Technical Report No. 254

ACCURACY IN CENSUSING BREEDING PASSERINES ON THE SHORTGRASS PRAIRIE

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U.S. International Biological Program

May 1974

TABLE OF CONTENTS

ABSTRACT

Accuracy of several census methods in estimating breeding populations of five species of birds was investigated on the shortgrass prairie on 10, 8.1-ha plots and a 39.4-km roadside route. Methods employed included spot-mapping, flushing, total count, ratio, roadside and Emlen strip count procedures. Systematic nest searches provided an absolute base. Live-trapping on the study plots gave another index of breeding densities. For reasons discussed, the mapping method was the most accurate.

Final calculated densities were horned larks - 51.9 pr/100 ha, McCown's longspurs - 28.4, lark buntings - 27.2, Brewer's sparrow - 13.6 and western meadowlarks - 4.9.

A detailed field analysis was made of factors affecting the accuracy of the mapping method. Those factors tested were width of the census strip, speed of traverse, time of day, observer variation, weather and species effectivity. Results are presented.

Attempts to correlate weekly roadside counts to weekly plot counts and year-to-year population fluctuations with changes in climatic variables were inconclusive. In a separate analysis, slope proved to be nonsignificant as a factor in nest site selection by horned larks and McCown's longspurs.

ACKNOWLEDGEMENTS

This study would not have been possible without the invaluable guidance of my graduate adviser, Dr. Ronald A. Ryder. He provided the initial impetus, corrected the first faltering footsteps and secured the necessary financial aid. From beginning through reviewing the final manuscript, his assistance and suggestions were gladly given and always available. His professionalism throughout the broad field of ornithology was an inspiration to me. To him, I remain indebted.

Dr. Dale Hein served on my graduate committee and gave many helpful suggestions, especially on statistical aspects. He performed the tedious task of adviser on administrative affairs for me in Dr. Ryder's sabbatical absence. Dr. Paul H. Baldwin also served on the committee and was readily available for questions. I am especially grateful to Drs. Hein and Baldwin for their critical reviews of the thesis.

Dr. Phillip D. Creighton provided many meaningful insights for me into the behavior of the prairie avifauna as well as welcomed companionship in the field. Messrs. Stephen Henry and Martin Brandt worked long and hard for me, especially on nest searches. International Biological Program personnel, particularly Merrs. Larry Nell and David Swift, made available necessary administrative assistance and access to records. Financial assistance was provided by a National Science Foundation grant to the Grassland Biome, U. S. IBP, for "Analysis of Structure, Function and Utilization of Grassland Ecosystems."

CHAPTER I

INTRODUCTION

Since 1968, scientists from a variety of disciplines have been conducting in-depth studies into the functioning and interrelationships of the components of the shortgrass prairie ecosystem in northcentral Colorado. Their efforts have been directed by the Grassland Biome, U. S. International Biological Program (IBP), as part of the world-wide investigation into the complex interactions of six diverse ecosystems. In the United States the program is sponsored by The National Science Foundation. A primary goal of these exacting endeavors is to develop a predictive mathematical model of each ecosystem that is capable of accurately revealing the end results of various man-induced and naturally occurring perturbations.

Certain data on all state and driving variables of the ecosystem as well as the process (flow) mechanisms are needed as input for construction of the models. Estimates of density and standing crop biomass are necessary for all living state variables. This is true for species at upper as well as lower trophic levels of the ecosystem despite the reduced biomass present at upper levels because of the inefficiency of energy transfer through the system. Procedures for determination of these density estimates are almost as varied as the organisms themselves.

These procedures may be especially complex when highly mobile species such as birds are involved. For this reason, density estimates of birds are generally based on the status of the population during the breeding season when individuals are most stationary. Estimates made at other times of the year must often be limited to indirect counts, and the resulting indices of abundance may be unreliable (but see Robbins 1970).

In contrast with other avifaunas, detailed studies of the densities of prairie birds, especially as a unit, have been few. Early investigators (e.g., Linsdale 1928, Dice 1930) generally limited their comments on density to comparisons of relative abundance as determined by the number of individuals of a species encountered in a set time period. Later, densities were given as individuals or pairs occupying a certain area, such as birds per acre (Kendeigh 1941) or pairs per 100 acres (Wing 1949). Other measures of density have included number seen per unit distance (Bennett and Hendrickson 1938, Allen and Sime 1943) or per unit volume (Davis 1942). More recent studies (Cody 1966, 1968; Wiens 1969, 1973; Creighton 1973) have been concerned with previously unrecognized variety of niches available to grassland birds that permits spatial segregation of bird species because of differences in vegetative growth form, height and density. Avian densities and biomasses are now often described and compared in relation to these minor divisions within the grassland community.

In July, 1968, two techniques for censusing the prairie avifauna were selected and initiated on the Pawnee Site in northcentral Colorado. This area is the intensive site for field studies within the Grassland Biome, U. S. IBP. One method consisted of a 50-stop, 39.4-km (24.5-mi) roadside count along a predetermined route. The other involved the periodic counting of six, 8.1-ha (20-A) permanent plots located in native pastures subjected to different degrees of grazing by domestic stock.

The first year's data from these counts were summarized and reported by Ryder and Cobb (1969). Giezentanner (1970, Giezentanner and Ryder 1969) expanded and continued the study during 1969 and 1970. Emphasis of the study was changed by Strong (1971, Strong and Ryder 1971) as he concentrated on reproductive rates, nestling growth and nesting phenology. Density data were still gathered by Strong but have not been published. Densities of large raptors, which require different methods of estimation, were reported by Olendorff (1972, 1973) and Ryder (1972).

The Problem

Throughout the aforementioned investigations on the Pawnee Site, there was no serious attempt to assess the accuracy of either census method. Validation of the project's predictive model required that accuracy of the census methods be assessed.

Therefore, the objectives of this study were:

1. To determine the actual breeding density of avian species nesting on the census plots;

2. To assess the accuracy of the plot count and roadside count methods as used in the past to measure actual breeding density of the avifauna of the shortgrass prairie;

3. If necessary, to select and test a new census method that might be more accurate than the above techniques;

4. To compare present densities with those of past studies and relate fluctuations to possibly causative climatic factors.

Delimitations

The census plots were located on the Central Plains Experimental Range (CPER) in northwestern Weld County, Colorado. The roadside census route extended through the CPER into the Pawnee National Grassland (Fig. 1). Attempts were made to conduct both censuses weekly during the breeding season (April 1 - July 31) in 1972 and 1973. Censuses were made monthly during the remainder of the year; however, those data are not presented. All birds observed during either census were recorded. However, only species which nested on the census plots will be included in the following discussions. These were the horned lark (*Eremophila alpestris*), McCown's longspur (*Calcarius mccownii*), lark bunting (*Calamospiza melanocorys*), western meadowlark (*Sturnella neglecta*), Brewer's sparrow (*Spizella*

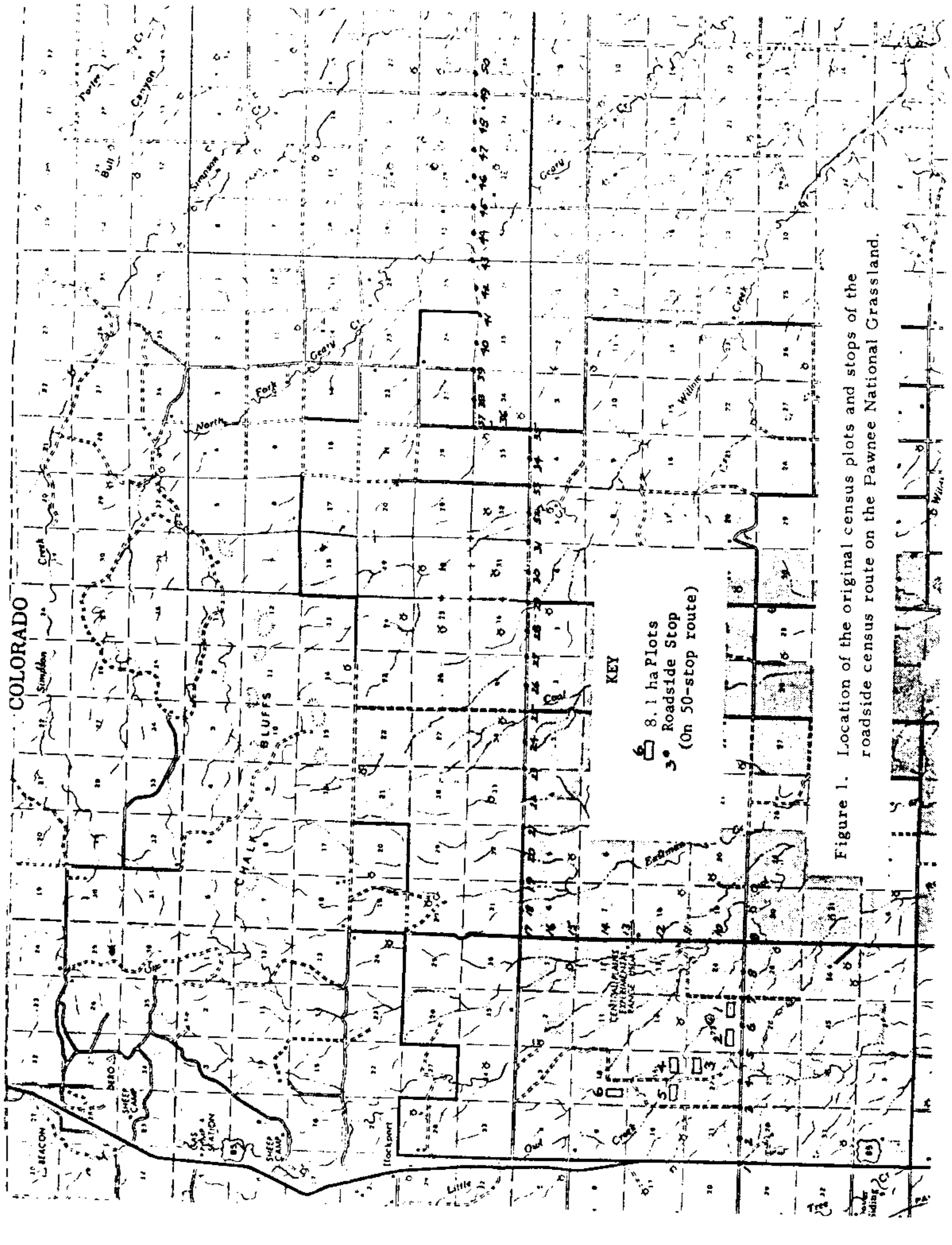


Figure 1. Location of the original census plots and stops of the roadside census route on the Pawnee National Grassland.

breweri), mourning dove (Zenaida macroura), and mountain plover (Charadrius montanus).

Definitions

Breeding density is defined as the number of pairs of birds believed to be nesting per 100 hectares.

Spot-mapping, or territorial mapping, is an area census procedure based on delineating territories by the repeated presence of singing males.

A registration is the recording of a singing male during one census or survey.

An observation is the recording of a non-singing bird during a census.

Species effectivity is "the percentage of the stationary population (of one species) which will be registered on the average at each standard survey" (Enemar 1959).

The flushing method is an area census technique based on delineating territories by repeated (20+) flushing of the territory holder.

The floating population is that part of the breeding population composed of non-stationary, non-breeding birds.

The total population is composed of the floating population and the stationary, breeding population.

The ratio method is an indirect area census procedure based on the ratio of the mean total population to the breeding population as determined by the flushing method. It is used for years in which the mean total population is known, and the flushing method has not been utilized.

The coefficient of detectability represents "the proportion of the population of an area that is ordinarily detected by an observer running a transect" (Emlen 1971).

CHAPTER II

STUDY AREA

The Pawnee Site of the Grassland Biome lies on the Central Plains Experimental Range of the Agricultural Research Service, U. S. Department of Agriculture. All census plots were located on this 6070-ha (15,000-A) native prairie area. The headquarters for the CPER is approximately 16 km north and 6.4 km east of Nunn, Weld County, Colorado (S 12, T 10 N, R 66 W, 6 PM; 40°51'N, 104° 43'W). Headquarters for the Pawnee Site is 12.8 km north and 1 km east of Nunn. The roadside census route extended through the CPER into the northwestern portion of the 312,660 -ha (772,000-A) Pawnee National Grassland, which is administered by the U. S. Forest Service.

Topography and Soils

Topography of the region is rolling hills with an average elevation near 1650 m (5400 ft). Elevation on the 10 census plots ranges from 1642.3 to 1684.3 m (5388 - 5526 ft). Lower areas are often quite flat and generally more heavily vegetated than the rockier hilltops. Playas and ephemeral ponds are common, and there are a few intermittent creeks. Soils are primarily sandy loams of the Ascalon, Vona or Renohill types with smaller areas of finer textures of complexes (Jameson 1969).

The area is characterized by a severe continental climate, subjecting it to a wide range of temperature extremes. Temperature records have been collected by CPER personnel since 1947 and indicate fluctuations in mean maximum temperatures from 22.2° C (40° F) in January to 47.2° C (85° F) in July (Jameson 1969). Extreme mean minimum temperatures are -12.2° C (10° F) for January and 27.8° C (50° F) for July. Daily temperatures are also capable of wide fluctuations, especially during the early part of the breeding season. Strong winds are common, especially in late winter and early spring.

Average annual precipitation ranges from 25.4 to 38.1 cm (10 - 15 inches). Approximately 80 percent of the rainfall occurs during May through September when light thunderstorms are common. Relative humidity is generally low.

Vegetation

The vegetation of the native prairie of the CPER and the Pawnee National Grassland is characterized by the dominance of two shortgrasses, blue grama (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*) (Klipple and Costello 1960). These may be supplemented locally by various thread leaf and needle leaf sedges, including *Carex filifolis* and *C. eleocharis*. Midgrasses, too, are occasionally found in association with the dominant shortgrasses. Some of the more important midgrasses are western wheatgrass (Agropyron smithii), needle-and-thread (Stipa comata), green needlegrass (Stipa viridula) and red three-awn (Aristida longiseta).

Commonly found perennial forbs included scarlet globemallow (Spaeralcea coccinea), slim flower scurfpea (Psoralea tenuiflora), slenderbush eriogonum (Eriogonum microthecium), silky crazyweed (Oxytropis sericea), scarlet gaura (Gaura coccinea) and senecio (Senecio spp.). Important annual forbs are Russian thistle (Salsola kali), pale evening primrose (Oenothera pallida) and lambsquarter (Chemopodium spp.).

The dominant shrubs are fourwing saltbush (Atriplex canescens), fringed sage (Artemisia frigida) and winterfat (Eurotia lanata). Other shrubs found occasionally include rubber rabbitbrush (Chrysothamnus nauseosus), broom snakeweed (Gutierrezia sarothrae) and big sage-brush (Artemisia tridentata). Plains prickly pear (Opuntia polyacantha) is plentiful throughout the area and often occurs in large, dense clumps. The ball cactus (Echinocerrus vivipara) is much less common.

The occurrence and dominance of many of the above plants can be strongly influenced by varying intensities and seasons of grazing (Klipple and Costello 1960). For example, fourwing saltbush is abundant on ungrazed or winter-grazed areas but is absent on heavily summer-grazed pastures. Studying the effects of these different utilizations by domestic stock has been one of the main areas of emphasis by the Agricultural Research Service on the CPER. To this end, use of certain pastures on the CPER for grazing has been controlled for over 30 years.

Summer-use pastures are generally grazed from about May 10 to November 10. The animals are then shifted to winter-use pastures for the remainder of the year. Each of the three different intensities of grazing--heavy, moderate and light--is administered to a summer- and winter-use pasture for a total of six treatments. The three intensities are designed to remove approximately 60, 40 and 20 percent, respectively, of the annual plant growth.

The distribution of the grazing within a certain pasture has been found to be quite variable. Lightly-grazed pastures are characterized by areas of heavy grazing, especially prevalent on hilltops and ridges, surrounded by areas with little or no grazing. Moderately-grazed ranges are intermediate between this patchy condition and the uniform appearance of heavily-grazed pastures. Giezentanner (1970) studied the effect of these grazing patterns on the distribution and abundance of grassland birds.

Study Plot Descriptions

Giezentanner established one, 8.1-ha plot for avian census in each of the six different grazing treatment pastures. Each plot measured 200 x 400 m (660 x 1320 ft) and was marked with a numbered grid pattern. To form the grid, 66, 12.7-cm (5-in) square steel plates with welded stakes were driven into the ground at 40 m (132 ft, 2 chain) intervals around the perimeter and throughout the interior of the plot. This subdivided a plot into 50 squares, each about 0.16 ha (0.40 A). The location of each plate was marked by small engineering flags for ease of orientation within the plot. Each plate was also painted with the north-south and east-west line numbers so that the exact position of that particular intersection within the grid could always be known.

Those same six census plots were used by the author in the present study. They were used exactly as laid out by their originator; only reflagging was necessary to bring them back to their original standards. Giezentanner (1970) gave a thorough description of the vegetation and topography of each of these original census plots. To avoid duplication, only a tabular recapitulation is given for completeness (Table 1).

In April 1972, four new 8.2-ha census plots were established in the heavily summer-grazed pasture, as it was considered most representative of the region as a whole. They were created to provide additional information about the breeding population on this typical shortgrass prairie area, especially increased precision of estimating the breeding density. The new plots, called 1A through 1D, were surveyed with a staff compass and two-chain tape and marked and labeled like the original plots. The location and orientation of these additional plots within the pasture is shown in Fig. 2.

Table 1. Characterization of the six original 8.1-hectare avian census plots on the Pawnee Site.*

Plot	Season of Grazing	Intensity of Grazing	Vegetation
1	Summer	Heavy	Shortgrass, pricklypear, little litter
2	Summer	Light	Short-midgrass, pricklypear, litter
3	Winter	Heavy	Short-midgrass,@ saltbush, locoweed, little litter
4	Summer	Moderate	Short-midgrass, few forbs, moderate litter
5	Winter	Moderate	Short-midgrass, saltbush, locoweed, litter
6	Winter	Light	Short-midgrass, saltbush, heavy litter

*Adapted from Giezentanner, 1970.

@Underlining indicates dominance.

