WILDLIFE POPULATION AND HABITAT EVALUATION ON A NORTHCENTRAL OKLAHOMA SITE USING LANDSAT-1 IMAGERY

By

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LANDSAT-1 IMAGERY

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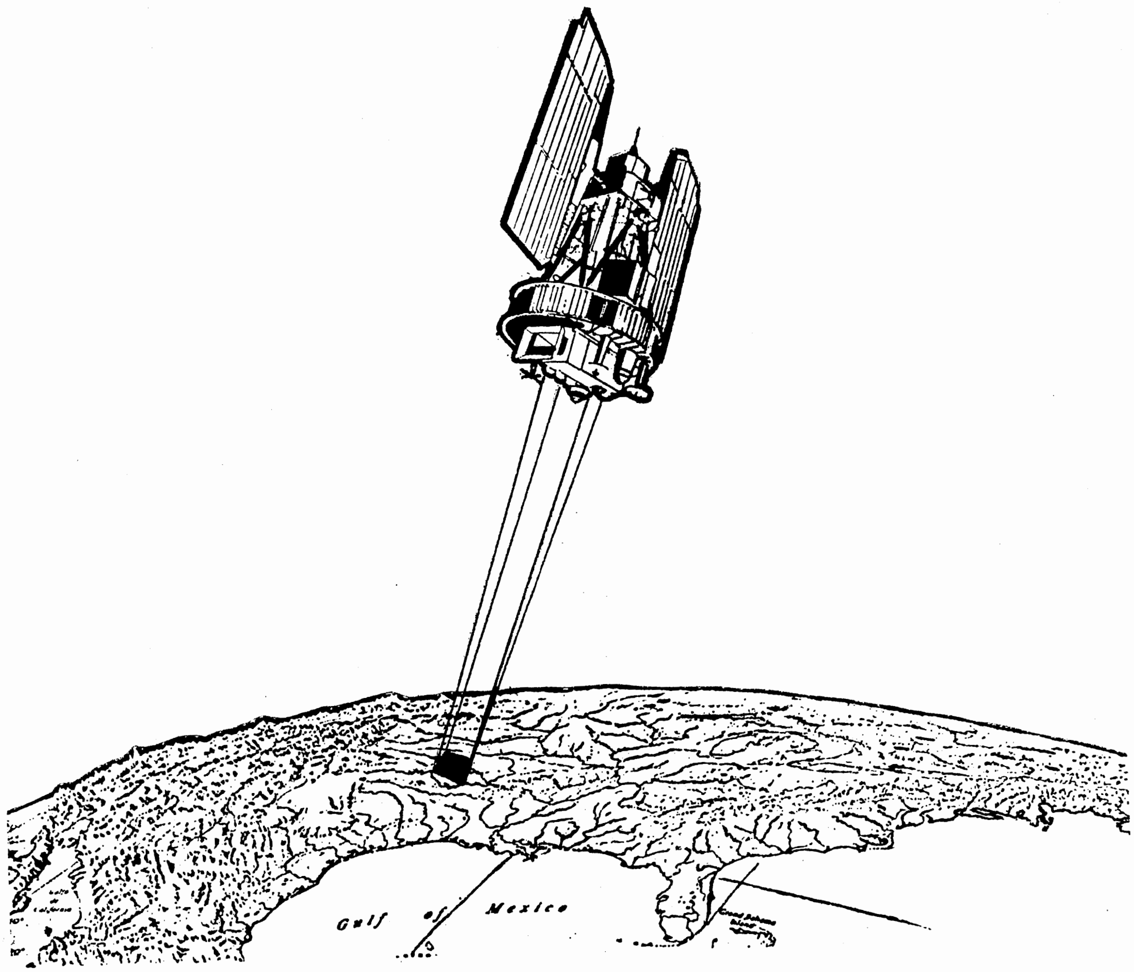

Gulf of Mexico

CHAPTER I

INTRODUCTION

Statement of Problem

A challenge which has confronted wildlife biologists for many years is the need to develop cost-effective techniques for assessing the real and/or inherent biological values of specific land or water areas. This problem has been brought into sharper focus with the ongoing development of ecological planning and evaluation procedures by Hickman (1974), and similar developments by other resource management agencies and institutions. Most approaches to habitat classification and evaluation appear to be largely experimental. Additional testing of many procedures appears warranted before uniform standards will be available as evidenced by the diverse viewpoints expressed at the 1976 National Symposium on the "Classification, Inventory and Analysis of Fish and Wildlife Habitat."

Many wildlife ecologists have, in recent years, sought to apply many sophisticated advances in rapidly developing technological data to persistent problems of wildlands management and evaluation (Giles 1969: 73, Adams 1969:92). One of the most promising of these technological advances is satellite imagery. This study was conducted in an effort to investigate the feasibility of utilizing LANDSAT-1 satellite imagery in wildlife resource evaluation.

Literature Review

Remote sensing had its beginning as early as 1935 when black and white aerial photographs of the scale 1:20,000 first became available for limited areas (Mayer 1950). An acceleration in aerial photographic work occurred during and following World War II (Henriques 1949). Surprisingly, even today first-time coverage at acceptable scales is being flown over important areas (Poulton 1970).

In more recent years such airborne remote sensing instruments as the panoramic camera, the multiband camera, the optical-mechanical scanner, side-looking airborne radar, and the gamma ray spectrometer have shown promise in providing more specific and sophisticated information concerning our environment (Colwell 1968).

With the launch in July 1972 of the Earth Resources Technology Satellite-1 (LANDSAT-1) a new era was born in the monitoring of earth's resources and environment. Data are collected via a multi-spectral scanner (MSS) in four electromagnetic bands (i.e., green, red and two near-infrared bands) and stored on computer compatible magnetic tape. The advantage of the LANDSAT-1 satellite over conventional data gathering methods are many. Greater speed, accuracy and convenience of data collection are obvious attributes of the system. Because the satellite's orbit carries it over the same point once in approximately every two weeks, monitoring of any changes in land use or environmental effect is readily accomplished (Auburn University Engineering Systems Design Summer Faculty Fellows 1972). Many other advantages may be seen depending upon the specific nature of the study involved.

The majority of the studies to date involving the use of LANDSAT-1 data have concerned its application in agriculture, geology (mineral production) and city or metropolitan area planning (NASA 1973, NASA 1974). Little attention has been paid this new tool in the more "natural" areas of land use planning such as wildlife habitat assessment. Much of the wildlife work that has utilized LANDSAT-1 or other remote sensing data has been restricted to wetlands (Anderson 1968, Anderson 1969, Burge and Brown 1970, Nelson et al. 1970, Gilmer et al. 1973, Work et al. 1973, Cowardin and Meyers 1974, Work and Thompson 1974, Work et al. 1974a and 1974b), although more terrestrial applications are appearing in the literature (e.g., McKeon 1977, Anonymous 1976).

Application to the Study Area

The Lake Carl Blackwell Land Use Area (LCBLUA), established as a federal demonstration project area during the mid-1930's, presented an acceptable site for use of LANDSAT-1 data along with other more conventional techniques in evaluating the wildlife resource. The size of the area (8,097 ha) lends itself well to this type of analysis. It is not so extensive that one worker cannot, with the aid of LANDSAT-1, cover the area in a reasonably short duration. By the same token, this size does warrant the use of satellite data over more conventional mapping techniques. Because of the limited amount of time and manpower available, together with the lack of current vegetative cover data for the study area, the use of a system such as LANDSAT-1 was invaluable in this study.

Objectives

This study sought to establish a data base on which decisions could be made regarding usage of lands owned by Oklahoma State University. In this light the objectives were: (1) to test the validity of applying LANDSAT-1 data to a wildlife resource evaluation problem; (2) to survey vegetative cover types regarding their present and potential value to wildlife populations; (3) to survey (index) the relative abundance and distribution of wildlife populations on the study area; (4) to suggest management practices for the study area based on data collected.

During the initial phases of this study it was determined that a more detailed evaluation of the techniques being examined could be better accomplished using a smaller study area. As a result this study dealt only with approximately 2,330 hectares of the LCBLUA located south of State Highway 51 and east of Coyle road. Lack of time, manpower and experience in using LANDSAT-1 data warranted this reduction of study area size.

Summary of Chapter Purposes

Chapter I contains a problem statement, literature review, objectives and this summary in order to explain purposes and motivations for this study. Chapter II describes the study area. Techniques used in data collection are presented in Chapter III. The results obtained using these techniques are presented along with analyses and discussion in Chapter IV. Chapter V contains a synthesis of these findings into various management suggestions for the study area. It is hoped that this chapter will provide some guidance to future managers of the study area. Chapter VI provides an overview of the thesis.

CHAPTER II

DESCRIPTION OF STUDY AREA

The study area was located on the Lake Carl Blackwell Land Use Area (LCBLUA) in northwestern Payne County, northcentral Oklahoma. This study area contained 2330 hectares and comprised that portion of the LCBLUA south of State Highway 51 and east of Coyle Road (Fig. 1).

Historical Background and Land-use

The LCBLUA was originally established by the Federal government as a Land Utilization Demonstration Project for research and demonstration of techniques to rehabilitate abused land (Park 1937). The Project was never completed and, in 1948, the area was leased to Oklahoma State University. As stated in the lease, the

> . . . prime purpose of this project is that of demonstration of readjustment in the former uses of land to more desirable uses yielding the highest stabilized potential well-being, and that, in effectuating this more desirable use, the future administration of the project will be carried out as a co-ordinated program under the supervision of the University (Anonymous 1948:1).

In 1954, the entire 8,097 hectare area was deeded to the University (Anonymous 1954). The chief land use activity on the study area since 1954 has been grazing by cattle through private lease contracts (personal communication, Satterfield 1977). A map of the lease pastures is found in Fig. 2. Pasture 10 came under the jurisdiction of the Departments of Botany, Zoology, and Entomology in 1967 and in 1974 under

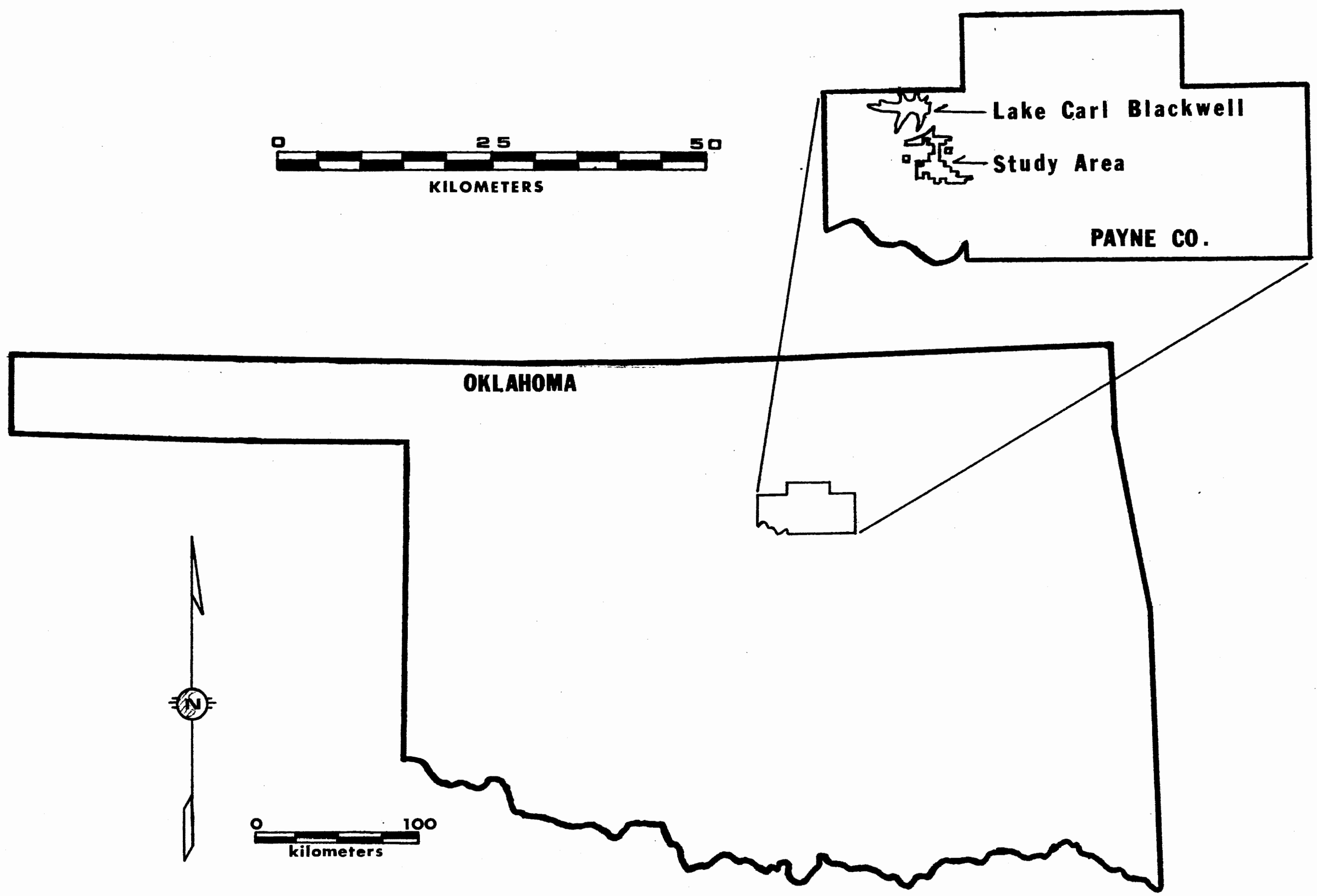


Fig. 1. Relative location of the study area.

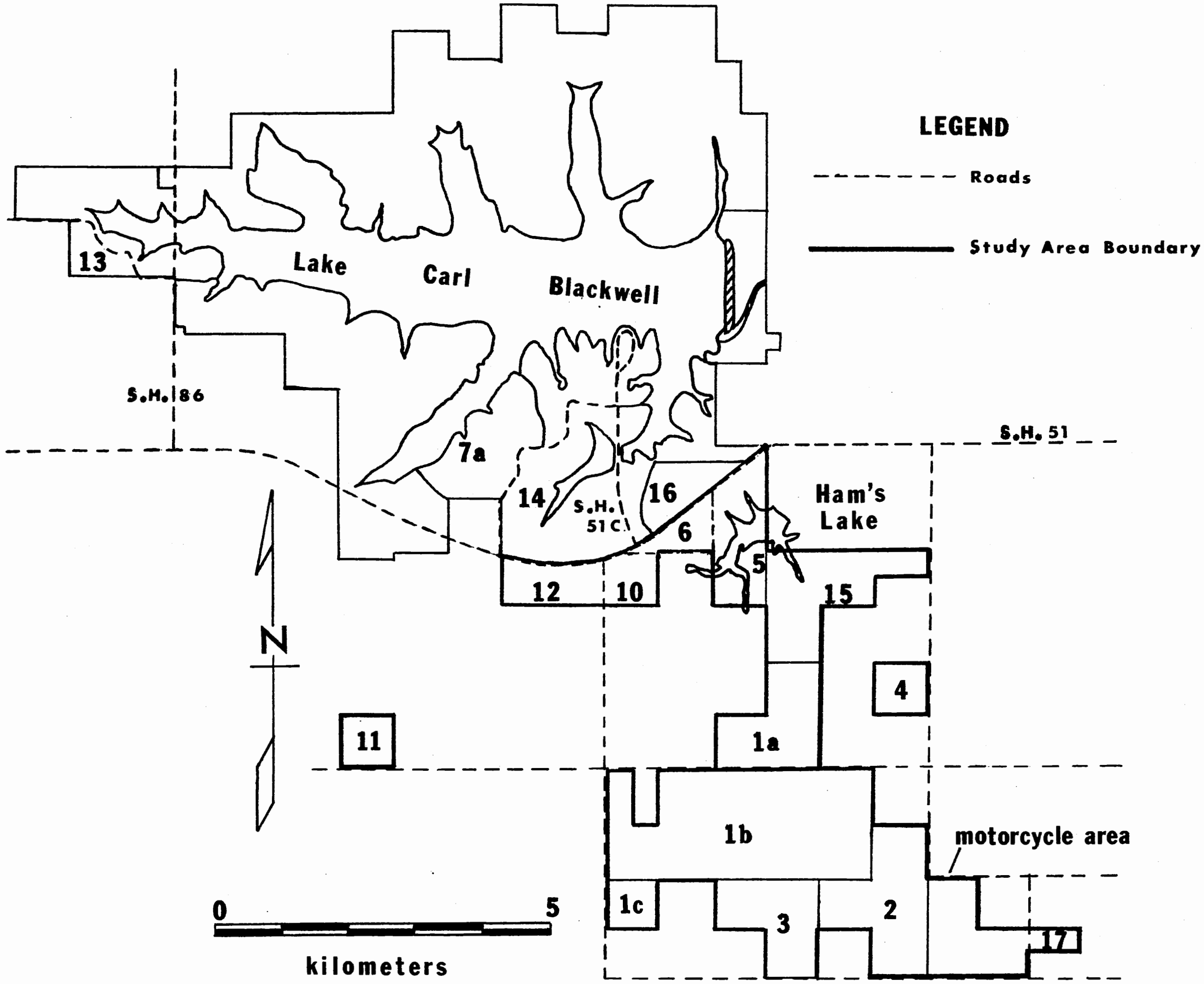


Fig. 2. Location of grazing units on the LCBLUA as of January 1977.

the School of Biological Sciences as the Oklahoma State University Ecology Preserve (personal communication, McPherson 1975). The School of Biological Sciences also controls pasture 4 (gained control in 1976). Pasture 17 was leased in 1972 to the City of Stillwater as a trail bike area. The City of Stillwater and the Stillwater Motorcycle Club have recently (fall 1976) leased a portion of pasture 2 as another motorcycle area. The Department of Animal Science has operated pastures 11 and 6 as grazing units since the late 1960's (personal communication, Satterfield 1975). The Department of Forestry maintains 1 c as an outdoor laboratory.

Climate

The study area has a Cfa, continental warm summer climate with average annual precipitation of 82 cm and an average annual temperature of 16° C (Oklahoma Water Resources Board 1972). The growing season approximates 210 days (Environmental Data Service 1972). Extremes in temperature, wind and precipitation are common (Myers 1976).

Soils, Geology and Topography

Three major soil groups occur on the study area (Brensing and Talley 1940a, Payne County Soil Conservation District 1973). The distribution of these groups is shown in Fig. 3. A general description of each group includes the following:

1. Reddish soils of the rolling prairie upland. The Renfrow-Zaneis-Vernon association occupies gently rolling plains underlain by interbedded sandstones and clay beds. These soils have a high clay

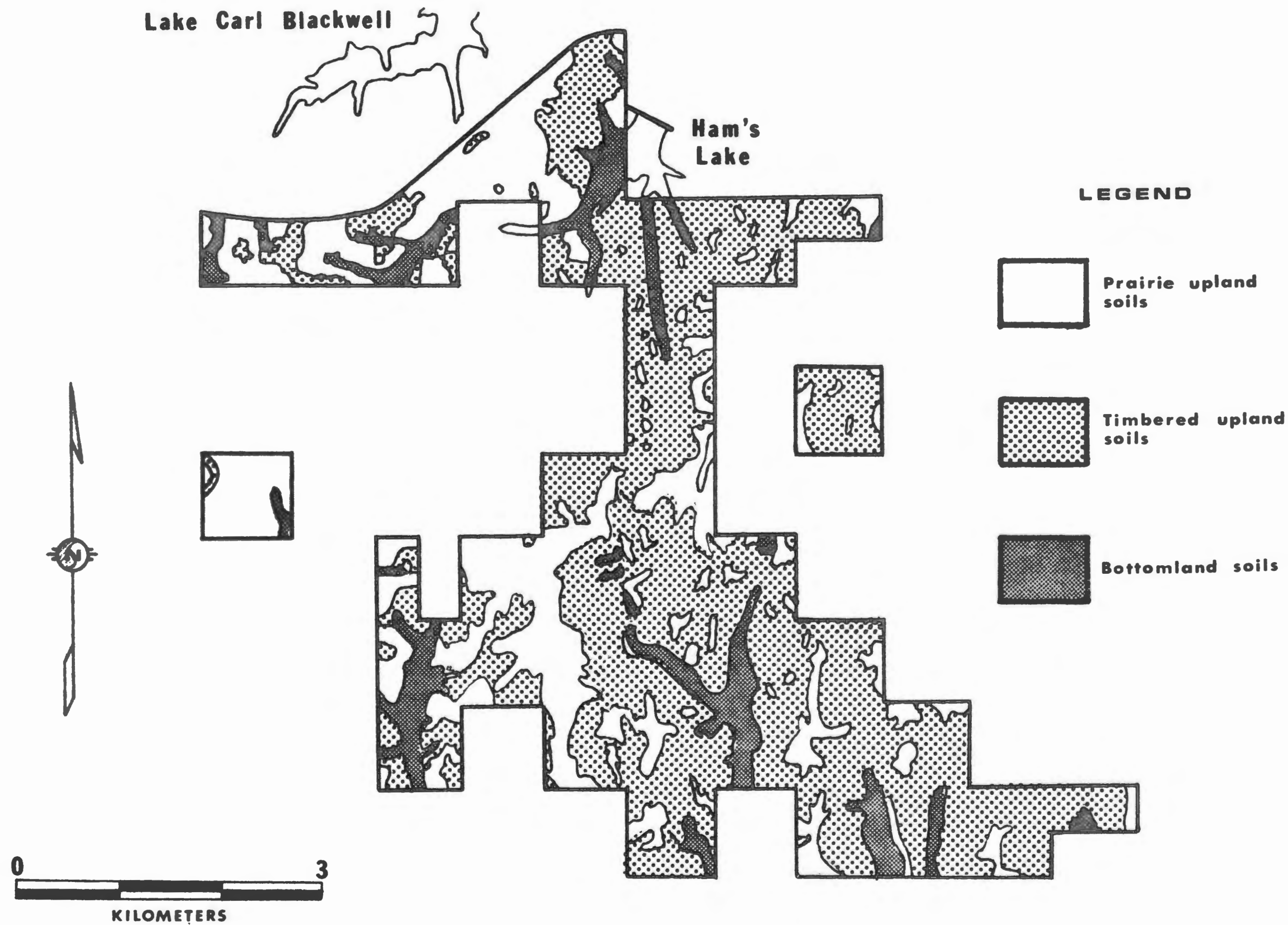


Fig. 3. Relative distribution of soil associations on the study area.

content. They have developed under the native grassland vegetative cover type.

2. Light brown soils of timbered upland. Darnell-Stephenville: Darnell soils are shallow, underlain or sometimes overlain by sandstone. Ledge rock outcroppings are common. Stephenville soils are moderately deep with developed subsoils occupying ridges and gentle slopes. These soils are generally sandy and have developed under the upland hardwood vegetative cover type.

3. Deep soils of the flood plains and low benches. Yahola-Reinach: Soils of the Yahola-Reinach association are the most common soils of the stream bottoms and low terraces. These soils have been derived from red Permian age sedimentary parent materials and developed under the bottomland hardwood vegetative cover type (Brensing and Talley 1940b).

The study area is rolling but contains some small uplands that are nearly level. The average elevation is under 305 m, ranging from 344 m to 287 m. The LCBLUA lies within the drainage of the Cimarron River (Payne County Soil Conservation Service 1973). The northeast portion of the study area is drained by Harrington Creek. The remainder drains into Wildhorse Creek to the south. Harrington Creek forms an arm of Ham's Lake while Wildhorse Creek is a tributary of the Cimarron River.

Vegetation

The LCBLUA lies within the boundaries of the southern tall grass prairie vegetation region (Smith 1966) and more specifically within the reddish prairies and cross timbers resource areas of Oklahoma (Oklahoma Water Resources Board 1972). The vegetative cover types identified on the study area for the purposes of this study include native grassland, upland hardwood forest, bottomland hardwood forest, oak-savannah-brush, aquatic sites and eroded sites. The climax dominant plant species which are characteristic of these types on the study area include: native grassland--little bluestem (scientific names appear in Appendix A, p. 106), big bluestem, switchgrass and Indiangrass; upland hardwood forest--post oak and blackjack oak; bottomland hardwood forest--elm, pecan, sumacs, poison ivy, wildgrape, virginia creeper and hackberry; oak-savannah-brush--post oak, blackjack oak, sumacs, poison ivy and wildgrapes; aquatic sites--pondweeds and smartweeds; eroded sites--sideoats grama, little bluestem, bluegrama, hairy grama and buffalograss (Anonymous 1964).

Hydrologic Features

The study area is drained by numerous small intermittant and ephemeral streams. Many springs are found along these drainages. During dry periods, flow ceases in these streams with pools forming below these springs. A number of man made impoundments have been constructed on and surrounding the study area. They include Lake Carl Blackwell, Ham's Lake and numerous farm ponds and SCS-type (PL-566) structures.

CHAPTER III

METHODS AND MATERIALS

Evaluation of Habitat

Distribution of Vegetative Cover Types

The well-being of any wildlife population is determined by the presence of suitable habitat, and especially by the distribution of various vegetative cover types (Giles 1969, Frye 1973). Determination of the distribution of the vegetative cover types on the study area was accomplished by the analysis of various early (c. 1940) vegetation and soils maps plus aerial photographs (A.S.C.S. 1969) and classification of MSS data collected by the LANDSAT-1 satellite. Satellite data processing was carried out in collaboration with Dr. Ron Oines of the Oklahoma State University Research Foundation. The satellite data (scene) used in this study were collected 5 April 1973.

In order to utilize these MSS data in the determination of cover type distribution, various analysis and refinement techniques were employed. Since the data were given as a matrix of reflectance values, i.e., a vector of four for each pixel (picture element), a multivariate statistical analysis technique which linearly explains variance structures (principle component analysis, Morrison 1967) was helpful in interpreting the data matrix. Using this technique, principle component values were generated for each vector, such that the first described a line in four dimensional space which lay along the pathway of the greatest amount of linear variance in the data set. Since the first two principle component values explained virtually all of the variation (99%) in the data set, these numerical values were used to classify each pixel or matrices of pixels (e.g., 1 x 1, 2 x 2 or 3 x 3 matrices) within that scene into divisions (classes). This was accomplished by assigning value ranges around the first two principle components into which the value of a pixel must fall in order to be accepted into a specific class. (This procedure is termed unsupervised classification.) In this study, six classifications were used, corresponding to the 6 cover types. The ranges about the principle components were determined through ground-truthing and comparison of computer-generated maps with existing vegetative conditions and distribution. The value ranges used in this classification system are presented in Table 1 with their corresponding vegetative cover types and classification symbols.

Habitat Diversity

The study area was divided into forty 64.75 hectare units (quarter-section plots). From the classified satellite data, percentages of each cover type were computed by plot. These plots are shown in Fig. 4.

From the results of the classification of the principle component data, a vegetative cover diversity index (H) was computed for each plot using the formula (Shannon and Weaver 1964):

$$H = -\Sigma \left(\frac{ni}{N}\right) \log \left(\frac{ni}{N}\right)$$

Table 1. Value ranges used in unsupervised classification of satellite data by vegetative cover type.

Cover type	Map Symbol	Distance from principle component I	Distance from principle component II
Native grassland	@	-3.9000	0.0000
Oak-savannah-brush	#	-0.9000	1.7000
Eroded sites	*	5.1000	-1.6000
Aquatic sites	$	-7.8000	4.0000
Bottomland hardwood	-	-10.7000	-3.5000
Upland hardwood	+	-7.2000	-2.1000

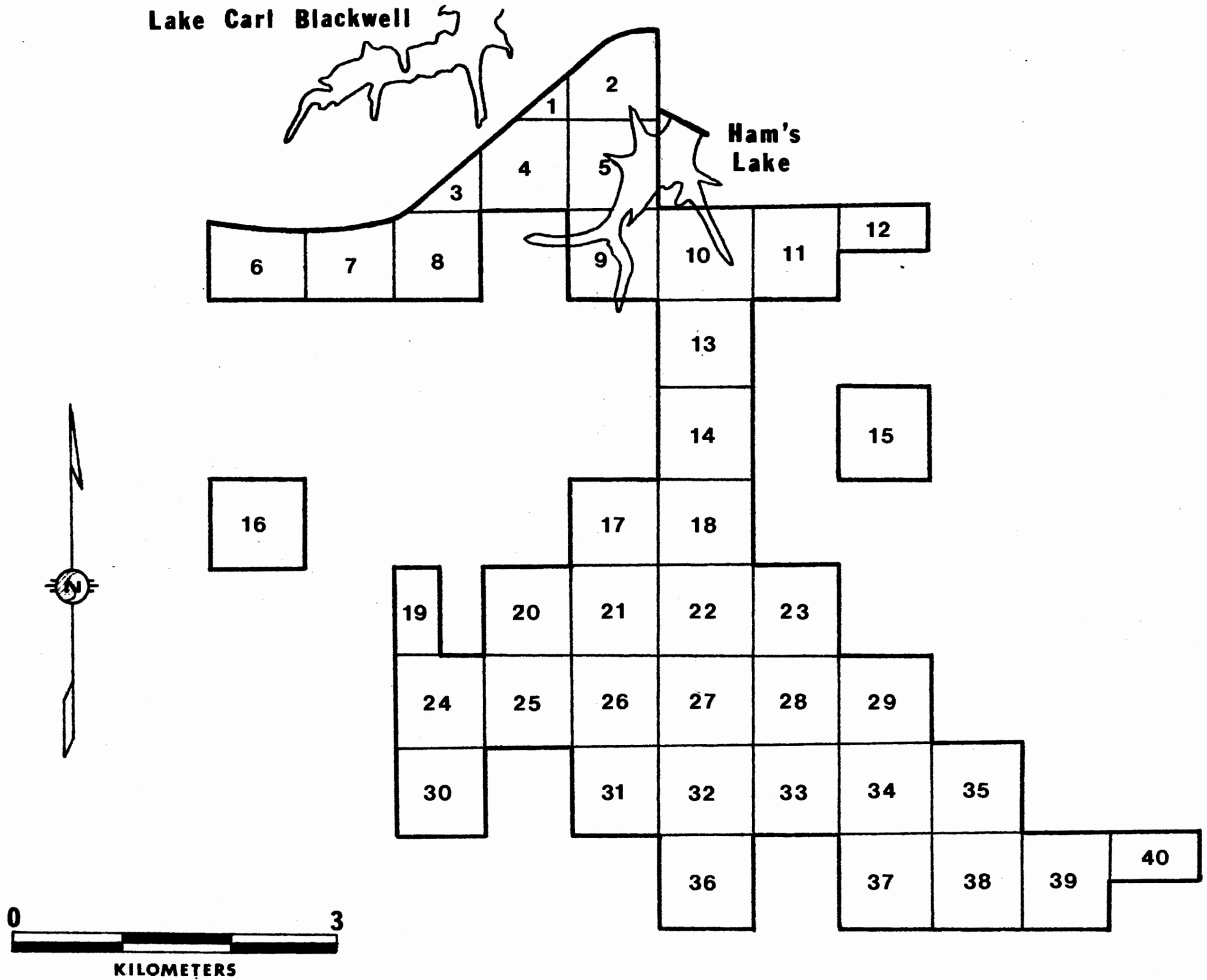


Fig. 4. Location of plots on the study area.

where ni = number of pixels within the i^{th} tract (a subunit of distinct vegetative cover type within a plot)

N = total number of pixels within a plot

log = natural logarithm.

