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ABSTRACT

A combination of both the horizontal and vertical approaches to the study of avian succession was applied over a 20-year period in research on the breeding birds of fallow farmland in Long Island, New York. Eight fields, representing stages in secondary plant succession from bare soil to a field 45 years old, varied in size from 0.41 to 1.88 hectares. Botanical data on average cover of herbaceous species and upright woody species, and on the density of trees by height class and by diameter characterize the vegetation of each study area. Breeding bird censuses were counts of all individuals, not indices to or estimates of population size. Particular attention was given to nest location and construction and to light readings taken at the nests to provide an index of relative nest cover.

The sequence in which bird species became established in these fields was: Red-winged Blackbird, Song Sparrow, Field Sparrow, Indigo Bunting, Common Yellowthroat, Blue-winged Warbler, Gray Catbird, Brown Thrasher, and Rufous-sided Towhee. This is the same sequence of species derived by an arrangement in order of increasing cover at the nest. Likewise, this is the order in which these same species disappear from the continuum of communities that characterizes old field succession on Long Island. The concordance among these three sequences suggests that species-specific requirements with respect to cover at the nest plays an important role in determining which stages of old field succession a species finds attractive for nesting.

There was a rapid increase in species diversity with an increase in age of the fields, and a leveling-off in numbers of territorial species from about 15 years (open shrubland) to 40 years (dense shrubby woodland) after cultivation. A more mature oak woodland in the same region (60 years after clear-cutting) had a greater species diversity than that of any earlier stage of old field succession. This progressive increase in species diversity with succession from herbaceous fields to mature forest is consistent with the findings of others.

The density of breeding birds continued to increase beyond that age at which species diversity began to level off (about 15 years after cultivation) and did not reach peak density until another 15 years had elapsed. Density within the more mature oak woodland was significantly less than that of the 30- to 40-year old shrubby woodland. Whether or not there is a decline in density of breeding birds as succession approaches climax probably is determined by the relative availability of moisture. Other investigators have confirmed that in the more xeric successions, such as described in this study, a decline in density is the rule. In the more mesic successions, density is higher in the forest than in the intermediate shrubland stage.

Species diversity and density were significantly lower in study areas where succession was arrested than in those permitted to revegetate naturally.

INTRODUCTION

Plant succession on fallow farmland is characterized by a continuously varying series or continuum of vegetational communities from bare soil to woodland. Species of birds exhibit different patterns of response to the physiognomic and physical features of this continuum. Although differing from species to species, these responses overlap to form a continuum of changing avian communities as well. There has been widespread interest in the interrelationships of avian and plant succession and the usual approach by investigators has been to sample simultaneously the birds of a number of sites representing different stages of succession (e.g., Saunders, 1936; Kendeigh, 1948; Odum, 1950; Johnston and Odum, 1956; Karr, 1968; and Shugart and James, 1973). This "horizontal approach," which infers that the oldest site sampled has passed through stages represented by the other sites, has the advantage of enabling the accumulation of data in a short period of time, often a single breeding season, but introduces undesirable variables associated with differences in the communities being censused. The alternative to this composite picture of succession is the "vertical approach," in which the same study area is followed over a longer period of time (e.g., Evans, 1978), but this has not been practical for most investigators because of the time commitment and the necessity for continuity of prescribed land use and professional supervision.

When the American Museum of Natural History established its Kalbfleisch Field Research Station in Huntington, New York, in 1958, I sensed the unique opportunity this Station provided for conducting studies of avian succession on fallow Long Island farmland, using a combination of both the horizontal and vertical approaches. The availability of student assistance for the census work, a parallel study of plant succession by a staff botanist and his students, a grid system of reference coordinates throughout the property, an active bird-banding program to insure numbers of color-banded birds, and the likelihood of a continuity of prescribed land-use over a considerable period of time were factors that made such an intensive research program feasible and attractive. The present paper reports the results of research, conducted over 20 years (1958–1977).

ACKNOWLEDGMENTS

The great volume of data that was generated during this study could only have been accumulated with the assistance of many people. The bulk of the survey work, both avian and botanical, was done by college students who were participants in the American Museum of Natural History's Undergraduate Research Program, sponsored in part by the National Science Foundation (Grants E 13/43-0589, G 15-934, GE 2381, GE 6387, GY 350, GY 289, GY 2716, GY 4349, GY 6055, and GY 8923), and were in residence at the Kalbfleisch Field Research Station for one or more summers. Since the bird-banding program at the Station facilitated the census work by providing numbers of individually marked birds, the volunteers who contributed time to this program have played a vital role in the research on succession. I am grateful to all for the zeal, energy, and expertise that they brought to this work: John Alcock, Michael G. Barbour, Michael Barnett, Jerome J. Barry, Godfrey R. Bourne, Richard Bradley, Marilyn Jordan Buchauer, Richard D. Chandler, Charles Clinger, Jack Combes, David N. Ewert, Kent L. Fiala, Douglas J. Futuyma, Douglas E. Gill, Frank B. Gill, Edward Gilman, Martha H. Balph, Gerhard A. Hauptmann, Violet A. Hicks, Marshall A. Howe, Shaun Ince, Thomas M. Jasikoff, H. Lee Jones, Geoffrey Kaufman, Erik Kiviat, Warren R. Keammerer, Cynthia Lanyon-Duncan, Scott Lanyon, Vernia Lanyon, Dale Lewis, James B. Meade, James W. Morrow, Darrell Needham, Fred C. Olday, Christopher Pineo, George R. Pisani, George V. N. Powell, Peter Puleston, Deborah Rabinowitz, David Schwartz, Peter Seymour, Alan P. Smith, Neal G. Smith, Edwin Richard Squiers, Ralph E. Taggart, David Waite, Doug Wechsler, Joseph M. Wunderle, Jr., and Linda D. Vardy. Frank B. Gill deserves special credit for providing supplementary data over a period of several years on the breeding population of Blue-winged Warblers at the Kalbfleisch Station. Likewise, David N. Ewert and Jon S. Greenlaw shared with me data from their concentrated studies of the Rufous-sided Towhee at Kalbfleisch. James Mansky, the current Superintendent of the Kalbfleisch Station, conducted breeding bird censuses and tree density surveys for me during the final years of the study.

Appropriate credit has been given for those photos not taken by me.

Andrew M. Greller, Associate Professor of Botany at Queens College in Flushing, New York, has been conducting research at the Kalbfleisch Station in recent years and hence was able to critically review the botanical data in this manuscript; he has my sincere thanks for his suggestions and counsel.

I have an enormous debt to my former colleague at the American Museum of Natural History, Jack McCormick, who worked closely with me to initiate the successional studies at the Kalbfleisch Station and who for many years supervised the vegetational research there. It is regrettable that his untimely death in 1979 precluded his sharing in the satisfaction that comes with the eventual

analysis and interpretation of data gathered throughout a lengthy study such as this.

To conduct a long-term research program such as this one requires an environmental laboratory seldom available to research institutions. That this is so is affirmed by the scarcity of comparable studies. It was my good fortune that Augusta S. Kalbfleisch was determined that her property on Long Island would continue to provide sanctuary for birds and other wildlife after her death, and that several succeeding administrations within the American Museum of Natural History were convinced of the research potential of this property. It was my misfortune not to have had the opportunity and pleasure of knowing Miss Kalbfleisch personally.

DESCRIPTION OF STUDY AREAS

KALBFLEISCH FIELD RESEARCH STATION

The study was confined to the Kalbfleisch Field Research Station, a 38 hectare (94 acre) field laboratory located in the Dix Hills section of the Town of Huntington, Suffolk County, New York, less than 60 km. from the center of New York City (fig. 1). The Dix Hills are part of the Ronkonkoma terminal moraine deposited during the Wisconsin glacial stage, and are located almost centrally within the main land mass that is Long Island. The soils of the Station are developed from unstratified sands and gravelly sands with varying admixtures of clay and silt fractions. The local topographic relief is only 22 m., from approximately 69 m. to 91 m. above mean sea level. High Hill (122 m.), the highest elevation on Long Island, is only 6.5 km. west of the Station. The fertility of the area soils is low. The mean annual precipitation for Long Island is 45 inches.

The mature forest in Dix Hills has been classified as Oak-Mixed Heath (Greller, 1977), a xeric oak forest with a canopy dominated by *Quercus coccinea*, *Q. alba*, and *Q. velutina* and a distinctive low shrub layer dominated by members of the heath family, notably *Gaylussacia baccata* and *Vaccin-*

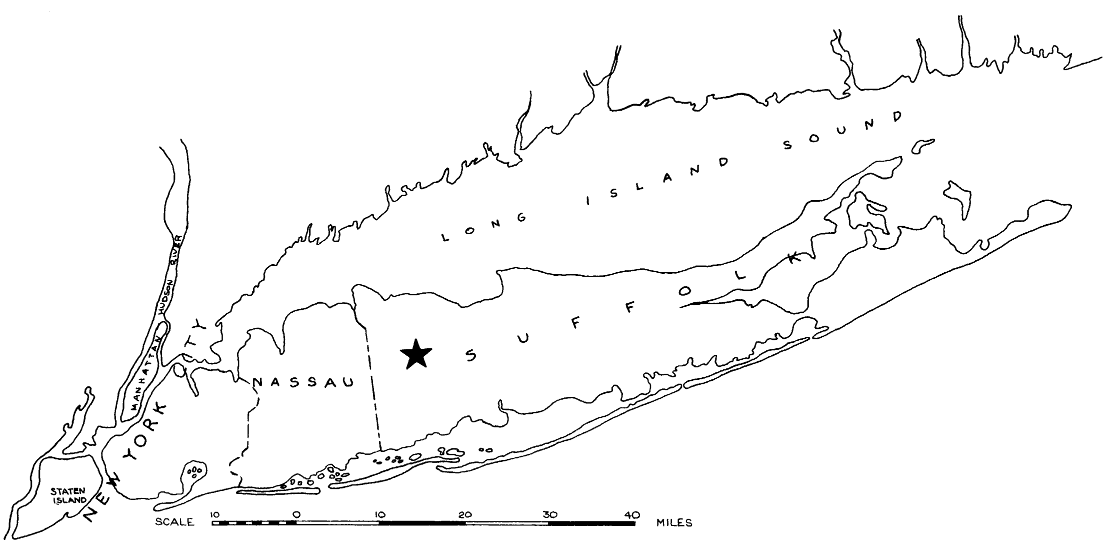

FIG. 1. Outline map of Long Island and adjacent areas to show location of the Kalbfleisch Field Research Station (star).

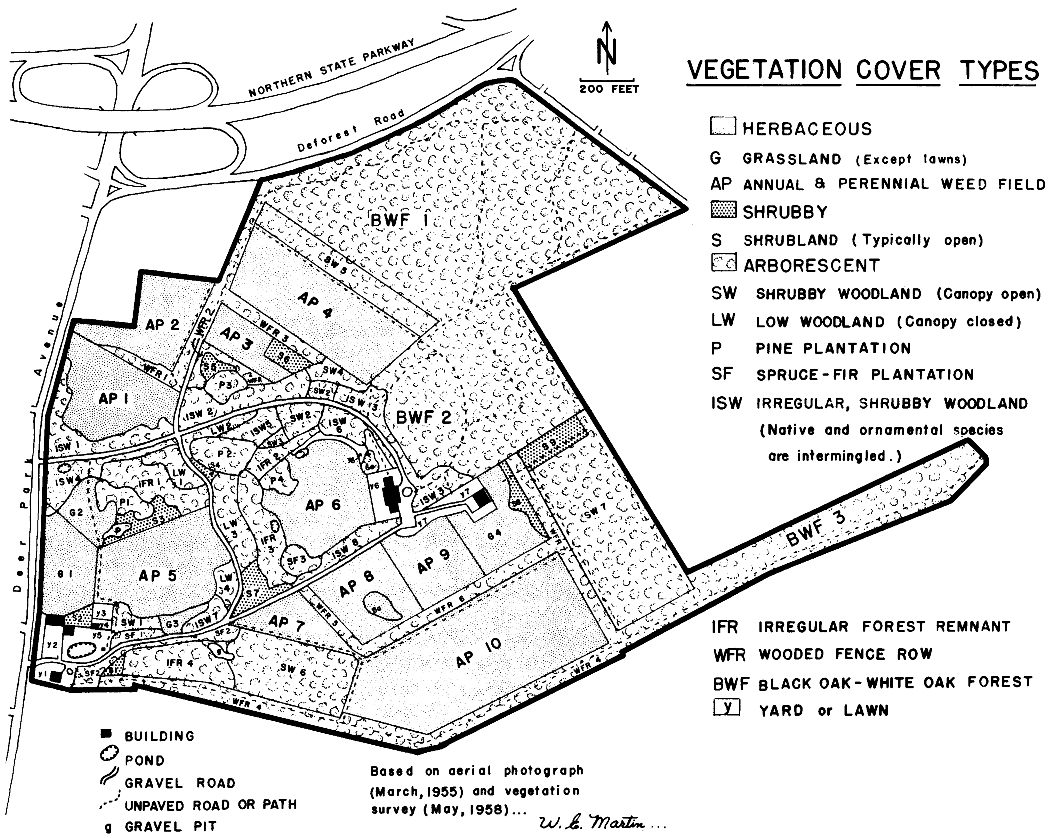

FIG. 2. Map of the Kalbfleisch Field Research Station showing vegetation cover types based on conditions extant in 1958. See text.

ium vacillans. The three predominant vegetation communities on Kalbfleisch Station are oak woodlands, shrubland and woody fencerows, and old fields. Irregular plantings of ornamental conifers border the Station's roadways and lawns. A small permanent pond and several vernal ponds and experimental pools are the only aquatic communities (fig. 2).

The land now included within the Station's boundaries had been cultivated, pastured, or operated as farm woodlots for at least 150 years before it was acquired in 1957 by the American Museum of Natural History. The property was part of a farm operated since the early 1800s by Jacob Baldwin and his descendants. In December 1929 the major part of the tract was purchased by Augusta S. Kalbfleisch.

During 1929, the last year of Baldwin ownership, the land was used for pasturage and truck farming (fig. 3, top). Agricultural activities were curtailed after 1930, new buildings and roadways were constructed, and extensive ornamental trees and shrubs were planted. Crop production was terminated in 1930 and all the fields were used as pastures or mowed for hay. From 1938 through 1954 certain fields were cultivated again for crop production. All agricultural activity under Kalbfleisch ownership was terminated after the 1954 harvest, and several of the fields have remained fallow since (fig. 3, bottom). Subsequent to the establishment of the

FIG. 3. Aerial photos of the property in Huntington, Long Island, that was to become the Kalbfleisch Field Research Station. *Top:* May 1930, courtesy of the Long Island State Park Commission; note absence of buildings, roads, and ornamental plantings; there is evidence of differential cutting in the woodlot along the northern boundary; Miss Kalbfleisch had assumed ownership of most of the land during the preceding year but did not move in until 1931. *Bottom:* March 1955, taken by Lockwood, Kessler and Bartlett of Syosset, New York; note new housing and roadways; all cultivated fields were permitted to be fallow following the harvest in 1954.

FIG. 4. Aerial photos of the Kalbfleisch Field Research Station. *Top:* June 1962, taken by Lockwood, Kessler and Bartlett of Syosset, New York, during the fifth year of the Station's operation. *Bottom:* March 1976, taken by Aerographics of Bohemia, New York, during the nineteenth year of the Station's operation; note contrast in the vegetation of control and managed study areas as delineated in figure 5.

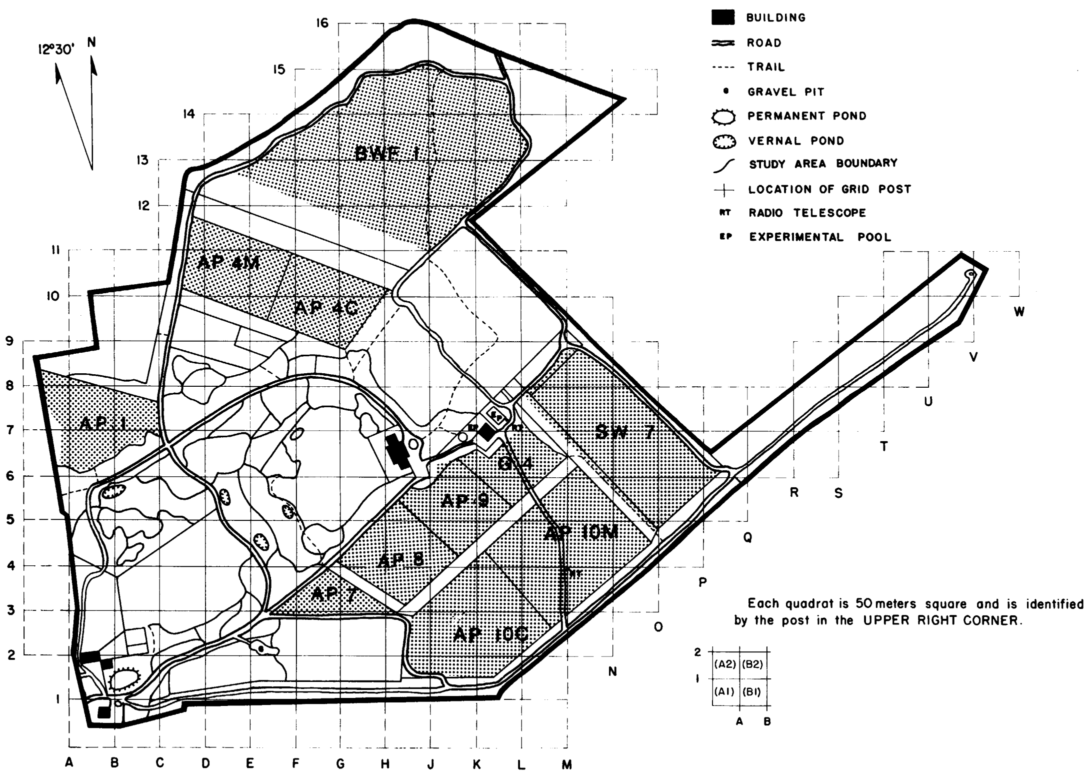

FIG. 5. Outline map of the Kalbfleisch Field Research Station with grid system and location of study areas (stippling), as identified in the text.

