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RICE CREEK FIELD STATION
OSWEGO, STATE UNIVERSITY OF NEW YORK
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The Rice Creek Associates (RCA) small grants program in support of research at Rice Creek Field Station enters its thirteenth year in 2008. The financial support supplied by Rice Creek Associates continues to be supplemented by the College Provost and by the Office of Research and Sponsored Programs. Most of the projects supported by this program have been conducted by faculty members or other professional scientists and have employed undergraduate students as research assistants. Several independent student research projects have been completed within the larger context of the RCA supported research efforts.

In addition to student presentations and reports for courses and programs at SUNY Oswego and reports in previous issues of Rice Creek Research Reports (see below), RCA supported research has been reported in poster and oral presentations at numerous local, national, and international professional conferences and in professional publications (see bibliography on inside back cover). In this issue, Peter Weber and Joel Ralston report on a preliminary study of the impact of habitat management practices on bird nesting behavior in the open fields at Rice Creek Field Station. This project was a direct offshoot of the work reported by Weber, Preston, Duglos and Nelson in a paper due to be published in the April, 2008, issue of the *Natural Areas Journal.*

Andrew P. Nelson, Director
Rice Creek Field Station
January 30, 2008

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Breeding Birds in Old Fields in Central New York State in Relation to Field Mowing

Peter G. Weber
Emeritus Professor of Biology
SUNY Oswego
Oswego, NY 13126

Joel Ralston*
Department of Biological Sciences
SUNY Oswego
Oswego, NY 13126

*Present Address: Department of Biological Sciences, University at Albany, State University of New York

Introduction

The study of breeding bird communities in old field (shrubland) ecosystems has yielded important insights into changes that occur to avian communities during secondary succession. Early cross-sectional studies showed that breeding bird density and species diversity increases with ecological age from bare ground of recently abandoned farm fields (Kendeigh, 1946; Kendeigh, 1948; Odum, 1950; Johnston & Odum, 1956) or strip-mining operations (Karr, 1968) through shrub seral stages to forest. Later studies, both cross-sectional (Shugart & James, 1973; Kricher, 1973; Lanyon, 1981; May, 1982; Bollinger, 1995) and longitudinal (Lanyon, 1981) have supported these findings. These studies have also shown that most bird species are to varying degrees limited in breeding to one or two old field seral stages, although some may breed over several stages.

Recent studies of old field birds have focused on threats to their populations (Askins, 2001; Hunter, Buehler, Canterbury, Confer & Hamel, 2001). With a decline in farming practices and an increase in urbanization (Hart, 1968, Kambly, 2006, Numbers, ND), old field specialists have suffered declines in populations as shrublands disappear (Askins, 1998; Dettmers, 2003). Shrublands are second only to grasslands in the proportion of species with significant population declines (50% vs. 70% for grassland birds). Askins (1998) presents data showing statistically significant population declines between 1966 and 1994 for brown thrasher (*Toxostoma rufum*), golden-winged warbler (*Vermivora chrysoptera*), chestnut-sided warbler (*Dendroica pensylvanica*), indigo bunting (*Passerina cyanea*), and field sparrow (*Spizella pusilla*) east of the Mississippi River. To this list Dettmers (2003) adds eastern towhee (*Pipilo erythropthalamus*) and American goldfinch (*Carduelis tristis*) with significant declines. Each of these species occurs in the managed fields on Rice Creek Field Station (RCFS) grounds as possible or confirmed breeders.

Most sites in temperate portions of the world, if not maintained by mowing, grazing or burning, would succeed to deciduous or mixed forest. Concomitantly, bird populations on a site would change as meadow-adapted species are replaced by shrub-adapted and eventually by woodland-adapted species (Johnston & Odum, 1956; Shugart & James, 1973; Lanyon, 1981; Bollinger, 1995; Yahner, 2003). In order to maintain habitat diversity, the personnel at RCFS keep three fields at various early stages of old field succession by a schedule of mowing. As a field site changes vegetatively in years following mowing so should its avian community. We wished to document these changes through the field station's mowing cycle.

The majority of mowing studies have investigated the effects on grassland birds in prairie regions. Dale, Martin and Taylor (1997) found numbers of Sprague's pipit (*Anthus sprageuii*) and western meadowlark (*Sturnella neglecta*) to increase the year following mowing. However, LeConte's sparrows (*Ammodramus leconteii*), savannah sparrows (*Passerculus sanwitchensis*) and Baird's sparrows (*A. bardii*) decreased following mowing. Horn and Koford (2000) found sedge wrens (*Cistothorus platensis*), LeConte's sparrows and red-winged blackbirds (*Agelaius phoenicus*) declined following mowing while savannah sparrows became more abundant. Johnson, Igl & Schwartz (in Johnson 2000) found that three shortgrass species responded favorably in the year following haying. However, many more grassland species responded with reduced breeding densities following haying. Walk and Warner (2000) compared breeding densities of five species of grassland specialists between mowed, hayed, burned, grazed and undisturbed management areas of warm and cool-season grasses. Overall abundance was lowest in recently burned cool-season grassland areas. Swengel and Swengel (2001) found haying significantly increased the abundance of Henslow's (*Ammodramus henslowii*) and grasshopper sparrows (*A. savannarum*) compared to burning, but had no effect on dickcissel (*Spiza americana*) in southwestern Missouri tallgrass prairies.

Other workers have investigated the effects of mowing on birds in crop fields. Johnston and Odum (1956), while not focused on mowing *per se*, found a slight decline in grasshopper sparrow breeding density following mowing of an oat field. Bollinger, Bollinger and Gavin (1990) found a 29-45% mowing-induced mortality in bobolinks (*Dolichonyx oryzivous*) in upstate New York hayfields. Frawley and Best (1991) found the absence of four species, the reduction in two species and no effect in two species following mowing in Iowa alfalfa fields. Few studies concerning the effects of mowing on old field bird populations *per se* exist and none have investigated changes during a rotational mowing cycle as in our study.

The only systematic study of breeding birds on RCFS grounds has been by Weeks (1998). Weeks documented the kinds and numbers of birds breeding in the immediate wetlands surrounding Rice Pond. In a similar vein we set out to document the kinds and number of birds breeding in managed field sectors. We were most interested in how the diversity and numbers of breeders might change during the four-year mowing cycle. Moreover, our interest was also in how these changes might be related to sector characteristics (e.g. area, vegetation height, length of edge, etc.).

Methods

Study Area

Rice Creek Field Station is located in the Town of Oswego, Oswego County, New York. The properties extend from approximately 43°25′34″ to 43°26′33″ N and 76°32′33″ to 76°33′25″ W. The three maintained fields in which we investigated breeding birds are located from east to west from the top of a drumlin, at 104 m elevation, to a low of 83 m at Rice Creek (Figure 1). The upper and middle fields are divided into sectors, each which is on a four-year mowing cycle (Table 1, Figure 2). We considered these sectors as distinct sampling areas. There are four such sectors in the upper field and nine in the middle field. Younger sectors in the upper and middle fields are contiguous to older sectors. The lower field is not sub-divided into sectors and is mowed in its entirety every four years; we considered it as one sector.

Mowing with an International Harvester Brush Hog to an approximate height of 18 cm occurred each year of the study in early August; leaving cut forbs, grasses and woody stems in place. Mowing in late summer minimizes disturbance to most nesting species (Mass Audubon, 2007, Sample & Mossman, 1997). Following Reschke's (1990) classification (as revised in Edinger, Evans et al, 2002), in the first and second year after mowing, sectors can be considered as successional old fields; in the third and fourth year after mowing most sectors meet her criteria of a successional shrubland. Sectors varied in area (0.15 ha to 0.40 ha), in length of wooded periphery (25.86 m to 296.3 m) and in percent of coverage by permanent woody vegetation (0% to 38%) (Table 1). Eight sets of back to back nest houses, each set mounted on a pole and situated in mowed circles of approximately 10 m diameter, were located in six sectors of the middle field (Figure 1,

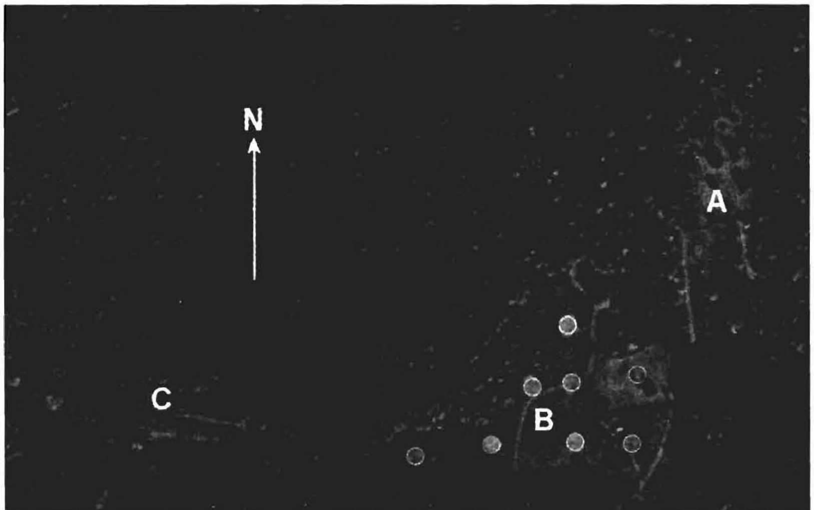


Figure 1. Aerial showing the mowed fields on the Rice Creek Field Station grounds (A = upper field, B = middle field, C = lower field, white circles delineate mown areas around nest boxes in middle field).

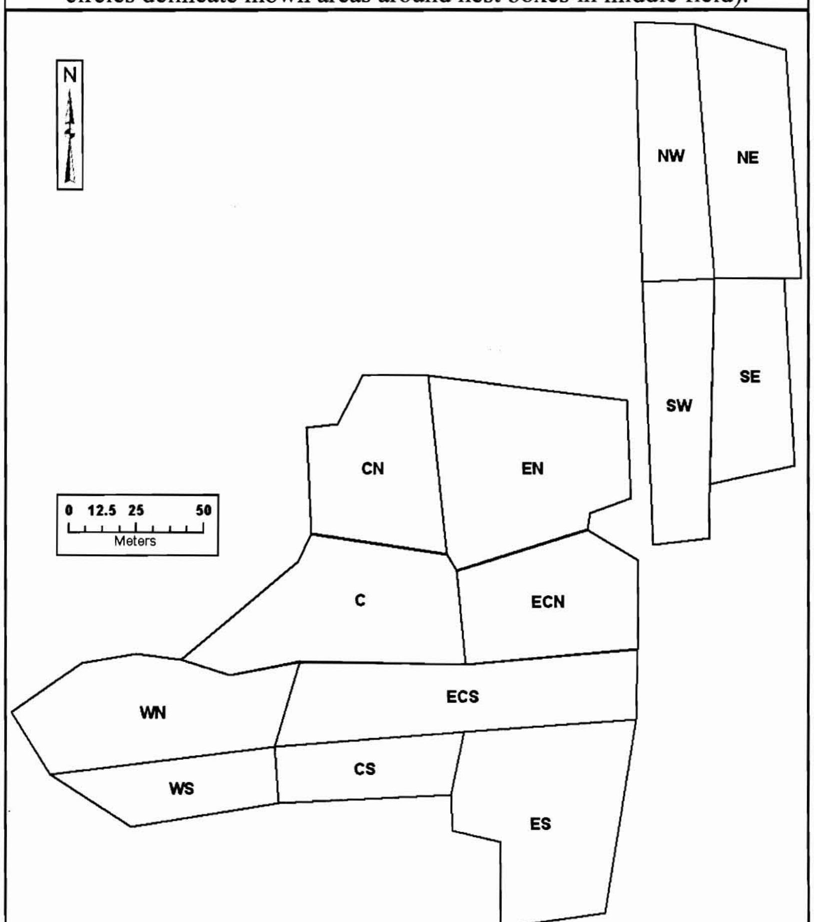


Figure 2. Sector notations used in Tables 1, 2, and 6.

Table 1). Since cavity nesters may be influenced by the height and quality of the surrounding vegetation (e.g. Belles-Isles & Picman, 1986), we included them in most of our analyses.

Sector areas and periphery lengths were determined with the field calculator in ESRI® ArcMap™ v. 9.1. The percent coverage of sectors by permanent woody vegetation was estimated by placing a grid of 5 m^2 blocks over a relatively recent (April 2003) aerial map of a sector. The number of blocks filled with permanent tree or shrub vegetation, known from their locations drawn on a map in the field, were then tallied and divided by the total blocks in the sector. Blocks that were a quarter, a third or half filled were scored as such.

Table 1. Location, area, periphery lengths, elevation, coverage by permanent vegetation, mowing schedule and notable features of mowed study areas. For location of sectors in middle and upper fields see Figure 2.

Location (Field & Sector)	Sector Area (ha)	Length of Wooded Periphery (m)	Length of Non-wooded Periphery (m)	Total Periphery Length (m)	Elevation (m)	% Coverage by Permanent Woody Vegetation	Mowing Schedule	Notable Features
Middle Field							Each sector every four years on a rotating schedule	Woods bordering three sides & a hedge on east side
EN	0.40	139.9	117.0	256.9	100.5	22.0		—
ECN	0.26	54.8	137.4	192.2	100.1	16.0		Back to back bluebird houses on a pole in lawn mowed circle
ECS	0.36	25.9	292.5	318.3	94.9	9.0		Back bluebird houses on a pole in lawn mowed circle
ES	0.38	175.0	84.3	259.3	97.8	20.0		Back to back bluebird houses on a pole in lawn mowed circle; brush pile in SW end
C	0.35	68.2	205.7	273.9	92.3	25.0		Back to back bluebird houses in E end & a second set in W end
CN	0.27	96.3	117.5	213.8	96.1	7.0		Back to back bluebird houses on a pole in lawn mowed circle
WN	0.33	95.8	162.5	258.3	89.9	2.0		Back to back bluebird houses in E end & a second set in W end
WS	0.15	91.2	104.8	196.0	88.8	0.0		—
CS	0.16	64.4	128.6	193.0	91.2	2.0		Brush pile in center of sector
Upper Field							Each sector every four years on a rotating schedule	Woods bordering three sides & a hedge on the west side
SE	0.21	101.7	101.5	203.2	103.6	21.0		—
SW	0.23	138.8	102.1	240.9	102.7	10.0		Brush piles in N & S ends
NE	0.29	126.3	120.2	246.5	102.8	34.0		—
NW	0.23	118.3	121.0	239.3	102.4	38.0		—
Lower Field	0.38	296.3	9.0	305.3	84.4	16.0	Entire field every four years on a rotating schedule	Woods bordering three sides & Rice Creek on W side; brush pile in NE end

Sampling

Vegetation: We divided each field sector into 15 m^2 grids and randomly sampled half of the grids in each sector. Since sectors each differed in area, the number of sampled grids in each varied (Appendix A). Within each grid we then randomly sampled at two points. Following Wiens (1969), to characterize vegetation structure in each sector, once in early June and once in mid to late July, we measured eleven vegetative characteristics at each of the two random points in each grid. Vegetation height was measured as the height to which vegetation reached on a vertical rod. Vertical vegetation density (VVD) was measured as the number of contacts per dm by dead and living plant parts onto a vertical rod. We also measured illumination at 10 cm above ground level and above the vegetation with an A. W. Sperry, SLM-110 photometer to obtain the proportion of full sun at 10 cm above ground (as a reflection of "canopy development"). Each measurement was taken with the photometer pointing north. We made six specific vegetative determinations: "general vegetation form" (graminoid, forb, woody), "stem arrangement" (parallel, radiating, network), "stem thickness" [thin (<2mm diameter), medium (2-6mm), heavy (6mm-10cm), very heavy (>10cm)], "leaf shape" [leafless, very narrow (length > 5 x width), narrow (length 2-5 x width), medium (length 1-2 x width), and broad (length < width)], "leaf size" as leptophyll (< 25 sq. mm), nanophyll (25-225 sq. mm), microphyll (225-2025 sq. mm) or mesophyll (> 2025 sq. mm), and "leaf type" (simple or compound). Lastly, we identified the dominant and/or co-dominant vegetative species at each point.

