



Western Michigan University
ScholarWorks at WMU

Dissertations

Graduate College

4-1981

The Relationship between Adjacent Residential Development and Breeding Bird Populations

Steven L. Harbron
Western Michigan University

Follow this and additional works at: <https://scholarworks.wmich.edu/dissertations>



Part of the Ecology and Evolutionary Biology Commons

Recommended Citation

Harbron, Steven L., "The Relationship between Adjacent Residential Development and Breeding Bird Populations" (1981). *Dissertations*. 2585.

<https://scholarworks.wmich.edu/dissertations/2585>

This Dissertation-Open Access is brought to you for free and open access by the Graduate College at ScholarWorks at WMU. It has been accepted for inclusion in Dissertations by an authorized administrator of ScholarWorks at WMU. For more information, please contact wmu-scholarworks@wmich.edu.



**THE RELATIONSHIP BETWEEN ADJACENT RESIDENTIAL
DEVELOPMENT AND BREEDING BIRD POPULATIONS**

by

Steven L. Harbron

**A Dissertation
Submitted to the
Faculty of the Graduate College
in partial fulfillment of the
requirements for the
Degree of Doctor of Philosophy
Science Education**

**Western Michigan University
Kalamazoo, Michigan
April 1981**

THE RELATIONSHIP BETWEEN ADJACENT RESIDENTIAL
DEVELOPMENT AND BREEDING BIRD POPULATIONS

Steven L. Harbron, Ph.D.

Western Michigan University, 1981

The breeding bird populations of a 40.9 acre grassland-thicket, the Colony Farm Tract, Kalamazoo, Michigan, were studied over 18 years, from 1961-1979. The purpose of the study was to discover any variations in the avian populations that resulted from the construction of an adjacent residential development. Particular attention was directed toward establishing the kinds of relationships that existed between the breeding bird populations and the adjacent residential development.

Information concerning the study area's breeding bird populations was collected using the Williams territory-mapping censusing technique. Yearly population values were determined for each bird species. Total numbers of male breeding bird territories representing the entire breeding bird fauna were also determined for each year of the study.

To determine the possible effect the changing character of the study area's grassland plant community, especially successional changes, had on the avian populations, plant studies were conducted from 1959-1979. Eight years after cessation of farming practices in 1959 the grassland was sampled thoroughly to determine the kinds and numbers of woody plants that were invading the grassland. This procedure was repeated 12 years later. These data were compared

and a measure of the extent of plant succession was established.

In order to determine if fluctuations in the study area's breeding bird populations were related to the construction of the adjacent residential development or were simply manifestations of population fluctuations in the surrounding area at large, breeding bird data for Kalamazoo County and the State of Michigan were compared with the study area's data.

To obtain a measure of the extent of disturbance the study area has experienced since abandonment, all recorded incidences of disturbance were compiled. Using this information the numbers and kinds of disturbances for each year of the study were determined and their locations within the study area were established. To obtain additional measures of disturbance, 21 hours of specific disturbance observations were conducted. These data were employed to investigate the relationships that existed between disturbance, one aspect of residential development, and the Colony Farm Tract's breeding bird populations.

The effectiveness of "keep-out" signs in reducing disturbance on the study area was investigated. Twenty-one such signs were posted along the perimeter of the study area and observations for subsequent disturbances were made. After sign placement, twenty hours of observation were conducted. The data collected before and after the posting of the signs were compared.

The findings seem to indicate that plant succession had a noticeable effect on the breeding bird populations during the

early years of the study. About five years after cessation of farming practices, following notable changes in the plant communities of the study area, more species and numbers of birds selected the area as breeding habitat. However, little change seems to have taken place in the last five years in the character of the plant communities. Consequently, it appears that plant succession has not had a significant influence on the area's breeding bird populations during about the last five years of the study.

It was found that the study area's breeding bird populations were similar in many respects before and after construction of the adjacent residential development. However, it was determined that following construction and paralleling increased incidence of disturbance some species of birds were lost from the breeding fauna and the numbers of other species were reduced.

One year following placement of the "keep-out" signs it was found that the incidence of disturbance was reduced. It was speculated that the increase in breeding bird species diversity, which was noted one year after the study was officially concluded, was the result of reduced disturbance.

ACKNOWLEDGEMENTS

I would like to thank my dissertation advisor, Dr. Richard D. Brewer for his guidance he provided throughout the duration of this study. Appreciation is also given to Doctors Clarence J. Goodnight, George G. Mallinson, and Philip P. Micklin for their service as dissertation committee members. An additional note of appreciation is extended to Dr. George G. Mallinson for his expert help in editing and for the constant encouragement he provided me. To Raymond J. Adams, Jr., research biologist with the Kalamazoo Nature Center, thanks is given for providing the Kalamazoo County breeding bird data. For many hours of invaluable help in the field, thanks is extended to John C. Stiner. A Science Education Fellowship from the Graduate College, Western Michigan University, made my continued graduate study possible and is appreciated.

A special note of appreciation is extended to my family. To my wife, Linda, who endured ten years of hard times while I attended to my education, I extend my heart of love. To my children, Heather, Amy, and Jacob, who have loved me even when I could not play with them because of study, to them I dedicate my life. To my parents, Gerry and Viola, who sacrificed for years so that I might attain what they never dreamed for themselves, I pledge my affections for eternity. To God, who made and loves me, the worth of my education I dedicate to Him.

Steven L. Harbron

INFORMATION TO USERS

This was produced from a copy of a document sent to us for microfilming. While the most advanced technological means to photograph and reproduce this document have been used, the quality is heavily dependent upon the quality of the material submitted.

The following explanation of techniques is provided to help you understand markings or notations which may appear on this reproduction.

- 1. The sign or "target" for pages apparently lacking from the document photographed is "Missing Page(s)". If it was possible to obtain the missing page(s) or section, they are spliced into the film along with adjacent pages. This may have necessitated cutting through an image and duplicating adjacent pages to assure you of complete continuity.**
- 2. When an image on the film is obliterated with a round black mark it is an indication that the film inspector noticed either blurred copy because of movement during exposure, or duplicate copy. Unless we meant to delete copyrighted materials that should not have been filmed, you will find a good image of the page in the adjacent frame.**
- 3. When a map, drawing or chart, etc., is part of the material being photographed the photographer has followed a definite method in "sectioning" the material. It is customary to begin filming at the upper left hand corner of a large sheet and to continue from left to right in equal sections with small overlaps. If necessary, sectioning is continued again—beginning below the first row and continuing on until complete.**
- 4. For any illustrations that cannot be reproduced satisfactorily by xerography, photographic prints can be purchased at additional cost and tipped into your xerographic copy. Requests can be made to our Dissertations Customer Services Department.**
- 5. Some pages in any document may have indistinct print. In all cases we have filmed the best available copy.**

**University
Microfilms
International**

300 N. ZEEB ROAD, ANN ARBOR, MI 48106
18 BEDFORD ROW, LONDON WC1R 4EJ, ENGLAND

8109335

HARBON, STEVEN LEE

THE RELATIONSHIP BETWEEN ADJACENT RESIDENTIAL
DEVELOPMENT AND BREEDING BIRD POPULATIONS

Western Michigan University

PH.D.

1981

University
Microfilms
International 300 N. Zeeb Road, Ann Arbor, MI 48106

TABLE OF CONTENTS

ACKNOWLEDGEMENTS	ii
LIST OF FIGURES.	iv
LIST OF TABLES	vi
Chapter	
I. INTRODUCTION	1
II. STUDY AREA	3
III. METHODS.	11
IV. RESULTS AND DISCUSSION	27
Vegetation Change.	27
Bird Populations	38
Effectiveness of Posted "Keep-Out Signs in Reduc- ing Disturbance.114
V. MITIGATING MEASURES.118
VI. POST STUDY PRELIMINARY FINDINGS.120
VII. SUMMARY.122
BIBLIOGRAPHY125
APPENDIX131

LIST OF FIGURES

FIGURE		PAGE
1	Scale map of Colony Farm Tract.	4
2	Colony Farm Tract and adjacent areas.	8
3	Scale map of Colony Farm Tract as it appear- ed in 1950.	13
4	Scale map of Colony Farm Tract as it appear- ed in 1960.	14
5	Scale map of Colony Farm Tract as it appear- ed in 1967.	15
6	Scale map of Colony Farm Tract as it appear- ed in 1974.	16
7	Scale map of Colony Farm Tract as it appear- ed in 1979.	17
8	Changing acreage of thicket from 1950-1979. . .	18
9	Changing acreage of grassland from 1950-1979. .	19
10	Locations of posted "keep-out" signs.	25
11	Total numbers of grassland woody plants re- corded in each specific grassland quadrat for year 1967	30
12	Total numbers of grassland woody plants re- corded in each specific grassland quadrat for year 1979	31
13	Total numbers of grassland woody plants re- corded in each non-border grassland quadrat for year 1967	32
14	Total numbers of grassland woody plants re- corded in each non-border grassland quadrats for year 1979	33
15	Number of grassland breeding bird territories for years 1961-1979	45

FIGURE		PAGE
16	Number of thicket breeding bird territories for years 1961-1979.	46
17	Locations of 1965 disturbances	77
18	Locations of 1968 disturbances	78
19	Locations of 1969 disturbances	79
20	Locations of 1970 disturbances	80
21	Locations of 1972 disturbances	81
22	Locations of 1973 disturbances	82
23	Locations of 1974 disturbances	83
24	Locations of 1975 disturbances	84
25	Locations of 1976 disturbances	85
26	Locations of 1977 disturbances	86
27	Locations of 1978 disturbances	87
28	Locations of 1979 disturbances	88
29	Appearance and composition of posted "keep-out" signs.	117

LIST OF TABLES

TABLE		PAGE
1	NUMBER OF APRIL THROUGH AUGUST CENSUSES	22
2	WOODY PLANT NUMBERS FOR ALL GRASSLAND QUADRATS. . .	28
3	WOODY PLANT NUMBERS FOR NON-BORDER QUADRATS	34
4	NON-BORDER QUADRAT WOODY PLANT NUMBERS FOR EACH SECTION OF GRASSLAND.	36
5	COLONY FARM TRACT THICKET BREEDING BIRD NUMBERS . .	39
6	COLONY FARM TRACT GRASSLAND BREEDING BIRD NUMBERS .	43
7	COLONY FARM TRACT GRASSLAND BREEDING BIRD POP- ULATION VALUES.	48
8	COLONY FARM TRACT GRASSLAND BREEDING BIRD POP- ULATION VALUES FOR SPECIFIC TIME PERIODS.	53
9	PERCENT CHANGES IN GRASSLAND BREEDING BIRD POP- ULATION VALUES.	59
10	MICHIGAN GRASSLAND BREEDING BIRDS	63
11	MICHIGAN GRASSLAND BREEDING BIRD POPULATION VALUES FOR SPECIFIC TIME PERIODS.	64
12	KALAMAZOO COUNTY GRASSLAND BREEDING BIRD NUMBERS. .	65
13	KALAMAZOO COUNTY GRASSLAND BREEDING BIRD POPULAT- ION VALUES FOR SPECIFIC TIME PERIODS.	66
14	CHANGES IN GRASSLAND BREEDING BIRD POPULATION VALUES FOR COLONY FARM TRACT AND STATE OF MICHIGAN.	68
15	CHANGES IN GRASSLAND BREEDING BIRD POPULATION VALUES FOR COLONY FARM TRACT, STATE OF MICHIGAN, AND KALAMAZOO COUNTY.	70
16	DISTURBANCE OR EVIDENCE OF DISTURBANCE FOR YEARS 1961-1979	74

TABLE		PAGE
17	COLONY FARM TRACT THICKET BREEDING BIRD POP- ULATION VALUES FOR SPECIFIC TIME PERIODS. . . .	97
18	MICHIGAN THICKET BREEDING BIRD NUMBERS.	101
19	KALAMAZOO COUNTY THICKET BREEDING BIRD NUMBERS. .	103
20	PERCENT CHANGE IN THICKET BREEDING BIRD POP- ULATION MEANS	106
21	POPULATION VALUES FOR COLONY FARM TRACT THICKET BREEDING BIRD SPECIES FOR SPECIFIC TIME PERIODS	107
22	POPULATION VALUES FOR MICHIGAN THICKET BREEDING BIRD SPECIES FOR SPECIFIC TIME PERIODS.	109
23	POPULATION VALUES FOR KALAMAZOO COUNTY THICKET BREEDING BIRD SPECIES FOR SPECIFIC TIME PERIODS	112
24	DISTURBANCE BEFORE AND AFTER PLACEMENT OF "KEEP- OUT" SIGNS.	115

CHAPTER I

INTRODUCTION

In 1960, ecological studies were begun by Dr. Richard D. Brewer and various graduate and undergraduate students in biology at Western Michigan University, on 40.9 acres of land referred to as the Colony Farm Tract. The land has not been cultivated or in any other way directly disturbed since 1959, although about 35 of the 40.9 acres were once farmed (Brewer, Raim, and Robins 1969). Since 1961 plant studies have been conducted resulting in identification of species present and determination of existing vegetational associations (Brewer, Raim, and Robins 1969). In all years from 1961 through 1979, except 1971, studies of breeding bird populations were conducted. Particular attention has been directed toward discovering variations in avian populations and changes in the plant community, especially successional changes, occurring with time.

In 1970, construction of a Planned Unit (housing) Development (PUD), referred to as Parkview Hills, was initiated on land bordering the Colony Farm Tract. This development was conceived as a "complete" community where man and the products of his existence could coexist with the natural environment, allowing nature to retain its integrity (Upjohn 1971).

The effect of changes in wildlife habitat due to various land use practices or direct development on populations of breeding

birds has been documented, although less thoroughly than might be expected (McClure and Othman 1965; Warbach 1958; Childs 1951; Dambach and Good 1940; Waters 1967; Woolfenden and Rohwer 1969; Homes 1957; Post and Wiley 1976; Guthrie 1974; Titterington, Crawford, and Burgason 1979; Stapleton and Kiviat 1979; Anderson 1979; Ramsden, Lyon, and Halvorson 1979; Whitcomb, Whitcomb, and Bystrak 1977). Effects produced by changes in land use practices or development on bird populations of adjacent land, however, have scarcely been considered. This study was conducted because nine years of pre-PUD baseline breeding bird data were available that could be used to evaluate the effects of development on adjacent avian populations. This could be accomplished by discovering if any changes occurred in the breeding bird populations after PUD construction that seemed to be deviations from the pre-PUD baseline data.

CHAPTER II

STUDY AREA

The Colony Farm Tract is a long, narrow brome grass-alfalfa hayfield with a strip of thicket located along approximately half of its northeastern edge (Figure 1). The Congressional Land Survey System locates the area in the NE 1/4 of Sec. 31, T 2 S, R 11 W of Kalamazoo County within the city limits of Kalamazoo, Michigan.

The study area is about 2700 feet long; its width varies from about 300 to approximately 1000 feet. It is located between 920 and 940 feet above sea level. The entire area contains 40.9 acres. Situated within the study area's total acreage are 2.6 acres of marsh and fringing thickets, located within coordinates E-F/1-3.5, that are not considered in this study.

The total relief of the tract is slightly more than 40 feet with most of the area gently rolling and displaying a maximum relief of less than 20 feet (Brewer, Raim, and Robins 1969). The east border of the thicket from about line 4 northward displays a 20% slope as it runs to the marsh (Raim 1974). A ravine runs east-west through the grassland and thicket between coordinate lines 4 and 5. Around D/10, within coordinates C $\frac{1}{2}$ -D $\frac{1}{2}$ /9.5-10, there is a closed drainage that does not hold standing water. (This area was omitted from the woody plant invasion investigation portion of this study that is considered in a later section).

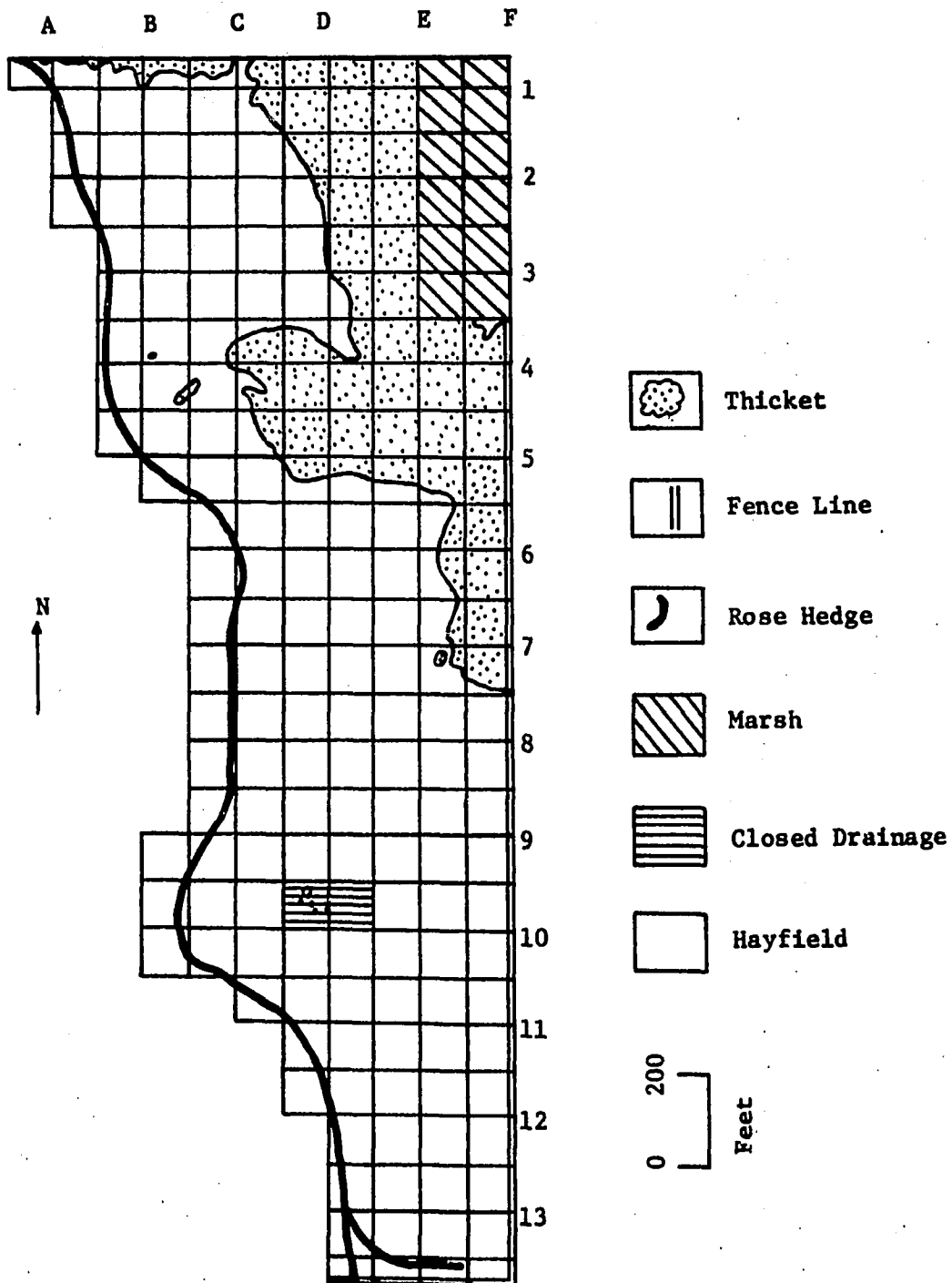


Figure 1. Scale map of Colony Farm Tract showing area as it appeared in 1979.

The grassland, that contained 29.2 acres in 1979, is dominated by smooth brome grass, *Bromis inermis*. Also important are bluegrass, *Poa compressa* and *Poa pratensis*, and quack grass, *Agropyron repens*. Alfalfa, *Medicago sativa*, that occurred in nearly half of 29 square meter quadrats sampled in 1963 (Brewer, Raim, and Robins 1969), had almost disappeared by 1974. The height of the brome grass generally ranges from 45-100 cm, being lowest in the southern section of the field. The mean heights for the southern, middle, and northern portions are 55 cm, 78 cm, and 73 cm, respectively (Brewer, Raim, and Robins 1969). Average litter depth was found to be 5.6 cm when randomly sampled in 1972 (Harbron 1977). Included within the grassland acreage are a multiflora rose, *Rosa multiflora*, hedge and fence rows.

A number of woody plants are located in the grassland, the greatest density being in the area south of coordinate 7. Species that are common throughout most of the grassland are white mulberry, *Morus alba*; staghorn sumac, *Rhus typhina*; and wild cherry, *Prunus serotina*. Woody species and the changing character of the grassland due to woody plant invasion are considered in a later section.

The Kalamazoo State Hospital cultivated the hayfield portion of the study area for many years. Portions of the hayfield were taken out of cultivation at the following times: south (south of coordinate 7) in 1958; middle (between coordinates 5 and 7) in 1953; and north (north of coordinate line 5) in 1954. The north

and middle portions were seeded to oats and alfalfa-brome-red clover whereas the south portion was planted with oats and brome. Hay was cut and removed from the entire field through 1959 (Brewer, Raim, and Robins 1969).

Black locust, *Robinia pseudoacacia*, hickory, *Carya* sp., and elm, *Ulmus* sp. are the main species over 1 inch dbh in the thicket (Brewer, Raim, and Robins 1969). Between lines 5 and 7 the vegetation is less dense than in the rest of the thicket and is an open aggregation of black cherry and white mulberry with some sweet pignut hickory, *Carya ovalis*, also present (Brewer, Raim, and Robins 1969). The total acreage of the thicket was 9.1 in 1979 and included the growth of aspen, *Populus grandidentata*, elms, and willows, *Salix* sp., located between the northern border and coordinate B-1.

An irregular and incomplete strip of multiflora rose forms the outer edge of the western boundary. The land west of the rose strip has been cultivated in strip crop rotations of hay (oats, alfalfa, or clover), wheat, and corn by Western Michigan University's Agriculture Department since 1961.* Before 1961 this area was hayfield similar to the study area (Brewer, Raim, and Robins 1969).

Until 1970, the area was bordered by similar fields on the south and east boundaries from about the 7th east-west coordinate

*Lee Baker 1977: personal communication.

southward. Commencing in 1970, construction of a Planned Unit Development (housing project) was initiated along these southern and eastern boundaries of the study area (Figure 2). This project is said to have grown out of the pioneering concept of environmentalist Dr. H. Lewis Batts who conceived it as an answer to the urban environment in which man has little opportunity to experience the natural world in his daily life. In order to create a community where man and the natural world were in harmony, five years of intensive research and careful planning are said to have preceded actual construction. The result was a master land-use plan that is said to have provided for underground utility and TV cables, traffic flow engineered for maximum safety and minimum congestion, subdued street lighting, winding streets, and open places appropriately landscaped so that a "natural" appearance was imparted to the development (Upjohn 1971).

"Community feeling" was a quality of life that planners hoped to create at Parkview Hills. Plans stated that there would be a home to fit every life style and, that in every case, aesthetics would be considered in the development of all buildings. To further add to "community feeling", plans called for a leisure-gearred community building, year-round swimming pool, and tennis courts. To enhance the concept of the "natural world" more than 100 acres of open space, five miles of nature trails, 300 feet of sandy beach, and a picnic grove were planned (Upjohn 1971).

In June 1970 construction was noted along the eastern perimeter

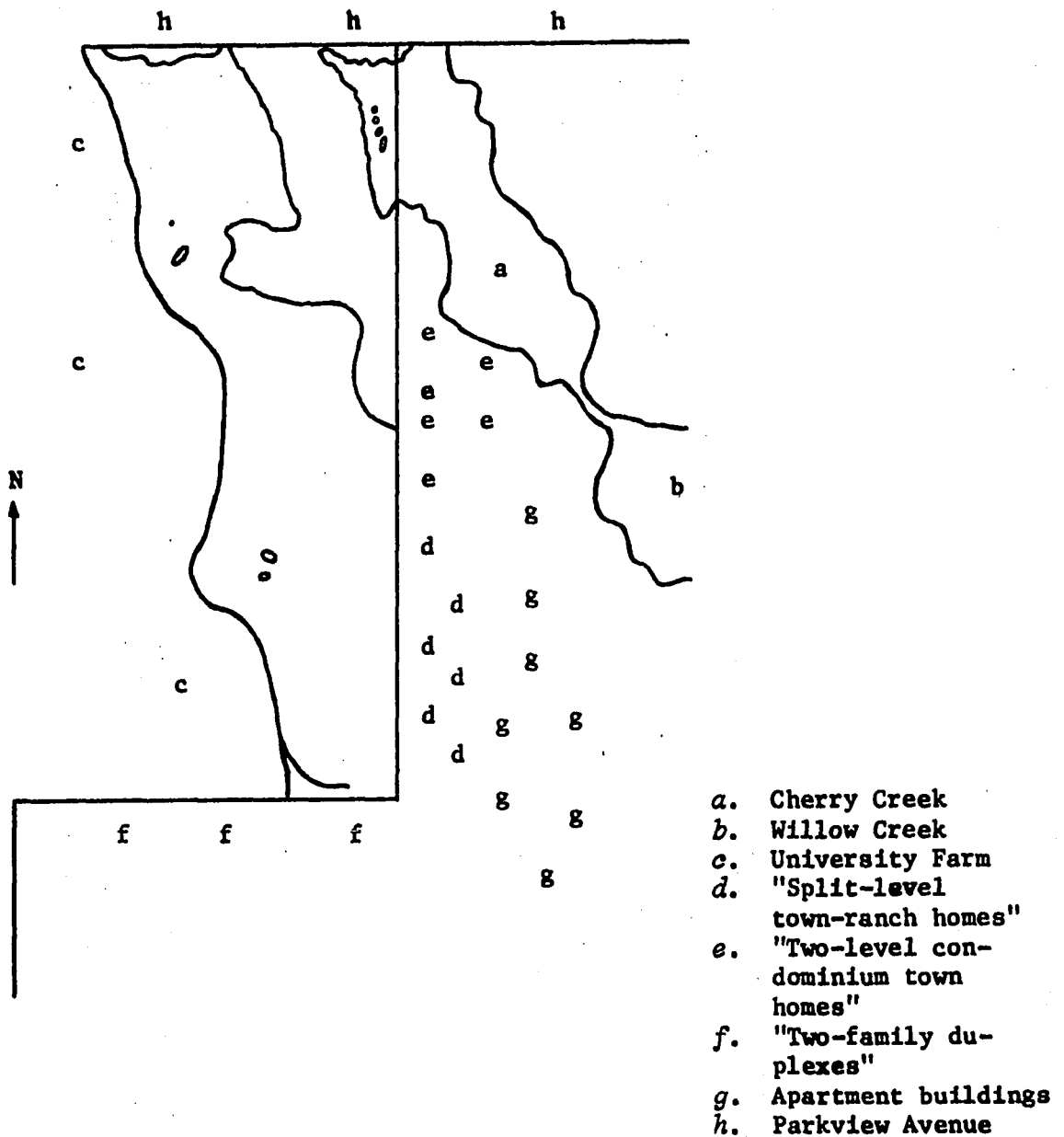


Figure 2. Diagrammatic representation of Colony Farm Tract and adjacent portions of the Planned Unit Development (PUD) and University Farm.

from coordinates F-9 through F-14 and along the entire southern border. By spring 1972 "split-level town-ranch homes" (apartment buildings), adjacent to the Colony Farm Tract's eastern border, located between coordinate F-10 through F-14, were opened for occupancy. During the winter 1972 construction began on buildings composed of multiple units of "two-level condominium town homes" along this perimeter down to the F-7 coordinate. By the summer 1973 construction was initiated on "two-family duplexes" along the entire southern border of the study area. At this time further construction of buildings composed of multiple units of "two-level condominium town homes" continued along the eastern perimeter down to about the F-5 coordinate. From 1970 through 1979 development continued. Many buildings such as "Town-country homes", rental apartments, penthouse apartments, and private homes were raised within the PUD at varying distances from the PUD-Colony Farm Tract borders.

The boundary lines separating the Colony Farm Tract and the housing development are fence rows with large scattered black cherry; pignut hickory; sassafras, *Sassafras albidum*; and red oak, *Quercus borealis* (Brewer, Raim, and Robins 1969). Between east-west coordinates 3.5 and 5.5 the study area is adjoined by thicket much like the thicket of the study area. From 3.5 northward, along the eastern border, the area is adjoined by the marsh that has varied considerably in its water content from 1961 through 1979. It decreased in moisture from very wet in 1961 to a dryish

hummocky meadow in 1966. In 1967 it was a wet meadow (Brewer, Raim, and Robins 1969). The water reached its highest level in the years 1972 through 1974 presumably because of the development of a shallow nearby lake located within the housing development.*

The north boundary of the tract is formed by a steep bank that drops to Parkview Avenue. Thickets and fields similar to those of the Colony Farm Tract are located to the north of Parkview Avenue.

*Richard Brewer 1974: personal communication.

CHAPTER III

METHODS

In 1961 the area was divided into a grid with coordinates located 200 feet apart. Those coordinates running north-south were lettered; those oriented east-west were numbered. Coordinate intersections were marked with wooden stakes that projected about 3 feet above the ground. By employing the grid system during plant studies it was possible to establish the approximate locations of the individual woody plants invading the grassland. The grid system was also used to locate bird positions while conducting breeding bird censuses.

In 1967 the entire grassland coordinate system was further divided at 100-foot intervals and all woody plants in the grassland were located, identified, measured for height, and recorded at their appropriate locations on scale maps of the area (Brewer, Raim, and Robins 1969). In 1979 the old grid system was re-established by placing permanent metal stakes that projected about 4 feet above the ground in locations that, in so far as possible, duplicated the locations of the original 1961 wooden stakes. As in 1967, the grassland coordinate system was further divided at 100-foot intervals. These 100-foot-square quadrats were partitioned into 20 foot wide sections by stringing clothesline across the quadrats. Each section was sampled methodically by two observers walking slowly through each section. All woody plants in the

entire grassland were located, identified, measured for height and recorded at their appropriate locations on individual scale quadrat maps.

Aerial photographs taken of the area in 1950, 1960, 1967 and 1974, and ground surveys made in 1979 were employed in the construction of scale maps that represented the area as it appeared during these five different years (Figures 3-7). Grassland acreage for these stated years were calculated using the scale maps and Bruning areagraph random dot planimeter (97 percent precision). Curves were then constructed representing the changing acreage of the thicket and grassland for all years 1950 through 1979 (Figures 8 and 9). Examination of these curves made it possible to estimate thicket and grassland acreages for any individual year 1961 through 1979, even those for which aerial photographs were not available. These values were used when calculating birds per acre. Scale maps of the area, as it appeared in 1967 and 1979, were also used to plot the number of woody plants located in each 100-foot-square quadrat.

Bird censuses were accomplished by the territory-mapping procedures employed by Williams (1936), Lack (1937), and Kendeigh (1944). Using this procedure, all birds seen or heard were plotted on scale maps of the Colony Farm Tract by the investigator while walking through the area. Additional information about birds that was helpful in establishing presence of territories, such as carrying food or nesting material, was also recorded.