Kalbfleisch Field Research Station in 1958, plant succession has been arrested on selected study areas by means of various management techniques, including cultivation, controlled burning, application of silvicide, and mowing to maintain a diversity of habitat and to permit controlled studies of the responses of certain animal populations to successional and experimental changes in the plant communities (fig. 4).

Martin (MS) made a preliminary survey of the Station and prepared a map of vegetation cover types (fig. 2). The classifications used by Martin were adapted to conditions extant in 1958 and were based primarily on vegetation physiognomy and secondarily on floristic composition. Two or more stands of each physiognomic type occurred on the Station, and these stands were further distinguished by serial numerical designations, e.g., AP 1, AP 2, . . . AP 10. These alphanumeric symbols are no longer meaningful cover-type symbols, for the physiognomy of the vegetation on most of the areas has changed significantly since 1958. However, the symbols introduced by Martin have proved useful for designation of study areas and are used in that context here.

To provide a uniform and permanent system for recording precise locations on the Station, a grid of 202 quadrats 50 m. on a side was established by transit survey. The intersections of these quadrats are identified by the letter and number of the intersecting lines. Each quadrat is identified by the alphanumeric designation of the grid point in its northeast corner, and all grid points are marked with aluminum posts (fig. 5).

FIG. 6. Views of study area AP 1. *Top:* photo taken in June 1965, from the eastern boundary and looking west along the area's long axis (see fig. 5); sparse herbaceous vegetation, dominated by *Erigeron* and *Chrysanthemum leucanthemum,* characterize the field during this first year fallow; no birds nested within the study area this year. *Bottom:* during the second year after cultivation, *Solidago* and *Apocynum* have become more prominent; the Red-winged Blackbird, one of the first species to nest in fallow fields, uses a clump of *Apocynum* to support its exposed nest (arrow); photo taken by G. V. N. Powell in June 1966.

DESIGNATED STUDY AREAS: LAND-USE HISTORY, MANAGEMENT, AND SUCCESSION

In the following descriptions of the study areas I have included general information on the successional stages found on each area during the period of the study, size, soils, and land-use history. Details of vegetation as they relate to the use of these areas by breeding birds are reserved for the section on response of the birds to old field succession. Vegetation management procedures are noted, and summary information is given on the years during which breeding bird censuses were conducted. The locations of all study areas are given in figure 5.

The early stages of succession during the first few years following cultivation could be studied only on the two study areas (AP 1 and AP 7) that were cultivated as part of the Station's management program.

AP 1

This 0.80 hectare (1.98 acre) study area was censused over a 13-year period (1965–1977), during which time it passed through stages from bare soil to dense, shrubby woodland (figs. 6 and 7). It provides a longer period of continuous successional data from the bare soil stage than does AP 7.

There is a fairly uniform 5 to 7 percent slope running from east to west, and a range of elevation from 74 m. to 69 m. at the northwest corner. The soil has been classified as Bridgehampton silt loam, the dominant medium-textured soil of the Station; sandy loam (Rockaway) occurs only along the eastern and southern edges.

AP 1 was planted with corn regularly while it was part of the Baldwin farm. During Kalbfleisch ownership, it was used as a hayfield from 1930 until about 1946 and then cultivated once again (?potatoes ?corn) until permitted to go fallow following the 1954 harvest. The study area was recultivated in 1959, under the Station's vegetation management program and planted with corn, tomatoes, and squash through 1964. It has been fallow since the 1964 harvest.

AP 1 was censused for breeding birds during each of the first eight years, and in the tenth through thirteenth years following cultivation.

Data from vegetation surveys during the first eight years after cultivation are presented in table 1. The study area could be characterized as a herbaceous field for the

TABLE 1
Vegetation (Percent Cover) in Study Area AP 1 for the 8-Year Period after Cultivation
(Succession not arrested)

	Year after cultivation				
	First[a]	Second[a]	Fourth[a]	Sixth[b]	Eighth[b]
Herbaceous species					
Chrysanthemum leucanthemum	34	33	11	—	—
Erigeron	10	1	—	—	—
Ambrosia artemisiifolia	4	1	—	—	—
Hieracium	2	5	—	—	—
Apocynum	<1	2	8	<1	<1
Solidago	<1	8	66	59	50
Grasses and sedges	1	2	1	10	6
All upright woody species	<1	1	2	18	40
Myrica pensylvanica	0	0	0	15	31

[a] Based on plots in a permanently located rectangular area, 10 m. × 15 m., at the eastern end of the study area.
[b] Based on plots randomly located throughout the study area.

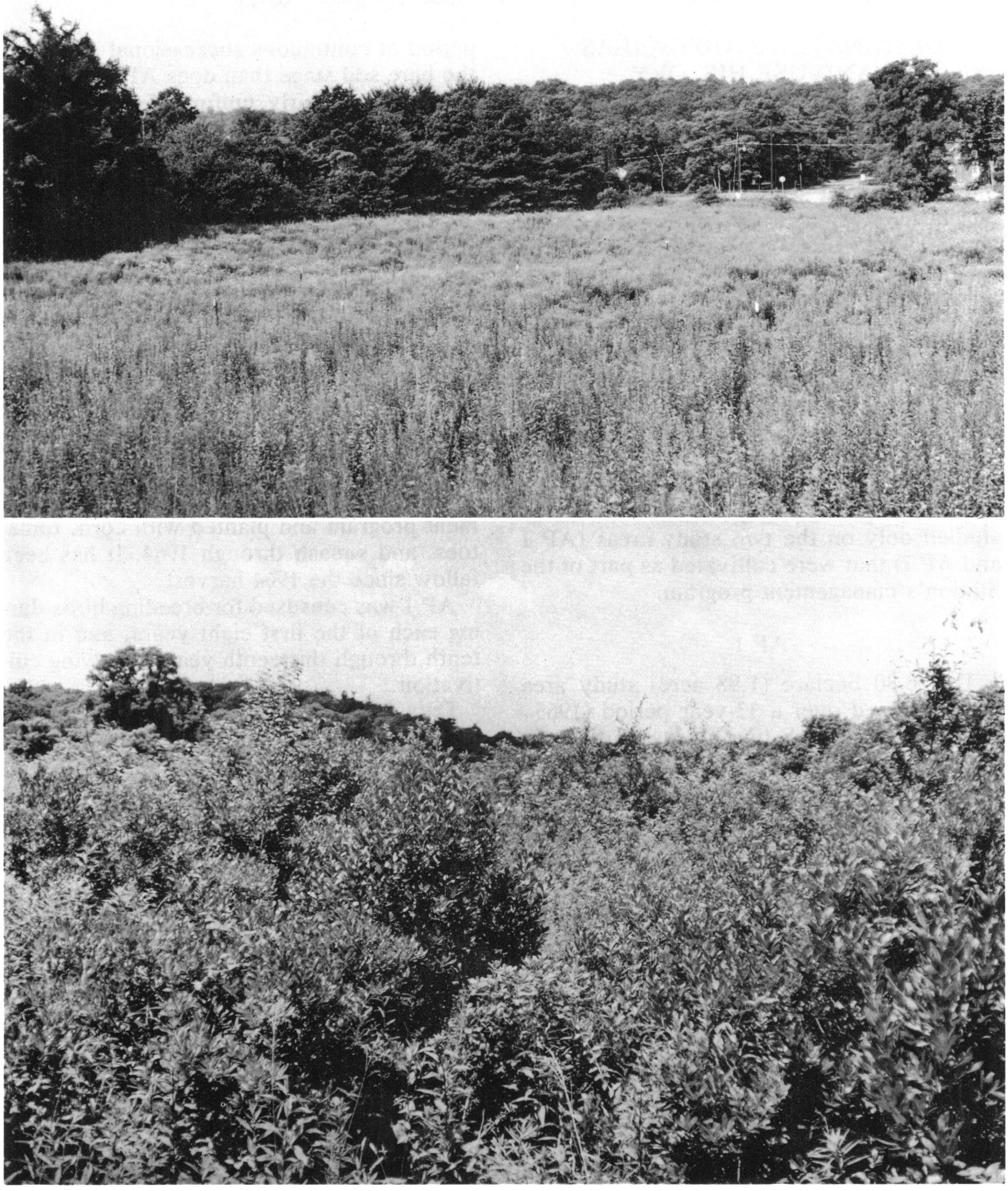

FIG. 7. Views of study area AP 1 in later stages of succession. *Top:* more dense herbaceous stage, four years after cultivation, is dominated by *Solidago*; only a few sparsely distributed clumps of woody vegetation are visible; photo taken by J. M. Wunderle, Jr., in July 1968. *Bottom:* shrubby woodland stage, 12 years after cultivation, dominated by dense growths of *Myrica pensylvanica, Prunus serotina, Pyrus sieboldii, Robinia pseudo-acacia,* and *Rosa multiflora*; Gray Catbirds first nested in AP 1 this year, using a dense grove of *Robinia pseudo-acacia*; photo taken in July 1976.

TABLE 2
Density of Trees (Over 1.25 m. High) in Study Area AP 1 12 Years after Cultivation

Species	Relative density (in %)	Density by height class (in cm.)					
		126–275	276–425	426–575	576–725	726–875	876–1025
Myrica pensylvanica	53	358[a]	20	0	0	0	0
Prunus serotina	19	45	69	13	6	1	0
Pyrus sieboldii	19	50	83	1	0	0	0
Robinia pseudo-acacia	4	4	2	8	13	2	1
Rosa multiflora	2	13	1	0	0	0	0
Rhus copallina	1	7	2	0	0	0	0
Viburnum dentatum	1	8	0	0	0	0	0
All species[b]	100	487	181	23	20	5	1

[a] Number of trees recorded in a 1000 m^2 transect; multiply by 10 to convert to density per hectare.
[b] Includes the following, none of which had a relative density greater than 1 percent: *Larix leptolepis, Quercus, Betula populifolia,* and *Acer ginnala.*

first four years, with no significant cover provided by woody species. Aspect dominants during the first year after cultivation were *Chrysanthemum leucanthemum* and *Erigeron* (fig. 6, top), but by the fourth year dominance had shifted to *Solidago* (fig. 7, top). It was during the next four years that low growths of upright woody vegetation became conspicuous, including *Myrica pensylvanica, Pyrus sieboldii, Prunus serotina,* and *Rosa multiflora*. A few *Robinia pseudo-acacia* had reached heights of 6 m. The number of trees and shrubs increased dramatically during the last four years of the study period (fig. 7, bottom), and tables 2 and 3 reflect the diversity and size of this growth during the twelfth year after cultivation. The densest growths were still *Myrica, Prunus,* and *Pyrus* at heights of 2 to 4 m. generally, whereas some *Robinia* and *Prunus* had grown to 10 m., the former with diameters (at breast height) up to 18 cm.

AP 7

The second study area that provides successional data from the bare soil stage is AP 7, a 0.41 hectare (1.01 acre) triangle, which was cultivated twice and censused

TABLE 3
Density of Trees (Over 7 cm. in Diameter at Height of 1.25 m.) in Study Area AP 1 12 Years after Cultivation

Species	Relative density (in %)	Density by diameter class (in cm.)				
		8–10	11–13	14–16	17–19	20–22
Robinia pseudo-acacia	59	18[a]	6	3	2	0
Larix leptolepis	16	4	4	0	0	0
Prunus serotina	10	5	0	0	0	0
Pyrus sieboldii	6	2	1	0	0	0
Quercus velutina	4	2	0	0	0	0
Pinus	4	2	0	0	0	0

[a] Number of trees recorded in a 1000 m^2 transect; multiply by 10 to convert to density per hectare.

FIG. 8. Views of study area AP 7 during the second seven-year cycle of succession from cultivation to open shrubland, taken from the eastern corner looking west (see fig. 5). *Top:* second year after cultivation; herbaceous stage, dominated by *Solidago, Hieracium* and *Ambrosia artemisiifolia*; Field Sparrows nested at the edge of the study area at this stage; photo taken by D. Wechsler in June 1972. *Bottom:* sixth year after cultivation, showing prominent clumps of *Myrica pensylvanica* that are used as song perches by Common Yellowthroats and Blue-winged Warblers; photo taken in July 1976.

TABLE 4
Vegetation (Percent Cover) in Study Area AP 7 for the 6-Year Period after Cultivation (First Cycle)
(Succession not arrested)

	Year after cultivation					
	First[a]	Second[a]	Third[a]	Fourth[b]	Fifth[b]	Sixth[b]
Herbaceous species						
Chrysanthemum leucanthemum	2	1	1	2	2	1
Erigeron	8	1	1	1	1	1
Ambrosia artemisiifolia	4	10	<1	<1	<1	1
Hieracium	7	13	37	45	42	59
Apocynum	0	0	0	0	<1	<1
Solidago	4	16	22	26	18	23
Grasses and sedges	4	1	1	2	8	12
All upright woody species	<1	<1	2	4	6	29
Myrica pensylvanica	0	<1	1	3	5	26

[a] Based on plots at permanently marked positions along transects throughout the study area.
[b] Based on plots randomly located throughout the study area.

over two seven-year cycles of succession from bare soil to open shrubland (fig. 8). Although it provides a shorter period of successional data from the bare soil stage than does AP 1 (seven years instead of 12), the two cycles yielded a larger sample of breeding bird data for these early stages of succession than did AP 1.

The terrain slopes gently toward the north and west, with a range of elevation from 79 m. to 83 m. A large part of this field is Rockaway sandy loam (the dominant moderately coarse-textured soil of the Station). Small areas are gravelly and subsoil texture is coarser than the surrounding sandy loam.

The field was mowed for hay until 1947, planted with potatoes from 1948 until 1953 and with cabbage in 1954, the last year of cultivation under Kalbfleisch ownership. It remained fallow for the next four years, and then was planted in corn in 1959, 1960, and 1961 under the Station's vegetation management program.

While fallow for the next seven years (1962 through 1968) AP 7 was censused for all species of breeding birds during the third, fifth, sixth, and seventh years. Additional data on certain species are available for the first and second years. This study area was cultivated once again (but no crop planted) in 1969 and 1970, to repeat this seven year cycle. During the second cycle bird censuses were conducted in the first, second, fourth, sixth, and seventh years.

Data from vegetation surveys during the first six years after cultivation (first cycle) are presented in table 4 and reveal a rapid growth of *Solidago* and *Hieracium,* both of which had achieved prominence by the third year. As in AP 1, woody species provided significant cover by the sixth year, with *Myrica* clearly the dominant species.

Two fields (AP 4, AP 10) had already been fallow for four years when the Station was established in 1958. In 1960 each field was divided approximately in half, and the resulting sections were arbitrarily designated as "managed" and "control." Succession was arrested at the herbaceous stage on the managed sections, through procedures identified below, but permitted to continue to dense, shrubby woodland in the control sections. The increasing disparity between the vegetation of these managed and control sections can be appreciated by locating and comparing these study areas on the map in figure 5 and then in the aerial photos in figure 3, bottom, and figure 4, bottom.

FIG. 9. Views of study area AP 4C, in which succession was permitted to proceed to a woodland stage; taken from the southeast corner, looking north across the study area (see fig. 5). *Top:* herbaceous stage, five years after cultivation, is still dominated by *Solidago, Apocynum,* and *Hieracium*; small saplings of *Robinia pseudo-acacia* along the northern border reveal direction from which invasion by that species will occur; photo taken in July 1959. *Bottom:* woodland stage, 22 years after cultivation, is dominated by *Robinia pseudo-acacia,* with an understory of *Solidago* and thickets of *Rosa multiflora*; Gray Catbirds and Rufous-sided Towhees nested regularly at this stage; photo taken in July 1976.

TABLE 5
Vegetation (Percent Cover) in Study Area AP 4 C for the 16-Year Period after Cultivation
(Succession not arrested)

	Year after cultivation			
	Sixth[a]	Eighth[a]	Eleventh[b]	Sixteenth[a]
Herbaceous species				
Solidago	26	42	59	47
Apocynum	10	7	8	15
Hieracium	10	17	25	8
Grasses and sedges	29	16	5	4
All upright woody species	2	2	14	26
Myrica pensylvanica	1	1	8	10
Robinia pseudo-acacia	<1	<1	3	10
Rosa multiflora	0	0	<1	2
Pyrus sieboldii	0	0	1	1

[a] Based on plots at permanently marked positions along transects throughout the study area.
[b] Based on plots randomly located throughout the study area.

AP 4C

This 0.83 hectare (2.05 acres) study area was censused over a 16-year period (1962–1977), during which time it passed through the successional stages from herbaceous field to dense, shrubby woodland (fig. 9).

There is a fairly uniform 4 to 6 percent slope running from northeast to southwest, and a range of elevation from 77 m. to 73 m. at the southwest corner. The principal soil type is Bridgehampton gritty silt loam, and is moderately well drained. A strip of Rockaway sandy loam occurs along the southern edge and also along the northeastern edge.