Birds: We sampled for actively nesting birds mainly by repeated visits to sectors to locate breeders. At each visit we listened and searched for territorial or breeding individuals until no new individuals were recorded. Sectors were small enough in area, the largest only 0.40 ha (Table 1), that bird activity could be seen or heard from the edges. We recorded the location of territorial or breeding individuals on a map of the given sector. Repeated visits allowed us to see patterns of territory locations by various species in a sector and later, during the nestling stage, to locate parents with food. This technique yielded the most breeding confirmations. Since many old field species utilize edge habitat we sampled into a sector's edge approximately 3 m. Table 2 outlines the number and duration of visits in each year; in 2005 we visited active sectors more times, in 2006 we attempted to apportion visits between sectors more evenly. In 2005 we sampled approximately every three days from April 11 until Sept. 18; in 2006 sampling was approximately every two days from April 11 until August 21. We also sampled by dragging a 10 m rope between us to flush nesters. This technique was used in the second year in one and two-year sectors. We also systematically walked through a sector side by side within 2 m of one another searching for active nests. Active nests were photo-documented and their location established using a Garmin eTrex Legend GPS unit. Lastly, we searched for nests after leaves had fallen and nests could easily be located.

We used the N.Y. State Breeding Codes (Anonymous 2000) to establish "Possible", "Probable" and "Confirmed" breeders. For each sector we finished at the conclusion of a season with a list of species in each breeding category. "Possible" breeders included all species appearing in a sector excepting if the habitat was unsuitable for a given species to breed in. So, for example, eastern bluebird (*Sialia sialis*) was deleted in 2006 from sector WS because the vegetation was mainly woody and the mean height exceeded 1 m making

Table 2. Number of sampling sessions and total time in each sector in 2005 and 2006. For location of sectors in middle and upper fields see Figure 2.

Field and Sector	Number of Sessions in Sector				Time in Sector (person h)	
	2005		2006		2005	2006
	Pre-mow	Post-mow	Pre-mow	Post-mow		
Upper						
SE	26	5	41	1	14.4	8.75
SW	30	7	38	1	20.1	8.02
NE	22	6	34	1	12.5	6.43
NW	24	6	37	1	13.0	7.27
Middle						
EN	47	5	48	1	27.6	7.78
ECN	29	5	46	1	12.9	7.46
ECS	46	5	48	1	23.9	7.36
ES	34	3	48	2	17.2	7.96
C	34	7	47	2	16.6	9.03
CN	40	5	49	0	22.9	9.04
WN	39	7	49	0	21.4	9.03
WS	22	6	48	1	14.6	8.66
CS	22	5	48	1	8.5	7.51
Lower	29	4	37	0	20.6	20.82
Total	**444**	**76**	**618**	**13**	**246.15**	**125.12**

it unsuitable breeding habitat, even if suitable cavities were in the sector's edge. If a species was apparently holding a territory in the same local of a sector for three or more visits a week apart, we considered it to be a "Probable" breeder in the sector. A species was considered a "Confirmed" breeder in a sector using the following criteria: distraction display by parent, parent carrying a fecal sac, parent with food, nest with eggs or young, newly fledged young or a used nest following the season providing the species was active in the sector during the season.

We removed as many nests as we could find from the previous breeding season to insure that any nest found in the following season must have been created that year. The identity of nests located after the following breeding season, was determined by comparing their measurements to the literature and relating the nest location to confirmed or probable breeders in that portion of the sector that might have constructed the nest. We used a Swiss Precision Instruments 2000 vernier caliper to measure nest dimensions. All measurements were by PGW except in the instance of the blue-winged x Brewster's warbler nest which was additionally measured by JR and an independent investigator.

Analysis

Vegetation: To describe the vegetation in a sector, we determined by visual impact which plant species (or two species) was dominant at a given sampled point. The number of points sampled in a sector depended on the size of the sector and varied from a low of 10 to a high of 32 (Appendix A). We then ranked these plants by the frequency of points of occurrence to determine which plant species were dominant in a sector (Appendices B – D).

We compared mean vegetation heights, VVD and percent full sunlight in 1 – 4 y sectors via one-way analysis of variance and determined which means differed by a Tukey multiple comparison test.

Birds: We compared counts of total pairs of confirmed breeders for the four mow ages using a χ^2 test for equal proportions. The post hoc analysis compared counts from each of the three pairs of consecutive years, using an exact one-sample test to ascertain whether the proportion of total pairs of breeding species found in the later period was different from ½, with P-values adjusted to account for the multiple comparison.

To determine which measured field variables might influence counts, we aggregated counts (square root transformed) of probable breeders for each season, and treated these as the response using the general linear model for our analysis. We chose data from probable breeders because the data for confirmed breeders were too few; and the data for possible breeders were too uncertain in as much as migrants and floaters could have been included. As predictors in our first model we included four fixed field characteristics: Area, Elevation, the Proportion of Cover by Permanent Woody Plants (i.e. ones not mowed) in the sector, and the Ratio of a Sector's Non-wooded Edge to Total Edge. This last measure was to avoid sector size as a bias. This edge ratio was log-transformed. Three properties of fields that change over time were included as predictors: Vegetation Height, VVD and Percent of Full Sunlight; the Year and the age (years) since last mowing (Mow Age) were our other two predictors. Sector Mow Age was treated as qualitative. We excluded the lower field from the analysis since its characteristics were quite different from the two other fields. (Its inclusion in the analysis showed it to be highly influential on the overall fit.) The analysis was repeated with a second model using only Area and Mow Age as predictors.

To measure overall species diversity of probable breeders in sectors of different mow age we used the Shannon index (MacArthur, 1955). The Shannon index is a measure of overall species diversity which incorporates both the number of species (Richness) and the distribution of individuals among the species (Evenness) into a single value. Since these two components influence the overall index, we were further interested in how each might independently vary over the mowing cycle. We measured Evenness as: $J = H/\log S$, where H is the Shannon index and S the count of probable breeding pairs of species. We measured Richness simply as the count of probable breeding species per ha. We again used the general linear model with the Shannon index, Evenness and Richness as the response variables. For each we fit a general linear model using Sector Mow Age (1, 2, 3, and 4), Year (2005, 2006) and Sector Area as predictors. We tested to determine which interactions had no predictive value and could be removed from the model. When interactions were removed from the model it was also possible to assess the presence of main effects with significance tests. In post hoc analyses we investigated the response variables as a function of Sector Mow Age (adjusted for area). When Year and Sector Mow Age interacted, these comparisons were made within years. The lower field was excluded from the analysis as were nest box breeders.

We obtained data on field and edge species population trends in the lower Great Lakes / St. Lawrence Plain region from the Patuxent Breeding Bird Survey website (Sauer, Hines and Fallon, 2005).

Results

Vegetation Changes During the Four-year Mowing Cycle

Successional vegetative changes should drive successional changes in avian breeders. Here we describe vegetative changes during the four year mowing cycle. One-year sectors in all fields were dominated nearly exclusively by herbaceous vegetation (Appendix B – D). The dominant plants in one-year sectors, based on their frequency of occurrence, included goldenrod (mainly *Solidago canadensis*), aster (mainly *Aster lateriflorus* and *A. novae-angliae*), knapweed (*Centaurea jacea*), bedstraws (*Galium sp.*), vetches (mainly *Vicia sativa* and *V. villosa*) and sensitive fern (*Onoclea sensibilis*). Two-year sectors were similarly dominated by herbaceous vegetation. In some sectors of the middle field, by the second year following mowing, woody species, particularly silky dogwood (*Cornus amomum*), established themselves as second ranked dominants. In three-year sectors woody vegetation, including silky dogwood, ash (*Fraxinus sp.*), highbush blackberry (*Rubus allegheniensis*), arrowood (*Viburnum dentatum*), common buckthorn (*Rhamnus cathartica*), and multiflora rose (*Rosa multiflora*), became dominant in most sectors. This pattern continued in the fourth year following mowing, except in the lower field where first year herbaceous vegetation persisted (Appendix D).

Figures 3 – 5 show changes in three vegetative measures across sectors (measurements from June and July were averaged together). Vegetation height increased in older sectors but not significantly so from one to two-year sectors (Figure 3). In 2005 the vegetation in three-year old sectors was significantly higher than in one, two or four-year sectors.

In the two years of sampling, overall VVD showed no consistent pattern over mow age (Figure 4). In 2005 VVD was significantly lower in three-year sectors than in one and two-year sectors, which did not differ significantly from each other while year four sector VVD was significantly higher than year three but not statistically different from year two sectors. In 2006 the pattern was somewhat more consistent, showing a successive significant decline in VVD in the last two years.

Percent full sun at 10 cm above ground is an indirect measure of canopy development. In 2005 this measure showed a significant decrease in three and four-year sectors from one and two-year sectors as woody vegetation replaced herbaceous (Figure 5A). In 2006 the percent of full sun decreased successively from year-one to year-four sectors. However, sectors of two, three and four years in age did not differ from each other but did from year-one sectors (Figure 5B).

Possible, Probable and Confirmed Breeders in Mowed Sectors

Possible Breeders: Table 3 gives the mean percent of sampling sessions, as a measure of relative abundance, in which the 34 possible nesting species occurred in 2005 and 2006. The majority (15) of species were old field specialists, somewhat fewer than half (11) were edge species and eight were both. Late in the study we documented the existence of a blue-winged warbler (*Vermivora pinus*) female mated to a Brewster's warbler (*Vermivora leucobronchialis* = *V. pinus* x *V. chrysoptera*) male. Since we also documented the presence of golden-winged warblers (*Vermivora chrysoptera*), in most instances by its song, we could not be certain if at all times the singing bird could not

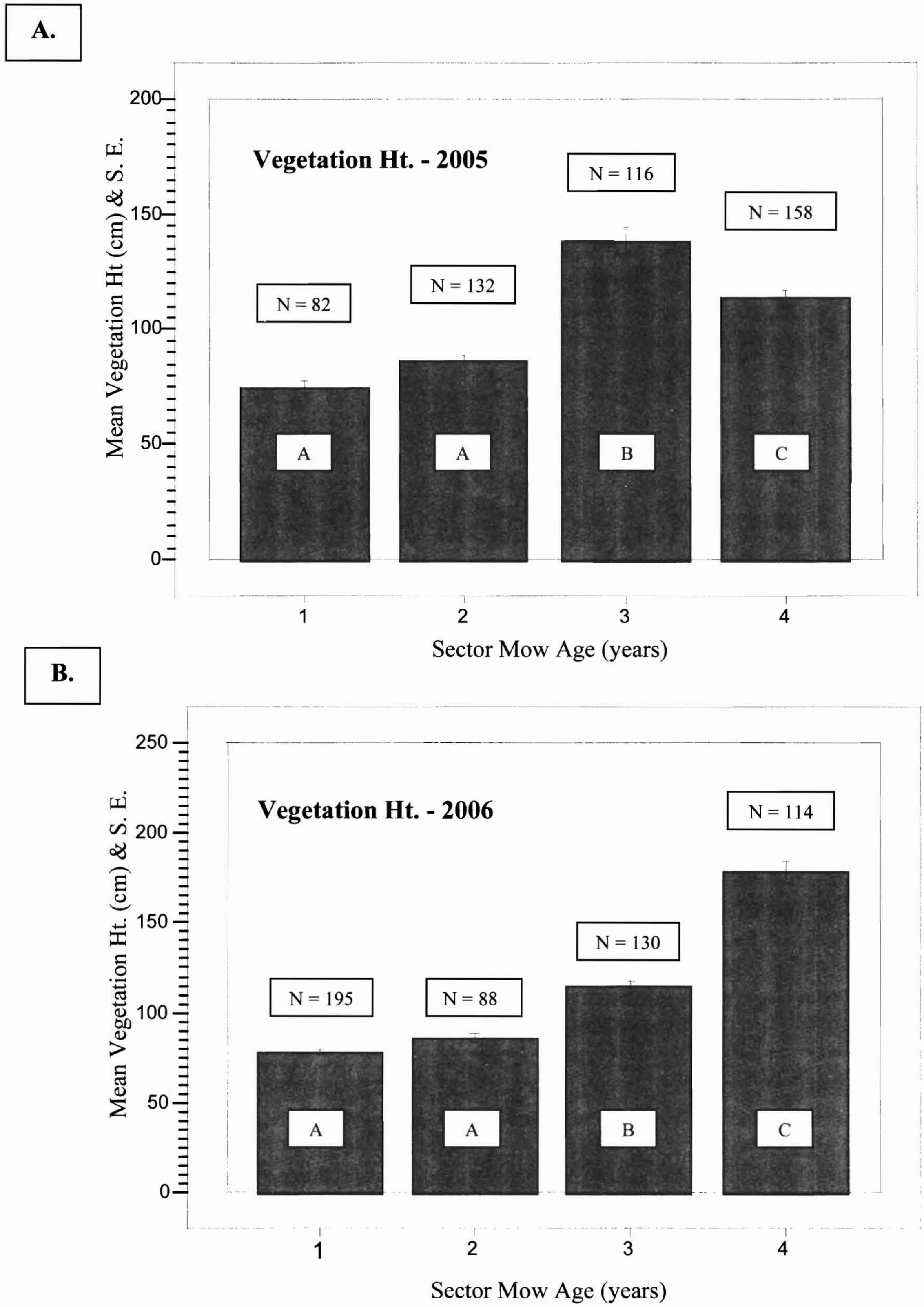
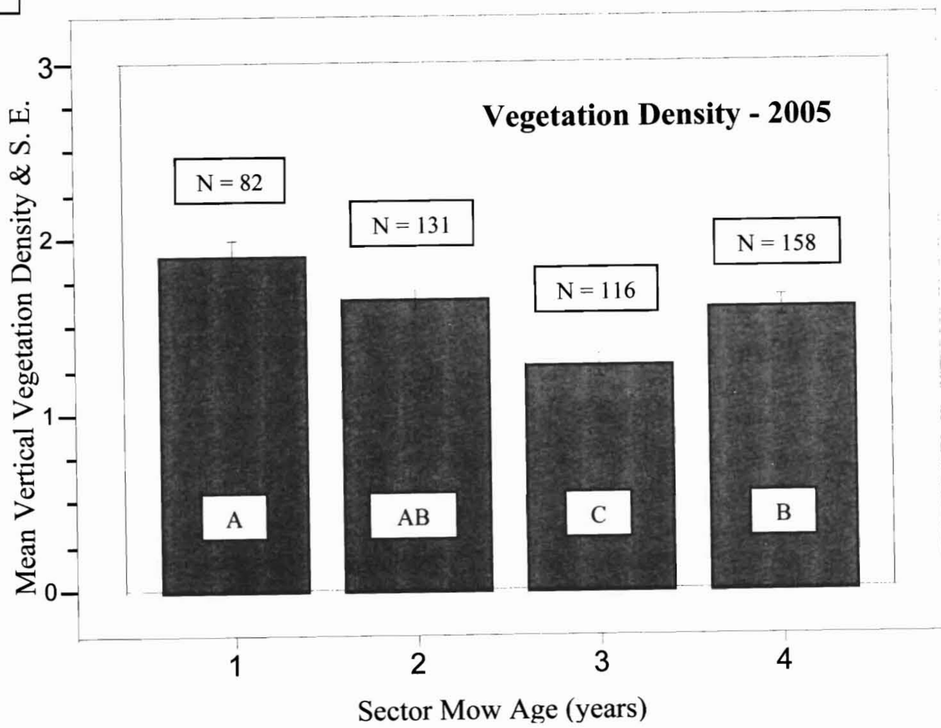


Figure 3 Mean vegetation height (cm) ± standard error in sectors of 1, 2, 3 and 4 years in A. 2005 and B. 2006. Means (bars) labeled A, B, C are statistically different from each other by a Tukey multiple comparison at p = 0.05; means sharing the same letter do not differ significantly.