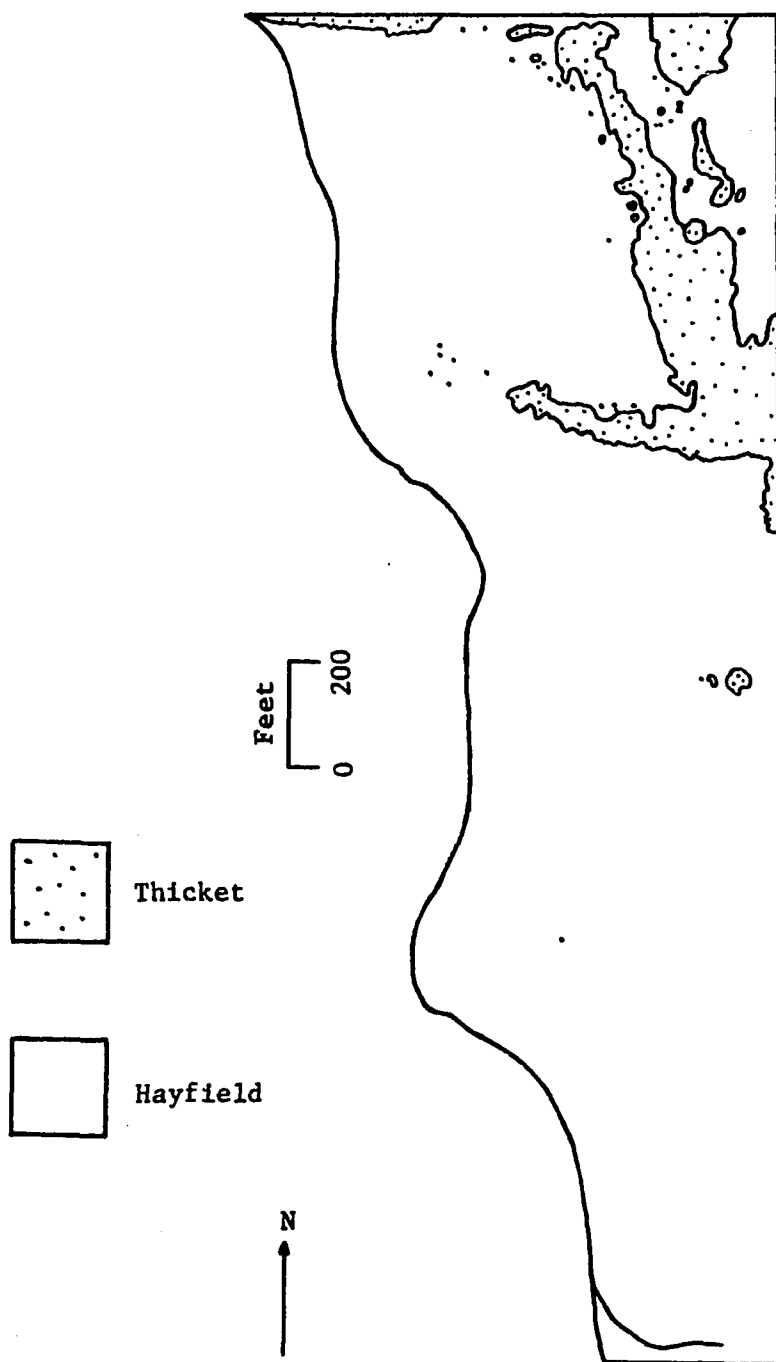


Figure 3. Scale map constructed from aerial photograph depicting Colony Farm Tract as it appeared in 1950. Rose hedge has been drawn in along the western boundary in the location it was eventually planted in 1961.

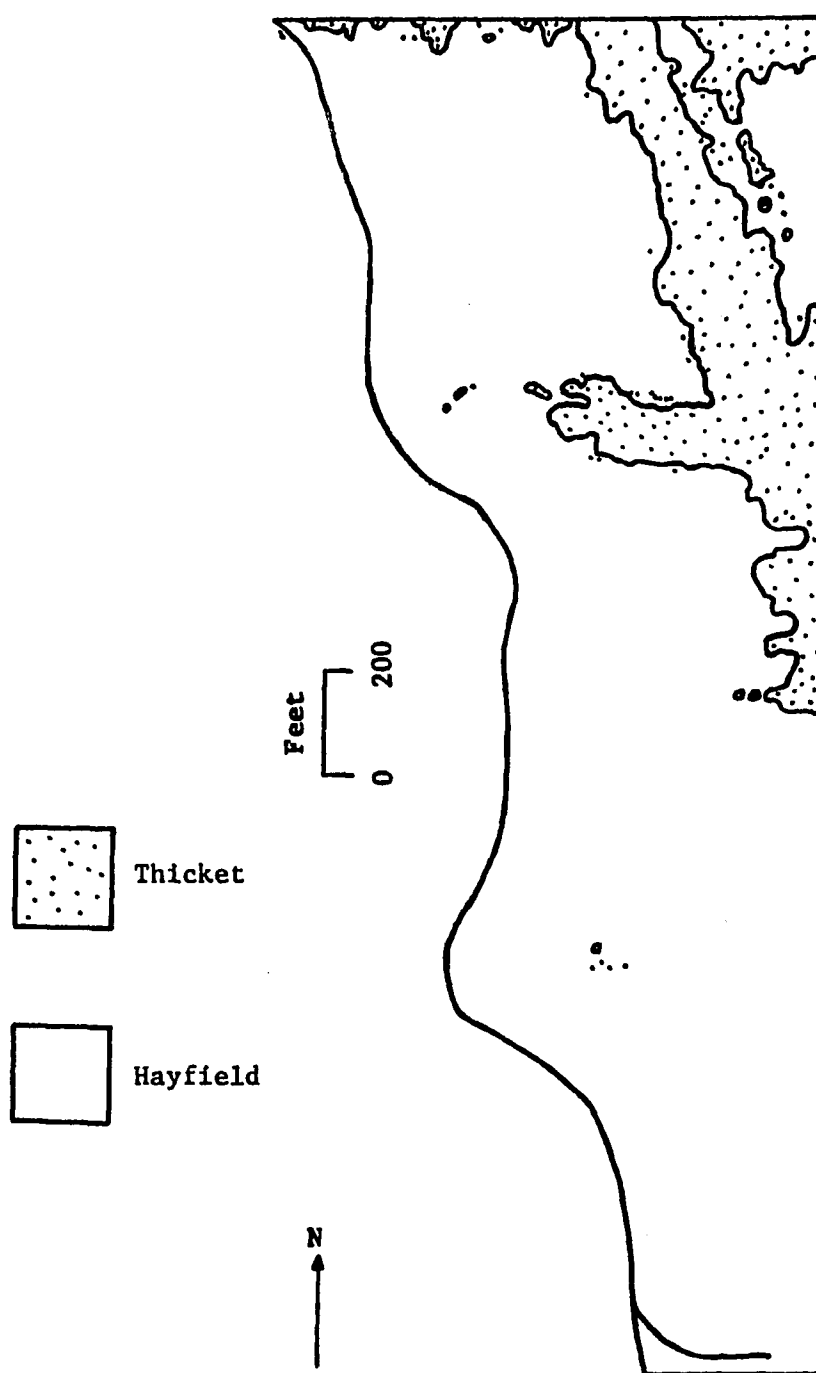


Figure 4. Scale map constructed from aerial photograph depicting Colony Farm Tract as it appeared in 1960. Rose hedge has been drawn in along the western boundary in the location it was eventually planted in 1961.

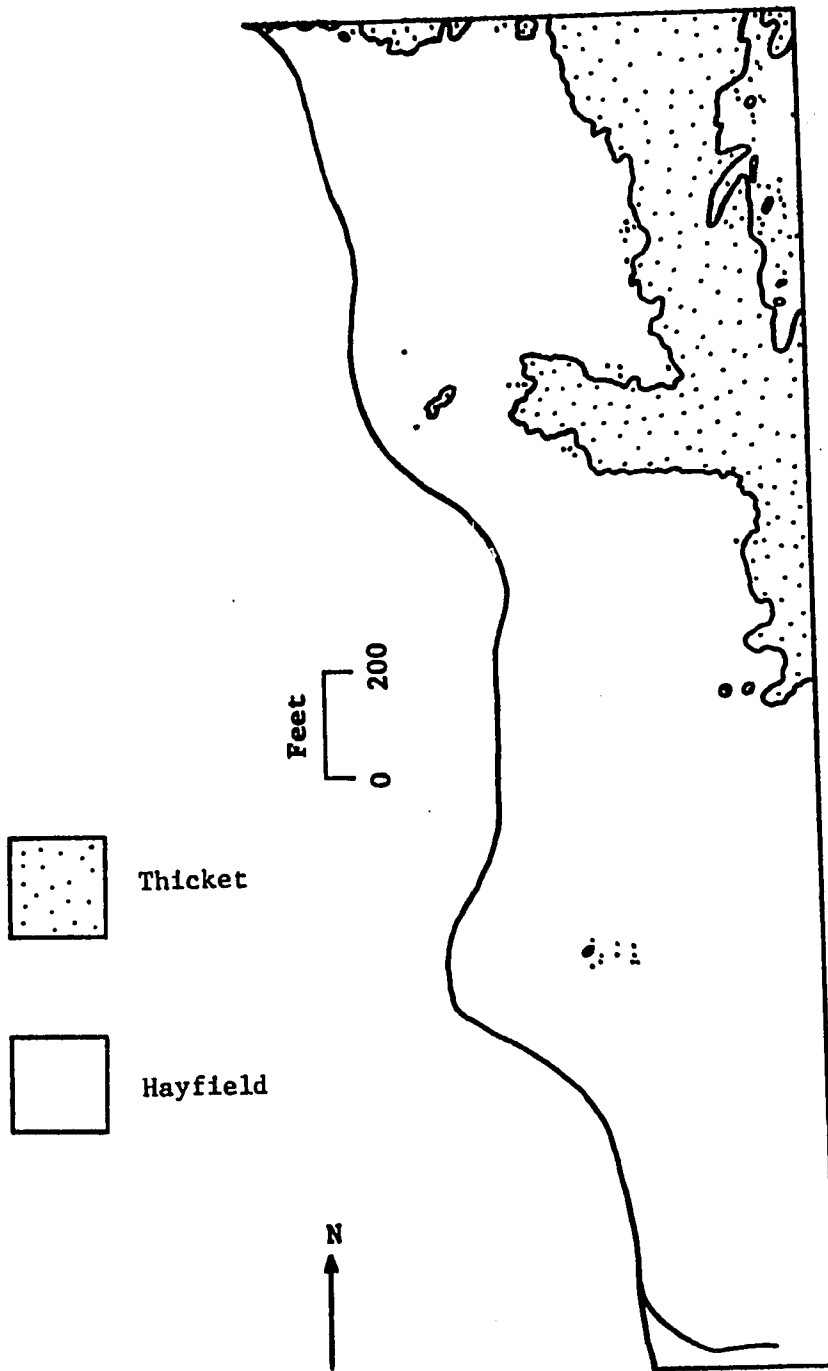


Figure 5. Scale map constructed from aerial photograph depicting Colony Farm Tract as it appeared in 1967.

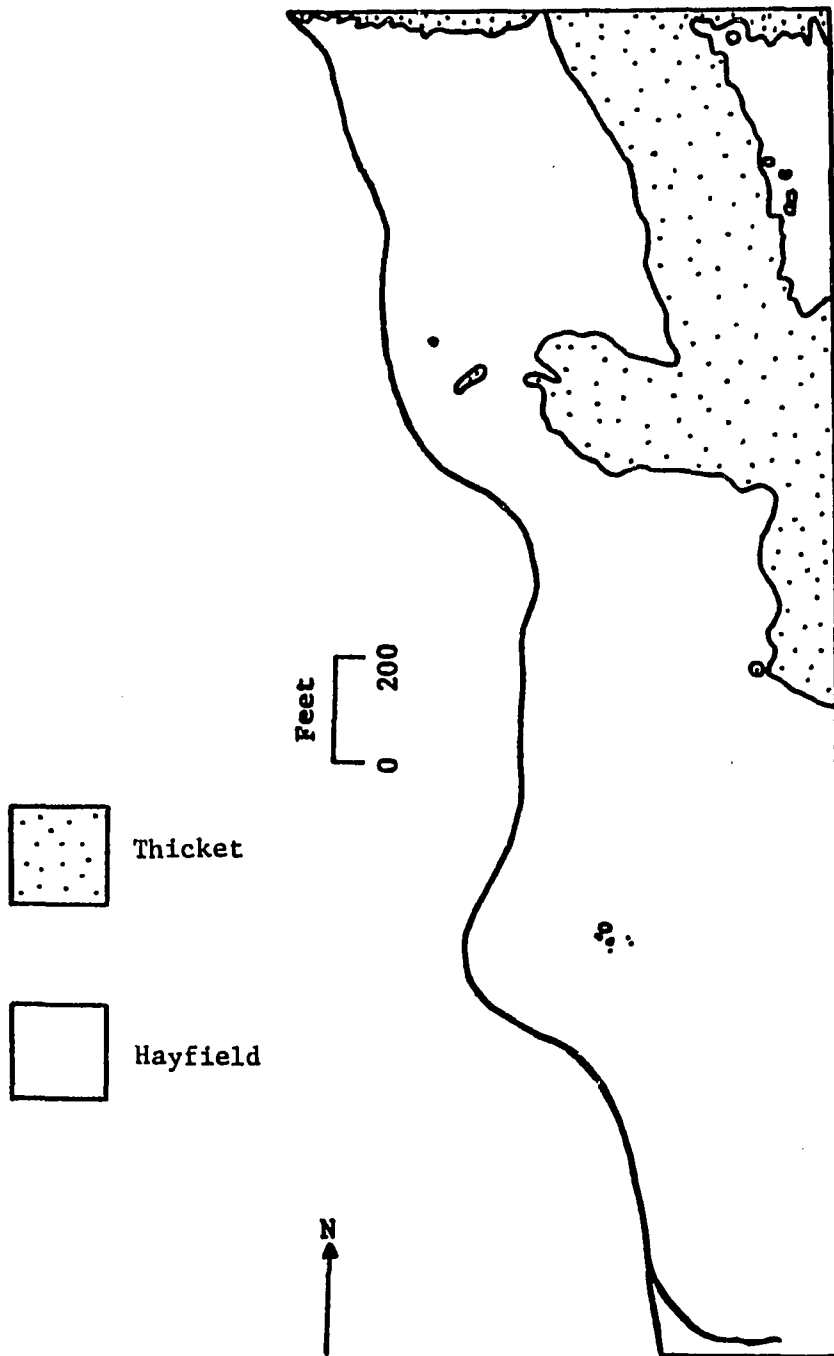


Figure 6. Scale map constructed from aerial photograph depicting Colony Farm Tract as it appeared in 1974.

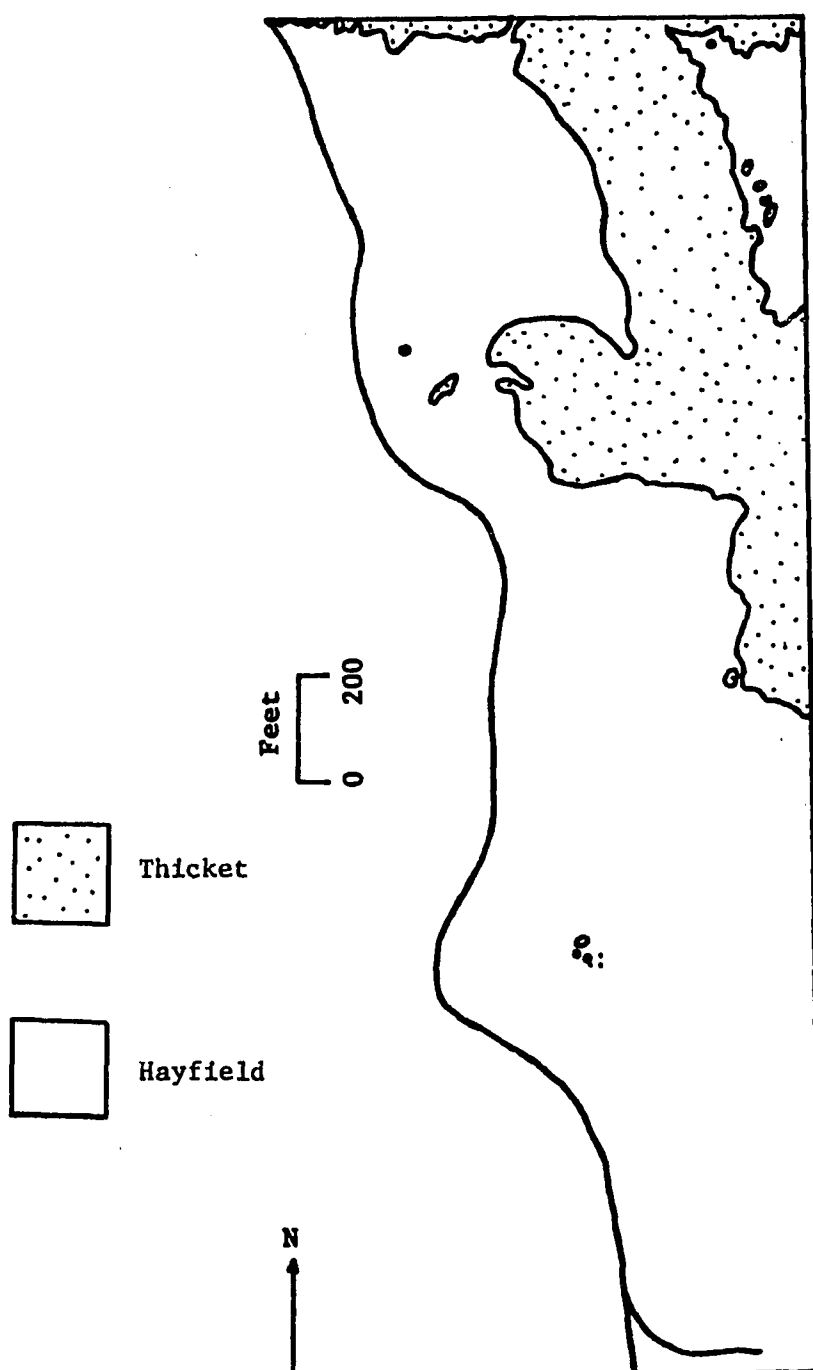


Figure 7. Scale map constructed from 1974 aerial photograph and 1979 ground surveys depicting Colony Farm Tract as it appeared in 1979.

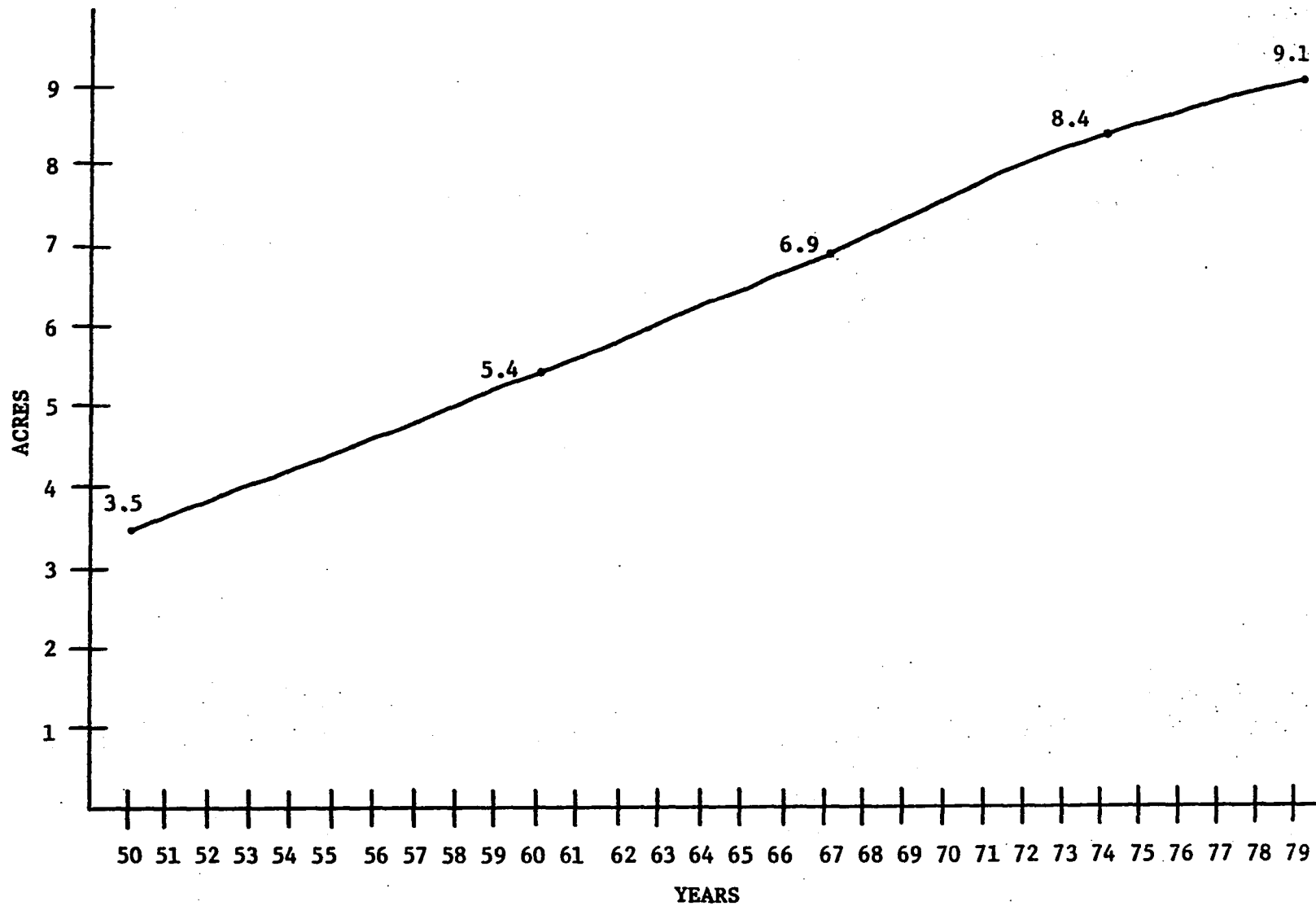


Figure 8. Changing acreage of the thicket over the years 1950-1979 (2.6 acres of marsh and fringing thickets excluded).

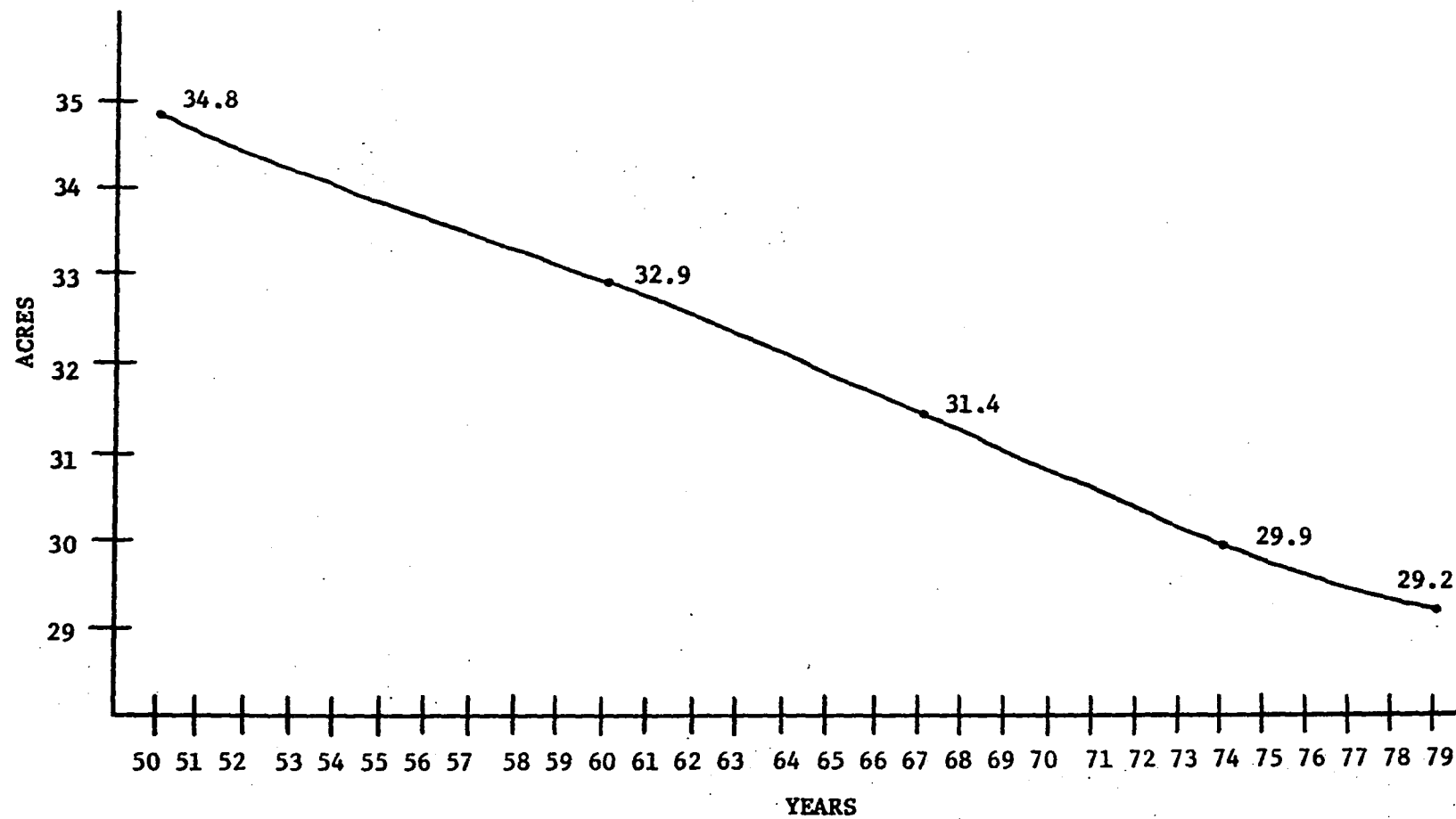


Figure 9. Changing acreage of the grassland over the years 1950-1979 (2.6 acres of marsh and fringing thickets excluded).

Male birds of the same species heard singing or seen simultaneously furnished information particularly useful for plotting territories. Later, on individual summary maps for each species, records formed the basis for outlining the approximate territorial boundaries. If a territory was partly outside the study area, only the fraction that was inside was included in calculating the density of the species in question. All species with territories or home ranges averaging as large or larger than the study area (for example, hawks), or individuals that were often observed on the tract but for which no accurate estimate of territory size could be ascertained are indicated in the tables by "plus" (+) signs. Such birds are definitely a part of the population of the study area but their actual densities cannot be determined satisfactorily (Johnston and Odum 1956). However, all +'s were assigned an arbitrary value of .1 male bird when calculating yearly territorial values and birds per acre. Species that were observed occasionally visiting the study area for only feeding purposes, or those only rarely observed and that did not appear to include the area or any part of it in their regular breeding territories, were regarded as "visitors" and their presence is indicated by a star (*). The *'s were assigned a value of 0 when calculating yearly territorial values and birds per acre. Species that were observed on the study area at different times during the study but never appeared to use the area for breeding purposes are not included in the tables. All final population estimates made from census summary data for

all years 1961-1979 were done by the investigator.

During the height of the breeding season, late April through August, the greatest number of censuses was conducted (Table 1). Because morning censuses have been found most productive (Warbach 1958), most April-June censuses were conducted between 7:00 a.m. and 10:00 a.m.. Although data were collected throughout the entire year, far fewer trips were made during the non-breeding seasons.

As denoted by Nice (1941), this territory-mapping census method is most accurate for birds holding type "A" territories. Such territories are defended areas that are used for mating, nesting, and feeding ground for the young with the result that adult birds remain within a more or less restricted area for a noticeable period of time. Most breeding birds of the Colony Farm Tract appear to establish type "A" territories.

Using Colony Farm Tract bird census data, the following factors were considered for each year: total number of April through August censuses, total number of census hours, number of bird territories, number of birds per acre, number of breeding species holding territories, and the total number of species observed on the entire area. This was done using both the grassland and thicket bird census data. When calculating birds per acre for both the grassland and thicket species, year to year changes in acreage of the grassland and thicket were taken into account. Means and standard deviations were computed for each of the species for their 18 yearly territorial values. This was done for both

TABLE 1
NUMBER OF APRIL THROUGH AUGUST CENSUSES

Year	Number of Censuses	Number of Hours
1961	17	39
1962	5	7
1963	14	20
1964	7	9
1965	35	68
1966	15	26
1967	30	84
1968	19	30
1969	15	29
1970	16	30
1972	43	107
1973	14	30
1974	7	15
1975	3	10
1976	6	13
1977	13	34
1978	14	31
1979	7	17

grassland and thicket populations. Mean and standard deviation were also calculated for the 18 yearly total territorial values. This was also done for both the grassland and thicket breeding populations. Means were also calculated for specific time periods for both the grassland and thicket breeding birds concerning number of territories, birds per acre, and number of breeding species observed. All Colony Farm Tract density values in the tables represent the number of territories occupied by male birds.

To evaluate more fully and accurately the effects of the PUD on the study area's avian populations, the bird populations in the State of Michigan and Kalamazoo County at large were compared with the Colony Farm Tract bird populations. For this purpose, bird census data collected by the U. S. Fisheries and Wildlife Services for the State of Michigan for years 1966-1979 (Chandler and Willet 1966, 1968, and 1969 and unpublished U. S. Fisheries and Wildlife data for years 1970-1979) and data for years 1970-1979 collected by Raymond J. Adams, Jr., research biologist with the Kalamazoo Nature Center, Kalamazoo, Michigan were used. Means were calculated for specific time periods for these data for the same time periods as were done for the Colony Farm Tract data. Although the data from the State of Michigan and Kalamazoo County were in units of birds per route and the Colony Farm Tract data were in units of number of male breeding bird territories, the gross population changes the three areas displayed over the years

were compared and contrasted. Population changes occurring at the Colony Farm Tract that seemed to be deviations from the bird populations in the State of Michigan and Kalamazoo County were subsequently investigated and attempts were made to establish possible relationships between their occurrences and the construction of the PUD.

To obtain a measure of the extent of disturbance the study area has experienced since abandonment, all daily census maps for years 1961-1979 were examined for recorded notes of disturbance. Using this information, the numbers and kinds of disturbances for each year were determined and the locations of their occurrences were plotted on scale maps of the area.

To obtain additional measures of disturbance, 21 hours of specific disturbance observations were conducted. For this purpose a wooden tower about 8 feet in height was used. Observations of disturbance were made with the use of 20x binoculars from atop this platform; all observations were recorded on scale maps of the area. These data were included with the disturbance data obtained from notes of disturbance recorded on the daily census maps.

The effectiveness of "keep-out" signs in reducing disturbance on the study area was determined by posting 21 such signs along the perimeter of the study area and observing for subsequent disturbances (Figure 10). After the placement of the signs 20 hours of observation were made from the wooden tower. To aid in observation, 20x binoculars were again employed. All observations

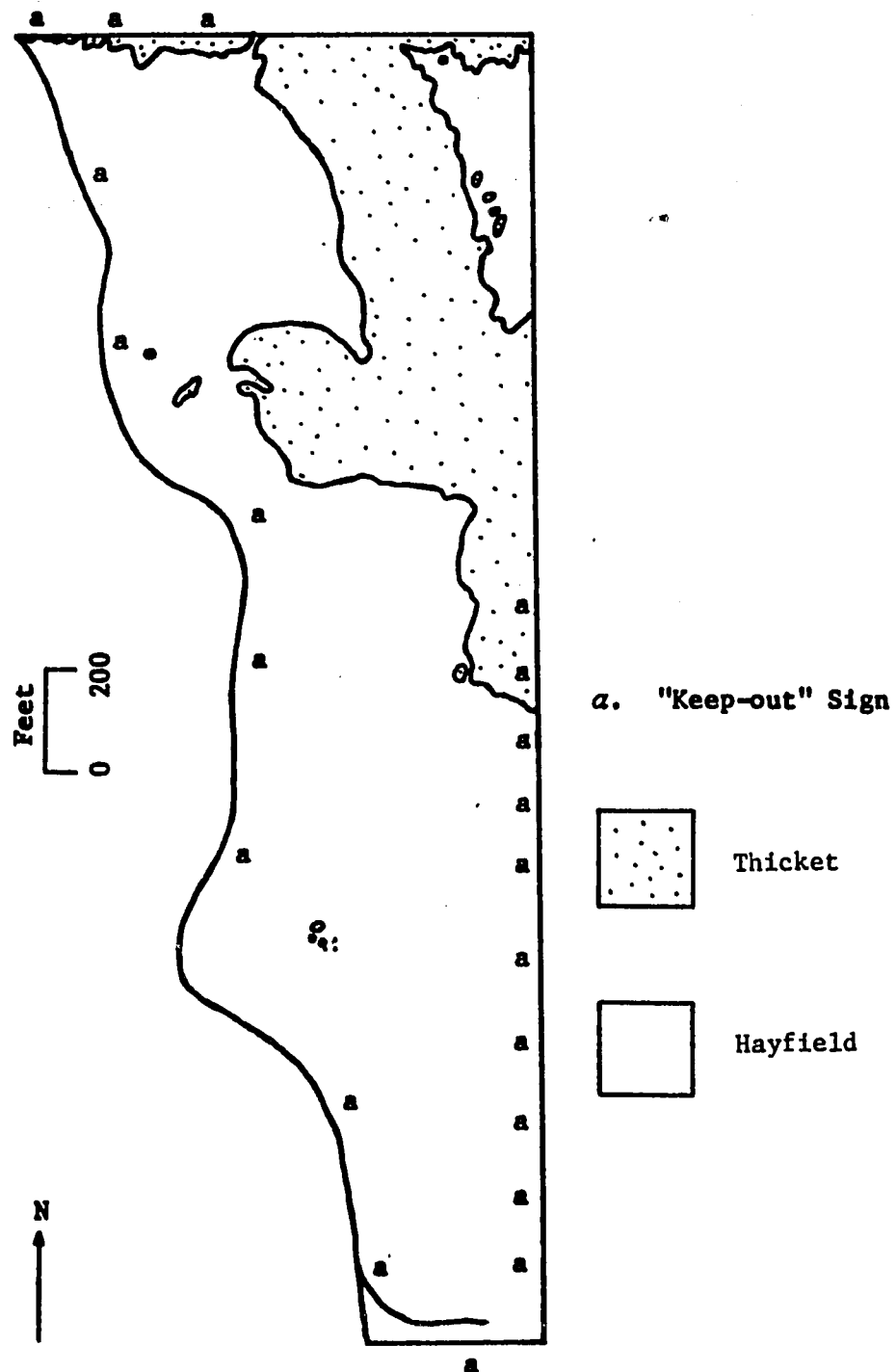


Figure 10. Scale map of Colony Farm Tract indicating approximate locations of posted "keep-out" signs.

of disturbance were recorded on scale maps of the area. The data collected before and after posting of the "keep-out" signs were then compared and notes were made of the numbers and kinds of disturbances that occurred during these two periods. These data were also included with the disturbance data obtained from notes of disturbance recorded on daily censuses.