The field was used for hay when it was part of the Baldwin farm, and mowing continued until 1946 under Kalbfleisch ownership. Potatoes were planted from 1947 until 1953, followed by cabbage in 1953 and 1954. After the harvest in 1954 the field was permitted to revegetate naturally.

Table 5 illustrates the increase in cover provided by woody vegetation during the study period. *Solidago* and *Hieracium* continued as prominent components of the herb layer, but grasses and sedges decreased dramatically. For a profile of the development of the dense, shrubby woodland in this study area, see tables 6 and 7. Sections of this woodland were dominated by *Robinia pseudo-acacia*, with a sparse understory of *Rubus* and *Rosa multiflora*. In the more open areas not occupied by *Robinia* there were clumps of *Myrica pensylvanica* and scattered individuals of *Juniperus virginiana* and *Pyrus sieboldii*.

Censuses of the breeding birds in this study area were conducted almost annually from 1962 (eighth year after cultivation) through 1977 (twenty-third year after cultivation).

AP 4M

Plant succession was arrested at the herbaceous stage on this 0.89 hectare (2.19 acres) study area by means of a program of controlled burning and mowing (fig. 10). There is a fairly uniform 4 to 6 percent slope running from northeast to southwest, and a range of elevation from 75 m. to 70 m. at the southwest corner. Soil, drainage, and previous land-use history are as in AP 4C.

After the 1954 harvest this area was permitted to revegetate naturally for five years. In 1960 I initiated a program of controlled burning to arrest plant succession at the herbaceous stage, and conditions permitted ef-

TABLE 6
Density of Trees (Over 50 cm. High) in Study Area AP 4 C During the 22-Year Period after Cultivation

Species and year after cultivation	Relative density (in %)	Density (per hectare) by height class (in cm.)							
		50–125	126–275	276–425	426–575	576–725	726–875	876–1025	1026–1175
Robinia pseudo-acacia									
Eighth	16	40	22	9	0	0	0	0	0
Eleventh	34	113	249	43	24	0	0	10	0
Sixteenth	50	250	550	319	188	106	44	63	13
Twenty-second	61	NA[a]	35	135	120	330	215	195	80
Myrica pensylvanica									
Eighth	54	75	164	0	0	0	0	0	0
Eleventh	47	268	337	0	0	0	0	0	0
Sixteenth	26	344	406	31	0	0	0	0	0
Twenty-second	21	NA	385	5	0	0	0	0	0
Pyrus sieboldii									
Eighth	14	49	13	0	0	0	0	0	0
Eleventh	8	40	60	10	0	0	0	0	0
Sixteenth	6	63	50	44	19	0	0	0	0
Twenty-second	5	NA	25	55	15	0	0	0	0
Juniperus virginiana									
Eighth	3	9	4	0	0	0	0	0	0
Eleventh	4	34	14	0	0	0	0	0	0
Sixteenth	2	19	38	13	0	0	0	0	0
Twenty-second	2	NA	15	10	0	10	0	0	0
Acer									
Eighth	1	4	0	0	0	0	0	0	0
Eleventh	3	25	9	0	0	0	0	0	0
Sixteenth	2	62	6	6	0	0	0	0	0
Twenty-second	2	NA	25	5	0	0	0	0	0
Rubus									
Eighth	5	22	0	0	0	0	0	0	0
Eleventh	0	0	0	0	0	0	0	0	0
Sixteenth	4	113	0	0	0	0	0	0	0
Twenty-second	6	NA	110	0	0	0	0	0	0
Rosa multiflora									
Eighth	1	4	0	0	0	0	0	0	0
Eleventh	<1	5	0	0	0	0	0	0	0
Sixteenth	2	25	50	0	0	0	0	0	0
Twenty-second	2	NA	25	5	0	0	0	0	0
All species[b]									
Eighth	100	219	211	9	0	0	0	0	0
Eleventh	100	482	726	53	24	0	0	10	0
Sixteenth	100	1076	1137	419	207	106	44	63	13
Twenty-second	100	NA	625	230	135	355	215	195	80

[a] Data not recorded.
[b] Includes the following species not represented above, none of which has a relative density greater than 1 percent: *Rhus, Viburnum, Cornus florida, Prunus, Vaccinium vacillans, Berberis thunbergeii, Pinus, Quercus, Carya ovalis.*

FIG. 10. Views of study area AP 4M, maintained at the herbaceous stage by means of periodic controlled burning. *Top:* view looking northeast along the eastern boundary of the study area (see fig. 5), showing the intensity of the controlled burn; a kerosene flame-thrower is used to initiate the burn; photo taken by R. G. Zweifel in April 1965. *Bottom:* view looking northwest across the study area from the southeast corner; *Solidago* and *Apocynum* are the dominant plant taxa, with no upright woody vegetation; Red-winged Blackbirds continue to nest throughout the study area, whereas Common Yellowthroats use the edge, close to elevated perches provided by bordering wooded fence rows; photo taken in July 1976.

TABLE 7
Density of Trees (Over 7 cm. in Diameter at Height of 1.25 m.) in Study Area AP 4 C 22-Years after Cultivation

Species	Relative density (in %)	Density (per hectare) by diameter class (in cm.)					
		8–10	11–13	14–16	17–19	20–22	23–35
Robinia pseudo-acacia	93	860	490	230	40	20	5
Prunus serotina	2	5	20	5	0	0	0
Populus grandidentata	2	15	20	5	0	0	0
Pyrus sieboldii	1	20	0	5	0	0	0
Betula	<1	5	0	0	5	0	0
Juniperus virginiana	<1	10	0	0	0	0	0
Pinus strobus	<1	5	0	0	0	0	0
All species	100	920	530	245	45	20	5

fective burns periodically from 1960 through 1970 (fig. 10). The controlled burns eliminated woody vegetation and favored the forbs over grasses and sedges, as indicated in table 8. The average cover provided by *Solidago* and *Hieracium* remained high, with the goldenrods actually increasing in dominance throughout this period. From 1972 through 1975 mowing (once annually, in August) was substituted for burning. No vegetational surveys were made on the area subsequent to 1970, but it was apparent from observation of the field that the change from a controlled burn to mowing favored the grasses over the forbs during the last seven years of the study.

Breeding bird censuses were conducted on this study area almost annually from 1962 (third year of management) through 1977 (eighteenth year of management).

AP 10C

This 1.40 hectare (3.46 acre) study area was censused over a 16-year period (1962–1977), during which time it passed through the successional stages from herbaceous field to dense, shrubby woodland (figs. 11 and 12).

TABLE 8
Vegetation (Percent Cover) in Study Area AP 4 M for the 16-Year Period after Cultivation
(Succession arrested after the sixth year)

	Year after cultivation			
	Sixth[a]	Eighth[a]	Eleventh[b]	Sixteenth[a]
Herbaceous species				
Solidago	21	30	62	75
Apocynum	19	17	11	22
Hieracium	11	17	18	14
Grasses and sedges	35	18	5	4
All upright woody species	1	2	3	5
Myrica pensylvanica	<1	<1	2	2
Robinia pseudo-acacia	0	0	0	0

[a] Based on plots at permanently marked positions along transects throughout the study area.
[b] Based on plots randomly located throughout the study area.

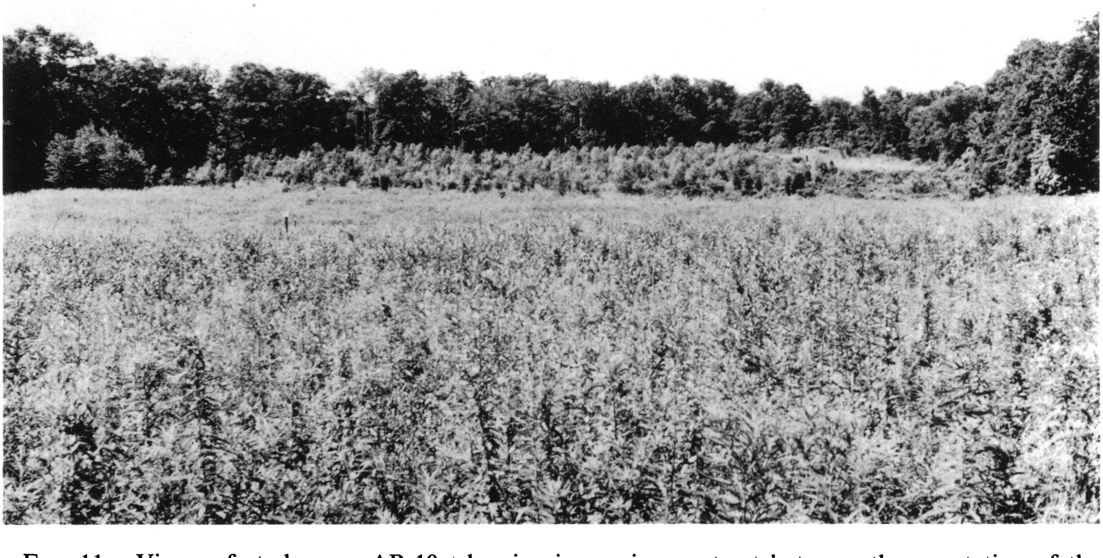

FIG. 11. Views of study area AP 10, showing increasing contrast between the vegetation of the managed and control sections. *Top:* looking southwest down the length of AP 10M (foreground) and AP 10C (see fig. 5); note absence of woody vegetation on the slightly higher elevations of the control section; photo taken by F. B. Gill in June 1960. *Bottom:* same view as above, but note the growth of woody vegetation in the control section, 14 years after cultivation; photo taken by D. N. Ewert in July 1968.

FIG. 12. Views of study area AP 10, showing the contrast between the vegetation on the managed and control sections at the end of the study period, 22 years after cultivation. *Top:* same view as in figure 11, but note increase in size of trees in AP 10C (background); photo taken in July 1976. *Bottom:* view along the border of AP 10C (left) and AP 10M (right); photo taken in July 1976.

TABLE 9
Vegetation (Percent Cover) in Study Area AP 10 C for the 17-Year Period after Cultivation
(Succession not arrested)

	Year after cultivation			
	Sixth[a]	Ninth[a]	Thirteenth[a]	Seventeenth[a]
Herbaceous species				
Solidago	14	26	41	56
Apocynum	1	1	1	1
Hieracium	9	10	32	12
Grasses and sedges	23	6	12	6
All upright woody species	4	3	34	41
Myrica pensylvanica	<1	<1	9	10
Pyrus sieboldii	0	0	6	12
Betula	3	1	13	9
Rosa multiflora	0	0	<1	1

[a] All surveys based on plots at permanently marked positions along transects throughout the study area.

The slope over much of the area is a gentle 4 to 8 percent, but a knob that marks the southwestern corner has a localized slope of as much as 24 percent. The elevation ranges from 87 m. on the knob at the western end to 81 m. at the northernmost corner. A mound and furrow microtopography, oriented perpendicular to the contour of the slope, is pronounced and has been maintained by some sheet erosion. The principal soil type is Rockaway sandy loam, but the knob at the western end is largely Galestown loamy sand.

The field was planted with corn prior to 1930, and used as a pasture from then until about 1946. Potatoes were planted from 1947 to 1953, and cabbage was raised in the field in 1954. After the 1954 harvest the area was permitted to revegetate naturally. Table 9 illustrates the increase in cover of woody species during the study period. When one compares the shrubby woodlands that developed in AP 4C and AP 10C (tables 6 and 10), several differences are noteworthy: (1) the complete absence of *Robinia pseudoacacia* in AP 10C and the dominance of this species over much of AP 4C; (2) the increase in relative density of *Myrica pensylvanica* in AP 10C in marked contrast to the decrease of this species in AP 4C, perhaps because of, and certainly correlated with, the dominance of *Robinia*; (3) the initial prominence of *Betula* in AP 10C followed by their decline in both relative and absolute density, and the absence of these species in the samples from AP 4C. As in AP 4C, *Solidago* and *Hieracium* continued as prominent components of the herb layer in AP 10C, whereas the cover of grasses and sedges decreased (table 9).

Censuses of breeding birds were conducted on this study area almost annually from 1962 (eighth year after cultivation) through 1977 (twenty-third year after cultivation).

AP 10M

Plant succession was arrested at the herbaceous stage on this 1.43 hectare (3.52 acre) study area, initially by selective applications of a silvicide and later by mowing (figs. 11 and 12).

There is a fairly uniform and gentle 3 to 5 percent slope from northeast to southwest, and a range of elevation from 86 m. to 81 m. at the southwest corner. The soil is moderately well drained and classified as Bridgehampton silt loam and, to a lesser extent, Rockaway sandy loam. Land-use history prior to 1962 is as in AP 10C.

In 1962 I initiated a program of removal of upright woody vegetation by cutting stems close to the ground and painting the stems

TABLE 10
Density of Trees (Over 50 cm. High) in Study Area AP 10 C During the 22-Year Period after Cultivation

Species and year after cultivation	Relative density (in %)	Density (per hectare) by height class (in cm.) 50–125	126–275	276–425	426–575	576–725	726–875	876–1025	1026–1175
Betula									
Seventh	51	780	0	0	0	0	0	0	0
Thirteenth	31	82	382	241	0	0	0	0	0
Seventeenth	19	264	294	218	88	12	0	6	0
Twenty-second	8	112	95	158	29	24	6	0	6
Myrica pensylvanica									
Seventh	23	357	0	0	0	0	0	0	0
Thirteenth	21	218	259	0	0	0	0	0	0
Seventeenth	31	1100	359	0	0	0	0	0	0
Twenty-second	57	594	2494[a]	0	0	0	0	0	0
Pyrus sieboldii									
Seventh	8	122	0	0	0	0	0	0	0
Thirteenth	15	35	259	47	0	0	0	0	0
Seventeenth	11	194	170	158	12	0	0	0	0
Twenty-second	7	12	147	176	29	0	0	0	0
Juniperus virginiana									
Seventh	5	83	0	0	0	0	0	0	0
Thirteenth	17	94	252	47	0	0	0	0	0
Seventeenth	10	118	153	159	12	6	0	0	0
Twenty-second	7	41	76	165	71	30	0	0	0
Rhus									
Seventh	5	73	0	0	0	0	0	0	0
Thirteenth	9	124	76	0	0	0	0	0	0
Seventeenth	7	188	153	0	0	0	0	0	0
Twenty-second	8	118	317	0	0	0	0	0	0
Acer									
Seventh	0	0	0	0	0	0	0	0	0
Thirteenth	1	18	0	0	0	0	0	0	0
Seventeenth	4	165	6	0	0	0	0	0	0
Twenty-second	3	88	88	0	0	0	0	0	0
Quercus									
Seventh	<1	6	0	0	0	0	0	0	0
Thirteenth	<1	0	12	0	0	0	0	0	0
Seventeenth	2	71	18	6	0	0	0	0	0
Twenty-second	3	47	88	30	0	6	0	0	0
Pinus									
Seventh	<1	6	0	0	0	0	0	0	0
Thirteenth	1	0	18	6	0	0	0	0	0
Seventeenth	2	24	30	12	6	0	0	0	0
Twenty-second	2	0	12	41	18	12	0	0	0

TABLE 10—(*Continued*)

Species and year after cultivation	Relative density (in %)	Density (per hectare) by height class (in cm.)							
		50–125	126–275	276–425	426–575	576–725	726–875	876–1025	1026–1175
Viburnum dentatum									
Seventh	<1	11	0	0	0	0	0	0	0
Thirteenth	2	12	24	0	0	0	0	0	0
Seventeenth	2	41	59	0	0	0	0	0	0
Twenty-second	1	0	30	18	0	0	0	0	0
All species[b]									
Seventh	100	1529	0	0	0	0	0	0	0
Thirteenth	100	607	1306	347	0	0	0	0	0
Seventeenth	100	2689	1272	553	130	18	0	6	0
Twenty-second	100	1152	3418	594	153	72	6	0	6

[a] Unusually high figure, undoubtedly due to recording "stems" rather than "clumps" in this survey.
[b] Includes the following species not represented above, none of which had a relative density greater than 1 percent: *Baccharis halimifolia, Sassafras albidum, Rosa multiflora, Rubus, Cornus florida, Celastrus orbiculates, Elaeagnus umbellata, Berberis thunbergii.*

with a silvicide (mixture of 190 ml. of 2, 4, 5 - T in 3.8 liters of kerosene). As a result of this management program, the woody vegetation was effectively eliminated (table 12). The average cover provided by *Solidago* and *Hieracium* remained high, with goldenrods actually increasing in prominence, whereas the growth of grasses and sedges declined. From 1972 through 1975 mowing (once annually, in August) was substituted for the treatment with silvicide. No vegetational surveys were made on the area subsequent to 1971, but this change in the method of arresting succession favored the grasses over the forbs during the final six years of the study. Censuses of breeding birds were conducted on this study area almost annually from 1962 (first year of management) through 1977 (sixteenth year of management).