Homogeneous tracts of a given cover type were used for diversity calculations rather than the total area of each cover type in order to gain a more realistic comparison of the amounts of edge within plots. This was justified under the precept that the amount of edge is a definitive expression of habitat quality (Yoakum and Dasmann 1969, Baxter and Wolfe 1973). In this manner, vegetative cover diversity index values were derived for each plot. MacArthur and MacArthur (1961) used a similar application of the Shannon-Weaver diversity formula in their study of vegetative height diversity in relation to avian diversity.

Present and Potential Habitat Productivity

In order to assess the present values of each cover type to the faunal populations occupying them, a habitat evaluation survey was performed during the summer of 1975. This survey followed basic techniques adopted by the U. S. Fish and Wildlife Service (Hickman 1974). Sampling sites within each vegetative cover type were evaluated on a scale of 1 to 5 by 0.5 increments regarding their estimated capability of meeting the requirements of one primary species from each major faunal group (i.e., big game, upland game mammals, furbearers, non-game mammals, upland game birds, waterfowl, other water and marsh birds, non-game birds and reptiles and amphibians). These values were assigned for food and cover in 1 to 3 vertical habitat strata (overstory, understory and ground cover). Criteria for assigning values were based on a search of the literature. Ten sample sites, chosen at random, were evaluated in the above manner in each cover type (60 sample sites in all). Average index values were obtained for each cover type, vertical stratum and habitat parameter within the stratum for all cover types.

In conjunction with this habitat evaluation survey, and as an additional means of assessing the present and potential value of each cover type to wildlife. Soil samples were collected from each habitat evaluation sample site. Sampling was accomplished by the use of soil probes to a depth of 13 cm (one probe per site, 10 probes per cover type). Soil samples from all sites within each cover type were then pooled for analysis. A detailed soil content analysis was conducted by the Oklahoma State University Soil Testing Laboratory. Parameters examined included percent organic matter; pH; p.p.m. NHy, NO_3-N, K, Ca, Mg, Fe, Zn, Mn, Na; and percents sand, silt and clay. The results of this analysis were examined regarding present and potential productivity of each cover type as it influenced the wildlife resource of the study area.

Since a very critical requirement for a healthy and diverse wildlife community is available and well-distributed aquatic habitat (Gabrielson 1959), especially in the drought-prone grasslands (Dasmann 1964), a survey of this cover type was conducted. Because of time and manpower limitations, only ponds and natural or man-made depressions were surveyed while streams were excluded. Pertinent studies of a more detailed nature concerning aquatic habitats on and in the vicinity of the study area include those by Baumgartner and Baumgartner 1941, Baumgartner and Howell 1941, Bennett 1947, Hancock 1951, Barstow 1967, Hysmith 1975 and Slimak 1975. Subjective observations were made by the author regarding: (1) degree of permanence--i.e., whether standing water would occur during an extended dry period as determined by basin depth, size and soil texture (note that these data were collected during a year of below normal precipitation); (2) turbidity--the clear pond was clear compared to the clearest encountered on the study area. The turbid pond was, in like manner, turbid in comparison to the clearest; (3) presence and type of aquatic vegetation-occurrence of submergent and emergent species in great enough biomass to provide food and/or cover for aquatic vertebrate species; and (4) management significance--whether or not a site had management significance was determined by a synthesis of the preceding parameters plus distance to adjacent vegetative cover greater than 1 m in height. The specific location of aquatic sites was determined from U. S. Geological Survey quadrangle (7.5 minute) maps of the study area and by field observation.

As a further means of estimating the value of existing habitat to wildlife on the study area, a system of habitat condition rating was employed using criteria shown in Table 2. In this technique, observers walked north-south transect lines, stopping at 91.4 m intervals to record cover type(s) and assign a numerical value (range 1 to 5) within that interval for each cover type. These values (condition ratings) were then averaged by plot and by cover type on each plot to determine indices of relative habitat condition which could be compared among the plots and among cover types. This technique has been incorporated into the sign-count transect method of faunal sampling which is discussed in detail later.

Table 2. Criteria used for habitat condition ratings.

Habitat condition ratings	Criteria
1 = very poor condition	Numerous severely eroded sites, little vegetative cover, deteriorating conditions
2 = generally poor condition	Some erosion, overgrazing, future trend toward #1 if management not altered
3 = fair condition	Slight to moderate overgrazing, generally good vegetative cover with only species composition indicating overgrazing, trend more or less constant
4 = good condition	Only moderate grazing pressure apparent, good wildlife cover present, good diversity of habitat types, trend constant or improving
5 = excellent condition	Apparent climax conditions, little or now grazing pressure, even better cover and diversity than in #4

Dominant plant species by cover type and by interval were also recorded during the sign-count transect survey of faunal populations. Using these data dominant plant species composition and diversity by cover type were calculated for each plot. The Shannon-Weaver formula was used for calculation of diversity index values (Shannon and Weaver 1964) by cover type for each plot sampled.

Faunal Resources

All plots on the study area were stratified by vegetative cover diversity index value into five strata. This stratification was accomplished by dividing the range of diversity values into five equal parts from the lowest to the highest index value. This resulted in unequal numbers of plots within the strata, ranging from three in stratum number five (the most diverse) to 14 in stratum number four.

Plots were selected at random from each stratum for sampling by the sign-count transect method of faunal survey (Barclay 1973). This technique was refined by the author and represents a modification of various published transect methods (Giles 1969, Hayne 1949 and Overton 1953). It is designed to utilize animal sign (indirect observations) and direct observation to verify the presence of species and develop indices regarding their relative abundance and distribution. Shultz and Muncy (1957) stated that indices to populations, based on the number of animals observed along transect lines, are frequently useful for studying potential hunting or the suitability of habitat for various species.

In collecting data from each plot three to five observers were utilized simultaneously to minimize bias in observation of sign. North-south transect routes were established at 100 step (91.4 m) intervals, nine routes per plot, beginning 50 steps (45.7 m) from the west edge of the plot. These routes were then walked by observers (one per transect line) who recorded any animal sign within 50 steps of his transect line. The observers stopped at each 100 step (91.4 m) interval to record species observed and type of sign observed for each species; cover type in which each sighting was made; cover types encountered in preceding interval; dominant plant species present within each cover type, and habitat condition rating for each cover type and the interval as a whole.

These data were than tabulated for each plot with respect to occurrence, distribution and relative abundance of animal species; number of encounters per species per cover type and per plot; average habitat condition per cover type and per plot; dominant plant species per cover type and per plot; and type of sign encountered by animal class (bird and mammal) per cover type. Indices to dominant plant species diversity and animal species diversity for the 19 sample plots were then calculated.

Sign-count transect sampling occurred in the spring (10 plots) and fall (9 plots) of 1975 in order to observe effects of season. All of the above data, together with environmental parameter information (number of observers, days since last precipitation, weather at time of sample, weather during previous week, temperature at the time of sample, moon phase the night previous to sample, humidity at time of sample, barometric pressure the night previous to sample and direction of barometric pressure change [after midnight] the night previous to sample), plus calculations of percentages of each cover type from satellite data and from a dated (1939) vegetation map from each sample plot were then subjected to detailed univariate and multivariate statistical correlation analyses by season and as a whole. Environmental parameter data were collected and analyzed to determine any effect they may have on the number of encounters, type of sign encountered and faunal species diversity encountered. Instructions and data sheet for the sign-count transect technique appears in Appendix E, p. 123.

In addition to sign-count transect sampling, techniques described below were employed to estimate the abundance of faunal species by plot, by cover type or per kilometer of road (roadside counts).

The number of deer per plot were estimated by a variation of a technique used by Tyson (1959) in which the number of deer encounters from transects A and I bordering the perimeter of each plot plus the number from the north and south ends of transects B through H were treated as the number of deer using the plot. The resulting number was divided by the plot's width (in km) times pi to obtain a relative number of deer per square kilometer for each plot. These estimates from each sampled plot were then used as indices of comparative abundance and distribution of deer.

A roadside avifauna call count was conducted during spring and summer 1975. Data taken (including that for both quail and mourning dove) were expressed as the number of calling or observed individuals encountered per species per 0.8 km, the interval at which 124 sampling stations were spaced along the route (Fig. 5). The observer remained at each station for three minutes counting and identifying species by call. Repeated calls from the same individual were ignored. The cover type(s) of each station was also recorded. Results were then tabulated by number of each species observed in each cover type or combination of types.

Since it was felt that the estimate of the density of the fox squirrel population from the results of the sign-count transect survey was not valid due for the most part to low detectability, a time-area count survey was conducted for both bottomland and upland hardwood cover types on the study area. Sample sites were selected in squirrel woods between 6 and 9 a.m. The observer sat down and remained as quiet

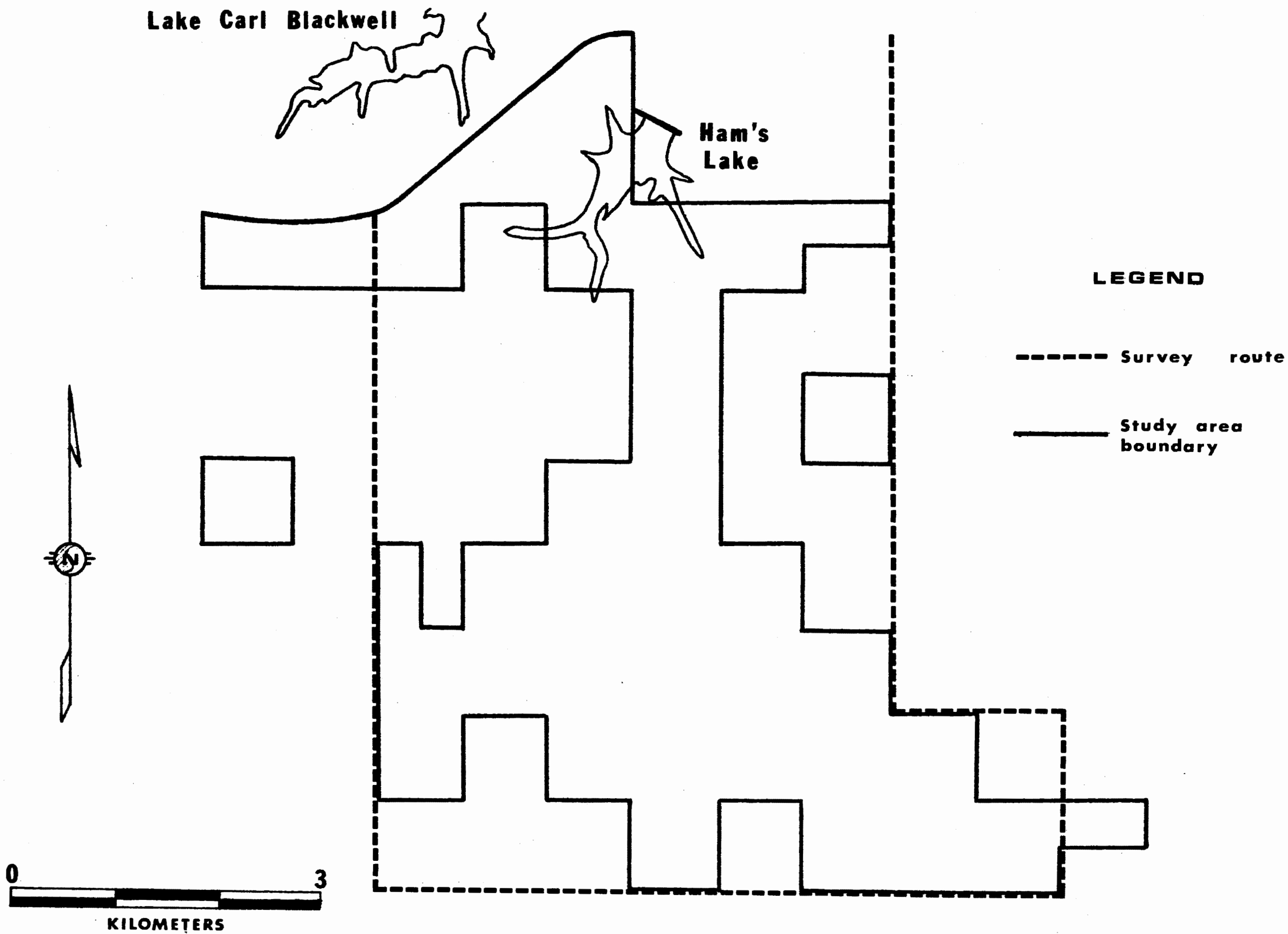


Fig. 5. Route of avifauna call-count survey.

and motionless as possible, counting squirrel for 30 minutes. The distance from the observer to each sighting was also recorded. The area of each sample was defined by the distance to the squirrel. Squirrels per kilometer^2 were then calculated and the survey continued until fluctuation in the number per kilometer^2 for each habitat type ceased (Uhlig 1956). The results of this technique, as mentioned by Uhlig (1956), should be treated as an index rather than a true census of the squirrel population on the study area.

Questionnaires were sent to the grazing lessees in order to tap their knowledge and/or concepts of the distribution and relative abundance of faunal populations on the study area and to determine their attitudes toward various land-uses. Questions were divided into categories including personal data, abundance of game animals and personal views on land-use issues. Also included were maps on which the lessee was to indicate the location of any encounters he may have had with wild game on his grazing lease.

Statistical tests used in analyses of habitat and fanunal data were conducted using the 95% level of confidence as a basis for determining significant differences, unless otherwise stated.

CHAPTER IV

RESULTS AND DISCUSSION

Evaluation of Habitat

Distribution of Vegetative Cover Types

A total of 2,330.18 hectares were measured by LANDSAT-1 in terms of spectral reflectance. This represented a difference of 19.82 hectares from the area of the study area listed by the Oklahoma State University Business Office, an error of only 0.86%.

Fig. 6 shows a LANDSAT-1 principle component grey image of the study area and some surrounding private lands. The lighter areas in this image represent wooded (upland and bottomland hardwood forests) tracts while the darker areas designate grassland. Aquatic sites (e.g., Ham's Lake) are noted by the "Z" signature. The aerial photograph in Fig. 7 is included for comparison of visual features with the satellite imagery in Fig. 6. The area shown in Fig. 7 is illustrated by the trapezoid enclosed by dashed line segments in Fig. 6. Figures 6 and 7 also portray what has been noted from various vegetative and habitat data (e.g., Duck and Fletcher 1945, Eubanks 1972) plus personal observation, namely that some of the last relatively undisturbed remnants of the native crosstimbers vegetative type in western Payne County occur on the study area. One other biologically important feature illustrated by Fig. 7 is the amount of interspersion and ecotone between forested

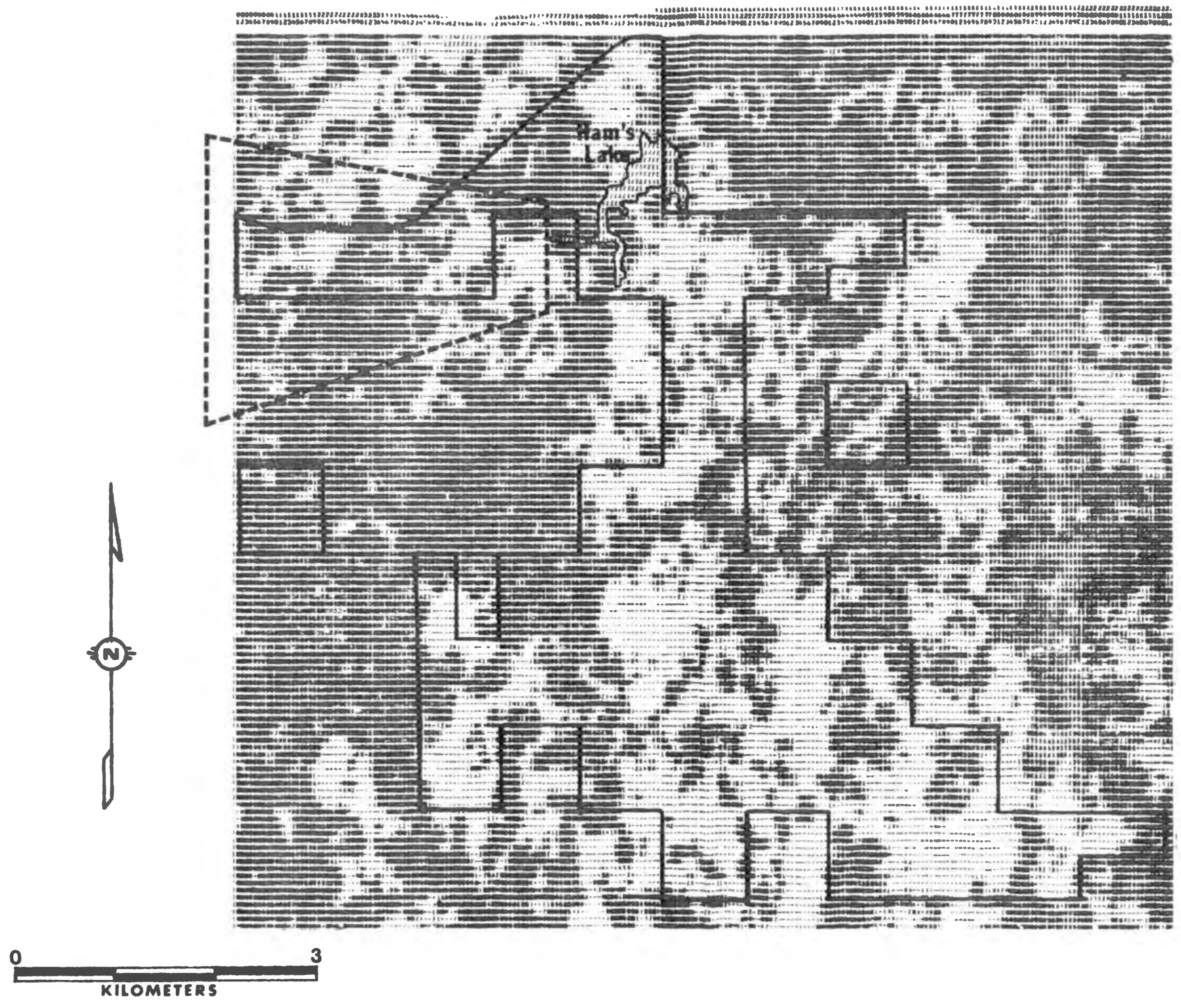


Fig. 6. LANDSAT-1 grey principle component image of the study area including the area shown in Fig. 7.

Fig. 7. Oblique aerial photograph of a portion of the study area, looking west.

tracts and grassland areas present on the study area in comparison to the surrounding private lands.

Offsetting somewhat the loss of edge and habitat diversity through the clearing tracts of hardwoods has been the construction of reservoirs, upstream flood control structures and farm ponds throughout the state.

Fig. 8 illustrates the magnitude of man-made impoundments which have been constructed on and in the vicinity of the study area (in general, those larger than 0.8 ha are shown). Slimak (1975) reported that approximately 3,000 ponds of all sizes (most less than 0.8 ha) exist within the same general area (Stillwater Creek Watershed).

Six classes resulted from the LANDSAT-1 classification system. These correspond to the vegetative cover types shown in Fig. 9. The hectares and percent of total area of each cover type for the study area are shown in Table 3. Table 3 also summarizes the number and percent of distinct vegetative cover type units (tracts) for the study area. Figs. 10, 11 and 12 present these cover types pictorially. The large number of tracts identified for upland hardwood forest, native grassland and oak savannah-brush cover types indicates a high interspersion of these cover types. This degree of interspersion is often considered by wildlife biologists to be valuable for maintaining many wildlife species, especially bobwhite quail (DeArment 1950). The data in Table 3 were compared to those shown on a 1939 vegetative map of the study area (Brensing and Talley 1940a) in order to examine the effectiveness of the imagery classification. (A more recent map would have been desirable for comparison with the classification, however one did not exist.) The results of this comparison are shown in Appendix B, p. 113.

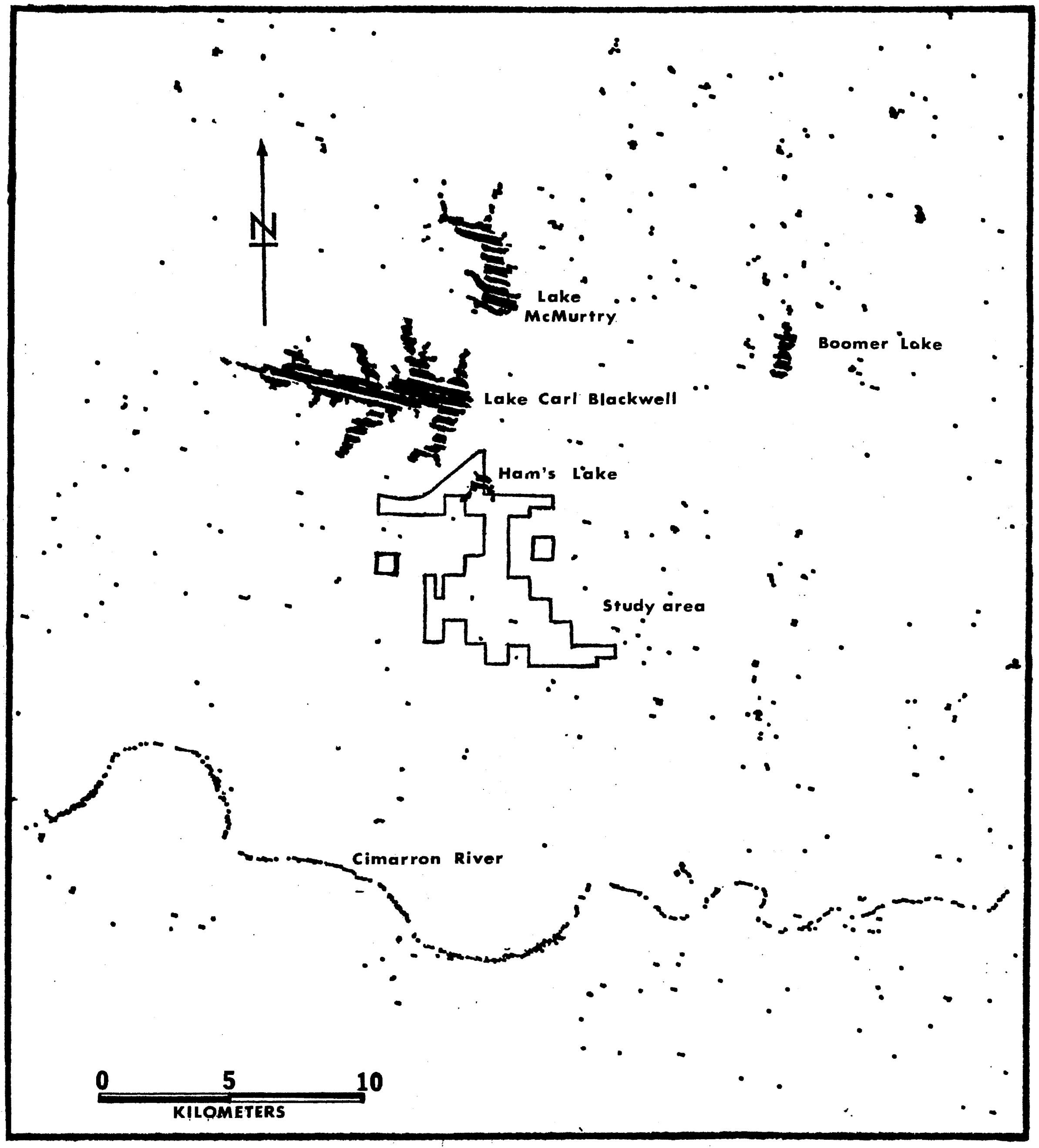
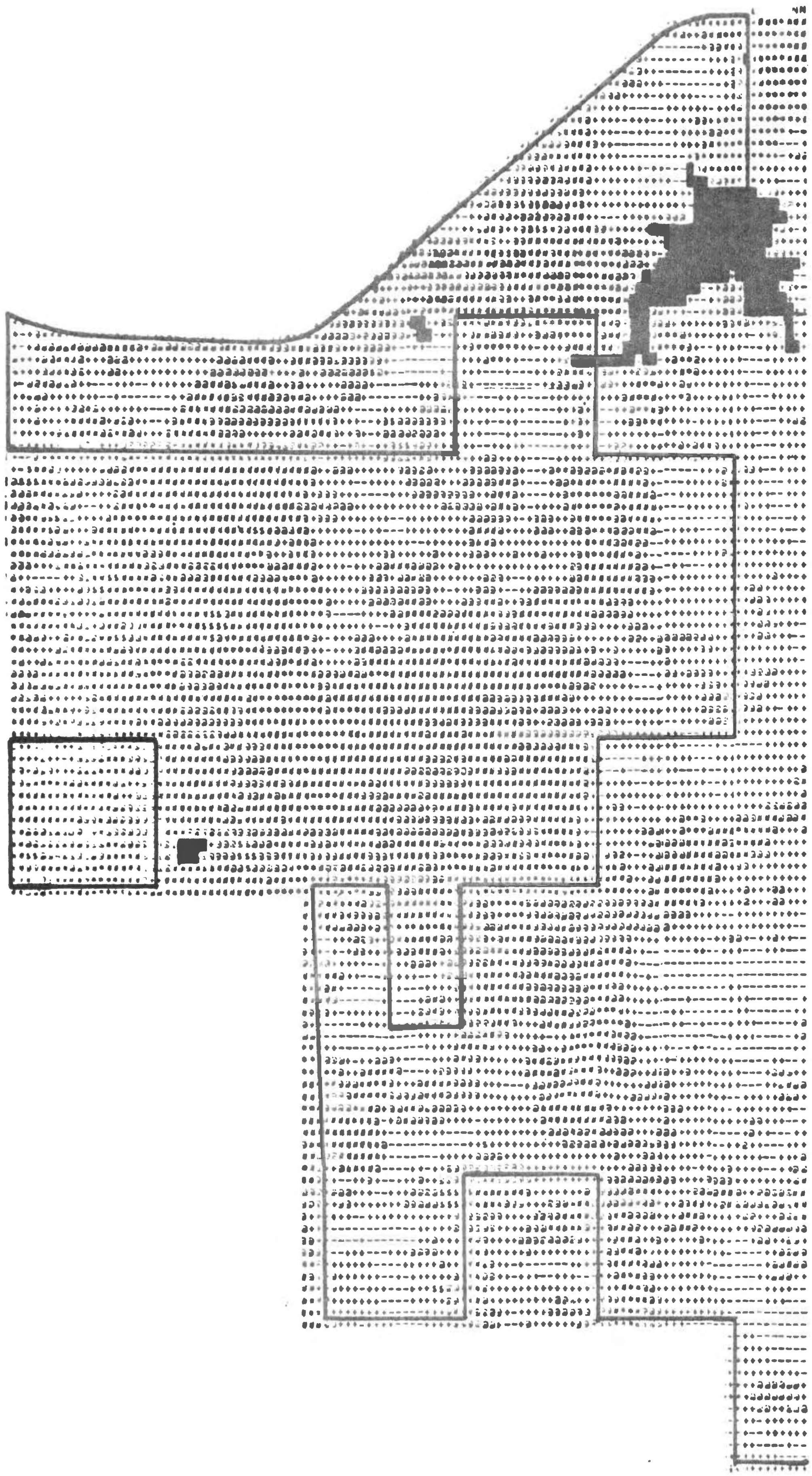


Fig. 8. A density slice from band 7 (IR^2-LANDSAT data) showing aquatic habitat in the vicinity of the study area.