All bird names were taken from the American Ornithologists' Union check-list (1957) and later supplements.

CHAPTER IV

RESULTS AND DISCUSSION

Vegetation Change

Because the physical nature and complexity of vegetation in any given habitat is so important in affecting avian populations (Kendeigh 1945; MacArthur and MacArthur 1961; Karr and Roth 1971; Willson 1974; Roth 1976), it is necessary to note the vegetational disposition of the study area and discover any changes that have occurred in its character with time. This will provide a background for interpreting variations in the area's breeding bird populations. It must be accomplished in order to help evaluate what effect alone the adjacent housing development has had on the breeding bird populations of the Colony Farm Tract.

There has been an increase in total numbers of woody plants throughout the grassland at large since 1959 (Table 2 and Figures 11 and 12). However, if only the area away from borders is considered and a few atypical areas are excluded from consideration, (Figures 13 and 14) it appears that the increase in numbers has occurred almost entirely in the higher height class categories (Table 3). The lower height class categories have actually had reductions in their numbers. Based upon the sizes of the woody plants in the smallest height category displaying a substantial increase in numbers from 1967 to 1979, it is suspected that the establishment of new woody plants has probably been much reduced

TABLE 2
WOODY PLANT NUMBERS FOR ALL GRASSLAND QUADRATS

YEAR	Height Categories											
	0-25 cm	26-50 cm	51-100 cm	101-150 cm	151-200 cm	201-250 cm	251-300 cm	301-350 cm	351-400 cm	401-450 cm	451-500 cm	501-550 cm
1967	5 (+ patch of TNC)	198	335	92	8	4	2					
1979	229 (+TNC)	357 (+TNC)	573	375	179	53	31	21	17	2	2	1
NET CHANGE	+224 (+TNC)	+159 (+TNC)	+238	+283	+171	+49	+29	+21	+17	+2	+2	+1

TNC = Too numerous to count.

TABLE 2 - Continued

Height Categories						
551-600 cm	601-650 cm	651-700 cm	701-750 cm	751-800 cm	NO HT.	TOTALS
644 + patch of TNC						
1				1	26	1868 + clone, some broken plants, and TNC
+1				+1	+26	1224 + clone, some broken plants, and TNC

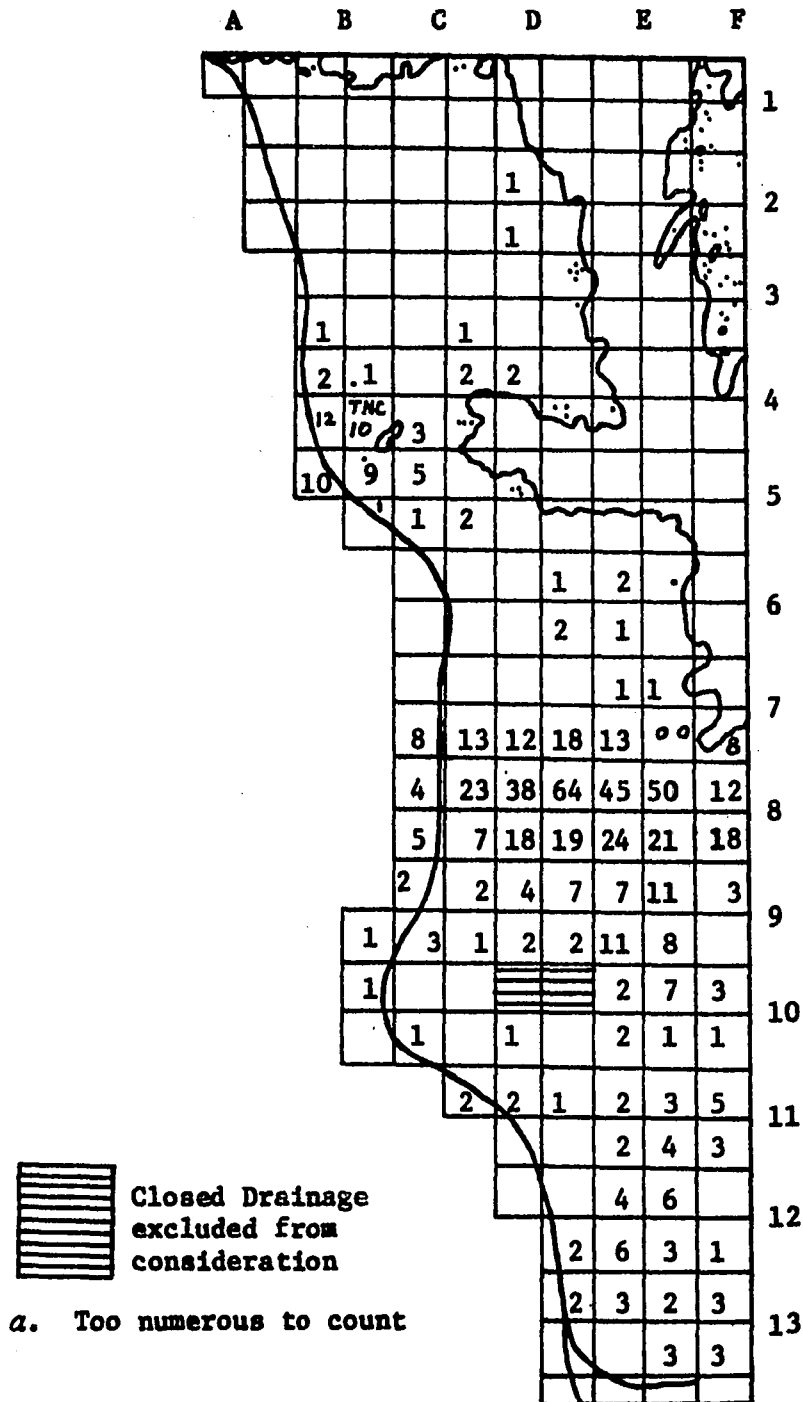


Figure 11. Total numbers of grassland woody plants recorded in each specific grassland quadrat for year 1967.

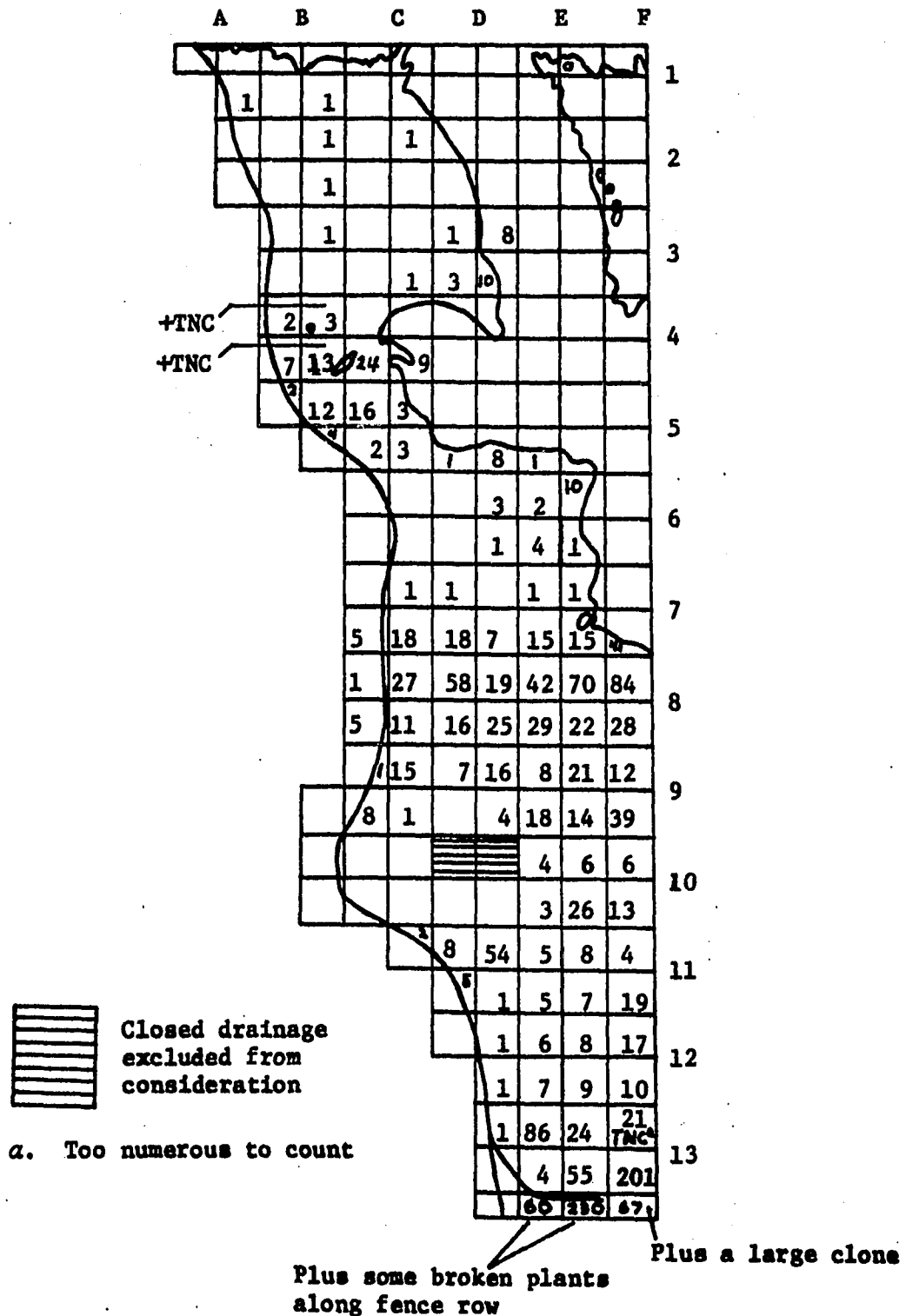


Figure 12. Total numbers of grassland woody plants recorded in each specific grassland quadrat for year 1979.

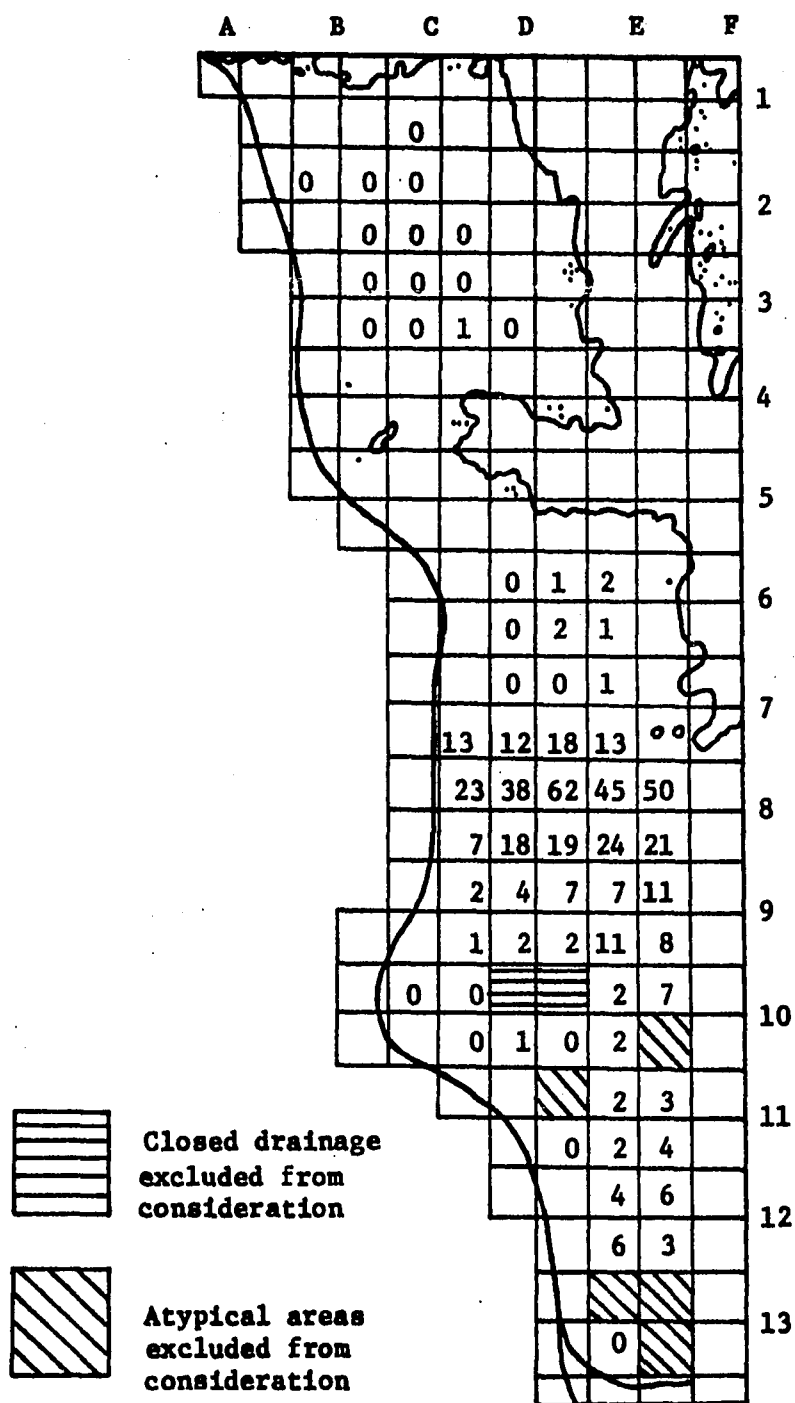


Figure 13. Total numbers of grassland woody plants recorded in each of the non-border grassland quadrats for year 1967.

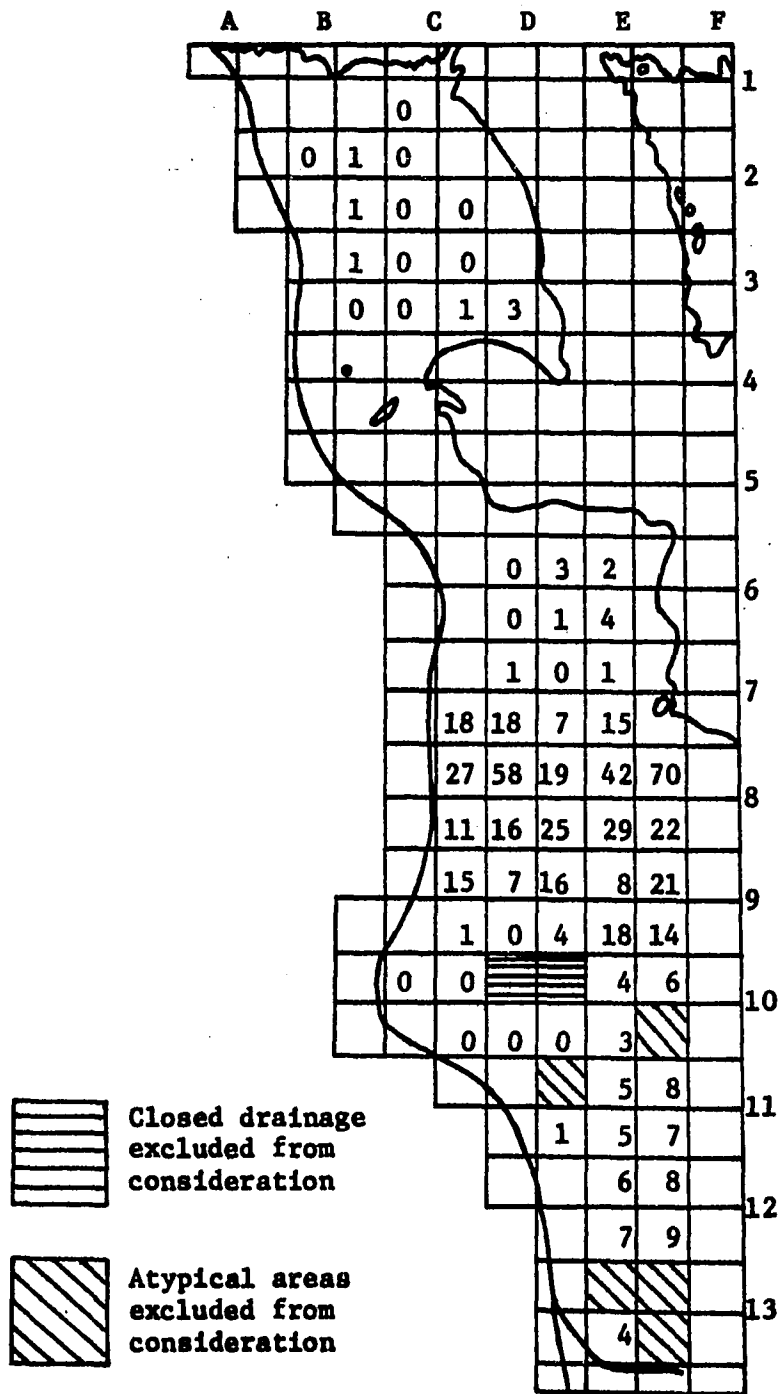


Figure 14. Total numbers of grassland woody plants recorded in each of the non-border grassland quadrats for year 1979.

TABLE 3
WOODY PLANT NUMBERS FOR NON-BORDER QUADRATS

YEAR	Height Categories											NO HT.	TOTAL
	0-25 cm	26-50 cm	51-100 cm	101-150 cm	151-200 cm	201-250 cm	251-300 cm	301-350 cm	351-400 cm	401-450 cm	451-500 cm		
1967	3	149	252	61	3								468
1979	7	45	217	195	72	23	8	3	1		1	1	573
NET CHANGE	+4	-104	-35	+134	+69	+23	+8	+3	+1		+1	+1	+105

NOTE: Atypical areas excluded; see figures 13 and 14.

for about the last 5 years. This is true for at least the non-border portion or 50 percent of the grassland and is especially true of the north (lines 1-5) and middle (lines 5-7) sections (Table 4). The actual percentage of the grassland experiencing such a trend in woody plant invasion is in reality much greater. This is because a large percentage of the total areas in most border quadrats, situated away from borders, more closely resembles the vegetation of non-border quadrats than that immediately adjacent a border. This suggests that most woody plant invasion is occurring only within about 25 feet of grassland border junctions.

It is speculated that the aforementioned changes in the vegetational character of the grassland would have produced changes in the grassland avian populations during specific times throughout the study. Major changes in bird populations due to woody plant invasion most obviously would be expected to have occurred soon after abandonment when invasion would have been ongoing at its most rapid rate. However, since little change has seemingly taken place in most of the grassland since about 1974, few bird population changes would be expected to have occurred since that time as the result of changes in the area's grassland vegetational features. The reason is that the Colony Farm Tract's grassland habitats in years 1974 through 1979 would have been very similar physically and biologically. Communities in similar habitats should be similar with respect to species richness, species composition and population density (Roth 1977).

TABLE 4
NON-BORDER QUADRAT WOODY PLANT NUMBERS FOR EACH SECTION OF GRASSLAND

LINES	Height Categories											
	YEAR	0-25 cm	26-50 cm	51-100 cm	101-150 cm	151-200 cm	201-250 cm	251-300 cm	301-350 cm	351-400 cm	401-450 cm	451-500 cm
7-14	1967	3	149	246	59	3						
	1979	7	44	213	192	68	20	8	3	1		1
	NET CHANGE	+4	-105	-33	+133	+65	+20	+9	+3	+1		+1
5-7	1967			5	2							
	1979			4	2	3	3					
	NET CHANGE			-1	0	+3	+3					
1-5	1967			1								
	1979		1	0	1	1						
	NET CHANGE		+1	-1	+1	+1						

NOTE: Atypical areas excluded; see figures 13 and 14.

TABLE 4 - Continued

Height Categories				
501-550 cm	551-600 cm	601-650 cm	651-700 cm	NO HT. TOTAL
				460
				558
				+98
				1
				+1
				7
				12
				+5
				1
				3
				+2

The thicket has experienced more profound vegetational changes than has the grassland. These changes include both a substantial expansion in size and the development of more forest-like characteristics.* However, because these changes have occurred slowly and at a nearly constant rate, it is probable that any changes in the thicket avian populations, due to these vegetational changes, would have occurred gradually since abandonment.

Bird Populations

Introduction

The total number of species observed at the Colony Farm Tract over the years 1961 through 1979 was about 120; the usual number of species seen per year was about 50. Many species restricted their activities to feeding on or above the area, migrating through the area during spring or fall, or were present occasionally as visitors and were known not to nest on the tract. A consequential number of these birds were sighted at different times of the year other than breeding periods. The entire list of species observed for years 1961 through 1979 appears in the Appendix.

Thirty-eight species established territories that were either situated entirely within the thicket portion of the study area, or at least included some portion of the thicket as breeding territory, over the years 1961 through 1979 (Table 5). The mean number of

*Richard Brewer 1974: personal communication.

TABLE 5
COLONY FARM TRACT THICKET BREEDING BIRD NUMBERS

SPECIES	YEARS																			
	61	62	63	64	65	66	67	68	69	70	72	73	74	75	76	77	78	79	\bar{X}	SD
Green Heron	*	0	0	0	+	0	0	1.0	1.0	1.0	1.0	+	+	0	0	0	+	0	.2	.4
Red-tailed Hawk	0	0	0	0	0	0	+	0	+	+	+	+	+	0	0	0	0	0	0	.1
Mourning Dove	3.0	+	1.0	2.0	4.0	2.0	2.0	1.0	1.0	1.0	1.0	+	+	*	+	+	+	*	1.0	1.2
Yellow-billed Cuckoo	0	0	0	+	*	*	2.0	1.0	1.0	*	1.0	+	0	0	0	.6	0	.7	.4	.6
Black-billed Cuckoo	1.0	0	0	0	1.0	*	0	+	*	0	.8	0	0	0	0	*	0	0	.2	.4
Great Horned Owl	0	0	0	0	0	0	+	*	0	0	+	+	0	+	0	+	0	0	0	.1
Common Flicker	.5	.4	.5	0	.6	.5	.6	.8	1.0	.5	1.2	.5	1.2	.6	0	.7	.4	*	.6	.4
Red-bellied Woodpecker	0	0	0	0	0	0	0	0	0	0	+	*	0	0	*	0	0	0	0	0
Hairy Woodpecker	*	0	*	0	0	*	0	1.0	*	*	*	0	0	0	0	0	0	0	.1	.2
Downy Woodpecker	+	.9	*	.5	.5	.3	.7	.9	*	+	.7	.5	*	0	+	0	+	*	.3	.3
Eastern Kingbird	.9	+	0	0	.5	.6	0	+	*	.7	.7	0	0	*	0	0	0	0	.2	.3
Great Crested Flycatcher	.5	0	+	0	.5	.4	.5	.8	.6	.1	.8	.5	.7	0	*	*	*	.5	.3	.3

NOTE: Numbers represent number of breeding males.

* = Visitor - did not establish breeding territory.

+ = Established breeding territory but no accurate estimate of territory size established.

TABLE 5 - Continued

SPECIES	YEARS																			
	61	62	63	64	65	66	67	68	69	70	72	73	74	75	76	77	78	79	\bar{X}	SD
Eastern Wood Pewee	0	0	0	0	.3	0	.8	0	*	*	*	*	0	0	0	0	*	.4	.1	.2
<i>Empidonax</i> spp.	.5	0	0	0	0	0	*	0	0	0	0	0	0	0	0	*	0	*	0	.1
Blue Jay	+	+	+	+	+	+	+	+	+	+	+	+	+	*	*	+	+	+	.1	.0
Common Crow	*	*	*	0	*	*	*	*	*	*	1.0	1.0	1.0	*	*	+	.7	1.0	.3	.4
Black-capped Chickadee	*	*	*	*	*	*	0	0	*	*	1.0	*	.5	.5	*	.1	.6	.4	.2	.3
Tufted Titmouse	+	*	*	*	*	0	*	*	*	+	.7	.5	.8	.4	.6	.6	.7	.5	.3	.3
White-breasted Nuthatch	0	0	*	*	*	0	+	.5	*	*	.6	+	.6	0	.7	+	0	.8	.2	.3
House Wren	*	0	.1	+	.8	.7	+	+	*	*	2.0	*	0	0	0	0	0	0	.2	.5
Gray Catbird	2.5	.9	.3	.5	1.4	2.0	1.6	.6	1.2	1.1	1.5	1.0	1.3	+	.9	+	*	.7	1.0	.7
Brown Thrasher	.3	.5	.6	.9	.7	.4	.4	.8	+	*	*	.5	0	0	0	.7	+	0	.3	.3
American Robin	+	+	+	*	+	+	+	+	+	+	+	2.0	+	.7	.6	+	*	*	.3	.5
Starling	*	*	*	0	*	1.0	1.0	+	*	*	*	*	*	*	*	*	*	*	.1	.3
Red-eyed Vireo	0	0	*	0	*	0	0	.6	+	*	0	0	*	0	0	+	0	0	0	.1
Warbling Vireo	0	0	0	0	*	1.0	0	0	*	0	*	0	0	0	0	0	0	0	.1	.2
Yellow Warbler	0	.1	*	*	.6	*	.5	0	*	+	*	*	0	0	*	0	0	0	.1	.2
Common Yellowthroat	3.9	4.2	1.8	.5	2.5	2.2	.4	1.0	1.3	.2	1.4	.6	0	0	.8	.1	2.0	.5	1.3	1.3

TABLE 5 - Continued

SPECIES	YEARS																			
	61	62	63	64	65	66	67	68	69	70	72	73	74	75	76	77	78	79	\bar{x}	SD
Northern Oriole	*	0	0	0	+	.8	+	.8	+	.8	1.0	1.0	+	0	*	.3	*	1.0	.3	.4
Common Grackle	0	0	0	0	+	*	*	*	*	*	*	+	+	+	+	*	+	*	0	.1
Brown-headed Cowbird	0	+	*	0	+	+	+	+	*	+	+	0	*	0	+	+	0	0	.1	.1
Cardinal	1.0	.8	.7	.8	.8	.9	1.0	.5	1.6	1.6	1.4	1.6	1.1	.3	.7	+	.6	.5	.9	.4
Rose-breasted Grosbeak	0	0	0	0	0	.2	*	.2	0	0	*	0	*	0	0	.2	*	*	0	.1
Indigo Bunting	1.4	0	1.6	1.4	.9	.5	2.0	.8	1.6	1.0	.9	0	0	0	0	0	.3	*	.7	.7
American Goldfinch	+	0	+	*	+	+	+	+	+	+	+	+	+	0	*	+	+	+	.1	0
Rufous-sided Towhee	1.0	1.2	.7	.9	1.2	.6	.7	.7	*	.7	.5	0	0	0	0	0	0	0	.5	
Swamp Sparrow	.1	.1	*	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Song Sparrow	2.0	1.2	1.1	.7	1.0	1.6	1.6	1.7	3.3	2.7	5.6	7.8	3.4	2.3	3.0	1.9	.1	1.4	2.4	1.9
Total Territories	19.1	10.8	8.8	8.5	18.0	16.1	16.7	15.5	14.3	12.2	25.5	18.4	11.4	5.1	7.7	6.3	6.1	8.6	12.7	5.6
Total birds per acre	3.4	1.9	1.5	1.4	2.8	2.4	2.4	2.2	2.0	1.6	3.3	2.3	1.4	.6	.9	.7	.7	1.0	1.8	.9
Total Number of Species	19	15	14	12	22	21	24	26	17	20	27	21	17	9	11	20	15	14	18.0	5.1

thicket territories for the 18 years was 12.7 with a standard deviation of 5.6 and a range of 20.4. These 12.7 territories are equal to an average of 1.8 birds per acre. There was a mean of 18.0 species per year represented in the thicket breeding fauna.

Thirteen different species established territories in the grassland during the span of the study (Table 6). These 13 species were the Mallard, Bobwhite, Ring-necked Pheasant, Short-billed Marsh Wren, Bobolink, Eastern Meadowlark, Red-winged Blackbird, Dickcissel, Savannah Sparrow, Grasshopper Sparrow, Henslow's Sparrow, Field Sparrow, and Song Sparrow. The mean number of grassland territories for the 18 years was 35.5 with a standard deviation of 5.5 and a range of 17.5. These 35.5 territories represent an average of 1.2 birds per acre which is comparable to 1.0 bird per acre reported by Kendeigh (1941) for a study in a Iowa prairie. The mean number of species represented in the grassland breeding fauna was 7.4 for the 18 years of study.

Kendeigh (1941) listed somewhat different species as grassland breeding birds than those observed here. Although many of the above listed species are not true grassland birds, they were included in this study with the species more often associated with grasslands, because they used the grassland portion of the study area for nest sites, feeding, or shelter to a far greater extent than the thicket portion of the tract. The Mallard's presence is believed to depend on the nearby marsh. Kendeigh (1941), in a similar study, reported the nesting of a Mallard

TABLE 6

COLONY FARM TRACT GRASSLAND BREEDING BIRD NUMBERS

SPECIES	YEARS																			
	61	62	63	64	65	66	67	68	69	70	72	73	74	75	76	77	78	79	\bar{X}	SD
Mallard	0	0	0	1.0	0	1.0	1.0	1.0	0	0	0	1.0	0	0	1.0	0	1.0	1.0	.4	.5
Bobwhite	0	0	0	0	0	0	0	0	0	0	.6	0	0	0	0	0	0	0	0	.1
Ring-necked Pheasant	+	1.5	1.0	+	4.0	+	+	1.0	+	+	1.2	1.0	2.0	.8	0	1.0	.7	1.3	.9	1.0
Short-billed Marsh Wren	0	0	0	0	0	6.0	.5	0	0	0	2.6	1.0	2.0	0	3.1	0	0	0	.8	1.6
Bobolink	3.0	2.0	3.0	4.0	3.0	5.2	8.1	4.0	4.6	4.2	5.6	5.3	4.3	6.6	6.4	6.6	4.9	5.5	4.8	1.6
Eastern Meadowlark	4.0	3.5	3.5	3.5	4.0	4.5	4.5	4.0	3.0	4.2	5.5	4.0	3.5	1.8	2.7	3.0	3.5	4.4	3.7	.8
Red-winged Blackbird	7.2	7.5	6.5	10.1	6.2	7.6	8.4	10.4	16.0	12.9	12.8	23.5	17.5	13.0	14.9	17.6	14.1	11.6	12.1	4.7
Dickcissel	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	.1	.4
Savannah Sparrow	0	0	0	0	0	.5	3.6	5.1	2.3	1.6	4.9	6.0	3.5	5.2	3.7	4.2	2.8	1.5	2.5	2.1
Grasshopper Sparrow	0	0	0	0	0	.2	0	0	0	0	0	0	0	0	0	0	0	0	0	.1
Henslow's Sparrow	15.5	17.0	17.5	16.2	12.0	15.0	8.1	4.5	15.0	15.3	10.4	3.5	1.0	0	0	0	0	0	8.4	7.2
Field Sparrow	1.3	.5	.6	.5	1.0	.5	.7	.9	0	1.8	1.1	.1	0	0	0	0	0	0	.5	.6
Song Sparrow	0	0	0	0	0	0	0	0	0	0	1.2	1.0	4.0	1.5	4.0	3.6	3.0	3.6	1.2	1.6
Total territories	31.1	32.0	32.1	35.4	30.2	40.6	36.5	30.9	41.0	40.1	45.9	46.4	37.8	28.9	35.8	36.0	30.0	28.9	35.5	5.5
Total birds per acre	1.0	1.0	1.0	1.1	1.0	1.3	1.2	1.0	1.3	1.3	1.5	1.6	1.3	1.0	1.2	1.2	1.0	1.0	1.2	.2
Numbers of species	6	6	6	7	6	10	10	8	6	7	10	10	8	6	7	6	7	7	7.4	1.6

NOTE: Numbers represent number of breeding males.

+ = Established breeding territory but no accurate estimate of territory size established.

in the middle of a 50-acre grassland next to a lake and marsh. Birds in this study considered by Kendeigh (1941) as true grassland species are the Bobolink and Eastern Meadowlark.