A.



B.

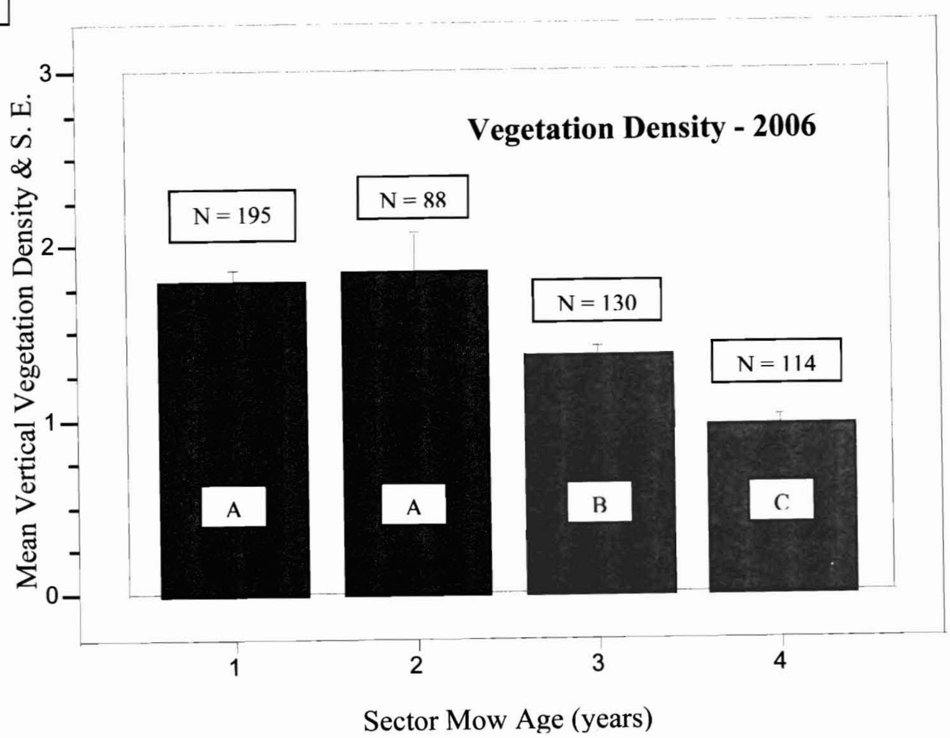


Figure 4. Mean vertical vegetation density (touches/dm) ± standard error in sectors of 1, 2, 3 and 4 years in A. 2005 and B. 2006. Symbols as in Figure 3.

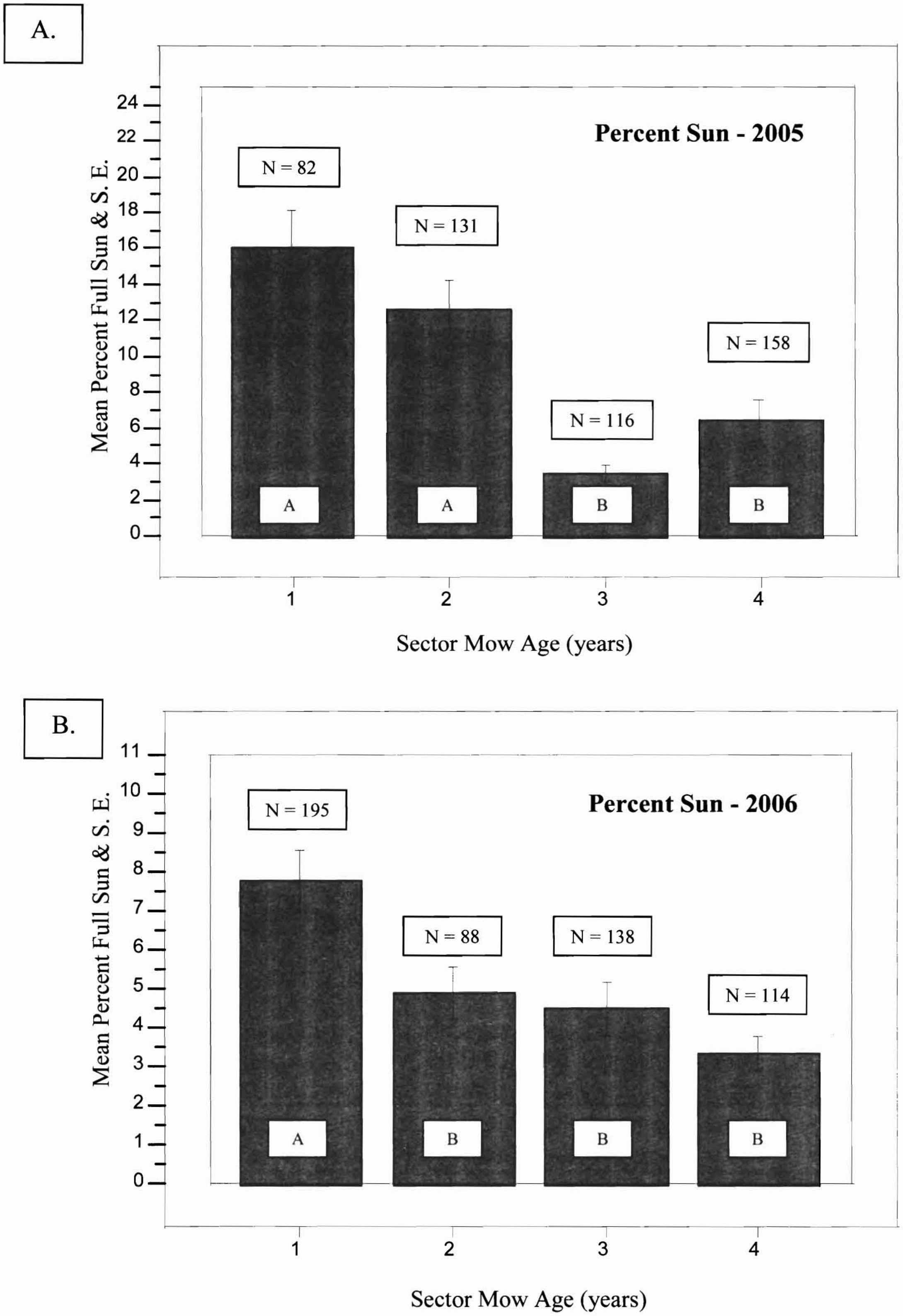


Figure 5. Mean percent full sun at 10cm above ground ± standard error in sectors of 1, 2, 3 and 4 years in A. 2005 and B. 2006. Symbols as in Figure 3.

Table 3. Mean percent of sampling sessions during which possible breeders were seen in field sectors of 1 to 4 y mow age in 2005 and 2006. Box nesters in bold; N = 7 in each year. Habitat preference taken from DeGraaf & Rudis,1986 and Herkert, 1995.

	Field or Sector Mow Age				**Habitat Preference**	
Species	**1 y**	**2 y**	**3 y**	**4 y**	**Old Field/ Shrubland**	**Edge**
Mallard	1.1	0.0	0.0	0.0	x	
Am. woodcock	1.3	0.9	0.4	0.9	x	
Mourning dove	1.3	0.0	0.0	0.0	x	x
Black-billed cuckoo	0.0	0.0	0.7	0.0	x	x
Ruby-throated hummingbird	8.0	0.3	0.7	2.7		x
Willow flycatcher	5.7	3.9	8.9	6.6	x	
Least flycatcher	0.0	0.0	0.0	1.0		x
Eastern phoebe	0.4	0.0	0.0	0.0		x
Great crested flycatcher	0.0	0.0	0.3	0.3		x
Eastern kingbird	0.0	0.0	0.3	1.0	x	x
Tree swallow	1.9	4.9	10.4	5.9	x	
Blue jay	0.0	0.0	1.4	0.0		x
House wren	23.9	19.6	27.6	19.7	x	
Blue-gray gnatcatcher	0.0	0.0	0.0	0.6		x
Eastern bluebird	0.0	0.3	0.3	0.0	x	
American robin	6.7	0.3	2.1	4.0		x
Gray catbird	21.4	12.3	25.1	39.0	x	x
Brown thrasher	0.0	0.0	0.3	0.0		x
Cedar waxwing	8.7	2.4	3.9	4.9		x
Blue-winged, golden-winged complex	7.6	2.3	5.4	10.6	x	
Yellow warbler	23.9	15.4	30.7	59.1	x	
Chestnut-sided warbler	3.7	0.3	3.3	2.7	x	
Common yellowthroat	26.6	43.1	47.3	52.9	x	
Northern cardinal	14.0	8.1	8.0	10.7	x	x
Rose-breasted grosbeak	0.0	0.0	1.1	0.9		x
Indigo bunting	12.3	7.6	7.4	10.6	x	x
Eastern towhee	11.7	9.1	13.9	16.6	x	x
Field sparrow	5.0	7.7	4.9	5.0	x	
Song sparrow	29.7	34.4	49.0	67.9	x	
Red-winged blackbird	1.3	0.0	0.3	1.1	x	
Baltimore oriole	3.4	1.6	2.0	3.0		x
Brown-headed cowbird	3.4	1.0	3.6	5.0	x	x
American goldfinch	18.1	13.9	25.9	39.0	x	
Mean of the Mean %	**7.3**	**8.5**	**11.7**	**15.7**		
Total Species	**24**	**21**	**28**	**26**		

have been a Brewster's. Thus we designated the category in this table as "blue-winged/golden-winged complex."

The dominant species based on their relative abundance, song sparrow (*Melospiza melodia*), yellow warbler (*Dendroica petechia*), common yellowthroat (*Geothrypis trichas*), gray catbird (*Dumetella carolinensis*) and American goldfinch (*C. tristis*) each reached peak abundance in year four. Overall abundance of possible breeders increased successively from one-year to four-year sectors but species richness peaked in three-year sectors. Mallard (*Anas platyrhynchos*), although not strictly a field breeder, was here included because it had bred in the lower field in 2004 (PGW, personal observation).

Table 4. Estimated pairs of probable breeding species in field sectors of 1 to 4 y mow age. Sampling years 2005 and 2006 combined; box nesters are in bold. Column headed "1 y - Lower Field" are data for 1 y sectors minus 1 y lower field data.

	Field or Sector Mow Age				
Species	**1 y**	**1 y - Lower Field**	**2 y**	**3 y**	**4 y**
Ruby-throated hummingbird	1	(0)	0	0	1
Willow flycatcher	1	(1)	0	1	3
Tree swallow	1	(1)	1	1	3
House wren	4	(3)	2	8	3
Gray catbird	4	(2)	4	6	9
Cedar waxwing	1	(0)	1	0	0
Blue-winged x Brewster's	0	(0)	0	1	0
Golden-winged warbler	1	(1)	0	1	2
Chestnut-sided warbler	1	(0)	0	1	1
Yellow warbler	3	(2)	2	6	8
Common yellowthroat	8	(6)	7	11	12
Northern cardinal	3	(2)	2	2	3
Indigo bunting	1	(1)	1	0	1
Eastern towhee	1	(0)	1	2	4
Field sparrow	2	(2)	3	3	4
Song sparrow	7	(4)	5	8	12
Brown-headed cowbird	1	(0)	0	1	2
Baltimore oriole	0	(0)	0	0	1
American goldfinch	1	(0)	2	10	6
Total Pairs	**41**	**(25)**	**31**	**62**	**75**
Total Species	**17**	**(11)**	**12**	**15**	**17**

Probable Breeders: We tallied 19 probable breeding species over the two years (Table 4). Total probable breeding pairs was higher in year one than in year two sectors, and the diversity of breeders was higher in year one than in years two and three (Table 4). If the lower field year one data are removed from the analysis (second column in Table 4) then the expected pattern of an increase in breeding pairs and species as sectors succeed from meadow to shrub is evident. Four of the five dominant species again peaked in four-year sectors; American goldfinch peaked in three-year sectors.

Confirmed Breeders: We confirmed breeding in 12 species (including Brewster's x blue-winged warblers) during our two-year study. Considering data from all sectors, the number of confirmed breeding pairs was higher in one-year sectors than in two-year sectors and peaked in three-year sectors (Table 5). The number of breeding species was also higher in one-year than in two-year sectors but it peaked in three and four-year sectors. The counts of total pairs of confirmed breeders were overall significantly different ($\chi^2(3) = 15.1$, $p = 0.002$), implying that the proportions of pairs of breeders in the four mow ages were not all equal. In post hoc tests only the second and third years were found to be significantly different ($z = 3.09$, $p = 0.009$).

Do Older Sectors Fill Up More Rapidly with Breeding Species?

We investigated the idea that older sectors fill more rapidly, and attain higher numbers of breeding species, by comparing probable breeding species with species accumulation curves in the nine sectors of the middle field in 2005 and 2006. In general older sectors tended to fill more rapidly and reach higher asymptotes (Figure 6A & B). Three exceptions to this pattern were: in 2005 a two-year and a four-year sector reached

Table 5. Number of pairs of confirmed breeding species in field sectors of 1 to 4 y mow age. Sampling years 2005 and 2006 combined; box nesters are in bold. Column headed "1 y - Lower Field" are data for 1 y sectors minus 1 y lower field data.

	Field or Sector Mow Age					
Species	1 y	1 y - lower field	2 y	3 y	4 y	4 y - lower field
Tree swallow	0	(0)	0	1	2	(2)
House wren	1	(1)	2	6	3	(3)
Gray catbird	3	(1)	1	1	4	(3)
Cedar waxwing	2	(1)	0	0	0	(0)
Blue-winged x Brewster's	0	(0)	0	1	0	(0)
Yellow warbler	1	(0)	0	5	4	(4)
Common yellowthroat	4	(3)	3	7	3	(2)
Indigo bunting	0	(0)	0	0	1	(1)
Field sparrow	1	(1)	2	1	2	(2)
Song sparrow	3	(1)	2	4	4	(4)
American goldfinch	0	(0)	0	7	1	(1)
Total Pairs	**14**	**(8)**	**8**	**26**	**19**	**(17)**
Total Species	**7**	**(6)**	**5**	**9**	**9**	**(9)**

similar mid-level asymptotes (Figure 6A) and in 2006 a three-year sector joined one and two-year sectors in reaching the lowest asymptote (Figure 6B).

We similarly compared the four upper field sectors and the lower field. In 2005 the oldest four-year sector of the upper and lower fields gained species more rapidly and attained higher asymptotes than the younger sectors (Figure 7A). However, in 2006 the lower field, which was now in its first year following mowing, clearly outpaced the older sectors of the upper field (Figure 7B).