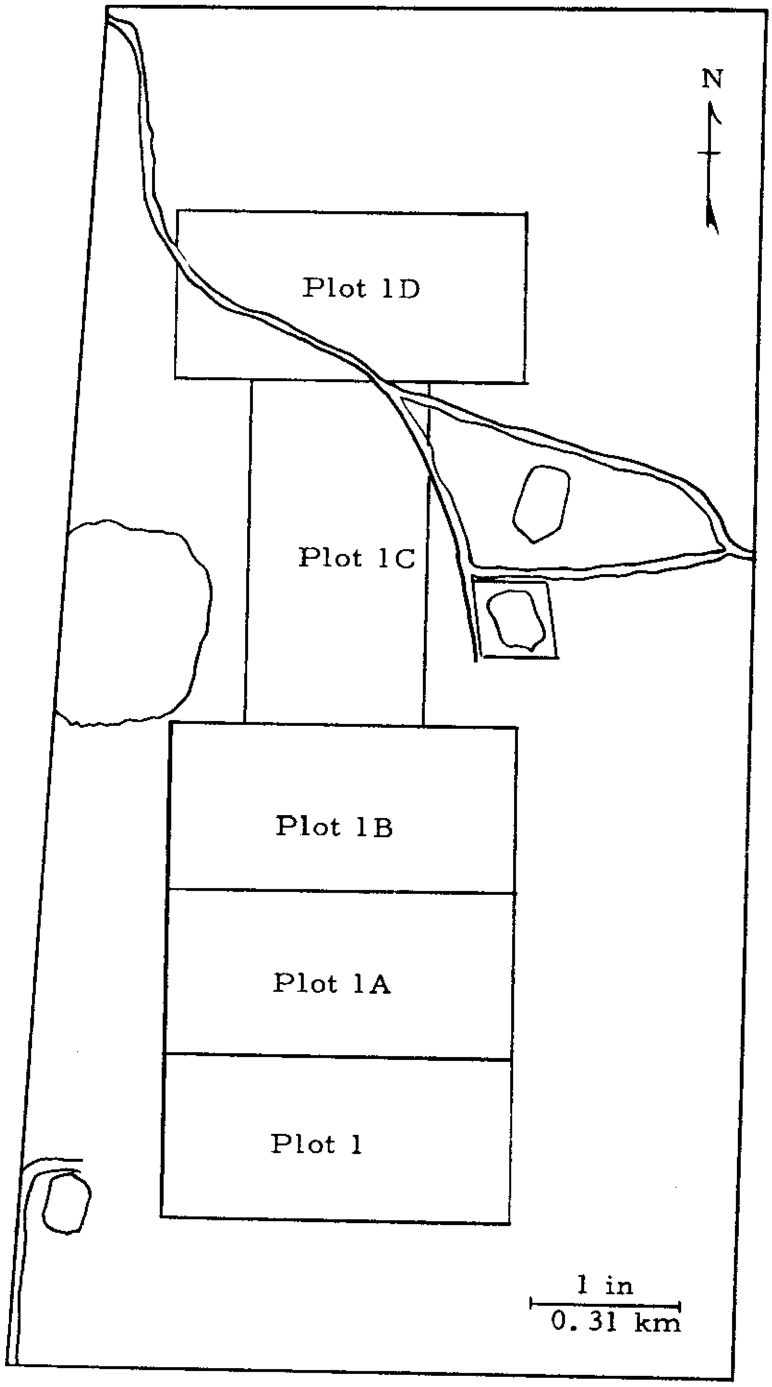
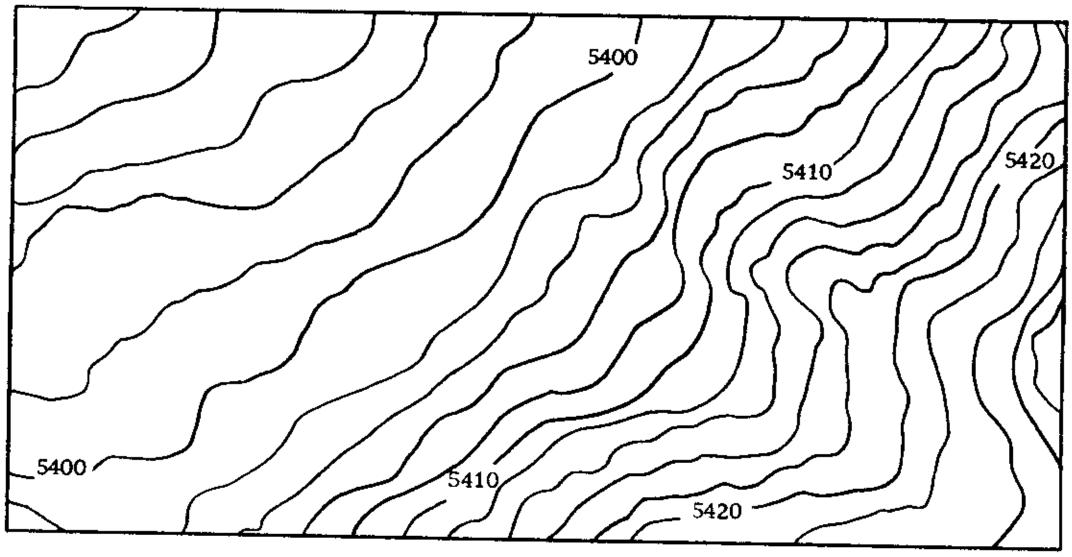


Fig. 2. Location and orientation of newly established replicate plots in 23E.

Enough similarities existed between the new plots and Plot 1, the original plot in the heavily summer-grazed pasture (23E), that they were deemed replicates and the data were treated accordingly. Although no quantitative vegetation analysis was performed, it was apparent that all plots in 23E were dominated by blue grama, buffalo grass and plains prickly pear. Little litter was present. Midgrasses were generally absent, and forbs were mostly widely scattered, although a dense patch of silky crazyweed approximately 0.4 ha in extent occurred near the middle of Plot 1B. Shrubs were absent. Most palatable plants were grazed to a height of 2.5 to 5.1 cm. It was also apparent that the northwestern part of Plot 1A and the northern half of Plot 1C had much densier stands of prickly pear than elsewhere in the pasture. Consequences of these were important in nest searches and will be discussed later. Elevation extremes only varied 23.5 m within this 129.9-ha (320-A) pasture. Topography of the new plots is shown in detail in Figs. 3 and 4.

Roadside Route Description

As mentioned earlier, the 50-stop, 39.4-km roadside census route extended through the CPER and into the Pawnee National Grassland. While most stops were at shortgrass prairie localities, a variety of other habitats were also encountered that were not found on the systematically selected census plots. Included in these diverse situations were windbreaks, dry and irrigated croplands and inhabited



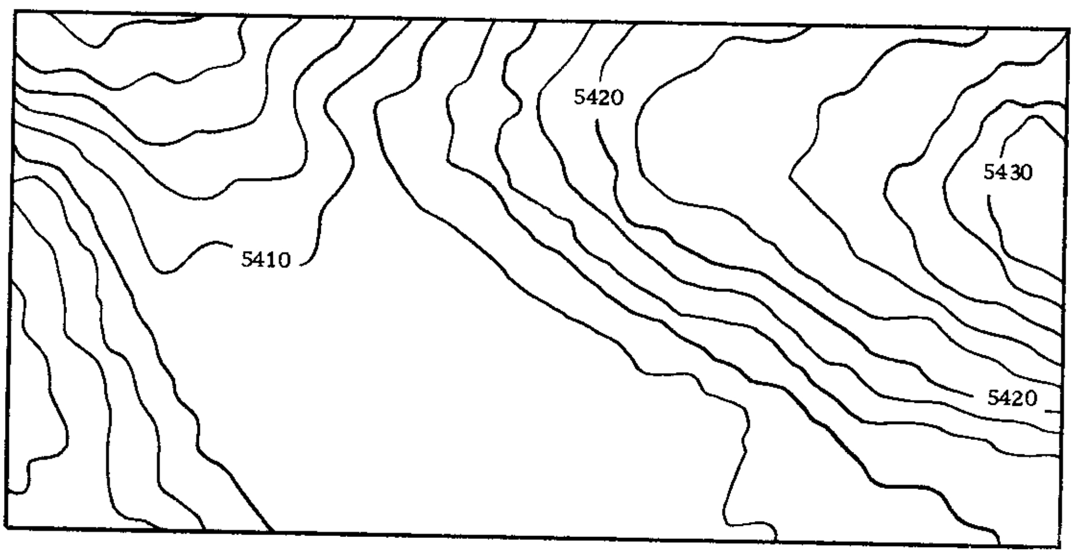


Fig. 3. Topography of two new replicate plots in 23E, Pawnee Site. Top - Plot 1B. Bottom - Plot 1A. Scale is 1" = 240', contour interval is 2' and north is toward the top of the page.

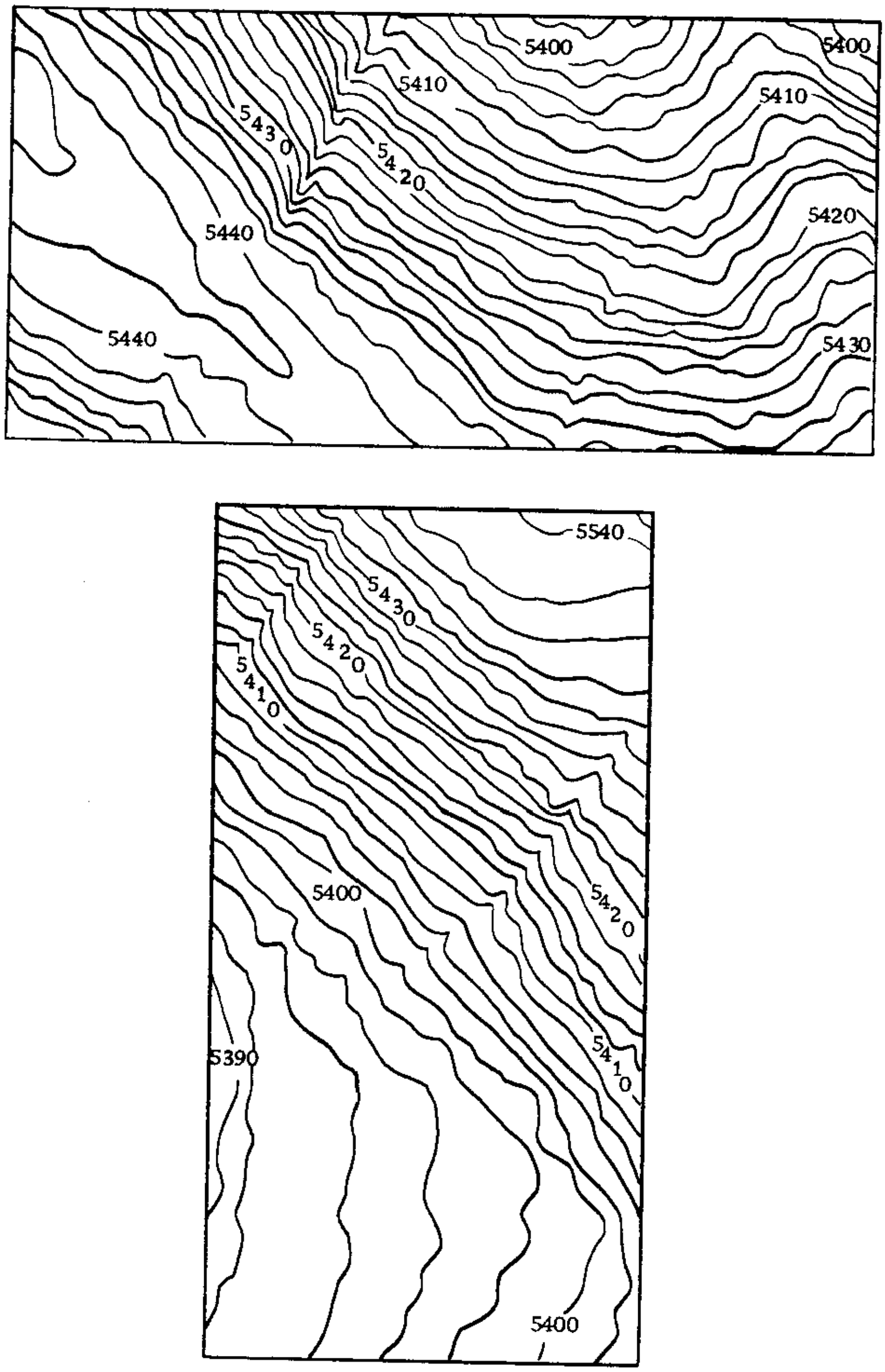


Fig. 4. Topography of two new replicate plots in 23E, Pawnee Site. Top - Plot 1D. Bottom - Plot 1C. Scale is 1"=240', contour interval is 2' and north is toward the top of the page.

and abandoned buildings. In addition, the roadway and its related features were a unique habitat in their own right. A summary of a qualitative assessment of the vegetation found along the route is presented in Table 2.

Table 2. Summary of qualitative assessment of vegetative types on the 50-stop, 39.4-km roadside census route, Pawnee National Grassland.

Type of Vegetation	No. of Stops	
	Dominant	Incidental
Shortgrass	38	8
Shortgrass with brush	11	2
Midgrass	--	7
Midgrass with brush	--	1
Agricultural field crops	--	5
Wind breaks	1	2
Buildings	--	7

CHAPTER III

METHODS AND MATERIALS

Plot Count Techniques

The original six census plots were counted weekly during the 1972 and 1973 breeding seasons. The new replicates and Plot 1 were censused weekly from the establishment of the new plots at the end of April to the end of the breeding season in 1972 and throughout the 1973 season. Each count of a plot consisted of walking the length of the plot twice along standard traverses that brought all areas of the plot within at least 50 m of the observer. All birds observed were recorded with the appropriate notation on a standardized form (Appendix A). Observations were made with 7 x 35, wide-angle binoculars.

A count of the original plots took one morning as did a count of the replicates in 23E. The former were counted in numerical order, while the sequence of survey was randomized for the latter. Attempts were made to begin counting at sunrise in order to conduct as much of the census as possible during the time of the birds' maximum activity. A survey of a single plot took approximately 25 to 30 minutes, indicating a speed of traverse of about 30-36 m per minute.

Data gathered from this basic procedure were analyzed in several ways as follows.

Total Count Method

Weekly counting of the plots permitted determination of the mean number of birds seen on these areas during the breeding season. Therefore, these figures represented a gross estimate of the breeding density.

Flushing Method

This technique, which was first described by Wiens (1969), was employed in this study only in 1973. Its basic premise was that the holder of a territory will remain within its territory despite continual disturbance. A singing individual was located and approached until it flushed from the singing site. This location, the flight path and landing site were recorded on a large scale map of the area. This procedure was repeated until a minimum of 20 consecutive flush points had been plotted. Approximate boundaries were then drawn around the points and flight paths to delineate the individual's territory. Birds which left the immediate area shortly after the initial flush were assumed to be non-territorial. Repeating the process on all birds exhibiting territorial behavior within a plot gave an estimation of the plot's density. A diagrammatic example is illustrated in Fig. 5.

Ratio Method

A combination of the two preceding techniques was termed the ratio method. This technique was originally utilized for 1968 and 1971

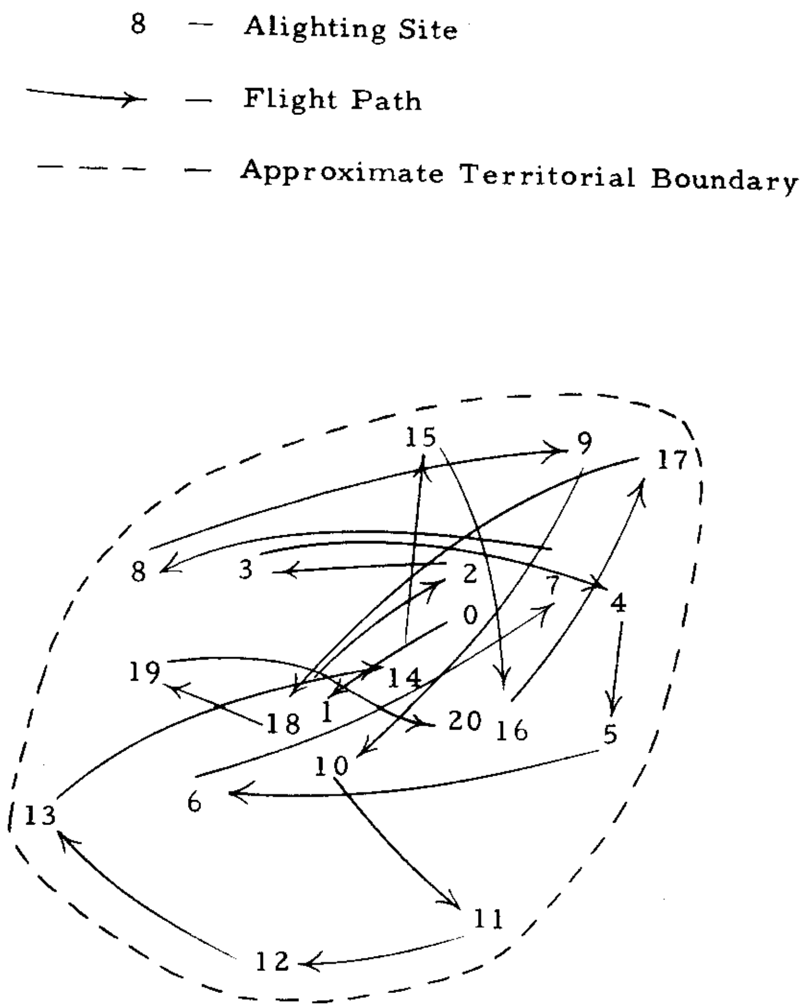


Fig. 5. Diagrammatic example of mapping territories with the flushing method. Data are from field work of lark bunting territories in Plot 6 on 4 June 1973.

data (R. A. Ryder pers. comm.) and was employed for comparative purposes in 1972 and 1973. It was based on a simple ratio of the mean total population of a plot to the breeding density of that plot as determined by the flushing method. The base ratio for the comparisons was that of 1970 data when extensive use was made of the flushing method in each of the original census plots. Comparison of the base ratio to data of years when only the mean total population of a plot was known gave an estimate of the breeding density for that plot during the given year.

Spot-mapping Method

All 1972 and 1973 plot census data were also analyzed by the mapping method. Also called spot-mapping or territorial mapping, this procedure is recommended for worldwide use by the International Bird Census Committee (Williamson 1969, Svensson 1970).

It requires a series of visits to the area during the breeding season with subsequent recording of the location of each singing male noted, known as a registration, on a map of the plot for each trip. Other indications of territoriality, e.g., aggressive interactions or food carrying, are also recorded. At the end of the season, a composite map with all registrations is compiled for each species. In theory, registrations should produce a cluster of points where a territory was located. Stray points not in clusters are assumed to represent transients or territorial birds away from their territories.

In either case, they are considered surplus and are not used in further calculations. An example of a composite map for McCown's longspur is shown in Fig. 6.

Because of certain characteristics of the species involved, basing estimates only on registrations would have greatly underestimated the populations. Therefore, observations, or the mere presence of a bird, served as an aid to help confirm territories indicated by registrations. An extreme example of the increased subjectivity this system introduced into the drawing of territorial boundaries can be seen in Fig. 7.

Certain factors are capable of exerting varying degrees of influence on the accuracy of this census technique. To study this, detailed field tests were conducted in 1972. Factors which were tested included width of census strip, speed of traverse, observer variation, time of day, weather and species effectivity. For the first three factors, tests were made by comparing census results based on the standard width, speed, procedure, etc., with an experimentally varied value as follows.