The data for both grassland and thicket populations show noticeable variability throughout the study (Figures 15 and 16). However, the 18 years of data display natural "breaks" into certain time periods that show upward or downward trends in both numbers of birds and numbers of bird species holding breeding territories. For the grassland, these time periods are 1961-1965, 1966-1974, and 1975-1979. The upward population trend that occurred between 1961-1965 and 1966-1974 is claimed to have been caused by biotic changes in the grassland's habitat. The most notable of these changes are believed to have been woody plant invasion and other factors associated with increased ecological age of the habitat. The downward population change observed to have occurred between time periods 1966-1974 and 1975-1979 is believed to have been the result of increased disturbance emanating from the PUD.

The thicket population displays periods during 1961-1964, 1965-1974 and 1975-1979. The cause for the upward population change that occurred between 1961-1964 and 1965-1974 is believed to be the result of vegetational changes in the thicket habitat - mainly, the increase in thicket size. The downward population change observed between time periods 1965-1974 and 1975-1979 is believed to be the result of the PUD construction and other

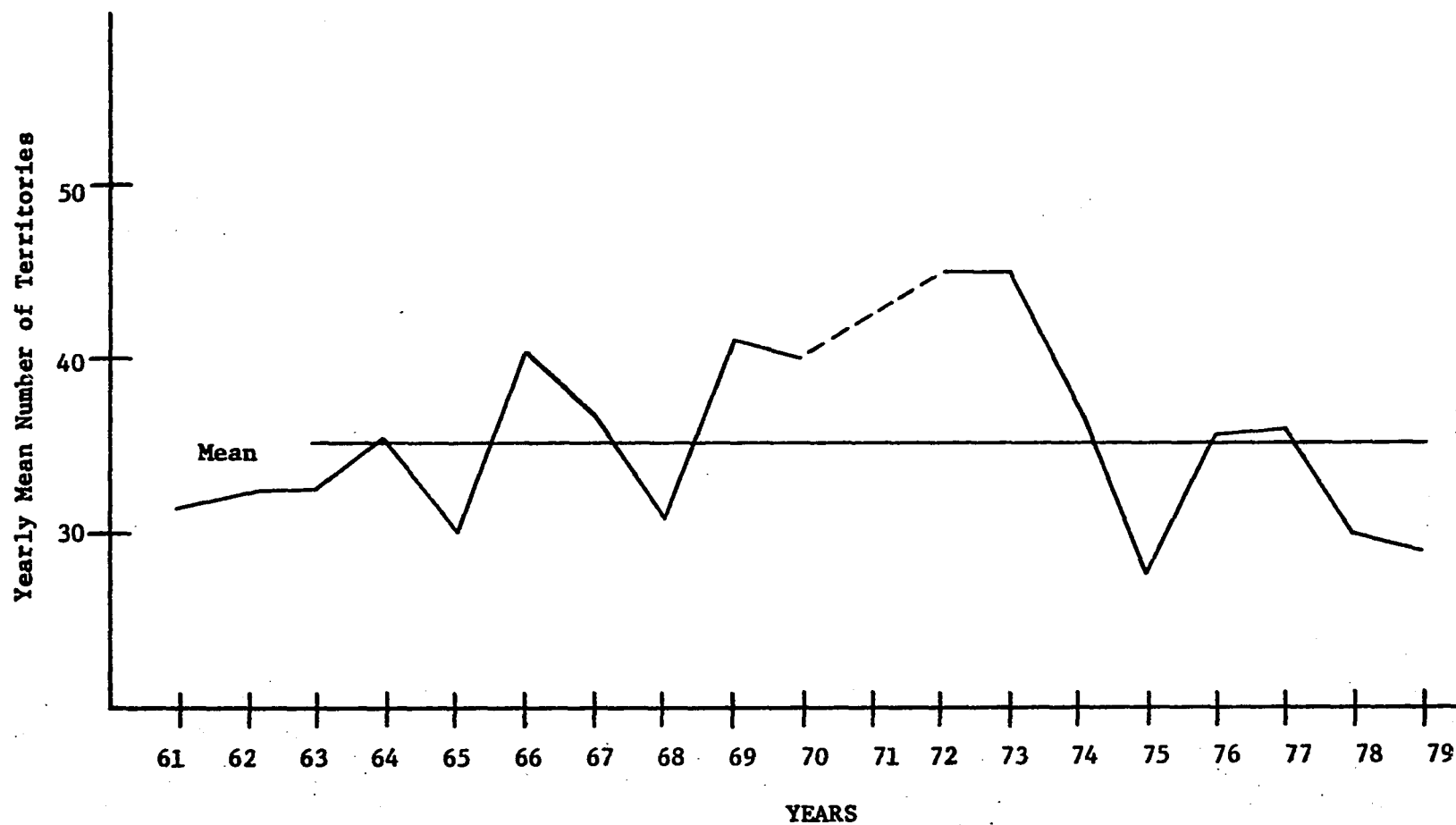


Figure 15. Number of grassland breeding bird territories for years 1961-1979.

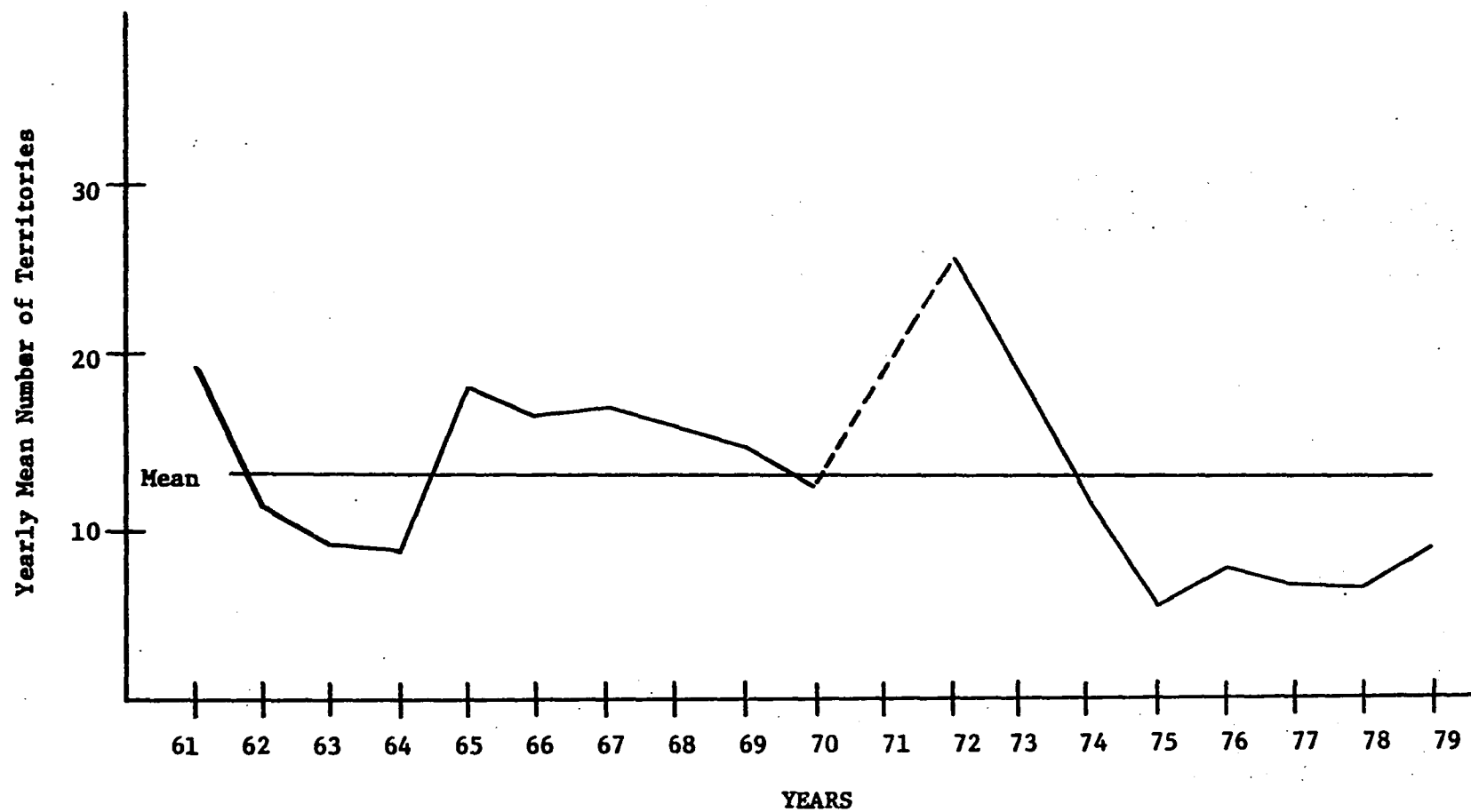


Figure 16. Number of thicket breeding bird territories for years 1961-1979.

factors associated with residential development.

Although biotic changes and human disturbance are believed to have been important in causing the major avian population changes that occurred during this study, the point must also be made that, at least until now, the affects of the adjacent development have not had catastrophic effects on most of the study area's bird species. In many ways the bird populations are the same as they were before the adjacent area was developed. However, little data concerning the breeding success of the area's avian fauna are available. Therefore, it is possible that the maintenance of the study area's somewhat stable bird populations is dependent on continued immigration from less disturbed areas. Ludwig (1979) has reported such a phenomena occurring with Caspian Terns in the Great Lakes region. To determine if this is an important factor affecting the Colony Farm Tract's avian populations specific studies will have to be conducted that address this question.

Grassland bird population period 1961-1965

This period began 2 years after cessation of farming practices and with the initiation of breeding bird censuses. The mean yearly total number of territories for this period was 32.2, the actual values displaying a spread from 30.2 to 35.4 for a range of 5.2 (Table 7). The mean number of birds per acre per year was 1.0; the values included a low of 1.0 and a high of 1.1 for a range of .1. The numbers of species represented in the breeding fauna varied

TABLE 7

COLONY FARM TRACT GRASSLAND BREEDING BIRD POPULATION VALUES

VALUES	TIME PERIODS							
	YEARS 61-65		YEARS 66-74		YEARS 70-74		YEARS 75-79	
	\bar{X}	SD	\bar{X}	SD	\bar{X}	SD	\bar{X}	SD
Total mean territories	32.2	2.0	39.9	5.0	42.6	4.3	31.9	3.7
Mean number of species	6.2	.5	8.6	1.6	8.8	1.5	6.6	.6
Mean number of birds/acre	1.0	.1	1.3	.2	1.4	.2	1.1	.1

\bar{X} = Mean

SD = Standard deviation

from 6 to 7 for a mean of 6.2 and a range of 1.0. Of the 13 grassland breeding bird species, the same 6, Ring-necked Pheasant, Bobolink, Eastern Meadowlark, Red-winged Blackbird, Henslow's Sparrow, and Field Sparrow, constituted the entire breeding fauna every year for the duration of the period except for the Mallard that nested on the study area in 1964. The 4 species contributing the greatest percentage of birds to the total population were the Bobolink, Eastern Meadowlark, Red-winged Blackbird, and Henslow's Sparrow. These species comprised 92.6% of the total breeding population.

Grassland bird population period 1966-1974

There was a mean of 39.9 yearly total breeding territories during this nine-year period. The values were as low as 30.9 and as high as 46.4 for a range of 15.5. There was a mean of 1.3 birds per acre with values ranging from 1.0 to 1.6. The mean number of species per year was 8.6; the actual number of species varied from 6 to 10 for a range of 4.0. The same 9 species of the 13 total grassland species were represented in the breeding fauna during most years. These 9 species were the Mallard, Ring-necked Pheasant, Short-billed Marsh Wren, Bobolink, Eastern Meadowlark, Red-winged Blackbird, Savannah Sparrow, Henslow's Sparrow, and Field Sparrow. Three of these 9 species, the Mallard, Short-billed Marsh Wren, and Savannah Sparrow became part of the common breeding fauna during this period. The actual year of

addition for the Short-billed Wren and Savannah Sparrow was 1966. In 1972 the Song Sparrow established itself in the breeding fauna and became, in terms of numbers, an important species from that time on. For the entire period, the Short-billed Marsh Wren, Savannah Sparrow, and Song Sparrow together constituted 14.3 percent of the total breeding population. They produced their alltime territorial highs during this period with 6.0 territories in 1966 for the Short-billed Marsh Wren and 6.0 territories for the Savannah Sparrow in 1973. During this period, the Song Sparrow produced its largest value of 4.0 territories in 1974, and also again in 1976 during the 1975-1979 period. The Bobwhite and Dickcissel were both represented in the breeding fauna during this period, 1967 for the Dickcissel and 1972 for the Bobwhite. It was found that they did not establish breeding territories at any other time during the study. The Grasshopper Sparrow was part of the breeding fauna in 1966 but it did not establish territories at any other time during the study. Approximately 89.0 percent of the total population was composed of the Bobolink, Eastern Meadowlark, Red-winged Blackbird, Savannah Sparrow, and Henslow's Sparrow. Thus, they constituted the greatest percentage of birds in the total breeding bird population during 1966-1974.

During this period, two individual years are especially noteworthy because their population values are markedly different from those of other years in the period. In 1973, the yearly total territorial value was 46.4, the highest value attained during the

study. There are at least two reasons for this high value. First, there were 10 species represented in the breeding fauna, each contributing to the total population. Second, the Savannah Sparrow and Red-winged Blackbird had population values of 6.0 and 23.5, respectively, their highest numbers for the entire study. The Red-winged Blackbird population value is especially noteworthy. The PUD construction adjacent the southern portion of the Colony Farm Tract grassland may have effected this year's population high. This species usually possessed territories in the southern section of the study area that extended into the adjacent pre-PUD fields; some Red-winged Blackbirds occupied territories that were entirely contained within these bordering fields. After construction started in 1970, these fields were gradually eliminated as breeding territory for Red-winged Blackbirds. It appears that many of these birds did not leave and find breeding habitat elsewhere but, instead, may have "squeezed" more of their numbers into the Colony Farm Tract. This would have increased their densities and partially explains their high of 23.5 territories recorded in 1973. However, during this year the Henslow's Sparrow began a population decline. Its territorial value was reduced to 3.5, the lowest since 1961 when the study was initiated; in 1974 its population decreased to 1.0 territory, continuing its downward population trend.

In 1972, the yearly total territorial value was 45.9, the second highest value attained during the study. There were 10

species represented in the breeding fauna during this year, each contributing to the total population. The addition of the Song Sparrow to the breeding fauna and the substantial numbers of Short-billed Marsh Wrens and Savannah Sparrows holding territories are the main causes of the high territorial value recorded during this year.

1961-1965 to 1966-1974 population change

The mean yearly total number of breeding territories increased from 32.2 in 1961-1965 to 39.9 in 1966-1974 for an increase of 7.7 territories or a percent increase of 23.9. The mean number of birds per acre increased from 1.0 to 1.3 for a .3 or 30 percent increase in birds per acre. There was an increase in the mean number of species per year from 6.2 in 1961-1965 to 8.6 in 1966-1974, the resultant difference of 2.4 species representing a 38.7 percent increase in species diversity. All individual species had increases in sheer numbers of birds from periods 1961-1965 to 1966-1974 except the Ring-necked Pheasant, Henslow's Sparrow, and Field Sparrow (Table 8). Because the Ring-necked Pheasant and Field Sparrow constituted a combined value of less than 7 percent of the total population in 1961-1965, their decrease of about 40 percent is insignificant in terms of its effect on the total population. The Henslow's Sparrow, however, displayed a more significant population decrease. It decreased from a mean of 15.6 territories (48.5 percent of total population) to a mean of

TABLE 8
COLONY FARM TRACT GRASSLAND BREEDING BIRD POPULATION VALUES FOR SPECIFIC TIME PERIODS

SPECIES	TIME PERIODS											
	YEARS 61-65			YEARS 66-74			YEARS 70-74			YEARS 75-79		
	\bar{X}	SD	% of total population	\bar{X}	SD	% of total population	\bar{X}	SD	% of total population	\bar{X}	SD	% of total population
Mallard	.2	.5	.6	.5	.5	1.3	.3	.5	.7	.6	.6	1.9
Bobwhite	0	0	0	.1	.2	.3	.2	.3	.5	0	0	0
Ring-necked Pheasant	1.3	1.6	4.1	.7	.7	1.8	1.1	.8	2.6	.8	.5	2.5
Short-billed Marsh Wren	0	0	0	1.5	2.1	3.8	1.4	1.1	3.3	.6	1.4	1.9
Bobolink	3.0	.7	9.4	5.2	1.3	13.1	4.9	.7	11.4	6.0	.8	18.8
Eastern Meadowlark	3.7	.3	11.5	4.2	.7	10.6	4.3	.9	10.0	3.1	1.0	9.7
Red-winged Blackbird	7.5	1.5	23.4	13.6	5.3	34.2	16.7	5.1	38.9	14.2	2.3	44.5
Dickcissel	0	0	0	.2	.5	.5	0	0	0	0	0	0
Savannah Sparrow	0	0	0	3.4	1.9	8.5	4.0	1.9	9.3	3.5	1.4	11.0
Grasshopper Sparrow	0	0	0	+	.1	0	0	0	0	0	0	0
Henslow's Sparrow	15.6	2.2	48.6	9.1	5.7	22.9	7.6	6.5	17.7	0	0	0
Field Sparrow	.8	.4	2.5	.6	.6	1.5	.8	.9	1.9	0	0	0
Song Sparrow	0	0	0	.8	1.4	2.0	1.6	1.7	3.7	3.1	1.0	9.7
Totals	32.2			39.9			42.6			31.9		

+ = <.1 bird (not included in totals)

\bar{X} = Mean

SD = Standard deviation.

9.1 territories (22.8 percent of total population) for a reduction of 6.5 territories or a 41.7 percent decrease in its number of breeding territories. This decline would have had a much more noticeable effect on the total population if it were not for the addition of the Short-billed Marsh Wren, Savannah Sparrow, and Song Sparrow to the breeding fauna and the increase in Red-wing Blackbird territories during the 1966-1974 period. Before this period, the Short-billed Marsh Wren, Savannah Sparrow, and Song Sparrow held no territories and thus represented 0 percent of the total population. During the 1966-1974 period these species came to account for 14.3 percent of the total population. The Red-winged Blackbird increased in numbers from a mean of 7.5 yearly territories (23.4 percent of total population) in 1961-1965 to a mean of 13.6 territories (34.2 percent of total population) in 1966-1974 for a 81.3 percent increase in its numbers. Thus, increases in the numbers of four species, Short-billed Marsh Wren, Savannah Sparrow, Song Sparrow, and Red-winged Blackbird, not only counterbalanced the large drop in the Henslow's Sparrow population but were mainly responsible for effecting the 23.9 percent increase in the total population from 1961-1965 to 1966-1974.

As time passed, following cessation of farming practices at the Colony Farm Tract in 1959, the area appears to have improved in its attractiveness to birds because more birds, both species and total numbers, selected this area as a breeding habitat. Although animal populations are known to be related to existing vegetation

in any given area (Buechner 1953 and Buss and Dziedzic 1955), one cannot always determine which particular characteristic or characteristics directly influence the distribution or abundance of most species of animals (Tester and Marshall 1961). Even though the increased attractiveness of the study area could include characteristics such as denser grass growth, increased litter depth, and the establishment of more varied flora and fauna (Smith 1940; Roberts 1932; Lanyon 1957), it is specifically proposed here that the major factor that improved the area's attractiveness and subsequently effected the increase in sheer numbers of birds and numbers of species from the period 1961-1965 to the period 1966-1974 was the increased presence of woody vegetation, paralleling increased ecological age. This trend has been reported by Saunders (1936), Kendeigh (1948), Karr (1968), Odum (1950), and Shugart and James (1973) in comparable studies. In particular, the increased presence of the woody species in the study area changed the physical nature of the vegetation, which has been found to be very important in affecting faunal populations in any given habitat (Miller 1942 and Pitelka 1941). Kendeigh (1945) found that community selection of shrubby fields by birds is related to the use of elevated positions. Lack (1937) also noted that in many cases habitat selection tends to be based on the structural features of vegetation and is often contingent upon the presence or absence of elevated perch sites. In a study by Johnston and Odum (1956) it was discovered that bird densities

increased as the grass and forb-covered fields became invaded by shrubs and small trees. Some birds are known to "follow" these shrubby plants into otherwise grassy fields (Kendeigh 1945) because of the essential protective cover, territorial singing and displaying perches, and nesting sites they provide (Johnsgard and Rickard 1957).

The Red-winged Blackbird, Savannah Sparrow, and Song Sparrow all appeared to be influenced particularly by the increase in numbers and height of woody plant species. For the years 1961 through 1965, when woody plant numbers and heights were of lesser magnitude, these bird species displayed mean densities of 7.5, 0, and 0 for the Red-winged Blackbird, Savannah Sparrow, and Song Sparrow, respectively. For the years 1966 through 1974, when the woody plants had increased in numbers and size, the respective means for these species were 13.6, 3.4, and .8. Sutton (1959), in a southeastern Michigan study, noted Savannah Sparrows singing from weedstalks, fenceposts, and occasionally even trees. During this study it was noted constantly that both Red-winged Blackbirds and Savannah Sparrows used woody vegetation from which to sing and give territorial displays. In 1972, 13 Red-winged Blackbird nests were discovered, all but one of which were attached to a small woody plant suggesting that the presence of woody plants adds to the attractiveness of potential habitat for this species.

The increase over the years in the height and width of the multiflora rose hedge increased its thicket character and is

believed to have especially affected the Savannah Sparrow and Song Sparrow populations since almost all territories of these species included large portions of this rose hedge. Roberts (1932) described the Savannah Sparrow habitat and included thickets on upland prairie as one of its preferred habitats. The Song Sparrow has also been reported to select similar breeding habitats (Wing 1949). Good and Damback (1943) found high concentrations of birds associated with fence row vegetation similar to the rose hedge vegetation seen in this study. This suggests that this type of habitat is preferred by many species of birds.

Grassland bird population period 1975-1979

This 5-year period displayed a mean yearly total number of 31.9 territories with the actual values ranging from 28.9 to 36.0 for a range of 7.1 territories. The mean number of birds per acre per year was 1.1, these values including a low of 1.0 and a high of 1.2 for a range of .2. The mean number of species represented yearly in the breeding fauna varied from 6 to 7 for a mean of 6.6 and a range of 1.0. Of the 13 grassland breeding bird species the same 8, the Mallard, Ring-necked Pheasant, Short-billed Marsh Wren, Bobolink, Eastern Meadowlark, Red-winged Blackbird, Savannah Sparrow, and Song Sparrow, constituted the entire breeding fauna every year during the period. The 5 species contributing the greatest percentage of birds to the total population were the Bobolink, Eastern Meadowlark, Red-winged Blackbird, Savannah Sparrow, and Song Sparrow with their total

percent contribution being 93.7. The Henslow's Sparrow displayed a mean yearly territorial value of 0 for this period, as did the Field Sparrow. During this period the Short-billed Marsh Wren was only represented in the breeding fauna in 1976. In 1979, the Red-winged Blackbird and Savannah Sparrow both displayed their lowest territorial values for this period.

1966-1974 to 1975-1979 population change

The mean number of yearly total territories decreased from 39.9 in 1966-1974 to 31.9 in 1975-1979 for a decrease of 8.0 territories or 20.1 percent (Table 9). The mean number of birds per acre per year decreased from 1.3 to 1.1 for a .2 or 15.4 percent decrease. There was a decrease in the mean number of species from 8.6 in 1966-1974 to 6.6 in 1975-1979 for a decrease of 2.0 species which represents a 23.3 percent drop. Five species, the Bobwhite, Dickcissel, Grasshopper Sparrow, Henslow's Sparrow, and Field Sparrow, that were present in the 1966-1974 period breeding fauna and constituted 25.2 percent of the total breeding population, were entirely absent from the breeding fauna during the 1975-1979 period. The Henslow's Sparrow alone accounted for 22.9 percent of the total 25.2 percent decrease. Therefore, its population decrease was the major factor in the overall population decline that occurred from 1966-1974 to 1975-1979. The Bobwhite, Dickcissel, Grasshopper Sparrow, and Field Sparrow comprising 2.3 percent of the total population during the 1966-1974 period and 0 percent during the 1975-1979 period were responsible for only a

TABLE 9

PERCENT CHANGE IN GRASSLAND BREEDING BIRD POPULATION MEANS

PERIODS	LOCATION		
	Colony Farm Tract	State of Michigan*	Kalamazoo County†
66-74 to 75-79	Total Territories 20.1% decrease	Birds/route 9.6% decrease	
70-74 to 75-79	Total Territories 25.1% decrease	Birds/route 10.5% decrease	Birds/route 5.9% increase

*Source: Chandler and Willet 1966, 1968, 1969 and unpublished U. S. Fisheries and Wildlife Service data for years 1970-1979.

†Source: Raymond J. Adams, Jr., research biologist, Kalamazoo Nature Center, Kalamazoo, Michigan.

small part of the total population decline.

Other birds exhibiting substantial changes from periods 1966-1974 to 1975-1979 were the Short-billed Marsh Wren, Red-winged Blackbird, Savannah Sparrow, and Song Sparrow. During the 1966-1974 period the Short-billed Marsh Wren was observed in 5 of the 8 years or 63 percent of the time. During the 1975-1979 period it was observed in only 1 out of 5 years or 20 percent of the time. The last time this species was observed on the study area was 1976. Although the Red-winged Blackbird and Savannah Sparrow had increases in their mean numbers of yearly territorial values from 1966-1974 to 1975-1979, both displayed substantial decreases in their numbers in 1979. The Red-winged Blackbird in 1979 produced a value of 11.6 territories that was its lowest yearly value since 1968. The Savannah Sparrow in 1979 produced a yearly territorial value of 1.5 that was its lowest value since 1966, the year of its addition to the study area's breeding fauna. The Song Sparrow was especially important during the 1975-1979 period since being added to the breeding fauna in 1972. It produced its highest mean yearly territorial value of the study during this period. If it were not for its increased numbers during this time, the total grassland population would have decreased to a period low of less than 29.0 mean territories.

Overall, the major changes include a change in species constituting the majority of the breeding fauna. These include the very substantial loss of the Henslow's Sparrow from the breeding fauna

and the noteworthy increase in numbers of Song Sparrows in the transition from the 1966-1974 period to the 1975-1979 period. The 5 species contributing the greatest percentage of birds to the total population in the 1966-1974 period were the Bobolink, 13.1 percent; Eastern Meadowlark, 10.6 percent; Red-winged Blackbird, 34.2 percent; Henslows' Sparrow, 22.9 percent; and Savannah Sparrow, 8.6 percent. The 5 species contributing the greatest percentage of birds to the total population in the 1975-1979 period were the Bobolink, 18.8 percent; Eastern Meadowlark, 9.7; Red-winged Blackbird, 44.5 percent; Savannah Sparrow, 11.0 percent; and Song Sparrow, 9.7 percent.

Evidence that Colony Farm Tract's downward grassland population change is abnormal

If habitat selection and territoriality have the degree of importance ascribed to them (Brown 1969), then population size on one area may be strongly dependent on the avian density in the entire region. Therefore, studies restricted to a single area may be inadequate for evaluating the effects of any number of ecological factors (Brewer 1963). For example, during years when high populations are realized and all suitable habitat in one location is occupied, submarginal habitat may display much higher populations than is generally the case (Tompa 1962). Thus, to evaluate more fully and accurately the effects of the PUD on the study area's avian populations it is necessary to examine avian population densities in the surrounding area.

Specific data concerning bird populations in the State of Michigan (Chandler and Willet 1966, 1968, 1969 and unpublished U. S. Fisheries and Wildlife data) for years 1966-1979 are available for comparison with the Colony Farm Tract data (Tables 10 and 11). Breeding bird data for Kalamazoo County for years 1970-1979 is also available for comparison with the Colony Farm Tract data (Tables 12 and 13).^{*} (Similar data for years 1961-1965 are not available). Considering all 13 grassland breeding species as a group, it was found that for the years 1966-1974 to 1975-1979 the Colony Farm Tract displays a 20.1 percent decrease in its total grassland bird population. For this same time period, for these same species, the population in the State of Michigan at large showed a 9.6 percent decline. Thus, both sources display downward trends. However, the Colony Farm Tract's population change is 10.5 percentage points greater in magnitude. Because the data for Kalamazoo County at large are not available earlier than 1970, the validity of the results obtained in a comparison with the study area's data may be less than desirable. However, the data from Kalamazoo County are, in one respect, more useful for comparison purposes than those from the State of Michigan at large because they can more clearly indicate what bird populations are like in the immediate vicinity of the study area. Again, considering all 13 grassland breeding species as a group, it is found that for years 1970-1974 to 1975-1979 the Colony Farm Tract

^{*}Raymond Adams 1979: personal communication.

TABLE 10
MICHIGAN GRASSLAND BREEDING BIRDS

SPECIES	YEARS															SD
	66	67	68	69	70	71	72	73	74	75	76	77	78	79	\bar{X}	
Mallard	.3	.7	1.4	1.4	3.4	1.3	1.6	2.1	1.9	3.4	2.5	1.5	1.9	1.6	1.8	.9
Bobwhite	15.3	5.7	6.9	8.4	8.5	6.8	7.9	11.3	10.1	14.2	11.0	4.7	1.9	1.4	8.2	4.1
Ring-necked Pheasant	16.2	7.5	7.2	8.2	12.6	8.7	19.2	15.2	15.4	14.6	16.0	11.5	11.7	8.0	12.3	3.9
Short-billed Marsh Wren	.1	.3	.9	.2	1.0	.4	.3	.7	.5	.9	.9	.3	.2	.2	.5	.3
Bobolink	11.1	12.2	9.4	12.3	13.0	14.3	14.6	16.2	13.2	15.1	16.6	13.9	12.2	13.2	13.4	1.9
Eastern Meadowlark	13.7	17.3	15.5	16.8	13.7	13.7	14.2	14.5	17.1	17.4	16.6	9.7	8.3	7.6	14.0	3.3
Red-winged Blackbird	118.4	104.5	88.8	121.4	121.8	115.0	96.2	98.6	103.9	104.9	109.6	103.8	104.3	89.5	105.8	10.6
Dickcissel	.2	.7	+	.4	+	.1	.4	.1	.1	.1	.1	0	0	0	.2	.2
Savannah Sparrow	13.7	16.6	18.4	18.6	18.2	15.9	18.1	19.9	18.1	18.7	16.4	16.0	16.6	15.4	17.2	1.7
Grasshopper Sparrow	1.9	2.0	1.8	1.6	1.0	1.7	1.9	1.3	.9	1.3	1.1	1.0	1.0	.8	1.4	.4
Henslow's Sparrow	.6	.3	1.0	1.2	.5	.5	.9	.7	.6	.7	.5	.5	.4	.5	1.0	1.5
Field Sparrow	8.9	7.3	8.8	11.1	9.8	10.2	9.1	11.4	8.1	8.9	7.2	6.6	5.6	4.5	8.4	2.0
Song Sparrow	32.3	36.3	39.3	44.1	39.1	37.2	34.8	35.4	32.9	37.5	33.9	30.1	22.2	19.8	35.0	5.3
Total birds/route	232.7	211.4	199.4	245.7	242.6	225.8	219.2	227.4	222.8	237.7	232.4	199.6	186.3	162.5	217.5	14.8

Source: Chandler and Willet 1966, 1968, 1969 and unpublished U. S. Fisheries and Wildlife Service data for years 1970-1979.

Note: Numbers represent average number of birds per route.

+ = .1 bird/route; 0 when figuring \bar{X} and SD.

\bar{X} = Mean

SD = Standard deviations.

TABLE 11

MICHIGAN GRASSLAND BREEDING BIRD POPULATION VALUES FOR SPECIFIC TIME PERIODS

SPECIES	TIME PERIODS								
	YEARS 66-74			YEARS 70-74			YEARS 75-79		
	\bar{X}	SD	% of total population	\bar{X}	SD	% of total population	\bar{X}	SD	% of total population
Mallard	1.6	.9	.7	2.1	.8	.9	2.2	.8	1.1
Bobwhite	9.0	2.9	4.0	8.9	1.8	3.9	6.6	5.7	3.2
Ring-necked Pheasant	12.2	4.5	5.4	14.2	3.9	6.2	12.4	3.1	6.1
Short-billed Marsh Wren	.5	.3	.2	.6	.3	.3	.5	.4	.3
Bobolink	12.9	2.0	5.7	14.3	1.3	6.3	14.2	1.7	7.0
Eastern Meadowlark	15.2	1.5	6.8	14.6	1.4	6.4	11.9	4.7	5.8
Red-winged Blackbird	107.6	12.0	47.8	107.1	11.0	47.1	102.4	7.6	50.3
Dickcissel	.2	.2	.1	.1	.2	0	0	.1	0
Savannah Sparrow	17.5	1.8	7.8	18.0	1.4	7.9	16.7	1.1	8.2
Grasshopper Sparrow	1.6	.4	.7	1.4	.4	.6	1.0	.2	.5
Henslow's Sparrow	.7	.3	.3	.6	.2	.3	.5	.1	.3
Field Sparrow	9.4	1.4	4.2	9.7	1.2	4.3	6.6	1.7	3.2
Song Sparrow	36.8	3.7	16.3	35.9	2.4	15.8	28.7	7.6	14.1
Totals	225.2			227.5			203.7		

Source: Based on data from Chandler and Willet 1966, 1968, 1969 and unpublished U. S. Fisheries and Wildlife Service data for years 1970-1979.