How is the Number of Old Field Breeders Related to Sector Characteristics?

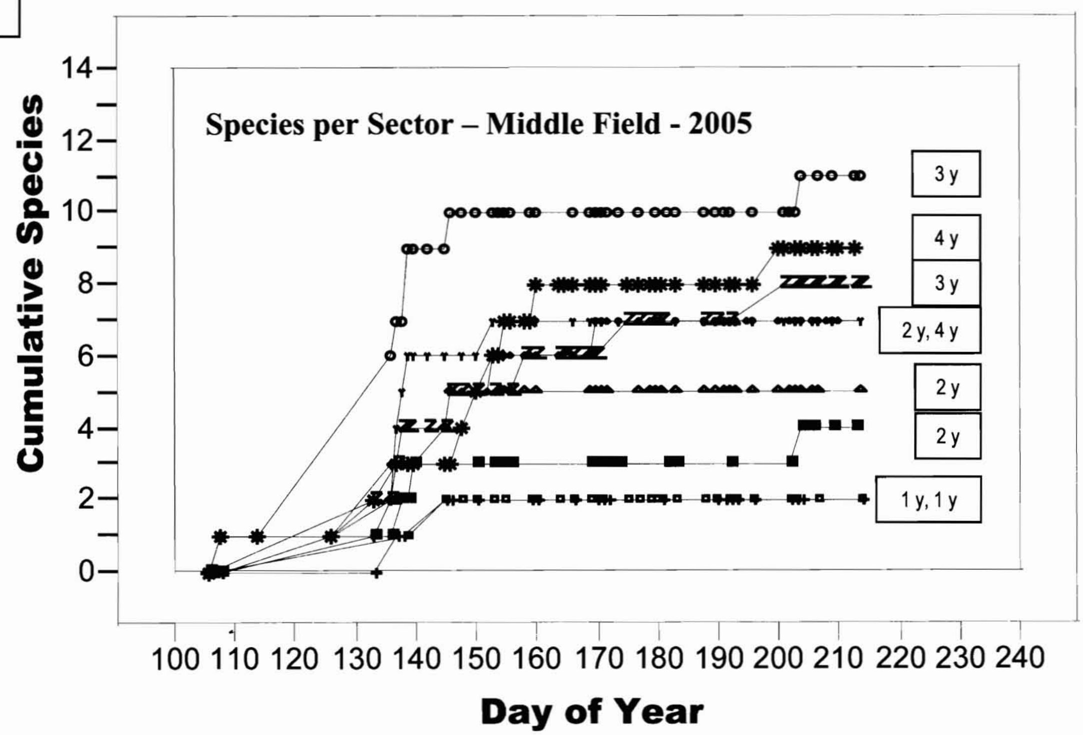
In addition to age, field sectors varied in a number of measurable variables, some of which are given in Table 1. We were interested in whether or not any of these variables are related to the number of breeders.

The results from our first analysis using the linear model suggested that most variables were not associated with probable breeders. That is, Sector Elevation, Proportion of Cover by Permanent Woody Plants, the Ratio of a Sector's Non-wooded Edge to Total Edge, Vegetation Height, VVD and Percent of Full Sunlight are not associated with the count of probable breeders ($F_{7,14} = 0.319$, $p = 0.9327$). We extended the analysis with a second model, using only Sector Area and Mow Age as factors. Counts of probable breeders were highly positively associated with Sector Area ($F_{1,3} = 15.23$, $p = 0.001$) and Sector Mow Age ($F_{1,3} = 16.39$, $p < 0.001$). There was no evidence of interaction between these two predictors ($F_{3,25} = 0.94$, $p = 0.442$). Next we compared mean counts in sectors of various mow ages via a Tukey-Kramer test for multiple comparisons (Figure 8). Counts increased with Sector Area for sectors of each mow age. Moreover, counts did not differ significantly in sectors of one and two years of mow age, nor of three and four years mow age. However, counts were significantly higher in years three and four than in years one and two.

Does the Diversity of Breeders Increase with Sector Mow Age?

Based upon previous old field studies by Johnston & Odum (1956), Shugart & James, (1974) and Lanyon (1981) one might expect an increase in both the diversity and numbers of breeders as sectors succeed from meadow to shrub. We next investigate this

A.



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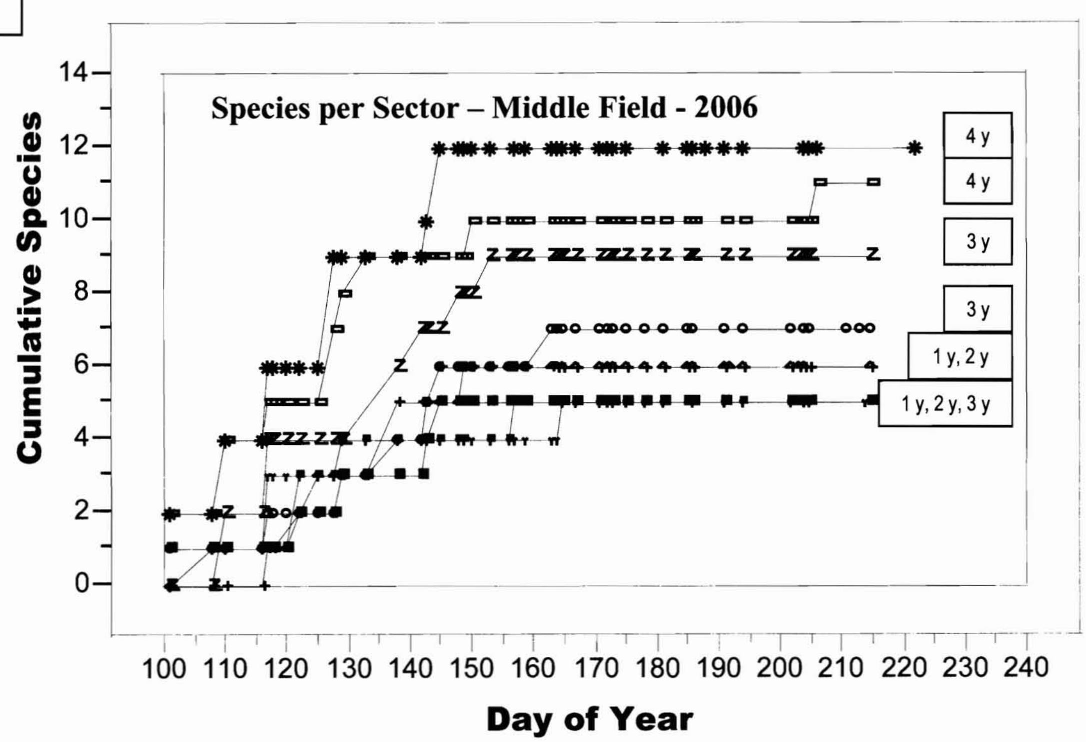
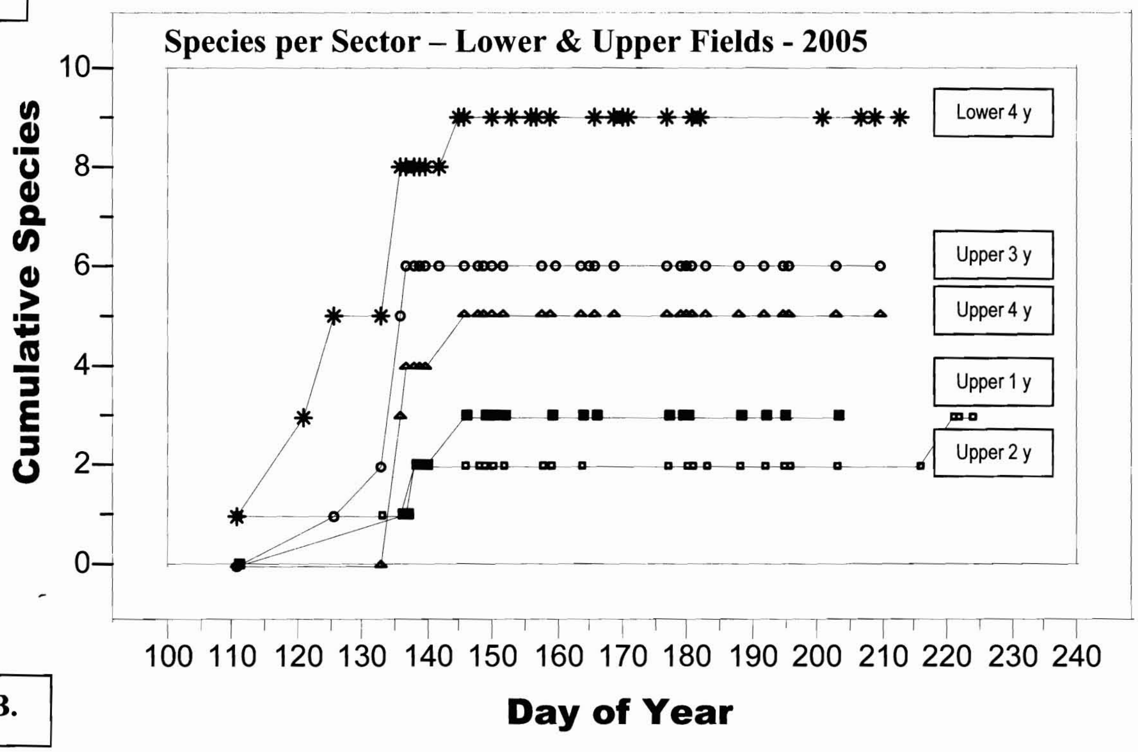


Figure 6. Cumulative probable breeding species in each of the nine sectors of the middle field in, A. 2005 and B. 2006.

A.



B.

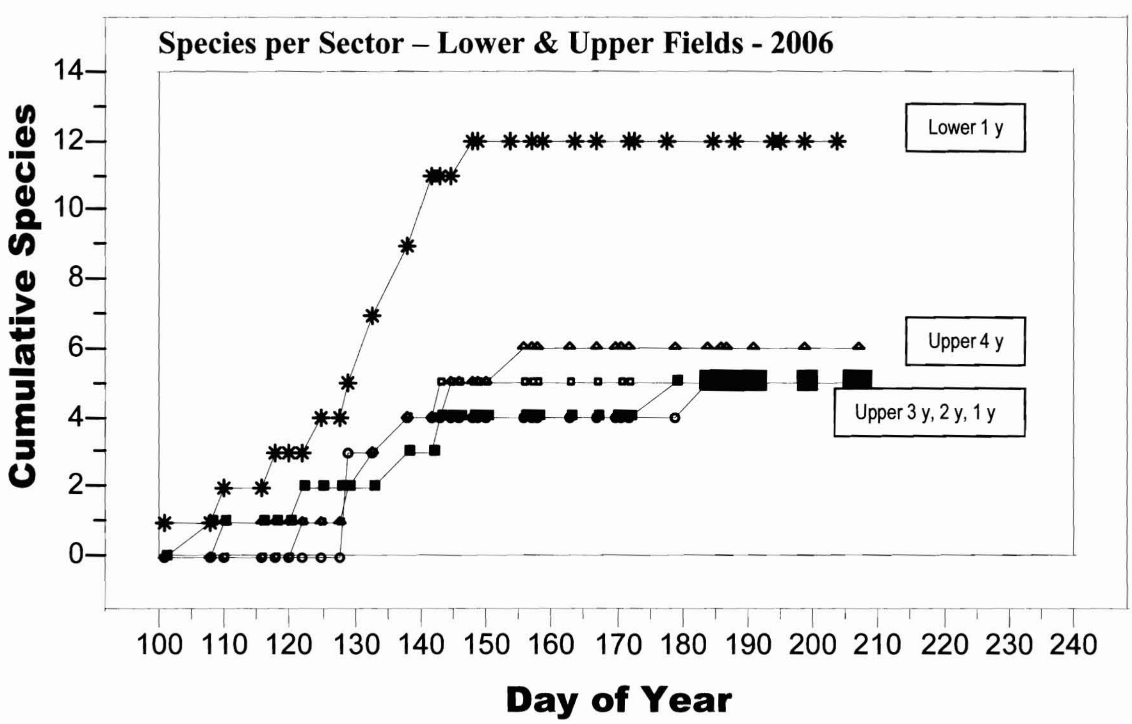


Figure 7. Cumulative probable breeding species in the lower field and each of the four sectors of the upper field in, A. 2005 and B. 2006.

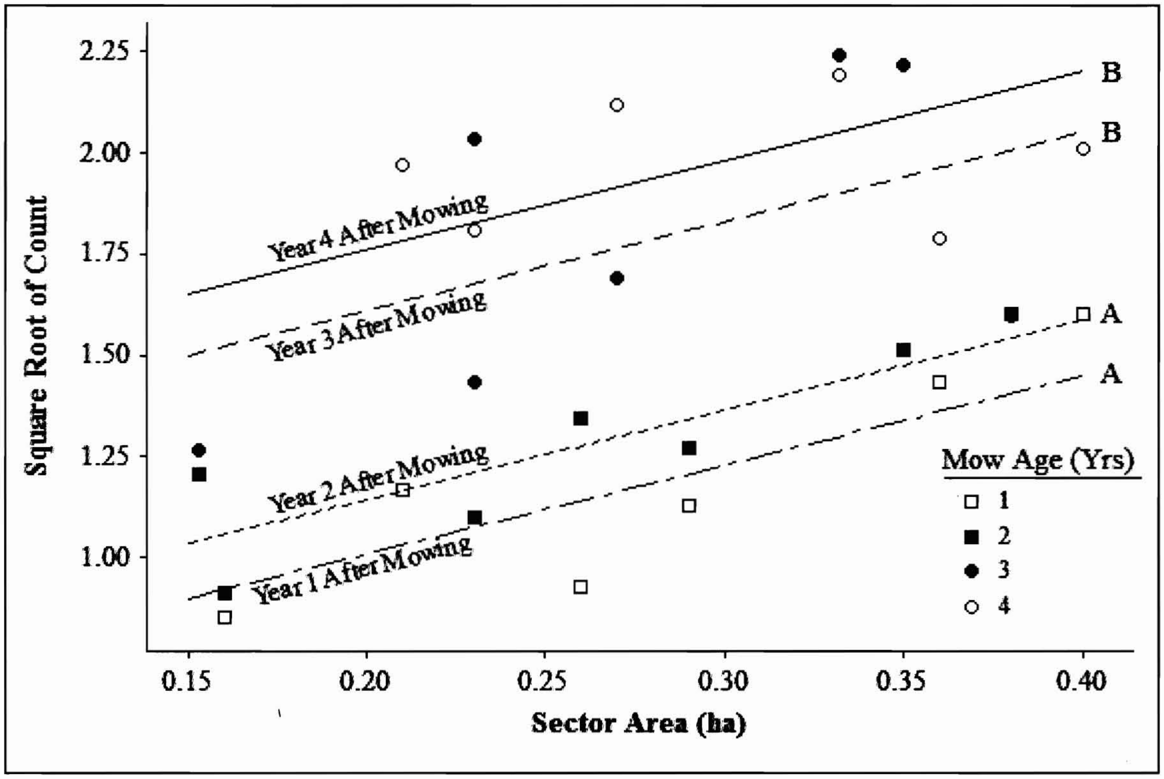


Figure 8: Square root transformed counts vs. sector area for sectors of 1, 2, 3, and 4 y mow age. Lines sharing a letter are not significant at p = 0.05 by a Tukey multiple comparison test.

expectation for probable breeders in field sectors of one to four-year mow age in each year of sampling.