To determine the effect of increasing or decreasing the strip width, four counts of Plot 1 and two counts of Plot 1B were made. Each count consisted of censusing a plot in one morning using three different width strips--80, 100 (standard) and 200 m. To test speed of traverse, four counts of Plot 1 and one of Plot 1B were conducted.

PLOT COUNTS

Section: Plot 1 23 E

Species: McCown's Longspur (males only)

Key: Plain number = Registration
Subscripted number = Observation
Hachures = Territory boundaries

1--May 3
2--May 11
3--May 15
4--May 22
5--May 29
6--June 5
7--June 12
8--June 19
9--June 26
10--July 5
11--July 10

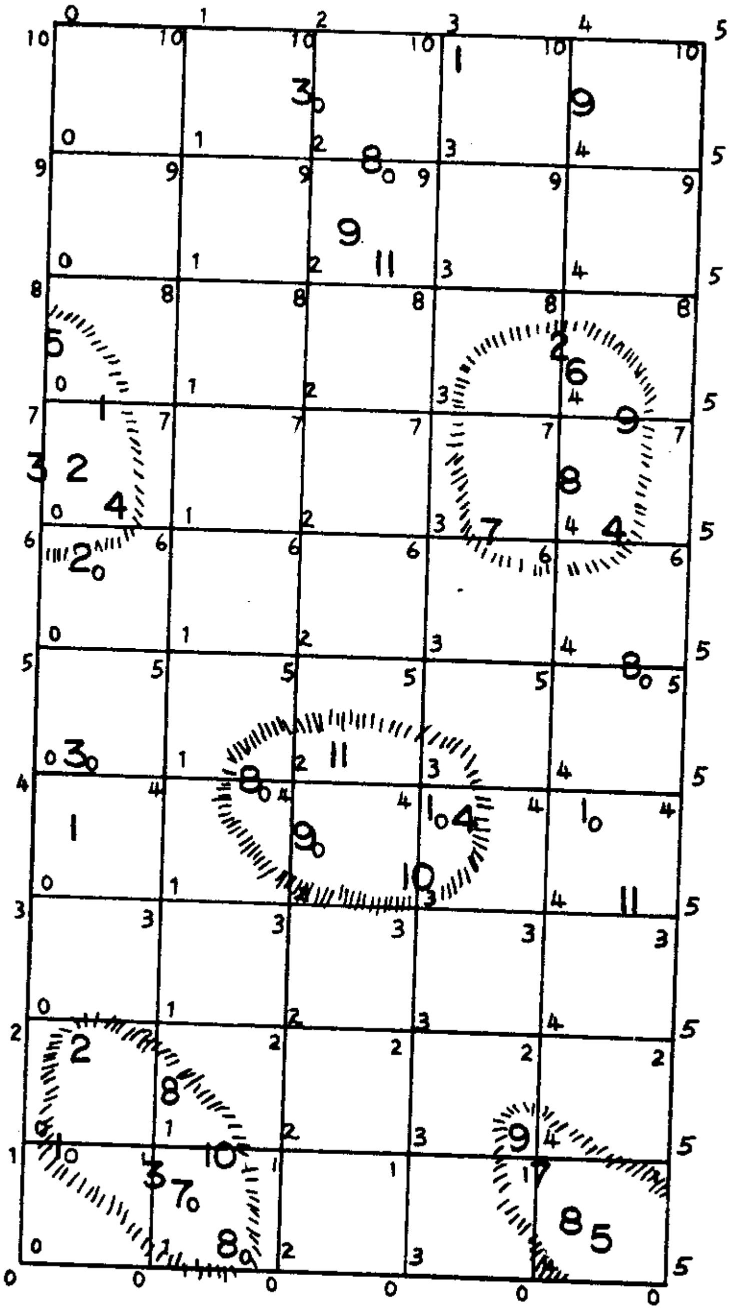


Figure 6. Example of a composite map based on the weekly censuses of Plot 1, 23E, 1972. Each square of the plot was 40m on a side.

PLOT COUNTS

Section: Plot 1 23 E

Species: Horned Lark (both sexes)

Key: Plain number = Registration
Subscripted number = Observation
Hachures = Territory boundaries

1--May 4
2--May 12
3--May 17
4--May 24
5--May 30
6--June 8
7--June 16
8--June 24
9--June 27
10--July 6
11--July 11

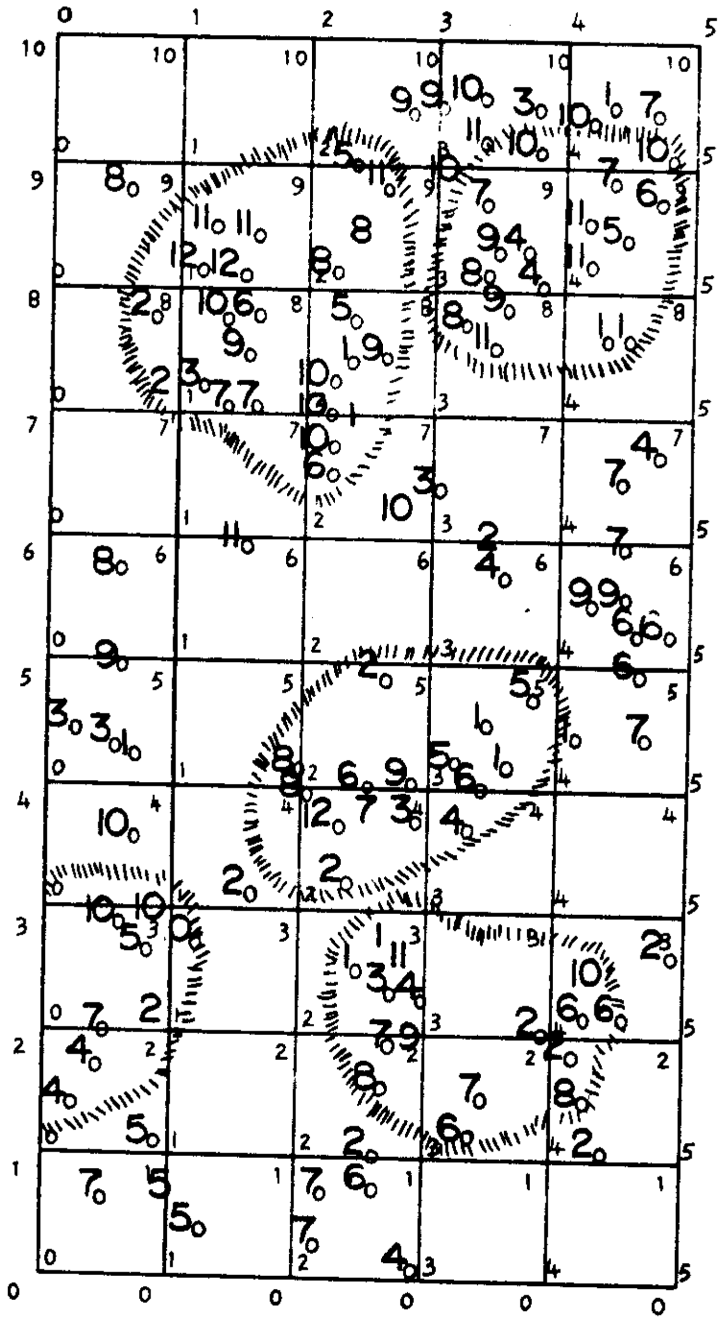


Figure 7. One example out of several possibilities of a composite map for the horned lark based on the weekly censuses of Plot 1, 23 E, 1972. Each square of the plot was 40m on a side.

Here each count involved two surveys, one at the standard speed of approximately 35 m per minute and one twice that speed. For observer variation, two other ornithologists familiar with the avifauna censused a total of six plots with the author. Surveys were made simultaneously with the observers approximately 300 m behind each other. In each case a concentrated effort was made to maintain all other factors except the one being tested as constant as possible.

Effects of time of day were assessed by conducting dawn-to-dusk surveys on 3 June 1972. Plots 1 and 1B were each counted every 2 hours, beginning one-half hour before sunrise. Data were separated into registrations and nonvocal and vocal observations to illustrate the temporal peaks of each. Variations in survey results because of adverse weather conditions were analyzed by comparing the inclement weather data with the nearest fair weather census for that plot. A total of 19 poor weather counts were made on plots in 23E.

Species effectivity was computed by determining the number of surveys on which a known territory holder was recorded as a registration and dividing that figure by the total number of surveys made while the territory in question was occupied.

Nest Site Selectivity

It was thought that variation in slope might explain some of the differences in numbers of birds found on the plots in 23E. To test this, an analysis was conducted as follows.

The boundaries of all plots in 23E were located and drawn on a large scale (1"=40') topographic (contour interval = 2') map of the pasture. The 5 x 10 grid system of each plot was also drawn in, so each 8.1-ha plot was broken down into 50, 0.16-ha squares. The number of contour lines in each square of plots 1, 1B and 1D, which were thoroughly searched for nests, was counted, and the number of squares containing a certain number of lines was totaled. Next, sites of all horned lark and McCown's longspur nests found on these plots were located, and the number of contour lines in squares containing nests was again counted, and the squares totaled. These totals permitted determination of expected and observed number of nests for a given number of contour lines per square, thus allowing use of a chi-square goodness-of-fit test.

Emlen Transect Count Method

This method, developed by J. T. Emlen (1971), was the only strip census used during the study. The original procedure consisted of walking a straight traverse of known length and recording the perpendicular distances from the traverse at which all birds were first noted. These distances were estimated to the nearest 10 feet for the first 100 feet from the traverse and from there recorded as being between 100 and 200 or 200 to 412 feet. The length of the traverse and width of the strip were arbitrary, but a strip 824 feet wide and one mile long conveniently encompassed 100 acres.

The basic assumption was that no birds are overlooked in the 50-foot basal strip on either side of the traverse. Therefore, numbers of each species seen within the first five strips were considered absolute (but see p. 74) and averaged to determine the "basal plateau". This level was then extrapolated to the boundary limits of the strip to estimate the total number of sightings theoretically possible during the census. Division of the observed sightings of a species by the total potential sightings yielded a "coefficient of detectability". This value represented the average proportion of the population seen on a transect. To obtain a density estimate, the observer need only divide the number recorded per mile by the coefficient of detectability.

Preliminary field tests of this method in 1972 showed the above dimensions of the strips to be inadequate for use on the shortgrass prairie for reasons discussed later. The dimensions used in 1973 were, on either side of the observer, a basal strip of 40 m, then 40 to 80 m and 80 to 140 m with a transect length of 1200 m. Total area encompassed was approximately 34 ha. All censuses were made in a north-south direction in 23E so the flags marking grid intersections of Plots 1 through 1D could be used as an aid in estimating distances of birds from the traverse.

Roadside Census

First developed by Nice and Nice (1921), the procedure of censusing birds via roadside observations was made into a viable avian census method by Howell (1951). The procedure employed for the 50-stop, 39.4-km roadside census in this study was that of the North American Breeding Bird Survey, as described by its originators, C. S. Robbins and W. T. Van Velzen (1967). Censuses had been conducted periodically along the route since July, 1968, and were continued during this study.

The procedure involved recording all birds heard at a designated stop and all birds seen within a 0.40-km radius of the stop. Stops were located 0.8 km apart along the predetermined route. Counts of routes in the Breeding Bird Survey begin promptly at one-half hour before local sunrise and are only made annually. Counts of the Pawnee route, which is not an official part of the Survey, were begun at sunrise and made weekly during the breeding season and monthly during the remainder of the year.

For reasons to be discussed, it was deemed desirable to attempt to correlate plot counts and roadside counts. With this goal in mind, data from the 1972 breeding season were submitted to the Colorado State University Computer Center for analysis by one of the statistical library programs, STAT 38R, Stepwise Multiple Regression.

In this program, independent variables are entered into the desired regression equation in an ordered fashion with the variable that makes the greatest reduction in the error sum of squares, and thus has the highest partial correlation, entered first. Any variable can be forced into the equation regardless of whether or not it is significant, if certain default operations are deleted.

Accurate densities necessary for comparisons were available only for species which nested on the census plots in sufficient numbers. These included the horned lark, lark bunting, McCown's longspur, western meadowlark and Brewer's sparrow. Total numbers of these species seen during the weekly censuses of the six original plots constituted the dependent variables. There were seven independent variables: corresponding totals for each species from the weekly roadside counts and temperatures, wind velocities and cloud covers (based on Weather Bureau code numbers) at the start and end of each weekly plot count.

To check if the roadside was also being influenced by these weather factors, the procedure was reversed. The roadside counts were then taken to be the dependent variables with the independent ones being the plot counts and the temperatures, wind velocities and cloud covers at the start and end of each weekly roadside survey.

Nest Searching

All nest searches on the census plots were made while on foot, without the aid of any flushing devices. Such searches were made systematically or randomly. Systematic searches involved checking each of the 50, 0.16-ha squares of a plot in strips of 2-3 m until the entire square was covered. Location and status of each nest were noted and recorded on standardized forms (Appendix B). Later, data were transferred to other forms (Appendix C) for inclusion in the North American Nest Record Card Program of the Laboratory of Ornithology at Cornell University.

To have an absolute base for comparison of different census techniques, several plots in 23E were systematically searched in 1972 and 1973. Plot 1 was searched a total of four times and Plots 1B and 1D twice each. Plots 1A and 1C were not systematically searched because of the aforementioned large, dense stands of cacti in them which would probably have caused the overlooking of some nests. Finding of nests in the other plots in 23E was believed to be complete due to the shortness and sparcity of the vegetation.

Plot 2 was searched once in both 1972 and 1973 to provide density figures for species nesting there, especially the lark bunting. The dense, tall vegetation of that plot no doubt caused the unavoidable overlooking of some nests. All shrubs in Plots 3, 4, 5 and 6 were checked once each year to ascertain Brewer's sparrow breeding densities.

Trapping and Banding

A grid of 124 Sherman small mammal traps baited with molasses-rolled oats was set in a 40-m interval on and around Plots 1 and 1A. The grid was checked at least once a day for 10 days in 1972 and 1973. The area encompassed by the grid, including a 20-m wide buffer strip, was 20.2 ha. Some additional trapping was also done with several 2-, 2- and 5-cell Potter traps.

All birds captured except western meadowlarks were individually color-banded in addition to the standard U. S. Fish and Wildlife Service leg band. Many other birds were caught in similar traps operated by IBP personnel engaged in small mammal studies. These birds were also individually color-banded. Additionally, all young fledged from known nests in 23E were banded.

It was originally hoped the individually marked birds would form the basis for a mark-recapture population estimation following Hewitt's visual "recapture" scheme. However, numerous difficulties caused the abandonment of this attempt. Retrapped birds did allow the use of the Petersen (1896) or Lincoln (1930) index and the Schnabel (1938) index for estimating population size.

The Petersen technique is based on a simple ratio of marked to unmarked in the population is as marked to unmarked is in the sample, or catch. The Schnabel technique is more complicated and is based on cumulative totals of recaptures.

Productivity Studies

During this study, certain data on avian productivity were collected for the IBP. This work primarily concerned the location of as many active nests of non-raptors as possible, especially of the dominant members of the prairie avifauna, and the subsequent rechecking of the nests throughout the breeding season. This permitted calculation of various reproductive parameters, e.g., mean clutch size, fledging success, etc., which were needed as modular input. Data on growth rates and on nesting phenology were also collected. However, for the sake of continuity, data unrelated to densities are not presented. The interested reader is referred to Strong (1971), Strong and Ryder (1971) and Porter and Ryder (in press) for presentation and discussion of non-raptorial productivity data gathered on the Pawnee Site.

CHAPTER IV

RESULTS AND DISCUSSION

Density Determinations

Data gathered during the weekly counts of the 10 census plots allowed calculation of densities in three ways--total counts, ratio and spot-mapping methods. Systematic nest searches also provided nesting densities of plots so covered. Estimates derived from the total count procedure (Tables 3, 4) obviously contained elements of both the floating and stationary populations and could not be considered a valid estimate of the breeding population. This procedure also failed to discriminate individual territories which might have been checked and collaborated by another technique. However, it was the only method used from which a separate estimate of the floating population could be calculated.

The main impetus of the study concerned the accurate assessment of the breeding, or stationary, population. To this end, it was necessary to compare estimates of the different methods (Tables 5, 6, 7, 8). To show the exact relationship between census results and actual breeding populations, intensive systematic nest searches were conducted as listed (see p. 32). Random searches and routine census work resulted in finding additional nests. All together, 92 nests of

Table 3. Average total birds on all plots in 1972 (densities in birds/100 ha in parentheses).

Species	Plot Number										All Plots
	1	1A	1B	1C	1D	2	3	4	5	6	Average
Horned Lark	12.4 (153.1)	10.9 (134.6)	9.3 (114.9)	10.2 (126.0)	9.7 (119.8)	5.0 (61.8)	6.3 (77.8)	8.5 (105.0)	8.2 (101.3)	8.2 (101.3)	8.8 (108.7)
Lark Bunting	0.5 (6.2)	1.0 (12.4)	1.0 (12.4)	0.5 (6.2)	1.1 (13.6)	4.1 (50.6)	6.4 (79.0)	4.3 (53.1)	3.7 (45.6)	5.4 (66.7)	2.8 (34.6)
McCown's Longspur	6.6 (81.5)	6.2 (76.6)	6.9 (85.2)	5.2 (64.2)	4.4 (54.3)	8.1 (100.0)	0.2 (2.5)	0.8 (9.9)	1.2 (14.8)	0.2 (2.5)	4.0 (49.4)
Western Meadowlark	0.2 (2.5)	0.5 (6.2)	0.5 (6.2)	0.5 (6.2)	0.3 (3.7)	1.2 (14.8)	1.0 (12.4)	0.6 (7.4)	0.9 (11.1)	0.8 (9.9)	0.7 (8.7)
Brewer's Sparrow	0 (0)	0.2 (2.5)	0.1 (1.2)	0 (0)	0 (0)	2.6 (32.1)	11.0 (135.9)	1.1 (13.6)	2.1 (25.9)	2.9 (35.8)	2.0 (24.7)
Mountain Plover	0.8 (9.9)	0.7 (8.7)	1.1 (13.6)	0.6 (7.4)	1.3 (16.1)	0.1 (1.2)	0.1 (1.2)	0.1 (1.2)	0.1 (1.2)	0 (0)	0.5 (6.2)
Mourning Dove	0.1 (1.2)	0.1 (1.2)	0.4 (4.9)	0.5 (6.2)	0.5 (6.2)	1.2 (14.8)	1.4 (17.3)	0.6 (7.4)	0 (0)	0 (0)	0.5 (6.2)
Others	0 (0)	0.3 (3.7)	0 (0)	0.3 (3.7)	0 (0)	0 (0)	1.0 (12.4)	0.3 (3.7)	0.2 (2.5)	0.8 (9.9)	0.3 (3.7)
TOTAL	20.6 (254.4)	19.9 (245.8)	19.3 (238.4)	17.8 (219.8)	17.3 (213.7)	22.3 (275.4)	27.4 (338.4)	16.3 (201.3)	16.4 (202.5)	18.3 (226.5)	19.6 (242.1)

Table 4. Average total birds on all plots in 1973 (densities in birds/100 ha in parenthesis).