AP 8,9/G 4

This is a heterogeneous study area, made up of three components with very different soil types and land-use history. Succession

TABLE 11
Density of Trees (Over 7 cm. in Diameter at Height of 1.25 m.) in Study Area AP 10 C 22-Years after Cultivation

Species	Relative density (in %)	Density (per hectare) by diameter class (in cm.)				
		8–10	11–13	14–16	17–19	20–22
Betula	40	90	15	10	15	5
Juniperus virginiana	31	80	25	0	0	0
Quercus	9	25	0	5	0	0
Pinus strobus	7	15	10	0	0	0
Acer	6	15	5	0	0	0
Prunus	6	5	0	10	5	0
Carya ovalis	1	0	0	5	0	0
All species	100	230	55	30	20	5

TABLE 12
Vegetation (Percent Cover) in Study Area AP 10M for the 17-Year Period after Cultivation
(Succession arrested after the eighth year)

	Year after cultivation			
	Sixth[a]	Ninth[a]	Thirteenth[a]	Seventeenth[a]
Herbaceous species				
Solidago	18	29	35	49
Apocynum	6	2	4	7
Hieracium	6	4	14	11
Grasses and sedges	16	4	6	5
All upright woody species	3	45[b]	3	3
Myrica pensylvanica	1	29[b]	<1	<1

[a] All surveys based on plots at permanently marked positions along transects throughout the study area.
[b] Program to remove upright woody vegetation, only in its second year, not yet fully effective.

was arrested at the herbaceous stage and grasses were encouraged by mowing (fig. 13). The 1.66 hectare (4.10 acre) study area was censused over a 16-year period (1962–1977).

The study area may be thought of as a G 4–AP 9–AP 8 topographic sequence, ranging in elevation from 85 m. on the knoll at the northeastern corner (G 4) to a low point of 80 m. at the southwestern end (AP 8). The well- to moderately well-drained soils vary from a Galestown sand and Haven silt loam in G 4, through Rockaway sandy loam in AP 9, to a shallow depression of imperfectly drained Bridgehampton silt loam in AP 8.

G 4 was used as a hay field until about 1950, sometimes planted with *Phleum pratense* and *Trifolium*, but not cultivated. From about 1950 until 1967 this portion of the study area was unmanaged. I initiated a program of mowing (once annually, in August) in 1967, and this management procedure was followed through 1975. In the fall of 1969 an accidental fire burned much of the ground cover in G 4.

The central part of this study area, AP 9, was also used as a hay field, but then was cultivated from 1936 until 1954 as a combination flower and vegetable garden. It was permitted to revegetate naturally after the

TABLE 13
Vegetation (Percent Cover) in Study Area AP 8,9/G 4
(Succession arrested)

	Total study area			G 4 (not cultivated)			AP 8,9 (cultivated until 1954)		
	1962[a]	1970[a]	1972[a]	1962	1970	1972	1962	1970	1972
Herbaceous species									
Solidago	23	31	15	4	19	7	33	33	18
Grasses and sedges	51	46	54	78	49	57	37	34	53
All upright woody species	3	3	<1	3	3	<1	4	3	1
Myrica pensylvanica	1	<1	<1	1	<1	<1	0	<1	<1

[a] All surveys based on plots randomly located throughout the study area.

FIG. 13. *Top:* view of study area AP 8,9/G 4, maintained as a grassland community through annual mowing; looking northeast down the length of the study area (see fig. 5); photo taken in July 1976. *Bottom:* view of study area SW 7 in July 1972, 40 years after cultivation; the poles used to support mist nets are 3.5 m. long; photo taken by D. Wechsler.

TABLE 14

Density of Trees (Over 7 cm. in Diameter at Height of 1.25 m.) in Study Area SW 7 46 Years after Cultivation

Species	Relative density (in %)	Density by diameter class (in cm.)														
		8–10	11–13	14–16	17–19	20–22	23–35	26–28	29–31	32–34	35–37	38–40	41–43	44–46	47–49	50–52
Quercus	30	78[a] (41)[b]	55 (29)	50 (27)	36 (19)	21 (11)	8 (4)	10 (5)	7 (4)	11 (6)	4 (2)	4 (2)	3 (2)	1 (.5)	0	2 (1)
Prunus	17	35 (19)	31 (16)	19 (10)	27 (14)	16 (9)	16 (9)	13 (7)	1 (.5)	2 (1)	0	1 (.5)	3 (2)	0	0	0
Cornus florida	17	82 (44)	45 (24)	20 (11)	6 (3)	8 (4)	2 (1)	1 (.5)	0	0	0	0	0	0	0	0
Nyssa sylvatica	11	27 (14)	20 (11)	8 (4)	18 (10)	13 (7)	10 (5)	5 (3)	2 (1)	0	0	0	0	0	0	0
Sassafras albidum	8	31 (16)	18 (10)	12 (6)	7 (4)	5 (3)	3 (2)	0	0	1 (.5)	0	0	0	0	0	0
Juniperus virginiana	4	15 (8)	13 (7)	6 (3)	3 (2)	4 (2)	0	1 (.5)	0	0	0	0	0	0	0	0
Carya ovalis	4	18 (10)	14 (7)	3 (2)	4 (2)	1 (.5)	1 (.5)	0	0	0	0	0	0	0	0	0
Acer	3	6 (3)	8 (4)	3 (2)	5 (3)	0	1 (.5)	3 (2)	3 (2)	2 (1)	0	0	0	0	0	0
Pyrus sieboldii	1	3 (2)	2 (1)	7 (4)	0	0	1 (.5)	1 (.5)	0	0	0	0	0	0	0	0
Betula	1	9 (5)	2 (1)	0	0	0	1 (.5)	0	0	0	0	0	0	0	0	0
Juglans nigra	1	3 (2)	1 (.5)	1 (.5)	0	1 (.5)	0	0	0	0	0	0	0	0	0	0
Pinus rigida	<1	1 (.5)	0	0	0	0	1 (.5)	0	0	0	0	0	0	0	0	0

[a] Number of trees recorded throughout the study area.

[b] Density per hectare.

1954 harvest and was included in the mowing program from 1967 through 1975.

Mowing on the southwestern section (AP 8) continued until 1947, after which it was planted to potatoes until 1953. Cabbage was raised in AP 8 in 1954, and then this section was permitted to revegetate naturally. All of AP 8 was mowed in August 1963, and then annually from 1967 through 1975.

In table 13 one can appreciate the influence of annual mowing and of previous land-use history on the relative prominence of grasses and sedges and of *Solidago* in this study area, the closest approximation to a grassland habitat on the Station.

SW 7

This 1.88 hectare (4.64 acre) woodland provided the oldest old field community (up to 45 years after cultivation) available on the Station, and was censused over a 17-year period (1961–1977; fig. 13).

The slope over most of this well-drained area is a gentle 4 to 6 percent. The principal soil type is a gritty Haven silt loam. The field was used as a pasture until about 1930, planted with corn in 1931 and 1932, and permitted to revegetate naturally thereafter. The increase in density of the woody vegetation throughout the 45 years after cultivation of this field can be appreciated by first locating the study area on the map in figure 5, and then by comparing its appearance in the aerial photos in figures 3 and 4.

Table 14 presents a profile of the density of the trees in this study area, 46 years after cultivation.

BWF 1

This 3.56 hectare (8.80 acre) woodland provided the oldest vegetational community on the Station (fig. 29). I have included this particular woodland habitat solely to comment on the presence or absence of those species of breeding birds discussed here in relation to old field succession.

At the turn of the century the dominant tree species was *Castanea dentata,* but today there are only scattered sprout-clumps and small saplings due to the introduction of chestnut blight fungus (*Endothia parisitica*) in the early 1900s. The area was virtually clear cut in 1910, though a few trees predate 1910 as shown by ring counts of core samples. The ensuing sprout woodland was selectively cut and subjected to some management (e.g., removal of dead trees) during Kalbfleisch ownership, 1930–1957. There has been no management of the study area since 1957. Today the woodland is dominated by three species of *Quercus* (*coccinea, velutina,* and *alba*), with a well-developed understory of *Cornus florida, Gaylussacia baccata, Vaccinium vacillans,* and *Viburnum acerifolium.* The soils are loam and sandy loam textures, and the topography is characterized by gently rolling 4 to 8 degree slopes and is well drained.

METHODS

VEGETATION SURVEYS

A study of plant succession in the old fields at the Kalbfleisch Station, paralleling that of avian succession, provides data (heretofore unpublished) that characterizes the vegetation of each of the study areas throughout the period of this study. Since my objective is not the documentation of plant succession, I have presented data only for certain plant species or groups of species, selected either on the basis of their relevancy to the subject of avian succession or because they are aspect dominants that help to characterize a certain stage of succession. This reliance on a data base generated for another study, with quite different objectives, has resulted in some inconsistencies in methodology that must be identified here. The data most useful for my purposes are those on average cover of herbaceous species and of upright woody species, and on the density of trees by height class and by diameter.

Average cover of herbaceous and woody

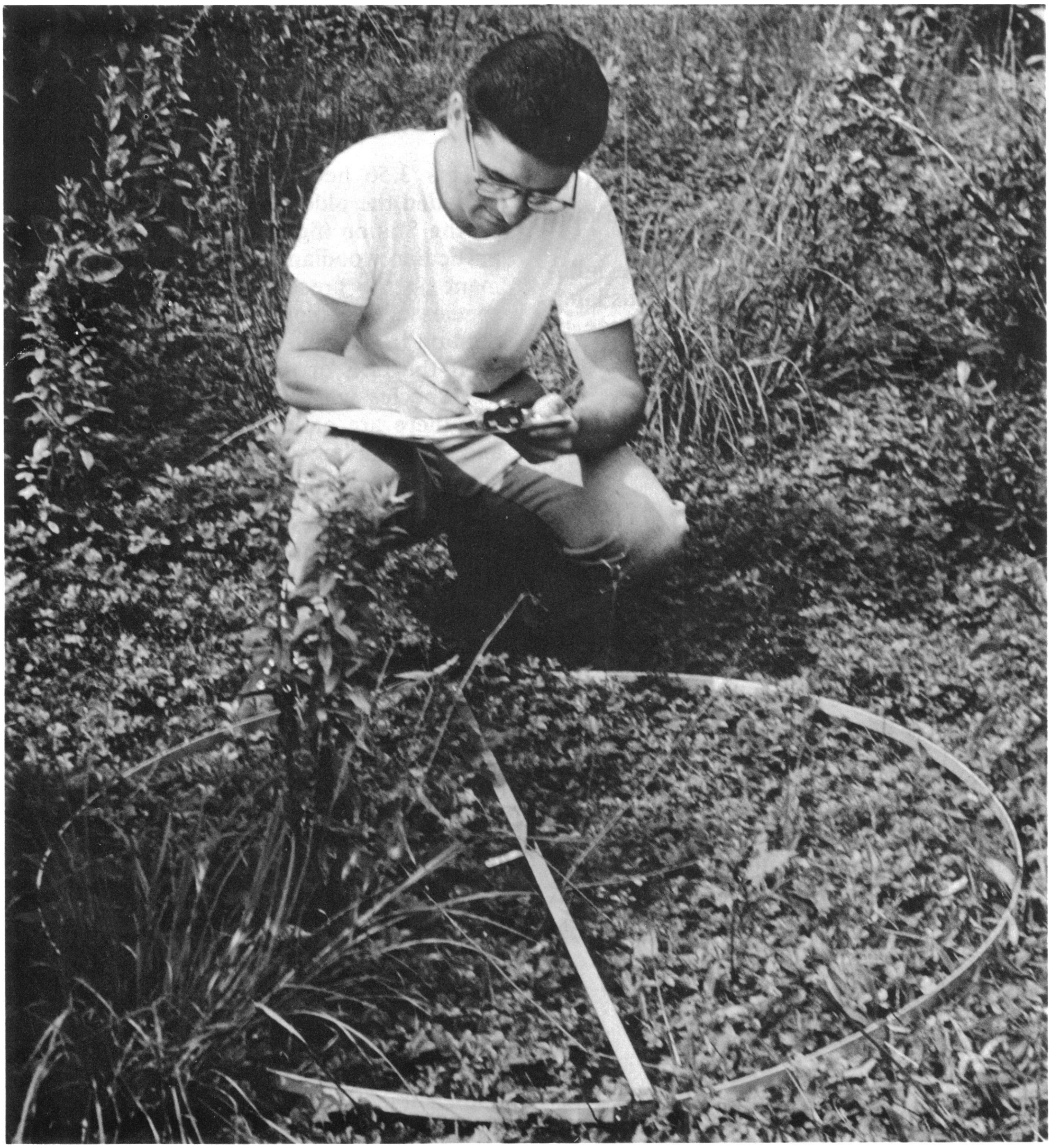

FIG. 14. Cover provided by herbaceous and woody vegetation was estimated ocularly from above each sample plot, delineated by an aluminum circular frame and, in this instance, located at witness stakes at intervals along permanent transects throughout the study area. Photo taken by R. Taggart in July 1961.

species was determined within sample plots delimited by an aluminum circular frame. Plots of two sizes were used (1 m^2, and $^1/_{32}$ m^2) in these surveys, but the data on average cover determined from these two plot sizes may be compared directly. In some surveys the plots were located at permanent steel witness stakes installed at intervals along permanent and parallel transects throughout the study area, whereas in others the plots were located randomly by drawing pairs of numbers representative of distances along two coordinates. I have indicated which procedure was used for each of the surveys cited here. Cover was estimated ocularly from above each plot (fig. 14), and is that portion of the plot, expressed to the nearest 1 percent, occupied by the living aerial parts of the individuals of a species (or group of species). Species present but occupying less than 0.5 percent are recorded as <1.

Density of trees was determined by counting the number of individuals of a species present within 5 m. wide stripes of land centered upon the same transects used to locate the permanent cover plots. The height of each shrub or tree was measured with a calibrated pole, and the results are expressed here by height class and in density per hectare. In some surveys the density of the larger trees was expressed according to diameter class, in which case the diameter was determined with calipers at a height of 1.25 m. ("breast height").

Areas of all study areas were calculated from base maps with a compensating polar planimeter.

Nomenclature for plant taxa follows Fernald (1950). The classification of soils is taken from Barbour (MS), who followed the nomenclature proposed by Cline (1961). The identification of the flora encountered in the study was by Jack McCormick, staff botanist, and his students (McCormick et al. 1969).

BREEDING BIRD CENSUSES

The censuses in this study were not indices to, or estimates of, population size, but instead were counts of all individuals known to be breeding or at least maintaining territories within each of the study areas. Such complete counts were feasible because of the relatively small size of the areas being censused (seldom more than one or two pairs of a species per study area) and the frequency with which color-banded birds facilitated recognition of individuals. The judicious use of a portable tape recorder and the playback of recordings to solicit behavioral responses from territorial males contributed to the accuracy of these counts.

Censuses were conducted from late May to early July, thus coinciding with the peak nesting season for songbirds on Long Island. Prime time daily (the first two to three hours after dawn) was devoted largely to determining numbers of singing males present and to mapping territorial boundaries through observations of song perches and interactions between males. Subsequent visits later in the day were to determine presence and activity of females and to locate nests.

All but one of the species encountered in these censuses are normally monogamous, and the results of the counts are expressed here in terms of number of pairs per study area. Instances of unmated males are noted. Red-winged Blackbirds are characteristically polygynous, however, and problems were encountered in determining the exact number of females in most Red-wing territories; for this species census results were expressed simply as number of males holding territories within a given study area.

Not all the study areas were censused in a given year, and these gaps in the census data are evident in the figures. Because of constraints of available time and personnel in some years, data were gathered on some species and not on others. Nomenclature for avian taxa follows that recommended by the American Ornithologists' Union (1957, 1973).

NESTS AND LIGHT READINGS

Particular attention was given to the location of nests within the study areas, to the height of nests above ground, and to the description of nest support, construction and materials. Voucher specimens of nests were placed in the collection at the American Museum of Natural History.

Light readings were taken at most nests to provide an index of the amount of sunlight reaching the nests and, indirectly, of relative nest cover. Readings were taken with a Weston photographic exposure meter, converted to read incident light (light which falls on the

TABLE 15
Nest Cover as Indicated by Percentage of Sunlight Reaching the Nest

	Meter 1			Meter 2		
Species	Mean %	Range	Sample size	Mean %	Range	Sample size
Red-winged Blackbird	74	24–99	81	20	2–100	38
Song Sparrow	74	—	1	—	—	—
Field Sparrow	74	73–78	5	15	3–38	7
Indigo Bunting	—	—	—	11	2–20	2
Common Yellowthroat	62	39–79	17	11	3–50	16
Blue-winged Warbler	63	42–83	8	8	2–17	6
Gray Catbird	61	29–78	20	9	<1–28	24
Brown Thrasher	61	51–75	6	11	1–32	15
Rufous-sided Towhee	55	24–88	9	3	3–4	2

nest rather than light reflected by the nest) by the addition of the Weston Invercone. To standardize for differing intensities of sunlight from day to day, control readings were taken in the nearest, unshaded area under the same sky conditions, and the results expressed as percentage of sunlight reaching the nest (table 15). An accident to the first meter, nearly halfway through the project period, required the substitution of a second Weston meter that used a different light scale. Even though incident light at the nest is expressed as a percentage, the converted percentages from the two meters were not comparable and hence could not be analyzed as a single set of data. Consequently, the results in table 15 are presented independently for the two meters. A serendipitous benefit of this unintended development in methodology is the opportunity to compare the rankings of the species, according to nest cover as indicated by percentage of sunlight reaching the nest and determined by two different instruments.

RESPONSE OF BREEDING BIRDS TO OLD FIELD SUCCESSION

Red-winged Blackbird, *Agelaius phoeniceus*

Regular and abundant migrant and summer resident at the Station; breeding population estimated at 40 to 90 individuals (territorial males are generally polygynous, hence utilization of study areas is expressed in number of males rather than pairs); the first species to use a fallow field for nesting, as early as the first year after cultivation.