Overall Species Diversity of Breeders: We found that all three of the interactions involving Area were statistically insignificant. Our final model set the Shannon index as a function of the three predictors as follows: Overall the model was highly significant ($F_{8,17} = 9.56$, $p << 0.001$). Sector Area was significant ($F_{1,17} = 7.15$, $p = 0.02$); each additional ha is estimated to result in a 1.02 ± 0.381 (S.E.) unit rise in overall breeding species diversity. Year was also significant ($F_{1,17} = 6.34$, $p = 0.02$); overall breeding species diversity was estimated to be 0.07 ± 0.028 (S.E.) lower in 2006 than in 2005. Sector Mow Age interaction with year was highly significant ($F_{6,17} = 8.96$, $p < 0.001$). In both years general species diversity increased as sector mow age increased. Multiple comparisons on the four levels of Sector Mow Age, stratified by Year, revealed significance between year 1 and all other years in 2005 and between year 1 and year 4 in 2006 (Figure 9).

Evenness: For three sectors with only one observed species, Evenness was undefined. We were unable to include and assess the three-way interaction among all predictors. All predictors except Year proved to be insignificant. Our final model set Evenness as a function of the Year ($F_{1,21} = 107.26$, $p < 0.001$): Evenness was significantly lower in 2006 than in 2005.

Richness: We found that all three interactions involving Area were statistically insignificant. Our final model set Richness as a function of the three predictors as follows: The overall model was highly significant ($F_{8,17} = 6.56$, $p < 0.001$). Sector Area was significant ($F_{1,17} = 7.91$, $p = 0.012$): Each additional ha is estimated to result in a 38.5

± 13.69 (S.E.) unit drop in Richness. For year ($F_{1,17} = 4.70$, $p = 0.045$): Richness is estimated to be 2.175 ± 1.003 (S.E.) higher in 2006 than in 2005. Although the pattern of evenness was different in each year, Richness generally increased as Sector Mow Age increased. Multiple comparisons on the four levels of Sector Mow age stratified by year showed that in 2005 year 1 sectors differed significantly from year 3 and 4 sectors; in 2006 year 1 and 2 sectors differed significantly from year 4 sectors (Figure 10).

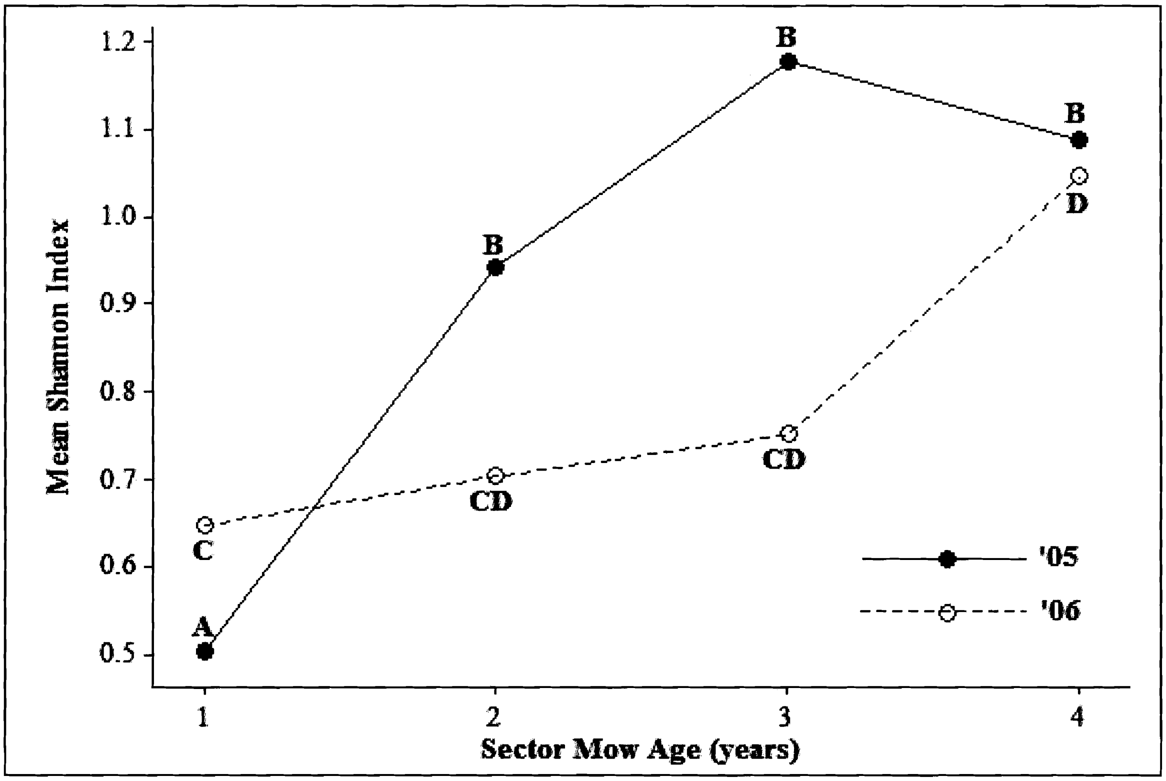


Figure 9. Mean Shannon index of probable breeding species in sectors of 1-4 mow age in 2005 and 2006. Means (points) labeled A, B, C are statistically different from each other by a Bonferroni multiple comparison test at $p = 0.05$; means sharing the same letter do not differ significantly.

Nest Locations

Figure 11 gives the GPS positions of most nests located in 2005 and 2006. Nests discovered in the autumn (after the breeding season), located outside the mown areas, or discovered only after being downed by mowing were not mapped. The majority of nests found were in shrubby vegetation (Table 6). Gray catbirds and yellow warblers appeared to choose multiflora rose (*Rosa multiflora*) as nesting locations; American goldfinch nested nearly exclusively in silky dogwood (*Cornus amomum*). Figure 12 compares the species of plant chosen for nest locations in our study in managed fields with that of Weeks (1998) in wetlands bordering Rice Pond. The majority of nests in wetlands were placed in *Typha* (13 nests, nearly exclusively red-winged blackbirds), the majority of nests in fields were placed in *Cornus amomum* (10 nests, nearly exclusively American goldfinch) and *Rosa multiflora* (8 nests).

A purported blue-winged x Brewster's warbler nest was found in the NW sector of the upper field. This three-year sector was 38% covered by permanent woody vegetation. The nest was photographed *in situ* and collected for measuring. Four particulars support

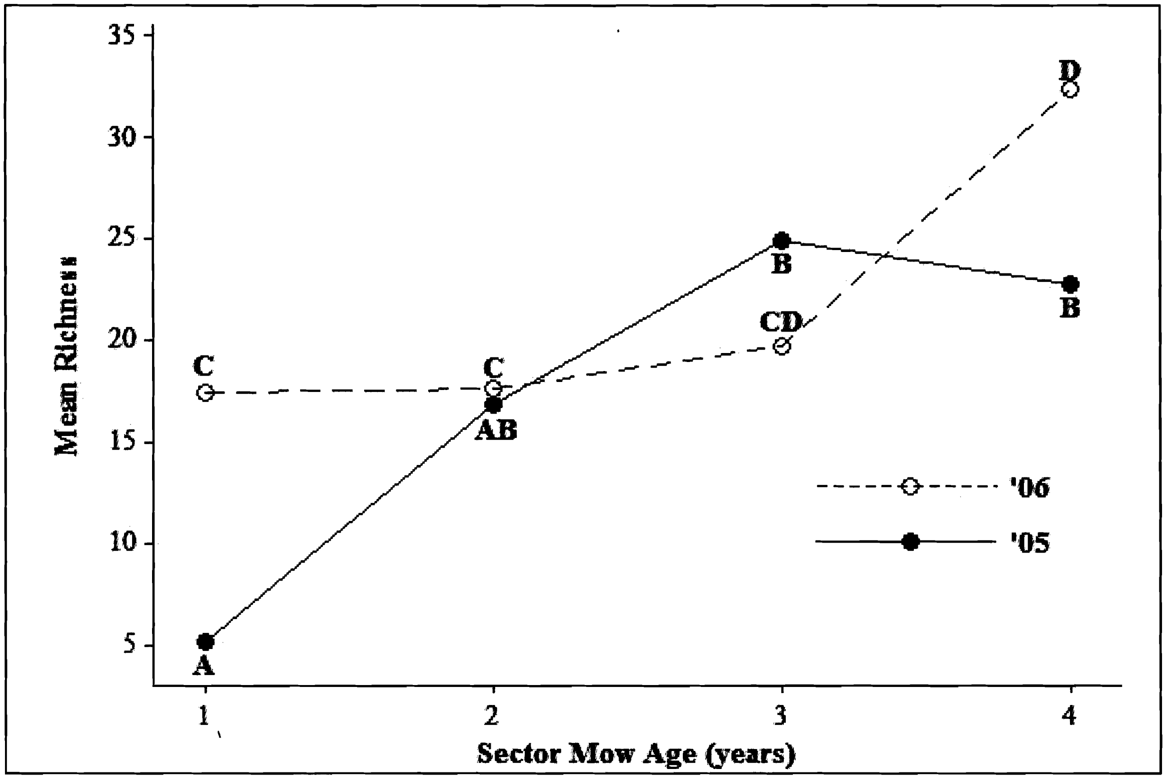


Figure 10. Mean Richness index of probable breeding species in sectors of 1-4 mow age in 2005 and 2006; means sharing the same letter do not differ significantly.

the nest as that of a blue-winged x Brewster's warbler. First, the parents, a female blue-winged and a male Brewster's warbler, were each observed with food in the sector at a location not far from the nest location. Second, the microhabitat of the ground nest which was attached to tall hairy goldenrod (*Solidago rugosa*) stems and located under small sapling common buckthorn (*Rhamnus cathartica*), is congruent with descriptions by authorities (Harrison, 1975; Dunn & Garrett 1997). Third, nest measurements appear to best fit that of a blue-winged or golden-winged warbler, although the other confirmed ground nester of similar size in the sector, common yellowthroat, can not be entirely excluded (Table 7). Lastly, the nest location fit the vegetative features of New York territories as described by Confer (1992): "...patches of herbs and shrubs, a few trees scattered throughout, and a tree row or forest edge forming most of the perimeter."

Comparative Scaling to Selected Habitat Features

Again, following Wiens (1969) we attempted to relate, in a preliminary manner because of few data, field breeders to a suite of habitat variables. Only species whose nests were located are included in these results. Box nesting species were not included because nest boxes were not present in all sectors.

Of the seven species that nested in fields, only four species had two or more located nests. The most consistent pattern was shown by American goldfinch. This species preferred to nest in tall woody vegetation with large simple leaves, a network stem arrangement, low vertical leaf density and high canopy development (Figure 13). These vegetative characteristics are typical, for the most part, of sectors in years three or four. Yellow warbler nested in sectors with vegetation of moderate height, moderate vertical density and relatively high percent full sunlight (i.e. lower canopy development).

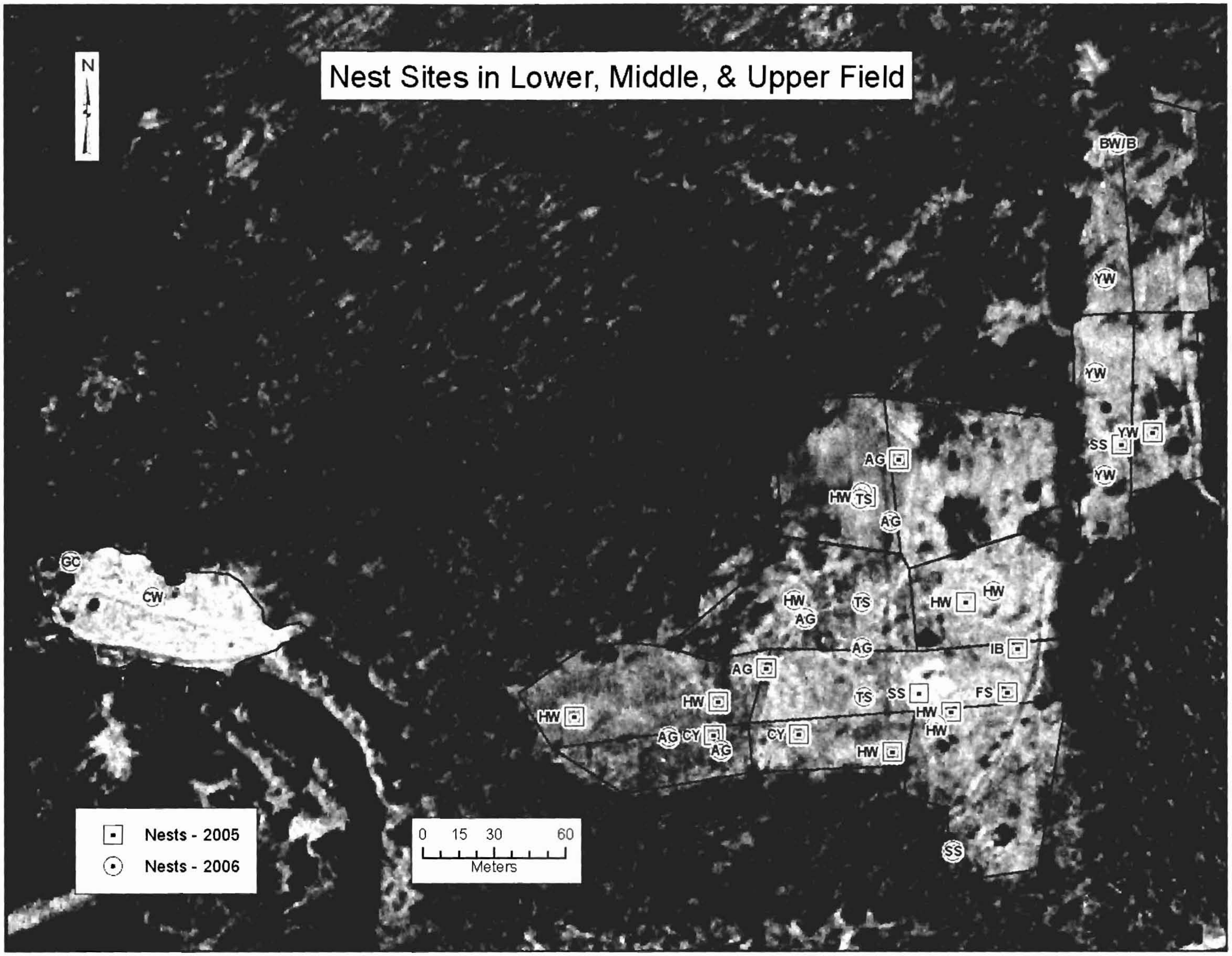


Figure 11. Locations of nests in 2005 and 2006 as determined by GPS. Symbols: American goldfinch (AG), cedar waxwing (CW), common yellowthroat (CY), field sparrow (FS), grey catbird (GC), house wren (HW), indigo bunting (IB), song sparrow (SS), tree swallow (TS), blue-winged x Brewster's warbler (BW/B) and yellow warbler (YW).

Table 6. Nest location, date, field and sector, sector mow age, plant species located in, height above ground, contents on date located and comments. For sector abbreviations see Figure 2.