Note: Numbers based on average number of birds per route.

\bar{X} = Mean

SD = Standard deviation

TABLE 12
KALAMAZOO COUNTY GRASSLAND BREEDING BIRD NUMBERS

SPECIES	1970	1971	1972	1973	1974	YEARS 1975	1976	1977	1978	1979	\bar{X}	SD
Mallard	5.1	2.6	6.0	7.2	4.0	23.9	10.0	6.8	5.6	6.2	7.7	6.0
Bobwhite	11.7	12.4	27.2	50.3	54.2	67.6	65.3	24.8	5.3	2.9	32.2	25.0
Ring-necked Pheasant	13.7	20.4	29.9	43.0	34.9	42.6	39.0	43.5	37.7	23.6	32.8	10.5
Short-billed Marsh Wren	.8	.7	.7	2.2	3.3	2.9	2.5	.2	.9	.8	1.5	1.1
Bobolink	5.7	8.0	9.1	11.2	11.8	11.3	9.5	13.3	7.4	11.3	9.9	2.3
Eastern Meadowlark	27.5	28.9	35.1	44.8	41.8	46.9	44.8	25.6	23.1	24.0	34.3	9.5
Red-winged Blackbird	215.7	246.6	278.5	329.8	303.4	298.2	342.8	261.6	249.1	238.3	276.4	41.4
Dickcissel	2.1	.3	2.3	2.9	.3	0	.3	0	.1	.2	.9	1.1
Savannah Sparrow	7.4	7.3	9.3	11.8	13.6	16.0	14.0	13.8	12.5	14.2	12.0	3.0
Grasshopper Sparrow	5.0	4.6	5.1	4.3	4.3	3.2	2.6	1.5	2.3	1.6	3.5	1.4
Henslow's Sparrow	2.5	2.1	1.9	3.3	1.2	1.8	1.9	1.3	.3	.5	1.7	.9
Field Sparrow	23.5	22.8	24.9	34.0	27.0	27.1	29.1	21.7	19.9	16.8	24.7	4.9
Song Sparrow	46.8	46.0	59.8	73.5	83.3	81.0	88.5	83.0	69.4	62.6	69.4	15.2
Totals	367.5	402.7	489.8	618.3	583.1	622.5	650.3	497.1	433.6	403.0	506.8	104.9

Source: Raymond J. Adams, Jr., research biologist, Kalamazoo Nature Center, Kalamazoo, Michigan.

Note: Numbers represent average number of birds per route.

\bar{X} = Mean

SD = Standard deviation.

TABLE 13

KALAMAZOO COUNTY GRASSLAND BREEDING BIRD POPULATION VALUES FOR SPECIFIC TIME PERIODS

SPECIES	TIME PERIODS					
	YEARS 70-74			YEARS 75-79		
	\bar{X}	SD	% of total population	\bar{X}	SD	% of total population
Mallard	5.0	1.8	1.0	10.5	7.7	2.0
Bobwhite	31.2	20.3	6.3	33.2	31.6	6.4
Ring-necked Pheasant	28.4	11.6	5.8	37.3	8.0	7.2
Short-billed Marsh Wren	1.5	1.2	.3	1.5	1.2	.3
Bobolink	9.2	2.5	1.9	10.6	2.2	2.0
Eastern Meadowlark	35.6	7.7	7.2	32.9	11.9	6.3
Red-winged Blackbird	274.8	45.1	55.8	278.0	42.7	53.3
Dickcissel	1.6	1.2	.3	.1	.1	0
Savannah Sparrow	9.9	2.8	2.0	14.1	1.3	2.7
Grasshopper Sparrow	4.7	.4	1.0	2.2	.7	.4
Henslow's Sparrow	2.2	.8	.5	1.2	.7	.2
Field Sparrow	26.4	4.5	5.4	22.9	5.1	4.4
Song Sparrow	61.9	16.4	12.6	76.9	61.9	14.8
Totals	492.3			521.3		

Source: Based on data from Raymond J. Adams, Jr., research biologist, Kalamazoo Nature Center, Kalamazoo, Michigan.

Note: Numbers based on average number of birds per route.

 \bar{X} = Mean

SD = Standard deviation

displays a 25.1 percent decrease in the total grassland bird population. For this same time period, for these same species, the figures for Kalamazoo County showed a 5.9 percent population increase. Thus, different trends of consequential magnitude are detected. The State of Michigan data showed a 10.5 percent population decrease for these same species from period 1970-1974 to period 1975-1979.

In a two-way comparison of the Colony Farm Tract data and the State of Michigan data for periods 1966-1974 and 1975-1979, 8 individual grassland breeding species display the same general trend as did the total grassland populations for these same periods of time. When a State of Michigan species decreased, the same Colony Farm Tract species decreased to a greater extent and when a State of Michigan species increased the same Colony Farm Tract species increased to a lesser extent or decreased (Table 14). However, this was not the situation for the Ring-necked Pheasant, Red-winged Blackbird, Savannah Sparrow, and Song Sparrow. In these cases the Colony Farm Tract species displayed increases when the same species for the State of Michigan at large exhibited decreases or increases of lesser magnitude than that displayed by the same Colony Farm Tract species. For the Ring-necked Pheasant, Bobolink, Red-winged Blackbird, and Savannah Sparrow, the population increases produced only slight effects on the total Colony Farm Tract breeding population and, therefore, do not substantially affect the overall trend. However, the increase in numbers dis-

TABLE 14

CHANGES IN GRASSLAND BREEDING BIRD POPULATION VALUES FOR COLONY FARM TRACT AND STATE OF MICHIGAN

SPECIES	LOCATION					
	COLONY FARM TRACT			STATE OF MICHIGAN *		
	Percent Change in Means From 66-74 to 75-79	% of total Population 66-74 75-79		Percent Change in Means From 66-74 to 75-79	% of total Population 66-74 75-79	
Mallard	20.0% increase	1.3	1.9	37.5% increase	.7	1.1
Bobwhite	100.0% decrease	.3	0	26.7% decrease	4.0	3.2
Ring-necked Pheasant	14.3% increase	1.8	2.5	1.6% increase	5.4	6.1
Short-billed Marsh Wren	60.0% decrease	3.8	1.9	0% change	.2	.3
Bobolink	15.4% increase	13.1	18.8	10.1% increase	5.7	7.0
Eastern Meadowlark	26.2% decrease	10.6	9.7	21.7% decrease	6.8	5.8
Red-winged Blackbird	4.4% increase	34.2	44.5	4.8% decrease	47.8	50.3
Dickcissel	100.0% decrease	.5	0	100.0% decrease	.1	0
Savannah Sparrow	2.9% increase	8.5	11.0	4.6% decrease	7.8	8.2
Grasshopper Sparrow	0% change	0 [†]	0	.4% decrease	.7	.5
Henslow's Sparrow	100.0% decrease	22.9	0	28.6% decrease	.3	.3
Field Sparrow	100.0% decrease	1.5	0	29.8% decrease	4.2	3.2
Song Sparrow	287.5% increase	2.0	9.7	22.0% decrease	16.3	14.1

*Source: Based on data from Chandler and Willet 1966, 1968, 1969 and unpublished U. S. Fisheries and Wildlife Service data for years 1970-1979.

† - was rounded to 0; actual value < .1 bird per route.

played by the Song Sparrow produced a much more consequential effect on the study area's breeding population. It alone contributed a mean increase of 2.1 territories from 1966-1974 to 1975-1979.

In a two-way comparison of the Colony Farm Tract data and State of Michigan data for periods 1970-1974 and 1975-1979, all 13 individual grassland breeding species except 3, the Mallard, Bobolink, and Song Sparrow display the same general trend as did the total grassland populations for these same periods of time (Table 15). When a State of Michigan species decreased, the same Colony Farm Tract species decreased to a greater extent. The trend was different for the Mallard, Bobolink, and Song Sparrow. The Mallard population increased statewide but the increase was greater at the Colony Farm Tract. The number of Mallards in the two areas under consideration was so small that even large percent increases affected their respective numerical populations only slightly. The Bobolink and Song Sparrow both decreased in the State at large but increased at the Colony Farm Tract 22.5 and 93.8 percent, respectively. These increases had a consequential effect on the overall Colony Farm Tract avian grassland population. Without increases in numbers by these 2 species the overall grassland population would have dropped to at least as low as 29.3 territories, 2.6 territories below its actual 1975-1979 period mean.

In a two-way comparison of the study area data and Kalamazoo

TABLE 15

CHANGES IN GRASSLAND BREEDING BIRD POPULATION VALUES FOR COLONY FARM TRACT, STATE OF MICHIGAN, AND KALAMAZOO COUNTY

SPECIES	LOCATION								
	COLONY FARM TRACT			STATE OF MICHIGAN*			KALAMAZOO COUNTY†		
	Percent Change in Means From 70-74 to 75-79	Z of total Population 70-74 75-79		Percent Change in Means From 70-74 to 75-79	Z of total Population 70-74 75-79		Percent Change in Means From 70-74 to 75-79	Z of total Population 70-74 75-79	
Mallard	100.0% increase	.7	1.9	4.8% increase	.9	1.1	110.0% increase	1.0	2.0
Bobwhite	100.0% decrease	.5	0	25.8% decrease	3.9	3.2	6.4% increase	6.3	6.4
Ring-necked Pheasant	27.3% decrease	2.6	2.5	12.7% decrease	6.2	6.1	31.3% increase	5.8	7.2
Short-billed Marsh Wren	57.1% decrease	3.3	1.9	16.7% decrease	.3	.3	0% change	.3	.3
Bobolink	22.5% increase	11.4	18.8	.7% decrease	6.3	7.0	15.2% increase	1.9	2.0
Eastern Meadowlark	27.9% decrease	10.0	9.7	18.5% decrease	6.4	5.8	7.6% decrease	7.2	6.3
Red-winged Blackbird	15.0% decrease	38.9	44.5	4.4% decrease	47.1	50.3	1.2% increase	55.8	53.3
Dickcissel	0% change	0	0	100.0% decrease	0	0	93.8% decrease	.3	0
Savannah Sparrow	12.5% decrease	9.3	11.0	7.2% decrease	7.9	8.2	42.4% increase	2.0	2.7
Grasshopper Sparrow	0% change	0	0	28.6% decrease	.6	.5	53.2% decrease	1.0	.4
Henslow's Sparrow	100.0% decrease	17.7	0	16.7% decrease	.3	.3	45.5% decrease	.5	.2
Field Sparrow	100.0% decrease	1.9	0	32.0% decrease	4.3	3.2	13.3% decrease	5.4	4.4
Song Sparrow	93.8% increase	3.7	9.7	20.1% decrease	15.8	14.1	24.2% increase	12.6	14.8

*Source: Chandler and Willet 1966, 1968, 1969 and unpublished U. S. Fisheries and Wildlife Service data for years 1970-1979.

†Source: Raymond J. Adams, Jr., research biologist, Kalamazoo Nature Center, Kalamazoo, Michigan.

County data for periods 1970-1974 and 1975-1979, all 13 individual grassland breeding species, except the Bobolink and Song Sparrow, show the same general trend as did the total grassland population for these same periods. When a Kalamazoo County species decreased, the same Colony Farm Tract species decreased to a greater extent and when a Kalamazoo County species increased the same study area species increased to a lesser extent or decreased. The Bobolink and Song Sparrow displayed a different trend. Both these species increased in numbers in Kalamazoo County and at the Colony Farm Tract. However, they had larger increases at the Colony Farm Tract.

It is worth noting that the Henslow's Sparrow, the species showing the greatest population drop from 1966-1974 to 1975-1979, displayed a markedly larger population decrease at the Colony Farm Tract than did this species in both the State and County at large. Although this species never accounted for more than .3 and .5 percent of the total population for periods 1966-1974 to 1975-1979 in the State of Michigan and County of Kalamazoo, respectively, it represented nearly 50 percent of the total population at the Colony Farm Tract at one point in the study. As late as 1972 it accounted for nearly 23 percent of the total Colony Farm Tract breeding population. These data suggest that, possibly as late as 1972, the Colony Farm Tract was an exceptionally good Henslow's Sparrow breeding habitat compared with the general habitats in both the State of Michigan and County of

Kalamazoo. It has been reported that all discovered suitable Henslow's Sparrow habitats in Kalamazoo County were, as of 1979, still occupied by this species for breeding purposes.* Although no quantitative data are yet available, it was noted that the number of Henslow's Sparrows breeding in Kalamazoo County in Spring 1980 was up from the number recorded in 1979.† There were no sightings of Henslow's Sparrows at the Colony Farm Tract in the Spring 1980.

The conclusion from these comparisons is that the Colony Farm Tract's grassland avian populations have, in general, displayed abnormal population decreases between the years 1966-1974 (and 1970-1974) to 1975-1979 as compared with the same populations in the surrounding areas.

Factors causing Colony Farm Tract's abnormal 1966-1974 to 1975-1979 downward grassland population change

The mean yearly total number of territories for periods directly preceding and directly following the initiation of PUD construction do not seem to display enough difference to suggest that the development immediately affected the entire breeding bird population to any appreciable extent. No decline in total bird numbers or species diversity was noted immediately following initiation of construction. Also none of the 13 individual grass-

*Raymond Adams 1979: personal communication.

†Raymond Adams 1980: personal communication.

land breeding species, except for possibly 2 species, the Henslow's Sparrow and Field Sparrow, exhibited population declines directly following the initiation of construction in 1970. The data, however, do display changes in trends between years 1961-1965, 1966-1974, and 1975-1979. The change that occurred between 1961-1965 and 1966-1974 has been attributed to grassland woody plant invasion and has been considered in a previous section. The change that occurred between 1966-1974 and 1975-1979 is suggested to have been the result of disturbance emanating from the PUD, that is believed to have increased dramatically in intensity since 1974.

Although recorded disturbances, or evidences of disturbance, were first recorded in 1965, it was not until 1973 that the disturbances became relatively numerous and varied in nature (Table 16 and Figures 17 through 28). By 1978 extensive disturbances were noted, and these continued and intensified in 1979. Of all disturbances recorded, it is suspected that those involving the presence of humans, and dogs and cats on the study area posed the greatest potential danger to the avian populations. It has been found that certain birds readily attract dogs because of strong game effluvium. This is particularly true of the Henslow's Sparrow (Graber 1968). Therefore, the frequent movement of dogs through the area might have kept the birds in a constant state of turmoil through continued harrassment and destruction of nests and young. The detection of 3 disturbed rabbit nests and a disturbed Mallard's nest provided evidence that at least some ground-nesting

TABLE 16

DISTURBANCE OR EVIDENCE OF DISTURBANCE FOR YEARS 1961-1979

YEAR*	HOURS OF "OBSERVATION"	DISTURBANCE OR EVIDENCE OF DISTURBANCE
1965	68	Excavation of fox den with shovels
1968	30	Grassland fire
1969	29	PUD truck traffic - noted over a period of weeks
1970	30	Truck traffic (believed to be PUD vehicle) Snowmobile tracks
1972	107	Bird feeders placed on tract Path formed (believed formed by human traffic) Deposition of many fresh dog feces Tractor traffic (believed to be WMU Agriculture Farm Vehicle)
1973	30	Cat tied to stake on study area Deposition of many fresh dog feces Much construction noise Many dog tracts Path maintained and extended Construction materials discarded
1974	15	Area spaded and garden planted Path maintained and extended
1975	10	Garden plot spaded Path maintained and extended
1976	13	Area spaded and corn planted Path maintained and extended Dead vegetation raked into pile Oramental vegetation planted
1977	34	Dog feces Area mowed Path maintained and extended PUD residents jogging

TABLE 16 - Continued

YEAR*	HOURS OF "OBSERVATION"	DISTURBANCE OR EVIDENCE OF DISTURBANCE
1978	31	<p>Much road noise in north-half of study area due to heavy traffic on Parkview Avenue</p> <p>Dog in area</p> <p>Two dogs in area</p> <p>Dog very near area to west of tract</p> <p>Two areas excavated with shovels</p> <p>Two areas with deposited lawn refuse</p> <p>Many fresh dog feces</p> <p>Dog feces area mowed</p> <p>Paths formed, maintained and extended</p>
1979	58	<p>Much noise in north-half of tract from heavy traffic on Parkview Avenue</p> <p>Bird nesting box placed on area</p> <p>Apiaries placed on area</p> <p>Area excavated to bury dead and diseased bees from apiaries</p> <p>Vegetation cut (Blackberries)</p> <p>4 target practice materials: 3 cans and 1 paper target</p> <p>Truck tracts</p> <p>2 areas of tractor tracts (WMU Agriculture farm tractor)</p> <p>Kite wreckage</p> <p>Household garbage</p> <p>1 Pop can in garbage bag</p> <p>3 Pop cans</p> <p>2 Beer cans</p> <p>2 Beer bottles</p> <p>Yard refuse (4 locations)</p> <p>Person traveling on tract (2 occasions)</p> <p>Disturbed Mallard's Nest</p> <p>Person walking dog (7 occasions)</p> <p>Discarded Christmas tree</p> <p>3 children walking in area</p> <p>3 disturbed rabbit nests</p> <p>Boy throwing Boomerang</p> <p>4 coordinate stakes removed</p> <p>Paths formed, maintained and extended</p> <p>Dog in area (3 occasions)</p> <p>2 Boomerangs found</p>

TABLE 16 - Continued

YEAR*	HOURS OF "OBSERVATION"	DISTURBANCE OR EVIDENCE OF DISTURBANCE
1979		<p>3 WMU Agriculture students measuring acreage of tract; accompanied by 2 dogs 2 trail bikes travel on tract 1 trail bike travels on tract Woman working in garden Area spaded and garden planted Matted down grass where something had recently lain (believed to be a dog or human) Dog feces area mowed (mowed several times during spring and summer) 2 bicycles abandoned (were present for a period of about 2 weeks, then removed) Tennis ball in area Boy with golf club looking about in grass Rocks and large pieces of sod (from WMU Agriculture Farm, 2 locations) Construction materials 2 women picnicing and walking 2 dogs</p>

*Numerous coordinate stakes were removed each year over the years.

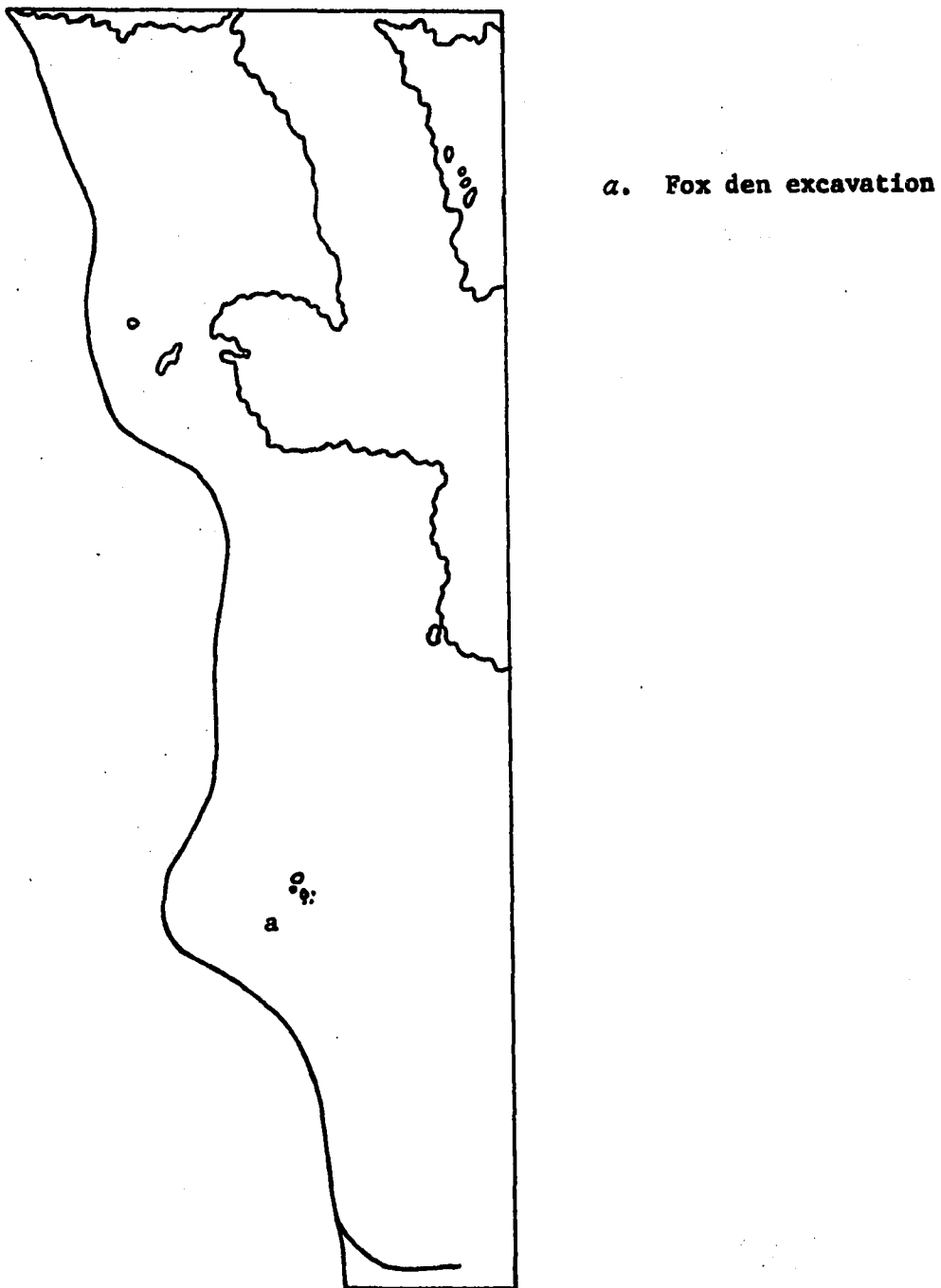


Figure 17. Map of Colony Farm Tract indicating approximate locations of recorded disturbances or evidences of disturbance for year 1965.

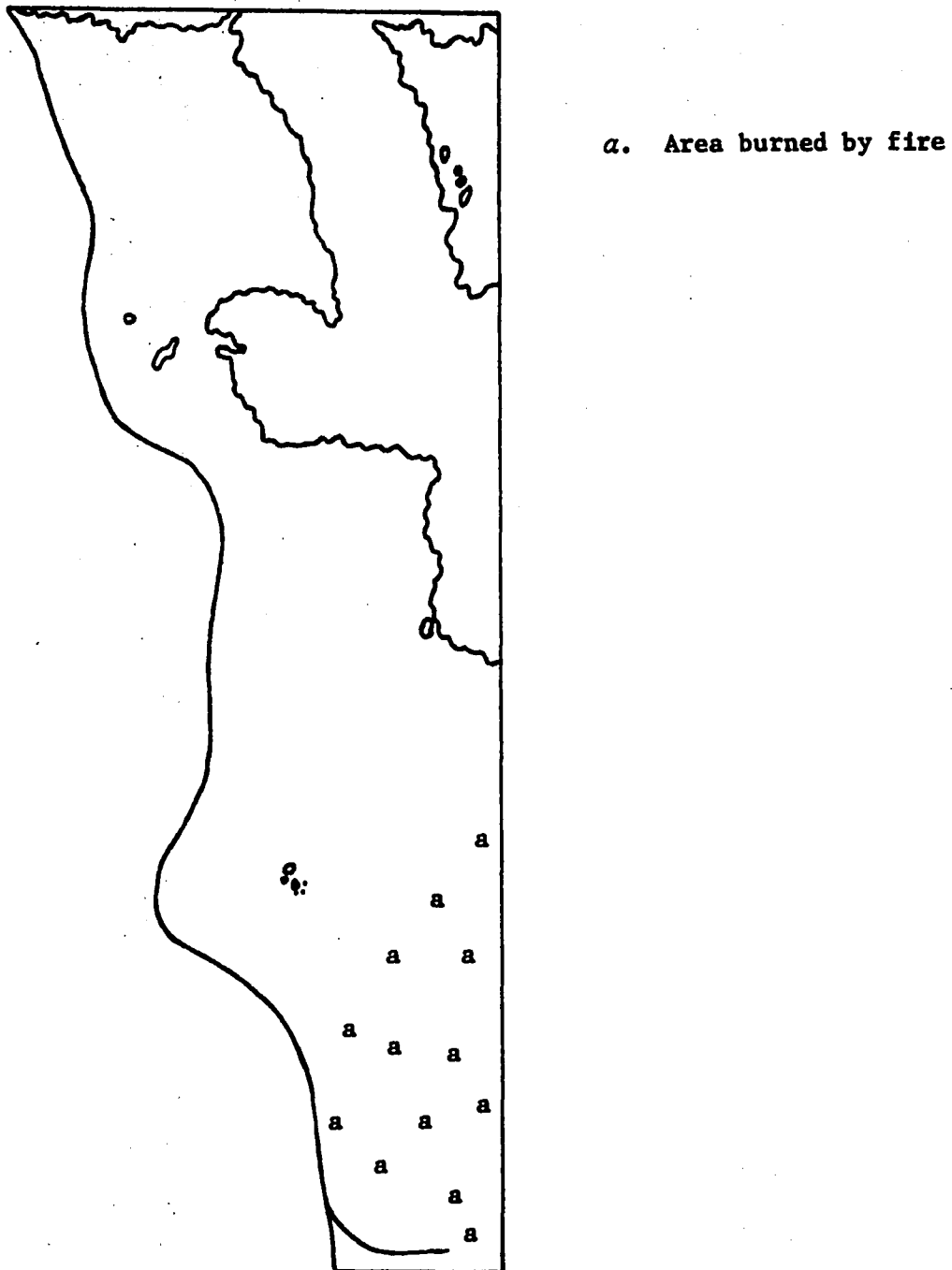


Figure 18. Map of Colony Farm Tract indicating approximate locations of recorded disturbances or evidences of disturbance for year 1968.

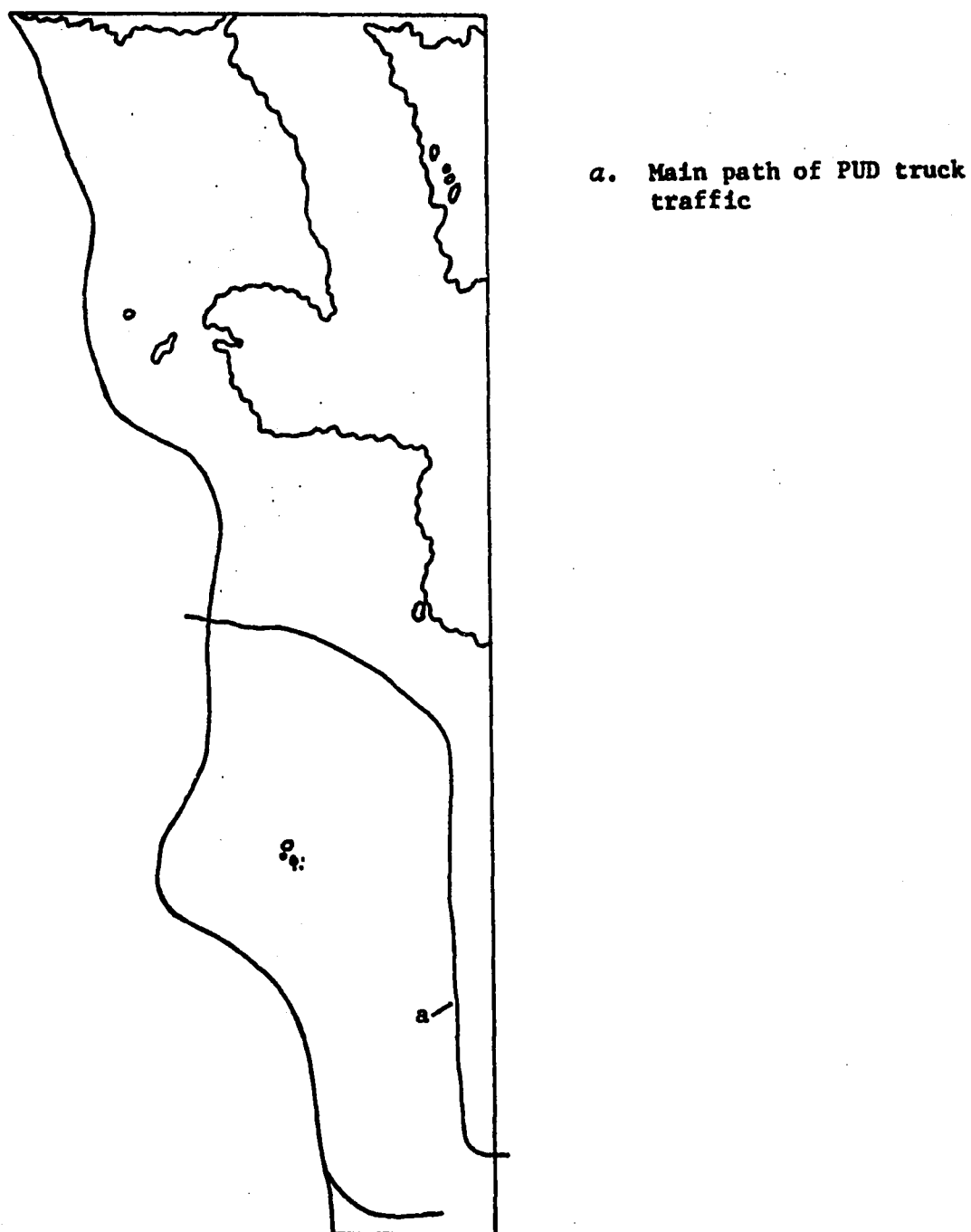


Figure 19. Map of Colony Farm Tract indicating approximate locations of recorded disturbances or evidences of disturbance for year 1969.

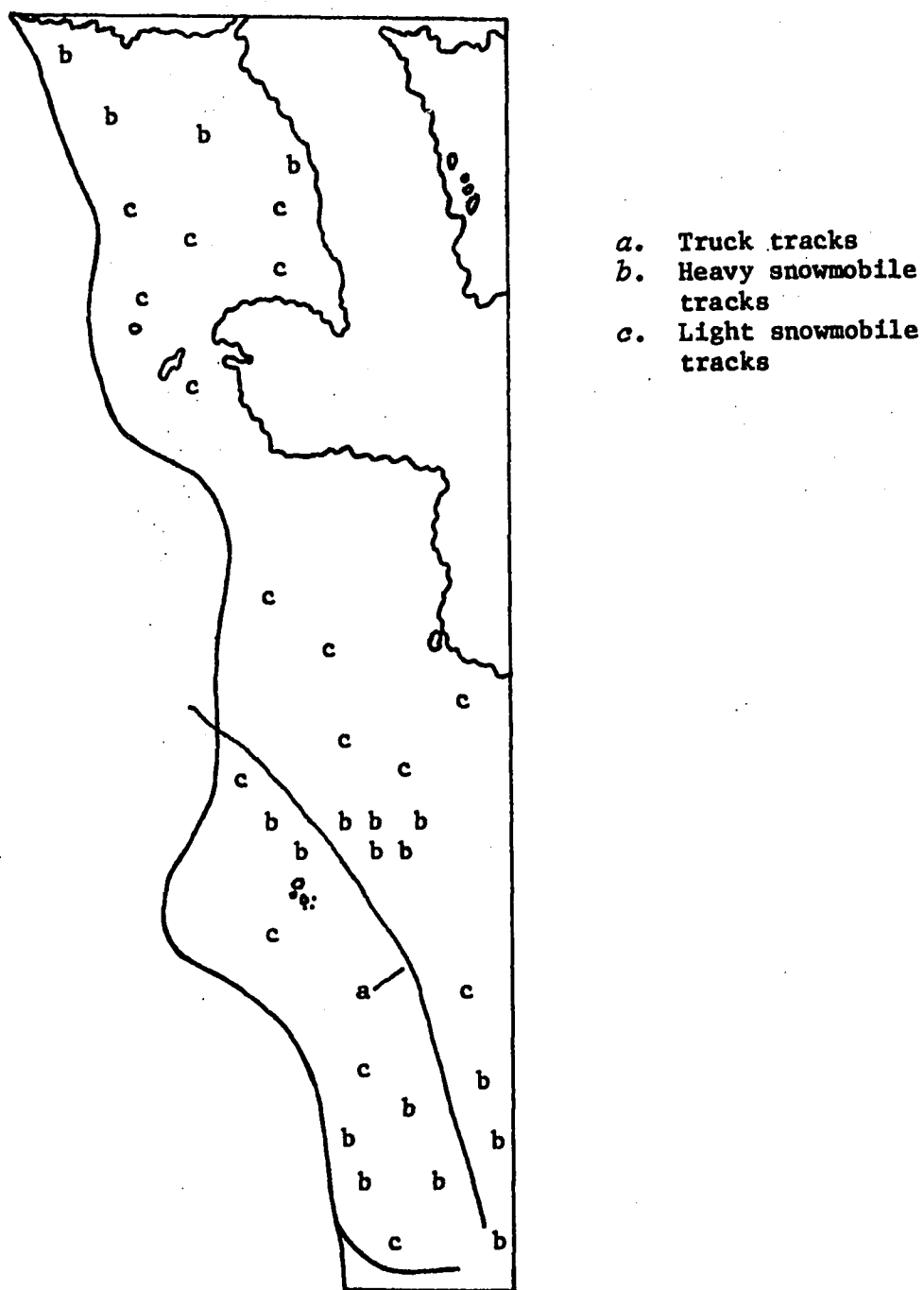


Figure 20. Map of Colony Farm Tract indicating approximate locations of recorded disturbances or evidences of disturbance for year 1970.