The Red-wing nest is an open cup with an average outside diameter of 11 cm. The outer shell is woven principally of coarse grasses and weed stalks but may contain fibrous material such as strippings from *Apocynum*. Occasionally there are pieces of string, cloth or paper, or a few dead leaves woven into the wall. The lining is of finer grasses and rootlets, and occasionally some downy material from the *Apocynum*. Table 16 identifies the types of support for 161 Red-wing nests and gives the heights above ground. Whether supported by herbaceous or woody vegetation, shade and cover are not important factors in the location of the nests, for nests frequently have light readings as high as the controls (table 15). There are no significant differences between light readings taken at nests supported by herbs and those

FIG. 15. Nests of Red-winged Blackbirds, supported by *Solidago* (*top*, photo by S. M. Lanyon in June 1974) and by *Pyrus sieboldii* (*bottom*, photo taken in June 1979).

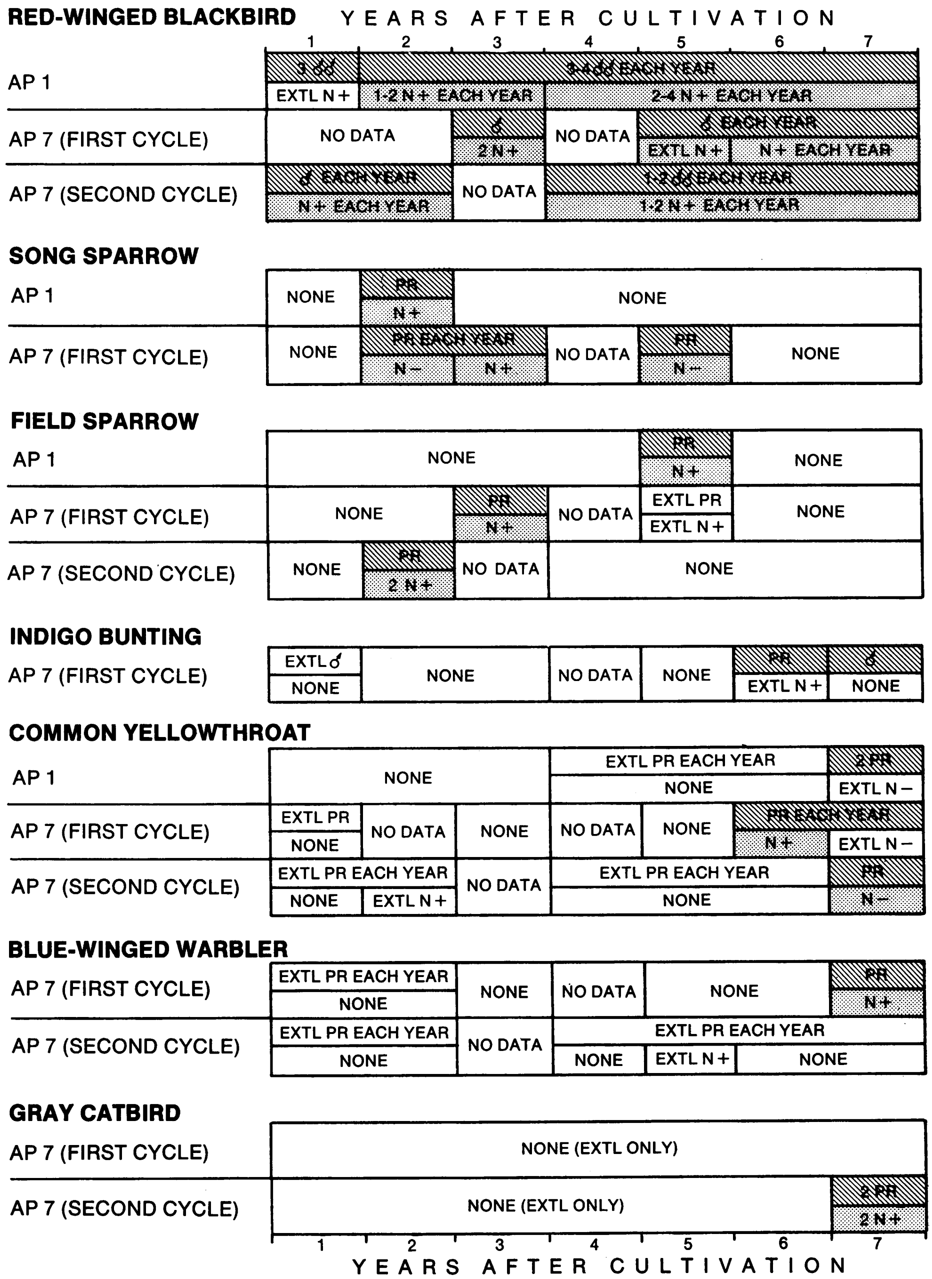

FIG. 16. Territorial (hatching) and nesting (stippling) activity during the first seven years of old field succession. Extl, extralimital or just outside the limits of the study area; N+, nest found; N−, nest suspected but not found.

taken at nests supported by woody vegetation (fig. 15).

Adequate support above ground level would appear to be the primary limiting fac-

TABLE 16
Support for 161 Nests of the Red-winged Blackbird

Type of principal support	No. of nests	% of total	Height above ground (in cm.)	
			Average	Range
Upright woody vegetation	101	63	141	25–500
Myrica pensylvanica	55	34	133	50–220
Rosa multiflora	11	7	86	25–185
Juniperus virginiana	8	5	147	98–195
Pyrus sieboldii	8	5	222	45–500
Betula spp.	6	4	142	60–228
Other species	13	8	154	30–400
Herbaceous vegetation	58	36	42	10–100
Solidago spp.	42	26	42	12–84
Grasses	13	8	33	10–80
Apocynum spp.	2	1	91	82–100
Vicia cracca	1	<1	60	—
On the ground	2	1	—	—

tor determining placement of the Red-wing nests. Since the stalks of pioneering forbs such as *Apocynum* and *Solidago* provide sufficient nest support, Red-wings were regularly territorial in the earliest successional stages following cultivation (fig. 16). A nest supported by *Apocynum* during the second year that AP 1 was fallow (fig. 6, bottom) had a light reading at the nest identical with the control reading (i.e., 100%), which illustrates the degree to which Red-wing nests may be exposed. *Solidago* provide the usual nest support during the early years of succession (tables 1 and 4, and fig. 15, top).

When woody vegetation becomes available, Red-wings show a preference for it as nesting substrate, and the nests then average higher above ground (table 16). The shift from herbs to *Myrica pensylvanica,* took place by the sixth year of succession in AP 7 (both cycles), which was the first year that *Myrica* became a dominant plant species in that field (table 4), but occurred somewhat later in AP 1 (table 1). *Myrica* remains a favorite support for Red-wing nests for at least 23 years after cultivation, though saplings of other woody species (*Prunus, Pyrus, Betula,* and *Juniperus*) begin to be used with increasing frequency by the tenth year (tables 2, 6, 10, and fig. 15, bottom).

The data in figure 16 suggest that Red-wings reach their optimal breeding density early, within the first or second year following cultivation and prior to the shift in the nesting substrate from herbaceous to woody vegetation, and then maintain that density at a relatively constant level for many years (fig. 17). The decline in suitability of the habitat for nesting territories does not begin before the twenty-fourth year following cultivation (AP 10C in fig. 17), but probably occurs well before the thirty-second year. The only field old enough to provide data on this point is SW 7. There was only intermittent use of this study area, by a single male, during the period from the thirty-second through the fortieth years following cultivation (fig. 18). The five Red-wing nests that were found in SW 7 during this period were located in small saplings (*Cornus, Pyrus,* and *Quercus*) within a restricted area in the northwest corner; each of these nests was less than 10 m. from that edge of the study area nearest to a younger field. No Red-wings were reported as territorial in the intensive censuses of SW 7 during the last three years of the study (forty-third through forty-fifth years following cultivation).

In those study areas where woody vegetation was removed through management

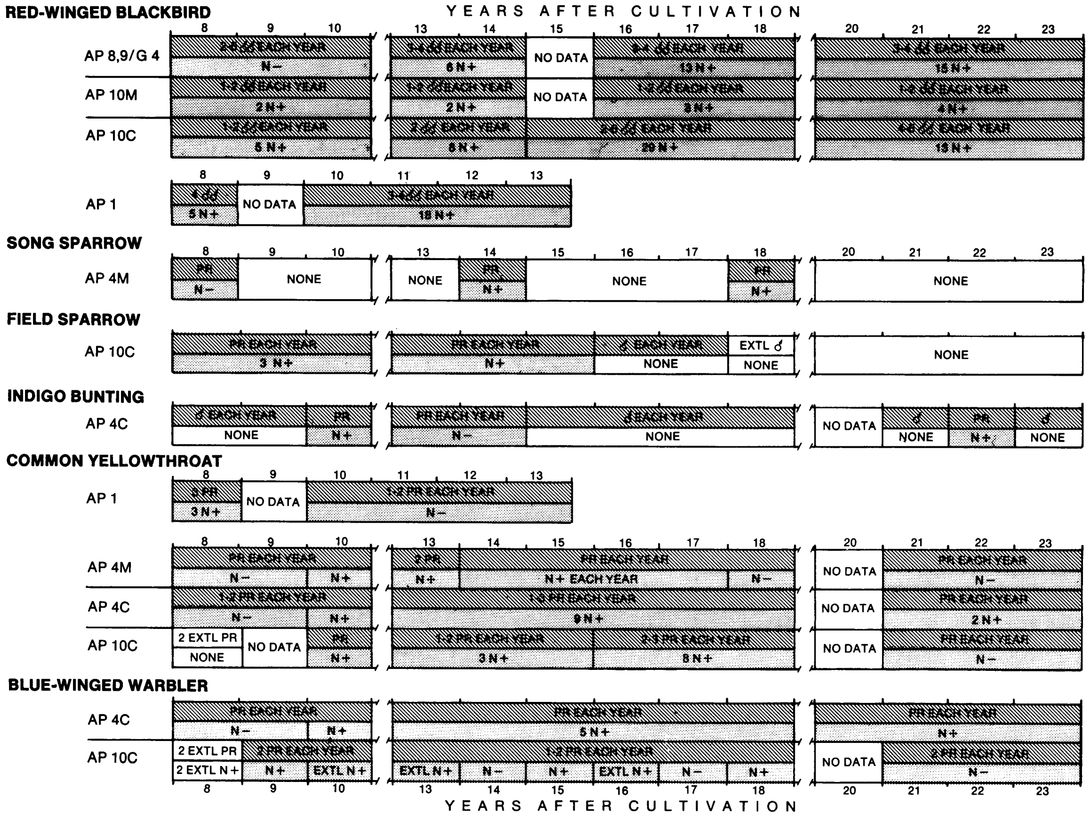

FIG. 17. Territorial (hatching) and nesting (stippling) activity from the eighth through the twenty-third year of old field succession. Symbols as in figure 16. Breaks in chronology represent years in which no censuses were conducted. See also figure 28.

procedures, Red-wings continued to use *Solidago* as the principal support for their nests (AP 8,9/G 4 and AP 10M in fig. 17). *Dactylis* was also important for nest support in AP 8,9/G 4 where grasses were encouraged through mowing. Although Red-wing males made frequent use of elevated song perches in the wooded fence rows surrounding the study areas, the females were not restricted to the perimeter of each area in selecting nest sites; the data in figure 19 argue against any such "edge effect."

Song Sparrow, *Melospiza melodia*

Regular and very common migrant, less common summer resident; breeding popula-

TABLE 17
Support for 5 Nests of the Song Sparrow

Type of principal support	No. of nests	% of total	Height above ground (in cm.) Average	Range
Upright woody vegetation	0	0		
Herbaceous vegetation (*Cirsium* sp.)	1	20	8	
On the ground	4	80		

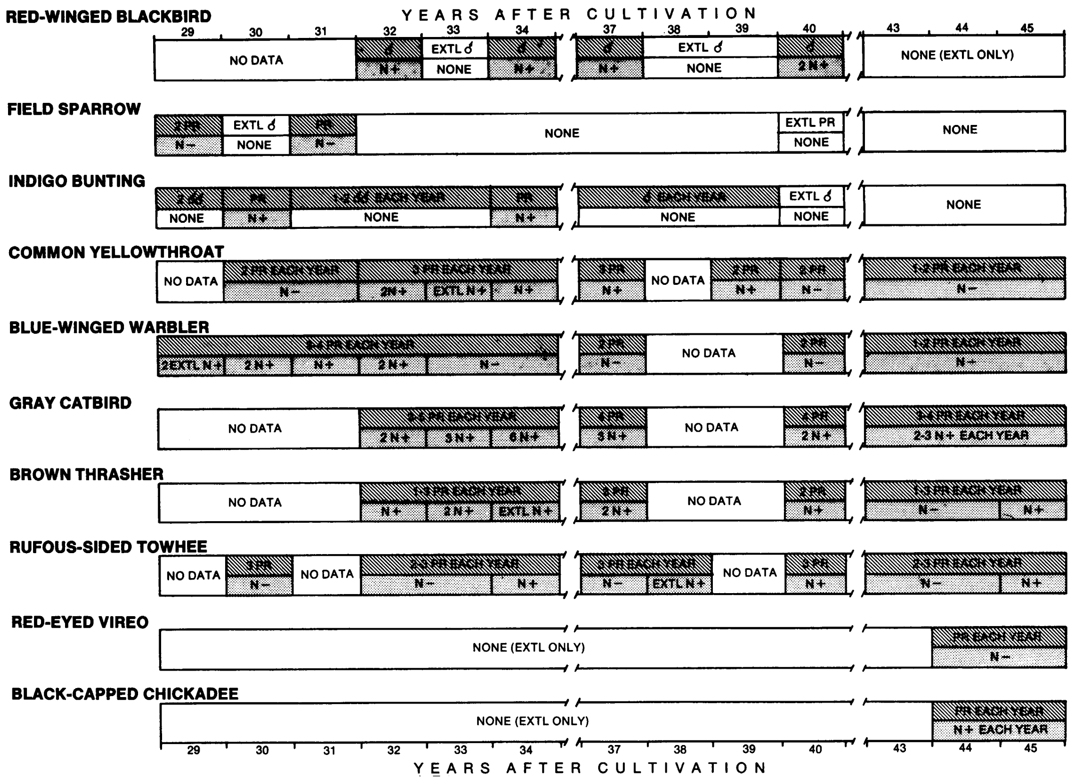

FIG. 18. Territorial (hatching) and nesting (stippling) activity in SW 7, for the period from 29 through 45 years following cultivation. Symbols as in figure 16. Breaks in chronology represent years in which no censuses were conducted.

tion estimated at five to eight pairs; one of the first species to use a fallow field for nesting, as early as the second year after cultivation.

The Song Sparrow nest is an open cup with an average outside diameter of 11 cm. The outer shell is woven of coarse grasses and weed stalks, whereas the lining is of finer grasses. Four of the five nests recorded in this study were located on the ground, in or near *Solidago*; none was supported by woody vegetation (table 17). Light readings, available only for one nest, were in the same range as those for Red-wing and Field Sparrow nests and lower than those for Yellowthroat and Blue-wing nests (table 15).

A low breeding population and infrequent use of the study areas make it difficult to compare the Song Sparrow with other pioneering species. They nested as early as the second year after cultivation in both AP 1 and AP 7 (fig. 16) but the data, are too few to determine whether they continue to nest in old fields as long as either Red-wings or Field Sparrows. Their presence in AP 4M as late as the fourteenth and eighteenth years after cultivation (fig. 17) may be due to succession having been arrested at the herbaceous stage through controlled burning. I have no record of Song Sparrows nesting in the control areas, where succession was not arrested, after the sixth year following cultivation. On the few occasions that Song Sparrows did nest in the study areas, they appeared to be quite dependent upon the wooded fence rows around the perimeter, and nests were located within a few meters of the borders of the study areas (fig. 20). Census takers consistently reported that Song Sparrows foraged primarily within the

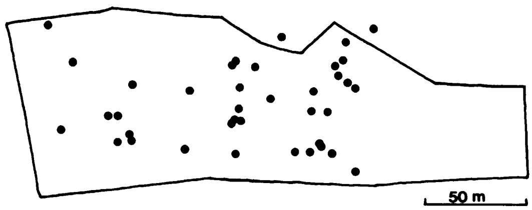

FIG. 19. Nest sites of Red-winged Blackbirds in study area AP 8,9/G 4, in which succession was arrested by annual mowing, argue against an "edge effect" as a determinant in nest location. Wooded fence rows border the study area. See text.

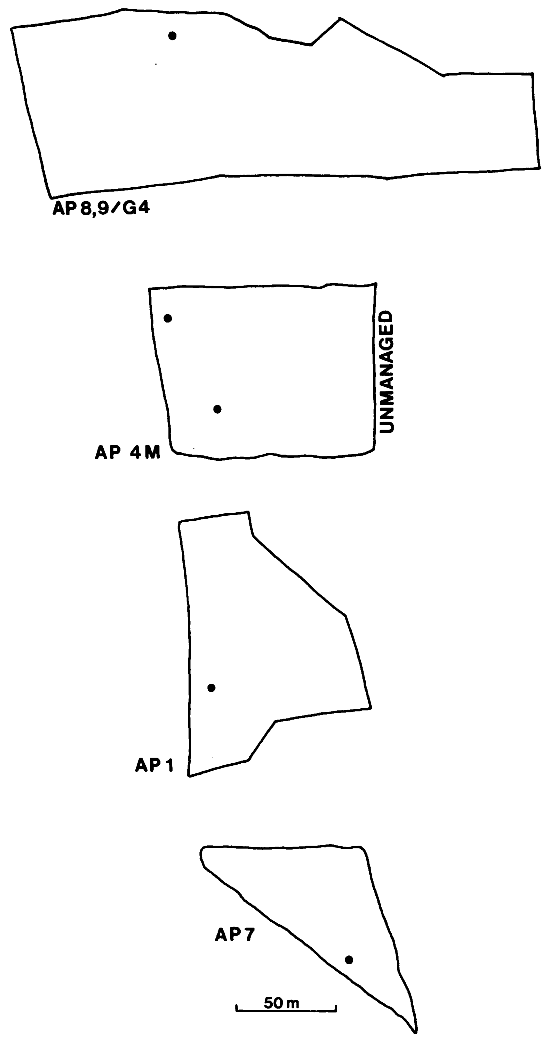

FIG. 20. An "edge effect" is illustrated by the locations of the five Song Sparrow nests recorded in this study. Wooded fence rows or shrubby woodlands border the study areas. See text.

wooded fence rows or shrubby woodlands bordering the study areas, rather than in the more open study areas where the nests were located.