Species	Date	Location (Field/ Sector)	Sector Mow Age (y)	Plant Species	Height Above Ground (cm)	Nest Contents (e = eggs) (yg = young)	Comments
Gray catbird (Dumetella carolinensis)	25-May-05	lower	4	Viburnum dentatum	—	4 e	2 m out of field
	22-Jun-06	lower	1	Rosa multiflora	184.15	5 yg	—
	28-Nov-06	lower	1	R. multiflora	182.88	—	2 m out of field; after season
	28-Nov-06	upper/SE	1	R. multiflora	147.32	—	2 m out of field; after season
Cedar waxwing (Bombycilla cedrorum)	23-Jul-06	lower	1	Acer negundo	408.90	4 e	—
	28-Nov-06	upper/SE	1	Fraxinus americana	457.20	—	nest located after season
Blue-winged x Brewster's (Vermivora pinus x V. leucobrachialis)	26-Jul-06	upper/ NW	3	Solidago rugosa, Rhamnus cathartica, Gallium molugo, Rubus flagellaris, Toxicodendron radicans, Céntaurea jacea, Aster lateriflorus, Clematis virginiana	0.00	fragments of 2-3 e	—
Yellow warbler (Dendroica petechia)	7-Jun-06	upper/ NW	3	R. multiflora	62.23	4 e	—
	19-Jun-06	upper/ SW	4	R. multiflora	104.14	4 yg	—
	20-Jun-06	upper /SW	4	R. multiflora	99.06	4 yg	—
	12-Jun-05	upper/SE	4	R. multiflora	106.00	4 e	—
	1-Sep-06	middle/CN	4	Cornus amomum	—	—	nest in dogwood downed by mowing
	28-Nov-06	middle/WS	3	C. amomum	115.57	—	nest located after season
Common yellowthroat (Geothlypis trichas)	19-Jun-05	middle/WS	2	Poaceae sp., C. amomum, Ranunculus acris	0.00	4 yg	—
	22-Jul-05	middle/CS	1	Solidago canadensis, Phleum pratense, Anthoxanthum odoratum, C. amomum, R. multiflora	0.00	1 e	—
Indigo bunting (Passerina cyanea)	19-Jun-05	middle/ECS	4	V. dentatum	57.00	3 e	—
Field sparrow (Spizella pusilla)	14-Jul-05	middle/ECS	4	R. multiflora	67.00	4 yg	—
Song sparrow (Melospiza melodia)	5-Aug-06	middle/ES	3	Poaceae sp, Stellaria graminifolia, Galium sp.	0.00	3 yg	—
	27-Jun-05	upper/SW	3	Poaceae sp, Hieracium sp., Glecoma hetderacea	0.00	4 yg	—
	1-Jun-05	middle/ECS	4	Fraxinus sp.	92.00	2 yg	—
	28-Nov-06	middle/C	3	R. multiflora	80.01	—	nest located after season
Am. goldfinch (Carduelis tristis)	17-Aug-06	middle/C	3	C. amomum	109.20	4 e	—
	17-Aug-06	middle/C	3	C. amomum	109.20	5 e	—
	17-Aug-06	middle/WS	3	C. amomum	149.90	5 yg	—
	17-Aug-06	middle/WS	3	C. amomum	106.70	2 e	—
	29-Jul-05	middle/CN	3	C. amomum	140.00	6 e	—
	7-Aug-06	middle/CN	4	C. amomum	—	1 e	nest lost to mowing 8-Aug-06
	10-Aug-05	middle/WN	3	C. amomum	143.00	2 e	—
	28-Nov-06	middle/C	3	mostly in C. amomum/part in R. multiflora	73.66	—	nest located after season

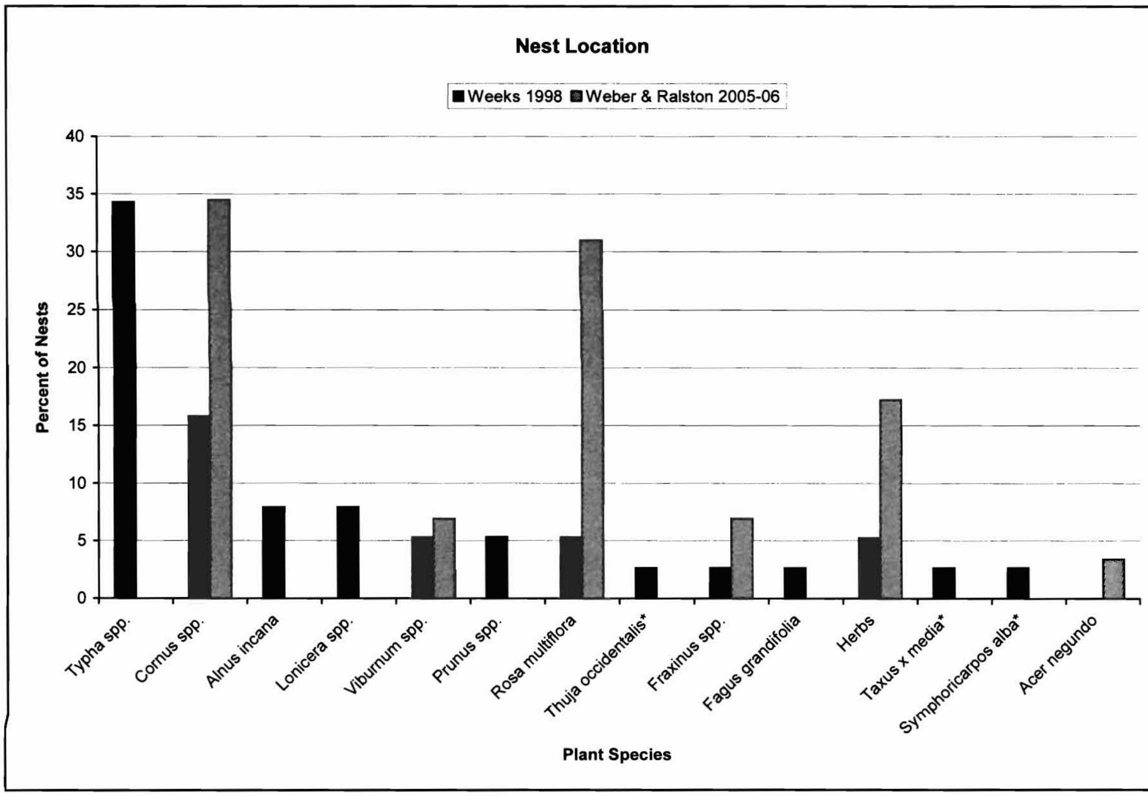


Figure 12. Comparison of nest location by plant species between the present oldfield study (light bars) with Week's (1998) wetland study (dark bars).

Moreover, yellow warblers nested in relatively thicker stemmed woody plants of moderately narrow, compound leaves characteristic of year three or four sectors. Song sparrow nested in sectors of moderate vegetation height, low vertical vegetation density and moderate percent full sun. The two common yellowthroat nests were located in sectors of low vegetation height, moderate vertical vegetation density and low percent full sun. Yellowthroat nests were in sectors with mainly forbs or grasses of small simple narrow leaves on plants with thin parallel stems, characteristic of sectors in the second year (Figure 13).

Table 7. Comparison of measured dimensions of purported blue-winged x Brewster's warbler nest in upper field with dimensions in Harrison (1975)* of three ground nesters found in NW & NE sectors of upper field in 2006. (PW = Peter Weber, NW = Nick Weber, JR = Joel Ralston)

	Published* Measurements			Independent Measurements of Ground Nest in Upper Field NW Sector				
Nest Dimension	Golden-winged / blue-winged	Common yellowthroat	Song sparrow	PW	NW	JR	Mean	S. D.
Outside dimension (cm)	9.2 – 12.7	8.3	12.7 – 22.9	10.8	8.6	8.18	9.1933	1.4
Inside dimension (cm)	4.4 – 6.4	4.4	6.4	4.17	4.3	4.15	4.2067	0.08
Heigth (cm)	7.6 – 12.7	8.9	11.4	5.07	5.1	5.52	5.23	0.25
Depth (cm)	3.3 – 6.4	3.8	3.8	4.5	4.7	4.1	4.4333	0.31

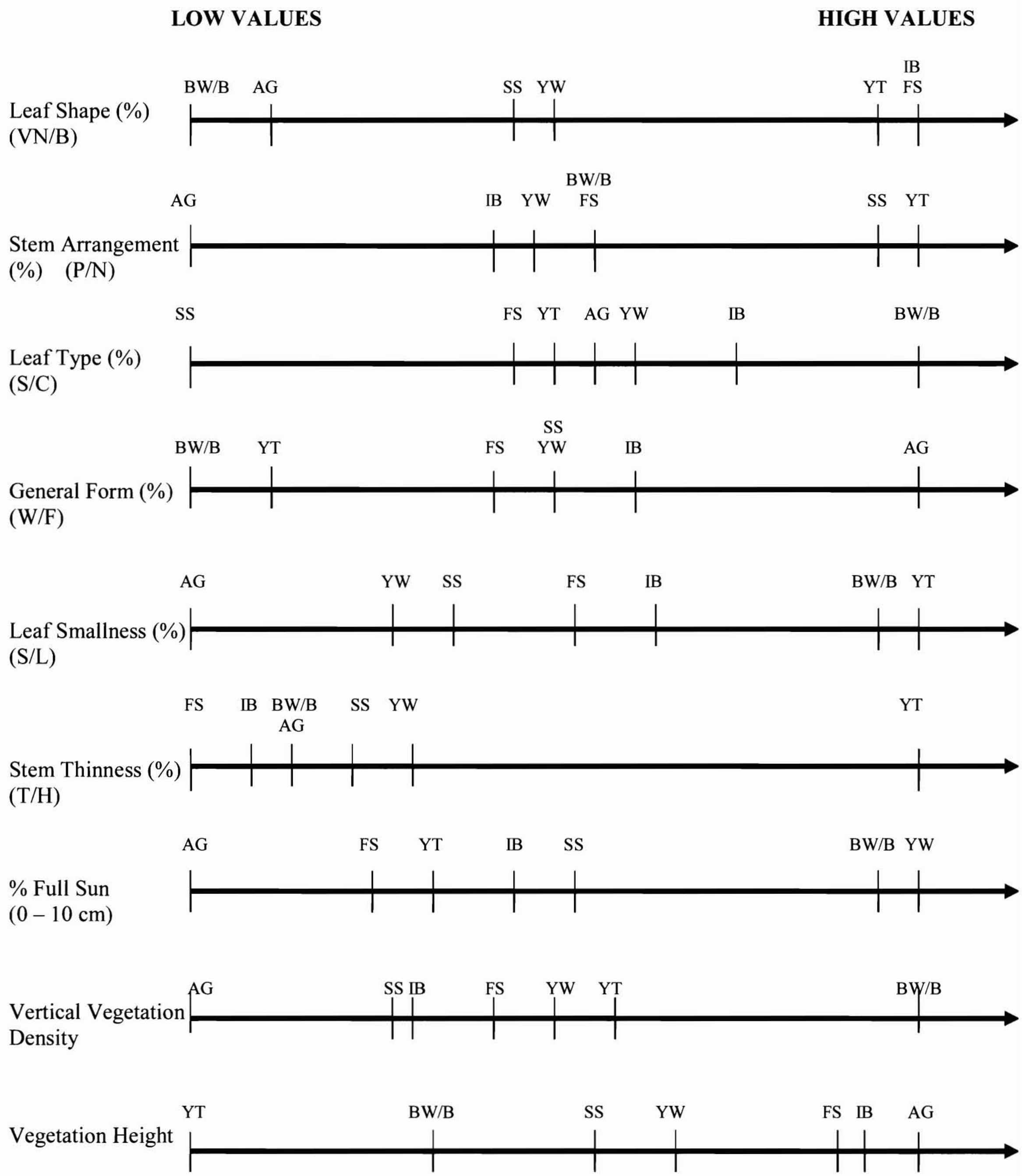


Figure 13. Comparative scaling of field breeding birds to nine selected habitat features. Placement of species on each scale is relative to other species. Leaf shape is from very narrow (VN) to broad (B); stem arrangement from parallel (P) to network (N); leaf type from simple (S) to compound (C); general form from woody (W) to forb (F); leaf smallness from small (S) to large (L); stem thinness from thin (T) to heavy (H); percent of full sun at 10 cm above ground; vertical vegetation density is number of touches per decimeter; vegetation height in cm. Species symbols as in Figure 10.

Population Trends in Regional Oldfield Birds

Table 8 shows that somewhat under one-half (42.5%) of field/edge species that could possibly have bred in RCFS managed fields during our study have declined from 1966 to 2005 in the Lower Great Lakes/St. Lawrence Plain physiographic region. In somewhat over a quarter of these species (27.3%) the decline trend is statistically significant. On the other hand, a greater percent (39.4%) have shown a statistically significant increased trend over the same time in this physiographic region. Three species that likely bred on the grounds, American woodcock, golden-winged and blue winged-warblers, are on the U.S. Fish and Wildlife National Watch List as species of conservation concern.

Table 8. Great Lakes Plain population trends, from 1966 to 2005, in bird species with a breeding status of "Possible" or higher found in managed fields or field edges at Rice Creek Field Station.

		Great Lakes Plain Trend[1]				
Species	Watch List Priority[2]	Significant Decrease	Decrease	Increase	Significant Increase	
Mallard	—	—	—	—	x	
American woodcock	Moderately High		trend uncertain			
Mourning dove	—	—	—	—	x	
Black-billed cuckoo	—	x	—	—	—	
Ruby-throated hummingbird	—	—	—	—	x	
Willow flycatcher	—	x	—	—	—	
Least flycatcher	—	x	—	—	—	
Eastern phoebe	—	—	—	—	x	
Great-crested flycatcher	—	—	x	—	—	
Eastern kingbird	—	x	—	—	—	
Tree swallow	—	—	—	—	x	
Blue jay	—	—	—	x	—	
House wren	—	—	—	—	x	
Blue-gray gnatcatcher	—	—	—	—	x	
Eastern bluebird	—	—	—	—	x	
American robin	—	—	—	—	x	
Gray catbird	—	—	—	—	x	
Brown thrasher	—	x	—	—	—	
Cedar waxwing	—	—	—	—	x	
Blue-winged warbler	Moderate	—	—	x	—	
Golden-winged warbler	Extremely High	x	—	—	—	
Yellow warbler	—	—	—	x	—	
Chestnut-sided warbler	—	—	x	—	—	
Common yellowthroat	—	—	—	x	—	
Eastern towhee	—	—	x	—	—	
Northern cardinal	—	—	—	—	x	
Rose-breasted grosbeak	—	—	—	x	—	
Indigo bunting	—	—	—	x	—	
Red-winged blackbird	—	x	—	—	—	
Baltimore oriole	—	—	x	—	—	
Brown-headed cowbird	—	x	—	—	—	Total
American goldfinch	—	—	—	—	x	
Total		9	5	6	13	33

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[1] Sauer, Hind & Fallon (2006)
[2] Hunter et al (2001)

Discussion

Vegetative changes over the mowing cycle

Sectors of one and two year post-mow age at Rice Creek generally were dominated by forbs and grasses. Sectors of these ages generally had the appearance of a meadow. Sectors of three and four years post-mow were dominated by a canopy of woody vegetation. Sectors of these ages generally had the appearance of a young shrubland. Some sectors by three years were nearly completely in shrub cover. The areas comprising the fields at Rice Creek were managed as farm pasture prior to 1966 when the Field Station was established. They were allowed to proceed through natural succession from 1966 until 1983, by which time the areas were all, to a greater or lesser degree, dominated by shrubs and saplings. In 1983, the areas now maintained as fields were cleared by hand cutting of woody vegetation at ground level, leaving isolated trees and shrubs for habitat diversity (as can be seen in Figure 1). In our study, sectors revert to the shrub stage more rapidly because field mowing does not uproot or kill woody vegetation. Other studies have found succession to the shrub stage to proceed much slower. For example, in a cross-sectional study in Georgia, fields were in a meadow stage from 1-10 years following cultivation and in shrubland from 11-20 years (Johnston & Odum, 1956). In a set of five fields on Long Island sampled longitudinally woody cover ranged from 5% by 8 years to 40% by 16 years (Lanyon, 1981). In both studies cultivated areas were allowed to develop successionally after they had been left fallow.