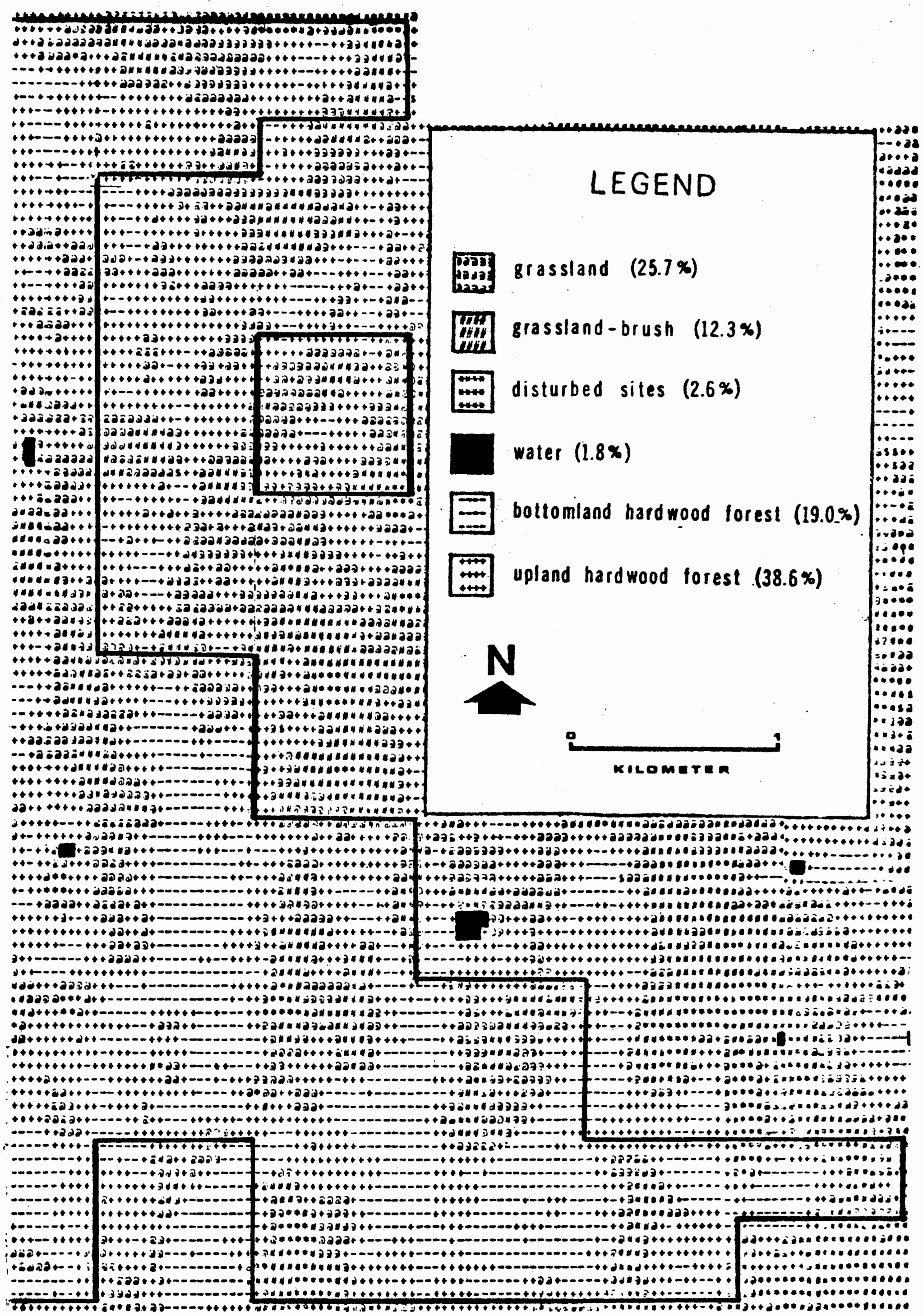


Fig. 9. Vegetative cover diversity map of the study area (LANDSAT imagery classification).

Table 3. Area (hectares) of cover types and number of units on the LCBLUA (LANDSAT-1 data).

Classification	Total area each type (hectares)	Percent of total area	Number of distinct units	Percent of all units	Mean size of units (hectares)
Upland hardwood forest	889.45	38.6	170	25.8	5.23
Native grassland	598.86	25.7	196	29.8	3.02
Bottomland hardwood forest	442.74	19.0	98	14.9	4.47
Oak-savannah-brush	286.61	12.3	131	19.9	2.16
Eroded sites	60.58	2.6	45	6.8	1.33
Aquatic sites	41.94	1.8	18	2.8	2.29
TOTALS	2330.18	100.0	658	100.0	3.50 (Avg.)

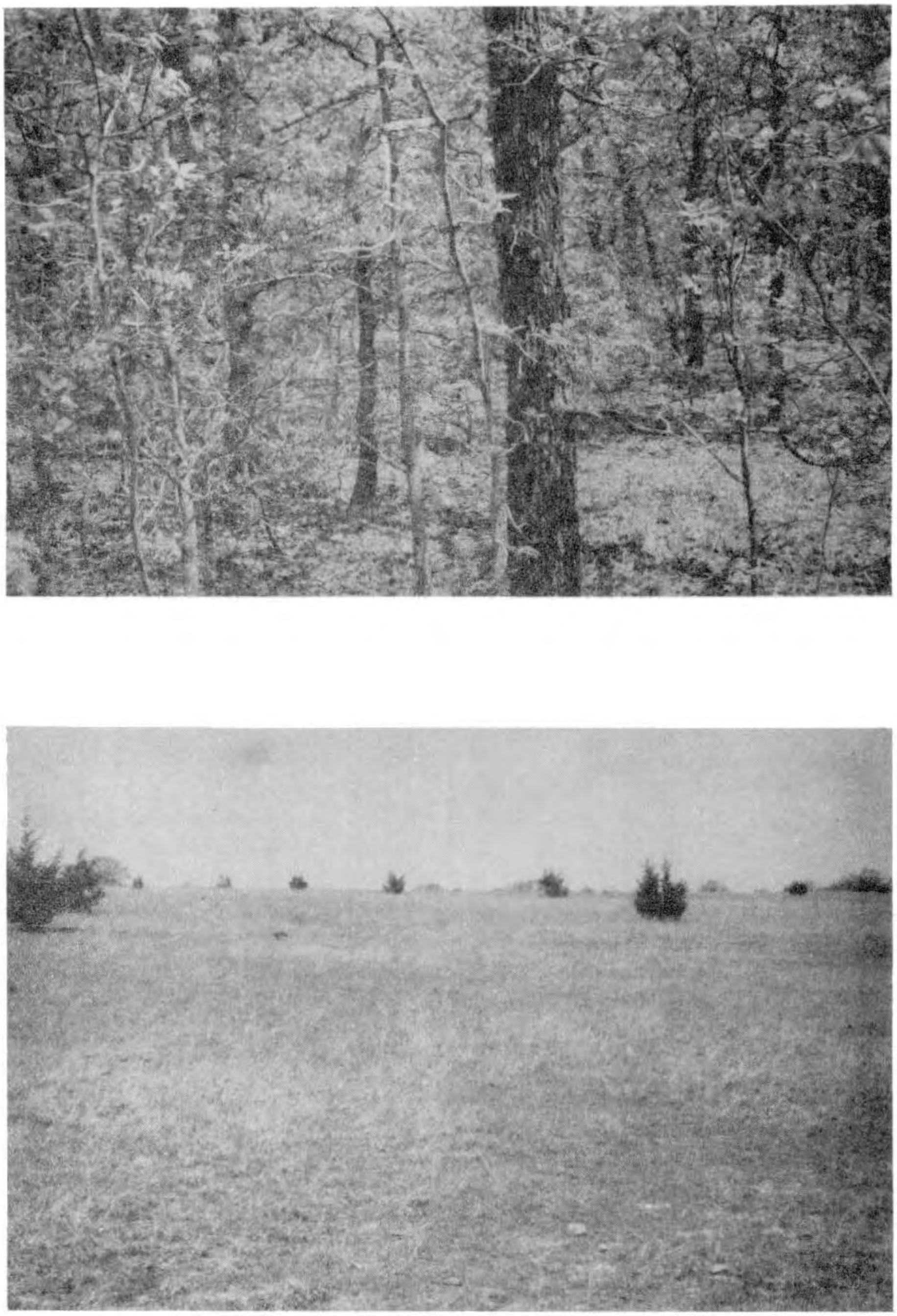


Fig. 10. Photographs of representative upland hardwood forest and native grassland cover type areas.

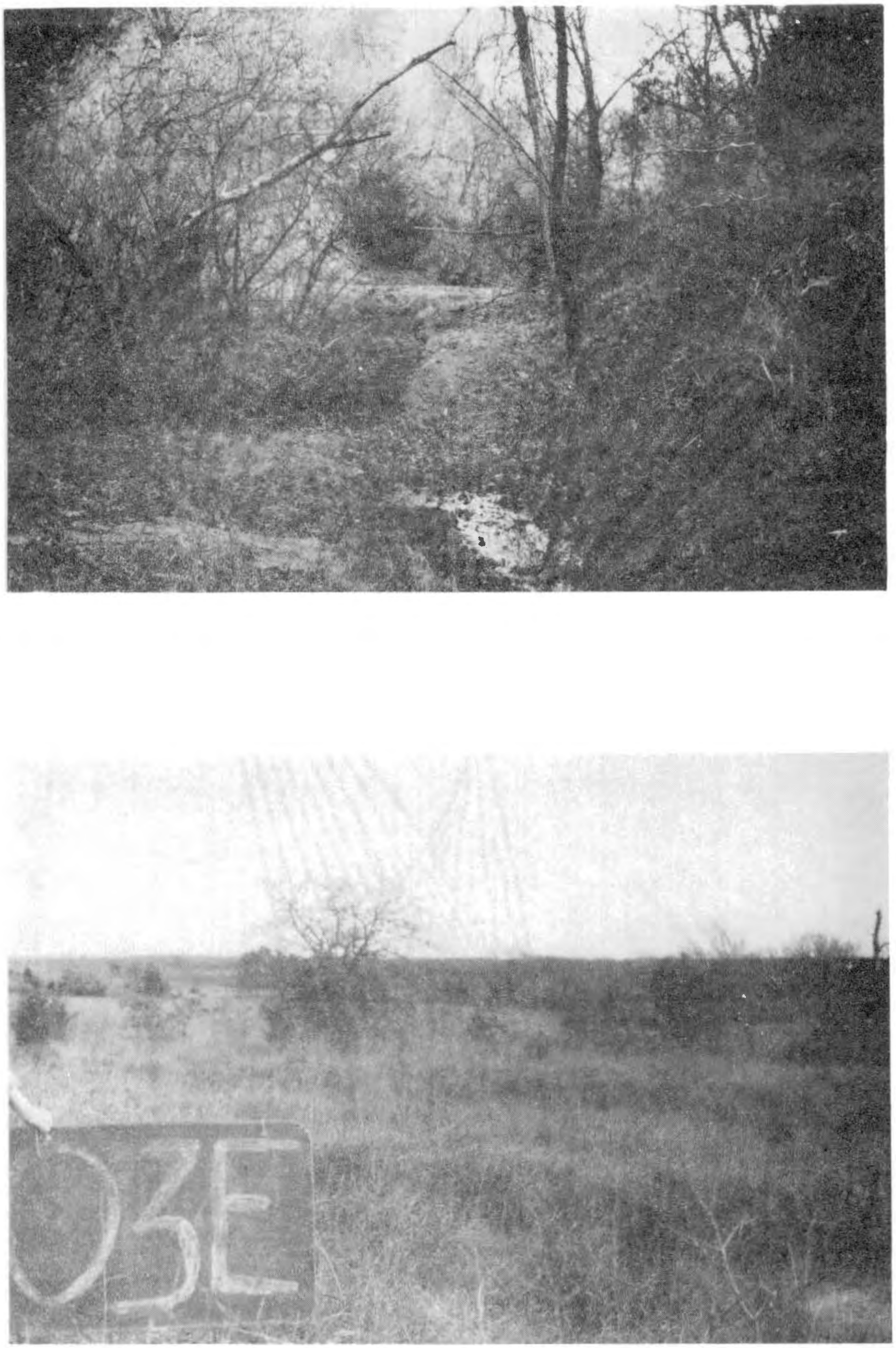


Fig. 11. Photographs of representative bottomland hardwood forest and oak-savannah-brush cover type areas.

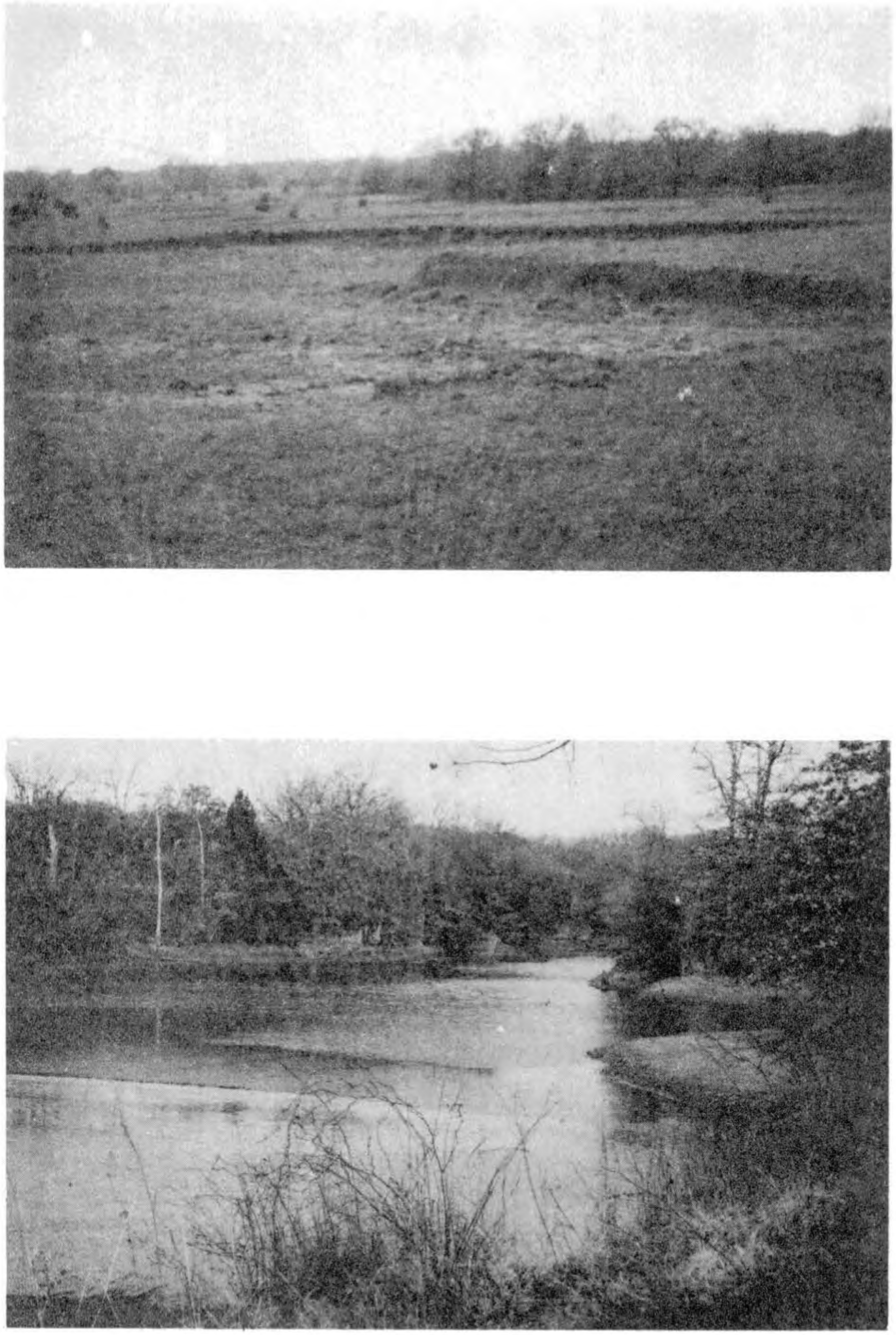


Fig. 12. Photographs of representative disturbed site and aquatic site areas.

The apparent differences for both upland hardwood forest and native grassland cover types are relatively small, 7.90% and 10.90% respectively. These differences could have come from a number of sources. Actual changes in the boundaries of cover type units could have and in all probability have occurred since 1939. Also, computer misinterpretation of the remote sensing data used as the basis of the calculation of cover type areal coverage could have occurred. At any rate field checks indicated that any errors made in delineating the boundaries of the upland hardwood forest and native grassland cover types by the computer classification of satellite data were insignificantly small.

In the case of the bottomland hardwood forest cover type, a difference of 126.48% resulted. This difference is explained by the inclusion of some adjacent areas of upland hardwood forest type along the stream courses in the southern portion of the study area by the satellite classification. The classification program discriminated between upland hardwood forest and bottomland hardwood forest to a large degree as a result of the reflectance values obtained in the green band of the light spectrum. Since in this portion of the study area early-greening (in spring) plant species (e.g., black locust, greenbriar, redbud, hackberry and red cedar) occur among the later-greening post oak and blackjack oak of the typical upland hardwood forest, these areas were classified as bottomland hardwood forest. Field inspection of the areas involved indicated that the upland hardwoods have been invaded by the earlier-greening species since none of the above mentioned plants were listed as dominants on the 1939 map. These species were, however, encountered as dominants in the upland hardwood forest habitat type during systematic field work throughout this portion of the study area. Although reflectance caused the computer classification program to overestimate the amount of true bottomland hardwood forest on the southern portion of the study area, the misclassified areas could be considered as ecological analogs of the bottomland hardwoods because of their species composition and occurrence adjacent to true bottomland hardwood sites. Although this point could be debated on various grounds, for the purpose of this study, these areas were treated as bottomland hardwood forest.

No valid comparisons between the 1939 vegetation map and the computer-aided satellite imagery classification map could be made for either the oak-savannah-brush or the disturbed or eroded habitat types since no comparable cover types were delineated on the vegetation map.

The discrepancies shown for aquatic habitat appear to be real and due almost entirely to the comparatively recent (1968) construction of Ham's Lake which has inundated an area of 40 hectares in the northern portion of the study area (Fig. 6).

Percentages of each cover type were also calculated for each plot on the study area (Appendix B, p. 113). On the plots sampled by the sign-count transect technique, percentages of native grassland and upland hardwood forest were significantly correlated (product-moment linear correlation, $\alpha < 0.05$) with the results obtained from the satellite imagery map and the 1939 vegetation map.

Vegetative Cover Diversity

Vegetative cover diversity index values for each sample plot were computed from the satellite data as a measure of relative value to the wildlife resource. The computed values appear in Appendix B along with the calculated percentages of each cover type per plot. The total hectares and percent by cover type for each grazing lease pasture on the study area are given in Table 4. The plots making up these pastures are also given. The plots were arbitrarily stratified into five groups on the basis of their vegetative cover index values. These strata were utilized in determining the sampling scheme used in indexing faunal populations and dominant plant species. Results of the grouping are shown in Fig. 13 by plot. The vegetative cover diversity index values ranged from a low of 1.61 on plot number 4 to a high of 3.70 on plot number 24. The mean value was 2.74. The means and variances for each stratum are given in Table 5. The small variances (by definition) within each of the strata lends credence to this stratification scheme. The distribution of the index values by plots and stratum is illustrated in Fig. 14.

Habitat Productivity

Habitat Survey. The habitat evaluation survey was based on procedures reported by Hickman (1974) and yielded the index values shown in Tables 6 and 7. Use of this procedure (see Appendix D, p. 121) required that the calculated index value for each site by compared to that site which had the highest value on the entire study area. Since a range of site values could be assigned within each vegetative cover type, only small differences between cover types and faunal groups are likely to result. Therefore, differences of the magnitude of 0.25 were considered to be important. Table 6 gives comparative index values by vertical vegetative stratum and characteristic (food and cover) for each cover type defined by the computer-aided

Table 4. Percentages of vegetative cover types by pasture--LCBLUA--(LANDSAT-1 data), 1973.

Pasture number	Hectares[1]	NG[2] (percent)	OS-B (percent)	ES (percent)	AQ (percent)	BH (percent)	UH (percent)	Mean H[3]	Plot numbers
1a	184.1	23	13	< 1	< 1	7	56	2.33	14,17,18
1b	613.1	27	13	3	< 1	23	35	2.72	19 through 28
1c	64.8	18	1	--	--	23	54	2.81	30 (Forestry Department)
2	452.0	18	10	2	--	33	39	2.90	29,33,34,35, 37,38,39
3	195.1	25	6	2	--	23	44	2.72	31,32,36
4	56.7	47	16	1	--	3	33	2.60	15
5	177.3	14	7	6	19	15	39	2.88	2,5,9
6	95.9	47	30	8	< 1	1	13	2.32	1,3,4
7a	Not in study area								
7b	Animal Science (not in study area)								
8	Animal Science (not in study area)								
9	Animal Science (not in study area)								
10	59.1	44	4	--	4	21	28	3.61	8 (Ecology Preserve)

Table 4 (Continued)

Pasture number	Hectares[1]	NG[2] (percent)	OS-B (percent)	ES (percent)	AQ (percent)	BH (percent)	UH (percent)	Mean H[3]	Plot numbers
11	66.0	48	43	4	1	1	1	3.08	16 (Animal Science)
12	104.0	37	24	--	1	6	32	3.38	6,7
13	Not in study area								
14	Not in study area								
15	227.4	22	6	1	1	13	58	2.32	10,11,12,13
16	Not in study area								
17	34.0	29	15	11	--	22	23	3.40	40 (City of Stillwater)

[1]Excluding roads and highway rights-of-way.

[2]Symbols for vegetative cover types: NG--native grassland, OS-B--oak-savannah-brush, ES--eroded sites, AQ--aquatic sites, BH--bottomland hardwoods and UH--upland hardwoods.

[3]Habitat diversity value for all plots in pasture.

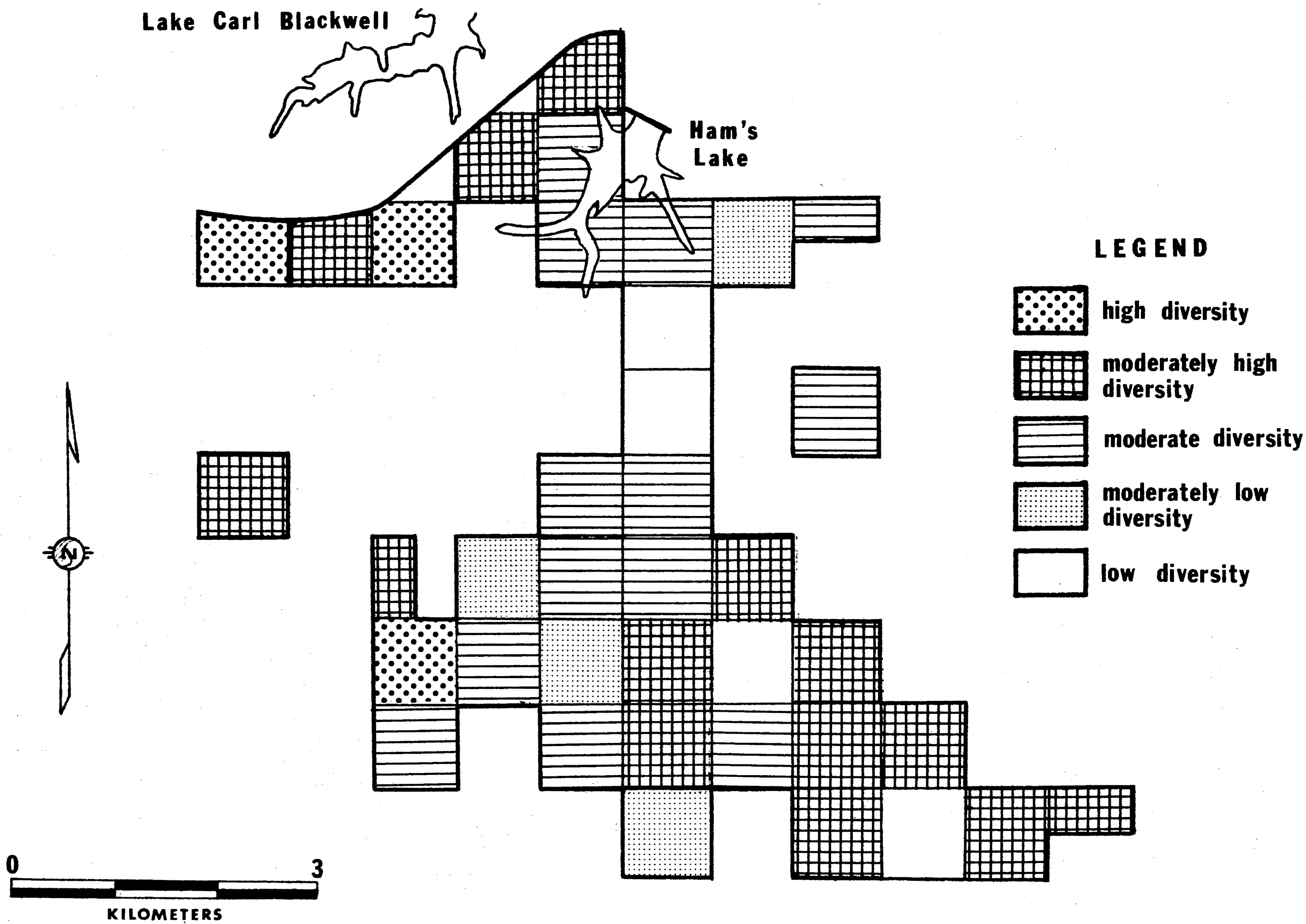


Fig. 13. Average vegetative cover diversity by stratum for each 65 hectare unit on the study area.

Table 5. Means and variances of plot vegetative cover diversity index values by stratum.

Stratum number	Sampling plots		Mean diversity index value	Variance
	Number	Percent		
1	6	15	1.79	0.030
2	4	10	2.29	0.010
3	13	32	2.72	0.010
4	14	35	3.12	0.020
5	3	8	3.64	0.003
Overall	40	100	2.74	0.290

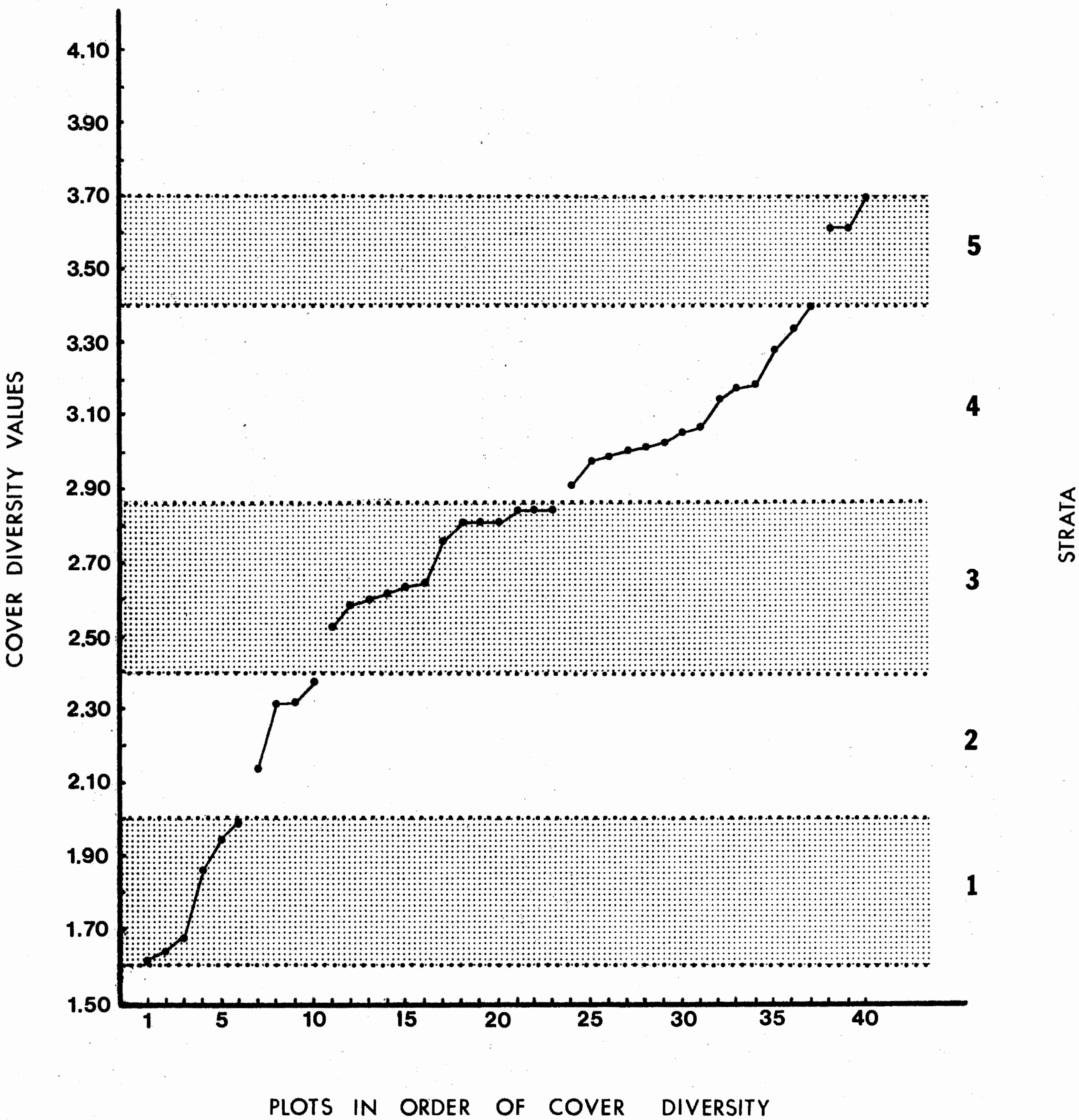


Fig. 14. Distribution of vegetative cover diversity index values by plot in order of cover diversity and by stratum.