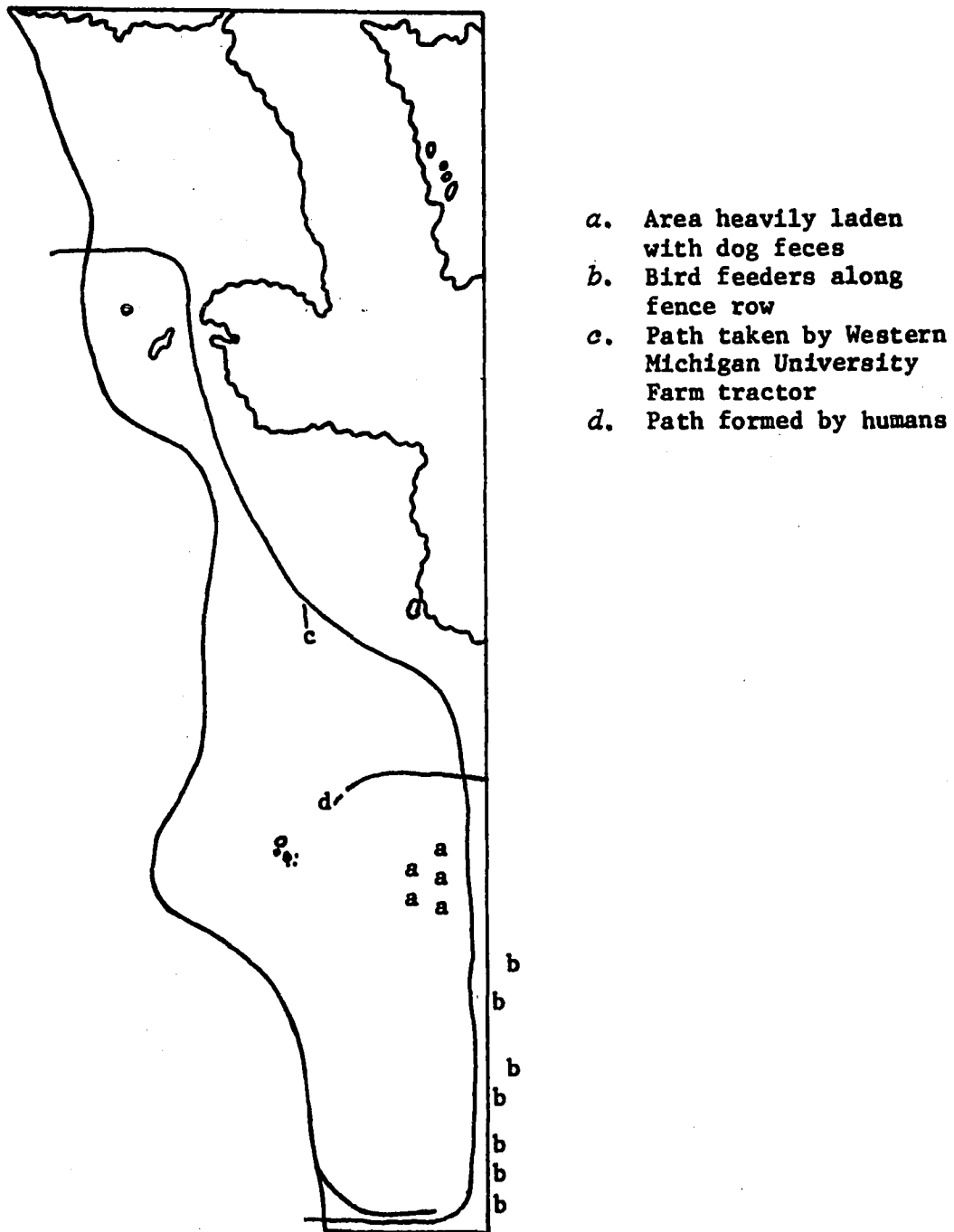


Figure 21. Map of Colony Farm Tract indicating approximate locations of recorded disturbances or evidences of disturbance for year 1972.

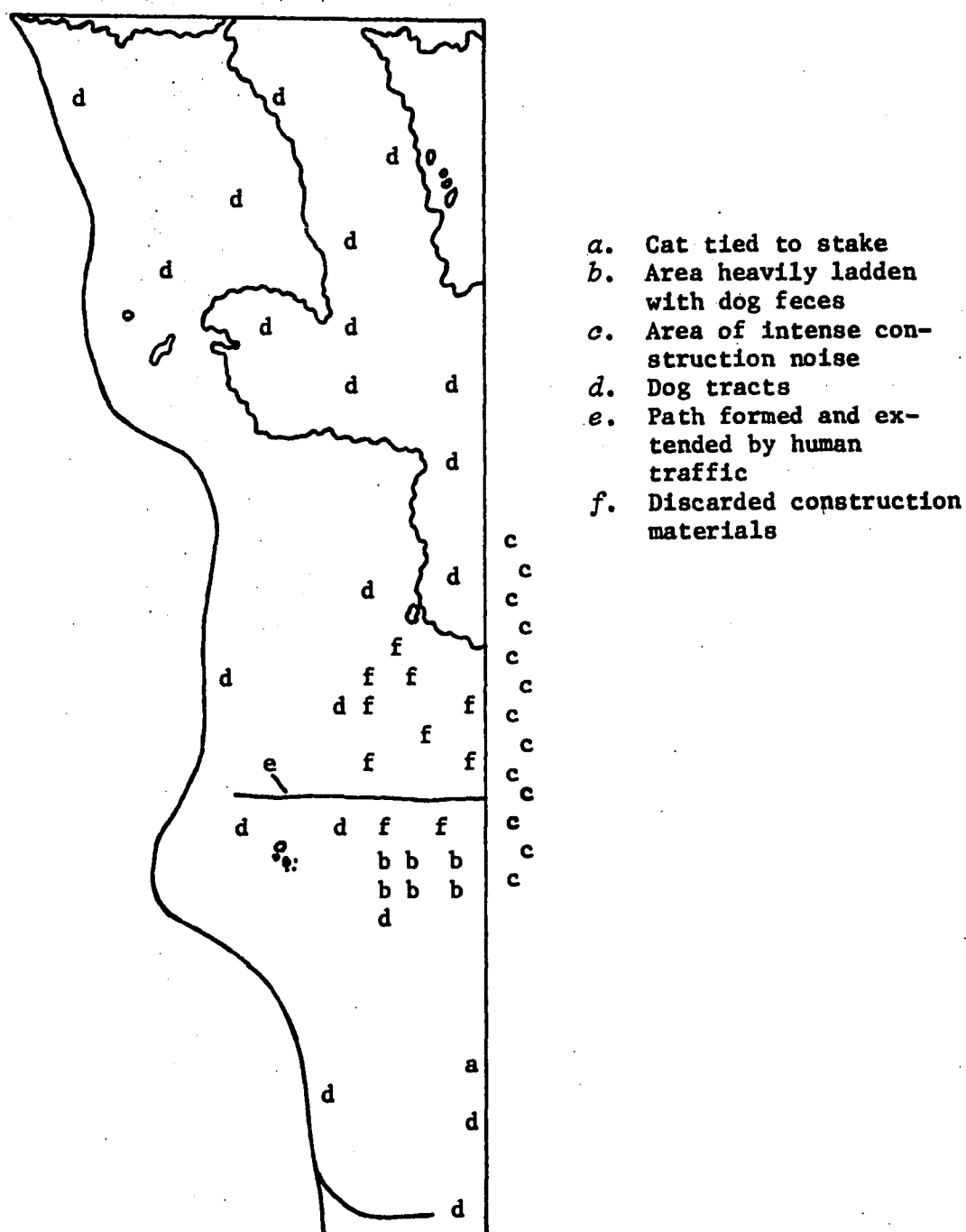


Figure 22. Map of Colony Farm Tract indicating approximate locations of recorded disturbances or evidences of disturbance for year 1973.

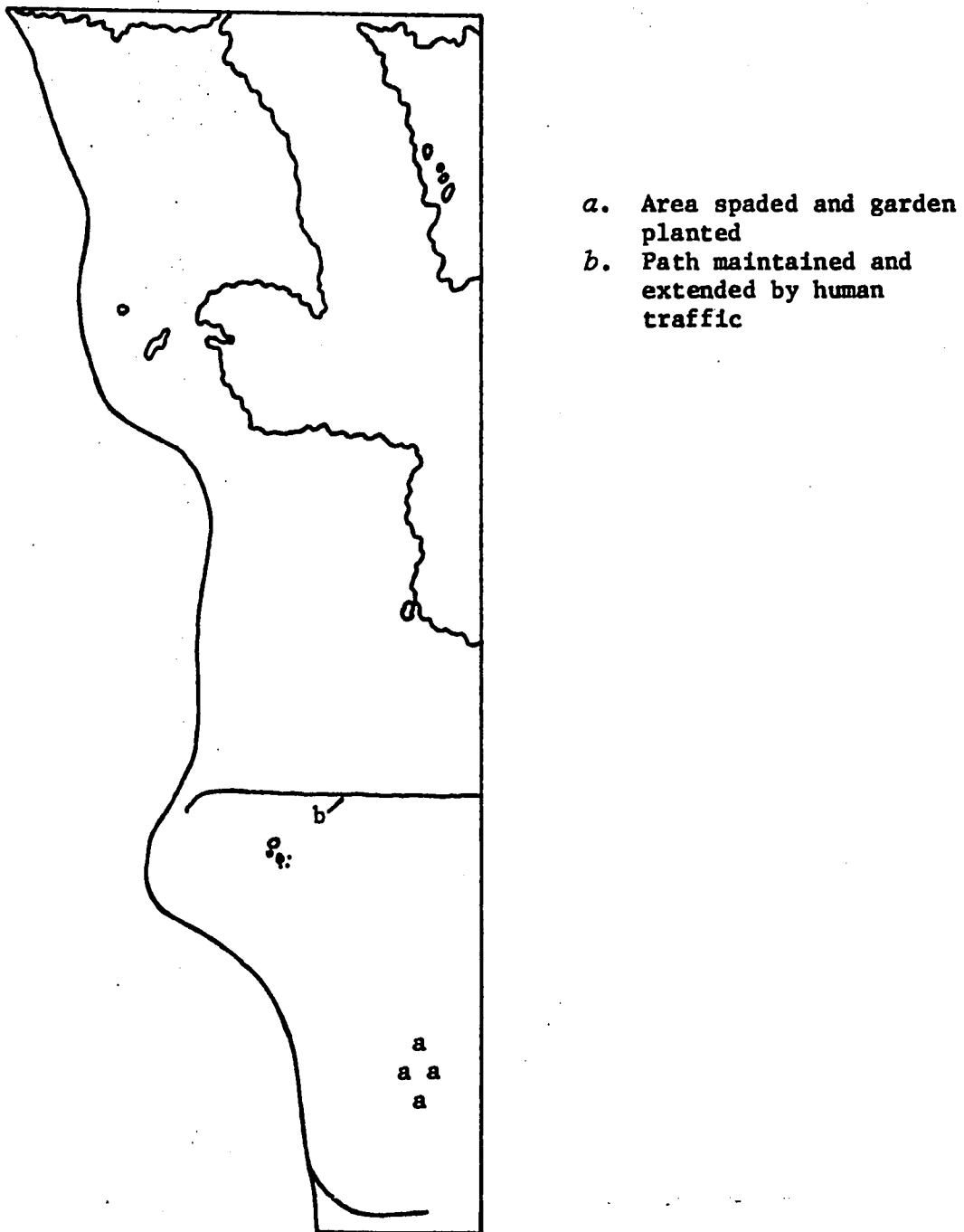


Figure 23. Map of Colony Farm Tract indicating approximate locations of recorded disturbances or evidences of disturbance for year 1974.

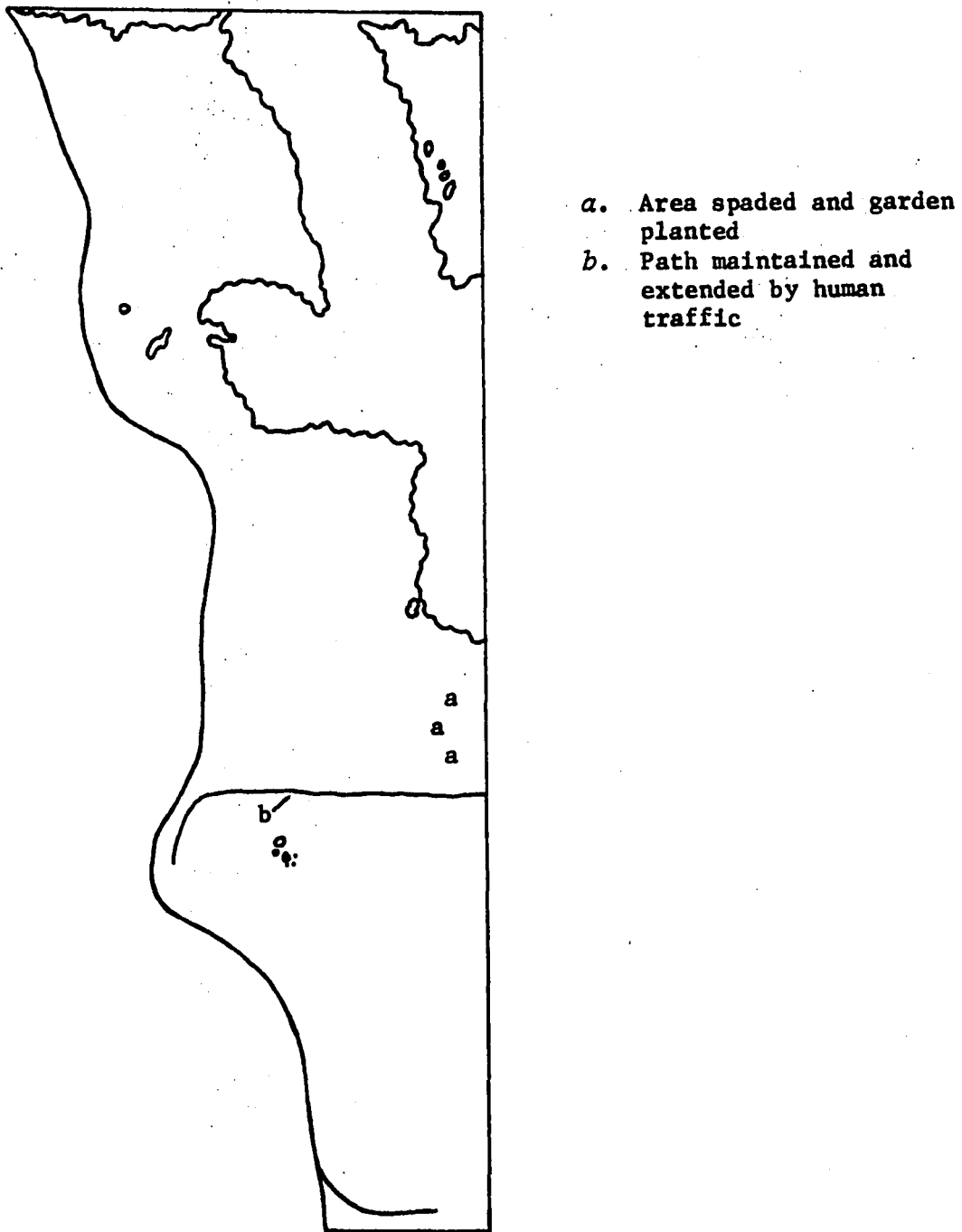


Figure 24. Map of Colony Farm Tract indicating approximate locations of recorded disturbance or evidences of disturbance for year 1975.

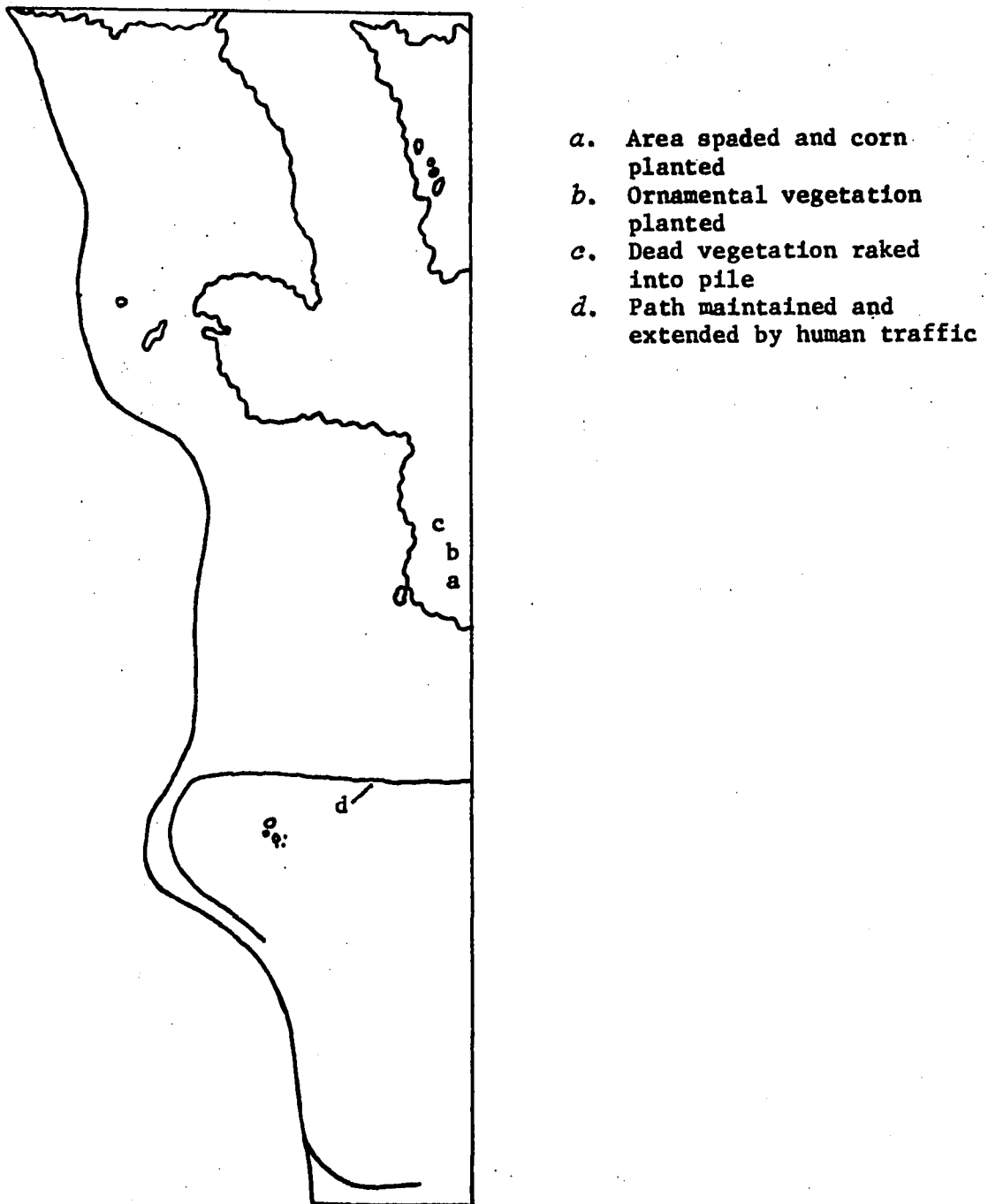
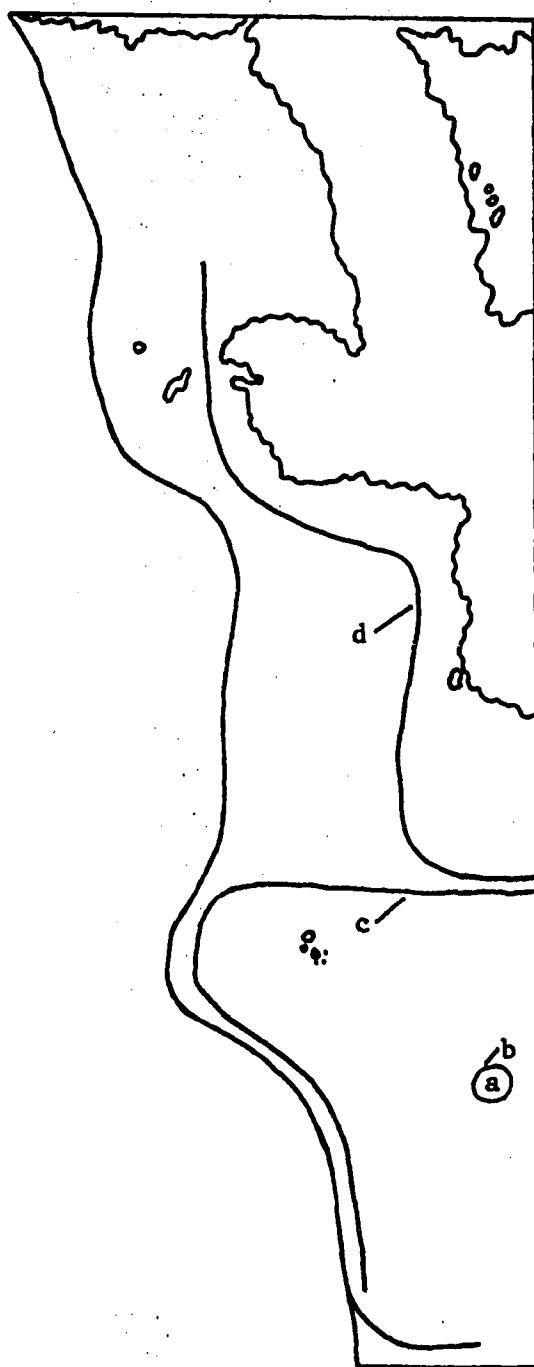


Figure 25. Map of Colony Farm Tract indicating approximate locations of recorded disturbances or evidences of disturbance for year 1976.



- a. Dog defecation area mowed
- b. Many dog feces
- c. Path maintained and extended by human traffic
- d. Path taken by two jogging PUD residences

Figure 26. Map of Colony Farm Tract indicating approximate locations of recorded disturbances or evidences of disturbance for year 1977.

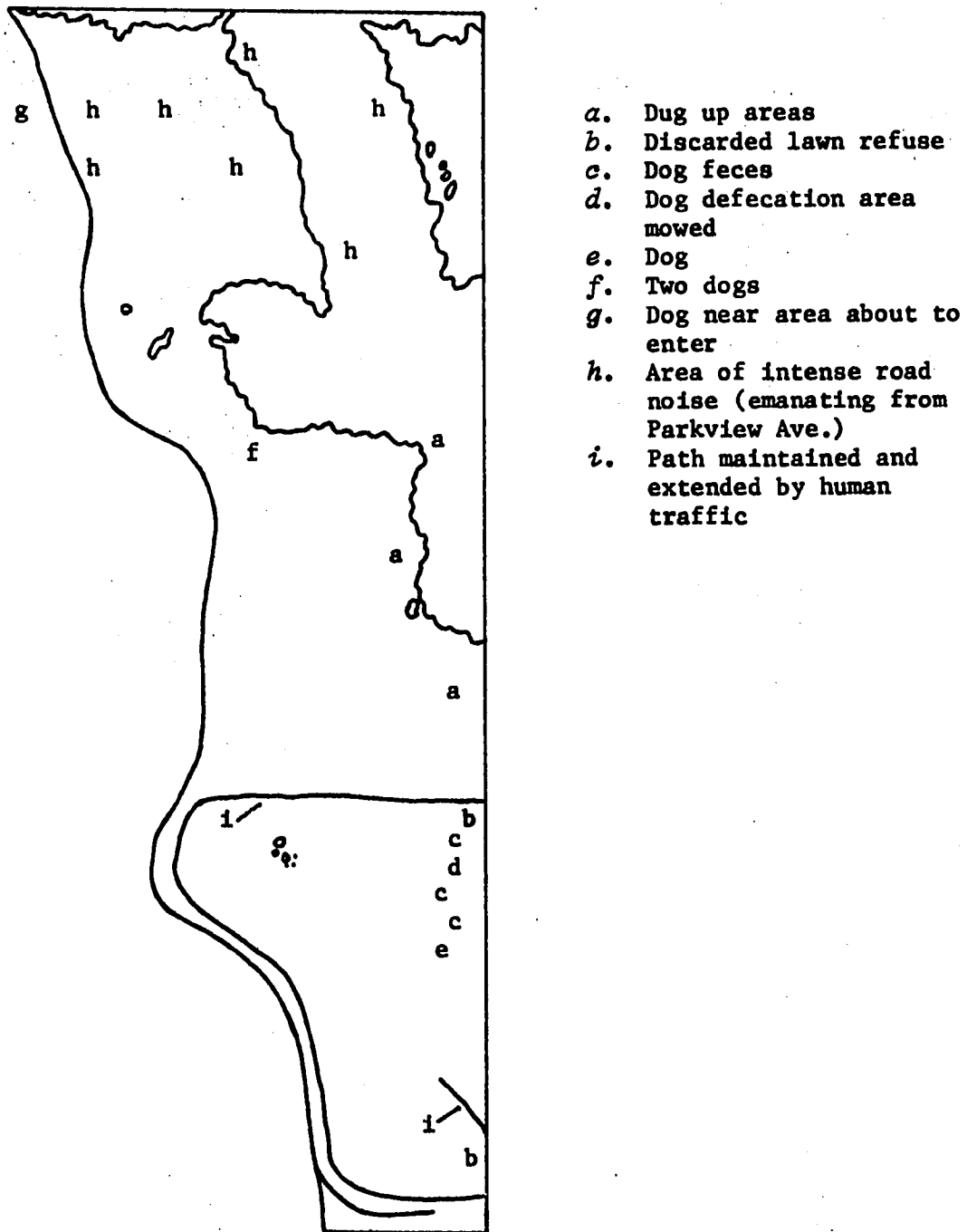


Figure 27. Map of Colony Farm Tract indicating approximate locations of recorded disturbances or evidences of disturbance for year 1978.

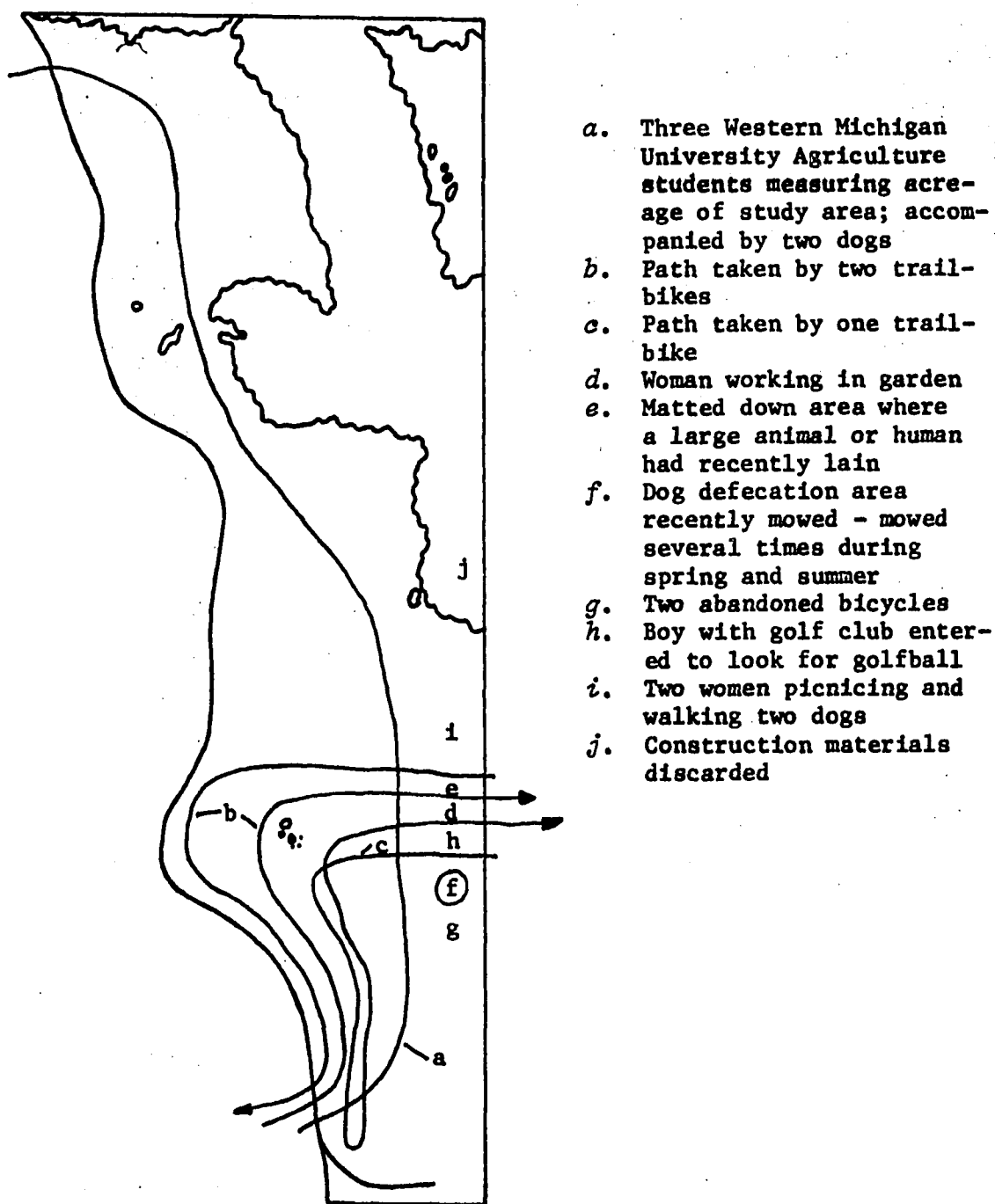
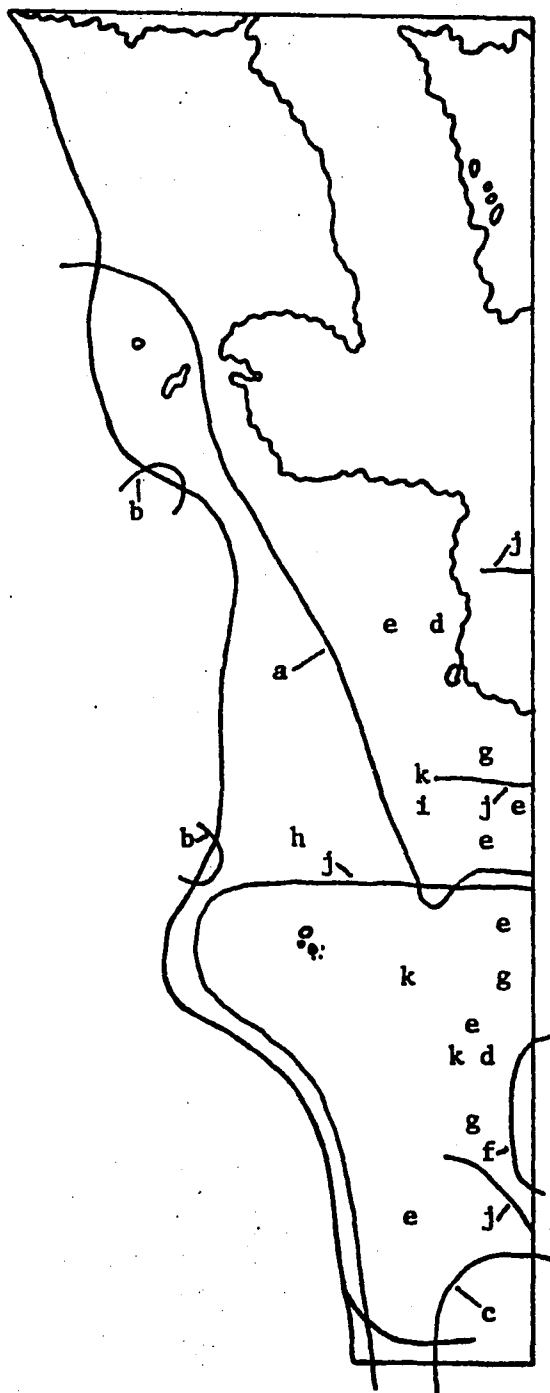


Figure 28 - Continued



- a. Truck tracks
- b. Tractor tracks - University Farm tractor
- c. Path taken by paper boy
- d. Man in area walking
- e. Person walking dog
- f. Path taken by three children walking through area
- g. Disturbed rabbit nest
- h. Disturbed Mallard nest
- i. Boy throwing boomerang
- j. Paths formed and maintained by human traffic
- k. Dog in area

Figure 28 - Continued

animals at the Colony Farm Tract have fallen victim to predation. The constant presence of humans on the study area may have had the same general effect as that for dogs. Although the persons traveling through the area may have had no intention to harass the birds, they may have done so merely by their frequent presence. It has been found in other studies that the mere presence of humans has had a detrimental effect on the breeding success of at least one species of bird (Swenson 1979; Dunston 1968; Reese 1977). Human disturbance also seems to be responsible for fewer than the expected number of species inhabiting a given habitat (Lussenhop 1977). Also, as the number of humans traveling through the area becomes greater, the probability of nests and young being stepped on increases. The mere scent of humans and dogs left on the vegetation following passage through the area is possibly enough to ward off some species and cause them to select habitats elsewhere.