The physical changes in vegetation (vegetation height, VVD and percent full sun) were generally more similar in years one and two then changed, usually significantly, in years three and four which, in turn were more similar. This implies that during the first two years following mowing sectors are somewhat alike, as they are in the last two years following mowing.

Breeders

We confirmed 12 breeding species over the two years. We also found willow flycatcher, chestnut-sided warbler, Eastern towhee, Northern cardinal and brown-headed cowbird were species present throughout the season in both years. These were species we were unable to confirm but that possibly bred in the field edges among older shrub and tree vegetation.

The dominant in-field breeders in the first year following mowing were song sparrow and common yellowthroat, both capable of nesting on or near the ground. In abandoned farmland on Long Island, red-winged blackbirds were the dominant species in the earliest successional stage, song sparrows established second (Lanyon, 1981). A pattern similar to Long Island's seemed to occur in abandoned strip-mined land in East-central Illinois (Karr, 1968). Although red-winged blackbirds appeared sporadically early in the season, exclusively in middle field sectors, they presented no indication of being probable breeders.

If one considers the number of pairs of confirmed breeders only, counts were similar in the first two years following mowing and counts increased in years three and four which, again, were similar. This pattern approximately reflects the pattern of physical changes in the vegetation over the same mowing period.

All other things being equal, older habitats (those of three and four years mow age), because they contain a higher proportion of vertical vegetation and therefore have greater vegetational structural complexity than younger sectors, should also contain more breeding species (MacArthur & MacArthur, 1961; Cody, 1968; Roth, 1976). Such habitats might also fill up more rapidly with breeders than the simpler one dimensional meadow habitats of one and two years. This does seem to be the case as the species accumulation plots appear to show.

Sector Characteristics and Breeders

We investigated the relationship between counts of probable breeders and eight sector characteristics: only two showed a significant relationship. Counts increased significantly with sector area: larger sectors held more breeders. This is not surprising since mowed sectors could be considered as small habitat islands. And, according to the theory of island biogeography, species counts should increase with island area, other factors being equal (McArthur and Wilson, 1967). Our results here support those of Bay (1996). Counts also differed between mow ages of the sectors: years one and two did not differ but counts in years three and four were significantly higher than in one and two. Years three and four, again, were not different statistically from each other. This supports the contention that the first two years following mowing are similar as are the last two, and that a change in density of breeders occurs between years two and three. Our two-year data set was too small to discern significant patterns between counts of breeders and any of the other six variables.

Breeder Species Diversity

Overall species diversity increased over mow age in both seasons, but the pattern was different in each. In 2005 the increase was sharp from one year sectors to three; in 2006 the increase was gradual from one year sectors to three. In either season there did not appear to be a jump in species diversity from year two to year three paralleling the jump in counts of breeders. We also analyzed the two components of overall diversity: evenness and richness. In neither year was there a significant pattern, although evenness was significantly lower in 2006. The pattern of richness mimicked that of overall diversity. It seems that the overall higher diversity in 2005 was due to the higher value of evenness in that year.

Other studies have reported a similar rapid increase in bird species diversity during early oldfield succession. However, comparison with our result is difficult because the authors either did not give the age of the habitat (Shugart & James, 1973) or did not measure diversity by a Shannon index (Lanyon, 1981). Where both the Shannon index and habitat age are given (Kritcher, 1973, reanalysis of Johnston & Odum, 1956) the early increase (in habitats of 1-10 years) in breeding bird diversity does not seem to be as steep as ours in sectors from 1- 4 years. For example by 10 years breeding diversity had reached an index of 1.0 whereas in our study it was over 1.0 in 4 year sectors in both sampling seasons. This difference could be due to the rapid regrowth of the already established shrubby vegetation following mowing in our study.

Nest Locations

Shrubs were most favored for nest placement (Table 6). The most commonly utilized shrub species were *Cornus amomum* (10 nests) and *Rosa multiflora* (8 nests). Weeks (1998) found *Typha* was most favored (13 nests) and *Cornus* second favored (6 nests) in wetlands. Bramble, Yahner and Byrnes (1994) found blackberry (*Rubus allegheniensis*) by far the favored, followed by witchazel (*Hammamelis virginiana*) in a central Pennsylvania electric utility line right-of-way. How nest choice plant species is related to the proportion of each plant species available was not determined in any of these studies and would be interesting to know.

Late Breeding Species

A concern regarding mowing as a method of maintaining early successional habitat, as it pertains to birds, is the timing of mow relative to renesting or first nesting. Four-year sectors about to be mowed are quite suitable as breeding habitat for the possible late nesting and renesting species that are found on RCFS grounds.

We documented a song sparrow with three nestlings in a three-year sector on August 5, and a common yellowthroat with a single egg in a one year sector on July 22 (Table 6). These birds could just as well have renested in four-year sectors as their occurrence as possible breeders was high there (Table 3). Had that been the case, their breeding effort would have been lost to mowing. American goldfinch and cedar waxwing are late breeding species that could breed in sectors that potentially are mowed while they are in the nesting stage. The latter species is of little concern in regard to nest destruction by mowing since it nests in trees or tall shrubs (Ehrlich, Dopkin & Wheye, 1988) that are not mowed. The former, however, breeds at the time of mowing in low woody shrubs of older sectors that are about to be mowed. In choosing to breed in such sectors these birds would have made an inappropriate breeding decision, thus falling into an ecological trap (Battin, 2004; Schlaepfer, Runge & Sherman, 2002). Fortunately, in the two years of our study only one of eight American goldfinch nests was in a four-year sector (Table 6). This nest, with its single egg, was destroyed by mowing one day after it was discovered on August 7, 2006. Although we did not mark birds, it is thought that the pair renested in a three-year sector shortly after their nest had been destroyed. Whether American goldfinches on the Station grounds have, by and large, in some manner adapted to the mowing cycle by choosing to mostly nest in three-year sectors and less in four-year sectors would be interesting to know.

Late July or early August may well be the optimal time to mow field sectors at RCFS. Nonetheless, it would be worth while to have long term data documenting nesting and renesting in four year sectors about to be mowed. No such data documenting the potential loss of breeding effort to systematic management mowing exists in the literature.

Decline in Oldfield Birds

Askins (2000) points out that, according to Breeding Bird Survey data, only one of 16 shrubland species east of the Mississippi River has shown a significant population increase since 1966. Breeding Bird Survey data indicates that out of 34 possible RCFS shrubland breeders, about 27% have shown significant declines since 1966 in the Lower Great Lakes/St Lawrence Plain physiographic region. If we widen the view to the entire continent, 59% of possible RCFS shrubland breeders have declined, of which 50% have shown a significant decline over the same time period (data from Sauer, Hines and Fallon, 2005). This decline is due to loss of early successional habitat with increased urbanization and regrowth of forests with a decline in agriculture. Maintaining early successional habitat as the Station does by a mowing cycle is an important management tool in providing breeding habitat for disturbance-dependent birds such as breed in the managed fields at RCFS.

Conclusions

A. Counts of breeders remained similar in years one and two following mowing, and then increased significantly in years three and four, which also remained similar.
B. Out of eight sector characteristics, counts of breeders showed significant positive relationships only with sector area and mow age.
C. Diversity of breeders may increase much more rapidly in habitats that are field mowed compared to habitats that begin succession from plowed (or burned) bare ground.
D. Late breeding species may be at risk of loosing their reproductive effort when mowing occurs in late July or early August. However, a much larger data base than our pilot study provides would be required to ascertain the risk.
E. Due to the loss of habitat populations of many oldfield bird species have subtly declined---many species of which still appear to be common. If such a trend continues, field mowing in preserves such as RCFS will be of increasing importance in maintaining early successional habitat for oldfield species.
F. Our pilot study was carried on for only two years of the four-year mowing cycle. In order to ascertain breeding patterns in oldfield birds relative to mowing and the optimal time to mow, such a study would likely need to be carried through two to three four-year mowing cycles.

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Sontag for confirming the identity of the Brewster's warbler from video footage.

Appendices

Appendix A. Sector age, date of sampling and number of points sampled for vegetative characteristics in field sectors.

Field and Sector	Sector Age	Year	Sampling Date	Number of Points Sampled	Field and Sector	Sector Age	Year	Sampling Date	Number of Points Sampled
Upper					**Middle (con't)**				
NE	1	2005	1-Jun	16	C	2	2005	2-Jun	20
	1	2005	14-Jul	20		2	2005	20-Jul	20
	2	2006	7-Jun	20		3	2006	14-Jun	20
	2	2006	26-Jul	20		3	2006	24-Jul	20
NW	2	2005	1-Jun	15	ES	2	2005	7-Jun	20
	2	2005	14-Jul	16		2	2005	19-Jul	20
	3	2006	7-Jun	16		3	2006	14-Jun	20
	3	2006	26-Jul	14		3	2006	24-Jul	20
SW	3	2005	1-Jun	16	WN	3	2005	3-Jun	24
	3	2005	14-Jul	16		3	2005	20-Jul	24
	4	2006	5-Jun	16		4	2006	14-Jun	24
	4	2006	25-Jul	14		4	2006	25-Jul	24
SE	4	2005	1-Jun	16	CN	3	2005	7-Jun	18
	4	2005	15-Jul	20		3	2005	20-Jul	18
	1	2006	5-Jun	20		4	2006	14-Jun	18
	1	2006	25-Jul	20		4	2006	25-Jul	18
Middle					ECS	4	2005	7-Jun	18
ECN	1	2005	2-Jun	14		4	2005	19-Jul	18
	1	2005	15-Jul	14		1	2006	8-Jun	18
	2	2006	12-Jun	14		1	2006	27-Jul	18
	2	2006	24-Jul	14	EN	4	2005	7-Jun	20
CS	1	2005	2-Jun	10		4	2005	19-Jul	20
	1	2005	15-Jul	10		1	2006	12-Jun	20
	2	2006	12-Jun	10		1	2006	24-Jul	20
	2	2006	23-Jul	10	**Lower**				
WS	2	2005	2-Jun	10		4	2005	2-Jun	32
	2	2005	15-Jul	10		4	2005	20-Jul	30
	3	2006	14-Jun	10		1	2006	8-Jun	30
	3	2006	24-Jul	10		1	2006	23-Jul	30

Appendix B. Frequency of occurrence of sampled plant species in upper field in 2005 and 2006.

— 2005 —				— 2006 —			
Sampling Date	Points Sampled	Dominant Species	Frequency	Sampling Date	Points Sampled	Dominant Species	Frequency
Sector NE - Mow age 1 yr				**Sector NE - Mow age 2 yr**			
1-Jun	16	*Galium sp.*	25%	7-Jun	20	*Solidago sp./Aster sp.*	35%
		Toxicodendron radicans	25%			*Onoclea sensibilis*	30%
		Rhamnus cathartica	25%			*Toxicodendron radicans*	15%
		T. radicans & Rubus flagellaris	13%			*Galium sp.*	10%
		Onoclea sensibilis	13%			*Clematis virginiana*	5%
						Rosa multiflora	5%
14-Jul	20	*Onoclea sensibilis*	35%	26-Jul	20	*Centaurea jacena*	40%
		Solidago sp./Aster sp.	15%			*Solidago sp./Aster sp.*	15%
		Centaurea jacena	10%			*Toxicodendron radicans*	15%
		Eupatorium maculatum	10%			*Onoclea sensibilis*	10%
		Toxicodendron radicans	10%			*Aster sp.*	10%
		Setaria pumila	5%			*Cornus amomum*	5%
		Convolvulus arvensis	5%			*Rubus flagellaris*	5%
		Phleum pratense	5%				
		Rubus flagellaris	5%				
Sector NW - Mow age 2 yr				**Sector NW - Mow age 3 yr**			
1-Jun	15	*Solidago sp./Aster sp.*	57%	7-Jun	16	*Solidago sp./Aster sp.*	44%
		Galium sp.	43%			*Centaurea jacena*	25%
						Galium sp.	13%
						Asclepias syriaca	6%
						Cornus amomum	6%
						Rhamnus cathartica	6%
14-Jul	16	*Solidago sp./Aster sp.*	55%	26-Jul	14	*Solidago sp./Aster sp.*	50%
		Onoclea sensibilis	20%			*Centaurea jacena*	21%
		Cornus amomum	10%			*Rhamnus cathartica*	7%
		Centaurea jacena	10%			*Fraxinus sp.*	7%
		Fraxinus sp.	5%			*Rosa multiflora*	7%
						Asclepias syriaca	7%

— 2005 —				— 2006 —			
Sampling Date	Points Sampled	Dominant Species	Frequency	Sampling Date	Points Sampled	Dominant Species	Frequency
Sector SW - Mow age 3 yr				**Sector SW - Mow age 4 yr**			
1-Jun	16	*Rubus allegheniensis*	22%	5-Jun	16	*Solidago sp./Aster sp.*	44%
		Galium sp.	11%			*Rubus alleghenensis*	13%
		Cyperaceae	11%			*Asclepias syriaca*	6%
		Vicia sp.	11%			*Viburnum dentatum*	6%
		Onoclea sensibilis	11%			*Lonicera sp.*	6%
		Medicago sativa	11%			*Lotus corniculata*	6%
		Cornus amomum	11%			*Elaeagnus umbellata*	6%
		Rhamnus cathartica	11%			*Cornus amomum*	6%
						Rhamnus cathartica	6%
14-Jul	16	*Solidago sp./Aster sp.*	38%	25-Jul	14	*Solidago sp./Aster sp.*	36%
		Centaurea jacena	25%			*Centaurea jacena*	21%
		Phleum pratense	6%			*Fraxinus sp.*	14%
		Rubus allegheniensis	6%			*Rhus hirta*	7%
		Rosa multiflora	6%			*Viburnum dentatum*	7%
		Carex sp.	6%			*Rhamnus cathartica*	7%
		Galium sp.	6%			*Toxicodendron radicans*	7%
		Lotus corniculata	6%				
Sector SE - Mow age 4 yr				**Sector SE - Mow age 1 yr**			
1-Jun	16	*Galium sp.*	25%	5-Jun	20	*Poaceae sp.*	35%
		Solidago sp./Aster sp.	17%			*Solidago sp./Aster sp.*	30%
		Rhamnus cathartica	13%			*Galium sp.*	10%
		Onoclea sensibilis	8%			*Ranunculus acris*	5%
		Toxicodendron radicans	8%			*Onoclea sensibilis*	5%
		Rubus occidentalis	8%			*Toxicodendron radicans*	5%
		T. radicans & R. flagellaris	4%			*Rosa multiflora*	5%
		Cyperaceae	4%			*Lonicera sp.*	5%
		Vicia sp.	4%				
		Medicago sativa	4%				
		Cornus amomum	4%				

— 2005 —				— 2006 —			
Sampling Date	Points Sampled	Dominant Species	Frequency	Sampling Date	Points Sampled	Dominant Species	Frequency
15-Jul	20	*Solidago sp./Aster sp.*	55%	25-Jul	20	*Solidago sp./Aster sp.*	55%
		Onoclea sensibilis	20%			*Poaceae sp.*	10%
		Cornus amomum	10%			*Centaurea jacena*	5%
		Centaurea jacena	10%			*Vitis riparia*	5%
		Fraxinus sp.	5%			*Erigeron philadelphicus*	5%
						Cornus amomum	5%
						Rubus flagellaris	5%
						Aster sp.	5%
						Fraxinus sp.	5%

Appendix C. Frequency of occurrence of sampled plant species in middle field in 2005 and 2006.