Table 6. Average habitat evaluation index results by vegetative cover type, stratum and characteristic.

Classification	Overstory		Understory		Ground cover		Average
	Food	Cover	Food	Cover	Food	Cover	
Upland hardwood forest	3.49	3.88	3.46	3.81	3.45	3.79	3.64
Native grassland	----	----	----	----	3.32	3.50	3.41
Bottomland hardwood forest	3.64	3.77	3.69	3.88	3.59	3.81	3.74
Oak-savannah-brush	2.96	3.38	3.21	3.49	3.37	3.45	3.31
Eroded sites	----	----	----	----	2.48	2.88	2.68
AVERAGE	3.36	3.68	3.45	3.73	3.24	3.49	----
	Physical		Chemical		Biological		
Aquatic sites	3.85		4.20		3.95		4.00
OVERALL AVERAGE							3.46

Table 7. Estimated average value of the vegetative cover types to major terrestrial vertebrate groups on the study area as determined from the habitat evaluation survey.

Vegetative type	Big game (deer)	Upland game mammals	Fur-bearers	Other mammals	Upland game birds	Water-fowl	Other water & shore birds	Other birds	Reptiles & Amphibians	Average
Upland hardwood forest	3.58	3.51	3.60	3.76	3.85	NA	NA	3.84	3.33	3.64
Native grassland	NA	3.26	3.45	3.28	3.78	NA	NA	3.55	3.08	3.41
Bottomland hardwood forest	3.77	3.63	3.84	3.80	3.67	NA	NA	3.86	3.55	3.74
Oak-savannah-brush	2.73	2.81	3.44	3.51	3.65	3.00	NA	3.62	3.22	3.31
Eroded sites	1.50	2.69	3.00	2.80	2.88	NA	NA	1.98	2.30	2.68
Aquatic sites[1]	----	----	----	----	----	----	----	----	----	----
AVERAGE	3.40	3.22	3.54	3.54	3.71	2.97	2.93	3.63	3.24	3.45

[1]Aquatic sites were sampled in terms of physical, chemical and biological parameters rathern than in terms of life forms as were the other habitat types.

LANDSAT-1 imagery classification. The values presented in Table 6 can be interpreted as relative indices to wildlife habitat productivity on the study area. Any value approaching 3.70 and above was considered to be high or evident of favorable habitat conditions; by the same measure values approaching 2.75 and below were considered to be low or pointing toward habitat imbalance (applies to both tables). The cover component consistently achieved higher average values than did food. This higher rating for cover is probably a true representation of most natural habitats and areas, especially those which are evolutionarily fire-climax in origin but in which fire has been suppressed (DeVos and Mosley 1969). Apparently a disclimax situation has evolved on the study area in which a disproportionate amount of cover is present relative to the food base.

Table 7 shows the average habitat index values determined for each vertebrate life form (faunal classification) category as determined by Hickman (1974). The highest index values were obtained for upland game birds, non-game birds (other birds), non-game mammals (other mammals) and furbearers. These results imply that management for other life forms (i.e., big game, upland game mammals, waterfowl, other water and shore birds and reptiles and amphibians) may be necessary on the study area if it were desirable to enhance their populations.

Soil Survey. The results of the soil analyses for the six cover types are tabulated in Appendix E, p. 123. Three parameters, namely pH, nitrogen level and organic matter content provided additional insights to area productivity, past and potential, for wildlife populations. Duncan's multiple range test was applied, showing the following:

The pH value for eroded sites was significantly more basic than for the other habitat types. The relatively high organic matter contents of the upland hardwood forest and oak-savannah-brush cover types correlate with high values of nitrogen for both types along with the bottomland hardwoods and indicate a good potential for production of healthy wildlife populations utilizing these three habitat types (DeVos and Mosby 1969). Game species which could benefit from those comparatively productive soils are white-tailed deer, cottontail rabbit, fox squirrel, Rio Grande turkey, bobwhite quail, mourning dove and mammalian predators and furbearers. The native grasslands cover type, however, showed a much lower nitrogen content. The grassland soil organic content was relatively high (1.4%), although not comparable to the value of 2.83% given by Hill (1971) as an average for "virgin prairie soil" of the Vernon loam soil type (1.62% is given as an average for "cropped soil").

Soil test results for percent organic matter, nitrogen, phosphorus and potassium were used to calculate a soil productivity index. These parameters were chosen because they most generally represent limiting factors to biomass productivity in any ecosystem (Hill 1971). Present organic matter was included because of its importance in the moisture and nutrient-holding capacity of the soil (Weaver 1968). The results of this index determination are found in Appendix F, p. 129.

Index values were obtained by multiplying the resultant soil test values from each cover type by the cover type percentages for each plot. This was done for each of the soil productivity parameters and totaled by plot. These numbers were then arbitrarily stratified by equal increments into five groups. The results for each plot are shown in Fig. 15 by stratum. This productivity index may be very useful

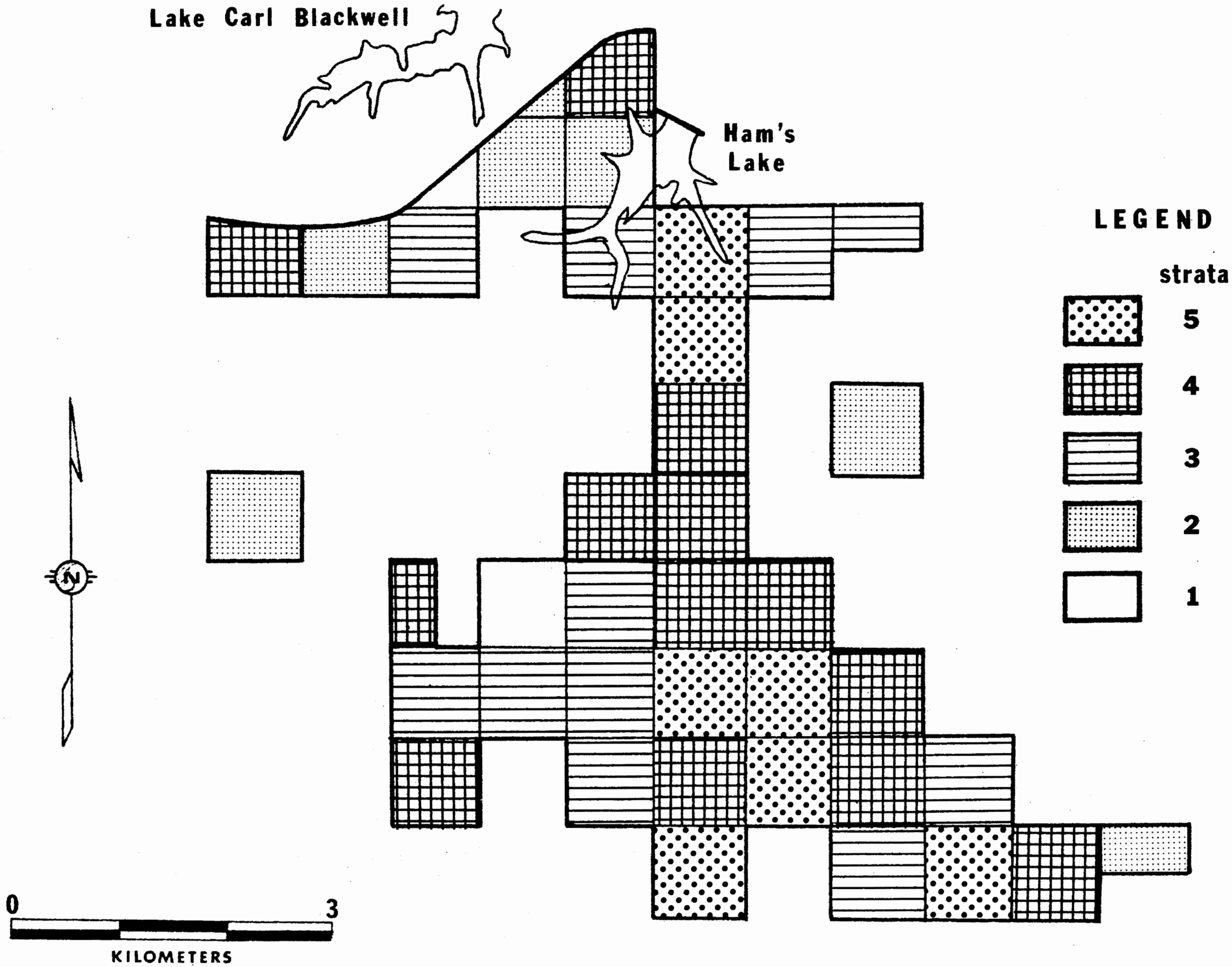


Fig. 15. Study plots by soil productivity index strata (stratum 5 is most productive).

to future management efforts on the study area. When used in combination with a soil survey map, desirable management areas could be determined on the most productive soils.

Pond Survey. Results of the pond survey conducted on the study area during the spring of 1975 waterfowl migration are presented in Fig. 16. Waterfowl were encountered on several of these ponds. Species seen most often in order of abundance were pintail, American wigeon and gadwall. A few mallards were also observed.

Only 11 of the 29 ponds on the study area had a spillway level surface area of over 0.4 ha (1 acre) and only 9 smaller ones were considered permanent. An average of one permanent aquatic habitat unit was found per 117 hectares on the study area (this calculation does not include Ham's Lake which extends into the northeast portion of the study area). A few of the survey ponds occurred on very permeable soils. As a consequence their water levels are low or non-existent during drought periods.

None of the ponds surveyed are fenced although many were formerly. Fig. 17 shows a tank constructed below a pond on the study area originally built for livestock water. The tank is filled by gravity flow through a pipe beneath the pond dam. Several of these structures were found on the study area. Degradation of the fencing around these ponds has allowed livestock to trample emergent vegetation, and puddle the shorelines, thereby increasing turbidity and eliminating vegetative food and cover. This disturbance has decreased the value of the ponds to all classes of wildlife. Re-fencing of the ponds should allow natural processes to restore their inherent value (Logan 1976).

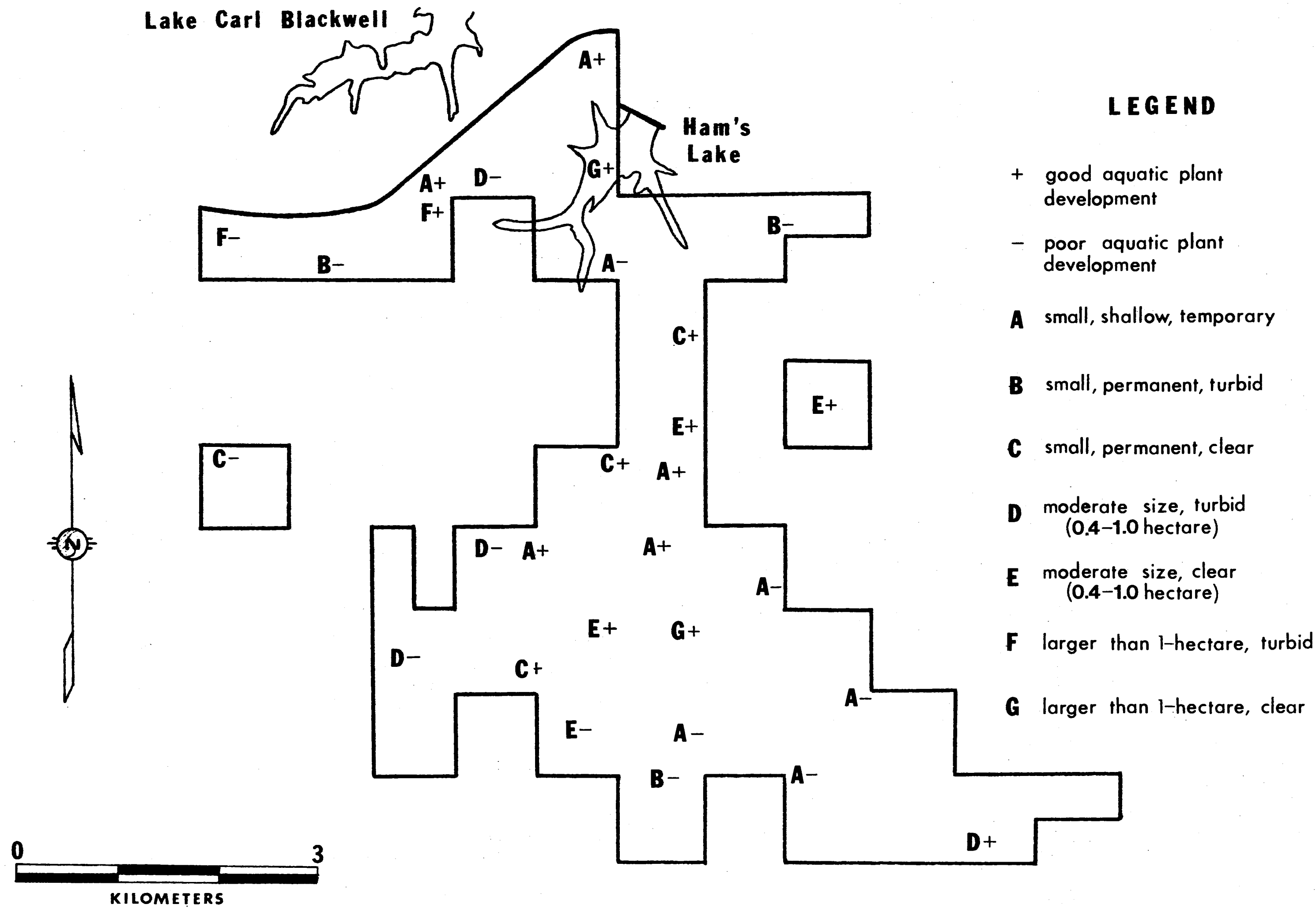


Fig. 16. Location and condition of aquatic habitat on the study area.

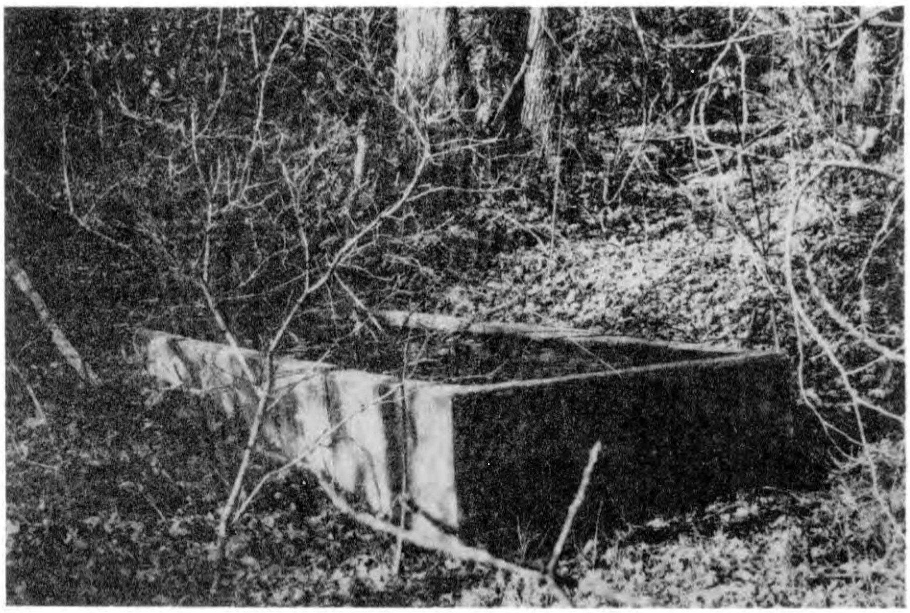


Fig. 17. Photograph of a tank below a pond constructed for livestock water on the study area.

Habitat Condition Survey. The results of the habitat condition index survey are shown in Table 8. Plot number 8 (O.S.U. Ecology Preserve) is ungrazed and presents near-climax conditions (as measured) by dominant plant species present for the cover types sampled on the plot). This plot may be used as a control for comparison of the habitat condition ratings for the other sampled plots. Condition values ranged from a high of 4.64 (upland hardwood forest on plot number 8) to a low of 1.33 (native grassland on plot number 3). These values were averaged by cover type and overall for each of the sampled plots. The principle criterion measured was range condition, whereas the vegetative type evaluation survey estimated food and cover values for various wildlife groups. The native grassland cover type yielded consistently low habitat condition index values, indicative of overgrazing and improper forage utilization in the past. The observed numbers of deer and cottontail rabbit were significantly correlated (linearly, $\alpha < 0.05$) with overall habitat condition ratings of the plots sampled by sign-count transects. Values approaching 3.50 and above indicate good habitat condition while those below 3.50 indicate situations which appear to be regressing.

Dominant Plant Species. The dominant plant species by cover type were recorded during transect sampling of the plots. The dominant plant species were summarized and used to determine successional stage and to estimate the overall value of the plot to wildlife populations.

The upland hardwood forest was dominated by post oak and blackjack oak dominants of the western Cross Timbers Resource area (OWRB 1972).

Table 8. Seasonal range condition ratings for the three major vegetative cover types on sampled plots, LCBLUA study area, 1975.

Plot number	Native grassland	Upland hardwood	Bottomland hardwood	Average
Spring				
8 (ungrazed)	4.20	4.64	4.33	4.36
11	2.44	3.24	4.00	3.05
24	2.84	3.32	3.54	3.22
35	2.10	2.60	3.64	2.55
28	2.52	2.74	3.85	3.01
33	1.85	2.70	3.93	3.19
20	2.67	2.95	3.17	2.69
17	2.88	2.85	2.82	2.84
14	2.40	2.86	3.50	2.75
Average	2.66	3.08	3.71	3.08
Fall				
6	2.23	2.95	3.67	2.70
7	3.48	2.87	4.00	3.17
3	1.33	2.00	3.80	2.57
39	2.93	3.05	4.02	3.11
24	2.36	3.50	3.65	3.17
10	2.75	3.73	3.00	3.25
9	2.50	3.23	3.81	3.27
2	2.50	2.50	3.25	2.51
5	1.57	2.48	2.50	2.18
Average	2.41	2.93	3.52	2.88

Table 8 (Continued)

Plot number	Native grassland	Upland hardwood	Bottomland hardwood	Average
Combined average	2.54	3.01	3.62	2.97

These two species provide mast crops which can be important food sources for several game species including the eastern fox squirrel, white-tailed deer, Rio Grande turkey and bobwhite quail. Small mammals which serve as the basic food for furbearers (i.e., coyote, bobcat, red fox, grey fox and badger) also depend heavily on the acorns of the post oak and blackjack oak when available (Martin et al. 1961). Eastern red cedar appeared as the third dominant plant species in the overall average in the upland forest. This species provides both food and cover for many wildlife species, especially seed-eating songbirds. The dominance of eastern red cedar is probably due to a lack of fire in the fire-climax prairie biome since settlement by white man (Weaver 1968). Buckbrush was another upland hardwood dominant which provides some food, but is most valuable on the study area as cover for bobwhite quail, furbearers and small rodents. Smooth and winged sumacs are important as an emergency food source for many bird species, grouping cover for bobwhite quail and escape and resting cover for white-tailed deer and other game and furbearing mammals (Martin et al. 1961, Wiseman 1977).

The dominant plant species in the native grassland cover type were little bluestem, ragweeds, silver bluestem, red cedar, Indiangrass and three-awns. The absence of two of the four dominant tall grass prairie grass species, big bluestem and switch grass, indicated subclimax conditions for the native grassland vegetative cover type on the study area. Subclimax grassland conditions are often beneficial to wildlife populations because of a greater overall biomass production, i.e., energy flow (Smith 1966). However, the dominance of ragweeds (invaders on Red Clay Prairie range sites), silver bluestem and three-awns (increasers on Red Clay Prairie range sites) indicates past over-utilization of forage (Anonymous 1964) and a present over-grazed situation. The consistently low habitat condition ratings (Table 8, p. 54) for the native grassland type also bear out the degree to which they have been over-used. This is not to say that livestock grazing should be eliminated from any management plan. However, a grazing system should be initiated which will enhance the productivity of this cover type for both livestock and wildlife populations.

The bottomland forest type consistently received the highest food/cover index values for each vertical vegetation stratum, characteristic (habitat evaluation index) and habitat condition ratings and proved to be the most valuable cover type on the study area. Three of the five most dominant plant species in the bottomland forest were annual-bearing white oaks, placing this cover type in a good position regarding food production for mast-eating wildlife species. Elms also dominated and are important in providing early spring food for many game and non-game species (Martin et al. 1961).

Dominant plant species of the brush type were smooth and winged sumacs, sandplum, elms and red cedar in descending order of importance. Dogwoods were also present in some locations. All of these species are most important to wildlife populations as resting, grouping, nesting and feeding cover, although some food is produced by each. If occurring adjacent to or within native grassland, these brushy areas are especially important to bobwhite quail as fall and winter grouping cover, escape and resting cover for upland furbearers, and nesting sites for songbirds and small mammals (e.g., rodents and lagomorphs).

Table 9 shows the dominant plant species diversity by cover type for each plot sampled. These values were obtained from the sign-count data by using a variation of the Shannon-Weaver formula ($H' = -\Sigma\ n_i \log n_i$) where appropriate for a population sample. (This formula was used in all following diversity index calculations.) The results of this computation show the bottomland hardwoods and native grasslands to have the greatest diversity of dominant plant species. This may be a significant factor in determining the value of these cover types to the wildlife resource of the study area. MacArthur and MacArthur (1961) found that as vegetative diversity increased, bird diversity also increased.

Evaluation of Populations

Faunal Resources

Sign-count Survey. The plots sampled using the sign-count transect technique for determining distribution of faunal populations are shown in Fig. 18. All sample plots were chosen at random from the 5 vegetative cover diversity strata (equal numbers from each stratum) with the following exception. Because of time and manpower limitations, fall sampling data for plots 2, 5, 9 and 10 were taken by members of the

Table 9. Dominant plant species diversity by cover type and plot sampled in 1975 on the LCBLUA study area.[1]

Plot number (as sampled)	Upland hardwood forest	Native grassland	Bottomland hardwood forest	Brush	Total for plot
8	2.78	2.61	3.01	----	4.63
11	2.44	----	----	----	3.54
24	2.72	3.15	3.14	----	4.37
35	2.36	3.03	----	----	3.80
37	2.23	----	3.01	----	3.79
28	2.72	3.32	2.20	----	4.16
33	2.48	----	2.69	----	3.58
20	2.26	3.04	----	----	4.00
17	2.47	----	----	----	3.18
14	2.58	----	----	----	3.15
6	2.20	----	----	----	3.83
7	2.82	3.08	2.48	----	4.49
3	----	----	----	----	3.96
39	2.51	2.86	----	----	4.00
24	2.66	3.02	3.32	----	4.42
10	2.72	2.93	----	----	4.07
9	2.46	----	3.17	----	4.01
2	2.99	----	----	----	3.95
5	2.34	----	----	----	3.65

Table 9 (Continued)

Plot number (as sampled)	Upland hardwood forest	Native grassland	Bottomland hardwood forest	Brush	Total for plot
Total[2]	2.86	3.68	3.95	2.57	3.92[3]

[1]Blanks denote insufficient sample size to approach asymptote.

[2]Average H' for the plots (does not equal $\bar{x}$ for totals for cover type).

[3]Total H' within cover types are by definition smaller than total H' for all plots.

fall 1975 Wildlife Management Techniques class (Zoology 5414) in conjunction with a study of the Ham's Lake area. Identical sampling procedures were followed, however, and these data were treated equally with those obtained by the author. Results of this survey are presented in Appendix F (p. 129).

The bluejay was the most common avian species encountered followed by Carolina chickadee, bobwhite quail, blue-grey gnatcatcher and tufted titmouse. The abundance of bobwhite quail indicates a good potential for research and management of this resource. A limited number of Rio Grande turkeys were also encountered on the study area. The management potential for this species may approach that for the bobwhite quail. Other common bird species were turkey vulture, cardinal and common flicker. The most abundant mammal encountered was the armadillo. This species was prevalent in all three of the major cover types, native grassland, upland hardwood forest and bottomland hardwood forest), accounting for 38.2% of the total number of mammals actually observed

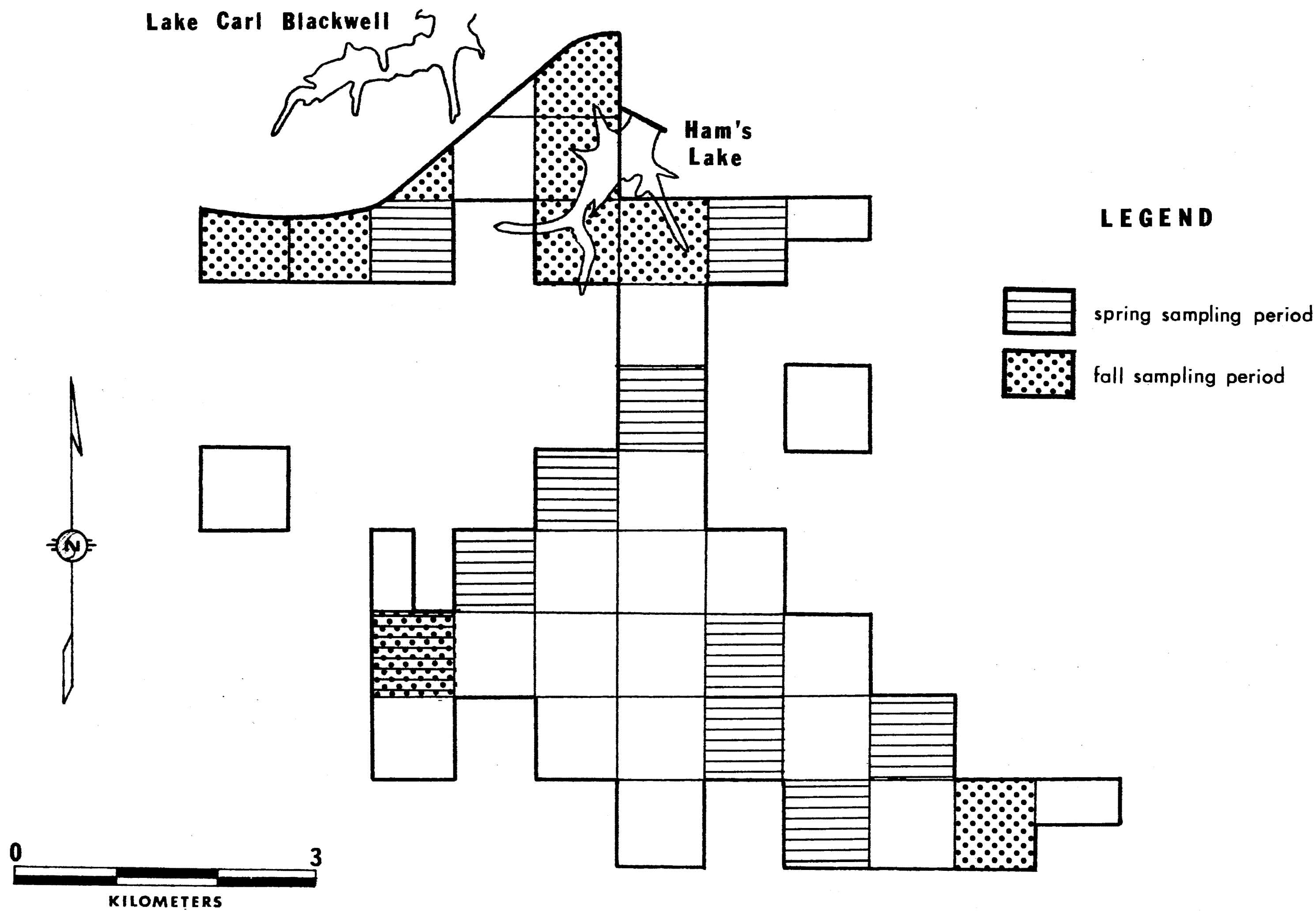


Fig. 18. Plots sampled by the sign-count transect techniques on the study area by season, 1975.

(for all cover types) and 13.8% of all the individuals (mammalian and avian) encountered during faunal sampling by sign-count transect. Further investigation of this species on the study area seems to be warranted to more fully assess its role in the ecosystem. Following the armadillo in abundance were the eastern fox squirrel, small rodents (e.g., the genera Peromyscus and Sigmodon), raccoon, eastern cottontail rabbit and white-tailed deer.

Table 10 shows the number of species, number of individuals and diversity values for fauna encountered during sign-count transect observation on the study area. The greatest number of species were encountered in the upland hardwood forest. Although the upland forest contained a greater number of species and individuals, the bottomland forest yielded a higher diversity index of avian and mammalian life. This was due to large numbers of certain species dominating in the upland forest (e.g., bluejay, armadillo).

Fig. 19 illustrates the relative numbers of game versus non-game birds and mammals encountered on the study area during sign-count transect observations taken during spring and fall respectively. With the exception of the eastern fox squirrel and the eastern cottontail rabbit, all game species were encountered proportionately more often in fall than in spring, indicating an increase in respective population numbers during the growing season (apparent increase in numbers of non-game birds and mammals is due to fall migration). One possible explanation for the decline in the observed number of squirrels and rabbits in fall is a corresponding increase in the number of avian predators which prey on these two species (0.7 raptors per plot in

Table 10. Number of species, number of individuals and diversity values for fauna encountered during sign-count transect observation on the study area.