Species	Plot Number 1	1A	1B	1C	1D	2	3	4	5	6	All Plots Average
Horned Lark	12.6 (155.6)	11.5 (142.0)	11.1 (137.1)	11.2 (138.3)	10.6 (130.9)	4.4 (54.3)	5.7 (70.4)	10.2 (126.0)	7.0 (86.5)	7.7 (95.1)	9.2 (113.6)
Lark Bunting	0.4 (4.9)	1.6 (19.8)	1.2 (14.8)	1.6 (19.8)	1.3 (16.1)	9.4 (116.1)	7.8 (96.3)	6.9 (85.2)	3.7 (45.7)	7.9 (97.6)	4.2 (51.8)
McCown's Longspur	6.6 (81.5)	5.9 (72.9)	5.1 (63.0)	7.1 (87.7)	5.7 (70.4)	5.6 (69.2)	0 (0)	1.1 (13.6)	1.7 (21.0)	1.6 (19.8)	4.0 (49.4)
Western Meadowlark	0 (0)	0.4 (4.9)	0.1 (1.2)	0.1 (1.2)	0.3 (3.7)	1.7 (21.0)	1.7 (21.0)	0.6 (7.4)	1.0 (12.4)	0.4 (4.9)	0.6 (7.4)
Brewer's Sparrow	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.1 (1.2)	3.9 (48.2)	0.1 (1.2)	1.2 (14.8)	4.7 (58.1)	1.0 (12.4)
Mountain Plover	2.1 (25.9)	1.0 (12.4)	1.6 (19.8)	1.1 (13.6)	2.0 (24.7)	0 (0)	0 (0)	0 (0)	0.1 (1.2)	0 (0)	0.8 (9.9)
Mourning Dove	0.1 (1.2)	0 (0)	0 (0)	0.1 (1.2)	0.5 (6.2)	0.2 (2.5)	0.4 (4.9)	0 (0)	0.1 (1.2)	0.3 (3.7)	0.2 (2.5)
Others	0.3 (3.7)	0.5 (6.2)	0 (0)	0.1 (1.2)	0.2 (2.5)	0.5 (6.2)	0.6 (7.4)	0.1 (1.2)	1.3 (16.1)	0.1 (1.2)	0.4 (4.9)
TOTAL	22.1 (272.9)	20.9 (258.1)	19.1 (235.9)	21.3 (263.1)	20.6 (254.4)	21.9 (270.5)	20.1 (248.2)	19.0 (234.6)	16.1 (198.8)	22.7 (280.4)	20.4 (251.9)

Table 5. Pairs of breeding birds on the six original plots in 1972 as estimated by four different methods (densities in pairs/100 ha in parenthesis).

Species	Plot 1				Plot 2				Plot 3			
	M	N	M+N	R	M	N	M+N	R	M	N	M+N	R
Horned Lark	4.5 (55.6)	5.0* (61.8)	5.0 (61.8)	3.8 (46.9)	2.0 (24.7)	0.5* (6.2)	2.5 (30.9)	2.5 (30.9)	2.5 (30.9)	0	2.5 (30.9)	3.0 (37.1)
Lark Bunting	0 (0)	0* (0)	0 (0)	0 (0)	5.0 (61.8)	8.0* (98.8)	8.5 (105.0)	2.9 (35.8)	4.0 (49.4)	0	4.0 (49.4)	2.2 (27.2)
McCown's Longspur	4.0 (49.4)	3.5* (43.2)	4.0 (49.4)	2.2 (27.2)	4.5 (55.6)	1.5 (18.5)	4.5 (55.6)	3.8 (46.9)	0 (0)	0	0 (0)	0 (0)
Western Meadowlark	0 (0)	0* (0)	0 (0)	0 (0)	1.0 (12.4)	0* (0)	1.0 (12.4)	1.0 (12.4)	1.0 (12.4)	0	1.0 (12.4)	0.9 (11.1)
Brewer's Sparrow	0 (0)	0* (0)	0 (0)	0 (0)	0 (0)	0* (0)	0 (0)	0 (0)	2.5 (30.9)	3.0* (37.1)	3.0 (37.1)	6.9 (85.2)
Mountain Plover	0.5 (6.2)	0.5	0.5 (6.2)	0.3 (3.7)	0 (0)	0.5	0.5 (6.2)	0 (0)	0 (0)	0	0 (0)	0 (0)
Mourning Dove	0 (0)	0* (0)	0 (0)	0 (0)	0 (0)	0* (0)	0 (0)	0 (0)	1.0 (12.4)	1.0	1.0 (12.4)	0 (0)
TOTAL	9.0 (111.2)	9.0	9.5 (117.3)	6.3 (77.8)	12.5 (154.5)	10.5	17.0 (210.0)	10.2 (126.0)	11.0 (135.9)	4.0	11.5 (142.0)	13.0 (160.6)

Table 5 Continued.

Species	Plot 4				Plot 5				Plot 6			
	M	N	M+N	R	M	N	M+N	R	M	N	M+N	R
Horned Lark	3.0 (37.1)	0	3.0 (37.1)	2.4 (29.6)	4.0 (49.4)	1.0	5.0 (61.8)	4.0 (49.4)	3.5 (43.2)	0	3.5 (43.2)	2.8 (34.6)
Lark Bunting	4.0 (49.4)	0.5	4.5 (55.6)	2.6 (32.1)	2.0 (24.7)	1.0	3.0 (37.1)	1.7 (21.0)	5.0 (61.8)	0	5.0 (61.8)	3.3 (40.8)
McCown's Longspur	0 (0)	0	0 (0)	0 (0)	0.5 (6.2)	0	0.5 (6.2)	0.7 (8.7)	0 (0)	0	0 (0)	0 (0)
Western Meadowlark	0 (0)	0	0 (0)	1.0 (12.4)	1.0 (12.4)	0	1.0 (12.4)	0.8 (9.9)	1.0 (12.4)	0	1.0 (12.4)	1.0 (12.4)
Brewer's Sparrow	0 (0)	0* (0)	0 (0)	0.8 (9.9)	1.0 (12.4)	3.0* (37.1)	3.0 (37.1)	2.2 (27.2)	3.0 (37.1)	6.5* (80.3)	6.5 (80.3)	2.2 (27.2)
Mountain Plover	0 (0)	0	0 (0)	0 (0)	0 (0)	0	0 (0)	0 (0)	0 (0)	0	0 (0)	0 (0)
Mourning Dove	1.0 (12.4)	1.0	1.0 (12.4)	0 (0)	0 (0)	0	0 (0)	0 (0)	0 (0)	0	0 (0)	0 (0)
TOTAL	8.0 (98.8)	1.5	8.5 (105.0)	6.8 (84.0)	8.5 (105.0)	5.0	12.5 (154.4)	9.4 (116.1)	12.5 (154.4)	6.5	16.0 (197.6)	9.3 (114.9)

M = Mapping method.
N = Nest searches
M + N = Mapping and nest searches combined
R = Ratio method.
* = Thorough nest search(es).

Table 6. Pairs of breeding birds on the replicate plots in 1972 as estimated by four different methods (densities in pairs/100 ha in parenthesis).

Species	Plot 1A				Plot 1B				Plot 1C				Plot 1D			
	M	N	M+N	R	M	N	M+N	R	M	N	M+N	R	M	M	M+N	R
Horned Lark	4.5 (55.6)	1.0	4.5 (55.6)	3.4 (42.0)	3.5 (43.2)	3.5* (43.2)	3.5 (43.2)	2.9 (35.8)	4.5 (55.6)	0.5	5.0 (61.8)	3.1 (38.3)	5.5 (67.9)	3.5* (43.2)	6.0 (74.1)	3.0 (37.1)
McCown's Longspur	4.0 (49.4)	1.5	4.0 (49.4)	2.1 (25.9)	3.5 (43.2)	3.5* (43.2)	5.0 (61.8)	2.3 (28.4)	2.0 (24.7)	2.5	2.5 (30.9)	1.7 (21.0)	3.0 (37.1)	2.5* (30.9)	3.0 (37.1)	1.5 (18.5)
Mountain Plover	0 (0)	0	0 (0)	0.2 (2.5)	0.5 (6.2)	0.5	0.5 (6.2)	0.4 (4.9)	0 (0)	0	0 (0)	0.2 (2.5)	0 (0)	0.5	0.5 (6.2)	0.5 (6.2)
Mourning Dove	0 (0)	0	0 (0)	NR	0 (0)	0	0 (0)	NR	0 (0)	0	0 (0)	NR	1.0 (12.4)	1.5	1.5 (18.5)	NR
Western Meadowlark	1.0 (12.4)	0* (0)	1.0 (12.4)	NR	0 (0)	0* (0)	0 (0)	NR	0 (0)	0	0 (0)	NR	0 (0)	0* (0)	0 (0)	NR
TOTAL	9.5 (117.3)	2.5	9.5 (117.3)	5.7	7.5 (92.6)	7.5	9.0 (111.2)	5.6	6.5 (80.3)	3.0	7.5 (92.6)	5.0	9.5 (117.3)	8.0	11.0 (135.9)	5.0

M = Mapping method
N = Nest searches
M + N = Mapping and nest searches combined
R = Ratio method
NR = No comparative ratio available
* = Thorough nest search(es).

Table 7. **Pairs of breeding birds on the six original plots in 1973 as estimated by four different methods (densities in pairs/100 ha in parenthesis).**

Species	Plot 1				Plot 2				Plot 3			
	M	N	M+N	R	M	N	M+N	R	M	N	M+N	R
Horned Lark	5.5 (67.9)	6.5* (80.3)	7.0 (86.5)	3.9 (48.2)	2.0 (24.7)	0.5* (6.2)	2.0 (24.7)	2.2 (27.2)	3.0 (37.1)	0	3.0 (37.1)	2.7 (33.4)
Lark Bunting	0 (0)	0* (0)	0 (0)	0 (0)	4.0 (49.4)	5.0* (61.8)	5.0 (61.8)	5.6 (69.2)	3.0 (37.1)	1.0	3.0 (37.1)	2.7 (33.4)
McCown's Longspur	4.0 (49.4)	6.5* (80.3)	5.5 (67.9)	2.2 (27.2)	3.0 (37.1)	3.0* (37.1)	3.0 (37.1)	2.6 (32.1)	0 (0)	0	0 (0)	0 (0)
Western Meadowlark	0 (0)	0* (0)	0 (0)	0 (0)	1.0 (12.4)	1.0* (12.4)	1.0 (12.4)	1.5 (18.5)	1.0 (12.4)	0	1.0 (12.4)	1.4 (17.3)
Brewer's Sparrow	0 (0)	0* (0)	0 (0)	0 (0)	0 (0)	0* (0)	0 (0)	0 (0)	1.0 (12.4)	2.0* (24.7)	2.0 (24.7)	2.4 (29.6)
Mountain Plover	0.5 (6.2)	0.5	0.5 (6.2)	0.7 (8.7)	0 (0)	0	0 (0)	0 (0)	0 (0)	0	0 (0)	0 (0)
TOTAL	10.0 (123.5)	13.5	13.0 (160.6)	6.8 (84.0)	10.0 (123.5)	9.5	11.0 (135.9)	11.9 (147.0)	8.0 (98.8)	3.0	9.0 (111.2)	9.2 (113.6)

Table 7 Continued.

Species	Plot 4				Plot 5				Plot 6			
	M	N	M+N	R	M	N	M+N	R	M	N	M+N	R
Horned Lark	3.0 (37.1)	1.5	3.5 (43.2)	2.8 (34.6)	3.5 (43.2)	0.5	3.5 (43.2)	3.3 (40.8)	3.0 (37.1)	0.5	3.5 (43.2)	2.8 (34.6)
Lark Bunting	4.0 (49.4)	1.5	4.5 (55.6)	4.2 (51.9)	1.0 (12.4)	0	1.0 (12.4)	1.7 (21.0)	4.0 (49.4)	1.0	4.0 (49.4)	3.8 (46.9)
McCown's Longspur	1.0 (12.4)	0	1.0 (12.4)	0.5 (6.2)	1.5 (18.5)	0	1.5 (18.5)	1.0 (12.4)	0 (0)	0	0 (0)	0 (0)
Western Meadowlark	0 (0)	0	0 (0)	1.0 (12.4)	1.0 (12.4)	0	1.0 (12.4)	0.9 (11.1)	0 (0)	0	0 (0)	0.4 (4.9)
Brewer's Sparrow	0 (0)	0* (0)	0 (0)	0 (0)	1.0 (12.4)	1.0* (12.4)	1.0 (12.4)	1.3 (16.1)	3.0 (37.1)	5.5* (67.9)	6.5* (80.3)	4.0 (49.4)
Mountain Plover	0 (0)	0	0 (0)	0 (0)	0 (0)	0	0 (0)	0 (0)	0 (0)	0	0 (0)	0 (0)
TOTAL	8.0 (98.8)	3.0	9.0 (111.2)	8.5 (105.0)	8.0 (98.8)	1.5	8.0 (98.8)	8.2 (101.3)	10.0 (123.5)	7.0	14.0 (172.9)	11.0 (135.9)

M = Mapping method
N = Nest searching
M + N = Mapping and nest searching combined
R = Ratio method
* = Thorough nest search(es).

Table 8. Pairs of breeding birds on the replicate plots in 1973 as estimated by four different methods (densities in pairs/100 ha in parenthesis).

Species	Plot 1A				Plot 1B				Plot 1C				Plot 1D			
	M	N	M+N	R	M	N	M+N	R	M	N	M+N	R	M	N	M+N	R
Horned Lark	3.5 (43.2)	1.5	4.0 (49.4)	3.5 (43.2)	5.0 (61.8)	6.0* (74.1)	6.0 (74.1)	3.4 (42.0)	4.5 (55.6)	2.0	4.5 (55.6)	3.5 (43.2)	4.0 (49.4)	4.5* (55.6)	5.5 (67.9)	3.3 (40.8)
Lark Bunting	0 (0)	0	0 (0)	0 (0)	0 (0)	0* (0)	0 (0)	0 (0)	0 (0)	0	0 (0)	0 (0)	0 (0)	0.5* (6.2)	0.5 (6.2)	0 (0)
McCown's Longspur	3.0 (37.1)	3.5	4.0 (49.4)	2.0 (24.7)	2.5 (30.9)	1.5* (18.5)	2.5 (30.9)	1.7 (21.0)	2.5 (30.9)	2.0	2.5 (30.9)	2.4 (29.6)	3.5 (43.2)	3.5* (43.2)	4.0 (49.4)	1.9 (23.5)
Mountain Plover	0.5 (6.2)	0	0.5 (6.2)	0.4 (4.9)	0 (0)	0	0 (0)	0.6 (7.4)	0.5 (6.2)	0	0.5 (6.2)	0.4 (4.9)	0.5 (6.2)	0	0.5 (6.2)	0.7 (8.7)
TOTAL	7.0 (86.5)	5.0	8.5 (105.0)	5.9 (72.9)	7.5 (92.6)	7.5	8.5 (105.0)	5.7 (70.4)	7.5 (92.6)	4.0	7.5 (92.6)	6.3 (77.8)	8.0 (98.8)	8.5	10.5 (129.7)	5.9 (72.9)

M = Mapping method
N = Nest searching
M + N = Mapping and nest searching combined
R = Ratio method
* = Thorough nest search(es).

seven species were found on the 10 plots in 1972 and 106 nests of six species in 1973.

Tables 5, 6, 7 and 8 show a wide discrepancy among results of the different methods. With few exceptions, the ratio technique had the lowest estimate for all species in 1972; however, the results were more mixed in 1973. Notable divergences occurred for lark buntings on Plot 2 in 1972, Brewer's sparrow on Plots 3 and 6 in 1972 and McCown's longspurs on Plot 1 in 1973.

The best comparison of the techniques (Table 9) was from intensively searched plots, which provided as near an absolute base as possible. The great amount of time and effort required to search a plot precluded this method from being an extensive census procedure. Data from these searches were adjusted (see M+N columns of Tables 5, 6, 7, 8) where the mapping method indicated territories contained more than one nest or where nests were apparently overlooked. This latter case may have resulted in some territorial but nonbreeding males being counted as representing a breeding pair. However, this source of error was probably minor and is present in most studies of breeding density.

Table 9 indicated the mapping method was more accurate than the ratio method in three of the four species. The mapping procedure was 41 percent more efficient for McCown's, 19 percent for horned larks and 4 percent for lark buntings. For Brewer's sparrow, close

Table 9. Comparison of breeding densities as estimated by the ratio (R), mapping (M) and mapping and nest searching (M+N) methods, Pawnee Site, 1972-73. Values are from plots thoroughly searched for nests (see text).

Species	R[1]	M[1]	M+N[1]
Horned Lark	25.0	32.0	37.5
Lark Bunting	8.5	9.0	14.0
McCown's Longspur	15.2	28.0	31.5
Brewer's Sparrow	18.0	13.5	22.0

[1] Total breeding pairs.

inspection of Table 5 revealed that the apparent greater accuracy by the ratio method was actually the result of a cancelling of large errors in 1972. That year Plot 3 was greatly overestimated, while Plot 6 was underestimated.

Modular input densities were, therefore, based on results of nest searching and mapping combined. The 2-year, 10-plot average breeding densities were horned larks - 51.9 pr/100 ha (86.5 pr/100 ha), McCown's longspurs - 28.4 (67.9), lark buntings - 27.2 (105.0), Brewer's sparrows - 13.6 (80.3), western meadowlarks - 4.9 (12.4), mountain plovers - 2.5 (6.2) and mourning doves 2.5 (18.5). The figures in parenthesis were the maximum density observed, calculated from the optimum plot for that species. Average breeding density for the combined species was 131.0 pr/100 ha. The total density for the avian community is well within the range reported from other grassland studies across North America (Table 10).

As compared to the base population, the mapping method by itself was a good estimator of horned lark and McCown's densities, accounting for 85 and 89 percent of the respective populations. However, the procedure recorded only 64 and 61 percent of the populations for lark buntings and Brewer's sparrows, respectively. Plots containing the greatest densities of the former two species were consistently censused earlier in the morning than plots having the greatest densities of the latter two species. Thus, time of day and its effect

Table 10. Results of censuses of breeding birds in grassland habitats in North America.