— 2005 —				— 2006 —			
Sampling Date	Points Sampled	Dominant Species	Frequency	Sampling Date	Points Sampled	Dominant Species	Frequency
Sector ECN - Mow age 1 yr				**Sector ECN - Mow age 2 yr**			
2-Jun	14	*Onoclea sensibilis*	27%	12-Jun	14	*Robinia hispida*	21%
		Galium sp.	36%			*Solidago sp./Aster sp.*	14%
		Rubus idaeus	9%			*Cornus amomum*	14%
		Solidago sp./Aster sp.	9%			*Rhamnus cathartica*	14%
		Lotus corniculata	9%			*Lonicera sp*	7%
		Galium sp., T. radicans, R. flagellaris	9%			*Rubus alleghenensis*	7%
						Viburnum dentatum	7%
						Asclepias syriaca	7%
						Galium sp.	7%
15-Jul	14	*Solidago sp./Aster sp.*	43%	24-Jul	14	*Solidago sp./Aster sp.*	36%
		Vicia villosa	21%			*Cornus amomum*	14%
		Centaurea jacena	7%			*Toxicodendron radicans*	14%
		Vitis riparia	7%			*Centaurea jacena*	14%
		Toxicodendron radicans	7%			*Robinia hispida*	7%
		Rubus allegheniensis	7%			*Galium sp.*	7%
		Galium sp.	7%			*Rhamnus cathartica*	7%
Sector CS - Mow age 1 yr				**Sector CS - Mow age 2 yr**			
2-Jun	10	*Onoclea sensibilis*	33%	12-Jun	10	*Onoclea sensibilis*	50%
		Solidago sp./Aster sp.	33%			*Solidago sp./Aster sp.*	30%
		Solidago sp./Aster sp., Poaceae	17%			*Phleum pratense*	10%
		Ranunculus acris, Poaceae	17%			*Poaceae*	10%
15-Jul	14	*Solidago sp./Aster sp.*	60%	23-Jul	10	*Solidago sp./Aster sp.*	60%
		Onoclea sensibilis	20%			*Cornus amomum*	20%
		Fraxinus sp	10%			*Rubus alleghenensis*	10%
		Cornus amomum	10%			*Onoclea sensibilis*	10%
Sector WS - Mow age 2 yr				**Sector WS - Mow age 3 yr**			
2-Jun	10	*Ranunculus acris*	22%	14-Jun	10	*Onoclea sensibilis*	40%

— 2005 —				— 2006 —			
Sampling Date	Points Sampled	Dominant Species	Frequency	Sampling Date	Points Sampled	Dominant Species	Frequency
		Cornus amomum	22%			*Cornus amomum*	30%
		Solidago sp./Aster sp.	22%			*Viburnum dentatum*	20%
		Onoclea sensibilis	11%			*Fraxinus sp.*	10%
		Poaceae, R. acris	11%				
15-Jul	10	*Cornus amomum*	70%	24-Jul	10	*Cornus amomum*	60%
		Onoclea sensibilis	10%			*Fraxinus sp.*	20%
		Solidago sp./Aster sp.	10%			*Eupatorium maculatum*	10%
		Fraxinus sp	10%			*Solidago sp./Aster sp.*	10%
Sector C - Mow age 2 yr				**Sector C - Mow age 3 yr**			
2-Jun	20	*Onoclea sensibilis*	35%	14-Jun	20	*Cornus amomum*	30%
		Cornus amomum	18%			*Onoclea sensibilis*	30%
		Viburnum dentatum	12%			*Solidago sp./Aster sp.*	15%
		Solidago sp./Aster sp.	12%			*Fraxinus sp.*	10%
		Carex sp.	6%			*Rhamnus cathartica*	5%
		Fraxinus sp	6%			*Rosa multiflora*	5%
		Ranunculus acris	6%			*Viburnum dentatum*	5%
		Poaceae, Vicia sp.	6%				
20-Jul	20	*Onoclea sensibilis*	30%	24-Jul	20	*Cornus amomum*	25%
		Solidago sp./Aster sp.	30%			*Solidago sp./Aster sp.*	20%
		Cornus amomum	20%			*Onoclea sensibilis*	10%
		Centaurea jacena	5%			*Centaurea jacena*	10%
		Poaceae	5%			*Fraxinus sp.*	10%
		Aster lanceolatus	5%			*Viburnum dentatum*	10%
		Vitis riparia	5%			*Vitis riparia*	5%
						Eupatorium maculatum	5%
						Rosa multiflora	5%
Sector ES - Mow age 2 yr				**Sector ES - Mow age 3 yr**			
7-Jun	20	*Solidago sp./Aster sp.*	15%	14-Jun	20	*Solidago sp./Aster sp.*	35%
		Impatiens capensis	5%			*Fraxinus sp.*	20%
		Solidago sp./Aster sp., R. multiflora	5%			*Onoclea sensibilis*	10%

— 2005 —				— 2006 —			
Sampling Date	Points Sampled	Dominant Species	Frequency	Sampling Date	Points Sampled	Dominant Species	Frequency
		Solidago sp./Aster sp., Veronica sp.	5%			*Viburnum dentatum*	10%
		Poaceae, T. radicans	5%			*Lotus corniculata*	10%
		T. radicans, Fragaria virginiana, Ulmus americana	5%			*Toxicodendron radicans*	5%
		R. allegheniensis, Poaceae	5%			*Ulmus americana*	5%
		Poaceae	5%			*Rubus alleghenensis*	5%
		Solidago sp./Aster sp., Vicia sativa, Poaceae	5%				
		Fraxinus sp / Solidago sp.	5%				
		Fraxinus sp, Galium sp., R. acris, Vicia sp.	5%				
		Lonicera sp.	5%				
		Galium sp., V. riparia, Parthenocissus quinquefolia	5%				
		Fraxinus sp., Prunus virginiana, Lotus corniculata	5%				
		Medicago sativa, Echinochloa crusgalli	5%				
		O. sensibilis, Galium sp.	5%				
		O. sensibilis, Fraxinus sp., Solidago sp., R. multiflora, Poaceae	5%				
		Onoclea sensibilis	5%				
19-Jul	20	*Solidago sp./Aster sp.*	65%	24-Jul	20	*Solidago sp./Aster sp.*	55%
		Fraxinus sp.	10%			*Onoclea sensibilis*	15%
		Rubus allegheniensis	5%			*Cornus amomum*	5%
		Cornus amomum	5%			*Toxicodendron radicans*	5%
		Phleum pratense	5%			*Rubus alleghenensis*	5%
		Onoclea sensibilis	5%			*Lonicera sp.*	5%
		Rhamnus cathartica	5%			*Phleum pratense*	5%
						Centaurea jacena	5%
Sector WN - Mow age 3 yr				**Sector WN - Mow age 4 yr**			
3-Jun	24	*Cornus amomum*	54%	14-Jun	24	*Cornus amomum*	54%

— 2005 —				— 2006 —			
Sampling Date	Points Sampled	Dominant Species	Frequency	Sampling Date	Points Sampled	Dominant Species	Frequency
		Rubus allegheniensis	13%			*Fraxinus sp.*	13%
		Solidago sp./Aster sp.	8%			*Solidago sp./Aster sp.*	13%
		Viburnum dentatum	4%			*Viburnum dentatum*	8%
		Cornus sp., V. dentatum, R. occidentalis	4%			*Salix sp.*	8%
		R. occidentalis, V. dentatum	4%			*Rosa multiflora*	4%
		Onoclea sensibilis	4%				
		Solidago sp./Aster sp., O. sensibilis	4%				
		Rubus occidentalis	4%				
20-Jul	24	*Cornus amomum*	63%	25-Jul	24	*Cornus amomum*	67%
		Fraxinus sp.	13%			*Solidago sp./Aster sp.*	13%
		Solidago sp./Aster sp.	8%			*Viburnum dentatum*	8%
		Viburnum dentatum	8%			*Fraxinus sp.*	4%
		Rhamnus cathartica	4%			*Onoclea sensibilis*	4%
		Cyperaceae sp.	4%			*Eupatorium maculatum*	4%
Sector CN - Mow age 3 yr				**Sector CN - Mow age 4 yr**			
7-Jun	18	*R. cathartica, R. multiflora*	11%	14-Jun	18	*Rhamnus cathartica*	44%
		Lonicera sp., Solidago sp./Aster sp.	6%			*Cornus amomum*	22%
		Cornus sp., V. dentatum, O. sensibilis	6%			*Solidago sp./Aster sp.*	11%
		R. cathartica, C. amomum	6%			*Rosa multiflora*	11%
		O. sensibilis, Galium sp.	6%			*Viburnum dentatum*	6%
		Lonicera sp.	6%			*Onoclea sensibilis*	6%
		O. sensibilis, Solidago sp./Aster sp., R. allegheniensis	6%				
		R. multiflora, O. sensibilis, Fraxinus sp.	6%				
		Onoclea sensibilis	6%				
		Rhamnus cathartica	6%				
		Viburnum dentatum	6%				
		O. sensibilis, R. allegheniensis	6%				
		R. multiflora, C. amomum, R. allegheniensis, V. dentatum	6%				
		Cornus amomum	6%				

— 2005 —				— 2006 —			
Sampling Date	Points Sampled	Dominant Species	Frequency	Sampling Date	Points Sampled	Dominant Species	Frequency
		R. cathartica, Fraxinus sp.	6%				
		Solidago sp./Aster sp., R. acris	6%				
20-Jul	18	*Cornus amomum*	44%	25-Jul	18	*Rhamnus cathartica*	44%
		Solidago sp./Aster sp.	17%			*Cornus amomum*	22%
		Onoclea sensibilis	17%			*Solidago sp./Aster sp.*	11%
		Rhamnus cathartica	17%			*Rosa multiflora*	11%
		Rosa multiflora	6%			*Viburnum dentatum*	6%
						Onoclea sensibilis	6%
Sector ECS - Mow age 4 yr				**Sector ECS - Mow age 1 yr**			
7-Jun	18	*Solidago sp./Aster sp.*	22%	8-Jun	18	*Solidago sp./Aster sp.*	22%
		Cornus amomum	11%			*Centaurea jacena*	17%
		Poaceae, Solidago sp./Aster sp.	11%			*Vicia sp.*	17%
		R. cathartica, V. dentatum	6%			*Onoclea sensibilis*	11%
		R. cathartica, C. amomum	6%			*Poaceae*	11%
		C. amomum, V. dentatum	6%			*Cornus amomum*	6%
		C. amomum, O. sensibilis	6%			*Viburnum dentatum*	6%
		Onoclea sensibilis	6%			*Galium sp.*	6%
		V. dentatum, C. amomum, V. riparia	6%			*Asclepias syriaca*	6%
		C. amomum, Fraxinus sp.	6%				
		C. amomum, V. dentatum	6%				
		Solidago sp./Aster sp.,T. radicans, V. riparia, Asclepias syriaca	6%				
		Poaceae, R. acris, Solidago sp./Aster sp., T. radicans	6%				
19-Jul	18	*Solidago sp./Aster sp.*	39%	27-Jul	18	*Solidago sp./Aster sp.*	28%
		Fraxinus sp.	17%			*Onoclea sensibilis*	22%
		Cornus amomum	17%			*Poaceae*	17%
		Viburnum dentatum	11%			*Rhamnus cathartica*	17%
		Centaurea jacena	6%			*Asclepias syriaca*	11%
		Poaceae	6%			*Fraxinus sp.*	6%
		Onoclea sensibilis	6%				

2005				2006			
Sampling Date	Points Sampled	Dominant Species	Frequency	Sampling Date	Points Sampled	Dominant Species	Frequency
Sector EN - Mow age 4 yrs				**Sector EN - Mow age 1 yrs**			
7-Jun	20 points	*Solidago sp./Aster sp.*	25%	12-Jun	20	*Solidago sp./Aster sp.*	35%
		Onoclea sensibilis	5%			*Toxicodendron radicans*	15%
		V. dentatum, Prunus virginiana	5%			*Onoclea sensibilis*	10%
		C. amomum, Clematis virginiana	5%			*Viburnum dentatum*	10%
		Rosa multiflora	5%			*Poaceae*	5%
		O. sensibilis, Galium sp., Vicia sativa	5%			*Fraxinus sp.*	5%
		C. amomum, Fraxinus sp., V. riparia	5%			*Rhamnus cathartica*	5%
		Rubus idaeus, Vicia sativa, Solidago sp./Aster sp.	5%			*Galium sp.*	5%
		Lonicera sp., Acer sp., R. cathartica	5%			*Clematis virginiana*	5%
		Solidago sp./Aster sp., R. multiflora	5%			*Parthenocissus quinquifolia*	5%
		O. sensibilis, Solidago sp./Aster sp.	5%				
		Viburnum dentatum	5%				
		Lonicera sp., V. riparia, O. sensibilis	5%				
		Lonicera sp.	5%				
		R. cathartica, R. multiflora, Fraxinus sp.	5%				
		R. cathartica, V. riparia, Fraxinus sp.	5%				
19-Jul	20	*Solidago sp./Aster sp.*	35%	24-Jul	20	*Solidago sp./Aster sp.*	30%
		Rhamnus cathartica	25%			*Onoclea sensibilis*	25%
		Cornus amomum	15%			*Lonicera sp.*	15%
		Centaurea jacena	10%			*Cornus amomum*	10%
		Rubus allegheniensis	10%			*Rosa multiflora*	5%
		Onoclea sensibilis	5%			*Vitis riparia*	5%
						Rhamnus cathartica	5%
						Rubus alleghenensis	5%

Appendix D. Frequency of occurrence of sampled plant species in lower field in 2005 and 2006.

— 2005 —				— 2006 —			
Sampling Date	Points Sampled	Dominant Species	Frequency	Sampling Date	Points Sampled	Dominant Species	Frequency
Mow age 4 yr				**Mow age 1 yr**			
2-Jun	32	*Solidago sp./Aster sp.*	40%	8-Jun	30	*Vicia sp.*	67%
		Galium sp.	30%			*Poaceae sp.*	13%
		Vicia sp.	7%			*Solidago sp./Aster sp.*	7%
		Lonicera sp.	3%			*Anemone canadensis*	3%
		Vicia sp. & Galium sp.	3%			*Cyperaceae sp*	3%
		Solidago sp./Aster sp. & Galium sp.	3%			*Galium sp.*	3%
		Rosa multiflora	3%			*Epilobum coloratum*	3%
		Rhus hirta	3%				
		Fraxinus sp.	3%				
		Fraxinus sp. & Solidago sp./Aster sp.	3%				
20-Jul	30	*Solidago sp./Aster sp.*	57%	23-Jul	30	*Solidago sp./Aster sp.*	37%
		Centaurea jacena	20%			*Galium sp.*	33%
		Galium sp.	7%			*Centaurea jacena*	23%
		Asclepias syriaca	3%			*Lonicera sp.*	3%
		Cornus amomum	3%			*Solanum carolinense*	3%
		Vitis riparia	3%				
		Rosa multiflora	3%				
		Poaceae sp.	3%				

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