Cover types	Number of species encountered			Number of individuals encountered			Species diversity (H')	
	Birds	Mammals	Total	Birds	Mammals	Total	Birds	Mammals
Native grassland	38	13	51	329	266	595	4.02	2.99
Upland hardwood forest	51	16	57	1,333	657	1,990	4.03	2.77
Bottomland hardwood forest	35	17	52	353	221	574	4.15	3.29
Combined types	69	20	89	2,015	1,144	3,159	4.07[1]	3.02[1]

[1]Average for combined types.

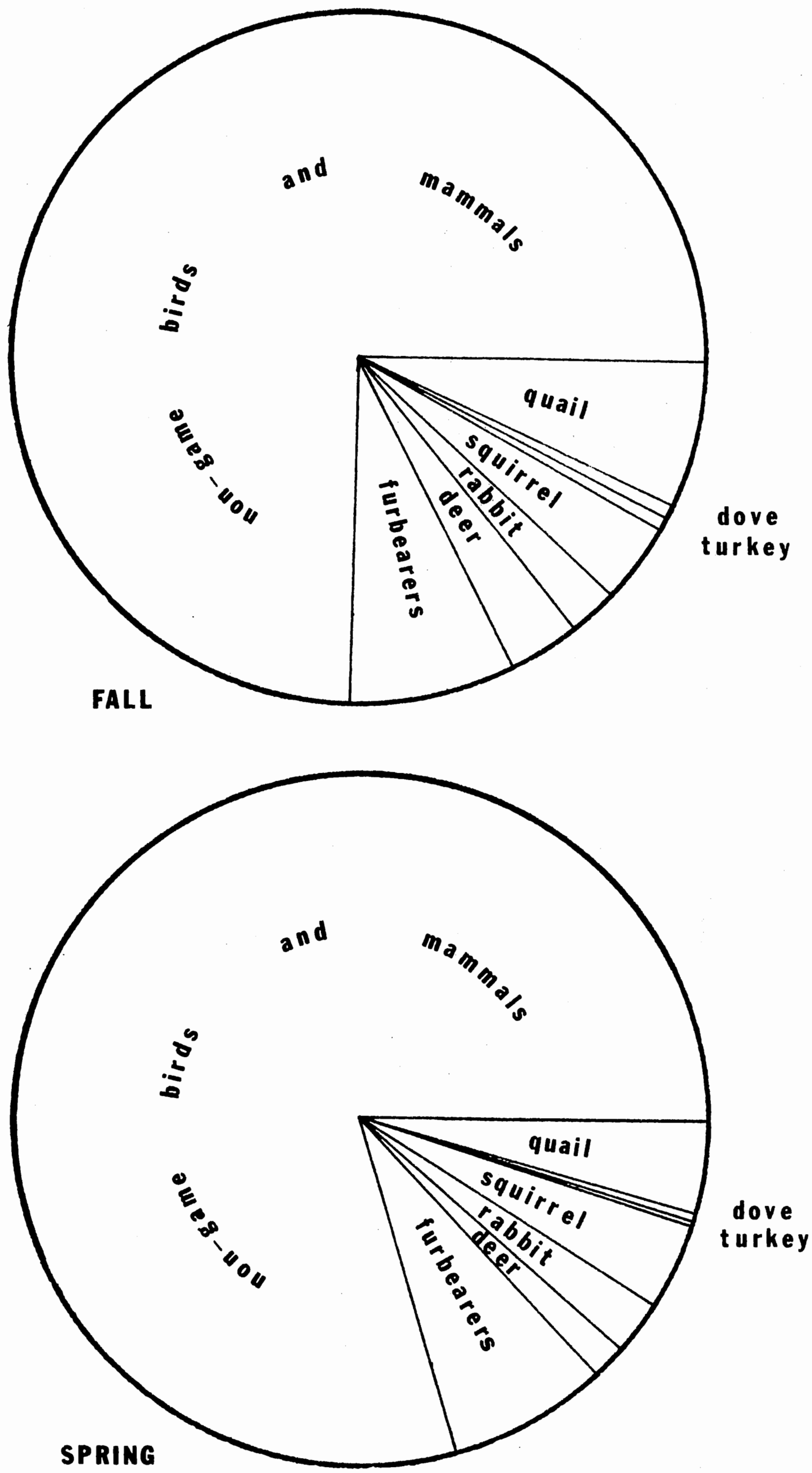
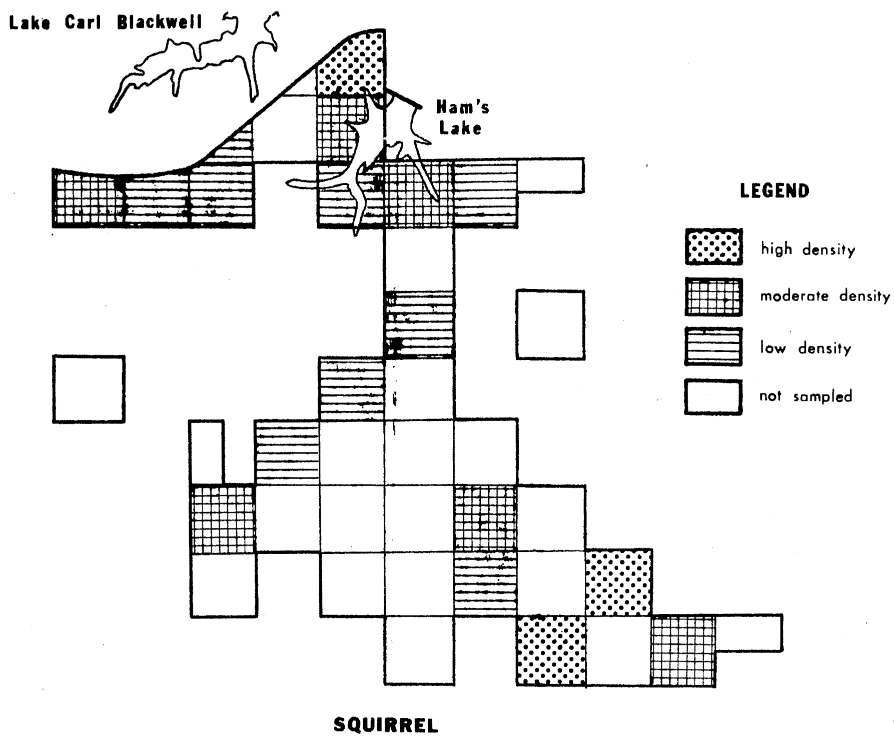


Fig. 19. Relative numbers of game versus non-game birds and mammals encountered on the study area during spring and fall sign-count transect observations, 1975.

spring to 1.7 per plot in fall). This could also be due to migration of avian species during fall (Sutton 1967). Because of the much drier ground conditions in fall, no similar valid comparison for mammalian predators could be made (observation of tracks was the most important means of encountering mammalian predators). Also, detectability of squirrels and rabbits could be lower in fall since more foliage cover is present during this sample period.

Figs. 20 and 21 show the relative densities of eastern fox squirrel, white-tailed deer, eastern cottontail rabbit, bobwhite quail, respectively, encountered on the sample plots. Criteria of high, moderate and low densities were assigned for each species by proportionately stratifying the number of individuals of that species encountered on each sample plot. Therefore, these parameters pertain only to this study, as a means of comparing relative densities of each species.

In order to determine a measure of credibility in applying the results of the faunal data gathered from the sampled plots to the study area as a whole, class-area curves (Smith 1966) were plotted for the following classes of birds and mammals: non-game birds, game birds, raptors, non-game mammals, game mammals and furbearing mammals. These curves are plotted in Figs. 22 and 23. All curves except that for non-game birds flatten out rather quickly, indicating a comparatively small likelihood of encountering a new species. However, because of the migratory nature of most non-game birds and the timing of faunal sampling, many spring and fall migrants were encountered. This implies that more bird species use the study area than were encountered during sign-count transect observation. This is probably true and is supported



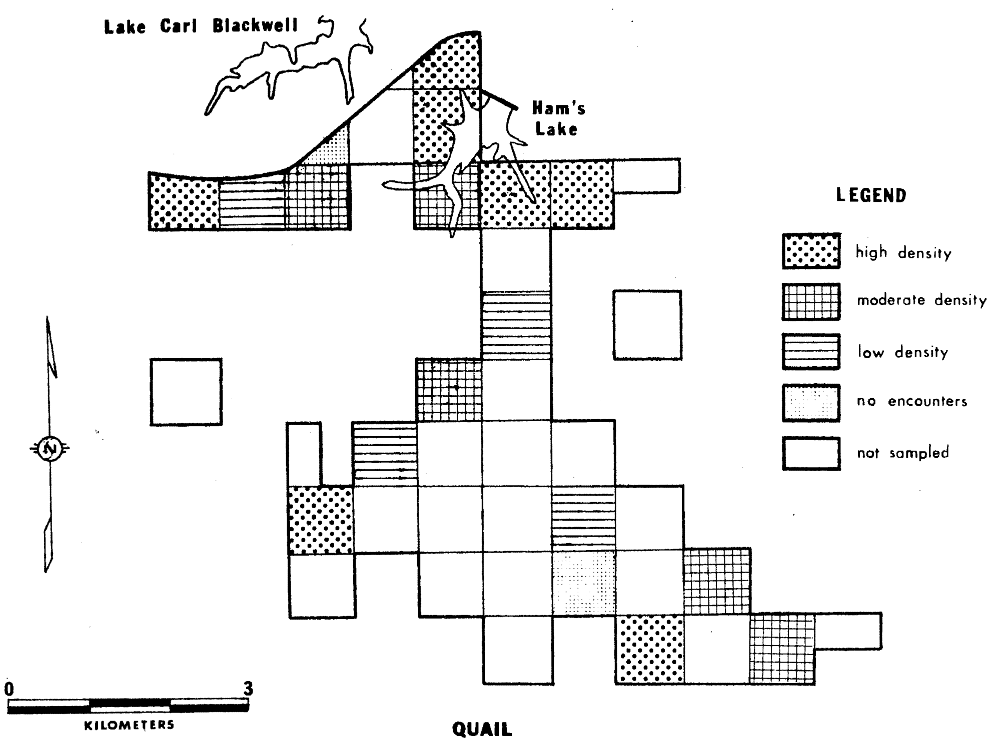
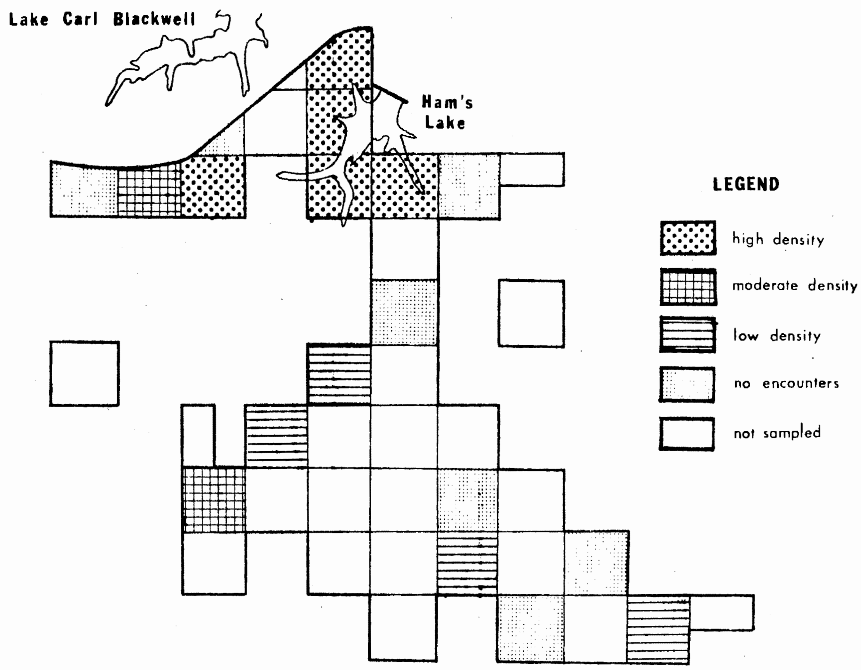
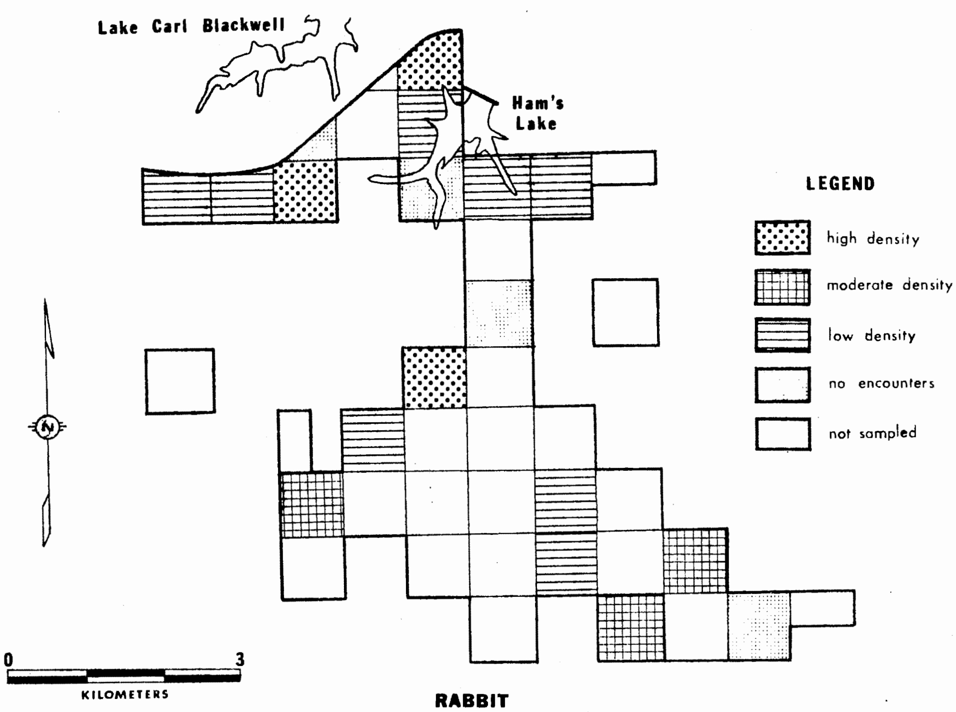


Fig. 20. Relative density of eastern fox squirrel and bobwhite quail on sign-count transect sample plots.



DEER



RABBIT

Fig. 21. Relative density of white-tailed deer and cottontail rabbit on sign-count transect sample plots.

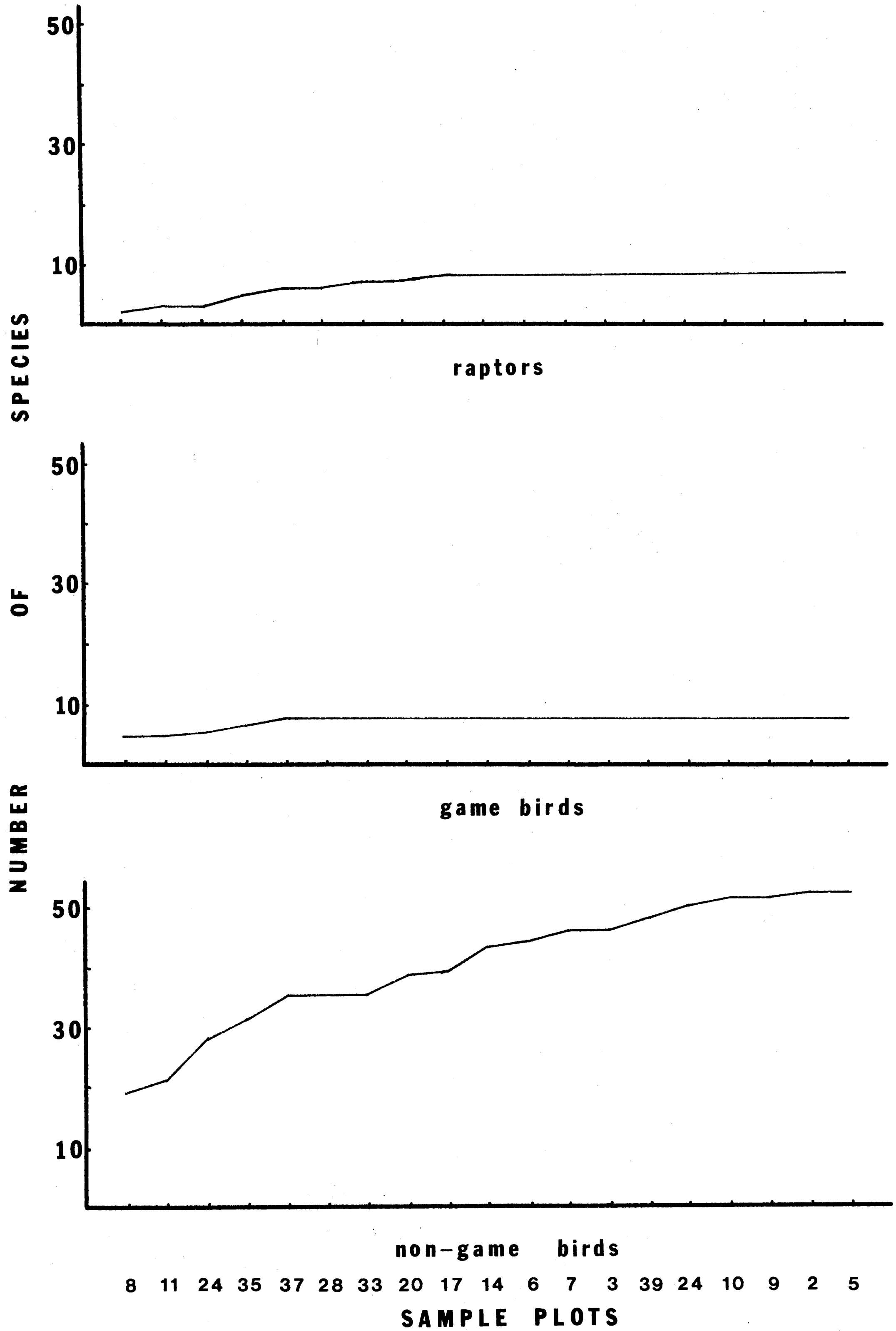


Fig. 22. Species-area curves for non-game birds, game birds and raptors (sign-count transect data).

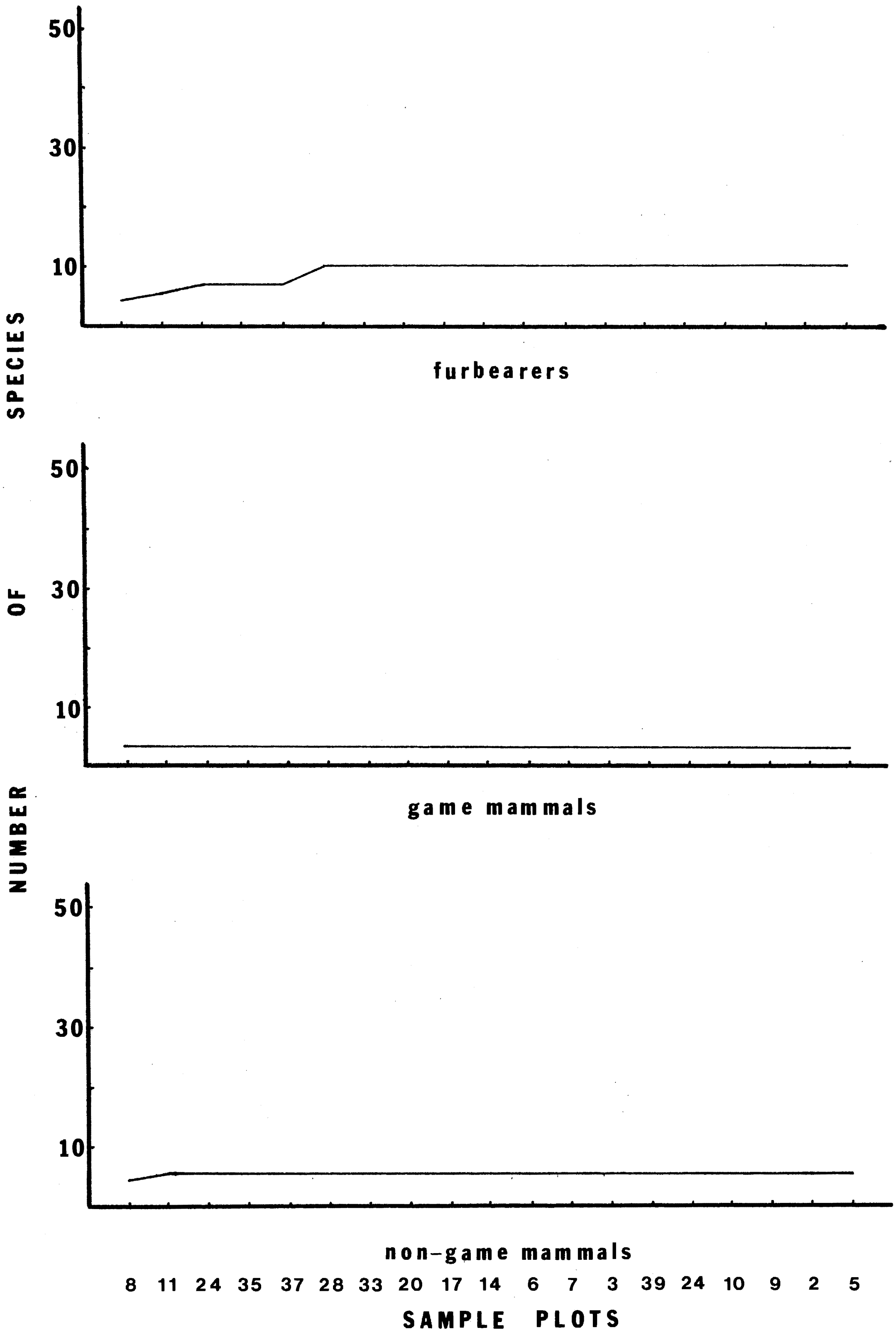


Fig. 23. Species-area curves for non-game mammals, game mammals and furbearers (sign-count transect data).

by data in Appendix A which lists all avian and mammalian species noted during this study (includes entire LCBLUA). Table 11 compares published data concerning densities of game species (Barclay and Myers 1974) with the densities obtained for the study area. Minimum population estimates are given for the study area based on extrapolations from the results of the various faunal sampling techniques described in Chapter III.

The area of cover type for each species was determined as follows:

Eastern fox squirrel--upland hardwood forest + bottomland hardwood forest.

White-tailed deer--upland hardwood forest + bottomland hardwood forest + oak savannah-brush + .50 x native grassland.

Eastern cottontail rabbit--area of all habitat types in the study area.

Bobwhite quail--area of all habitat types in the study area.

Rio Grande turkey--upland hardwood forest + bottomland hardwood forest + oak savannah-brush.

All estimates are rated as low on the study area for their habitats except white-tailed deer (note that the estimates are minimum and derived from indices). The estimate for cottontail rabbit was extremely low. Further research and management efforts directed towards both game and non-game species on the study area could provide many much-needed insights into the interrelationships of species with their environments in the Cross Timbers transition zone.

<u>Call-Count Survey</u>. The results of the early morning call-count survey of breeding birds are shown in Appendix G, p. 135. The species

Table 11. Estimated number of game species on the study area compared with published data.[1]

Species	Density class	Number of individuals per hectare of respective habitat: Published	Number of individuals per hectare of respective habitat: Study area	Hectares of habitat (study area)	Estimated minimum number of individuals (study area)
Eastern fox squirrel	High	4.84+	0.62 (upland)	900 (upland)	1,585
	Moderate	2.42-4.84	2.32 (bottomland)	400 (bottomland)	
	Low	0.00-2.42			
White-tailed deer	High	0.05+	0.05	1,830	96
	Moderate	0.02-0.05			
	Low	0.00-0.02			
Eastern cottontail rabbit	High	9.68+	0.05	2,320	122
	Moderate	2.42-9.68			
	Low	0.00-2.42			
Bobwhite quail	High	2.42+	0.02	2,320	48 (No. coveys)
	Moderate	0.48-2.42	1.20 (No. coveys per plot)		
	Low	0.00-0.48			
Rio Grande turkey	High	0.24+	0.01	1,630	23
	Moderate	0.04-0.24			
	Low	0.00-0.04			

[1]References on population numbers by species: Eastern fox squirrel--Brown and Yeager 1945, Parker 1952, Packard 1962; white-tailed deer--Hough 1949, Stout 1971; Eastern cottontail rabbit--Majors 1955, Bellig 1962, Lord 1963, Frye 1973; bobwhite quail--DeArment 1950, Packard 1962; Rio Grande turkey--Hewitt 1967, Buikstra 1968.

most often encountered was the bobwhite quail. Since the majority of quail continued to call into the summer, indicating non-pairing or re-nesting, the number of broods produced should have been limited by the number of breeding females and environmental conditions (Derdeyn 1975). Since the habitat potential was rated as relatively high for this species (Table 7) and estimated numbers were low (sign-count data), it seems that either sampling error or some biological factor was causing production to fall short of potential. Possible answers to this problem could be susceptibility to predation due to inadequate ground cover and/or insufficient food supplies necessitating greater foraging efforts (see p. 89 , Chapter V). It is further hypothesized that the same factors could also be responsible for the low number of cottontail rabbits as discussed earlier (p. 69).

Selected species (those encountered more than 20 times) of breeding birds are shown in Table 12 by their number of encounters in each habitat type combination (combinations of cover types in which birds were observed). The greatest number of birds were observed in the native grassland-upland hardwood cover combination. The native grassland-upland hardwood-bottomland hardwood combination yielded the next greatest number of individuals. Again, this points toward the importance of the upland hardwood forest (post oak-blackjack) cover type to the ecological stability of this transition biome.

Linear Correlations. Linear correlation coefficients (Barr and Goodnight 1972) were calculated for all of the variables sampled by the LANDSAT-1 satellite classification system and by the sign-count transect faunal and habitat sampling technique. Two variables which were examined in this manner and found to be important were vegetative

Table 12. Major breeding bird species[1] encountered during the call-count survey by vegetative cover type combinations[2] on the LCBLUA study area, spring 1975.

Species	NG	NG/UH	NG/OS-B	NG/BH	NG/UH/BH	UH/BH	BH/NG/C	BH/C
Bobwhite quail	9	78	3	8	25	12	3	6
Mourning dove	3	27	2	-	7	14	3	2
Yellow-bellied cuckoo	-	18	2	1	8	7	1	-
Red-bellied woodpecker	1	11	-	2	9	3	2	3
Common crow	4	36	-	2	12	8	-	3
Tufted titmouse	-	16	-	3	12	10	1	1
Eastern bluebird	-	6	-	-	7	-	-	9
Blue-gray gnatcatcher	-	16	-	-	4	11	1	1
Brown-headed cowbird	-	33	-	3	8	7	1	1
Cardinal	-	33	-	1	16	13	9	6
Blue grosbeak	-	8	-	-	9	4	-	3
Lark sparrow	-	15	-	-	3	3	4	-
Field sparrow	-	51	-	7	26	6	3	2

Table 12 (Continued)

Species	NG	NG/UH	NG/OS-B	NG/BH	NG/UH/BH	UH/BH	NG/NG/C	BH/C
Total observed	17	348	7	27	147	98	28	37

[1]Only species encountered over 20 times were included.