The actual occurrence of human and dog travel on the area is probably much greater than the number of direct observations would seem to indicate. The paths that were first formed in 1972 were undoubtedly formed from human traffic. The many dog feces in the vicinity of the paths suggest that people frequently walk their dogs on these paths. The fact that the original paths were extended over the years 1972 through 1979 and new ones were also being formed during this period strongly suggest that human and dog traffic has increased since 1972. Several observations of this

specific disturbance substantiate this assumption.

Although vandalism has not been extreme at the study area, it has occurred. Many coordinate stakes (wooden 1 x 1" stock until 1978) have been removed or knocked down over the years, much more frequently since 1972. From August 1978 to April 1979, 4 of the permanent metal fence post now used as coordinate stakes were removed. Target practice materials discovered in the study area indicate that humans with firearms have traveled through the area. This evidence, in conjunction with evidence of vandalism, certainly suggests the possibility that humans might have shot birds, thus reducing their numbers.

Other more subtle disturbances may have also significantly affected the Colony Farm Tract's breeding populations. It was noted that several garden plots of several square feet were spaded and planted with domestic vegetation. In one instance all the dead woody vegetation of an area encompassing several square meters was raked into a large pile. Numerous foreign materials such as construction paraphernalia, apiaries, and lawn refuse were discovered in the area. In addition, an area in the grassland of about 7 meters in diameter was frequently mowed close to the ground for dog elimination purposes. All these aforementioned disturbances substantially altered the physical features of the habitat's vegetation that have been determined to be important in habitat selection by birds (Kendeigh 1945).

It also seems possible that other subtle effects associated

with habitation could be important in effecting decreases in bird populations. For example, the Henslow's Sparrow has been reported to sing intensely in early evening and through the night (Hyde 1939). The light and noise coming from the development at dusk and continuing into the night might disturb the singing activity of this species enough to cause its population to decline. Since it has been speculated that habitat selection by birds is largely a visual process (Hilden 1965), a subtle effect might be as simple as birds being repelled by the development's lawns, roads, and buildings. It should be noted that all known suitable and available Henslow's Sparrow breeding habitats in the County of Kalamazoo were occupied by Henslow's Sparrows in 1979; however, there was not one recorded instance of this species establishing breeding territories near residential areas.*

Another subtle effect that undoubtedly was deleterious on the bird populations of the study area was the loss of adjacent undisturbed habitat that resulted when the development was constructed. Some of the birds that established territories on the Colony Farm Tract before PUD construction either included some of the neighboring pre-PUD fields in their territories or at least visited the adjacent area to gather food or carry on some other activity. When this land was converted to residential development, the adjacent natural communities disappeared. Consequently, the resulting

*Raymond Adams 1979: personal communication.

landscape was less attractive and less useful for the birds at the study area and population decreases could have resulted. In addition, the destruction of the adjacent natural habitat transformed the Colony Farm Tract into a habitat island and resulted in a reduction in the total size of potential breeding habitat. It has been well documented that the number of species present in a particular habitat is strongly influenced by the size of that habitat (Galli, Leck, and Forman 1976; Preston 1960; Diamond and May 1976; Morse 1977; May 1975; MacArthur and Wilson 1967). It is also believed that elimination of adjacent habitat decreases the colonization rate to a habitat island by effecting a reduction in the number of available colonists. This makes the remaining habitat less likely to be chosen by potential breeding species (Whitcomb 1977). Furthermore, the study area's bird population might have been reduced due to the establishment of a new equilibrium between local extinction and immigration. It has been found that following transformation of continuous habitat into island habitat, the number of species in that habitat falls to a lower equilibrium point with time (Diamond and May 1976).

Related is the loss of dispersal corridors. The loss of adjacent undisturbed habitat due to the PUD construction could have cut off corridors of habitats that birds would have used to move onto the tract. On any single small site, such as the Colony Farm Tract, species occasionally have a bad year. As compensation, populations are replenished by dispersal from adjacent areas

(MacClintock, Whitcomb, and Whitcomb 1977). A housing development, and the PUD is no exception, is acceptable habitat for few native species and, therefore, possesses low numbers of these birds. Consequently, the replenishment of these species becomes less probable and the likelihood increases that species will be lost and not replaced (MacClintock, Whitcomb, and Whitcomb 1977).

The bird feeders along the Colony Farm Tract - PUD borders might have also contributed to the study area's population decrease. The feeding of birds in the winter by the PUD residents has caused an increase in winter bird numbers along the Colony Farm Tract - PUD border. These high numbers of birds might have increased the intensity of competition among birds in the area. The high numbers of birds maintained artificially during the winter might consume large amounts of the native food in the area thus lowering the resource base of the potential Colony Farm Tract breeders. This would cause the area to lose some of its attractiveness as potential breeding habitat. The result might be that birds would leave the area and select suitable habitat elsewhere. The feeding of summer residents, that has occasionally been observed, might also have the same effect on the Colony Farm Tract breeding fauna. Bird feeding also supports larger than normal populations of Blue Jays and Common Grackles. It is well documented that these species are serious predators on the eggs and young of birds (Fretwell 1973; McDaniel 1976; Carleton and Owre 1975; and Trine 1935).

Thus, the PUD associated disturbances observed during this

study and those hypothetical disturbances and their speculated effects presented here are believed to be the cause for the downward grassland population trend that began in 1974. Certainly, the relationship between the number and kind of disturbances and the 1975-1979 grassland population decline is undeniable.

Thicket bird population period 1961-1964

The mean yearly total number of territories for 1961-1964 was 11.8. The actual values varied from 8.5 to 19.1 for a range of 10.6 (Table 17). The mean number of birds per acre per year was 2.1, these values including a low of 1.4 and a high of 3.4 for a range of 2.0. The number of species represented in the breeding fauna varied from 12 to 19 for a mean of 15.0 and range of 7.

Thicket bird population period 1965-1974

The mean yearly total number of breeding territories during this 10 year period was 16.5. The values included a low of 11.4 and a high of 25.5 for a range of 14.1. The number of birds per acre included values from 1.4 to 3.3 for a range of 1.9 and a mean 2.3. The mean number of species per year was 21.7. The actual number of species varied from 17 to 27 for a range of 10.

1961-1964 to 1965-1974 population change

The mean yearly total number of territories increased from 11.8 in 1961-1964 to 16.5 in 1965-1974 for an increase of 4.7

TABLE 17

COLONY FARM TRACT THICKET BREEDING BIRD POPULATION VALUES FOR SPECIFIC TIME PERIODS

PARAMETERS	TIME PERIODS							
	YEARS 61-64		YEARS 65-74		YEARS 70-74		YEARS 75-79	
	\bar{X}	SD	\bar{X}	SD	\bar{X}	SD	\bar{X}	SD
Total mean territories	11.8	5.0	16.5	4.1	16.9	6.6	6.8	1.4
Mean number of birds per acre	15.0	2.9	21.7	3.5	21.3	4.2	13.8	4.2
Mean number of species	2.1	.9	2.3	.6	2.2	.9	.8	.2

 \bar{X} = Mean

SD = Standard deviation

territories or a percent increase of 39.8. The mean number of birds per acre increased from 2.1 to 2.3 for a 9.5 percent increase. There was an increase in the mean number of species per year from 15.0 in 1961-1964 to 21.7 in 1965-1974. The resultant difference of 6.7 species represents a 44.7 percent increase in species diversity. Of all the 37 thicket breeding species, 22 displayed increases in their numbers from 1961-1964 to 1965-1974 thus indicating that 59.5 percent of the total number of species increased in number. There were 7 species displaying decreases and 8 species maintained approximately the same values from 1961-1964 to 1965-1974. No one species produced a change in the number of territories that was large enough to alone cause a marked population increase. The Song Sparrow was the species with the single greatest increase in the number of territories, 1.3 to 3.2 for periods 1961-1964 and 1965-1974, respectively. The common yellowthroat displayed the single greatest reduction in the number of territories from 1961-1964 to 1965-1974 with a 1.5 mean territorial value reduction.

Vegetational changes occurring in the thicket over the years 1961-1964 to 1965-1974 are believed to be the cause for the increase in the number of birds during these years. The most influential aspect of vegetational change that appeared to effect the change was thicket size. The average number of acres during period 1961-1964 was 5.9 or 69.8 percent of its current acreage. During 1965-1974 there was an average of 7.4 acres or 81.3

percent of its 1979 acreage. This change of 1.5 acres represents a 25.4 percent increase. There simply was more space in the thicket for breeding during period 1965-1974 over that of the 1961-1964 period. Accordingly, this larger area was able to support a greater diversity of species and, thereby, a greater number of individual birds than it could previously. It has been well documented that the number of species present in a particular habitat is strongly influenced by the size of that habitat (Lussenhop 1977; Galli 1976; Preston 1960; Gleason 1922). Also important in vegetational change was the development of more forest-like characteristics that occurred in various sections of the thicket. This enhancement of the ecological diversity of the thicket would in turn be expected to encourage increases in bird species diversity and sheer numbers of birds.

Thicket bird population period 1975-1979

During this 5-year period the mean yearly total number of breeding territories was 6.8. The actual values varied from 5.1 to 8.6 for a range of 3.5 territories. The mean number of birds per acre per year was .8; the values included a low of .6 and a high of 1.0 for a range of .4. The mean number of species represented yearly in the breeding fauna varied from 9 to 20 for a mean of 13.8 and a range of 11. The Song Sparrow was the single most common species, accounting for 25.6 percent of the total population during this period.

1965-1974 to 1975-1979 population change

The mean yearly total number of breeding territories decreased from 16.5 in 1965-1974 to 6.8 in 1975-1979. This decrease amounted to 9.7 territories for a 58.8 percent decrease. The mean number of birds per acre per year decreased from 2.3 to .8 for a 1.5 or 65.2 percent decrease. There was a decrease in the mean number of species from 21.7 in 1965-1974 to 13.8 in 1975-1979 which represents a 36.4 percent decrease. Of all the 37 thicket breeding species, 24 displayed decreases in their numbers from 1965-1974 to 1975-1979 thus indicating that 64.9 percent of the total species showed decreases in their numbers. There were 5 species that displayed increases and 8 species that maintained approximately the same values from 1961-1964 to 1965-1974. The Mourning Dove, Gray Catbird, Cardinal, Indigo Bunting, and Song Sparrow alone experienced a combined territory loss of 5.3 or 54.6 percent of the total thicket territorial reduction that occurred from 1965-1974 to 1975-1979.

Evidence that the Colony Farm Tract's downward thicket population change is abnormal

In addition to data from years 1961-1979 for birds in the Colony Farm Tract thicket, data are available for State of Michigan and Kalamazoo County thicket birds for many of the years of the study (Table 18 and 19). A comparison of data from the State of Michigan with the Colony Farm Tract data indicates that

TABLE 18
MICHIGAN THICKET BREEDING BIRD NUMBERS

SPECIES	YEARS														\bar{X}	SD
	66	67	68	69	70	71	72	73	74	75	76	77	78	79		
Green Heron	.5	.3	.4	1.2	1.2	1.5	1.3	1.2	1.1	1.3	1.4	1.5	.9	1.0	1.1	.4
Red-tailed Hawk	.1	.3	.3	.7	.3	.3	.3	.3	.3	.4	.5	.6	.3	.2	.4	.2
Mourning Dove	15.1	14.1	19.9	20.8	20.8	17.1	22.3	20.8	21.3	25.1	26.3	22.4	21.8	18.8	20.5	3.4
Yellow-billed Cuckoo	.1	1.1	.3	.5	1.3	1.3	.7	1.4	.4	.6	.7	.6	.8	1.1	.8	.4
Black-billed Cuckoo	1.0	2.2	2.0	1.1	1.3	1.9	.9	1.1	.8	.9	1.2	1.6	1.6	1.7	1.4	.5
Great Horned Owl	0	0	0	0	0	.1	.1	0	0	.1	.1	.2	.2	0	.1	.1
Common Flicker	4.9	5.3	7.9	6.9	6.9	6.5	7.3	7.2	6.4	5.8	5.2	4.5	3.2	3.2	5.8	1.5
Red-bellied Woodpecker	.2	.1	.4	.4	.6	.4	.3	.3	.3	.5	.6	.6	.3	.4	.4	.2
Hairy Woodpecker	.3	.5	.5	.5	.3	.6	1.0	.6	.6	.5	.5	.7	.4	.5	.5	.2
Downy Woodpecker	.7	1.1	2.1	1.5	1.5	1.8	1.5	1.4	1.3	1.6	1.3	1.7	1.8	1.7	1.5	.3
Eastern Kingbird	4.7	6.3	7.1	7.5	5.5	6.3	6.1	5.3	6.1	6.6	6.9	7.9	6.3	5.6	6.3	.9
Great Crested Flycatcher	3.2	4.0	3.8	3.8	4.4	4.3	4.3	3.9	4.5	3.7	4.7	5.0	5.3	5.0	4.3	.7
Eastern Wood Pewee	2.1	3.1	3.5	4.2	4.2	4.0	3.2	4.2	3.6	3.2	3.7	4.0	4.8	4.1	3.7	.7
Blue Jay	7.6	9.3	11.2	10.2	9.7	9.4	12.3	12.0	11.8	13.0	11.4	12.3	12.5	11.6	11.0	1.6
Common Crow	19.9	21.6	22.7	33.2	28.7	24.8	28.1	30.4	26.0	28.3	27.9	31.5	23.3	24.0	26.5	3.9

Source: Chandler and Willet 1966, 1968, 1969 and unpublished U. S. Fisheries and Wildlife Service data for years 1970-1979.

Note: Numbers represent average number of birds per route.

TABLE 18 - Continued

SPECIES	YEARS															\bar{x}	SD
	66	67	68	69	70	71	72	73	74	75	76	77	78	79			
Black-capped Chickadee	3.3	3.0	2.9	2.7	2.2	2.3	3.0	2.7	3.4	3.6	3.5	4.1	3.6	4.8	3.2	.7	
Tufted Titmouse	1.2	1.4	1.4	.8	1.3	1.2	1.2	1.5	1.4	2.0	2.1	1.5	1.7	1.4	1.4	.3	
White-breasted Nuthatch	.4	.8	2.6	2.0	1.4	1.7	1.4	2.2	1.6	1.5	1.9	2.2	2.0	2.5	1.7	.6	
House Wren	2.6	2.3	3.2	3.6	3.9	4.7	5.3	3.9	5.2	7.0	5.0	4.3	3.8	3.9	4.1	1.2	
Gray Catbird	5.2	4.1	4.9	6.7	5.8	5.6	6.0	5.6	5.1	5.3	5.9	5.4	5.1	6.0	5.5	.6	
Brown Thrasher	3.8	5.0	3.9	4.6	4.5	5.5	3.6	4.4	4.6	5.4	4.6	4.6	4.1	3.4	4.4	.6	
American Robin	41.7	41.7	44.8	46.7	50.2	50.3	51.3	50.9	52.8	52.7	46.9	46.8	45.9	44.3	47.6	3.7	
Starling	74.2	81.2	108.1	102.1	89.5	93.6	85.9	97.1	103.1	122.4	119.1	97.4	62.1	73.9	93.6	17.2	
Red-eyed Vireo	10.2	11.3	8.4	9.4	8.2	8.6	8.6	8.6	6.8	6.0	5.9	11.2	10.5	10.5	8.9	1.8	
Warbling Vireo	2.3	3.1	3.5	3.9	4.1	4.8	5.2	3.1	3.1	3.6	4.6	3.9	3.4	3.4	3.7	.8	
Yellow Warbler	2.8	4.0	4.9	4.3	6.5	3.7	4.5	4.5	4.9	4.0	4.9	4.0	4.3	4.4	4.4	.8	
Common Yellowthroat	7.1	7.4	9.0	8.0	10.2	8.8	7.9	11.2	9.8	9.7	9.5	10.4	10.1	8.6	9.1	1.2	
Northern Oriole	2.2	3.8	3.1	4.2	4.5	5.6	6.1	5.2	5.3	5.6	6.7	5.0	6.1	5.2	4.9	1.2	
Common Grackle	66.5	45.5	60.1	71.7	70.0	62.2	65.6	65.5	71.7	68.0	60.5	52.0	48.9	42.6	60.8	9.8	
Brown-headed Cowbird	16.4	19.1	18.1	13.0	20.4	15.6	17.3	15.4	16.7	13.7	15.5	12.6	10.5	8.5	15.2	3.3	
Cardinal	5.8	4.2	6.1	6.3	7.4	6.3	6.0	6.8	6.6	7.2	7.5	5.7	7.2	6.6	6.4	.9	
Rose-breasted Grosbeak	2.7	3.1	3.1	3.5	3.7	4.8	4.4	5.8	5.9	7.0	6.5	8.5	8.0	5.6	5.2	1.9	
Indigo Bunting	6.9	8.8	9.8	10.1	9.2	9.7	8.8	11.4	9.1	11.0	11.5	11.3	8.2	7.7	9.5	1.4	
American Goldfinch	13.6	16.0	21.0	17.6	15.0	16.0	12.2	14.0	13.1	16.5	11.8	12.8	7.9	8.4	14.0	3.5	
Rufous-sided Towhee	2.3	2.6	2.5	2.1	1.9	2.9	3.9	3.0	2.9	2.8	2.1	2.3	2.3	1.9	2.5	.5	
Swamp Sparrow	.1	.8	.4	.5	.9	.6	.7	1.2	.9	1.1	1.7	1.6	1.0	.9	.9	.4	
Song Sparrow	32.3	36.3	46.8	44.1	39.1	37.2	34.8	35.4	32.9	37.5	33.9	30.1	22.2	19.8	34.5	7.2	
Totals	364.0	374.8	450.7	460.4	446.6	432.0	433.4	449.5	451.4	485.2	464.0	433.4	362.4	353.2	425.8	43.3	

TABLE 19

KALAMAZOO COUNTY THICKET BREEDING BIRD NUMBERS

SPECIES	YEARS										\bar{X}	SD
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979		
Green Heron	2.5	4.2	3.0	3.3	4.1	4.8	5.0	3.0	2.3	3.6	3.6	.9
Red-tailed Hawk	1.0	1.2	1.0	1.8	1.6	2.0	1.9	1.5	2.0	2.0	1.6	.4
Mourning Dove	42.3	40.9	53.4	51.7	57.9	73.3	58.9	48.8	47.2	51.8	52.6	9.3
Yellow-billed Cuckoo	.8	1.3	1.2	5.8	3.4	1.8	2.2	1.1	3.6	6.9	2.8	2.1
Black-billed Cuckoo	1.0	1.1	1.0	1.7	1.7	1.5	1.2	.6	2.8	10.3	2.3	2.9
Great Horned Owl	0	.2	0	0	.1	.3	.1	.3	.3	0	.1	.1
Common Flicker	10.5	10.6	10.1	9.4	7.8	8.3	9.6	6.6	6.5	7.0	8.6	1.6
Red-bellied Woodpecker	1.4	2.5	2.4	3.0	3.6	3.5	3.4	3.8	3.1	3.4	3.0	.7
Hairy Woodpecker	.8	.8	1.1	.9	1.4	1.0	1.6	1.1	1.6	1.6	1.2	.3
Downy Woodpecker	3.5	4.6	5.2	4.8	5.4	4.4	6.2	4.8	4.6	4.4	4.8	.7
Eastern Kingbird	8.0	9.4	11.0	11.6	8.3	11.3	9.9	10.8	11.5	11.3	10.3	1.3
Great Crested Flycatcher	5.4	7.3	7.8	8.1	7.3	5.8	11.8	11.7	8.9	12.3	8.6	2.5
Eastern Wood Pewee	4.6	3.3	2.7	2.3	3.7	3.4	3.2	6.5	5.4	6.3	4.1	1.5
Blue Jay	17.8	19.4	22.2	27.3	29.6	27.8	24.8	19.9	26.2	24.5	24.0	4.0
Common Crow	20.4	26.2	26.3	28.8	23.7	30.3	33.3	34.1	38.5	32.4	29.4	5.4
Black-capped Chickadee	2.9	3.1	3.6	2.1	2.3	4.7	2.5	4.0	4.6	6.1	3.6	1.3

Source: Raymond J. Adams, Jr., research biologist, Kalamazoo Nature Center, Kalamazoo, Michigan.

Note: Numbers represent average number of birds per route.

TABLE 19 - Continued

Species	YEARS												\bar{X}	SD
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979				
Tufted Titmouse	6.9	6.1	6.7	10.2	9.9	10.7	14.8	11.3	13.4	13.0	10.3	3.0		
White-breasted Nuthatch	3.8	2.8	3.5	3.2	4.3	3.5	3.7	4.0	4.5	3.9	3.7	.5		
House Wren	8.7	9.5	12.2	9.5	10.3	13.4	14.1	8.3	9.2	8.3	10.4	2.1		
Gray Catbird	14.1	18.0	19.1	16.9	20.2	20.2	22.1	20.2	23.8	21.8	19.6	2.8		
Brown Thrasher	4.5	7.6	11.8	10.8	9.5	14.1	12.1	10.3	12.3	11.3	10.4	2.7		
American Robin	50.7	58.9	70.3	69.3	76.9	74.5	69.4	71.8	76.9	72.7	69.1	8.3		
Starling	144.5	158.9	144.7	156.3	175.9	190.2	190.5	144.0	128.5	105.7	153.9	26.7		
Red-eyed Vireo	1.2	2.5	2.4	2.2	3.3	6.0	6.8	8.5	9.4	9.0	5.1	3.2		
Warbling Vireo	10.8	11.3	13.1	13.0	12.3	13.3	13.8	13.1	15.2	16.7	13.3	1.7		
Yellow Warbler	5.1	6.2	10.7	12.3	15.8	15.2	17.2	16.3	21.4	20.3	14.1	5.5		
Common Yellowthroat	13.8	13.1	13.8	17.7	19.0	19.6	23.8	24.3	27.2	24.6	19.7	5.1		
Northern Oriole	10.8	16.8	17.1	22.2	23.3	30.0	27.1	23.4	25.7	30.8	22.7	6.3		
Common Grackle	108.4	112.4	150.4	141.8	138.9	280.7	152.0	117.8	122.3	146.8	147.2	49.6		
Brown-headed Cowbird	13.3	20.1	27.6	27.8	27.3	33.6	26.8	23.8	30.3	23.9	25.5	5.6		
Cardinal	19.1	18.6	23.3	25.9	27.3	26.1	28.8	25.6	29.8	28.4	25.3	3.9		
Rose-breasted Grosbeak	3.2	4.8	5.3	9.8	8.2	10.3	9.2	10.1	12.1	16.2	8.9	3.8		
Indigo Bunting	12.6	13.3	16.3	19.5	23.3	21.6	28.8	24.2	23.9	26.2	21.0	5.4		
American Goldfinch	22.8	23.8	17.7	20.9	19.1	20.3	25.0	24.8	21.5	19.4	21.5	2.5		
Rufous-sided Towhee	5.5	6.3	6.8	6.7	5.3	6.4	6.7	6.3	7.2	6.2	6.3	.6		
Swamp Sparrow	2.3	3.3	3.4	5.2	5.3	5.7	7.5	7.7	8.0	7.2	5.6	2.0		
Song Sparrow	46.8	46.0	59.8	73.5	83.3	81.0	88.5	83.0	69.4	62.6	69.4	15.2		
Totals	631.8	696.4	788.0	837.3	880.6	1080.6	964.3	837.4	861.1	858.9	843.6	119.3		

the breeding bird population in the Colony Farm Tract's thicket has experienced an unusually large decrease in numbers from 1965-1974 to 1975-1979. The study area experienced a 58.8 percent reduction in its thicket bird numbers whereas the State of Michigan at large displayed only a 2.2 percent reduction in the numbers of these same species (Table 20). Similar data are not available for comparison for years 1965-1974 to 1975-1979 for Kalamazoo County. Data are, however, available for the State of Michigan, Kalamazoo County, and the Colony Farm Tract for periods 1970-1974 and 1975-1979. From 1970-1974 to 1975-1979 the Colony Farm Tract and State of Michigan populations experienced decreases in their numbers of 59.8 percent and 5.1 percent, respectively. However, the Kalamazoo County bird population experienced a 20.0 percent increase in numbers. It is clear that the Colony Farm Tract's thicket bird population experienced a similar downward trend as did the State of Michigan thicket bird population, although it decreased in much greater magnitude. However, the Colony Farm Tract's trend was opposite to that of Kalamazoo County where there was a substantial 20.0 percent increase in the numbers of the same thicket bird species. Also, from 1970-1974 to 1975-1979 21 species decreased in numbers, 12 maintained the same numbers, and 4 increased in numbers at the Colony Farm Tract (Table 21). For these same periods 16 species decreased in numbers and 21 species experienced increases in their numbers in the State of Michigan at large (Table 22). In Kalamazoo County 2 species decreased in

TABLE 20
PERCENT CHANGE IN THICKET BREEDING BIRD POPULATION MEANS

PERIODS	LOCATION		
	COLONY FARM TRACT	STATE OF MICHIGAN [†]	KALAMAZOO COUNTY ^{††}
65*-74 to 75-79	58.8% decrease	2.2% decrease	
70-74 to 75-79	59.8% decrease	5.1% decrease	20.0% increase

* "66" for U. S. Fisheries and Wildlife service data.

[†]Source: Chandler and Willet 1966, 1968, 1969 and unpublished U. S. Fisheries and Wildlife Service data for years 1970-1979.

^{††}Source: Raymond J. Adams, Jr., research biologist, Kalamazoo Nature Center, Kalamazoo, Michigan.

TABLE 21
POPULATION VALUES FOR COLONY FARM TRACT THICKET BREEDING BIRD SPECIES FOR SPECIFIC TIME PERIODS

SPECIES	YEARS							
	\bar{X}	61-64 SD	\bar{X}	65-74 SD	\bar{X}	75-79 SD	\bar{X}	70-74 SD
Green Heron	0	0	.5	.5	0	0	.6	.5
Red-tailed Hawk	0	0	.1	.1	0	0	.1	0
Mourning Dove	1.5	1.3	1.4	1.2	.1	.1	.6	.5
Yellow-billed Cuckoo	0	.1	.6	.7	.3	.4	.3	.5
Black-billed Cuckoo	.3	.5	.2	.4	0	0	.2	.4
Great Horned Owl	0	0	0	.1	0	.1	.1	.1
Common Flicker	.4	.2	.8	.3	.3	.3	.9	.4
Red-bellied Woodpecker	0	0	0	0	0	0	0	.1
Hairy Woodpecker	0	0	.1	.3	0	0	0	0
Downy Woodpecker	.4	.4	.4	.3	0	.1	.3	.3
Eastern Kingbird	.3	.4	.3	.3	0	0	.4	.4
Great Crested Flycatcher	.2	.2	.5	.2	.1	.2	.5	.3
Eastern Wood Pewee	0	0	.1	.3	.1	.2	0	0
<i>Empidonax</i> spp.	.1	.3	0	0	0	0	0	0
Blue Jay	.1	0	.1	0	.1	.1	.1	0
Common Crow	0	0	.3	.5	.4	.5	.8	.5
Black-capped Chickadee	0	0	.2	.4	.3	.3	.4	.5

TABLE 21 - Continued

SPECIES	YEARS							
	61-64		65-74		75-79		70-74	
	\bar{X}	SD	\bar{X}	SD	\bar{X}	SD	\bar{X}	SD
Tufted Titmouse	0	.1	.2	.3	.6	.1	.5	.3
White-breasted Nuthatch	0	0	.2	.3	.3	.4	.3	.3
House Wren	.1	.1	.4	.7	0	0	.5	1
Gray Catbird	1.1	1.0	1.3	.4	.4	.4	1.2	.2
Brown Thrasher	.6	.3	.3	.3	.2	.3	.1	.3
American Robin	.1	.1	.3	.6	.3	.3	.6	1.0
Starling	0	0	.2	.4	0	0	.1	0
Red-eyed Vireo	0	0	.1	.2	0	0	0	0
Warbling Vireo	0	0	.1	.3	0	0	0	0
Yellow Warbler	0	.1	.1	.2	0	0	0	.1
Common Yellowthroat	2.6	1.8	1.1	.9	.7	.8	.6	.6
Northern Oriole	0	0	.5	.4	.3	.4	.7	.4
Common Grackle	0	0	0	.1	.1	.1	.1	.1
Brown-headed Cowbird	0	.1	.1	.1	0	.1	.1	.1
Cardinal	.8	.1	1.2	.4	.4	.2	1.4	.2
Rose-breasted Grosebeak	0	0	0	.1	0	.1	0	0
Indigo Bunting	1.1	.7	.9	.7	.1	.1	.5	.6
American Goldfinch	.1	.1	.1	0	.1	.1	.1	0
Rufous-sided Towhee	1.0	.2	.5	.4	0	0	.3	.4
Swamp Sparrow	.1	.1	0	0	0	0	0	0
Song Sparrow	1.3	.6	3.2	2.2	1.7	1.1	4.9	2.3
Total	11.8		16.5		6.8		16.9	

TABLE 22
POPULATION VALUES FOR MICHIGAN THICKET BREEDING BIRD SPECIES FOR SPECIFIC TIME PERIODS

SPECIES	YEARS					
	\bar{X}	66-74 SD	\bar{X}	70-74 SD	\bar{X}	75-79 SD
Green Heron	1.0	.4	1.3	.2	1.2	.3
Red-tailed Hawk	.3	.2	.3	0	.4	.2
Mourning Dove	19.1	3.0	20.5	2.0	22.9	2.9
Yellow-billed Cuckoo	.8	.5	1.0	.4	.8	.2
Black-billed Cuckoo	1.4	.5	1.2	.4	1.4	.3
Great Horned Owl	0	0	0	.1	.1	.1
Common Flicker	6.6	1.0	6.9	.4	4.4	1.2
Red-bellied Woodpecker	.3	.1	.4	.1	.5	.1
Hairy Woodpecker	.5	.2	.6	.3	.5	.1
Downy Woodpecker	1.4	.4	1.5	.2	1.6	.2
Eastern Kingbird	6.1	.9	5.9	.4	6.7	.8
Great Crested Flycatcher	4.0	.4	4.3	.2	4.9	.7
Eastern Wood Pewee	3.6	.7	3.8	.4	4.0	.6
Blue Jay	10.4	1.6	11.0	1.4	12.2	.7
Common Crow	26.2	4.4	27.6	2.2	27.0	3.4

Source: Chandler and Willet 1966, 1968, 1969 and unpublished U. S. Fisheries and Wildlife Service data for years 1970-1979.

Note: Numbers based on average number of birds per route.