Location	Ele. (m)	Vegetation	Yrs. of Study	No. Breeding Species	Total Density (pr/100 ha)	Census Technique Used	Source
Northcentral Colorado $40^{o}49'$, $104^{o}44'W$	1645	Shortgrass <u>Bouteloua</u>-<u>Buchloe</u>	1	3	148.1	Mapping	Cassel 1952
Southeast Wyoming $41^{o}6'N$, $104^{o}50'W$	1950	Shortgrass <u>Bouteloua</u>-<u>Buchloe</u>	2	3	263.1	Mapping	Finzel 1964
Northcentral Texas $34^{o}55'N$, $102^{o}20'W$	1125	Shortgrass <u>Bouteloua</u>-<u>Buchloe</u>	1	4	113.6	Flushing	Weins 1971
Southeast Wyoming $41^{o}19'N$, $105^{o}52'W$	2240	Shortgrass-midgrass <u>Bouteloua</u>-<u>Stipa</u>	3	3	172.2	Mapping	Finzel 1964
Southwest Saskatchewan $51^{o}5'N$, $108^{o}40'W$	610	Shortgrass-midgrass <u>Bouteloua</u>-<u>Agropyron</u>-<u>Koeleria</u>	2	6	154.3	Unknown	Maher 1970
Northcentral Colorado $40^{o}52'N$, $104^{o}42'W$	1645	Shortgrass-shrub <u>Bouteloua</u>-<u>Buchloe</u>-<u>Atriplex</u>	1	4	143.2	Mapping	Cassel 1952
Southeast Wyoming $41^{o}19'N$, $105^{o}47'W$	2240	Shortgrass-shrub <u>Bouteloua</u>-<u>Buchloe</u>-<u>Chrysothamnus</u>	5	6	147.7	Mapping	Mickey 1939, 1940, 1941, 1942
Northcentral Texas $35^{o}27'N$, $101^{o}48'W$	1110	Shortgrass-shrub <u>Bouteloua</u>-<u>Buchloe</u>-<u>Prosopis</u>	3	9	237.4	Mapping	Allen 1938; Allen and Sime 1939, 1940
Southcentral Alberta $51^{o}25'N$, $112^{o}10'W$	915	Midgrass <u>Festuca</u>	1	5	135.3-UG* 68.0-HG@	Mapping	Owens 1971

Table 10 Continued.

Location	Ele. (m)	Vegetation	Yrs. of Study	No. Breeding Species	Total Density (pr/100 ha)	Census Technique Used	Source
Southeast Washington 46°42'N, 117°17'W	870	Midgrass-shrub Festuca-Agropyron-Symphorocarpus	6	12	293.3	Mapping	Wing 1949; Johnsgard & Rickard 1957
Northeast Kansas 39°16'N, 96°45'W	365	Midgrass-clover Bromus-Melilotus	3	7	215.6	Mapping	Zimmerman 1965, 1966, 1967
Northwest Iowa 43°23'N, 95°11'W	395	Midgrass Poa	1	4	128.4	Mapping, Nest search	Kendeigh 1941
Southcentral Wisconsin 42°54'N, 89°22'W	320	Midgrass Poa-Phleum	3	7	248.7	Flushing	Wiens 1969
Southeast Minnesota 45°16'N, 93°13'W	250	Midgrass Agropyron-Poa	1	2	72.1	Mapping	Mitchell 1961
Westcentral Minnesota 47°20'N, 95°53'W	400	Tall grass-midgrass Andropogon-Sorghastrum-Stipa	3	3	154.4	Mapping	Tester and Marshall 1961
Northcentral Michigan 45°33'N, 84°42'W	215	Midgrass Poa	1	5	131.0	Mapping	Kendeigh 1948
Southeast Ontario 44°1'N, 78°14'W	Unk.	Clover-midgrass Melilotus-Phleum-	1	7	331.0	Hollow square (Merikallio 1958)	Speirs and Orenstein 1967
Northeast Georgia 33°55'N, 83°25'W	215	Midgrass-tall grass Digitaria-Sorghum-Andropogon	1	2	67.9	Mapping	Johnston and Odum 1956

*UG - Ungrazed. @HG - Heavy grazing.

on the birds' activity may have affected the results. Inconspicuousness of Brewer's sparrows in the shrubby pastures they inhabited no doubt contributed to underestimating their numbers.

As mentioned previously, the base year for the ratio method was 1970 when Giezentanner (1970) made extensive use of the flushing method to determine the breeding bird/total count ratio. The shortcomings of the ratio technique were illustrated above. This could have been due to 1) incorrect ratio of breeding bird/total count for the base year, 2) yearly changes in the ratio, or 3) inaccuracy in the flushing method.

The first possible reason could not be assessed during the present study. That the second might have been quite important can be seen by comparing ratios from Tables 3 and 5 versus those of Tables 4 and 7. For example, horned lark and McCown's ratios for Plot 1 were 0.403 versus 0.556 and 0.606 versus 0.833, respectively. Field testing of the third possibility, the flushing method, was made in June, 1973.

None of the seven horned larks and only one of the nine McCown's engaged in territorial behavior at the time of approach fulfilled the criterion of 20 consecutive flushes within the immediate area of the site of the initial flush. It is difficult to believe that only one out of 16 of these birds exhibiting territorial behavior was actually breeding on the area surveyed. However, half the male lark buntings tested showed strong affiliation to the area near the initial flush site.

Other investigators have also reported variable results with the method. As above, Creighton (pers. comm.), working on the same study area, noted little success with McCown's and a high degree of success with lark buntings. However, he also reported a high rate of success for horned larks when delineating their territories in April. Ells (pers. comm.) found the technique to be fruitless for lark buntings as well as horned larks. Thus, valid results seemed to have been as much dependent on the investigator applying the technique as they do on the species to which they are applied. For this study, the method proved invalid.

The overall results indicated that the mapping method provided the best assessment of the breeding population. The author feels even its accuracy would have been increased if all counts were conducted within 30 minutes (+ or -) of sunrise and limited to a shorter period of the breeding season, e.g., 2 or 3 weeks, when the species were most actively advertising their territories. This same conclusion has been reached by others (Bell et al. 1973).

Between Plot Variation

One-way analysis of variance was applied to total numbers seen of the primary breeding species on plots used for nesting (>0.5 pr/plot) by that species. McCown's, Brewer's, meadowlarks and mountain plovers all showed no significant differences in 1972 at the standard 0.05 probability level. Results were identical in 1973 for the latter three; however, differences in longspur numbers were highly significant ($p < 0.005$). This divergence was the consequence of including Plots 4 and 5 (see Table 7) in the 1973 analysis. The contrasting results pointed out that habitat alone did not determine the density of McCown's, as the numbers seen were high in both lightly- and heavily-grazed summer-use pastures or low or absent in the moderately-grazed summer-use pasture.

Lark bunting populations on Plots 2 through 6 were statistically different in 1972 ($p < 0.05$) but not in 1973 ($p = 0.096$). Similarly, horned lark numbers on Plots 1 through 1D were unequal ($p < 0.05$) in 1972 and not ($p > 0.25$) the next year. However, in both years horned larks had highly significant ($p < 0.005$) differences in numbers seen on Plots 1 through 6.

Significance in the above comparisons inferred that some plots used for nesting by a species were utilized less than others. Non-significance inferred that if a plot was suitable at all for nesting, it was used to the same degree as any other suitable plot. These analyses and their input data allowed determination of nesting habitat preferences.

Horned larks and mountain plovers preferred heavily-grazed pastures, while lark buntings and western meadowlarks preferred moderately- or lightly-grazed ones. The apparent contrast of McCown's habitats was noted earlier; however, roadside censuses and general observations indicated a strong preference for heavily-grazed pastures. Brewer's sparrows nested only in areas containing saltbush.

Density Indices

During banding operations on and around Plots 1 and 1A, 47 captures were made of four avian species in 1972. Horned larks accounted for over 70 percent of these captures and were the only species caught in large enough numbers to allow estimations of population size from recapture rates. Data from 1973 were considered insufficient for valid calculation.

During the 10 trap dates, 24 recaptures were included in the 47 captures. Although numbers were small, it was still possible to compute the size of the population using the Schnabel (1938) procedure. The final estimate was 26.8 birds on the grid, or 130.9 birds/100 ha.

Another index of population size was obtained by viewing the last day's catch as input for the Petersen (1896) estimation technique. Ideally, all marking should have taken place at one time, but so few birds were caught each day that this was impossible. The estimate from this method was 28.4 birds, or 140.0 birds/100 ha.

The average of all horned larks seen on Plots 1 and 1A in 1972 was 11.75 birds, or 145.1 birds/100 ha. Considering the small sample size and inherent problems of indices, their results compared favorably with this direct count. The three estimates of total population were naturally higher than the estimated stationary population for these two plots, 117.2 birds/100 ha. The difference between the total and stationary populations, 27.9 birds/100 ha, was an estimate of the average floating population of horned larks on these plots.

Nest Site Selectivity

It was previously noted that differences occurred among the breeding and total populations of the five plots in the heavily summer-grazed pasture, 23E. Since this pasture appeared to have fairly uniform vegetation throughout, it was thought that variations in slope might explain some of the differences in bird numbers. To test this, an analysis of 1972 and 1973 data was conducted (see p. 27). Results of this test are given (Table 11).

According to this analysis, neither species showed selection for or against various degrees of slope at standard significance levels. This was contrary to the general impression the author received from his field work, which indicated a definite preference by both species for flatter areas, especially by McCowns' for ridgetops. The chi-square values did increase for both species when the 2 years of data were pooled, possibly indicating that a larger sample size may yet reveal a statistically significant relationship.

Accuracy of the Mapping Method

Composite mapping of the location of territorial singing males has become the most widespread method of censusing passerines in the breeding season. Originally proposed by Alexander and Alexander

Table 11. Effects of the degree of slope on nest site selection of horned larks and McCown's longspurs in 23E, Pawnee Site, 1972-73.

	No. of Contour Lines per Square									
	0	1	2	3	4	5	≥ 6	Total	X^2	Probability
No. of Squares	4	25	41	21	21	19	19	150		
Obs. No. Horned Lark Nests - 1972	2	4	6	5	2	2	4	25	4.77	0.58
Obs. No. Horned Lark Nests - 1973	2	6	12	4	5	2	1	33	6.48	0.39
Obs. No. McCown's Longspur Nests - 1972	0	6	5	3	1	3	0	18	6.77	0.36
Obs. No. McCown's Longspur Nests - 1973	0	4	8	2	5	2	0	21	6.08	0.43

Overall Horned Lark $X^2 = 6.87$; $p = 0.35$

Overall McCown's Longspur $X^2 = 8.47$; $p = 0.22$

(1909), it was first used in this country by Williams (1936). It is now the recommended technique of the International Bird Census Committee (Svensson 1970). It is currently used for national censuses in many countries, including the Common Birds Census of Great Britain (Batten 1971), as well as the American Birds annual breeding census in this country. As with any census method, though, it has shortcomings. Critical evaluations by Enemar (1959) and Hogstad (1967) among others have shown various factors are capable of influencing the results. The following discussion attempts to explain the reason for the degree of these influences on the accuracy of censusing breeding passerines on the shortgrass prairie. Test procedures are outlined in Methods and Materials.

1. Strip Width

Some general conclusions were apparent from Table 12. As was expected, the greater the transect width, the fewer the birds observed per plot. For the two primary species and the total, the number recorded in the 200 m strip was, with one exception, less than the number seen in one of the narrower strips. Table 13 compares the three widths based only on sightings of territorial male McCown's longspurs. Out of 18 trials, seven birds were not recorded on all three width strips for that count. Of these seven incomplete sightings, five were cases of the bird being recorded on the 80- and 100-m strips, but not on the 200-m.

Table 12. Effects of varying the width of the census strip on sightings of primary breeding species in 23E, Pawnee 1972.

Plot	Date	Strip Width (m)	Horned Lark	McCown's Longspur	Other Species	Total
1	May 25	80	18	3	2	23
		100	14	4	1	19
		200	7	4	1	12
1	June 10	80	17	6	1	24
		100	11	6	5	21
		200	7	3	2	12
1	June 17	80	9	6	1	16
		100	12	5	0	17
		200	6	3	1	10
1	June 29	80	17	10	1	28
		100	11	11	1	23
		200	12	7	0	19
1B	May 25	80	7	3	0	10
		100	14	6	2	22
		200	7	1	3	11
1B	June 30	80	8	2	0	10
		100	5	8	0	13
		200	9	3	0	12

Table 13. Effects of varying the width of the census strip on sightings of territorial male McCown's longspurs, Pawnee 1972.

Plot	Date	Location	80 m Strip	100 m Strip	200 m Strip
1	May 25	7/0	X	X	X
		6/3	X	X	--
		3/2	X	X*	X
1	June 10	7/3	X	X	X
		2/5	X*	X	--
		4/3	X	X	X
1	June 17	7/3	X	X	X
		2/2	X*	X	X
		1/5	--	--	X
1	June 29	6/4	X	X	X
		4/4	X	X	X
		1/4	X	X	X
		3/2	X	X	--
1B	May 25	1/2	--	--	X
1B	June 30	4/5	X*	X	--
		5/2	X	X	X*
		7/2	X	X	X*
		9/1	X	X	--

X = registration

X* = observation.

The widest census strip clearly caused unnecessary omissions, even for conspicuous aerial singers. Since no territorial birds were missed whether the strip was 80 or 100 m, other factors must have caused the differences in Table 12. Use of a 80-m strip required three traverses and thus increased the chance of a bird passing over the plot and being recorded. Similarly, having only one traverse explained some, but not all, of the reduced observations with the 200-m strip. Probably a more important reason for the increased sightings with the 80-m strip was duplication. Obviously, the smaller the strip, the easier it was for a bird to be recorded in adjoining strips. Considering the layout of the plots and the species involved, a 100-m strip appeared best.

2. Speed of Traverse

At least within the range tested, speed of traverse had little effect on registering territorial birds (Table 14). Out of 13 sightings of territorial male longspurs, 11 birds were seen at both speeds for that plot. While the relationship was not so precise, the tendency toward similarity was still evident when all longspurs were considered, probably because territorial birds comprised most of the sightings (Table 15). However, Table 15 also revealed a consistently lower number of horned larks, and thus total birds, observed when the speed was doubled. Non-displaying birds made up almost all of the horned

Table 14. Effects of varying speed of traverse on registrations of McCown's longspurs, Pawnee 1972.

Plot	Date	Location	30 m/min	60 m/min
1	June 2	2/1	X	X
		7/2	X	X
		7/4	X	X
1	June 10	7/4	X	X
1	June 11	7/4	X	X
		6/4	X	X
		5/1	X	X
1	June 27	6/3	X	X
		5/1	X	X
		8/5	--	X
1B	June 11	1/4	X	X
		3/0	X	--
		4/4	X	X

X = registration.

Table 15. Effects of varying the speed of traverse on sightings of primary breeding species in 23E, Pawnee 1972.

Plot	Date	Traverse Speed (m/min)	Horned Lark	McCown's Longspur	Other Species	Total
1	June 2	30	14	3	2	19
		60	13	4	1	18
1	June 10	30	13	4	0	17
		60	8	4	0	12
1	June 11	30	10	4	1	15
		60	6	5	0	11
1	June 27	30	12	4	3	19
		60	7	6	1	14
1B	June 11	30	6	6	6	18
		60	3	3	2	8

lark sightings. These non-displayers were naturally less conspicuous and thus easier to overlook as speed of traverse increased. Apparently, either speed was adequate for determining territories but the slower one allowed a more accurate assessment of the floating population which was necessary for total biomass calculations.

3. Time of Day

It is well known among professional and amateur ornithologists alike that non-nocturnal singing birds show a peak in singing intensity shortly after dawn (e.g., see Winterbottom 1972). To illustrate this phenomenon on the Pawnee, censuses were made in 23E throughout the day on 3 June 1972 from 0500 until 1800. Several attempts to repeat the procedure had to be cancelled because of adverse weather conditions.

Combined results of all censuses generally paralleled the expected pattern, although species differences became apparent (Fig. 8). Both singing and calling were greatest in the first period which included counts beginning 30 minutes before and ending 30 minutes after sunrise. Horned larks and McCown's longspurs accounted for all 34 registrations. In the first period there were 11 registrations, 32 percent of the total, including 53 percent of all horned lark registrations. The early peak of singing was then attributable primarily to horned larks. Although not documented, field work suggested the interval between

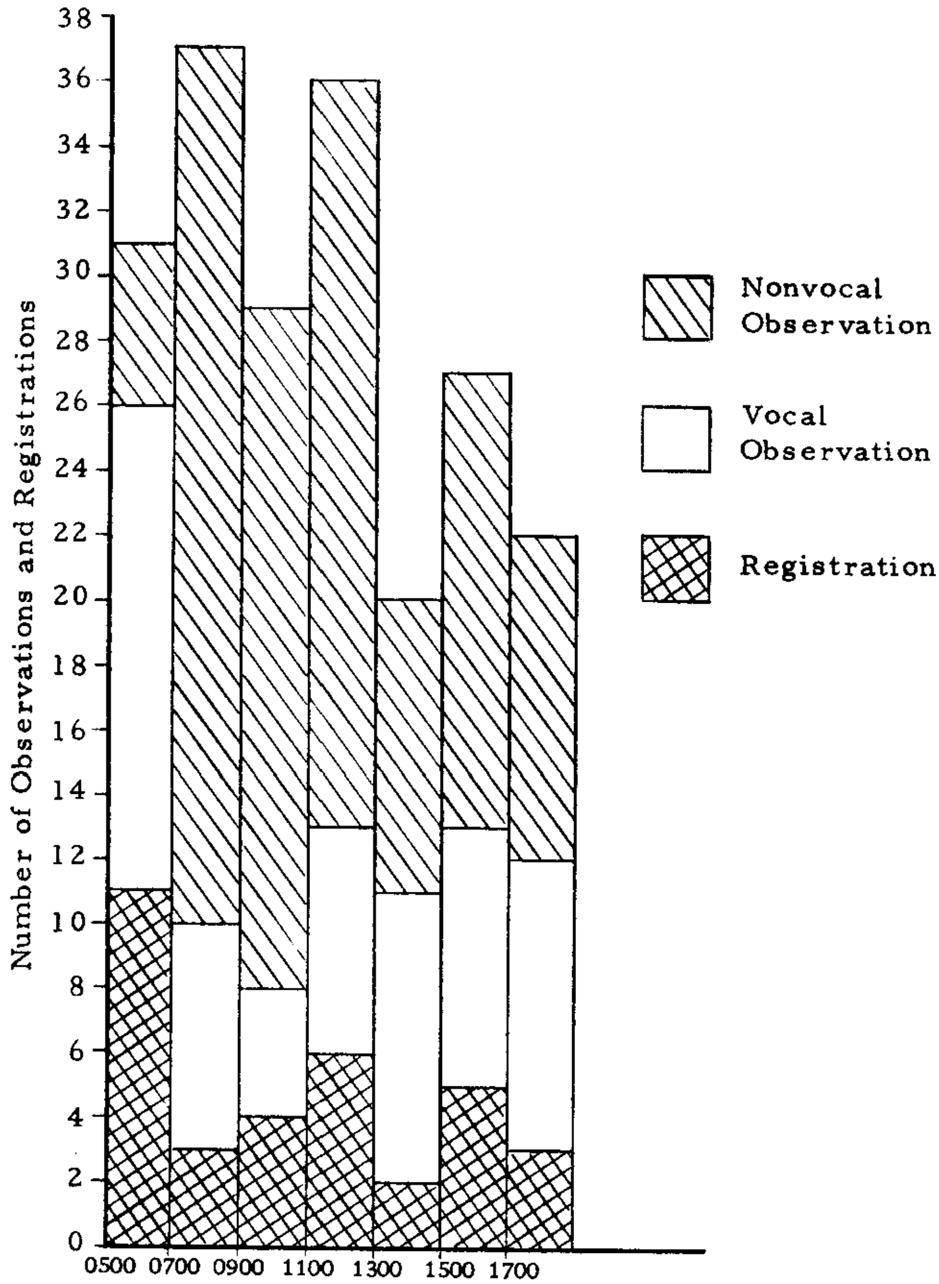


Fig. 8. Trends in singing and calling for nesting species in 23E on June 3, 1972. Each column represents Plots 1 and 1A combined. Sunrise was 0530.

song flights for the longspur increased greatly after early morning. Observations peaked in the second period and were higher in the morning than in the afternoon.