[2]NG = native grassland, UH = upland hardwood, OS-B = oak savannah-brush, BH = bottomland hardwood, C = cropland.

cover type diversity by plot and faunal diversity by plot. It had been hypothesized that these two variables would correlate positively since, as the cover components become more diverse, more faunal niches should be present (MacArthur and MacArthur 1961) and a greater diversity of animal life would presumably occur. Fig. 24 shows the faunal diversity index values from each sampled plot grouped by vegetative cover diversity strata (both seasons combined). These variables correlated positively at a significance level of $\alpha = 0.0395$. While expected, this does lend validity to the results of both the habitat and faunal surveys. Other statistically significant ($\alpha \leq 0.05$) positive linear relationships are illustrated in Fig. 25. Dominant plant diversity correlated with vegetative cover diversity, faunal diversity, vegetative cover diversity stratum (stratum one being least diverse), habitat condition and percentage of oak savannah-brush cover type. It should follow that the more diverse the dominant plant species composition for a given plot, the more diverse would be that plot's faunal species composition (MacArthur and MacArthur 1961). Range condition should regulate plant species diversity since over-use by livestock tends to reduce the number of dominant plant species present (Weaver 1968). The reasons for significant correlation between dominant plant diversity and percentage of the oak-savannah-brush cover type is not fully understood and should be examined further. An important relationship which may have management implications is that between the number of encounters of Rio Grande turkey and the percentage of bottomland hardwood forest. The number of sightings (actual encounters) per sample plot increased from spring to fall probably due

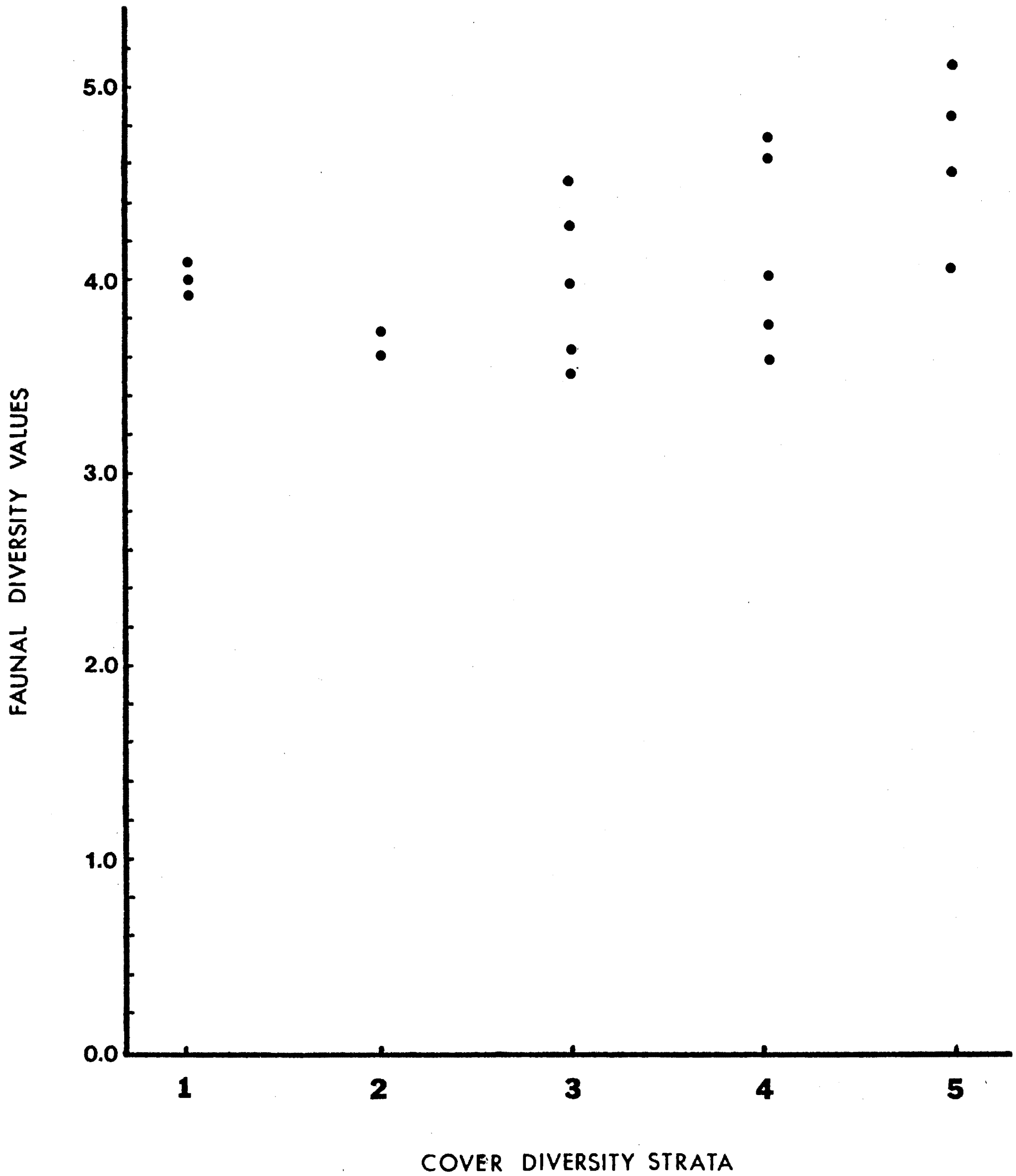


Fig. 24. Faunal diversity by vegetative cover diversity stratum for both sampling periods (seasons) combined (linear correlation significance level [α] = 0.0395).

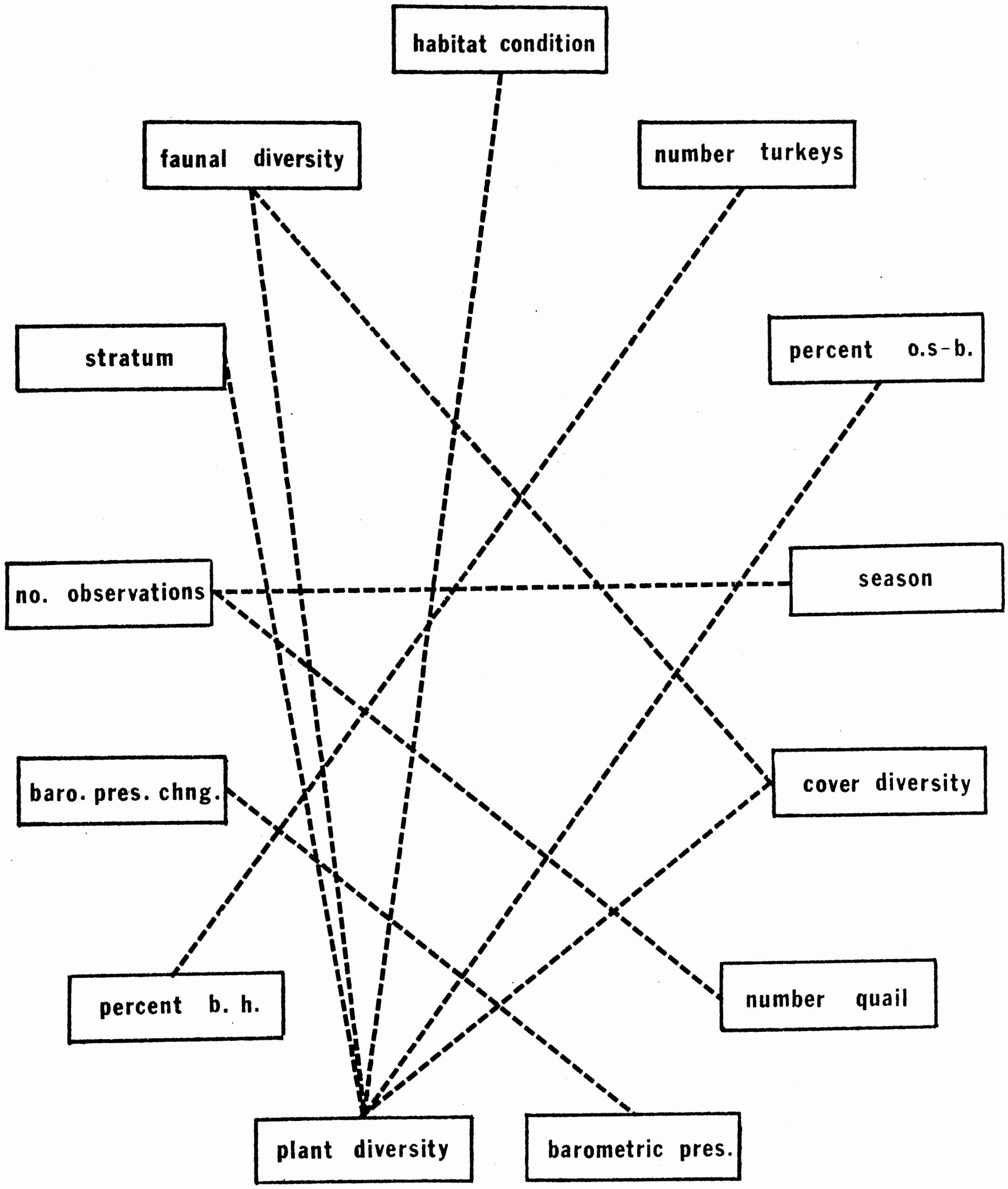


Fig. 25. Positive linear correlation relationships among various parameters ($\alpha \leq 0.05$).

to the natural increase during a normal reproductive season (a normal reproductive season was assumed).

Matrix Analysis of Plots

A matrix analysis was performed using standardized performance values (ranging from 1 to 5, with 5 indicating highest performance) for several habitat and faunal parameters in order to gain an estimate of each of the 40 plots' potential value to wildlife. The standardized values were calculated by stratifying the range of values obtained for each sampled parameter into 5 groups. These values were then multiplied by weighting factors and totaled for each plot. Table 13 shows the parameters used and their associated weighting factor. Results of the matrix analysis are shown in Appendix H, p. 138. The weighting factors were assigned on the basis of the author's estimate of the relative importance and reliability of the results of each parameter. Habitat diversity was considered the most important parameter measured. It was directly measured for all plots in the study area. The habitat evaluation index and soil index were probably as important as the cover diversity index but were extrapolated for each plot, not directly measured, and hence given a lower weighting factor. Various investigations on the study area found the bottomland hardwood forest to be the most productive cover type. Consequently, this parameter was included in the matrix analysis. The pond index was included due to similar reasoning. Habitat condition, plant diversity and faunal diversity, while shown to be very important, were all assigned weights of one. These values were derived from their respective correlations with cover diversity. Although these correlations were all significant ($\alpha \leq 0.05$), a one to one correlation ($\alpha \leq 0.00$) was assumed in the calculations of values for unsampled plots. Since this assumption is not completely valid, the lower weighting factors were assigned. The values were then stratified into five strata with stratum five being most important to wildlife.

Table 13. Parameters and associated weighting factors used in matrix analysis of each plot's value to the wildlife resource.

Parameters	Weighting factors
Cover diversity	3
Habitat index	2
Soil index	2
Percent BH index	2
Habitat condition	1
Dominant plant diversity	1
Pond index	2
Faunal diversity	1

The results of this matrix analysis, illustrated in Fig. 26, show the relative value of each plot on the study area to the wildlife resource (values for each parameter appear in Appendix H, p. 138). Plots in strata 4 and 5 are obviously most important to this resource. (Note the relationship among the densities of game species shown in Figs. 20 and 21 and the plots placed in the higher

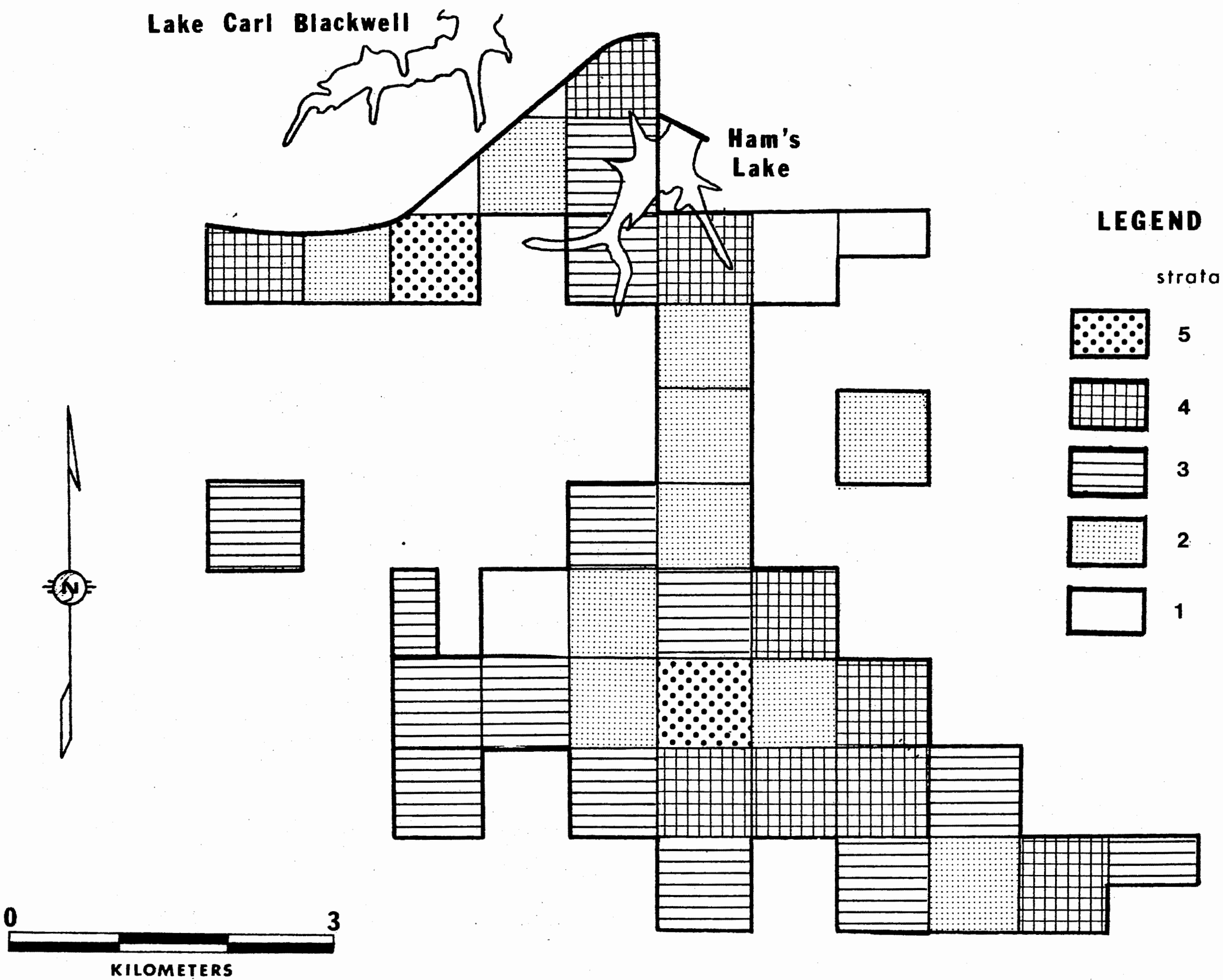


Fig. 26. Strata analysis of plots to the wildlife resource on the study area as determined by matrix analysis (stratum 5 has greatest value).

matrix strata as shown in Fig. 26.) These plots should have special significance in further research efforts.

Lessee Questionnaire Survey Results

Eight of the nine lessees surveyed returned their questionnaires promptly (see Appendix I, beginning on page 142). The ninth was never returned although three mailings were made. These missing data were ignored in compilation and analyses. Since the majority of responding lessees failed to indicate the locations at which they had observed game animals, these data were also ignored (maps were provided as a part of the questionnaire).

Due to the biased nature of the responses from the lessees, the results of the survey were not used in any habitat or faunal applications. They are presented here as an index to attitudes of lessees toward various wildlife management and outdoor recreational activities which could conceivably occur on their leases. While a slight majority of the lessees did not hunt and the same percentage did fish, the overwhelming majority would not allow hunting on their respective leases (Table 14). Most lessees would allow fishing, hiking, picnicking, nature photography and bird watching, but not camping. Sentiments against hunting and camping on leased lands ran very strong. Reasons given most often (Table 15) were shooting of livestock, gates left open, shooting from the road and possible fires. Fear of the violation of property rights seemed to be the reason most often given, in summary.

Table 16 shows the responses of lessees when asked to note the relative abundance of various game species. Bobwhite quail, Rio Grande turkey and cottontail rabbit were consistently indicated as low in abundance while white-tailed deer, fox squirrel and waterfowl (ducks) were rated as moderate to low. The only predator included in this portion of the survey, the coyote, was the only species rating consistently high in abundance.

Table 14. Attitudes of lessees to various outdoor recreational activities.

	Percent of Responses to Questions	
Do you hunt?	42.9 yes	57.1 no
Do you fish?	57.1 yes	42.9 no
Would you allow hunting on your lease with your permission?		
	14.3 yes	85.7 no
Would you allow any of the following types of recreation on your lease?		
fishing	71.4 yes	28.6 no
hiking	87.7 yes	14.3 no
camping	14.3 yes	85.7 no
picnicking	57.1 yes	42.9 no
nature photography	71.4 yes	28.6 no
bird watching	71.4 yes	28.6 no

Table 15. Reasons of lessees for not allowing people on their lease.

Of the following reasons, which are the most important in influencing your decision not to allow people on your lease? (Importance index, 5 indicating greatest concern.)

Desire to have game available for friends and relatives only	1	Gates left open	5
Littering	2	Roads blocked	1
Possible fires	4	Belligerent sportsmen	2
Shooting livestock	5	Drunken sportsmen	1
Property stolen	3	Opposed to hunting	1
Damage to buildings	1	Personal and family safety	2
Damage to fences	3	Shooting from road	4

Table 16. Relative abundance of game species as indicated by questionnaire respondents.

Species	Densities (percent of responses)		
	High	Moderate	Low
Bobwhite quail	14.7	14.7	70.6
Rio Grande turkey	14.7	0.0	85.3
White-tailed deer	33.3	50.0	16.7
Fox squirrel	16.7	50.0	33.0
Coyote	66.7	33.3	0.0
Cottontail rabbit	16.7	33.3	50.0
Ducks	16.7	50.0	33.3
Average	28.1	35.9	35.9

These results compare with the following found by the author: bobwhite quail--low, Rio grande turkey--low, white-tailed deer--moderate to high, fox squirrel--low to moderate, cottontail rabbit--low, waterfowl--seasonally low to moderate, and coyote--moderate. Relative agreement is found except in the case of the coyote. Possible reasons for high lessee ranking of this species are varied, and could range from actual encounter of numerous individuals to reasoning that even the presence of one coyote constitutes a high abundance. (Note that the author's population estimates are minimum.)

The attitude survey seemed to indicate some bias on the part of lessees toward certain management and recreation activities related to the wildlife resource on the study area. Cooperation from lessees in future management and research efforts was not indicated.

CHAPTER V

MANAGEMENT SUGGESTIONS

The purpose of this chapter is to present various management suggestions for the study area based on interpretations of available literature, plus analyses of data collected and observations made by the author during the study. The suggestions are those of the author and may or may not reflect existing policy, procedures or support by the University, its subdivisions or programs.

Grazing

Grazing by livestock on the study area has been nearly continuous since about 1954 when the University received the deed for the LCBLUA from the Federal government (personal communication, Satterfield 1977). This study has shown (dominance of invader and increaser plant species) that much of the rangeland on the study area has been overgrazed. A study could be initiated to evaluate each grazing lease pasture's sustained carrying capacity and suggest means for proper utilization of the range resource in regard to grazing. This study could be conducted as a range management class project (Department of Agronomy). A comprehensive grazing system could then be devised for all pasture leases on the study area.

Wildlife and Fisheries Management

Permanent reference markers could be established at the center of each plot from which photographic documentation of vegetative and range condition changes over a period of years could be obtained. Tagged steel fence posts (orange) have proven adequate in past similar applications. Photographs would then be taken at these points at each compass angle (north, south, east and west) at regular intervals (e.g., once every three years). These photographic records would then be labeled and filed for future comparisons and reference.

An experimental hunting and trapping program could be initiated on the study area with a system of first-come, first-serve access permits controlling the number and distribution of participants. Huntable populations of quail, turkey, fox squirrel, cottontail rabbit and deer are present. Furbearing species which have trappable numbers are stripped skunk, opossum, raccoon, coyote and bobcat. Table 17 shows the estimated 1975 populations of game and furbearing species, the recommended number of access permits which should be issued per species, suggested prices for these permits and the estimated minimum revenue which could be derived from permit sales. (These numbers do not include anticipated increases resulting from management.) The permits would be sold and detailed records maintained at the Lake Carl Blackwell Headquarters. All permittees should be required to check in at the Headquarters where appropriate measurements of game and furbearers would be taken and recorded as a means of determining sex and age ratios, productivity, physical condition, and response of faunal populations to management practices. Migratory waterfowl should probably not be hunted on the study area except as part of specific research projects. As a point of reference, Table 18 shows the initial results from a program similar to the one proposed here. These data are the results of the first year of a permit-only hunting program on land administered by the School of Biological Sciences. The program was controlled by the Biological Sciences Lands Advisory Board through the Wildlife Ecology Program and the manager of the Lake Carl Blackwell Resources Area.

Table 17. Harvestable annual surplus estimates for game animals on the study area and potential permit revenue.[1]

Game species	Total estimated number	Surplus number	Number permits	Price per permit	Potential annual revenue
Eastern fox squirrel	1585	1000	75	$2.00	$150.00
White-tailed deer	96	20	20	5.00	100.00
Eastern cottontail rabbit	122	50	10	2.00	20.00
Furbearers	NA	NA	5	5.00	25.00
Mourning dove	NA	NA	30	2.00	60.00
(Contingent upon management efforts)					
Bobwhite quail	480	300	25	3.00	75.00
Rio Grande turkey	23	5	5	5.00	25.00
Waterfowl	NA	NA	15	5.00	75.00
TOTAL			185		$630.00

[1]NA--no data available.

Table 18. Permits sold for the fall 1976 hunting season on the Hunt Creek--LCBLUA.[1]

Species	Number permits issued	Cost per permit	Revenue collected
Eastern fox squirrel	5	$2.00	$ 10.00
White-tailed deer	2	2.00	4.00
Eastern cottontail rabbit	30	2.00	60.00
Bobwhite quail	18	2.00	36.00
Rio Grande turkey	15	2.00	30.00
TOTAL	70		$140.00

[1]Calculated by author from permit ticket stubs.

The selective placement of artificial nest boxes or structures in the upland and bottomland cover types would increase the use of these areas by fox squirrels and other animal life. These nest structures should be of the wooden and rubber tire types described in Giles (1969). Predator proof nest boxes should also be placed in suitable habitat for wood ducks, particularly near Ham's Lake and some of the larger ponds.

In order to increase revenue, establish food plots and increase cover diversity and edge, cultivation could be reestablished in a few suitable locations. These areas, shown in Fig. 27, could be share-cropped with three-fifths of the crop going to the farmer, one-fifth going to the University and one-fifth remaining standing. Crops grown would include wheat, milo (including WGF--wild game food) and alfalfa with contour stripcropping being practiced. Game species that would

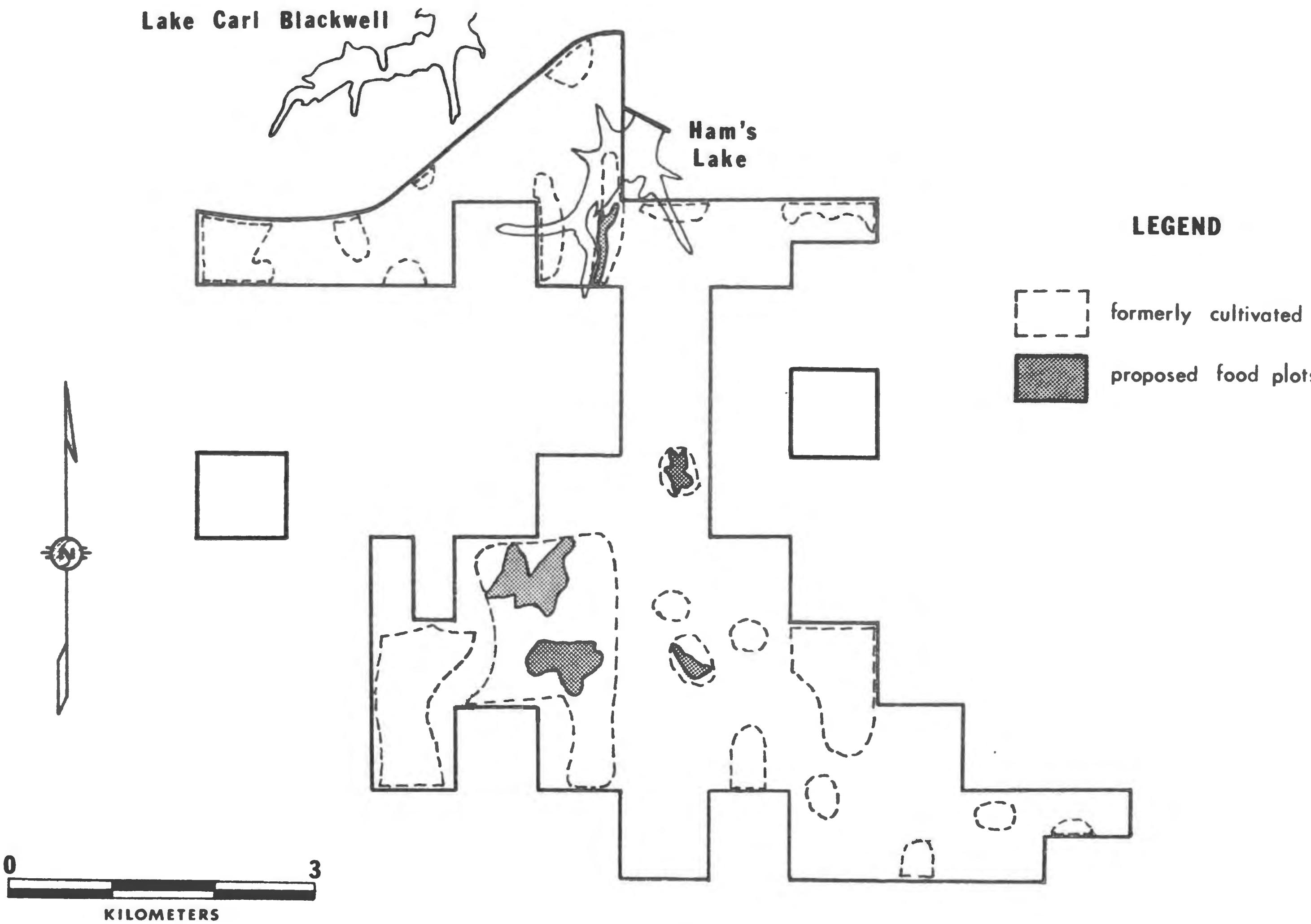


Fig. 27. Map showing locations of formerly cultivated areas and proposed "food plots" on the study area.

utilize these plots heavily are deer, quail, turkey, waterfowl and mourning dove (Martin et al. 1961). Special hunting permits could be sold for access to these plots during mourning dove season.

A management tool which could be beneficial in increasing edge, forage production, and vegetative cover diversity where needed on the study area, is the carefully controlled clearing of non-linear strips (8 to 10 meters wide) and openings (20 to 25 meters in diameter) in pre-determined locations of dense upland hardwood forest. This clearing should be done on a contour with a slope no greater than 5%. All snags, den trees and mature trees should be left standing. Immediately following clearing (should be accomplished during late winter or spring), a seedbed should be prepared and seeded with native grasses, lespedezas and sweetclovers to prevent soil erosion and provide wildlife food and cover. The suggestion stated here does not in any way embrace the idea of large-scale clearing of woody vegetation.

In conjunction with the clearing of travel lanes and feeding areas, brush piles could be created, mainly in grassland areas adjacent to the upland forests being treated. These brush piles would greatly increase the nesting and escape cover for game species such as quail and cottontail, while creating travel lanes for other game and non-game species. Areas which would benefit most from clearing, seeding and brush pile establishment are shown in Fig. 28.

Controlled burning could be practiced on most of the study area where consistent with safety and good conservation. This cost-effective management tool has been shown to be irreplaceable in retarding succession, resulting in increased food production and energy flow (Black 1968, Yoakum and Dasmann 1969).

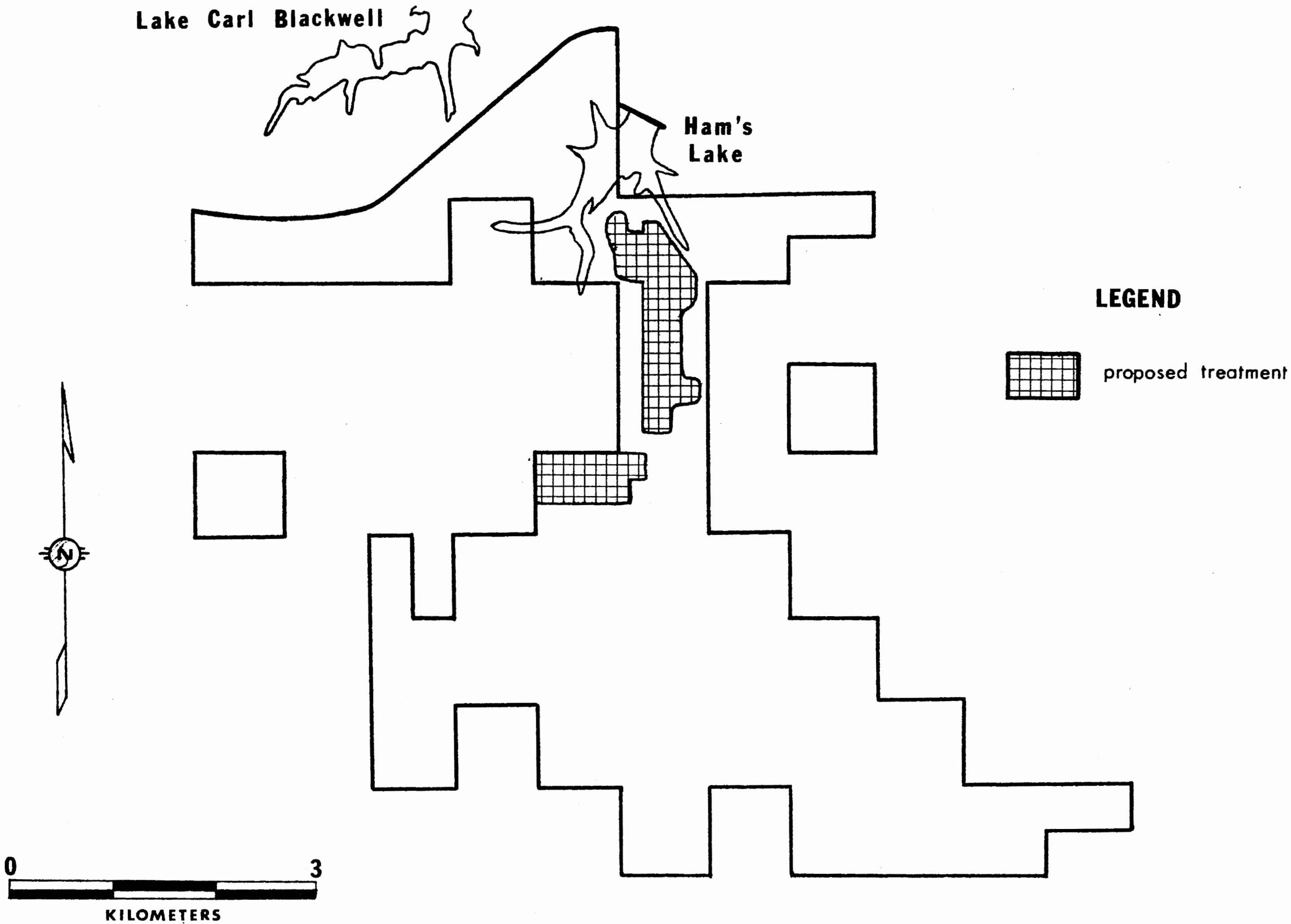


Fig. 28. Map showing areas proposed for strip-clearing, brush pile creation and seeding.