Field Sparrow, *Spizella pusilla*

Regular and fairly common migrant, but irregular and less common summer resident at the Station; breeding population generally two to four pairs, but varied from none to five pairs; one of the first species to use a fallow field for nesting, as early as the second year after cultivation.

The Field Sparrow nest is an open cup with an average outside diameter of 8 cm. The outer shell is woven of coarse grasses and weed stalks, whereas the lining is of finer grasses and plant material; there were no leaves or conspicuous bark strippings in this sample. Only four of 17 nests were resting on the ground. Table 18 identifies the types of support for 17 Field Sparrow nests and gives the heights above ground. Light readings taken at Field Sparrow nests average nearly as high as those at Red-wing nests (table 15).

Field Sparrows began to nest nearly as early after cultivation as Red-wings and Song Sparrows (fig. 16), e.g., the second and third years in AP 7 (fig. 8, top) and the fifth year in AP 1. In those fields where my study commenced in the eighth year of succession, the Field Sparrow was already established as a nesting species (AP 10C in fig. 17).

The data suggest that the presence of seedlings and small saplings of woody vegetation may be an important factor in whether or not Field Sparrows will nest in a field, either as support for the nest or to provide a song perch for the male. The study area most consistently used by Field Sparrows was AP 10C, which continued to have a territory annually until the seventeenth year after cultivation (fig. 11, bottom). There were only two

TABLE 18
Support for 17 Nests of the Field Sparrow

Type of principal support	No. of nests	% of total	Height above ground (in cm.) Average	Range
Upright woody vegetation	6	35	20	9–32
Herbaceous vegetation				
Solidago spp.	6	35	18	12–32
Grasses	1	6	15	—
On the ground	4	24	—	—

nesting attempts in AP 4M, and in each case the nest was located in or near small *Myrica* that had escaped management by fire. One or two pairs nested in AP 10M through the tenth year following cultivation, but the program to remove upright woody vegetation from this section was not fully effective until about that time (table 12). The only nesting record for AP 10M after that year is a nest in the eighteenth year, located near a small *Myrica* that had escaped silvicide management. In AP 8,9/G 4, mowed annually to eliminate woody vegetation and encourage grasses, I have no record of nesting Field Sparrows.

The lack of records in AP 10C after the seventeeth year following cultivation and in AP 4C after the sixteenth year of succession suggests the approximate stage of old field succession at which the habitat becomes less attractive for nesting Field Sparrows. In SW 7 Field Sparrows were present during the first three censuses (29 through 31 years after cultivation), but not thereafter (fig. 18). Their disappearance before Red-wings, in SW 7, can probably be attributed to the difference in heights of their nests. While Red-wings can continue to utilize the more elevated nest sites afforded by small shrubs and saplings, Field Sparrows suffer from the disappearance of the *Solidago* and isolated small seedling habitat.

Indigo Bunting, *Passerina cyanea*

Regular and fairly common migrant, but uncommon summer resident; summer population consists of one to three males that are only irregularly successful in attracting and pairing with females; a pioneer species that nests in fallow fields as soon as there is adequate support and cover for the nest and providing there are song perches available nearby.

The Indigo Bunting nest is an open cup with an average outside diameter of 8 cm. The outer shell is woven principally of coarse grasses, but also contains bark strippings, dried flowers and fibrous material, and the decaying leaves of deciduous trees. The lining is of finer grasses and fibrous material. The five nests recorded in this study were supported in woody and herbaceous vegetation, 20 to 50 cm. off the ground (table 19). Light readings, available for only two nests, were in the same range as those for nests of the Common Yellowthroat and Blue-winged Warbler, and lower than those for nests of the Red-winged Blackbird and Field Sparrow (table 15).

The irregularity with which males were able to attract and hold females on my study areas precludes anything but very general statements with repect to the Indigo Bunting and succession. Males did not establish territories until the sixth and seventh years after cultivation (fig. 16) and probably are responding to the same kinds of environmental factors as the Common Yellowthroat, i.e., the presence of dense, upright woody vegetation for both song perches and for cover. Their dependence upon upright woody vegetation is suggested by the fact that they made no or very little use of the managed study

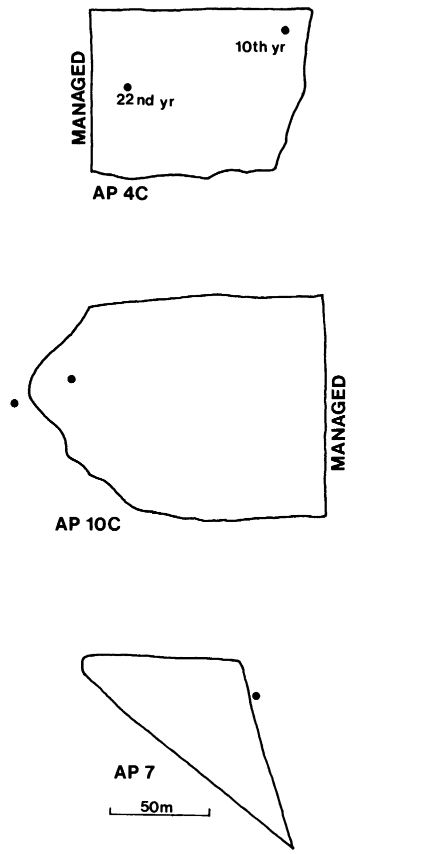

FIG. 21. An "edge effect" is illustrated by the locations of the five Indigo Bunting nests recorded in this study. Wooded fence rows and shrubby woodlands surround the study areas, with the exception of two borders on managed areas where succession was arrested, as indicated. See text.

areas. The few nests that were found were near the periphery of the study areas, where wooded fence rows provided elevated song perches and cover (fig. 21). In AP 4C, a nest in the tenth year following cultivation was located in a corner of the field only meters from the wooded perimeter. A second nest, in the twenty-second year of succession, was located much farther from the edge of the study area but in a habitat that, through the growth of upright woody vegetation in the intervening years, had become similar to the earlier site (fig. 21).

Male Indigo Buntings continued to hold territories in SW 7 for about as long (through the thirty-ninth year following cultivation) as Red-winged Blackbirds, but were not present in that study area for as long as Common Yellowthroats and Blue-winged Warblers (fig. 18).

Common Yellowthroat,
Geothlypis trichas

Regular and common migrant and summer resident at the Station; breeding population estimated at 12 to 16 pairs; a pioneer species that nests in fallow fields as soon as there is sufficient cover provided by upright woody vegetation.

The Yellowthroat nest is an open cup with an average outside diameter of 9 cm. The outer shell is woven principally of coarse grasses, weed stalks, and the decaying leaves of a variety of species of deciduous shrubs and trees (especially *Quercus*). Occasionally there is fibrous material woven into the shell, including strippings from herbaceous plants such as *Apocynum*. The lining is of finer grasses and rootlets, Nearly all the 38 nests recorded in this study were supported within clumps of *Solidago,* up to a height of 31 cm. above ground, or were located on the ground at the base of a *Solidago* clone (table 20; fig. 22). No nest was sup-

TABLE 19
Support for 5 Nests of the Indigo Bunting

Type of principal support	No. of nests	% of total	Height above ground (in cm.)
Upright woody vegetation (*Rubus* sp. and *Myrica pensylvanica*)	2	40	44, 50
Woody vines (*Lonicera japonica*)	1	20	50
Herbaceous vegetation (*Solidago* spp.)	2	40	20, 30
On the ground	0	0	—

FIG. 22. Habitat and nest of the Common Yellowthroat in study area AP 7; photos taken by G. V. N. Powell in July 1967. *Above:* aspect of the study area, with dense growths of *Solidago* and scattered clumps of *Myrica pensylvanica*; white card, left center, marks the location of the nest. *Right:* nest at the base of a clone of *Solidago*.

ported exclusively by upright woody vegetation. Light readings taken at Yellowthroat nests average significantly lower than those at Red-wing nests (table 15).

Yellowthroats did not nest regularly within the study areas until the sixth and seventh years in some fields and still later in others. The data from AP 1 most convincingly demonstrate this delay in the use of a fallow field for nesting, and contrast sharply with the regular use of the same field by Red-wings as early as the second year following cultivation (fig. 16). Since *Solidago* dominates the vegetation of these fields within the first two or three years of succession (tables 1 and 4), thereby providing suitable nest support for Yellowthroat nests, there must be another factor responsible for this delay.

Yellowthroats make frequent use of dense upright woody vegetation, mainly *Myrica pensylvanica* in my study areas, for both

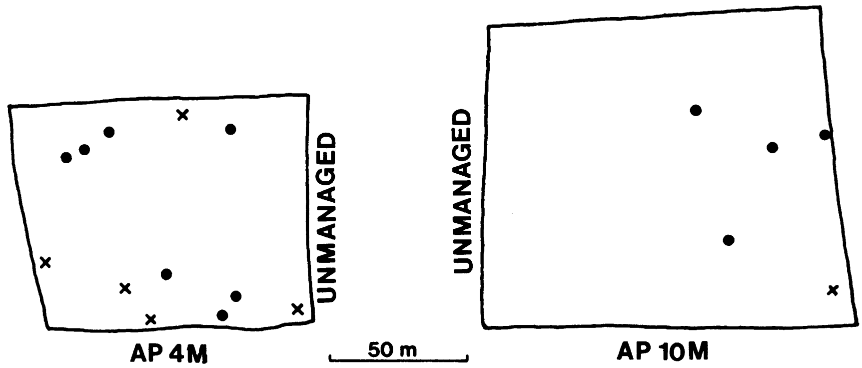

FIG. 23. An "edge effect" as illustrated by the locations of nests of Common Yellowthroats (circles) and Blue-winged Warblers (crosses) in two study areas in which succession was arrested at the herbaceous stage. Wooded fence rows and shrubby woodlands surround the study areas, with the exception of two borders on unmanaged areas as indicated. See text.

song perches and for cover during their approach and departure to and from nests. There is an excellent correlation between the time that Yellowthroats begin to nest regularly in a given field and the time that *Myrica* becomes a prominent component of the vegetation in that field. The first regular nesting by Yellowthroats was earlier (sixth and seventh years) in those fields where *Myrica* became prominent earlier (AP 1 and AP 7 in tables 1 and 4; fig. 22), but somewhat later (tenth year) in those fields where the appearance of *Myrica* was delayed (AP 4C and AP 10C in tables 5 and 9). Unlike Red-wings, which continue to use those fields in which *Myrica* and other upright woody vegetation are removed, Yellowthroats cease to nest or nest only irregularly in those study areas managed in this manner (AP 4M and AP 10M in tables 8 and 12). In AP 8,9/G 4, a field dominated by grasses and *Solidago* and devoid of *Myrica* because of an annual program of mowing (table 13), there are no records of nesting Yellowthroats.

Further evidence of the importance of dense upright vegetation near the nest site may be found in an analysis of the locations of the Yellowthroat nests within study areas. In those areas in which succession was arrested at the weed field stage (fig. 23), Yellowthroat nests tended to be situated closer to the perimeter of the study area, and particularly to those edges bounded by wooded fence rows or shrubby woodlands that provide song perches and cover. A similar "edge effect" can be seen in the locations of nest sites within those study areas in which succession was not arrested (fig. 24), provided one distinguishes between the nests associated with the earlier successional stages

TABLE 20
Support for 38 Nests of the Common Yellowthroat

Type of principal support	No. of nests	% of total	Height above ground (in cm.)	
			Average	Range
Upright woody vegetation	0	0		
Woody vines (*Lonicera japonica*)	2	5	25	18–31
Herbaceous vegetation (*Solidago* spp.)	28	74	14	3–30
On the ground	8	21	—	—

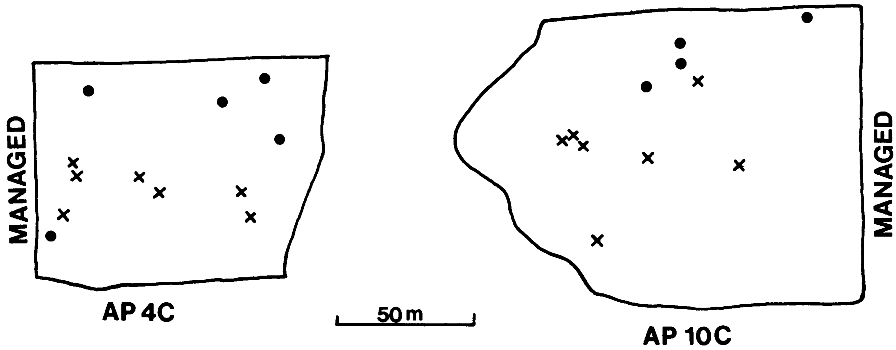

FIG. 24. Nest sites of Common Yellowthroats in two study areas in which succession was not arrested: (circles) nests recorded during the early stages of succession, tenth through fifteenth years following cultivation, tend to be more peripherally located; (crosses) nests recorded during later stages of succession, sixteenth through twenty-first years, tend to be more centrally located. Wooded fence rows and shrubby woodlands surround the study areas, with the exception of two borders on managed areas as indicated. See text.

and those in later stages. The nests recorded during early stages of succession, tenth through fifteenth years following cultivation, tend to be more peripherally located, whereas nests recorded during later stages of succession, sixteenth through twenty-first years, tend to be more centrally located in response to the inward growth of woody vegetation from the perimeter of the study area.

There were no fields in this study that were old enough to document a decline in suitability of habitat and consequently a cessation of nesting by Yellowthroats. Unlike Redwings, which probably experience such a decline by the thirty-second year following cultivation, Yellowthroats were nesting in SW 7 in the last year of the study, when this field had been fallow for 45 years (fig. 18). *Solidago* remains the preferred support for Yellowthroat nests even during these late stages of old field succession.

Blue-winged Warbler, *Vermivora pinus*

Regular and common migrant and summer resident at the Station; breeding population estimated at 10 to 14 pairs; a pioneer species that nests in fallow fields as soon as there is adequate cover for the nest and providing there are song perches available nearby.

The Blue-winged Warbler nest is an open cup with an average outside diameter of 9 cm. The outer shell consists largely of coarse strippings of bark (from *Apocynum, Betula,* etc.) and decaying leaves (mostly *Quercus*). The proportion of *Quercus* leaves to other materials is greater than in the nests of Yellowthroats. The lining is of finer strippings of bark, fibrous material such as root hairs,

TABLE 21
Support for 19 Nests of the Blue-winged Warbler

Type of principal support	No. of nests	% of total	Height above ground (in cm.) Average	Range
Upright woody vegetation	0	0		
Herbaceous vegetation (*Solidago* spp.)	2	11	5.5	5–6
On the ground	17	89		

FIG. 25. Habitat and nest of the Blue-winged Warbler. *Top:* optimal nesting habitat in study area AP 10C, 18 years after cultivation; note presence of elevated song perches; arrow marks location of a Blue-wing nest; photo taken by D. Wechsler in July 1972. *Bottom:* nest located at the base of a clone of *Solidago*; photo by T. Jasikoff in July 1972.

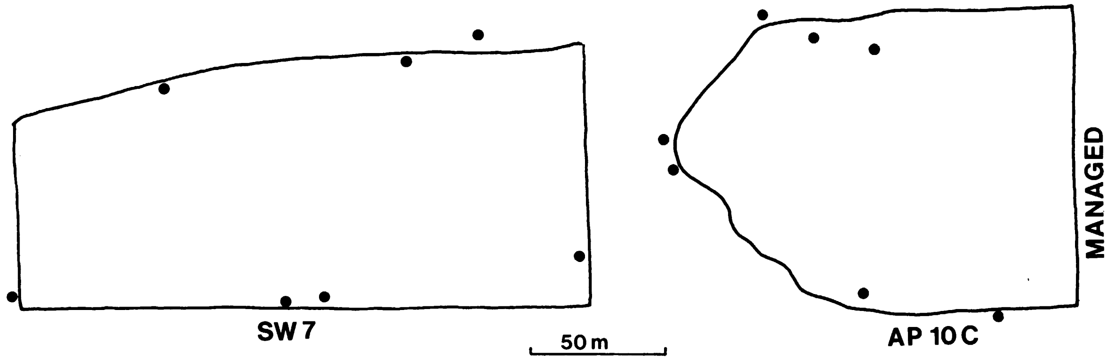

FIG. 26. An "edge effect" as illustrated by the locations of nests of the Blue-winged Warbler in two study areas in which successon was not arrested. Taller trees provide song perches in the wooded fence rows that border these study areas, with the exception of one border on a managed area as indicated. See text.

and fine grasses. All but two of the 19 nests recorded in this study were located on the surface of the ground or in a slight depression in the ground, generally at the base of a clone of *Solidago* and less frequently at the base of a woody plant (table 21; fig. 25). The two exceptions to these ground nests were supported at a height of 5 and 6 cm. aboveground in clones of *Solidago*. No Blue-wing nest was supported by upright woody vegetation. Light readings taken at Blue-wing nests average significantly lower than those at Red-wing nests and about equal those taken at the nests of Yellowthroats (table 15).

