so as long as this conversion continues.

Surveys

The analysis of prairie chicken surveys indicates that the rural mail carrier survey (RMCS) and booming ground survey be retained to provide an indicator of change in population trends and distribution. The small game harvest survey should be retained, since it does provide an index to harvest and hunter performance.

Population trends on the study area during Phase II indicated a reasonably stable population. Population counts from spring and fall booming ground counts indicated that the trend was high in the fall of 1975 and spring of 1976. The remaining years also showed parallel trends. The summer and fall walking and driving counts (prairie chickens seen/mile) show similar trends, but were the opposite of the booming ground counts.

Habitat Requirements

Food Requirements

Prairie chickens eat leafy green material all year. During summer, insects are a major portion of the diet, while in winter, a high percentage of both native and cultivated seeds are consumed.

Cover Requirement

Good nesting and brood cover (rangeland with light to moderate grazing) also serve as important habitats for fall and winter activities. Generally, prairie chickens utilize rangelands consisting of bunch grasses, which provide areas of sparse vegetation surrounded by taller grasses. This habitat, if at least six inches tall, provides vegetation easy to walk through and dense and tall enough for concealment.

Water Needs

Water is generally ingested from dew on plants and found in succulent vegetation and insects. Surface water is utilized when moisture is below normal.

Home Range

The area traversed in a day by prairie chickens is often less than one square mile. Summer movements are less, while winter movements are greater.

Management Techniques

Grasses Beneficial to Species

Grasslands are of vital importance to prairie chicken survival and should be composed of seventy to eighty percent grasses and ten to twenty percent forbs. The species of vegetation that typify rangeland are: big bluestem, little bluestem, dropseed, side oats grama, Japanese brome, Kentucky bluegrsss, hairy grama, and blue grama. Typical forbs are western ragweed, heath aster, lead plant, and ironweed.

Interspersion of Habitat Requirements

An interspersion of 75 percent grassland and 25 percent cropland provides optimum habitat. Prairie chickens will survive in areas of less than 50 percent interspersion (grassland) or in blocks of total grassland, if these areas are properly managed.

Food Plots

Feed fields (minimum of 15 acres) of soybeans, sorghum, or corn will furnish winter feed and provide areas for hunter harvest.

Native Food Establishment

In areas that are being considered for reseeding, such as old cropfields, some native food can be established by adding appropriate forb seed to the native grass mix. Leadplant, annual ragweed, Illinois bundleflower, and roundhead lespedeza are some of the forbs useful to prairie chickens. Mixing any of these forbs with native grass mix and planting in the spring will help increase plant diversity for feeding, nesting and other cover requirements.

Prescribed Burning/Fencing

Burning is necessary to maintain a good quality tallgrass prairie, but should be done only every three or four years on a rotational basis; that is, burning from one-third to one-fourth of the range unit annually. Generally, burning for best range management conditions occurs after mid-April, about the same time as nest initiation. This will cause some nest losses, but hens will renest. If pasture burning is rotated annually, suitable habitat will be available for subsequent nesting.

Fencing grasslands into large pastures is most beneficial because of uneven pasture grazing. This will provide booming ground habitat on overgrazed hilltops, lightly grazed areas for nesting, and moderately grazed areas for brood and winter roost areas.

Grazing

Seasonal

The best type of grazing is during the growing season, especially on native, warm-season grasses. Native pastures and prairie chicken populations do best when yearling steers moderately graze the pasture from May through September.

Rotation

There is a variety of rotation grazing systems which can be utilized. The type of system is determined by the operator's livestock, land uses, and overall program. Rotation systems probably benefit poor-condition range more than good-to-excellent condition ranges and therefore may be very useful in renovating poor prairie. Range improvement is probably the most important use of rotation grazing when considering prairie chicken habitat.

Rotation grazing can be detrimental to prairie chicken nest success if the pasture is grazed extremely hard in April, May, and June, resulting in little or no residual cover during the nesting season. Conversely, rotation grazing will also provide areas which are not grazed until early in the summer. These areas offer good nesting habitat in most years.

Deferred

Deferred grazing involves delaying stocking native range for the first six weeks of growth or until about 15 June. Cool-season pastures are often utilized early. As with rotational grazing, this system can be useful to prairie chickens, if it is utilized to relieve pressure on native range.

Since deferred grazing does not utilize grass in May, native forbs have a better opportunity to increase on many range sites. Higher forb populations will make excellent brood rearing habitat and provide seeds in the fall.

Year-round

With year-round grazing, there is a tendency to overuse the prairie and, ultimately, prairie chicken habitat will be lost.

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