Permits or fees could also be sold (charged) for fishing privileges to the numerous ponds on the study area. Before this program could be initiated, however, fish populations should be sampled. This could be accomplished as a part of a fisheries class project (e.g., Zoology 4524, Fisheries Management). Fig. 29 shows the ponds which should be included in this program.

All ponds on the study area should be fenced with narrow lanes extending into deep areas to provide livestock water. This would allow the growth of shoreline vegetation and reduce water turbidity, both important to productive fish, waterfowl and furbearer habitat.

Several of the original ponds on the study area were constructed on permeable soils. The sites were evidently not sealed to prevent excessive percolation. As a result the water level in these ponds is either below normal for a comparable watershed or non-existent. A sealing material such as Bentonite[R] should be used to increase the value of these aquatic sites.

Many potential sites exist for the construction of new ponds. Some of these sites are illustrated in Fig. 29. These ponds should also be fenced in the manner described above. This would provide more fish and waterfowl habitat as well as increasing the availability and proximity of water to livestock and other species of wildlife.

In order to increase the amounts of aquatic habitat on the numerous intermittent streams on the study area a system of variable level water control wiers could be constructed. Potential locations for these structures are shown in Fig. 30.

Trespass and unlawful hunting activities are prevalent on the study area. Vandalism and illegal wood-cutting are also common (author's

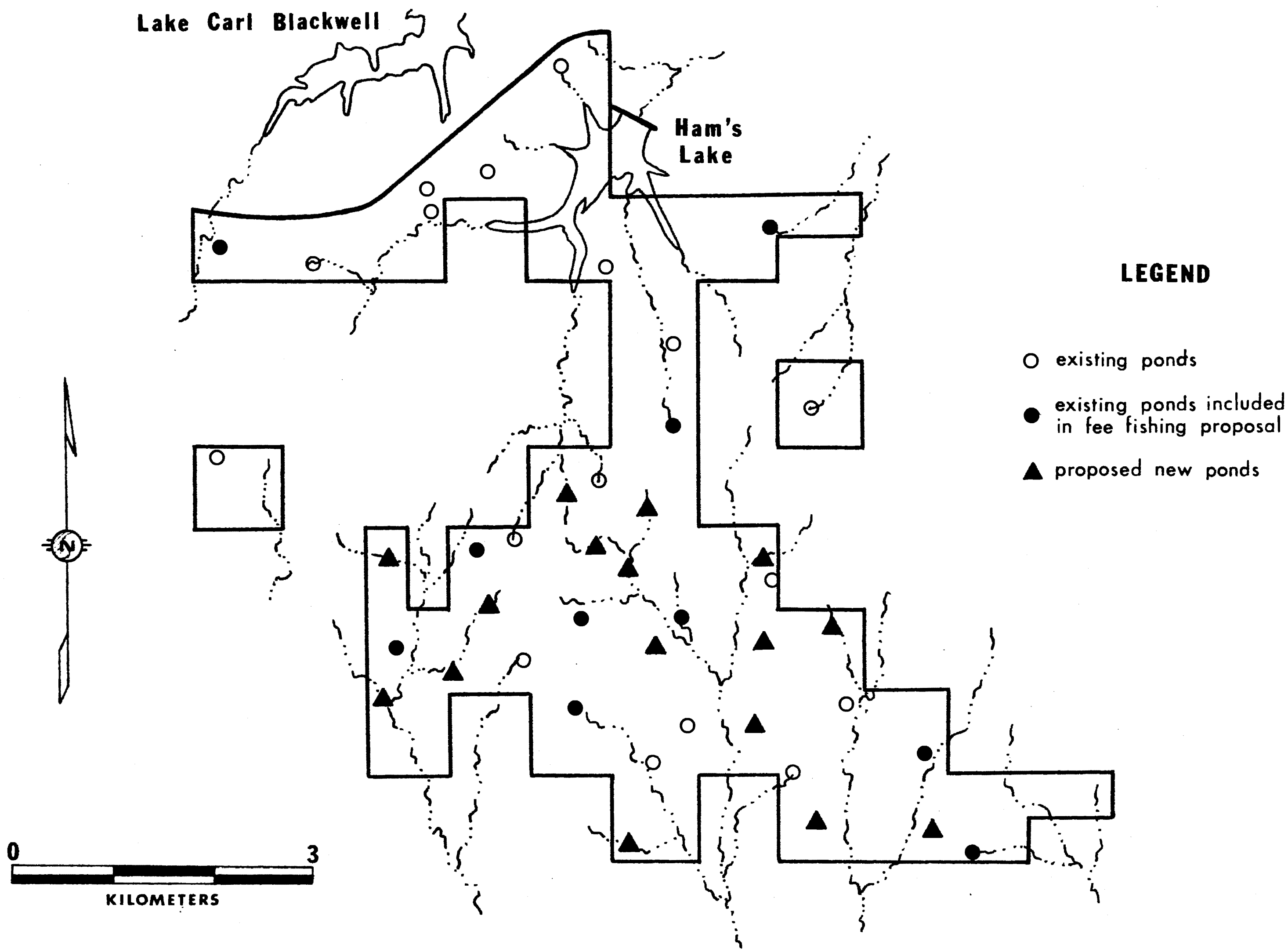


Fig. 29. Map of existing and proposed ponds on the study area (includes existing ponds recommended for use in the fee fishing proposal).

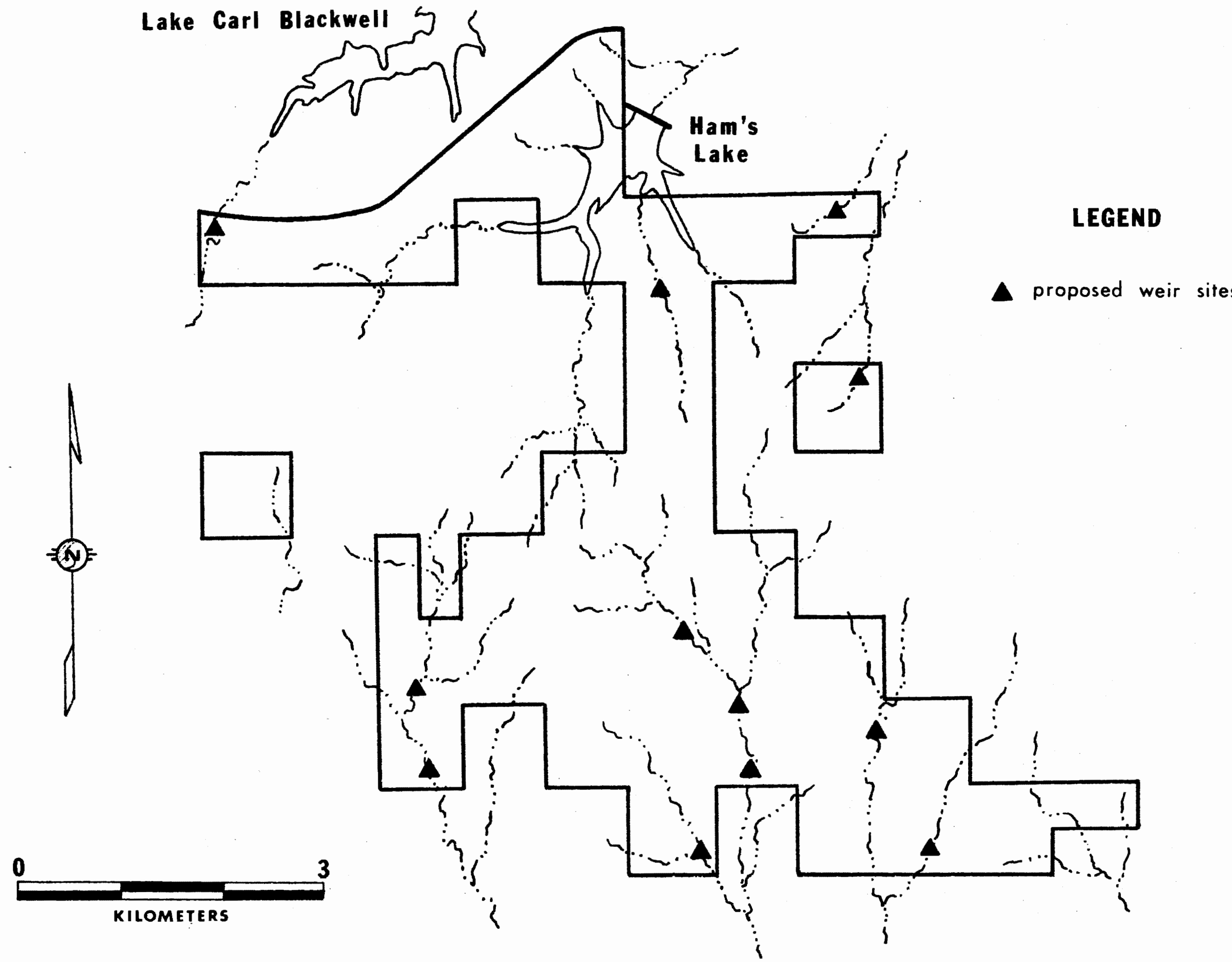


Fig. 30. Map showing proposed locations of water level control weirs.

observations). These activities should be controlled.

Research, Demonstration and Education

Research should be encouraged on the study area. Interdisciplinary projects related to various land-use problems could be stressed. In order to avoid any conflicts among research projects, a coordinating body could be designated.

Demonstration projects could also be undertaken on the study area to illustrate new techniques and proper land resource management. Again, a coordinating body could be helpful in precluding any incompatibilities among projects.

The study area could provide a natural laboratory for various University classes and student groups. More use could be made of the area for the educational needs of these groups.

CHAPTER VI

SUMMARY OF RESULTS AND CONCLUSIONS

The study area comprised 2330.18 ha on the Lake Carl Blackwell Land Use Area south of S. H. 51 and east of Coyle Road as measured by LANDSAT-1. This area contained 899 ha of upland hardwood forest, 599 ha of native grassland, 443 ha of bottomland hardwood forest, 287 ha of oak savannah-brush, 61 ha of disturbed or eroded sites and 42 ha of aquatic sites. The percentage of upland forest on the study area was much higher than on the surrounding private lands.

Vegetative cover diversity indices were calculated for each plot on the study area using the Shannon-Weaver formula. High values were shown for 15% of the plots while low values resulted for 17.5% of the plots. These values correlated significantly with systematic examinations of faunal diversity and dominant plant diversity. Measurements of vegetative cover diversity appeared to be the most useful overall measure of a given plot's value to wildlife populations. Dominant plant species by cover type for the study area (in order of dominance) were upland hardwood forest--post oak, blackjack oak, red cedar, buckbrush and sumacs; native grassland--little bluestem, ragweeds, silver bluestem, red cedar and Indiangrass; bottomland hardwood forest--chinkapin oak, elms, bur oak, post oak and greenbriar; brush--sumacs, sandplum, elms and red cedar. The dominance of ragweeds, silver bluestem and red cedar in the native grasslands (increaser and invader species) illustrates existing sub-climax conditions, probably due to overgrazing in recent years compounding the effects of ill-advised cultivation following White settlement of the region. Fig. 27 illustrates the degree to which cultivation was practiced prior to Federal government purchase. Results of the soil analyses showed low phosphorous and nitrogen levels in the soils of the native grassland cover type. Sodium is higher in the grasslands soils than for all other types, excepting the eroded sites.

The habitat evaluation index showed that the present average food and cover values to wildlife groups for each cover type are ranked as follows (highest value first): aquatic sites, bottomland hardwood forest, upland hardwood forest, native grassland, oak savannah-brush and eroded sites.

Another measurement parameter which also yielded poor ratings of the native grasslands on the study area was the range condition survey. This cover type received consistently lower ratings regarding range condition than did the other vegetative types.

The survey of ponds on the study area noted 20 ponds considered to be permanent. In most cases trampling and grazing of the shoreline vegetation by livestock has removed most of their value for wildlife. Many of the ponds were originally fenced (Park 1937) and remnants of fencing are present in several locations.

Faunal resources on the study area were surveyed by various methods. The most numerous bird was the bluejay while the most numerous mammal was the armadillo. Considering only game species, however, the bobwhite quail and eastern fox squirrel were most frequently encountered. Good populations of Rio Grande turkey, white-tailed deer and various fur-bearers were also found. As a whole, 135 bird species were observed (including all species observed on the LCBLUA during this study) along with over 16 species of mammals (not including any breakdown of the small mammal category). Mammals and birds observed are listed in Appendix A. Harvestable populations of bobwhite quail, Rio Grande turkey, eastern fox squirrel, eastern cottontail rabbit, white-tailed deer, bobcat, coyote, raccoon, opossum, and striped skunk were present on the study area and could be utilized in a controlled manner.

Matrix analysis, incorporating all survey parameters, was utilized to better determine each plot's overall value to the wildlife resource of the study area. Fig. 26 shows the results of this analysis. Two major areas of high biological value were detected, one in the northern portion of the study area and one in the southern portion.

Lessee attitudes toward outdoor activities were found to be positive in all but two situations. The two activities which would not be favored by the majority of the lessees were hunting and camping. The majority of lessees claimed that they would permit fishing, hiking, picnicking, nature photography and bird-watching. The only animal whose density was considered high by the lessees was the coyote.

Several management practices were suggested for the study area. Better management of the range forage resource would benefit both livestock and wildlife. Permanent reference markers should be installed as designated in order to assure uniform monitoring of changes in habitat over a period of years.

A research program involving limited harvest of game birds and mammals, furbearers and fish could be initiated. A program of selectively providing food plots, nest boxes, brush piles and other habitat improvements could also be implemented. Prescribed burning could also be beneficial.

The construction of ponds and weirs at various suitable sites throughout the study area would greatly increase the availability and value of aquatic habitat. Existing and future ponds should be fenced with provision for watering of livestock.

Serious problems which exist on the study area include illegal trespass, poaching, and harassment of wildlife. Laws regarding such activities should be enforced.

The greatest asset that the study area presents to the University is that of a research, education and demonstration area. Further and continued effort through such groups as the Lake Carl Blackwell Advisory Committee, the Environmental Institute, and University schools, colleges and departments should be geared toward optimum utilization of the LCBLUA as a research, education and demonstration facility in fulfillment of the three major objectives of the land grant university system.

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APPENDIXES

APPENDIX A

SCIENTIFIC NAMES FOR PLANTS AND ANIMALS

MENTIONED IN THE TEXT OR NOTED IN

THE DATA TAKEN DURING

THE STUDY

Scientific Name	Common Name
Flora (Alphabetical Order)	
Amaranthus spp.	Pigweeds
Ambrosia spp.	Ragweeds
Amorpha causcens	Leadplant
Andropogon gerardii	Bluestem, big
A. saccharoides	Bluestem, silver
A. scoparius	Bluestem, little
A. ternarius	Bluestem, splitbeard
Aristida spp.	Three-awns
Artemesia spp.	Sages
Aster spp.	Asters
Bouteloua curtipendula	Grama, sideoats
B. gracilis	Grama, blue
B. hirsuta	Grama, hairy
Bromus catharticus	Rescue grass
Bromus spp.	Bromes
Buchloe dactyloides	Buffalo grass
Bumelia lanuginosa	Chittumwood
Carya illinoensis	Pecan
Carya spp.	Hickories
Celtis occidentalis	Hackberry
Cercis canadensis	Redbud
Chamaecrista fasciculata	Partrigepea, showy
Chloris verticillata	Windmill grass
Cornus spp.	Dogwoods
Cynodon dactylon	Bermuda grass
Cyperus spp.	Sedges
Digitaria sanguinalis	Crab grass
Eleocharis spp.	Spikerushes
Elymus spp.	Wildryes
Eragrostis spp.	Lovegrasses
Euphorbia marginata	Snow on the Mountain
Festuca spp.	Fescues
Fraxinus pennsylvanicum	Ash, green
Gutierrezia sp.	Broomweeds
Helianthus spp.	Sunflowers
Hordeum pusillum	Barley, little
Juglans nigra	Walnut, black
Juniperus virginianus	Red cedar, eastern
Jussiaea spp.	Primrose, water
Lespedeza spp.	Lespedezas
Ludwigia palustris	Purslane, marsh
Melilotus spp.	Sweetclovers
Morus rubra	Mulberry, red
Opuntia spp.	Prickly pear
Panicum scribnerianum	Panicum, scribner
P. virgatum	Switchgrass
Parthenocissus quinquefolia	Virginia creeper
Pinus spp.	Pines
Platanus occidentalis	Sycamore

Scientific Name	Common Name
Populus spp.	Cottonwoods
Prunus angustifolia	Plum, sand
P. mexicana	Plum, Mexican
Quercus alba	Oak, white
Q. macrocarpa	Oak, bur
Q. marilandica	Oak, blackjack
Q. muehlenbergii	Oak, chinkapin
Q. shumardii	Oak, shumard
Q. stellata	Oak, post
Rhus radicans	Poison ivy
Rhus spp.	Sumacs
Robinia pseudoacacia	Locust, black
Salix spp.	Willows
Sapindus drummondii	Soapberry
Setaria spp.	Bristlegrass
Smilax spp.	Greenbriars
Solanum spp.	Nightshades
Solidago spp.	Goldenrods
Sorghastrum nutans	Indiangrass
Symphoricarpos orbiculatus	Buckbrush
Tridens flavus	Purpletop
Ulmus spp.	Elms
Uniola latifolia	Uniola, broad-leafed
Vernonia baldwinii	Ironweed
Vitis spp.	Grapes

Fauna (In Taxonomic Order)

Birds

Podilymbus podiceps	Grebe, pied-billed
Pelecanus erythrorynchos	Pelican, white
Phalacrocorax auritus	Cormorant, double-coated
Ardea herodias	Heron, great blue
Botaurus lentinginosus	Bittern, American
Bubulcus ibis	Egret, cattle
Butorides virescens	Heron, green
Cacmerodius albus	Egret, common
Leucophoyx thula	Egret, snowy
Nyctanassa violocea	Night heron, yellow-crowned
Nucticorax nycticorax	Night heron, black-crowned
Plegodis chihi	Ibis, white-faced
Branta canadensis	Goose, Canada
Anser albifrons	Goose, white-fronted
Chen hyperborea	Goose, snow

Scientific Name	Common Name
Anas acuta	Pintail
A. carolinensis	Teal, green-winged
A. cyanoptera	Teal, cinnamon
A. discors	Teal, blue-winged
A. platyrynchos	Mallard
A. strepera	Gadwall
Aix sponsa	Wood duck
Mareca americana	Wigeon, American
Spatula clypeata	Shoveler, Northern
Aythya affinis	Scaup, lesser
A. americana	Redhead
A. collaris	Ring-necked duck
A. marila	Scaup, greater
A. valisineria	Canvasback
Bucephala albeola	Bufflehead
B. clangula	Goldeneye, common
Mergus merganser	Common merganser
Cathartes aura	Vulture, turkey
Ictinia misisippiensis	Kite, Mississippi
Accipter cooperii	Hawk, Cooper's
Buteo jamaicensis	Hawk, red-tailed
B. lagopus	Hawk, rough-legged
B. platypterus	Hawk, broad-winged
B. swainsoni	Hawk, Swainson's
Haliaeetus leucocephalus	Eagle, bald
Circus cyaneus	Hawk, marsh
Pandion haliaetus	Osprey
Falco columbarius	Merlin
F. sparverius	Kestrel, American
Colinus virginianus	Quail, bobwhite
Meleagris gallopavo intermedia	Turkey, Rio Grande
Fulica americana	Coot, American
Porzana carolina	Rail, sora
Rallus limicola	Rail, Virginia
Charadrius vociferous	Killdeer

Scientific Name	Common Name
Actitis macularia	Sandpiper, spotted
Capella gallinago	Snipe, common
Erolia bairdii	Sandpiper, Bairds
E. melanotos	Sandpiper, pectoral
E. minutilla	Sandpiper, least
Philohela minor	Woodcock, American
Totanus flavipes	Yellowlegs, lesser
Tringa solitaria	Sandpiper, solitary
Larus delawarensis	Gull, ring-billed
L. pipixcan	Gull, Franklin's
Sterna forsteri	Tern, Forester's
Chlidonias niger	Tern, black
Columba livia	Dove, rock
Zenaidura macroura	Dove, mourning
Coccyzus americanus	Cuckoo, yellow-billed
Geococcyx californianus	Roadrunner
Bubo virginianus	Owl, great horned
Otus asio	Owl, screech
Strix varia	Owl, barred
Phalaentoptilus nuttallii	Poor-will
Caprimulgus carolinensis	Chuck-will's-widow
Chordeiles minor	Nighthawk, common
Chaetura pelagica	Swift, chimney
Archilochus colubris	Hummingbird, ruby-throated
Centurus carolinus	Woodpecker, red-bellied
Colaptes auratus	Flicker, common
Dendrocopos pubescens	Woodpecker, downy
D. villosus	Woodpecker, hairy
Dryocopus pileatus	Woodpecker, pileated
Melanerpes erythrocephalus	Woodpecker, red-headed
Contopus virens	Wood pewee, eastern
Muscivora forfic	Flycatcher, scissor-tailed
Myiarchus crinitus	Flycatcher, great crested
Pyrocephalus rubinus	Flycatcher, vermillion
Sayornis phoebe	Phoebe, eastern
Tyrannus tyrannus	Kingbird, eastern
T. verticalis	Kingbird, western
Eremophila alpestris	Lark, horned

Scientific Name	Common Name
Hirundo rustica	Swallow, barn
Iridoprocne bicolor	Swallow, tree
Petrolchelidon pyrrhonota	Swallow, cliff
Progne subis	Martin, purple
Corvus brachyrynchos	Crow, common
Cyanocitta cristata	Jay, blue
Parus carolinensis	Chickadee, Carolina
P. bicolor	Titmouse, tufted
Sitta carolinensis	Nuthatch, white-breasted
Certhia familiaris	Creeper, brown
Thryomanes bewickii	Wren, Bewick's
Thryothorus ludovicianus	Wren, Carolina
Mimus polyglottos	Mockingbird
Toxostoma rufum	Thrasher, brown
Hylocichla guttata	Thrush, hermit
H. mustelina	Thursh, wood
Sialia sialis	Bluebird, eastern
Turdus migratorius	Robin
Polioptila caerulea	Gnatcatcher, blue-gray
Regulus calendula	Kinglet, ruby-crowned
R. satrapa	Kinglet, golden-crowned
Lanius ludovicianus	Shrike, loggerhead
Sturnus vulgaris	Starling
Dendroica coronata	Warbler, yellow-rumped
D. petechia	Warbler, yellow
Mniotilta varia	Warbler, black and white
Vermivora peregrina	Warbler, Tennessee
Passer domesticus	Sparrow, house
Agelaius phoeniceus	Blackbird, red-winged
Euphagus cyanocephalus	Blackbird, Brewer's
Icterus galbula	Oriole, northern
Molothrus ater	Cowbird, brown-headed
Quiscalus quiscula	Grackle, common
Sturnella magna	Meadowlark, eastern
S. neglecta	Meadowlark, western
Piranga olivacea	Tanager, scarlet
P. rubra	Tanager, summer

Scientific Name	Common Name
Ammodramus savannarum	Sparrow, grasshopper
Chondestes grammacus	Sparrow, lark
Guiraca caerula	Grosbeak, blue
Junco hyemalis	Junco, dark-eyed
Nelspiza melodia	Sparrow, song
Passerina ciris	Bunting, painted
P. cyanea	Bunting, indigo
Pipilo erythrophthalmus	Towhee, rufous-sided
Pichomdena cardinalis	Cardinal
Spinus tristis	Goldfinch, American
Spiza americana	Dickcissel
Spizella arborea	Sparrow, tree
S. passerina	Sparrow, chipping
S. pusilla	Sparrow, field
Zonotrichia leucophrys	Sparrow, Harris'
Passerella iliaca	Sparrow, fox

Mammals

Didelphis virginianus	Opossum
Dasypus novencinctus	Armadillo
Scalopus aquaticus	Eastern mole
Procyon lotor	Raccoon
Mephitis mephitis	Striped skunk
Taxidea taxus	Badger
Canis latrans	Coyote
Urocyon cinereoargenteus	Grey fox
Vulpes fulva	Red fox
Lynx rufus	Bobcat
Castor canadensis	American beaver
Geomys bursarius	Plains pocket gopher
Neotoma floridana	Eastern woodrat
Peromyscus spp., *Sigmodon hispidus*	"Small rodents"
Sciurus niger	Eastern fox squirrel
Ondatra zibethica	Muskrat
Sylvalagus floridanus	Eastern cottontail
Odocoileus virginianus	White-tailed deer

APPENDIX B

PERCENTAGES OF VEGETATIVE COVER TYPES AND

VEGETATIVE COVER TYPE DIVERSITY INDEX

VALUES BY DIVERSITY STRATUM

(LANDSAT-1 IMAGERY

CLASSIFICATION)

Percentages of vegetative cover types and vegetative cover type diversity index values by diversity stratum (LANDSAT-1 imagery classification)

Categories of vegetative cover diversity and plot numbers	Percentage by cover type[1]						
	NG (percent)	OS-B (percent)	ES (percent)	AQ (percent)	BH (percent)	UH (percent)	$H\bar{d}$
Very low diversity							
14	25.9	0.9	0.0	0.9	3.8	68.4	1.61
28	18.4	1.3	0.0	0.0	49.6	30.7	1.63
13	16.5	0.0	0.0	0.0	13.1	70.4	1.68
38	3.8	0.0	0.0	0.0	63.8	32.5	1.86
1	48.8	41.9	0.0	0.0	0.0	9.3	1.94
3	61.5	9.0	2.6	0.0	1.3	25.6	2.00
Average	29.2	8.9	0.4	0.2	21.9	39.5	1.79
Low diversity							
20	58.2	32.0	9.3	0.0	0.0	0.4	2.13
36	12.9	0.0	0.0	0.0	45.0	42.1	2.31
11	40.2	10.0	0.0	0.0	1.3	48.5	2.32
26	28.4	2.7	0.0	0.0	12.9	56.0	2.38
Average	34.9	11.2	2.3	0.0	14.8	36.8	2.29

Categories of vegetative cover diversity and plot numbers	Percentage by cover type[1]						
	NG (percent)	OS-B (percent)	ES (percent)	AQ (percent)	BH (percent)	UH (percent)	$H\bar{d}$
Moderate diversity							
33	5.8	0.4	0.8	0.0	48.3	44.6	2.53
22	23.8	8.4	0.0	0.0	26.8	41.0	2.59
15	46.9	15.8	1.4	0.0	2.9	33.0	2.60
17	15.4	14.5	2.6	0.0	15.4	52.0	2.62
12	18.9	19.7	6.8	0.0	9.9	44.7	2.64
10	11.0	0.0	0.5	1.8	25.6	61.2	2.65
18	28.3	21.3	0.0	0.0	2.1	48.3	2.77
21	21.6	10.1	6.6	0.0	31.7	30.0	2.81
5	12.8	5.6	3.2	41.4	7.2	29.9	2.81
30	17.9	1.3	0.0	3.3	23.3	54.2	2.81
25	26.8	21.5	1.8	0.4	3.5	46.1	2.85
9	17.2	8.1	8.6	8.1	5.3	52.6	2.85
31	32.0	14.5	2.6	0.0	5.3	45.6	2.85
Average	21.4	10.9	2.7	4.2	15.9	44.9	2.72

Categories of vegetative cover diversity and plot numbers	Percentage by cover type[1]						
	NG (percent)	OS-B (percent)	ES (percent)	AQ (percent)	BH (percent)	UH (percent)	$H\bar{d}$
Moderately high diversity							
23	29.4	4.0	0.0	0.0	32.5	34.2	2.91
27	13.4	0.4	2.0	0.8	26.3	57.1	2.98
2	13.0	8.3	7.8	0.0	34.2	36.8	2.99
32	29.0	4.8	2.4	0.0	18.3	45.6	3.01
4	41.8	34.5	11.6	2.2	0.4	9.5	3.02
34	23.3	12.9	3.3	0.0	32.9	27.5	3.03
39	19.7	11.4	0.0	0.0	24.9	44.5	3.07
16	47.7	43.8	3.7	0.8	0.4	8.2	3.08
7	42.1	33.2	0.0	0.5	2.6	21.6	3.15
35	34.6	18.1	0.0	0.0	21.1	26.2	3.18
19	25.8	23.5	0.8	0.0	20.5	29.6	3.19
37	14.6	12.1	10.8	0.0	26.7	35.8	3.28
29	26.6	16.2	0.4	0.0	10.0	46.9	3.34

Categories of vegetative cover diversity and plot numbers	Percentage by cover type[1]						
	NG (percent)	OS-B (percent)	ES (percent)	AQ (percent)	BH (percent)	UH (percent)	$H\bar{d}$
Moderately high diversity (Continued)							
40	28.6	15.1	11.1	0.0	22.2	23.0	3.40
Average	27.8	17.0	3.9	0.3	19.5	31.9	3.12
High diversity							
6	31.9	15.5	0.0	0.0	9.8	42.8	3.61
8	44.0	3.7	0.0	3.7	21.1	27.5	3.61
24	23.4	29.1	6.5	0.0	21.8	19.2	3.70
Average	33.1	16.1	2.2	1.2	17.6	29.8	3.64
Average overall	25.7	12.3	2.6	1.8	19.0	38.6	2.74

[1]NG = native grassland, OS-B = oak savannah-brush; ES = eroded sites, AQ = aquatic sites, BH = bottomland hardwood forest, UH = upland hardwood forest.