Blue-winged Warblers did not nest within my study areas until seven to nine years following cultivation, hence followed a schedule similar to that of Yellowthroats (figs. 16 and 17). Since most Blue-wing nests are located on the ground, nest support *per se* is not a factor in this delay. As in the case of the Common Yellowthroat, Blue-wing nests are usually associated with low light intensities, suggesting that a certain density of herbaceous vegetation may be a prerequisite for nesting. Though Blue-wings nest on the ground, the males sing from elevated song perches, which constitute another habitat requirement, and these song perches average higher than those used by Yellowthroats (fig. 25). The more mature trees within the wooded fence rows bordering my study areas frequently provided these song perches, and this fact no doubt contributed to an "edge effect" upon the location of nests that was even more pronounced in Blue-wings than in Yellowthroats (fig. 23). Most remarkable was the fact that all seven Blue-wing nests found in SW 7 were located around the wooded perimeter, even though this study area had been fallow for 29 to 32 years (fig. 26). Blue-wings were still nesting in SW 7 in the last year of the study, when this field had been fallow for 45 years (fig. 18), hence I have no data on the age at which a field becomes less attractive or unsuitable for Blue-wings.

Gray Catbird, *Dumetella carolinensis*

Regular and abundant migrant and summer resident at the Station; breeding population estimated at 25 to 40 pairs; optimal nesting habitat is thickets of woody vegetation 1 to 2 m. high.

The nest of the Gray Catbird is an open cup with an average outside diameter of 12 cm. The outer shell consists of coarse woody twigs and vines, herbaceous stalks, grasses, bark fibers, and leaf litter. The lining is of finer pieces of the same materials. Occasionally there are pieces of plastic and paper woven into the nest. All 49 nests analyzed in this study were supported by woody vegetation, at an average height of 155 cm. above-

TABLE 22
Support for 49 Nests of the Gray Catbird

Type of principal support	No. of nests	% of total	Height aboveground (in cm.)	
			Average	Range
Upright woody vegetation	49	100.0	155	30–350
Rosa multiflora	7	14.3	112	75–140
Myrica pensylvanica	5	10.2	98	30–140
Viburnum spp.	5	10.2	201	140–290
Smilax rotundifolia	5	10.2	117	71–193
Juniperus virginiana	5	10.2	188	120–230
Betula populifolia	3	6.1	133	85–160
Rhus spp.	3	6.1	168	162–173
Forsythia intermedia	3	6.1	123	98–150
Robinia pseudo-acacia	2	4.1	155	140–170
Ilex sp.	2	4.1	225	220–230
Lonicera japonica	2	4.1	74	6–88
Cornus florida	1	2.0	150	—
Prunus serotina	1	2.0	225	—
Pyrus sieboldii	1	2.0	220	—
Nyssa sylvatica	1	2.0	158	—
Sassafras albidum	1	2.0	350	—
Pinus sylvestris	1	2.0	141	—
Quercus sp.	1	2.0	210	—
Herbaceous vegetation	0	0	—	—
On the ground	0	0		

ground (table 22). There was no preference for a single type of principal support, but 70 percent of these nests were situated in surrounding thickets of *Rosa multiflora, Smilax rotundifolia,* or *Lonicera japonica,* which accounted for light readings at the nests that averaged lower than those taken at the nests of the early pioneer species (table 15).

Old fields are not attractive to Gray Catbirds until there are suitable thickets of woody vegetation at a height of 1 to 2 m. (fig. 27). There was an exceptionally early nesting in AP 7 (second cycle), in the seventh year following cultivation (fig. 16), when two nests were recorded in *Rosa multiflora* thickets at the extreme edge of the study area. These were the only suitable thickets in the entire study area, and the adult Catbirds spent most of their time in the shrubby woodlands outside the area. There were only three other fields in which succession to thicket stage could be studied (AP 1, AP 4C, and AP 10C), and in these areas the first nesting by Catbirds was in the twelfth, thirteenth, and eighteenth years following cultivation (fig. 28). The timing of these first nestings is correlated in a general way with the increasing dominance of upright woody vegetation at this age of old field succession (tables 5 and 9), and with the growth of thickets, such as *Rosa multiflora* (table 6).

Study area SW 7 provided optimal habitat for Gray Catbirds from at least the thirty-second year of succession, the first year for which I have data, until the final year of the study when the field had been fallow for 45 years (fig. 18). I have no data on the age at which a field becomes less attractive or unsuitable for Catbirds. However, they were not present as breeding birds in the initial survey of the woodland study area, BWF 1 (48 years after it was clear-cut), and were not

FIG. 27. Habitat and nest of the Gray Catbird in study area AP 4C; photos taken by T. Jasikoff in July 1972, 18 years after cultivation. *Top:* aspect of optimal nesting habitat, in a thicket of *Rosa multiflora*. *Bottom:* bulky stick nest in the center of the rose thicket.

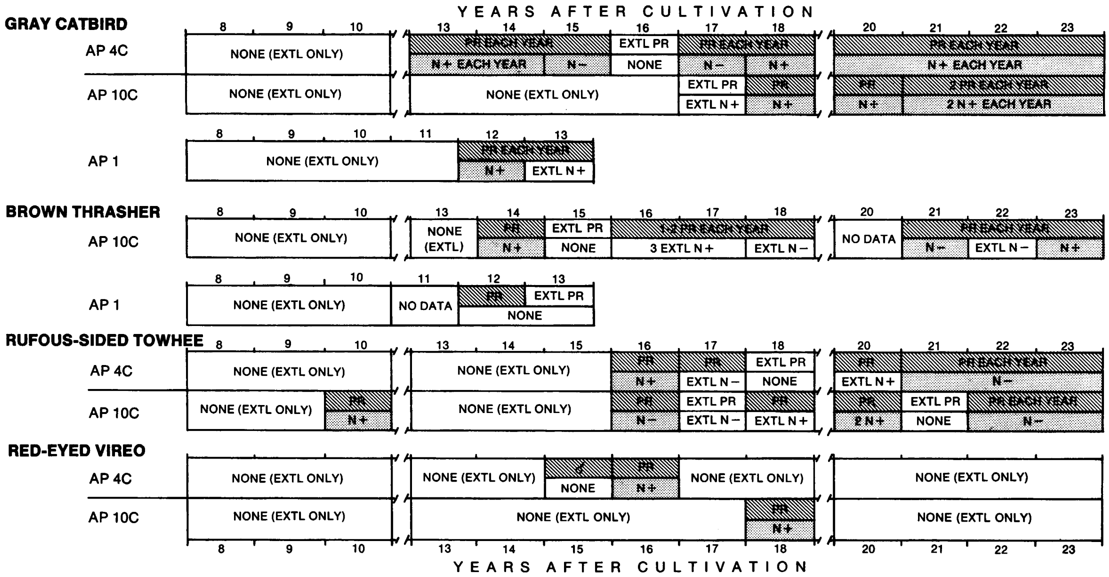

FIG. 28. Territorial (hatching) and nesting (stippling) activity from the eighth through the twenty-third year of old field succession. Symbols as in figure 16. Breaks in chronology represent years in which no censuses were conducted. See also figure 17.

recorded as nesting in that study area subsequently.

Brown Thrasher, *Toxostoma rufum*

Regular and common migrant and summer resident; breeding population estimated at 10 to 15 pairs; optimal nesting habitat is thickets of woody vegetation from ½ m. to 2 m. high, but will continue to utilize a woodland habitat after the canopy has closed.

The nest of the Brown Thrasher is an open cup with an average outside diameter of 15 cm. The outer shell consists mainly of coarse twigs (typically 2 to 3 mm. in width, but up to 5 mm. wide), bark strippings, dead and

TABLE 23
Support for 22 Nests of the Brown Thrasher

Type of principal support	No. of nests	% of total	Height aboveground (in cm.) Average	Range
Upright woody vegetation	22	100	128	58–230
Smilax rotundifolia	13	59	120	60–210
Rosa multiflora	2	9	69	58–80
Vaccinium spp.	2	9	135	120–150
Betula spp.	2	9	158	100–215
Viburnum dentatum	1	5	230	—
Lonicera japonica	1	5	221	—
Myrica pensylvanica	1	5	79	—
Herbaceous vegetation	0	0	—	—
On the ground	0	0	—	—

TABLE 24
Support for 23 Nests of the Rufous-sided Towhee

Type of principal support	No. of nests	% of total	Height aboveground (in cm.) Average	Range
Upright woody vegetation	6	26	73	50–120
Smilax rotundifolia	3	13	60	50–75
Juniperus virginiana	1	4	73	
Rubus sp.	1	4	63	
Lonicera japonica	1	4	120	
Herbaceous vegetation	0	0		
On the ground	17	74		

decaying leaves, and grasses. The lining is of finer twigs, rootlets, and grasses. All 22 nests analyzed in this study were supported by woody vegetation, at an average height of 128 cm. above ground (table 23). Over half of these nests were located in thickets of *Smilax rotundifolia,* and light readings at the nests were comparable to those taken at nests of the Gray Catbird (table 15).

The Brown Thrasher was inexplicably absent as a breeding bird in AP 4C, but the data from AP 10C and AP 1 can be used to identify the earliest stage that Thrashers find suitable for breeding territories (fig. 28). The earliest indication of territorial behavior within a study area was in AP 1, in the twelfth year of succession, but there was no suggestion that the pair nested within the area. The first nest in AP 10C was found in the fourteenth year and situated within a dense stand of *Betula lenta* along the eastern edge of the study area. It was an extremely flimsy nest that had to be reinforced to prevent the nestling from falling out prematurely. Though Thrashers were regularly territorial in AP 10C beginning with the sixteenth year, they are not believed to have nested within the area again until the twenty-first year. These data suggest that the Brown Thrasher may not find an old field suitable for breeding until a somewhat later stage than the Gray Catbird, though both species are responding to the growth of upright woody vegetation and particularly thickets of *Smilax*.

Study area SW 7 provided optimal habitat for Brown Thrashers from at least the thirty-second year of succession, the first year for which I have data, until the final year of the study when the field had been fallow for 45 years (fig. 18).

Unlike the Gray Catbird, Brown Thrashers will continue to breed in habitats in which the woodland canopy has closed. In my woodland study area, BWF 1, they held breeding territories around the perimeter of the area up through 1972, 62 years after the woodland was clear-cut. Only one Thrasher nest was located within the boundaries of this study area, but several were situated peripherally and the adults would routinely move their fledglings into the area to forage.

Rufous-sided Towhee,
Pipilo erythophthalmus

Regular and common migrant and summer resident; breeding population estimated at 15 to 20 pairs; uses the later stages of old field succession, and continues to utilize such habitat even after the woodland canopy has closed.

The nest of the Rufous-sided Towhee is an open cup with an average outside diameter of 11 cm. The outer shell consists mostly of leaves, bark fibers, and coarse grasses, with less frequent inclusion of plant stalks and small twigs. The lining is of finer grasses, plant stems, and rootlets. Most of the nests in this study were located on the ground (table 24) and usually in a moderate to heavy leaf litter, with cover provided by growths of *Solidago, Rhus radicans,* or *Vaccinium.* Elevated nests were also in good cover, such as provided by thickets of *Rubus, Smilax rotundifolia,* or *Lonicera japonica.* Light intensities averaged lower at Towhee nests than at the nests of the other species for which readings are available (table 15).

The low light intensities recorded at Towhee nests suggest that old fields are not attractive as nesting territories until sufficient cover has developed, particularly in the form of leaf litter and thickets of woody vegetation. I was able to document the initial utilization of old fields by Towhees in two of my study areas (AP 4C and AP 10C in fig. 28). One pair made an abortive attempt at nesting in AP 10C 10 years after cultivation, but there was only intermittent territorial and nesting activity thereafter, until a pair was nesting regularly beginning with the twenty-second year after cultivation. Towhees were first reported feeding within AP 4C in the fourteenth and fifteenth years after cultivation, but were not believed to be territorial in those years. During the following year, the sixteenth year fallow, a pair nested successfully in the extreme northeastern corner of the field; the territory was largely outside of the study area. Foraging and even some territorial behavior was reported in this portion of the study area over the next four years, but all nesting was thought to be extralimital. Not until the twenty-first year following cultivation did a pair of Towhees regularly defend territory and nest within the limits of the study area.

As already noted for the Gray Catbird and Brown Thrasher, study area SW 7 provided optimal habitat for Rufous-sided Towhees from the time that it was first surveyed for this species, in the thirtieth year of succession, until the final year of the study, when the field had been fallow for 45 years. Like the Brown Thrasher, Towhees will continue to breed in habitats in which the woodland canopy has closed. Towhees were recorded as defending territories in my woodland habitat, BWF 1, in the initial survey of that study area (48 years after it had been clear-cut) and continued to be reported as being territorial in surveys up through the final year of the study, 67 years after the woodland had been clear-cut. Only one Towhee nest was located within the study area during this period, but others were found on the perimeter or just outside the area.

Red-eyed Vireo, *Vireo olivaceus*

Regular and common migrant, but uncommon summer resident; breeding population estimated at one to three pairs; nests in open and closed canopy woodlands.

The nest of the Red-eyed Vireo is an open cup with an average outside diameter of 8 cm. The outside shell consists of strips of bark, fragments of dead leaves, and plant fibers, and may contain cobwebs. The lining is of finer pieces of the above materials. The five nests analyzed in this study (only two from within study areas) were hung from a forked branch near the outer edge of the canopy and at an average height of 3.5 m. (range of 1 to 7 m). The two nests located within study areas were supported by *Robinia pseudo-acacia* and *Quercus palustris.*

Because of the small population of this species breeding on the Kalbfleisch Station, it is difficult to draw any conclusions on the influence of succession on Red-eyed Vireos. The species nested twice in older fields, 16 and 18 years after cultivation (fig. 28), at a time when those fields were still very much open woodlands with very open canopies. In both instances, the nests were located at the extreme edge of the study area near closed canopy woodland. The species was absent from shrubby woodland habitat, SW 7, until the last two years of the study (44 and 45 years after cultivation), when a pair was believed to have nested (fig. 18). A pair of Red-eyed Vireos was recorded in the initial survey of my woodland habitat, BWF 1, and there was usually a pair breeding in this study area each subsequent year.

Black-capped Chickadee, *Parus atricapillus*

Common permanent resident; regular and very common migrant; breeding population estimated at three to five pairs; nests in tree

FIG. 29. *Top:* a nest cavity excavated by a pair of Black-capped Chickadees in a dead *Betula populifolia* in study area SW 7, 45 years after cultivation; photo taken in May 1977. *Bottom:* view of study area BWF 1, showing size of trees and nature of the understory in this woodland community, which was clear-cut in 1910; photo taken in July 1963.

cavities, usually excavated in soft wood, hence breeding distribution is influenced by availability of suitable nest trees.

Only two nests of the Black-capped Chickadee were found within my study areas. Both were located in cavities that had been excavated by the Chickadees in the soft pulp of dead *Betula populifolia* stubs (fig. 29). The entrance holes, about 5 cm. in diameter, were 1.8 m. and 1.5 m. from the ground. The diameter of the stub at the height of the entrance hole was about 9 cm. in each instance, which probably represents the smallest tree trunk in which it is possible for Chickadees to excavate a nest cavity.

The appearance of the Black-capped Chickadee as a breeding bird in abandoned fields is determined by the availability of tree trunks of adequate diameter and of sufficiently soft pulp to permit the excavation of nest cavities. Both of the nests in this study were found in SW 7 during the last two years of the study, 44 and 45 years after cultivation (fig. 18).

There were *Betula* in AP 10C 22 years after cultivation (table 11) that were of adequate diameter for Chickadee nests, but these trees were living and the wood too hard to be attractive to nesting Chickadees. Likewise, in the census of SW 7 in the thirty-fourth year after cultivation, it was noted that there were no dead *Betula* stubs available for cavity nesters. Heavy use by a pair of Chickadees and their brood (presumably fledged from a nest just outside the area) was reported in the census of SW 7 in the fortieth year following cultivation, and special attention was given that year to the presence of *Betula* and the availability of cavity sites. Of the 24 *Betula* trunks in excess of 8 cm. in diameter at a height of 1.3 m., there were five that were dead. But only two of these trunks were free from vines and hence suitable for excavation. It is noteworthy that it was these two dead *Betula* stubs that were used for the first two Chickadee nest cavities, four and five years later (fig. 29).

One to two pairs of Black-capped Chickadees were territorial in my woodland habitat, BWF 1, throughout the study period.

Downy Woodpecker, *Picoides pubescens*

Fairly common permanent resident; two or three pairs breed on the Station, but irregularly; nests in tree cavities, hence breeding distribution is influenced by availability of suitable nest trees.

The size of the tree trunk or limb required for the nest cavity probably limits the use of fallow farmland by Downy Woodpeckers to those fields that are at least 50 years old. No Downies nested in SW 7 up through the final year of the study, 45 years after cultivation. The species was present as a breeding bird in my woodland habitat, BWF 1, throughout the study period.