The results indicated the optimal time for conducting a census. Territorialism in both species was best assessed very early in the morning (sunrise $\pm$ 30 min), although McCown's longspurs continued to display throughout the day to some degree. Also, mornings were much better for estimating the floating population.

4. Observer Variation

Observer variation and bias are factors common to any investigation involving humans. In a long-term study, such as the IBP efforts, it is important to know if any serious discrepancies existed among observers. To discover if different observers obtained markedly different results from the same area, three project ornithologists simultaneously censused six plots in two mornings. Overall totals by species are given in Table 16.

While no distinct trends were evident, some personal tendencies appeared. Observer C, the last to census the plot in each case, usually recorded the most birds. Observer A, the first to survey the plot, noted fewer longspurs, while Observer B saw fewer horned larks. However, Table 16 included observations as well as registrations, so it was strongly affected by birds entering and leaving the

Table 16. Comparison of total sightings recorded by three observers in simultaneous surveys in 23E, Pawnee 1972.

Plot	Date	Observer	Horned Lark	McCown's Longspur	Other Species	Total
1	June 16	A	15	4	0	19
		B	12	4	2	18
		C	16	5	3	24
1A		A	9	4	6	19
		B	17	8	1	26
		C	15	8	3	26
1B		A	10	6	2	18
		B	7	12	2	21
		C	11	7	4	22
1	July 6	A	17	4	1	22
		B	8	7	2	17
		C	9	7	2	17
1A		A	12	10	0	22
		B	9	5	2	16
		C	11	6	1	18
1B		A	7	4	1	12
		B	5	7	2	14
		C	8	2	1	11

plot during the census. Table 17 avoided most of this problem by considering only territorial birds. Of the 26 longspurs, 14 were recorded by all three observers. Seven of the remaining 12 involved birds known not to be present on the plot during the entire census or those with territories extending beyond the plot boundaries. It was possible that some of the other five cases may have involved birds that left the plot unknown to the observers.

In any case, agreement among the observers was about 74 percent, signifying adequate coverage by each. Enemar (1962) in a similar experiment involving six ornithologists surveying a wooded area found the agreement was an almost identical 75 percent.

5. Weather

Nineteen counts were made of plots in 23E during inclement weather to illustrate the problems of censusing under these conditions. Ten counts were made on overcast mornings, five on raining or snowing mornings, and one each on a foggy and a windy morning. Results of two counts will not be discussed as no comparative, fair-morning census could be taken within a few days of the poor weather count.

The comparison of the inclement weather censuses with the nearest fair weather census can be found in Table 18. Precipitation, especially snow, caused the greatest discrepancy in survey results. The snows of April 14 and 26 drove all passerines (but not mountain plovers) from the plots, thus requiring reestablishment of territories

Table 17. Comparison of sightings of territorial male McCown's longspurs as recorded by three observers in simultaneous surveys in 23E, Pawnee 1972.

Plot	Date	Location of Bird in Plot	Observer A	Observer B	Observer C
1	June 16	9/3	X	--	--
1A	June 16	2/1	X	x	x
		7/3	X	x	x
		10/3	X	x	--
		WML	X	x	X
1B	June 16	3/2	X	X	X
		3/5	X	x	X
		1/3	X	x	X
		2/4	--	x	X
1	July 6	7/0	X	X	X
		4/2	X	X	X
		1/4	X	X	x
		0/0	X	X	X
		2/2	x	X	X
		4/4	*	X	X
		WML	X	x	X
1A	July 6	5/4	X	*	*
		1/4	X	*	*
		6/0	X	x	*
		10/1	x	*	X
		7/3	x	X	x
1B	July 6	8/2	X	X	X
		4/4	X	X	--
		9/1	*	X	*
		2/3	--	X	X
		3/5	*	X	*

X = registration
x = observation
WML = Western Meadowlark
* = Bird known to be absent from plot or having a territory extending beyond plot boundaries.

Table 18. Comparison of censuses made during inclement weather conditions with the nearest fair weather census.

Date of Inclement Weather Census	Date of Fair Weather Census	Plot Censused	Type of Inclement Weather	Horned Lark			McCown's Longspur			Other Species			Total		
				I	F	P	I	F	P	I	F	P	I	F	P
April 14	April 17	1	Snowing	1	13	7.7	0	10	0.0	0	2	0.0	1	25	4.0
April 19	April 17	1	Heavy Fog	12	13	92.3	3	10	30.0	5	2	100.0+	20	25	80.0
April 26	April 24	1	Snowing	0	10	0.0	0	10	0.0	0	1	0.0	0	21	0.0
May 1	May 1	1	Windy	6	8	75.0	4	13	30.8	0	0	-----	10	21	47.6
May 8	May 11	1	Overcast	3	11	27.3	9	9	100.0	2	0	100.0+	14	20	70.0
May 8	May 12	1A	Overcast	11	12	91.7	5	14	35.7	0	5	0.0	16	31	51.6
May 10	May 11	1	Overcast	4	11	36.3	5	9	55.6	0	0	-----	9	20	45.0
May 10	May 12	1A	Overcast	4	10	40.0	1	10	10.0	0	3	0.0	5	23	21.7
June 6	June 8	1	Overcast	7	8	87.5	4	6	66.7	0	4	0.0	11	18	61.1
June 6	June 8	1B	Overcast	6	7	85.7	3	3	100.0	1	5	20.0	10	15	66.7
June 19	June 20	1	Overcast	5	11	45.4	5	7	71.4	2	1	100.0+	12	19	63.2
June 19	June 16	1B	Overcast	1	10	10.0	7	6	100.0+	0	2	0.0	8	18	44.0
June 23	June 24	1	Overcast	5	11	45.5	5	6	83.3	1	4	25.0	11	21	52.4
June 23	June 24	1B	Overcast	5	11	45.5	2	2	100.0	1	2	50.0	8	15	53.3
June 30	June 27	1	Heavy Rain	2	12	16.7	2	4	50.0	0	3	0.0	4	19	21.1
July 3	July 5	1	Misting	8	14	57.1	4	6	66.7	0	2	0.0	12	22	54.5
July 3	July 6	1B	Misting	2	7	28.6	4	4	100.0	1	1	100.0	7	12	58.3

I = Inclement weather count

F = Fair Weather count

P = Percent I/F.

after the storm. The lone horned lark recorded on April 14 merely flew over the plot but did not land. In general, numbers of horned larks observed appeared more easily depressed than those of McCown's longspurs, except perhaps during windy conditions. Only half as many larks were seen on overcast mornings as compared to fair mornings, while the similar number was almost 60 percent for the longspur. Figures were 36 and 71 percent, respectively, for rainy mornings.

Registrations as well as observations decreased during poor weather. Only on 10 out of the 22 trials of Table 19 was a particular longspur recorded as a registration on both the fair and inclement weather censuses. Similar registrations occurred 53 percent of the time on overcast days but only 33 percent on windy days and 25 percent on rainy days.

For both species, fair weather mornings permitted a much more accurate estimation of the breeding and the floating populations.

6. Species Effectivity

The main premise of the preceding discussions is that when an observer surveys an area under favorable conditions, territorial birds will make their presence known by singing. However, several factors can lead to chance omissions of birds which are territorial. For example, they may simply not be on the study area at the time of the survey or may remain outside their territory and be dismissed as a surplus registration. Lengthy pauses in singing of some individuals

Table 19. Comparison of inclement and fair weather censuses based on sightings of territorial male McCown's longspurs in 23E, Pawnee 1972.

Date of Census	Date of Comparative Census	Type of Inclement Weather	Location	Fair Weather	Inclement Weather
May 1	May 1	Windy	7/1	X	--
			4/2	X	X
			3/2	X	--
May 8	May 11	Overcast	8/4	X	X*
			7/1	X	X
			2/1	X	--
May 10	May 11	Overcast	8/4	X	--
			7/1	X	X
			2/1	X	X
			9/2	--	X
June 6	June 8	Overcast	8/4	X	X
			5/5	X	--
			5/3	X	--
			1/3	X	X*
June 19	June 20	Overcast	1/4	X	X
			7/4	X	X
June 23	June 24	Overcast	1/4	X	X
			7/4	X	X
June 30	June 27	Heavy rain	1/4	X	--
			7/4	X	X

Table 19 Continued.

Date of Census	Date of Comparative Census	Type of Inclement Weather	Location	Fair Weather	Inclement Weather
July 3	July 5	Misting	1/1	X	--
			4/3	X	--

X = registration.

X* = observation.

can also lead to oversights. Enemar (1959) pointed out that birds with territories further from the path of traverse are less likely to be recorded, as passing through a territory induces the holder to more readily proclaim his presence. Then, too, males are known to sing more frequently and defend their territory more aggressively earlier in the nesting cycle. Perhaps most importantly, different species inherently have different singing intensities.

Colquhoun (1940) employed "coefficients of relative conspicuousness" to compensate for the differences in the ease of recording different species. Kendeigh (1944) also dealt with the conspicuousness problem in his classical work on measuring bird populations. Later, Enemar (1959) introduced the term "species effectivity" which he defined as "the percentage of the stationary population (of one species) which will be registered on the average at each standard survey." The reciprocal of species effectivity is the "measuring error", or the average percentage overlooked on each survey. The level of effectivity is highly important in determining the degree of confidence in results. For instance, densities based solely upon registrations for horned larks, which had low effectivity in this study, cannot be accurate.

Calculation of species effectivity was based upon the potential number of registrations that can be expected for that species (see p. 27). Following this procedure, an analysis was made of the effectivity of the species breeding on the plots (Table 20).

Table 20. Species effectivity for some common birds on the Pawnee Site, 1972.

Species	No. of Stationary Males	No. of Trials	No. of Registrations	Species Effectivity (%)
McCown's Longspur	22	331	146	44
Lark Bunting	20	152	84	55
Western Meadowlark	5	35	18	51

The first question concerning the results is why the omission of horned larks, Brewer's sparrows, mountain plovers and mourning doves, all of which nested in at least one of the plots. Problems associated with censusing the former two, including time of day and habitat, have already been mentioned. Their effectivity as measured, about 10-15 percent for both, was not considered valid and was, therefore, omitted. Lack of song and territory size in relation to plot size (2:1) invalidated any estimation of plover effectivity as did absence of territorial advertisement and low density in mourning doves.

Lark buntings had the highest effectivity of the three species adequately measured, 55 percent. The overall figures for the western meadowlark and McCown's longspur were 51 and 44 percent, respectively. Variation among individuals for all three was quite high, e.g., ranging from 30 to 100 percent among lark buntings. On the average survey, about half of the territories went unnoticed for these species. This was a dramatic illustration of the need for multiple surveys. These effectivity figures are at the low end of the 50-70 percent range Enemar (1959) found for some common forest birds. Additional years of data are necessary to determine if this low effectivity as measured is the true picture for the prairie avifauna.

Emlen Transect Count Method

The Emlen transect count method (1971) was employed during the 1973 breeding season after preliminary field tests in 1972. These tests indicated that birds tended to move away from the basal strip as the observer approached, often giving the second strip a greater number than the basal strip. This phenomenon led to the rejection of Emlen's original dimensions and partially to the establishment of those used.

The technique gave an independent estimate of the breeding population in 23E, as the area surveyed during the running of the transect included most of plots 1 through 1D. Three trials of the method yielded the results in Table 21.

The Emlen method estimated a population larger than the total count method for both horned larks and McCown's longspurs, the only two species present in number in 23E. The difference of the estimates was negligible for longspurs; however, it amounted to almost two birds per plot for horned larks. Also, if Emlen's technique were followed exactly, the differences would have been even greater as a "basal detectability adjustment" on the order of 1.5 is applied to increase the "basal plateau" to compensate for birds overlooked in the basal strip. It was believed that the shortness and sparsity of the vegetation in 23E allowed observation of all non-incubating birds within the basal strip, and therefore, the adjustment was deemed unwarranted. Incubating birds were probably equally overlooked by all methods except systematic searching for nests.

Table 21. Results of three runs of the Emlen transect count method in 23E, Pawnee Site, 1973.

Species	Average[1] C.D.	Average Number Seen	Density (birds/100 ha)	Density of Total Count Method (birds/100 ha)
Horned Lark	0.497	27.7	163.9	140.8
McCown's Longspur	0.429	11.3	77.5	75.3

[1] Coefficient of detectability - see text.

The reason for the resulting discrepancy in horned lark numbers was not readily apparent. It would seem that densities derived from plot counts would have been larger, for the possibility of recording a bird more than once was greater in a plot than on a transect. It may have been that time of conducting the census, rather than the technique, was more important (see Fig. 8). Emlen transect counts lasted from sunrise to sunrise + 50 minutes, while plot counts in 23E lasted from sunrise to sunrise + 100-120 minutes. With more singing birds in the population, the probability of recording a sighting toward the extremes of the transect boundaries was increased. The later-ending plot counts did not have this advantage but also did not have such relatively great distances between boundaries. Another possible cause of the discrepancy was overlooking birds during plot counts as the maximum distance between the observer and the plot boundaries (50 m) was greater than one-half the width of the basal strip of the transect (40 m). However, the problems associated with reducing the observation distance while counting the plots have been previously discussed (see p. 57).

In the above discussion, only the total population was considered, although the Emlen technique can also estimate breeding densities if, at the time of recording, singing individuals are so designated. Although this was done during the study, too few singing birds were noted to permit computations. This may have been due to the relatively low density inherent with grassland avifaunas (e. g., only four male longspurs would have had territories in the basal strip based on 1973 mapping densities) coupled with low species effectivity. The Emlen method does not enable the locating of individual territories which might be confirmed by other census methods.

In summary, the Emlen method could not be said to be better or worse than the total count method, from which the spot-mapping densities were derived. In addition to the above arguments, the greater efficiency of the transect procedure added much to its value. For the purposes of this study, the Emlen transect count served as a well-founded check which showed that the technique of the primary census methods furnished acceptable data.

Roadside Census

Weekly censuses along the 50-stop, 39.4-km roadside route were made during the breeding seasons in 1972 and 1973. Compared to plot counts, these censuses covered a much larger area surveyed per unit effort expended. However, this advantage was due to a less intense coverage. If this latter fact did not cause the results acquired from the roadside counts to differ greatly from those of the presumably more accurate plot counts, then the roadside would be preferred as accuracy in sampling increases as more of the population is sampled. Additionally, the roadside technique yielded data on seasons of occupancy and time of migration of species rarely found on the plots.

If both the above census techniques were accurately measuring the same population, there should have been a correlation between the weekly counts of each technique. To determine if this was so, data from the 1972 breeding season were submitted to the aforementioned statistical library program, STAT 38R, Stepwise Multiple Regression. Results of the first run, with numbers from the plot counts as dependent variables and numbers from the roadside counts and weather data gathered during plot counts as independent variables, are in Table 22. In the second run (Table 23), the dependent and independent variables were reversed.

The most readily apparent result of the first test was the surprisingly low correlation between the plot and roadside censuses of a given species. For the five species, only the lark bunting censuses showed a significant ($p = 0.006$) correlation. Numbers of McCown's longspurs seen during plot counts were significantly ($p < 0.050$) correlated with the starting temperature and starting cloud cover of these counts. Brewer's sparrow numbers also showed some relationship ($p = 0.087$) with the starting cloud cover and a significant ($p = 0.014$) correlation with the starting wind velocity. Numbers of horned larks and meadowlarks had no correlation ($p > 0.130$) to any of the independent variables of the first test. Test two results were similar, although then McCown's censuses were significantly ($p < 0.05$) correlated.

Table 22. Results of test one of correlation analysis with plot counts as dependent variables and roadside counts and weather factors associated with the plot counts as independent variables.

Species	Step No.	Independent Variable Entered	R^2	Increase in R^2	Partial F-Value
Horned Lark	1	Start T	0.16310	0.16310	2.73
	2	End W	0.25059	0.08749	1.52
	3	End T	0.29884	0.04825	0.83
	4	End C	0.41863	0.11979	2.27
	5	Start W	0.47806	0.05944	1.14
	6	Start C	0.53332	0.05525	1.07
	7	HL Road	0.53847	0.00515	0.09
Lark Bunting	1	LB Road	0.42441	0.42441	***10.32
	2	Start T	0.53425	0.10984	* 3.07
	3	End C	0.60019	0.06594	1.98
	4	End T	0.65690	0.05671	1.82
	5	Start W	0.68237	0.02546	0.80
	6	End W	0.68524	0.00287	0.08
	7	Start C	0.68610	0.00086	0.02
McCown's Longspur	1	Start T	0.33201	0.33201	** 6.96
	2	Start C	0.56133	0.22932	** 6.80
	3	MC Road	0.64089	0.07955	2.66
	4	End T	0.71095	0.07006	2.67
	5	End C	0.76162	0.05068	2.13
	6	End W	0.80104	0.03942	1.78
	7	Start W	0,80464	0.00359	0.15

Table 22 Continued.

Species	Step No.	Independent Variable Entered	R^2	Increase in R^2	Partial F-Value
Western Meadowlark	1	ML Road	0.02439	0.02439	0.35
	2	End W	0.06095	0.03656	0.51
	3	Start T	0.09604	0.03509	0.47
	4	Start C	0.17343	0.07739	1.03
	5	End C	0.17612	0.00270	0.03
	6	Start W	0.17693	0.00081	0.01
	7	End T	0.17743	0.00050	0.01
Brewer's Sparrow	1	Start W	0.36290	0.36290	**7.98
	2	Start C	0.49656	0.13366	*3.45
	3	BS Road	0.50889	0.01233	0.30
	4	End W	0.51538	0.00648	0.15
	5	Start T	0.52236	0.00699	0.15
	6	End T	0.58483	0.06246	1.35
	7	End C	0.59133	0.00650	0.13

T = Temperature
W = Wind Velocity
C = Cloud Cover
*** = Significant at 0.01 level
** = Significant at 0.05 level
* = Significant at 0.10 level
d.f. = 1, 15.