APPENDIX C

HABITAT EVALUATION SURVEY DATA SHEETS

TERRESTRIAL HABITAT EVALUATION

Form #1

Habitat Type ______________________ Code No. ______ Date ____________

Habitat Component ______________________ Compiled by: ____________

Planning Area ______________________

Sheet ________

Sample Unit Locations:
1. ______________________
2. ______________________
3. ______________________
4. ______________________

Habitat Characteristics		Sample Unit	Evaluation element: Big Game Species	Upland Game Mammals	Fur-bearing	Other Mammals	Upland Game Birds	Water-fowl	Other Water & Marsh B.	Other Birds	Reptiles & Amphbns.	Grand total
Over-story	Food											
	Cover											
Under-story	Food											
	Cover											
Ground cover	Food											
	Cover											
Total evaluation element values												
Total observation												

$\frac{\text{Grand total evaluation element values}}{\text{Number of observations}}$ = Avg. Habitat Type Unit Value = ______

AQUATIC HABITAT EVALUATION

Form #2

Habitat Component ______________________________

Sample Unit Location: Date: ____________

Compiled by:

1. ______________________________ ____________

2. ______________________________ ____________

3. ______________________________ ____________

4. ______________________________

5. ______________________________

6. ______________________________ Sheet no. ____________

Planning Area ______________________________

Existing Analysis /_/ Future without Target Year ____________

Habitat Characteristic	Sample Unit Number 1	2	3	4	5	6	Grand Total
Physical							
Chemical							
Biological							
Total Evaluation Values							
Number of Observations							

$$\frac{\text{Grand total evaluation values}}{\text{Total number of observations}} = \text{Avg. habitat unit value} =$$

APPENDIX D

SOIL TEST RESULTS FROM 60 SAMPLE SITES ON

THE LCBLUA BY COVER TYPE

Classification	pH	Percent O.M.	PPM										Percent Sand	Percent Silt	Percent Clay
			NO_3-N	NH_4	P	K	Ca	Mg	Fe	Zn	Mn	Na			
Upland hardwood forest	5.3	1.5	16.0	6.7	7	75	131	360	32	1.06	15.4	57	61	25	14
Native grassland	6.4	1.4	5.0	5.3	4	110	195	460	17	0.74	12.8	67	50	30	20
Bottomland hardwood forest	5.9	1.1	25.0	7.0	7	73	155	390	18	1.02	16.0	51	61	23	16
Oak savannah-brush	5.5	1.5	18.0	7.4	5	85	163	360	26	1.34	11.8	59	57	29	14
Eroded sites	7.1	0.5	6.0	1.8	4	100	376	111	6	0.32	5.2	870	38	58	4
Aquatic sites	6.4	0.6	3.0	7.4	10	110	273	650	54	0.42	45.8	66	43	35	22
AVERAGES	6.1	1.1	12.2	5.9	6	92	216	389	26	0.82	17.8	195	52	33	15

APPENDIX E

INSTRUCTIONS AND DATA SHEET FOR THE

SIGN-COUNT TRANSECT SURVEY METHOD

INSTRUCTIONS

PLEASE READ CAREFULLY BEFORE PROCEEDING!

INTRODUCTION:

Sign-count transects represent a modification of the King Transect method. They are designed to utilize animal sign (indirect observations) and direct observations to verify the presence of species and develop indices on their relative abundance and distribution. In this particular study a habitat condition analysis will also be incorporated.

OBJECTIVES:

1. To conduct sign-count surveys of the designated study area.

2. To determine avian and mammalian species composition by major cover types.

3. To compare cover types and plot areas by means of sign-count indices.

4. To analyze habitat condition by cover type and plot area.

EQUIPMENT:

1. Compass.

2. Data sheets.

METHODS:

1. Teams of three persons each shall assemble at designated quarter sections (plot areas).

2. Team members shall space themselves at 100 yard (paces) intervals along the north boundary of the plot area, starting at the west boundary line.

3. Each person shall walk due south. At each 100 yard interval stop and record the following on a data sheet (provided):

    a) Species observed (Space is provided for recording five species each of birds and mammals. If additional space is needed, use additional data sheet. Normally, however, one data sheet will be used per transect. After recording each encounter, write in parentheses the number of individuals of that species or their sign seen during that encounter.)

b) Type of sign observed for each species (Use the following symbols to designate the type of sign observed: D = den, burrow, nest; F = feeding sign, digging; R = remains, S = scat, pellet, dropping; T = track; V = visual sighting. Place symbols in columns corresponding to mammal and bird encounters.)

c) Cover type in which each species was observed (Use the following symbols: UH = upland hardwood forest; BH = bottomland hardwood forest; NG = native grassland; TG = tame grassland; B = brush; C = cropland.)

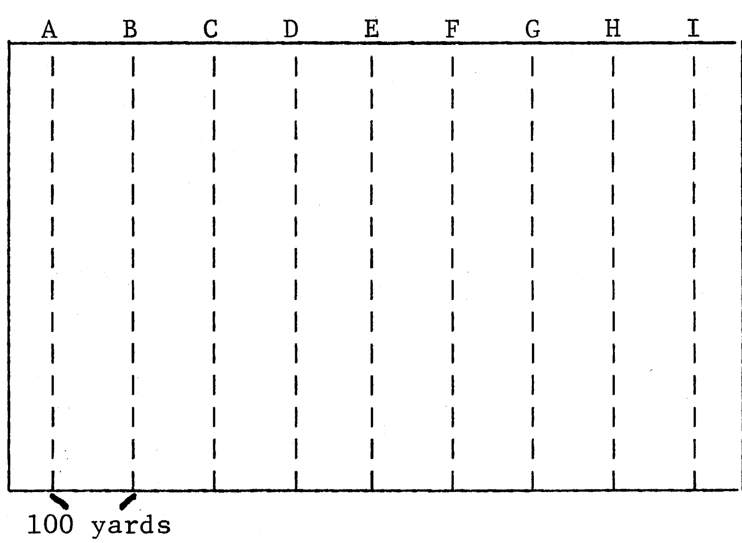
d) Dominant plant species within each cover type (List three species of plants in the order of their dominance. Use numbers from list on page 4.)

e) Habitat condition rating (Rate the general habitat condition of each 100 yard segment according to the following criteria: 1 = very poor condition; 2 = generally poor; 3 = fair; 4 = good; and 5 = excellent.)

4. Total distance should equal approximately 900 yards (paces), or 9 units of 100 yards each per transect.

5. At the south boundary of the plot area, each team member shall proceed 300 yards east along the boundary. From this point proceed northward along another transect line recording as before. Continue running transects in this manner until the plot area has been completely sampled. Nine transects (north/south) should be run per plot area. A map showing a typical plot area and its transect-numbering system is shown below.

6. In open areas such as grassland and cropland, record only those species observed within 50 yards of the transect line.



A LIST OF DOMINANT PLANT SPECIES

BY VEGETATIVE COVER TYPE

Upland Hardwood Forest

1. Asters
2. Bluestem, big
3. Bluestem, little
4. Bluestem, silver
5. Bristlegrass
6. Bromes
7. Buckbrush
8. Buffalograss
9. Cedar, red
10. Chittumwood
11. Dogwoods
12. Dropseeds
13. Elms
14. Fescues
15. Goldenrods
16. Gramas
17. Greenbriar
18. Hackberry
19. Hickories
20. Locust, black
21. Mulberries
22. Oak, blackjack
23. Oak, burr
24. Oak, chinkapin
25. Oak, post
26. Oak, white
27. Panicum, Scribner's
28. Pines
29. Plum, Mexican
30. Poison ivy
31. Ragweeds
32. Redbud
33. Snow on the mountain
34. Sumacs
35. Switchgrass
36. Three-awns

Bottomland Hardwood Forest

1. Ash
2. Bluestem, little
3. Buckbrush
4. Cedar, eastern red
5. Chittumwood
6. Cottonwoods
7. Dogwoods
8. Elms
9. Grapes
10. Greenbriars
11. Hackberry
12. Hickories
13. Locust, black
14. Mulberries
15. Oak, bur
16. Oak, chinkapin
17. Oak, post
18. Oak, Shumard's
19. Oak, white
20. Pecan
21. Poison ivy
22. Primrose, water
23. Purslane, marsh
24. Redbud
25. Rescuegrass
26. Sedges
27. Soapberry
28. Spikerushes
29. Sycamore
30. Sumacs
31. Uniola, broad-leafed
32. Virginia creeper
33. Walnut, black
34. Wildryes
35. Willows

Native Grassland

1. Asters
2. Barley, little
3. Bluestem, big
4. Bluestem, little
5. Bluestem, silver
6. Bluestem, splitbeard
7. Broomweeds
8. Buckbrush
9. Buffalograss
10. Cedar, red
11. Crabgrass
12. Dropseeds
13. Elms
14. Goldenrods
15. Grama, blue
16. Grama, hairy
17. Grama, sideoats
18. Indiangrass
19. Ironweed
20. Leadplant
21. Lespedezas
22. Lovegrasses
23. Nightshades
24. Oak, blackjack
25. Oak, post
26. Panicum, Scribner's
27. Partridge pea
28. Prickly pear
29. Purpletop
30. Ragweeds
31. Sages
32. Sedges
33. Sumacs
34. Sweetclover
35. Switchgrass
36. Sumacs
37. Sunflowers
38. Three-awns
39. Windmillgrass

Introduced Grassland

1. Bermudagrass
2. Crabgrass
3. Lovegrass, weeping
4. Nightshades
5. Pigweeds
6. Switchgrass

Brush

1. Bluestems
2. Buckbrush
3. Cedar, eastern red
4. Dogwoods
5. Elms
6. Greenbriars
7. Oaks

SIGN - COUNT TRANSECT DATA SHEET

Observer ________________ Date __________ Plot no. __________

Trans. no.	Fauna		Type sign		Hab. type		Dom. plants		Habitat Condition
	Mammals	Birds	M	B	M	B	Mammals	Birds	

APPENDIX F

MINIMUM NUMBER OF EACH ANIMAL SPECIES
ENCOUNTERED ON THE SAMPLE PLOTS AND
THE PERCENTAGES OF ALL INDIVIDUALS
PER CLASS ON THE SAMPLE PLOTS
(FROM SIGN-COUNT TRANSECT
OBSERVATIONS)

Native Grassland	Percent of Class	Minimum Number Present
Birds:		
Meadowlarks	24.6	81
Bluejay	13.1	43
Field sparrow	11.6	38
Lark sparrow	6.7	22
Common flicker	6.4	21
Turkey vulture	3.6	12
Grasshopper sparrow	3.3	11
Dark-eyed junco	3.3	11
Common crow	2.4	8
Mallard	2.4	8
Brown-headed cowbird	2.1	7
Eastern blueburd	2.1	7
Bobwhite quail	1.5	5
Blue-grey gnatcatcher	1.5	5
Robin	1.2	4
Carolina chickadee	1.2	4
Scissortailed flycatcher	1.2	4
Mockingbird	1.2	4
Rufous-sided towhee	< 1.0	3
Song sparrow	< 1.0	3
Tree sparrow	< 1.0	3
Cardinal	< 1.0	2
Tufted titmouse	< 1.0	2
Killdeer	< 1.0	2
Franklin's gull	< 1.0	2
Starling	< 1.0	2
Ring-necked duck	< 1.0	2
American woodcock	< 1.0	2
Red-tailed hawk	< 1.0	2
Common grackle	< 1.0	1
Red-bellied woodpecker	< 1.0	1
American kestrel	< 1.0	1
Carolina wren	< 1.0	1
Mourning dove	< 1.0	1
Purple finch	< 1.0	1
American goldfinch	< 1.0	1
Harris' sparrow	< 1.0	1
Rio Grande turkey	< 1.0	1
TOTAL	100.0	329
$\bar{d}$		4.02
Mammals:		
Armadillo	35.3	94
Striped skunk	16.2	43
Eastern cottontail rabbit	11.3	30
Coyote	10.2	27
Small rodents	9.0	24

White-tailed deer	6.4	17
Pocket gophers	4.5	12
Raccoon	4.1	11
Moles	3.8	10
Bobcat	1.1	3
Grey fox	< 1.0	2
Opossum	< 1.0	2
Eastern fox squirrel	< 1.0	1
TOTAL		266
$\bar{d}$		2.99

Upland Hardwood Forest

Birds:

Bluejay	21.9	292
Carolina chickadee	12.2	163
Bobwhite quail	10.4	139
Blue-gray gnatcatcher	9.5	127
Tufted titmouse	6.9	92
Cardinal	6.4	85
Turkey vulture	5.6	75
Field sparrow	3.8	51
Common crow	3.8	51
Common flicker	3.1	41
Dark-eyed junco	1.7	23
Red-bellied woodpecker	1.7	23
Meadowlarks	1.1	15
Robin	< 1.0	13
Red-headed woodpecker	< 1.0	12
Downy woodpecker	< 1.0	11
Mourning dove	< 1.0	10
Rufous-sided towhee	< 1.0	9
Rio Grande turkey	< 1.0	9
Red-tailed hawk	< 1.0	9
Mockingbird	< 1.0	8
Brown-headed cowbird	< 1.0	7
Ruby-crowned kinglet	< 1.0	6
Lark sparrow	< 1.0	6
Bewick's wren	< 1.0	5
Bobwhite quail	< 1.0	5
Black and white warbler	< 1.0	4
Grasshopper sparrow	< 1.0	4
Eastern bluebird	< 1.0	4
Great horned owl	< 1.0	4
Fox sparrow	< 1.0	4
Red-eyed vireo	< 1.0	4
Summer tanager	< 1.0	3
White-crowned sparrow	< 1.0	3
Cooper's hawk	< 1.0	3
Orange-crowned warbler	< 1.0	2

Carolina wren	< 1.0	2
Pileated woodpecker	< 1.0	2
Catbird	< 1.0	2
Common grackle	< 1.0	2
Hermit thrush	< 1.0	2
Golden-crowned kinglet	< 1.0	2
Yellow-rumped warbler	< 1.0	2
Yellow warbler	< 1.0	1
Eastern phoebe	< 1.0	1
Song sparrow	< 1.0	1
Screech owl	< 1.0	1
Hairy woodpecker	< 1.0	1
Brown creeper	< 1.0	1
Chuck will's widow	< 1.0	1
Blackburnian warbler	< 1.0	1
TOTAL	100.0	1333
$\bar{d}$		4.03

Mammals:

Armadillo	44.9	295
Eastern fox squirrel	13.2	87
Small rodents	8.8	58
White-tailed deer	6.7	44
Eastern cottontail rabbit	5.6	37
Moles	5.3	35
Coyote	3.7	24
Raccoon	3.2	21
Striped skunk	3.0	20
Eastern woodrat	2.6	17
Pocket gophers	< 1.0	6
Opossum	< 1.0	4
Bobcat	< 1.0	3
Badger	< 1.0	3
Black-tailed jackrabbit	< 1.0	2
Grey fox	< 1.0	1
TOTAL	100.0	657
$\bar{d}$		2.77

Bottomland Hardwood Forest

Birds:

Bluejay	12.7	45
Cardinal	11.6	41
Carolina chickadee	11.3	40
Bobwhite quail	9.3	33
Common flicker	6.8	24
Red-headed woodpecker	6.8	24
Tufted titmouse	6.8	24

Common crow	4.5	16
Blue-grey gnatcatcher	3.9	14
Red-bellied woodpecker	3.7	13
Brown-headed cowbird	3.7	13
Downy woodpecker	3.1	11
Dark-eyed junco	2.5	9
Turkey vulture	2.3	8
Mallard	1.4	5
Red-tailed hawk	< 1.0	3
Rufous-sided towhee	< 1.0	3
Robin	< 1.0	3
Eastern phoebe	< 1.0	3
Eastern bluebird	< 1.0	3
Black and white warbler	< 1.0	3
Yellow-rumped warbler	< 1.0	2
Rio Grande turkey	< 1.0	1
Harris' sparrow	< 1.0	1
Wood duck	< 1.0	1
Brown creeper	< 1.0	1
Indigo bunting	< 1.0	1
Sharp-skinned hawk	< 1.0	1
Barred owl	< 1.0	1
Song sparrow	< 1.0	1
Pileated woodpecker	< 1.0	1
Marsh hawk	< 1.0	1
Great blue heron	< 1.0	1
Green heron	< 1.0	1
Lark sparrow	< 1.0	1
TOTAL	100.0	353
$\bar{d}$		4.15

Mammals:

Armadillo	21.7	48
Raccoon	20.4	45
Eastern fox squirrel	14.0	31
Small rodents	11.3	25
White-tailed deer	6.8	15
Coyote	4.1	9
Eastern cottontail rabbit	4.1	9
Moles	3.6	8
Bobcat	3.2	7
Woodrat	3.2	7
Striped skunk	2.7	6
Opossum	2.3	5
Grey fox	< 1.0	2
Red fox	< 1.0	1
Beaver	< 1.0	1
Mink	< 1.0	1

Muskrat	< 1.0	1
TOTAL	100.0	221
$\bar{d}$		3.29
TOTAL BIRDS	63.8	2015
TOTAL MAMMALS	36.2	1144
TOTAL OBSERVATIONS	100.0	3159

APPENDIX G

RESULTS OF EARLY MORNING CALL-COUNT SURVEY

BREEDING BIRDS (124 STATIONS)

Species	No.	Species	No.
Green heron	2	Carolina chickadee	18
Turkey vulture	3	Tufted titmouse	43
Cooper's hawk	1	Bewick's wren	11
Bobwhite quail	144	Carolina wren	2
Killdeer	1	Mockingbird	19
Mourning dove	60	Brown thrasher	10
Yellow-billed cuckoo	37	Eastern bluebird	22
Chimney swift	3	Blue-gray gnatcatcher	33
Ruby-throated hummingbird	1	Ruby-crowned kinglet	1
Common flicker	1	Loggerhead shrike	2
Pileated woodpecker	2	Starling	9
Red-bellied woodpecker	32	House sparrow	1
Red-headed woodpecker	1	Eastern meadowlark	21
Hairy woodpecker	1	Western meadowlark	28
Downy woodpecker	3	Red-winged blackbird	5
Eastern kingbird	4	Northern oriole	1
Scissor-tailed flycatcher	3	Common grackle	6
Great crested flycatcher	11	Brown-headed cowbird	53
Eastern phoebe	3	Scarlet tanger	1
Eastern wood pewee	1	Cardinal	77
Vermillion flycatcher	1	Blue grosbeak	24
Barn swallow	17	Indigo bunting	18
Cliff swallow	1	Painted bunting	9
Blue jay	5	Dickcissel	9
Common crow	65	Rufous-sided towhee	2

Species	No.
Lark sparrow	25
Field sparrow	95
Song sparrow	6
TOTAL	954
Number of species	54
Diversity value	4.65

APPENDIX H

MATRIX ANALYSIS OF EACH PLOT'S VALUE TO THE WILDLIFE RESOURCE

Plot No.	Weighting factors								Total x weighting	Stratum index
	a	b	c	d	e	f	g	h		
	3	2	2	2	1	1	2	1		
	Habitat diversity	Habitat index	Soil index	Percent BH index	Habitat condition	Plant diversity	Pond index	Faunal diversity		
1	1.00	1.00	2.00	0.00	1.00	1.00	0.00	1.00	12.00	1
2	4.00	3.00	4.00	3.00	1.00	4.00	2.00	4.00	45.00	4
3	1.00	2.00	1.00	1.00	1.00	1.00	2.00	1.00	18.00	1
4	4.00	1.00	2.00	1.00	3.00	4.00	2.00	4.00	35.00	2
5	3.00	5.00	2.00	1.00	3.00	3.00	3.00	3.00	43.00	3
6	5.00	3.00	3.00	1.00	5.00	5.00	3.00	5.00	50.00	4
7	4.00	2.00	2.00	1.00	2.00	4.00	1.00	4.00	34.00	2
8	5.00	3.00	3.00	2.00	5.00	5.00	4.00	5.00	54.00	5
9	3.00	3.00	3.00	1.00	4.00	3.00	3.00	3.00	39.00	3
10	3.00	4.00	5.00	3.00	4.00	3.00	3.00	3.00	49.00	4
11	2.00	3.00	3.00	1.00	2.00	2.00	1.00	2.00	28.00	1
12	3.00	2.00	3.00	1.00	2.00	3.00	0.00	3.00	29.00	1
13	1.00	4.00	5.00	2.00	3.00	1.00	3.00	1.00	35.00	2
14	1.00	4.00	4.00	1.00	1.00	1.00	4.00	1.00	32.00	2

	Weighting factors									
	a	b	c	d	e	f	g	h		
	3	2	2	2	1	1	2	1		
Plot No.	Habitat diversity	Habitat index	Soil index	Percent BH index	Habitat condition	Plant diversity	Pond index	Faunal diversity	Total x weighting	Stratum index
15	3.00	2.00	2.00	1.00	3.00	3.00	3.00	3.00	34.00	2
16	4.00	3.00	2.00	1.00	2.00	4.00	3.00	4.00	38.00	3
17	3.00	3.00	4.00	2.00	2.00	3.00	3.00	3.00	41.00	3
18	3.00	2.00	4.00	1.00	3.00	3.00	2.00	3.00	36.00	2
19	4.00	2.00	4.00	2.00	2.00	4.00	0.00	4.00	38.00	3
20	2.00	2.00	1.00	0.00	1.00	2.00	4.00	2.00	25.00	1
21	3.00	3.00	3.00	3.00	2.00	3.00	0.00	3.00	35.00	2
22	3.00	4.00	4.00	3.00	3.00	3.00	2.00	3.00	44.00	3
23	4.00	4.00	4.00	3.00	4.00	4.00	0.00	4.00	46.00	4
24	5.00	2.00	3.00	2.00	4.00	5.00	2.00	5.00	43.00	3
25	3.00	3.00	3.00	1.00	4.00	3.00	3.00	3.00	39.00	3
26	2.00	4.00	3.00	2.00	3.00	2.00	3.00	2.00	37.00	2
27	4.00	4.00	5.00	3.00	3.00	4.00	5.00	4.00	57.00	5
28	1.00	4.00	5.00	4.00	3.00	1.00	0.00	1.00	34.00	2

Plot No.	Weighting factors								Total x weighting	Stratum index
	a	b	c	d	e	f	g	h		
	3	2	2	2	1	1	2	1		
	Habitat diversity	Habitat index	Soil index	Percent BH index	Habitat condition	Plant diversity	Pond index	Faunal diversity		
29	5.00	3.00	4.00	1.00	4.00	5.00	0.00	5.00	45.00	4
30	3.00	4.00	4.00	2.00	4.00	3.00	0.00	3.00	39.00	3
31	3.00	3.00	3.00	1.00	4.00	3.00	3.00	3.00	39.00	3
32	4.00	3.00	4.00	2.00	5.00	4.00	2.00	4.00	47.00	4
33	3.00	4.00	5.00	4.00	4.00	3.00	0.00	3.00	45.00	4
34	4.00	3.00	4.00	3.00	3.00	4.00	1.00	4.00	45.00	3
35	4.00	3.00	3.00	2.00	4.00	4.00	1.00	4.00	42.00	3
36	2.00	4.00	5.00	4.00	4.00	2.00	0.00	4.00	40.00	3
37	4.00	2.00	3.00	3.00	4.00	4.00	0.00	4.00	40.00	3
38	1.00	5.00	5.00	5.00	1.00	1.00	0.00	1.00	36.00	2
39	4.00	4.00	4.00	2.00	3.00	4.00	3.00	4.00	49.00	4
40	5.00	2.00	2.00	2.00	3.00	5.00	0.00	5.00	40.00	3

APPENDIX I

LESSEE QUESTIONNNAIRE AND COVER LETTER

LESSEE QUESTIONNAIRE

Questionnaire No. ____________

INSTRUCTIONS: Please complete the following questionnaire by filling in the blanks or checking the appropriate response.

1. What is your approximate age? (Please check one)
   21-30 ____ 31-40 ____ 41-50 ____ Over 50 ____

2. What is your present occupation? (Please check one)
   Farmer____ Rancher____ Educator____ Businessman____
   Laborer____ Other (please specify)______________________________

3. How many acres of land do you own? (Please check one)
   0-100 A.____ 101-300 A.____ 301-500 A.____ Over 500 A.____

4. How many acres of land do you lease?
   a. Lake Carl Blackwell land (Please check one)
      100-500 A.______
      501-1000 A._____
      Over 1000 A.____
   b. Other land (Please check one)
      0-100 A._______
      100-300 A._____
      301-500 A._____
      Over 500 A.____

5. How long have you leased Lake Carl Blackwell land? (Please check one)
   1-5 yrs.____ 6-10 yrs.____ 11-15 yrs.____ Over 15 yrs.____

6. Please rate your lease for the abundance of the following animals. (Please check appropriate box)

	Relative Abundance		
Species:	High	Moderate	Low
a. Bobwhite quail	____	____	___
b. Wild turkey	____	____	___
c. White-tailed deer	____	____	___
d. Fox squirrels	____	____	___
e. Coyote	____	____	___
f. Rabbits	____	____	___
g. Ducks	____	____	___

7. How many coveys of quail have you seen on your lease this season? (Please fill in the number of coveys seen) ________

8. How many wild turkeys have you seen on your lease this season? (Please fill in estimated number of individuals you have seen)_____

9. How many white-tailed deer have you seen on your lease this season? (Please fill in estimated number of individuals you have seen)_____

10. On the enclosed map(s) please mark the symbols in the areas you have encountered the respective animal.
Bobwhite quail--Q; Wild turkey--T; White-tailed deer--D; Fox squirrel--S

11. Do you hunt? Yes____ No____

12. Do you fish? Yes____ No____

13. If the OSU Board of Regents were to declare that hunting on University lands is legal, with the consent of the lessee, would you allow hunters on your lease? Yes____ No____

14. If no, then which of the following would be the major reason for your decision? (Please give values from 1 through 5 for each response, with 5 representing a matter of great concern to you and 1 representing a matter of no real importance. 2, 3 and 4 would indicate varying degrees of significance to your situation.)
    a. Desire to have game available to friends and relatives only ___
    b. Possible fires . . . . ___
    c. Shooting livestock . . . . ___
    d. Personal property stolen . . . . ___
    e. Damage to buildings . . . . ___
    f. Damage to fences . . . . ___
    g. Gates left open . . . . ___
    h. Roads blocked . . . . ___
    i. Sportsmen having belligerent or quarrelsome attitudes . . ___
    j. Drunken sportsmen . . . . ___
    k. Opposed to hunting in general . . . . ___
    l. Littering . . . . ___
    m. Personal and family safety . . . . ___
    n. Shooting from the road . . . . ___
    o. Other (please specify) ________________________________

15. Would you allow any of the following types of recreation, again with the consent of the OSU Board of Regents, on your lease? (Please check)
    a. Fishing Yes____ No____ d. Picnicking Yes___ No___
    b. Hiking Yes____ No____ e. Nature photography Yes___ No___
    c. Camping Yes____ No____ f. Bird watching Yes___ No___

Thank you very much for your time. Your help has been invaluable. Please feel free to make any additional comments below.

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Oklahoma State University

OFFICE OF THE BUSINESS MANAGER

STILLWATER, OKLAHOMA 74074
206 WHITEHURST HALL
(405) 624-5978

January 9, 1975

A study is being conducted by the Oklahoma State University School of Biological Sciences with the assistance of the Oklahoma State University Business Managers Office to determine the present extent of the wildlife resource (sizes and locations of animal populations) on University owned lands.

We would like to obtain your views and gain from your experience and knowledge of your particular lease area. Please fill out the attached confidential questionnaire. Your name and address need not be included, as this study seeks only general information from the lessees as a group.

Please return the completed questionnaire in the enclosed, stamped, self-addressed envelope. Please feel free to make any additional comments at the bottom of page two. It is important that every questionnaire be completed and returned to facilitate accurate analysis.

If you have any questions you may call me collect at Area Code 405, 372-9539 (after 5:00 p.m.). Your cooperation is greatly appreciated.

Sincerely,

Jerry J. Brabander
Graduate Research Assistant

Gene Satterfield
Business Manager

JJB:kj

Enclosures

VITA

Jerry Joe Brabander

Candidate for the Degree of

Master of Science

Thesis: WILDLIFE POPULATION AND HABITAT EVALUATION ON A NORTHCENTRAL OKLAHOMA SITE USING LANDSAT-1 IMAGERY

Major Field: Wildlife Ecology

Biographical:

Personal Data: Born in Blackwell, Oklahoma, February 13, 1951, the son of Mr. and Mrs. Joe Brabander; married M. Katherine Estes, May 19, 1973; son, Nathan, born March 12, 1976.

Education: Graduated from Deer Creek High School, Deer Creek, Oklahoma, in May 1969; received Bachelor of Science degree in Biology and Agricultural Ecology from Northwestern Oklahoma State University in 1974; completed requirements for the Master of Science degree at Oklahoma State University in July 1977.

Professional Experience: Graduate Research Assistant, School of Biological Sciences, 1974-1976; Research Technician, School of Biological Sciences and Oklahoma Cooperative Wildlife Research Unit, 1976-present.

Professional Societies: Member of The Wildlife Society.