In view of the absence of Downies in my abandoned fields, it is not surpising that two other hole-nesting species that require somewhat larger nest cavities than do Downies, the Hairy Woodpecker (*Picoides villosus*) and Great Crested Flycatcher (*Myiarchus crinitus*), also failed to nest within SW 7 up through the final year of the study. These two were also present as breeding birds in my woodland habitat, BWF 1, throughout the study period.

CONCLUSIONS

I am not suggesting that the species of breeding birds discussed here are in any way restricted to old field habitats, for certainly that is not the case. The objective of this study was not to determine the full range of habitats within which each of these particular species may be found, but instead, having limited my observations to a few old fields in one small region of Long Island, to inquire as to the nature of the succession of breeding birds that accompanies secondary plant succession on this fallow farmland.

None of the breeding birds discussed above can be considered a grassland species,

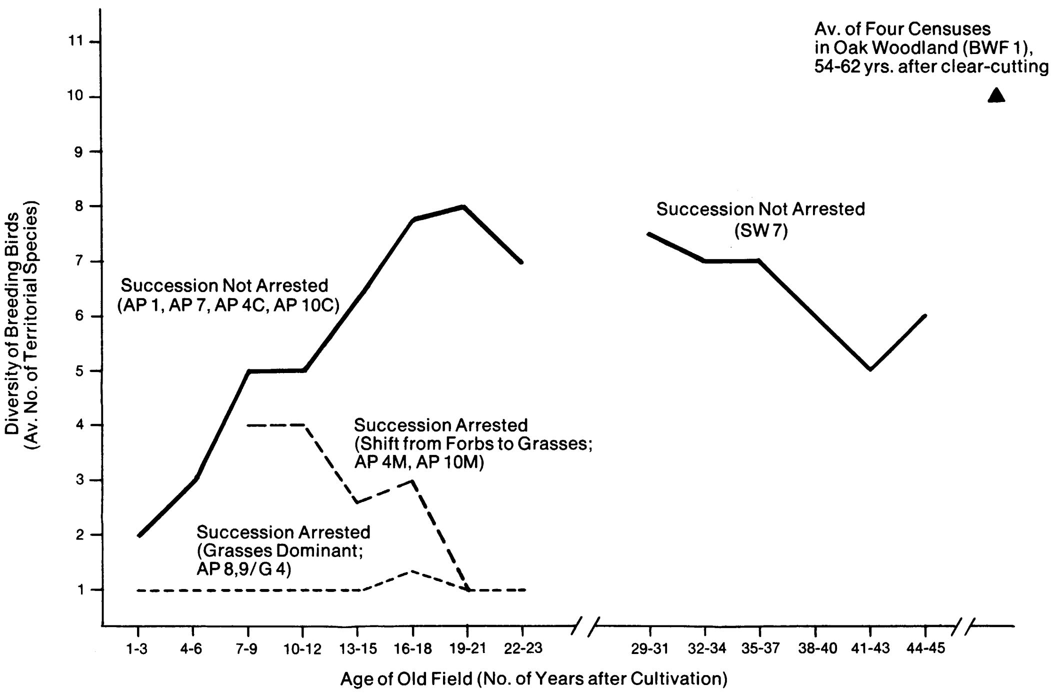

FIG. 30. Variation in diversity of species of breeding birds with age of old fields.

in the sense that it would normally breed in a large, homogeneous grassland community in which there was no wooded border and no shrub component. AP 8,9/G 4, though floristically a grassland due to annual mowing, was too small in size and too far removed from other grassland communities to attract true grassland birds. A pair of Eastern Meadowlarks (*Sturnella magna*) nested in this study area one year, but not subsequently, and was omitted from the species accounts.

Sequence of Breeding Birds and Old Field Succession

If we list the bird species in the order in which they became established as breeding birds in these old fields, taking into account their overall responses on all of the available study areas as summarized by the shaded and stippled areas in figures 16 and 28, the sequence of species reads as follows:

Red-winged Blackbird
Song Sparrow
Field Sparrow
Indigo Bunting
Common Yellowthroat
Blue-winged Warbler
Gray Catbird
Brown Thrasher
Rufous-sided Towhee

This is the same sequence that appears in table 15, where these species are arranged in order of increasing nest cover, as indicated by percentage of sunlight reaching the nest. Making allowances for the unavailability of study areas representing successional communities between a field 45 years old (SW 7 at the end of the study period) and an oak woodland 48 years old after clear-cutting (BWF 1 at the beginning of the study period), and for the problems of interpreting responses of small populations, the above sequence is likewise that in which these same species disappear from the continuum of communities that characterizes old field succession on Long Island (fig. 18 and species accounts). The concordance among these three sequences suggests that species-specific requirements with respect to cover at the nest, i.e., the amount of sunlight that it will tolerate at the nest, plays an important role in determining which stages of old field succession a species finds attractive for nesting.

Diversity of Breeding Birds and Old Field Succession

There was a rather rapid increase in species diversity with an increase in age of the fields undergoing succession, and a leveling off in numbers of territorial species was reached about 15 years after cultivation (fig. 30). This relatively high degree of diversity is maintained over the next 20 to 25 years, perhaps fairly constantly, as the habitat passes from an open shrubby woodland to a dense shrubby woodland. The disappearance of the pioneer species (Red-winged Blackbird, Song Sparrow, and Field Sparrow) during this period is offset by the appearance of species characteristic of shrubby woodlands and thickets, including the Gray Catbird, Brown Thrasher, and Rufous-sided Towhee. The more mature oak woodland (BWF 1) had a greater species diversity than in any of the earlier stages of old field succession (fig. 30), due to the presence of many species not previously encountered, such as the Downy and Hairy Woodpecker, Great Crested Flycatcher, Common Flicker (*Colaptes auratus*), Eastern Wood Pewee (*Contopus virens*), White-breasted Nuthatch (*Sitta carolinensis*), Black-and-white Warbler (*Mniotilta varia*), Ovenbird (*Seiurus aurocapillus*), and Scarlet Tanager (*Piranga olivacea*). The appearance of these woodland species was more than enough to counter the loss of old field species such as Indigo Bunting, Common Yellowthroat, Blue-winged Warbler, and Gray Catbird.

This progressive increase in species diversity with succession from herbaceous fields to mature forest is consistent with the findings of others (Saunders, 1936; Kendeigh, 1948; Odum, 1950; Johnston and Odum, 1956; Karr, 1968; and Shugart and James, 1973).

Species diversity was significantly lower in those study areas where succession was arrested than in those areas permitted to revegetate naturally. The habitat maintained as a grassland (AP 8,9/G 4) supported the least number of territorial species. This difference in species carrying capacity is demonstrated convincingly by the increasing disparity, with elapsed time since cultivation, in species diversity of the control and managed sections of AP 4 and AP 10. Prior to management these study areas were similar physiognomically, i.e., fields dominated by forbs with only sparse growths of woody vegetation (compare table 5 with table 8, and table 9 with table 12), and supported about the same number of territorial species (years 7–9 in fig. 30). With succession arrested, the managed portions of AP 4 and AP 10 failed to show the increase in diversity of breeding birds that characterized the control sections, and when management procedures were shifted during the late stages of the study to favor grasses over forbs, species diversity in both AP 4M and AP 10M dropped to that of the grassland habitat (AP 8,9/G 4), as seen in years 18 to 23 in figure 30.

Density of Breeding Birds and Old Field Succession

At the same time that species diversity was increasing with age of the fields undergoing succession, there was also an increase in density of breeding birds. My data suggest that the carrying capacity of these fields continued to increase beyond that age at which species diversity began to level off (about 15 years after cultivation) and did not reach peak density until another 15 years had elapsed (fig. 31). Although the oak woodland had a higher diversity of species than the old fields, the density of breeding birds in this woodland (BWF 1) was significantly less than that of the 30 to 40 year old field (SW 7; fig. 31). This decline in density of breeding birds in the woodland at Kalbfleisch is contrary to the results of Johnston and Odum

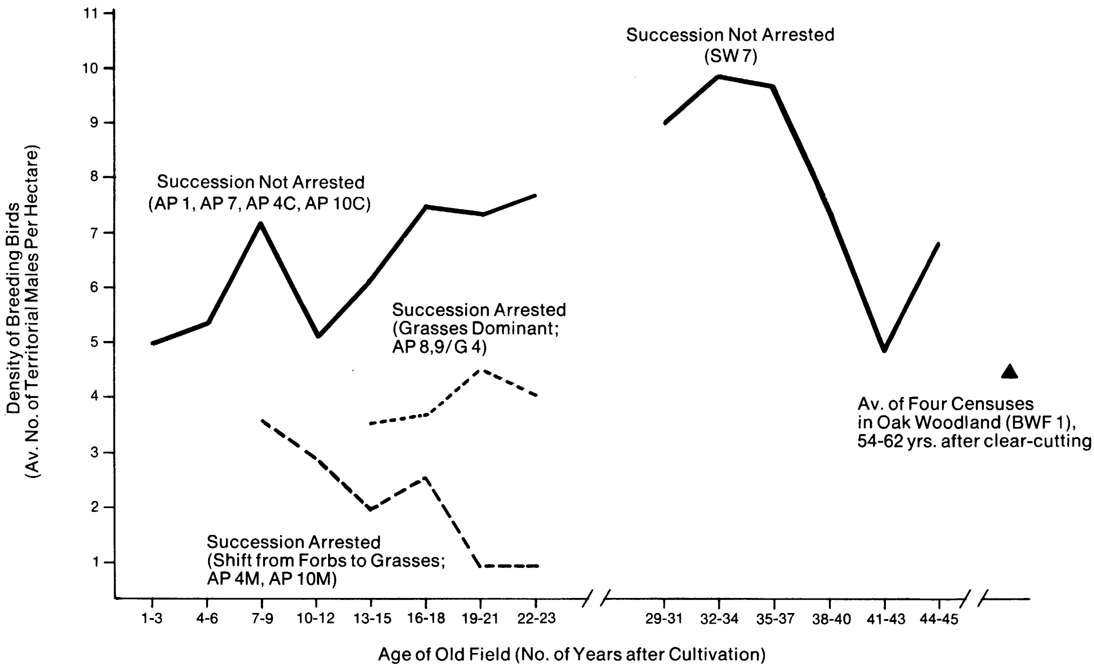

FIG. 31. Variation in density of territorial males with age of old fields.

(1956), who found the density in an oak-hickory woodland on the Piedmont of Georgia to be much greater than that of their 20-year old field. On the other hand, the Kalbfleisch data are consistent with those of Odum (1950), who found that density was higher in the shrubland than in the oak-chestnut woodland on the Highlands Plateau of North Carolina. Whether or not there is a decline in density of breeding birds as succession approaches climax probably is determined by the relative availability of moisture. The woodland on the Georgia Piedmont was relatively mesic, with two streams flowing through it, whereas the North Carolina woodland was more xeric like the one in this study.Other investigators have confirmed that in the more xeric successions, a decline in density is the rule. When Odum (1950) examined the more mesic succession to hemlock forest in North Carolina, he found that density was higher in the forest than in the shrubland stage. Similarly, in studies of avian succession in Arkansas, Shugart and James (1973) had a species density in their open canopy shrubland ("woody field") that was higher than that in their "xeric forest" but lower than the density in their "mesic forest." Karr (1968) likewise had higher densities in a bottomland forest than in a more xeric upland forest.

Density of breeding birds was significantly lower in those study areas where succession was arrested (fig. 31).

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APPENDIX OF BOTANICAL NAMES

Alphabetical list of botanical names used in the text, with corresponding colloquial names and annotations on occurrence at the Kalbfleisch Field Research Station

Acer—any of the following three species of maples

Acer ginnala—Amur Maple; spontaneous individuals of this introduced Asian species were found in several of the fallow fields

Acer rubrum—Red Maple; frequent in shrubby woodlands

Acer saccharum—Sugar Maple; occasional seedlings in fallow fields

Ambrosia artemisiifolia—Common Ragweed; abundant in early stages of old field successon

Apocynum—refers to either or both of the following two species

Apocynum androsaemifolium—Spreading Dobgane; common in fallow fields

Apocynum cannabinum—Indian Hemp; common to abundant in fallow fields

Baccharis halimifolia—Groundsel Bush; occasional in fallow fields

Berberis thunbergii—Japanese Barberry; volunteer plants are occasional in open woodlands

Betula—refers to either or both of the following two species of birches, which appear in late stages of old field succession

Betula lenta—Sweet Birch

Betula populifolia—Gray Birch

Carya ovalis—Sweet Pignut; occasional in shrubby woodlands

Castanea dentata—American Chestnut; present only in older woodlands as sprout-clumps and small trees

Celastrus orbiculatus—Oriental Bittersweet; small colonies became established in older fallow fields
Chrysanthemum leucanthemum—Ox-eye Daisy; common in early stages of old field succession
Cirsium—refers to either or both of the following two species of thistles, which are common in fallow fields
Cirsium arvense—Canada Thistle
Cirsium vulgare—Common Thistle
Cornus florida—Flowering Dogwood; common in fallow fields and as an understory in shrubby woodlands and older woodlands
Dactylis glomerata—Orchard Grass; frequent in fallow fields
Elaeagnus umbellata—Japanese Oleaster; spontaneous individuals of this introduced Asiatic tree were found in several of the fallow fields
Erigeron—refers to any or all of the following three species
Erigeron annuus—Daisy-Fleabane; abundant in early stages of succession
Erigeron canadensis—Horseweed; abundant in fallow fields
Erigeron strigosus—Daisy-Fleabane; occasional in fallow fields
Forsythia intermedia—Golden Bells; occasional in shrubby woodlands
Gaylussacia baccata—Black Huckleberry; abundant in older oak woodlands
Hieracium—refers to the hawkweeds, represented in fallow fields by the following three species
Hieracium flagellare—Hawkweed
Hieracium florentinum—King Devil
Hieracium pratense—Field Hawkweed
Ilex verticillata—Winter Berry; an occasional shrub in older fallow fields
Juglans nigra—Black Walnut; appears in older shrubby woodlands
Juniperus virginiana—Red Cedar; frequent in fallow fields and shrubby woodlands
Larix leptolepis—Japanese Larch; occasional in older fallow fields
Lonicera japonica—Japanese Honeysuckle; an abundant woody vine that forms dense ground cover and entwines shrubs and herbaceous stems in older fallow fields
Myrica pensylvanica—Bayberry; abundant in fallow fields and shrublands
Nyssa sylvatica—Black Gum; spontaneous individuals were found in older shrublands
Phleum pratense—Timothy; species of grass found in fallow fields
Pinus—refers to any or all of the following three species of pines
Pinus rigida—Pitch Pine; appears in some of the older fallow fields
Pinus strobus—White Pine; sporadic individuals in the older fallow fields
Pinus sylvestris—Scots Pine; occasional in the older fallow fields
Populus—refers to either or both of the following two species of aspens, which occur in late stages of old field succession
Populus grandidentata—Large-toothed Aspen
Populus tremuloides—Quaking Aspen
Prunus—refers to either or both of the following two species of cherries, which occur in late stages of old field succession
Prunus avium—Bird Cherry
Prunus serotina—Black Cherry
Pyrus sieboldii—Toringo Crab-Apple; volunteer plants of this ornamental were common in older fallow fields
Quercus—refers to any or all of the following three species of oaks, which characterize the older woodland communities
Quercus alba—White Oak
Quercus coccinea—Scarlet Oak
Quercus velutina—Black Oak
Rhus—refers to any or all of the following three species
Rhus copallina—Winged Sumac; common in old fields and shrublands
Rhus glabra—Smooth Sumac; common in old fields and shrublands
Rhus radicans—Poison Ivy; abundant trailing vine or sprawling shrub in older fallow fields and shrublands
Robinia pseudo-acacia—Black Locust; common in those fallow fields that were close to seed sources in adjacent wooded areas
Rosa multiflora—Multiflora Rose; occasional in older fallow fields
Rubus—refers to any or all of the following three species of bramble, which frequently were encountered in the older fallow fields and shrublands
Rubus flagellaris—Dewberry
Rubus pensilvanicus—Blackberry
Rubus phoenicolasius—Wineberry
Sassafras albidum—Sassafras; common in shrublands and in the understory of older woodlands
Smilax rotundifolia—Bull Brier; common in shrublands and in the understory of older woodlands
Solidago—refers to any or all of the following seven species of goldenrods, which were recorded as frequent to abundant in the Station's fallow fields

Solidago canadensis—Canada Goldenrod
Solidago graminifolia—Grass-leaved Goldenrod
Solidago juncea—Early Goldenrod
Solidago nemoralis—Gray Goldenrod
Solidago rugosa—Wrinkled Goldenrod
Solidago speciosa—Broad-leaved Goldenrod
Solidago tenuifolia—Narrow-leaved Goldenrod
Trifolium—refers to any or all of the following four species of clover, which have been recorded as occasional to frequent in the Station's fallow fields
Trifolium agrarium—Hop Clover
Trifolium hybridum—Alsike Clover
Trifolium pratense—Red Clover
Trifolium repens—White Clover
Vaccinium—refers to any or all of the following three species of blueberry that were recorded as frequent to abundant in the Station's older wooded areas
Vaccinium angustifolium—Low Sweet Blueberry
Vaccinium corymbosum—Highbush Blueberry
Vaccinium vacillans—Lowbush Blueberry
Viburnum—refers to either or both of the following two species
Viburnum acerifolium—Maple-leaved Viburnum; abundant in the understory of the older oak woodlands
Viburnum dentatum—Southern Arrow-wood; Occasional in the older fallow fields and shrublands
Vicia cracca—Tufted Vetch; occasional in fallow fields