TABLE 22 - Continued

SPECIES	YEARS								
	\bar{X}	66-74	SD	\bar{X}	70-74	SD	\bar{X}	75-79	SD
Black-capped Chickadee	2.8		.4	2.7		.5	3.9		.6
Tufted Titmouse	1.3		.2	1.3		.1	1.7		.3
White-breasted Nuthatch	1.6		.7	1.7		.3	2.0		.4
House Wren	3.9		1.1	4.6		.7	4.8		1.3
Gray Catbird	5.4		.7	5.6		.3	5.5		.4
Brown Thrasher	4.4		.6	4.5		.7	4.4		.7
American Robin	47.8		4.2	51.1		1.1	47.3		3.2
Starling	92.8		11.1	93.8		6.7	95.0		26.8
Red-eyed Vireo	8.9		1.3	8.2		.8	8.8		2.6
Warbling Vireo	3.7		.9	4.1		1.0	3.8		.5
Yellow Warbler	4.5		1.0	4.8		1.0	4.3		.4
Common Yellowthroat	8.8		1.4	9.6		1.3	9.7		.7
Northern Oriole	4.4		1.3	5.3		.6	5.7		.7
Common Grackle	64.3		8.1	67.0		3.8	54.4		10.0
Brown-headed Cowbird	16.9		2.2	17.1		2.0	12.2		2.7
Cardinal	6.2		.9	6.6		.5	6.8		.7
Rose-breasted Grosbeak	4.1		1.2	4.9		.9	7.1		1.2
Indigo Bunting	9.3		1.2	9.6		1.0	9.9		1.8
American Goldfinch	15.4		2.7	14.1		1.5	11.5		3.5
Rufous-sided Towhee	2.7		.6	2.9		.7	2.3		.3
Swamp Sparrow	.7		.3	.9		.2	1.3		.4
Song Sparrow	37.7		4.9	35.9		2.4	28.7		7.6
Total	429.3			442.6			419.7		

numbers and 35 species increased in numbers from 1970-1974 to 1975-1979 (Table 23).

Thus, the Colony Farm Tract experienced greater reductions in the number of thicket birds and displayed a greater number of species experiencing reductions in their numbers than did the birds from the State of Michigan and Kalamazoo County at large.

Factors causing Colony Farm Tract's abnormal 1965-1974 to 1975-1979 downward thicket population change

Although there were far fewer observations of disturbance or evidences of disturbance in the thicket than were observed in the grassland, disturbance is still believed to be one of the major factors effecting the thicket bird population decline. The population decline that began in 1974 almost exactly paralleled the increased incidence of disturbance.

The increased intensity of road noise emanating from Parkview Avenue was also believed to be important in the population decrease occurring in 1975-1979. Although no quantitative measures of noise are available, it has been noted that traffic on Parkview Avenue has become much greater over the years since 1961, intensifying most appreciably following the initiation of the PUD construction, and that the level of noise has increased dramatically since this time in the northern most portions of the study area.*

Thus, disturbance, basically direct human disturbance, and road

*Richard Brewer 1979: personal communication.

TABLE 23
POPULATION VALUES FOR KALAMAZOO COUNTY THICKET BREEDING BIRD SPECIES FOR SPECIFIC TIME PERIODS

SPECIES	YEARS			
	\bar{X}	SD	\bar{X}	SD
Green Heron	3.5	.7	3.7	1.2
Red-tailed Hawk	1.3	.4	1.9	.2
Mourning Dove	49.2	7.4	56.0	10.7
Yellow-billed Cuckoo	2.5	2.1	3.1	2.3
Black-billed Cuckoo	1.3	.4	3.3	4.0
Great Horned Owl	.1	.1	.2	.1
Common Flicker	9.7	1.2	7.6	1.3
Red-bellied Woodpecker	2.6	.8	3.4	.3
Hairy Woodpecker	1.0	.3	1.4	.3
Downy Woodpecker	4.7	.7	4.9	.8
Eastern Kingbird	9.7	1.6	11.0	.7
Great Crested Flycatcher	7.2	1.1	10.1	2.8
Eastern Wood Pewee	3.3	.9	5.0	1.6
Blue Jay	23.3	5.1	24.6	3.0
Common Crow	25.1	3.2	33.7	3.0

Source: Raymond J. Adams, Jr., research biologist, Kalamazoo Nature Center, Kalamazoo, Michigan.

Note: Numbers based on average number of birds per route.

TABLE 23 - Continued

SPECIES	YEARS			
	70-74		75-79	
	\bar{X}	SD	\bar{X}	SD
Black-capped Chickadee	2.8	.6	4.4	1.3
Tufted Titmouse	8.0	1.9	12.6	1.7
White-breasted Nuthatch	3.5	.6	3.9	.4
House Wren	10.0	1.3	10.7	2.9
Gray Catbird	17.7	2.3	21.6	1.5
Brown Thrasher	8.8	2.9	12.0	1.4
American Robin	65.2	10.4	73.1	2.8
Starling	156.1	12.9	151.8	37.8
Red-eyed Vireo	2.3	.8	7.9	1.5
Warbling Vireo	12.1	1.0	14.4	1.5
Yellow Warbler	10.0	4.4	18.1	2.7
Common Yellowthroat	15.5	2.7	23.9	2.7
Northern Oriole	18.0	5.0	27.4	3.1
Common Grackle	130.4	18.8	163.9	67.0
Brown-headed Cowbird	23.2	6.4	27.7	4.2
Cardinal	22.8	3.9	27.7	1.8
Rose-breasted Grosbeak	6.3	2.7	11.6	2.8
Indigo Bunting	17.0	4.5	24.9	2.7
American Goldfinch	20.9	2.5	22.2	2.6
Rufous-sided Towhee	6.1	.7	6.6	.4
Swamp Sparrow	3.9	1.3	7.2	.9
Song Sparrow	61.9	16.4	76.9	10.6
Totals	766.8		920.5	

noise from Parkview Avenue, much of it believed to be associated with PUD, appear definitely to be the factors causing the dramatic decline in the thicket bird population from 1965-1974 to 1975-1971.

Effectiveness of Posted "Keep-Out" Signs in Reducing Disturbance

The posting of the study area with the "keep-out" signs did not appear to reduce the number or kinds of disturbances (Table 24). There was a total of 7 incidences of disturbance or evidences of disturbances before the placement of the signs; a total of 6 disturbances or evidences of disturbance occurred following placement of the signs. During both the "before" and "after" periods the presence of dogs was the single most common disturbance. Most of the time the dogs were accompanied by humans, indicating that the area is purposely used by PUD residents for walking their dogs. Because of the close placement of the signs along the Colony Farm Tract - PUD borders it is unlikely that the signs were not observed. In fact, immediately following the posting of the signs, a number of PUD residents were observed to approach the PUD - study area borders, read the signs, and then return to their own residences. This observation suggests that the signs were readily visible to the PUD residents that entered the study area following sign placement.

The ignoring of the "keep-out" signs seems particularly significant in light of the fact that the PUD was planned and constructed with the goodwill of the environment in mind.

TABLE 24
DISTURBANCE BEFORE AND AFTER PLACEMENT OF "KEEP-OUT" SIGNS

PERIOD	DISTURBANCE OR EVIDENCE OF DISTURBANCE
<u>Before Signs</u>	
Aug. 9: 7:00 P.M. - 9:20 P.M.	None observed
Aug. 11: 11:00 A.M. - 1:45 P.M.	Man with dog
Aug. 12: 10:15 A.M. - 4:00 P.M.	Dog in area Boy with dog
Aug. 16: 3:45 P.M. - 7:00 P.M.	Man in area Woman with dog
Aug. 19: 11:15 A.M. - 2:30 P.M.	Woman with dog 2 bicycles lying in grass
<hr/>	
Total Time = Approximately 21 hours	
<u>After Signs</u>	
Aug. 25: 9:00 A.M. - 4:00 P.M.	2 women picnicing and walking 2 dogs
Aug. 26: 9:00 A.M. - 6:00 P.M.	Boy with golf club walked past sign and looked about in grass Dog in area Man with dog
Aug. 27: 6:30 A.M. - 9:15 A.M.	None observed
Aug. 30: 6:30 P.M. - 8:40 P.M.	2 motorized trail bikes through south-half of field 1 motorized trail bike through south-half
<hr/>	
Total Time = Approximately 20 hours	

According to Upjohn (1971), the development was conceived as a complete community where man and the products of his existence would coexist with the natural environment, allowing nature to retain its integrity. The "keep-out" signs were intentionally constructed in a manner consistent with this supposed environmental concern (Figure 29). The signs identified the area as a Western Michigan University ecological study area, stated that traffic in the area by humans, dogs, and cats might be harmful to wildlife, and solicited help in preserving the area. The observations of disturbance following the placement of the signs seem to indicate a lack of consistency in the intent of PUD planners and at least some PUD residents.

WESTERN MICHIGAN UNIVERSITY

Ecological Study Area

DO NOT ENTER

**Traffic in this area by humans, dogs, and cats may be harmful to ground-nesting
grassland birds and other wildlife.**

HELP PRESERVE THIS AREA

Figure 29. Appearance and composition of posted "keep-out" signs.

CHAPTER V

MITIGATING MEASURES

Because the findings of this study seem to indicate that development, especially disturbances associated with housing developments, adversely affect adjacent bird populations, some mitigating measures are suggested that may serve to reduce some adverse impacts of development.

Probably the single most important mitigating measure is reduction in the extent of development. A reduction in housing density along the boundaries of a natural area would probably effect a reduction in the extent of disturbance experienced by the natural area. Fewer humans and domestic animals would be in the area to disturb the habitat and its wildlife. In addition, this measure would have the effect of mitigating almost all influences associated with development. This effect could be even further heightened if the area between the development and the natural area was left more or less natural. This latter measure might tend to lessen the effect of lost adjacent undisturbed habitat.

Second, a setback requirement that would not permit development to occur closer than 150 feet from a natural area could be instituted in conjunction with a reduced development density policy or established as policy in itself. Because the intensity of light and sound decreases with the square of distance from the source this measure would lessen the influence of noise and light

emanating from developed areas. A setback requirement of 150 feet should reduce the influence to about one-ninth of that occurring at 50 feet.

Third, the placement of a high, wire-woven fence between a developed area and an adjacent natural area would effectively reduce the human and dog and cat traffic on the natural area. Fewer ground nesting animals would be harmed and most vandalism would probably be eliminated.

Fourth, the restriction of dogs and cats in a development adjacent natural habitat could drastically reduce the degree of disturbance experienced by the natural area. This measure is, however, probably the least practical and most difficult to enforce. It undoubtedly would be highly unpopular with tenants.

Because the development in this study has already been constructed few of the aforementioned mitigating measures can be instituted. However, a fence could easily be placed between the study area and the PUD. This would have the effect of reducing human and dog traffic on the area. Because human and dog traffic is believed to be one of the most important factors in reducing the bird populations on the study area, the erection of a fence might produce favorable results. In fact, if after its placement the bird population should increase, it might be possible to clarify the relationship that appears to exist between the presence of humans and dogs in a natural area and the number of breeding birds subsequently selecting the area for breeding habitat.

CHAPTER VI

POST STUDY PRELIMINARY FINDINGS

Breeding bird censuses were conducted during the spring and summer of 1980. Although population values for all species have not yet been determined, it has been established that two Henslow's Sparrows established breeding territories on the study area by the middle of summer. These territories were still being maintained as late as August 15. Sightings of this species were not made before June 1980.

Two factors are believed to have contributed to the return of the Henslow's Sparrow to the study area. First, preliminary data have suggested that the 1980 Kalamazoo County Henslow's Sparrow population is larger than it has been for a number of years.* It is possible then that all potential Henslow's Sparrow breeding habitats, possibly both optimal and suboptimal, were selected by this species in the County in order to accommodate the increased population. This would not necessarily indicate that the study area's disturbed habitat is a preferred Henslow's Sparrow habitat. Second, early 1980 findings indicate that the intensity of disturbance associated with the adjacent development is reduced from that of the most recent years. Although observations of specific disturbances have not been conducted, obvious evidence of disturbance is less evident. It is postulated that the

*Raymond Adams 1980: personal communication.

placement of the "keep-out" signs has been, at least in part, responsible in effecting this reduction in disturbance.

Further study will have to continue to determine the most probable cause of the recolonization of the Colony Farm Tract by the Henslow's Sparrow.

CHAPTER VII

SUMMARY

The data for both grassland and thicket bird populations show noticeable variability throughout the study. The 18 years of data do, however, display natural "breaks" into certain time periods that show definite upward and downward trends in both numbers of birds and numbers of bird species breeding on the study area. For the grassland, these time periods are: 1961-1965, 1966-1974, and 1975-1979. The upward population trend that occurred between periods 1961-1965 and 1966-1974 is believed to have been caused by woody plant invasion and other factors associated with the increased ecological age of the habitat. Results from Kalamazoo County and State of Michigan breeding bird population studies seem to indicate that the 1975-1979 Colony Farm Tract grassland breeding bird population decline was atypical when compared with similar bird populations at large. The population decline is believed to have specifically been the result of increased disturbance emanating from the adjacent residential development. The reduction in breeding bird numbers and species diversity that paralleled the increased incidence of disturbance associated with the development appears to support this notion. It is speculated that human and dog traffic on the study area affected the grassland breeding bird populations more than any other kind of disturbance.

The thicket displays population trends during 1961-1964, 1965-1974, and 1975-1979. The cause for the upward population change that occurred between 1961-1964 and 1965-1974 is believed to be the result of vegetational changes in the thicket habitat - mainly, the increase in thicket size. The downward population trend change observed between time periods 1965-1974 and 1975-1979 appears to be associated with the construction of the PUD and the increased intensity of road noise which is believed to be associated with the residential development. Data from the Kalamazoo County and State of Michigan breeding bird population studies seem to support the notion that the 1975-1979 Colony Farm Tract thicket breeding bird population decline is also atypical for the area at large and is therefore abnormal.

The "keep-out" signs which were posted along the perimeter of the study area in 1979 did not immediately appear to effect a reduction in the study area's incidence of disturbance. However, one year following placement of the signs a notable reduction in the evidence of disturbance was observed. It is believed that this reduction in disturbance, at least in part a result of the sign placement, effected the increase in the grassland breeding bird species diversity which also occurred one year after the posting of the signs.

Although biotic changes and human disturbance have been proposed as causing the major breeding bird population changes that occurred during this study, the affects of the adjacent

development do not appear to have had catastrophic affects on most of the study area's bird species. In many ways the bird populations are the same as they were before the adjacent area was developed. However, during the years following construction of the adjacent development, and especially during the years after 1974 when the incidence of disturbance dramatically increased, breeding bird species diversity and bird numbers decreased. Thus, it appears that there is an undesirable relationship between adjacent residential development and breeding bird populations.

BIBLIOGRAPHY

- American Ornithologists' Union. 1957. *Check-List of North American Birds*, 5th ed., Am. Ornith. Union. Baltimore, Maryland.
- Anderson, S. H. 1979. Changes in forest bird species composition caused by transmission-line corridor cuts. *Amer. Birds* 33:3-6.
- Brewer, R. 1963. Stability in bird populations. *Occas. Pap. C. C. Adams, Cent. Ecol. Stud.* No. 7.
- Brewer, R., Raim, A., and Robins, J. D. 1979. Vegetation of a Michigan grassland and thicket, *Occas. Pap. C. C. Adams Cent. Ecol. Stud.* No. 18.
- Brown, J. L. 1969. Territorial behavior and population regulation in birds. *Wilson Bull.* 81: 293-329.
- Buechner, H. L., 1953. Some biotic changes in the state of Washington particularly during the century 1853-1953. *Res. Studies, State College of Washington*, 21:154-192. In Johnsgard, P. A. and Richard, W. H., The relation of spring bird distribution to a vegetation mosaic in southeastern Washington. *Ecology* 38:171-174.
- Buss, I. O. and Dziedzic, E. S. 1955. Relation of cultivation to the disappearance of the Columbian Sharp-tailed Grouse from southeastern Washington. *Condor* 57:185-187.
- Carleton, A. R. and Owre, O. T. 1975. The Red-winged Bulbul in Florida. *Auk* 92:53.
- Chandler, S. R. and Willet, V. T. 1966. *The Breeding Bird Survey*. United States Dept. of the Interior, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife. Special Scientific Report. Wildlife No. 102.
- _____. 1968. *The Breeding Bird Survey*. United States Dept. of the Interior, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife. Special Scientific Report. Wildlife No. 124.
- _____. 1969. *The Breeding Bird Survey*. Administrative Report. Section of Migratory Non-Game Bird Studies. Bureau of Sport Fisheries and Wildlife. Migratory Bird Populations Station.
- Childs, H. E. 1951. Marsh, swamp, and forest during 45 years of human disturbance. *Audubon Field Notes* 5:231-233.
- Dambach, C. A. and Good E. E. 1940. Land use effect on bird populations. *J. Wildl. Mgmt.* 4:63-76.

- Diamond, J. M. and May, R. M. 1976. Island biogeography and the design of natural reserves. May, R. M., ed. *Theoretical ecology*. Philadelphia: W. B. Saunders Co.
- Dunston, T. C. 1968. Breeding success of Osprey in Minnesota from 1963 to 1968. *Loon* 40:109-112.
- Fretwell, S. 1973. Suburban Blue Jays. *The Bird Watch* 1. Bird Populations Institute, Kansas State University.
- Galli, A. E., Leck, C. F., and Forman, T. T. 1976. Avian distribution patterns in forest islands of different sizes in central New Jersey. *Auk* 93:356-364.
- Good, E. E. and Dambach, C. A. 1943. Effect of land use practices on breeding bird populations in Ohio. *J. Wildl. Mgmt.* 7:291-297.
- Graber, J. W. 1968. Western Henslow's Sparrow. In A. C. Bent and collaborators (Austin, O. L., Jr., ed.). *Life Histories of North American Cardinals, Grosbeaks, Buntings, Towhees, Finches, Sparrows, and Allies*. *U. S. Natl. Mus. Bull.* 237, Part 2:645.
- Gleason, H. A. 1922. On the relationship between species and area. *Ecology* 3:158-162.
- Guthrie, D. A. 1974. Suburban bird populations in southern California. *Amer. Midl. Nat.* 92:461-466.
- Harbron, S. L. 1977. Bird populations in a grassland-thicket in relation to plant succession and adjacent land use. M. A. thesis, Western Michigan Univ., Kalamazoo, Michigan.
- Hilden, O. 1965. Habitat selection in birds. *Ann. Zool. Fenn.* 2:53-75.
- Homes, R. C. 1957. The birds of the London area since 1900. *The New Naturalist*, London, Collins. In Woolfenden, G. E. and Rohwer, S. A. Breeding birds in a Florida suburb. *Bull. Fla. State Mus. Biol. Ser.* Vol. 13:1-83.
- Hyde, A. S. 1939. The life history of Henslow's Sparrow, *Passerherbulus henslowi* (Audubon). *Misc. Publ. Mus. Zool. Univ. Michigan* No. 41. In Sutton, G. M. 1959. The nesting fringillids of the Edwin S. George Reserve, southeastern Michigan 4. *Jack-Pine Warbler* 37:127-151.
- Johnsgard, P. A. and Richard, W. H. 1957. The relation of spring bird distribution to a vegetation mosaic in southeastern Washington. *Ecology* 38:171-174.

- Johnston, D. W. and Odum, E. P. 1956. Breeding bird populations in relation to plant succession on the piedmont of Georgia. *Ecology* 37:50-62.
- Karr, J. R. 1968. Habitat and avian diversity on strip-mined land in east-central Illinois. *Condor* 70:348-357.
- Karr, J. R. and Roth, R. R. 1971. Vegetation structure and avian diversity in several new world areas. *Am. Nat.* 105:423-435.
- Kendeigh, S. C. 1941. Birds of a prairie community. *Condor* 43:165-174.
- _____. 1944. Measurement of bird populations. *Ecol. Monogr.* 14:67-106.
- _____. 1945. Community selection by birds on the Helderburg Plateau of New York. *Auk* 62:418-436.
- _____. 1948. Bird populations and biotic communities in northern lower Michigan. *Ecology* 29:101-114.
- Lack, D. 1937. A review of bird census work and bird population problems. *Ibis* 14:369-395.
- Lanyon, W. E. 1957. The comparative biology of the Meadowlarks (*Sturnella*) in Wisconsin. Publications of the Nuttall Ornithological Club, No. 1.
- Ludwig, J. P. 1979. Present status on the Caspian Tern population of the Great Lakes. *The Michigan Academician* 12:69-77.
- Lussenhop, J. 1977. Urban cemeteries as bird refuges. *Condor* 79:456-461.
- MacArthur, R. H. and MacArthur, J. W. 1961. On bird species diversity. *Ecology* 42:592-598.
- MacArthur, R. H. and Wilson, E. O. 1967. *The theory of island biogeography*. Princeton: Princeton University Press.
- MacClintock, L., Whitcomb, R. F., and Whitcomb, B. L. 1977. 2. Evidence for the value of corridors and minimization of isolation in preservation of biotic diversity. *Amer. Birds* 31:6-12.
- May, R. M. 1975. Island biogeography and the design of wildlife preserves. *Nature* 254:177-178.

- McClure, H. E. and Othman, H. B. 1965. Avian bionomics of Malaya 2: The effect of forest destruction upon a local population. *Bird-Banding* 36:242-269.
- McDaniel, J. W. 1976. Blue Jay predation of artificial eggs. *Jack-Pine Warbler* 54:91-92.
- Miller, A. H. 1942. Habitat selection among higher vertebrates and its relation to intraspecific variation. *Am. Nat.* 76:25-35.
- Morse, D. H. 1977. The occupation of small islands by passerine birds. *Condor* 79:399-411.
- Nice, M. M. 1941. The role of territory in bird life. *Amer. Midl. Nat.* 26:441-487.
- Odum, E.P. 1950. Bird populations of the Highlands (North Carolina) Plateau region in relation to plant succession and avian invasion. *Ecology* 31:587-605.
- Pitelka, F. A. 1941. Distribution of birds in relation to major biotic communities. *Am. Midl. Nat.* 25:113-137.
- Post, W. and Wiley, J. W. 1976. The Yellow-shouldered Blackbirds--present and future. *Amer. Birds* 30:13-20.
- Preston, F. W. 1960. Time and space and the variation of species. *Ecology* 41:611-627.
- Raim, A. J. 1975. Territory and mating system of the Bobolink, *Dolichonyx oryzivorus*. M. A. thesis, Western Michigan Univ., Kalamazoo, Michigan.
- Ramsden, D. J., Lyon, L. J. and Halvorson, G. L. 1979. Small bird populations and feeding habitats--western Montana in July. *Amer. Birds* 33:11-16.
- Reese, J. C. 1977. Reproductive success of Ospreys in central Chesapeake Bay. *Auk* 94:202-221.
- Roberts, T. X. 1932. *The birds of Minnesota*. Minneapolis: Univ. Minnesota Press, 2 vols. In Tester, J. K. and Marshall, W. H. A study of certain plant and animal inter-relations on a native prairie in northwestern Minnesota. *Minn. Mus. Nat. Hist. Occas. Pap.* No. 8.
- Roth, R. R. 1976. Spatial heterogeneity and bird species diversity. *Ecology* 57:772-782.

- _____. 1977. The composition of four bird communities in south Texas brush grasslands. *Condor* 79:417-425.
- Saunders, A. A. 1936. Ecology of the birds of Quaker Run Valley, Allegheny State Park, New York. State Museum, Albany, New York. Handbook No. 16. In Johnston, D. W. and Odum, E. P. Breeding bird populations in relation to plant succession on the piedmont of Georgia. *Ecology* 37:50-62.
- Shugart, H. H. and James, D. 1973. Ecological succession of breeding bird populations in northwestern Arkansas. *Auk* 90:62-77.
- Smith, C. C. 1940. The effect of overgrazing and erosion upon biota of the mixed grass prairie of Oklahoma. *Ecology* 21:381-397.
- Stapleton, J. and Kiviat, E. 1979. Rights of birds and rights of way. *Amer. Birds* 33:7-10.
- Sutton, G. M. 1959. The nesting fringillids of the Edwin S. George Reserve, southeastern Michigan 4. *Jack-Pine Warbler* 37:127-151.
- Swenson, J. E. 1979. Factors affecting status and reproduction of Ospreys in Yellowstone National Park. *J. Wildl. Mgmt.* 43:595-601.
- Tester, J. R. and Marshall, W. H. 1961. A study of certain plant and animal inter-relations on a native prairie in northwestern Minnesota. *Minn. Mus. Nat. Hist. Occas. Pap.* No. 8.
- Titterington, R. W., Crawford, H. S., and Burgason, B. N. 1979. Songbird responses to commercial clear-cutting in Maine spruce-fur forests. *J. Wildl. Mgmt.* 43:602-609.
- Tomba, F. S. 1962. Territorial behavior: the main controlling factor of a local Song Sparrow population. *Auk* 79:687-697.
- Trine, Mrs. G. W. 1935. The case against the Bronzed Grackle. *Nebraska Bird Rev.* 3:54-55.
- Upjohn, E. S., ed. 1971. *The Parkviewer* 1:1-8.
- Warbach, O. 1958. Bird populations in relation to changes in land use. *J. Wildl. Mgmt.* 22:23-28.
- Waters, J. H. 1967. Avian populations in a recently disturbed old field succession. *Bird-Banding* 38:17-36.
- Whitcomb, R. F. 1977. Island biogeography and "habitat islands" of eastern forest. *Amer. Birds* 31:3-5.

- Whitcomb, B. L., Whitcomb, R. F., and Bystrak, D. 1977. 3. Long-term turnover and effects of selective logging on the avifauna of forest fragments. *Amer. Birds* 31:17-23.
- Williams, A. B. 1936. The composition and dynamics of a beech-maple climax community. *Ecol. Monogr.* 6:317-408.
- Willson, M. F. 1974. Avian community organization and habitat structure. *Ecology* 55:1017-1029.
- Wing, L. 1949. Breeding birds of virgin palouse prairie. *Auk* 66: 38-41.
- Wolfenden, G. E. and Rohwer, S. A. 1969. Breeding birds in a Florida suburb. *Bull. Fla. State Mus. Biol. Ser.* Vol. 13:1-83.

APPENDIX

BIRD SPECIES OBSERVED

Great Blue Heron	<i>Ardea herodias</i>
Green Heron	<i>Butorides striatus</i>
Canada Goose	<i>Branta canadensis</i>
Mallard	<i>Anas platyrhynchos</i>
Blue-winged Teal	<i>Anas discors</i>
Wood Duck	<i>Aix sponsa</i>
Turkey Vulture	<i>Cathartes aura</i>
Cooper's Hawk	<i>Accipiter cooperii</i>
Red-tailed Hawk	<i>Buteo jamaicensis</i>
American Kestrel	<i>Falco sparverius</i>
Bobwhite	<i>Colinus virginianus</i>
Ring-necked Pheasant	<i>Phasianus colchicus</i>
Sora	<i>Porzana carolina</i>
Common Gallinule	<i>Gallinula chloropus</i>
Killdeer	<i>Charadrius vociferus</i>
Black Tern	<i>Chlidonias niger</i>
Mourning Dove	<i>Zenaida macroura</i>
Rock Dove	<i>Columba livia</i>
Yellow-billed Cuckoo	<i>Coccyzus americanus</i>
Black-billed Cuckoo	<i>Coccyzus erythrophthalmus</i>
Great Horned Owl	<i>Bubo virginianus</i>
Whip-poor-will	<i>Caprimulgus vociferus</i>

Common Nighthawk	<i>Chordeiles minor</i>
Chimney Swift	<i>Chaetura pelagica</i>
Ruby-throated Hummingbird	<i>Archilochus colubris</i>
Belted Kingfisher	<i>Megasceryle alayon</i>
Common Flicker	<i>Colaptes auratus</i>
Red-bellied Woodpecker	<i>Melanerpes carolinus</i>
Red-headed Woodpecker	<i>Melanerpes erythrocephalus</i>
Yellow-bellied Sapsucker	<i>Sphyrapicus varius</i>
Hairy Woodpecker	<i>Picoides villosus</i>
Downy Woodpecker	<i>Picoides pubescens</i>
Eastern Kingbird	<i>Tyrannus tyrannus</i>
Great Crested Flycatcher	<i>Myiarchus crinitus</i>
Eastern Phoebe	<i>Sayornis phoebe</i>
<i>Empidonax spp.</i>	
Traill's Flycatcher	<i>Empidonax traillii</i>
Least Flycatcher	<i>Empidonax minimus</i>
Eastern Wood Pewee	<i>Contopus virens</i>
Olive-sided Flycatcher	<i>Nuttallornis borealis</i>
Horned Lark	<i>Eremophila alpestris</i>
Tree Swallow	<i>Iridoprocne bicolor</i>
Bank Swallow	<i>Riparia riparia</i>
Rough-winged Swallow	<i>Stelgidopteryx ruficollis</i>
Barn Swallow	<i>Hirundo rustica</i>
Purple Martin	<i>Progne subis</i>
Blue Jay	<i>Cyanocitta cristata</i>

Common Crow	<i>Corvus brachyrhynchos</i>
Black-capped Chickadee	<i>Parus atricapillus</i>
Tufted Titmouse	<i>Parus bicolor</i>
White-breasted Nuthatch	<i>Sitta carolinensis</i>
Red-breasted Nuthatch	<i>Sitta canadensis</i>
Brown Creeper	<i>Certhia familiaris</i>
House Wren	<i>Troglodytes aedon</i>
Long-billed Marsh Wren	<i>Cistothorus palustris</i>
Short-billed Marsh Wren	<i>Cistothorus platensis</i>
Gray Catbird	<i>Dumetella carolinensis</i>
Brown Thrasher	<i>Toxostoma rufum</i>
American Robin	<i>Turdus migratorius</i>
Hermit Thrush	<i>Catharus guttatus</i>
Swainson's Thrush	<i>Catharus ustulatus</i>
Gray-cheeked Thrush	<i>Catharus minimum</i>
Blue-gray Gnatcatcher	<i>Poliophtila caerulea</i>
Golden-crowned Kinglet	<i>Regulus satrapa</i>
Ruby-crowned Kinglet	<i>Regulus calendula</i>
Cedar Waxwing	<i>Bombycilla cedrorum</i>
Starling	<i>Sturnus vulgaris</i>
Yellow-throated Vireo	<i>Vireo flavifrons</i>
White-eyed Vireo	<i>Vireo griseus</i>
Red-eyed Vireo	<i>Vireo olivaceus</i>
Philadelphia Vireo	<i>Vireo philadelphicus</i>
Warbling Vireo	<i>Vireo gilvus</i>

Black-and-white Warbler	<i>Mniotilta varia</i>
Blue-winged Warbler	<i>Vermivora pinus</i>
Tennessee Warbler	<i>Vermivora peregrina</i>
Nashville Warbler	<i>Vermivora ruficapilla</i>
Yellow Warbler	<i>Dendroica petechia</i>
Magnolia Warbler	<i>Dendroica magnolia</i>
Black-throated Blue Warbler	<i>Dendroica caerulescens</i>
Yellow-rumped Warbler	<i>Dendroica coronata</i>
Black-throated Green Warbler	<i>Dendroica virens</i>
Blackburnian Warbler	<i>Dendroica fusca</i>
Chestnut-sided Warbler	<i>Dendroica pensylvanica</i>
Bay-breasted Warbler	<i>Dendroica castanea</i>
Palm Warbler	<i>Dendroica palmarum</i>
Ovenbird	<i>Seiurus aurocapillus</i>
Common Yellowthroat	<i>Geothlypis trichas</i>
Wilson's Warbler	<i>Wilsonia pusilla</i>
Canada Warbler	<i>Wilsonia candensis</i>
American Redstart	<i>Setophaga ruticilla</i>
House Sparrow	<i>Passer domesticus</i>
Bobolink	<i>Dolichonyx oryzivorus</i>
Eastern Meadowlark	<i>Sturnella magna</i>
Red-winged Blackbird	<i>Agelaius phoeniceus</i>
Orchard Oriole	<i>Icterus spurius</i>
Northern Oriole	<i>Icterus galbula</i>
Rusty Blackbird	<i>Euphagus carolinus</i>

Common Grackle	<i>Quiscalus quiscula</i>
Brown-headed Cowbird	<i>Molothrus ater</i>
Scarlet Tanager	<i>Piranga olivacea</i>
Cardinal	<i>Cardinalis cardinalis</i>
Rose-breasted Grosbeak	<i>Pheucticus ludovicianus</i>
Indigo Bunting	<i>Passerina cyanea</i>
Dickcissel	<i>Spiza americana</i>
American Goldfinch	<i>Carduelis tristis</i>
Rufous-sided Towhee	<i>Pipilo erythrophthalmus</i>
Savannah Sparrow	<i>Passerculus sandwichensis</i>
Grasshopper Sparrow	<i>Ammodramus savannarum</i>
Henslow's Sparrow	<i>Ammodramus henslowii</i>
Vesper Sparrow	<i>Poocetes gramineus</i>
Dark-eyed Junco	<i>Junco hyemalis</i>
Tree Sparrow	<i>Spizella arborea</i>
Chipping Sparrow	<i>Spizella passerina</i>
Field Sparrow	<i>Spizella pusilla</i>
White-crowned Sparrow	<i>Zonotrichia leucophrys</i>
White-throated Sparrow	<i>Zonotrichia albicollis</i>
Fox Sparrow	<i>Passerella iliaca</i>
Swamp Sparrow	<i>Melospiza georgiana</i>
Song Sparrow	<i>Melospiza melodia</i>