Table 23. Results of test two of correlation analysis with roadside counts as dependent variables and and plot counts and weather factors associated with roadside counts as independent variables.

Species	Step No.	Independent Variable Entered	R^2	Increase in R^2	Partial F-Value
Horned Lark	1	Start T	0.13139	0.13139	2.12
	2	Start C	0.25655	0.12516	2.19
	3	HL Plot	0.43667	0.18007	* 3.84
	4	End T	0.52625	0.08963	2.08
	5	End W	0.55053	0.02428	0.54
	6	End C	0.57390	0.02338	0.49
	7	Start W	0.58247	0.00857	0.16
Lark Bunting	1	LB Plot	0.42441	0.42441	***10.32
	2	Start C	0.53893	0.11452	* 3.23
	3	Start T	0.54798	0.00905	0.24
	4	End T	0.56062	0.01264	0.32
	5	End W	0.57225	0.01163	0.27
	6	Start W	0.58042	0.00816	0.18
	7	End C	0.58401	0.00359	0.07
McCown's Longspur	1	MC Plot	0.31956	0.31956	** 6.58
	2	Start W	0.37750	0.05794	1.21
	3	Start T	0.53201	0.15450	* 3.96
	4	Start C	0.56564	0.03364	0.85
	5	End T	0.58709	0.02144	0.52
	6	End W	0.59318	0.00609	0.14
	7	End C	0.59370	0.00052	0.01

Table 23 Continued.

Species	Step No.	Independent Variable Entered	R^2	Increase in R^2	Partial F-Value
Western Meadowlark	1	End T	0.16836	0.16836	2.83
	2	ML Plot	0.19112	0.02276	0.37
	3	Start T	0.20785	0.01673	0.25
	4	End C	0.21891	0.01106	0.16
	5	Start C	0.23200	0.01309	0.17
	6	End W	0.23902	0.00702	0.08
	7	Start W	0.24263	0.00361	0.04
Brewer's Sparrow	1	Start T	0.20356	0.20356	*3.58
	2	Start W	0.29304	0.08948	1.65
	3	Start C	0.33325	0.04021	0.72
	4	End T	0.49692	0.16367	*3.58
	5	End C	0.58059	0.08367	2.00
	6	End W	0.59866	0.01807	0.41
	7	BS Plot	0.60064	0.00198	0.04

T = Temperature
W = Wind Velocity
C = Cloud Cover
*** = Significant at 0.01 level
** = Significant at 0.05 level
* = Significant at 0.10 level
d.f. = 1, 15.

Reasons for the lack of correlation among variables were not easily discernible. The occasional scarcity of meadowlarks during plots counts, e.g., only one seen on six plots on June 19, probably contributed to the low percentage of its variation that was accounted for by regression. This may have been partially true for Brewer's sparrow, also. However, this was certainly not true of the other three species. Also, it was expected that wind velocities would exert a greater effect on aerial singers, such as lark buntings or McCown's longspurs, than on perch singers like the Brewer's sparrow. However, the opposite was true. Lack of significance in this case was probably caused by the cessation of either census when wind velocities became extreme (usually 23 kmph or more).

Apparently, unknown or unmeasured factors, possibly concerning the observer or the phenology of the breeding season, determined the relationship between the two counts. It should be pointed out that the roadside area is a unique habitat with numerous singing perches and other features not found in the plots. Wallace (1970), using a more sophisticated analysis with seven climate-related variables and time of day, failed to find any significant relationship between these variables and numbers of birds recorded on roadside counts. To the contrary, Klonglan (1955) found significant correlations between five of six weather variables and time of day and numbers of ring-necked pheasants (Phasianus colchicus) seen on roadside censuses.

As part of the phenological aspect of the problem, it was known that lark buntings and Brewer's sparrows did not arrive on the Pawnee until after the breeding seasons for the area as a whole had already begun. Both of these species tended to remain in flocks near the roads for a time after their arrival before dispersing into their individual territories in the pastures. Therefore, it was suspected that counts made during this period prior to territorial establishment were strongly influenced by chance encounters with flocks and thus subject to unnecessarily large fluctuations when compared to later counts. For this reason, two data points collected during this time were omitted for both species, and test one was rerun.

The resulting values of the rerun (Table 24) were quite different in each case. The simple r-squared value for the lark bunting counts more than doubled from 0.42441 to 0.96658, indicating the roadside count alone was a fairly accurate predictor of the plot counts during the 1972 breeding season of this species. However, the contribution of the counts toward the multiple r-squared value increased little for the Brewer's sparrow, although some weather variable's contributions did show a substantial increase. Thus the decision to delete data points during migration for the reason stated appeared valid for the lark bunting, but only partially so, if at all, for the Brewer's sparrow.

In light of the general lack of correlation between the weekly roadside and plot counts, it seemed questionable if the roadside was a

Table 24. Results of rerun of test one of correlation analysis after deletion of two data points for lark bunting and Brewer's sparrow that were collected during migration. Plot counts are dependent variables and roadside counts and weather factors associated with plot counts are independent variables.

Species	Step No.	Independent Variable Entered	R^2	Increase in R^2	Partial F-Value
Lark Bunting	1	LB Road	0.96658	0.96658	***404.97
	2	Start W	0.97200	0.00541	2.51
	3	End C	0.98409	0.01209	*** 9.12
	4	Start T	0.98490	0.00081	0.59
	5	Start C	0.98586	0.00096	0.68
	6	End T	0.98595	0.00009	0.06
	7	End W	0.98598	0.00003	0.02
Brewer's Sparrow	1	End W	0.27878	0.27878	** 5.41
	2	Start C	0.41706	0.13828	3.08
	3	Start T	0.44607	0.02901	0.63
	4	BS Road	0.53969	0.09361	2.24
	5	End T	0.63555	0.09586	2.63
	6	Start W	0.70443	0.06889	2.10
	7	End C	0.72299	0.01856	0.54

T = Temperature
W = Wind Velocity
C = Cloud Cover
*** = Significant at 0.01 level
** = Significant at 0.05 level
d.f. = 1, 13.

useful technique. Therefore, it would be worthwhile to determine if the roadside procedure as used in this study was capable of reflecting even the direction (+ or -) of population fluctuations and at least the general magnitude of these changes. Table 25 permits an assessment of this.

In each of the five comparisons, the direction of change is accurately indicated by the roadside method. For horned larks, lark buntings and Brewer's sparrows the magnitude of the change is also closely mirrored. Only for McCown's longspurs and meadowlarks did the fluctuations in population size differ to any large degree between the methods, and then it was only by 12 percent at most.

Therefore, the roadside census was reasonably accurate in portraying year-to-year changes. However, it should be recalled that one of the main points of the study was the accuracy of densities, figures necessary for input into the grassland model. Incomplete coverage at numerous stops along the roadside route, due to inability to see the prescribed 0.4 km in all directions and other factors, precluded the conversion of numbers of birds seen along the route into actual densities, necessitating reliance on plot methods.

Factors Affecting Population Fluctuations

After verifying the occurrence of population fluctuations, the logical question is what are the causative factors. In an effort to determine some of these, possible relationships between bird numbers

Table 25. Comparison of avian population changes on the Pawnee Site, 1972-73, as assessed by the mapping and nest searching (M+N) and the roadside (RS) methods.

Species	1972 M+N[1] Density	1973 M+N[1] Density	Direction and % change	1972 RS[2] Average	1973 RS[2] Average	Direction and % change
Horned Lark	21.5	22.5	+ 4.7	149.1	159.2	+ 6.8
Lark Bunting	25.0	17.3	-30.8	280.2	211.5	-24.5
McCown's Longspur	9.0	11.0	+22.2	45.7	51.3	+12.3
Western Meadowlark	4.0	3.0	-25.0	106.5	92.0	-13.6
Brewer's Sparrow	12.5	9.5	-24.0	40.7	29.0	-28.8

[1]Total breeding pairs from the original six plots.

[2]Average number observed on routes during the breeding season.

and three weather variables--average monthly maximum and minimum air temperatures and total monthly precipitation (Figs. 9, 10, 11)--were graphically analyzed. Roadside counts of Giezentanner (1970) and Strong (unpub.) along with the present study furnished comparable population data for periods 1969 through 1973 (Fig. 12). Weather data for the Pawnee were available from personnel of the CPER and IBP.

Assuming that population patterns in Fig. 12 were responses to changing climatic conditions, it was obvious that different species were not affected to the same degree, if at all, by the same weather factors. No two species showed increases or decreases that coincided for all five years. However, some tendencies were noticeable, such as the sharp declines of both lark buntings and meadowlarks and the mirror image of McCown's longspurs and Brewer's sparrows. Suspecting amount of precipitation to be especially critical, this factor was also viewed on a seasonal basis (Fig. 13). Again, no cause-effect relationships were clear.

Admittedly, such casual analyses might have failed where computerized statistical programs might have revealed significant but hidden correlations. Factors pertaining to the winter range further confound the problem when dealing with migratory species such as these. Certainly, lack of positive results in this instance did not indicate a non-relationship. Francis (1967), working with a non-migratory species, found climatic parameters, e.g., soil moisture,

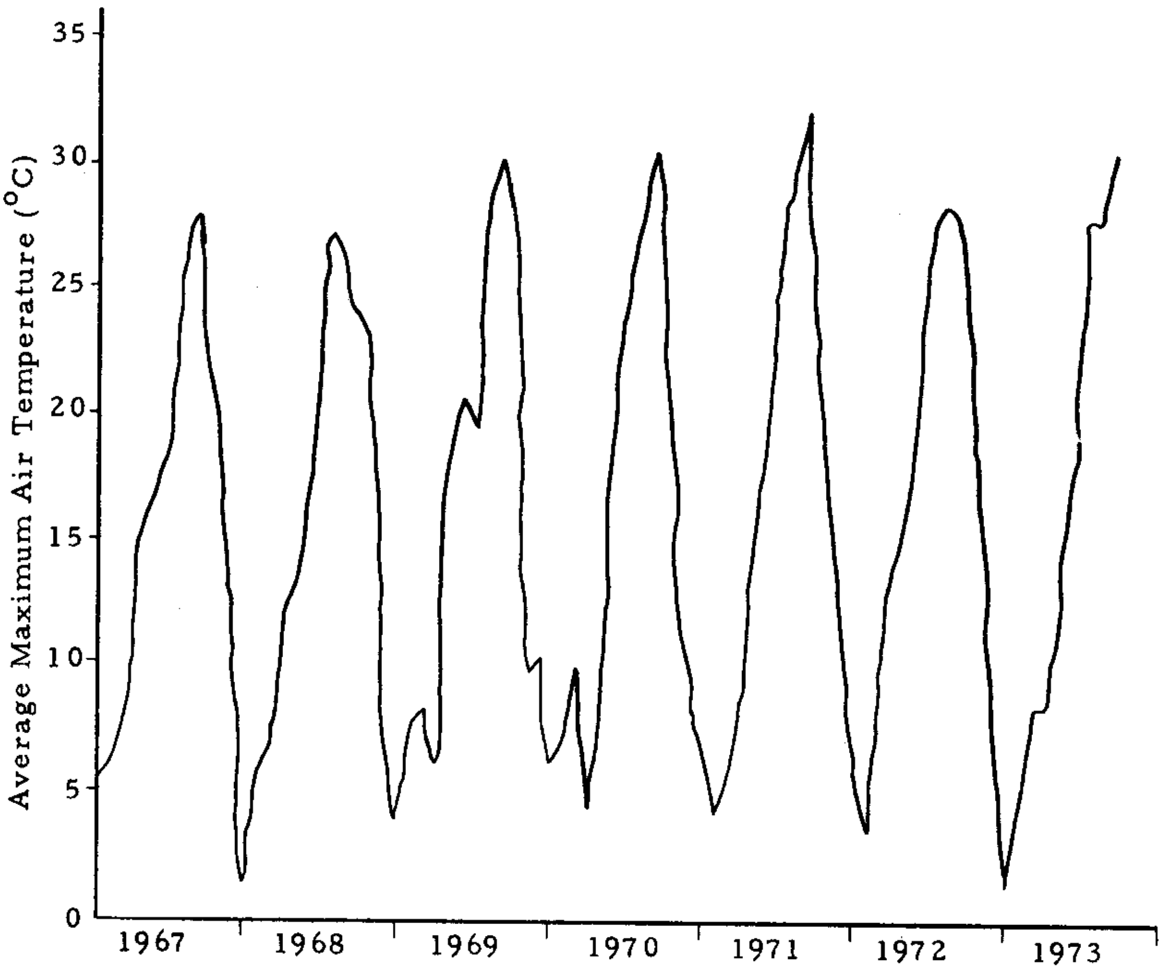


Fig. 9. Average monthly maximum air temperatures (°C) on the Pawnee Site, January, 1967-August, 1973.

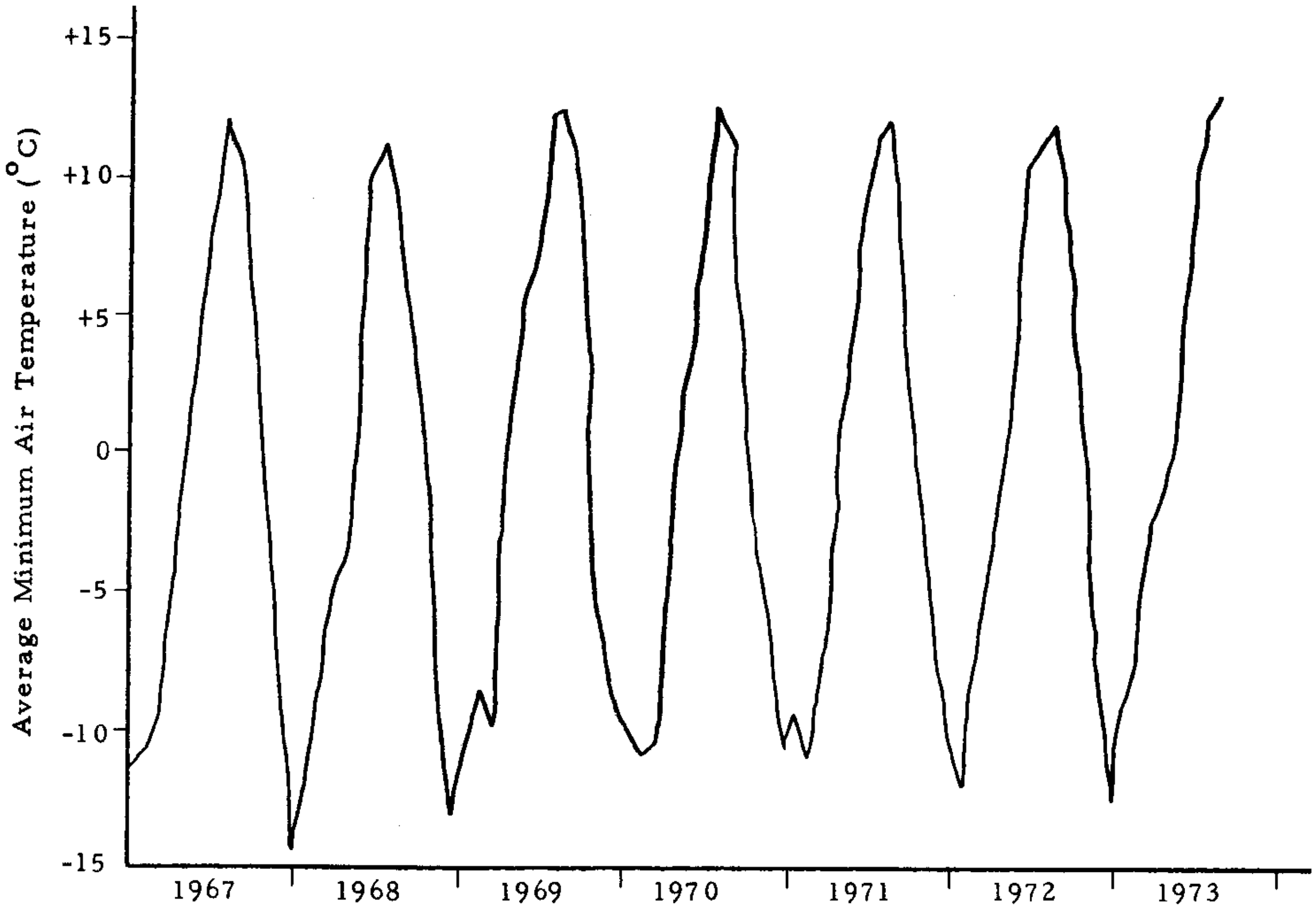


Fig. 10. Average monthly minimum air temperatures (°C) on the Pawnee Site, January, 1967-August, 1973.

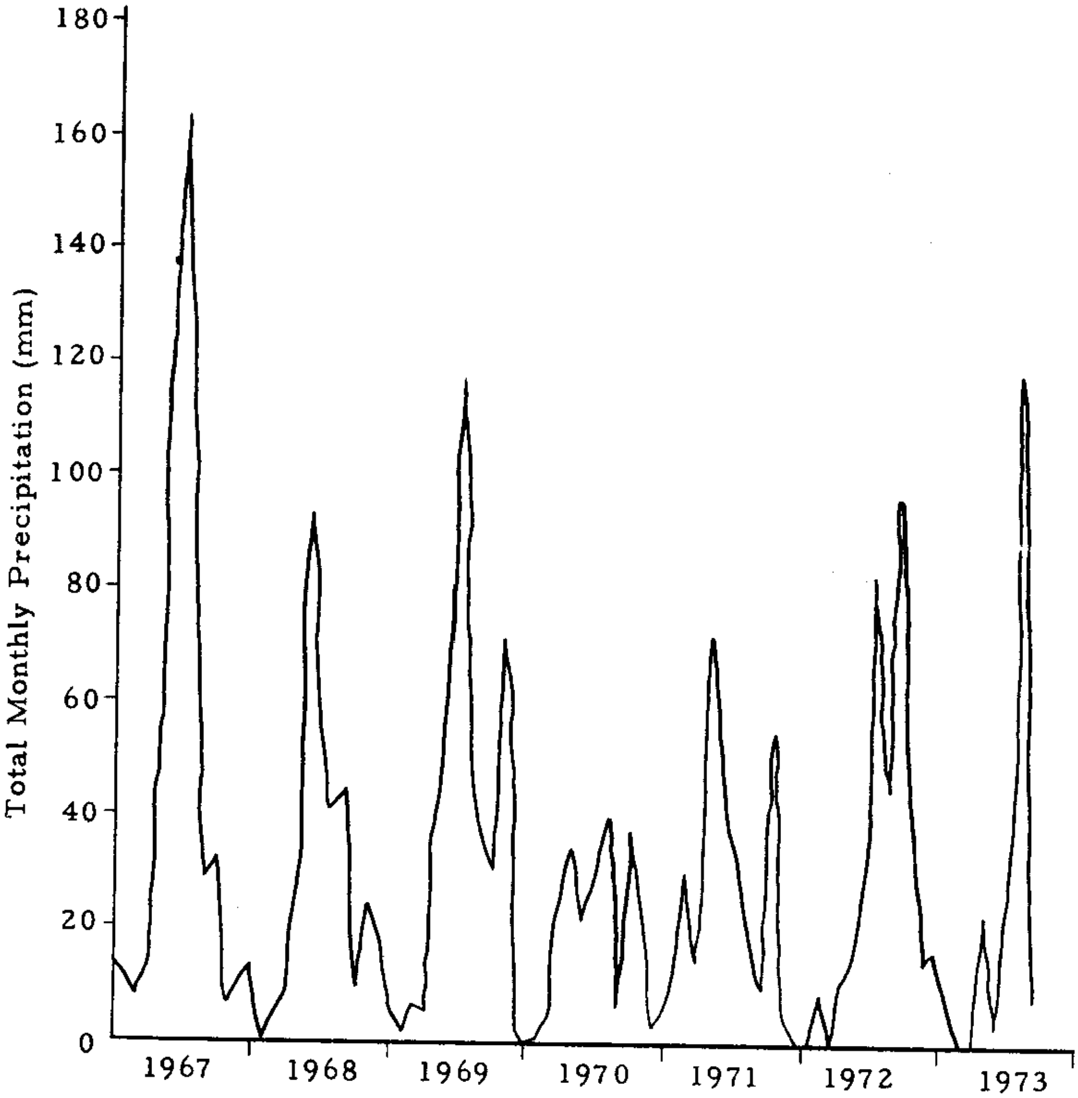


Fig. 11. Total monthly precipitation (mm) on the Pawnee Site, January, 1967-August, 1973.

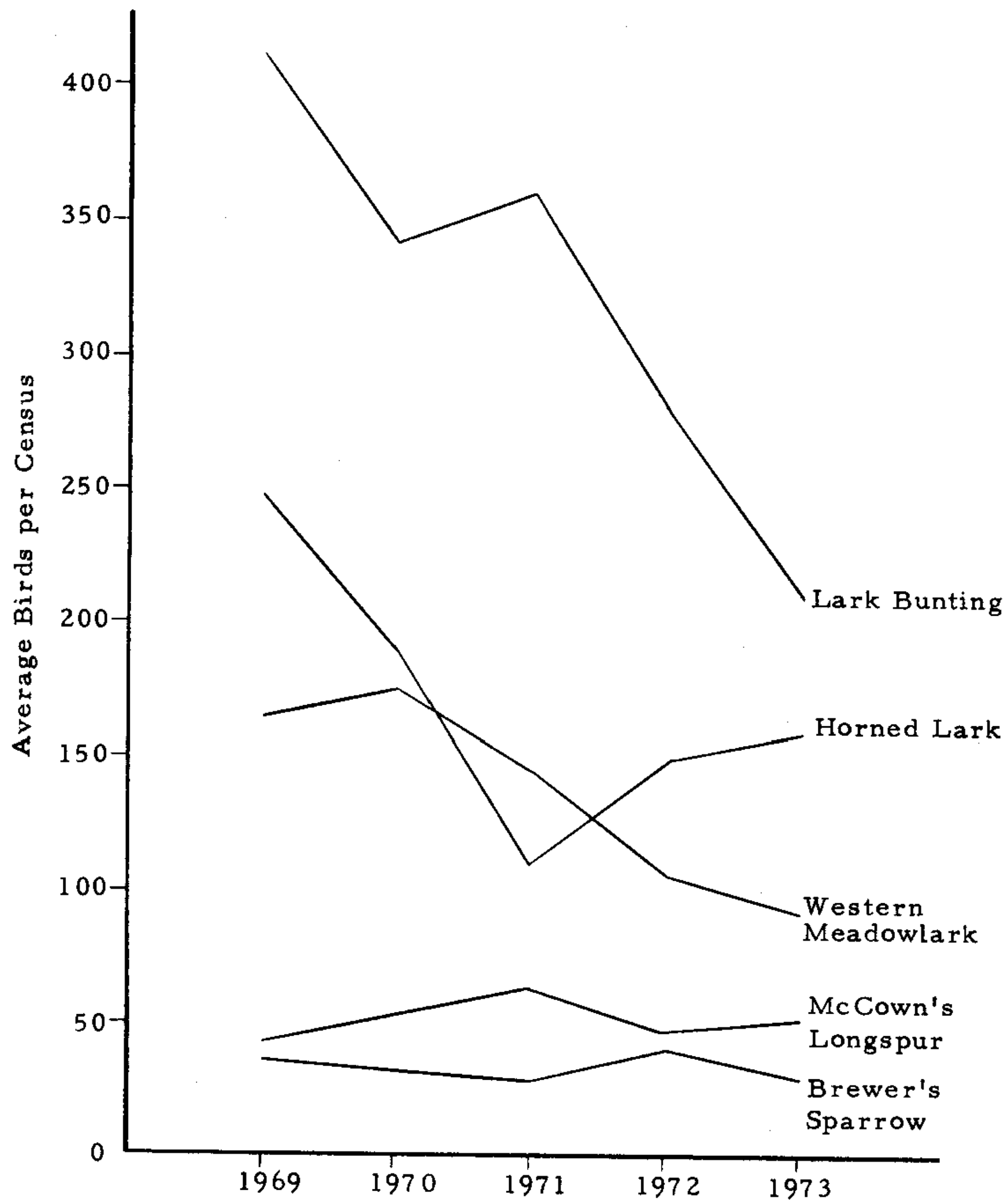


Fig. 12. Average numbers of birds seen on roadside censuses on the Pawnee National Grassland during the breeding season, 1969-1973.

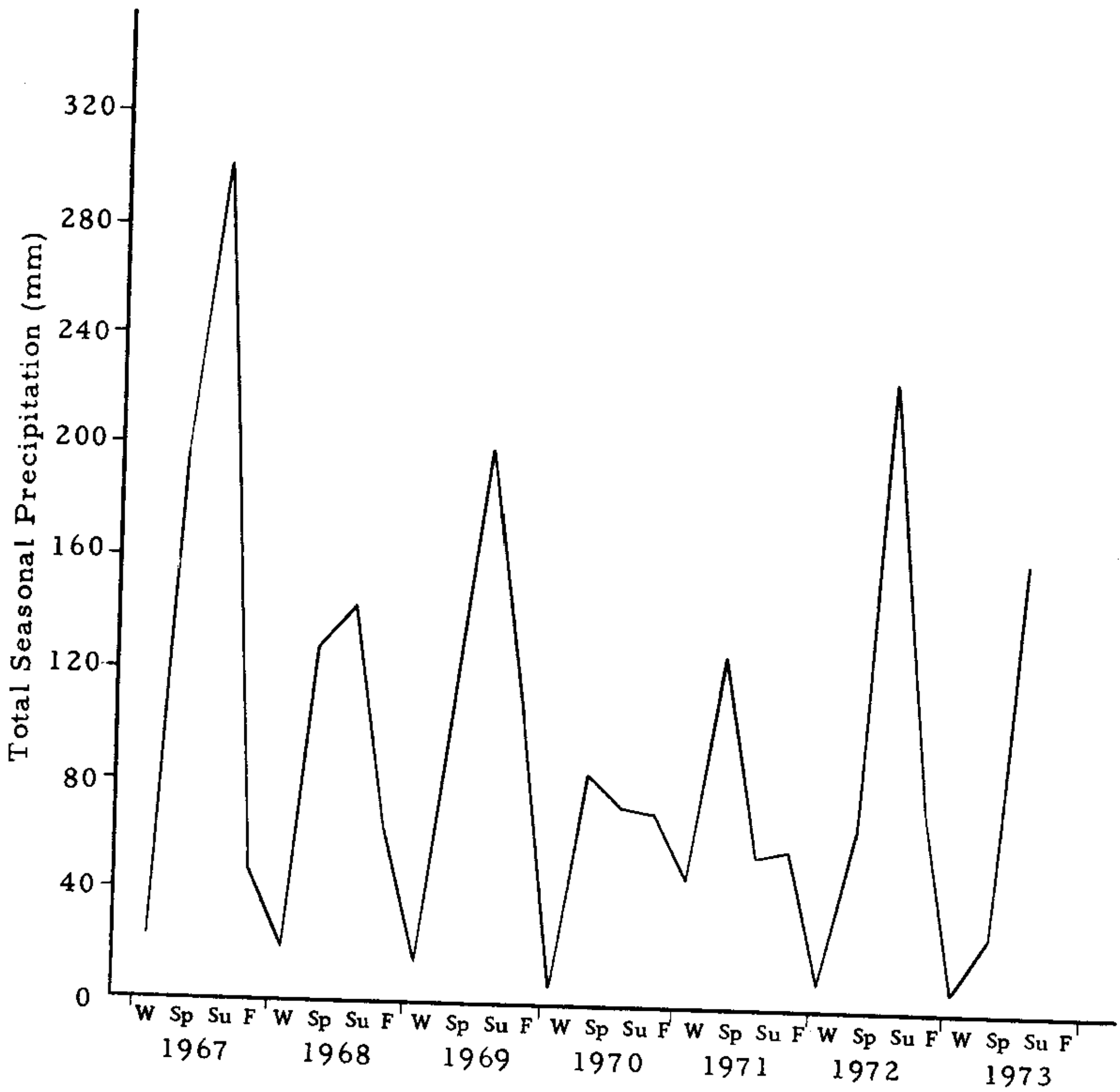


Fig. 13. Total seasonal precipitation on the Pawnee Site, 1967-1973. Seasons are winter (Dec., Jan., Feb.), spring (Mar., Apr., May), summer (June, July, Aug.) and fall (Sept., Oct., Nov.).

to be highly accurate for predicting population changes. Working on a much larger scale, Wiens (MS) aptly demonstrated the effect of long term climatic variations on bird population.

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APPENDIX A

For a further discussion of this appendix, see Appendix I on pages 58-62 of US/IBP Grassland Biome Technical Report No. 171 (Ryder 1972).

APPENDIX A

PLOT COUNTS

Section ______________________

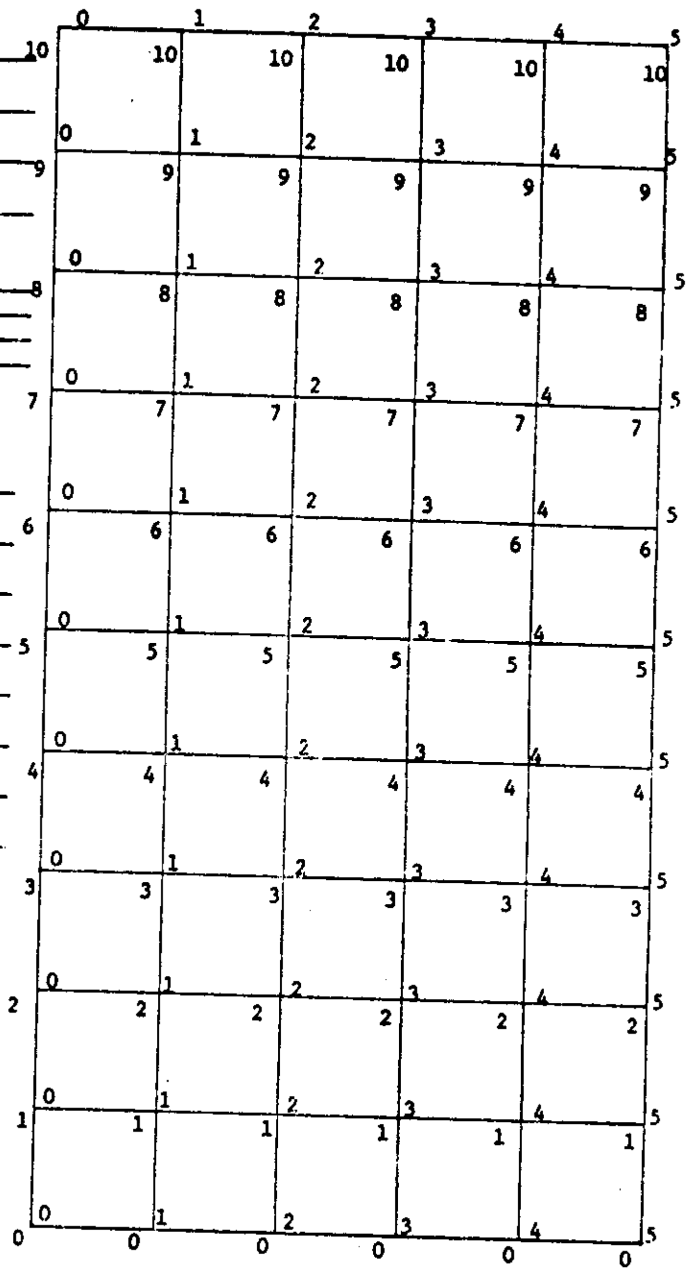
Date ______________________

Time __________ to __________

Observer ______________________

Weather
- Wind ______________________
- Temp ______________________
- Sky ______________________
- Other ______________________

Species	Number



Key:
- X = Lark Bunting ♂
- X̲ = Lark Bunting ♀
- O = Horned Lark
- W = Western Meadowlark
- H = McCown's Longspur
- B = Brewer's Sparrow
- ≻—O→ = Flew over plot, did not land
- ≻—O = Flew on to plot and landed
- O→ = Flushed on plot and flew off of plot
- (dashed circle) = Aggressive Encounter
- - - - - - - - = Contemporary Sighting
- ✱ = Singing
- + = Flying over 50 feet
- — = Flying under 50 feet

APPENDIX B

For a further discussion of this appendix, see Appendix I on pages 71-77 of US/IBP Grassland Biome Technical Report No. 252 (Porter and Ryder 1974).

IBP

GRASSLAND BIOME

U.S. INTERNATIONAL BIOLOGICAL PROGRAM

FIELD DATA SHEET--AVIAN NESTING A2U209

Data Type	Site	Gen/Spp	Nest No.	TWP	Range	Sec	Ht (cm)	Habitat	Code
1-2	3-4	5-8	9-12	13-15	16-18	19-20	21-24	25-69	70

Data Type	Site	Initials	Date			Time	Eggs	Young	Age	Adult	Number	Weight	Length	Primary	Number	Weight	Length	Primary	Number	Weight	Length	Primary	Number	Weight	Length	Primary	Code
			Day	Month	Year																						
1-2	3-4	5-7	8-9	10-11	12-13	14-17	18-19	20-21	22-23	24-25	26	27-30	31-33	34-36	37	38-41	42-44	45-47	48	49-52	53-55	56-58	59	60-63	64-66	67-69	70
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Site
01 ALE
02 Bison
03 Bridger
04 Cottonwood
05 Dickinson
06 Hays
07 Hopland
08 Jornada
09 Osage
10 Pantex
11 Pawnee

Number
E EGG
1,2,...,N Bird No.

Code
C Comment follows
S Nest summary card follows

Adult
01 Building
02 Incubating
03 Brooding
04 Near nest, alarmed
05 Not seen
06 Other

Outcome
01 Fledged, young seen leaving nest
02 Fledged, adults excited near
03 Fledged, adults with young near
04 Fledged, nest empty, in tact
05 Failure, nest deserted
06 Failure, weather
07 Failure, predator
08 Failure, other
09 Unknown

Data Type	Site	Initials	Date			Time	Outcome	Eggs Laid	Incubation Period	Eggs Hatched	Fledging Period	Young Fledged	Comments	Code
			Day	Month	Year									
1-2	3-4	5-7	8-9	10-11	12-13	14-17	18-19	20-21	22-23	24-25	26-27	28-29	30-69	70
26														

APPENDIX C

APPENDIX C

NORTH AMERICAN NEST-RECORD CARD PROGRAM — YEAR — Shaded Boxes not to be completed by observer

Species: [1 1] [9] [5] [9] [14]

Observer (two initials, last name) In squares in space opposite → [15] [17]

Locality (in relation to nearest town)

County

State or Province [34] [36]

Elevation (in feet above sea level)

Fill in if known: Latitude [29] [31] [33] Longitude [41] [44]

HABITAT (circle where appropriate)
1. Woods 2. Swamp 3. Marsh 4. Field 5. Grassland 6. Desert 7. Tundra 8. Suburban 9. Urban
0. Other (specify) [46]
01. Coniferous 02. Deciduous 03. Mixed 04. Orchard 05. Cultivated 06. Fallow 07. No Veget. 08. Hedgerow
09. Shrub 10. Salt 11. Brackish 12. Fresh 13. Sandy Beach 14. Gravel Beach 15. Other (specify) [47]
DOMINANT PLANT(S) IN HABITAT (list one or two) [49] [55]

NEST SITE (circle where appropriate)
01 Bare ground 02 On ground in vegetation 03 Floating 04 Low vegetation 05 Shrub 06 Palm 07 Deciduous tree branch
08 Deciduous tree cavity 09 Conifer branch 10 Conifer cavity 11 Nest box 12 Other structure 13 Cliff or bank [61]
14 Other (specify)
PRINCIPAL PLANT OR STRUCTURE SUPPORTING NEST [63]

Height of Eggs Above Ground or Water in Feet (feet and tenths if under five feet) [72] Feet Tenths [76]

If parasited by Cowbird check here ☐ and see instructions.
If same pair had other nestings this year, indicate which this is (1, 2, 3) (use separate card for each nesting) [77]

rev. 5-4-71 PLEASE COMPLETE BOTH SIDES OF THE CARD [78] [79] [80 1]

No. Col. 1-10 (Col. 1-14, card 2) — If used for colonial nesting check here ☐ and see instructions

	DATE		Eggs	Young	Edit		Build-ing	Adult On	COMMENTS Stage of building, if eggs warm, age of young, if banded, etc.
	Month	Day							

OUTCOME INCLUDING CASES WHERE OUTCOME UNKNOWN (circle where appropriate)
01 Unknown because not revisited
02 Young seen leaving nest
03 Parent(s) excited near nest
04 Parent(s) with young near nest
05 Nest empty, intact
06 Nest empty, damaged
07 Nest deserted
08 Failure due to weather
09 Failure due to predation
10 Failure due to invertebrate parasites
11 Failure due to cowbirds
12 Failure due to competition with other species
13 Failure due to human activities
14 Failure due to pesticides (give details separately)
15 Other (describe above) [76] [77]

Please complete both sides and return at end of season to your Regional Center or to Laboratory of Ornithology, Cornell University, Ithaca, New York 14850. We thank you for your time and efforts to this program. [78] [79] [80 2]