Studies of Bobolink and Related Bird Habitats on Agricultural Lands in Norfolk County

Final Report

Photo: Dave Reid

produced for

Norfolk Alternative Land Use Services (ALUS)

by

Jon D. McCracken, Stuart A. Mackenzie, Sonya Richmond & Eva Jenkins

June 2014

EXECUTIVE SUMMARY

North American grassland bird populations are in trouble throughout most of their range. This suite of bird species has become a major conservation issue. Within Norfolk County in southern Ontario, our study examined the following questions:

1. Compared to traditionally-managed agricultural landscapes, to what extent do ALUS projects and other habitat restoration activities enhance on-site breeding populations for grassland birds of high conservation concern in terms of their effects on levels of species abundance and diversity?
2. What specific kinds of conservation projects bring the most and least benefits to grassland birds?
3. To what extent would increased populations of grassland birds occur if ALUS and/or other types of conservation projects were rolled out at larger regional scales and/or had greater uptake among landowners within the region?
4. Where exactly do grassland species currently occur within the Norfolk County study area? What kinds of habitats are they mostly using and to what extent does the regional population occur in traditionally managed agricultural lands versus other kinds of open habitats?
5. How have regional population levels of Bobolinks and Eastern Meadowlarks changed over the past decade, and can these population changes be attributed to changes in habitat supply?
6. How can information from this study be used to better inform future conservation efforts?

Over a period of 3 years, breeding bird surveys were conducted at 366 different sample stations located in open field habitats, including hay, pasture, row crop, grain crop, old field, grassland restoration, and tree restoration. Generally, bird species richness and abundance were similar across all broad habitat categories, regardless of whether a field was in high-intensity agriculture, low-intensity agriculture, or in conservation land. Although there were few statistically significant differences between the various categories, ALUS properties had somewhat higher overall bird densities and numbers of species than other properties. As well, most of the sites that were in conservation lands were still in their earliest stages of habitat restoration, so conclusions about effect on overall species richness are premature. Even so, there were still often substantial differences in the response of individual bird species to individual treatments. Grassland-obligate species (Bobolink, meadowlark, Savannah Sparrow) were all recorded in greatest numbers in agricultural habitats (hay and pasture). This was also true for Horned Lark and Killdeer. Within the grassland bird guild, conservation lands had greater importance for Vesper Sparrow and Grasshopper Sparrow. These lands were also important for Tree Swallow (an aerial forager), and a variety of shrub-habitat species.

With the exception of Vesper Sparrow, adjacent forest cover generally had a strong negative influence on the occurrence of grassland bird species, and a positive influence on shrub and forest bird species. Other factors influencing grassland bird site occupancy included % grass cover (positive), % shrub cover (negative), grassland field size (positive), and longest distance to the open horizon (positive).

Over a 10-year period, we estimated that populations of Bobolink and Eastern Meadowlark in our study region declined by about 59% and 74%, respectively. These declines were heavily linked to declines in the amount of agricultural grassland (pasture and hay) in the region, owing to conversion to row crops (especially corn and soy). We also consider loss of rye, which is typically grown in rotation with tobacco, as another contributing factor.

We estimate that at least 3200 acres of grassland would need to be planted to recover regional populations of these two species to their former levels. This poses a significant conservation challenge, and one that may be best accomplished by concentrating on promoting more traditional hay and pasture, together with planting of tallgrass prairie in appropriate locations. In addition to habitat creation, grassland bird populations can also strongly benefit simply by delaying the first cut of hay until after 10 July. Incentive payments to landowners will almost certainly be needed to introduce this additional tool.

The report concludes with a series of recommendations, including ones for grassland restoration and management, ongoing monitoring, and some new research priorities.

INTRODUCTION

Farmland can provide important habitat for many species of birds (e.g., Boutin *et al.* 1999). However, in North America, many common farmland bird species (especially those associated with grasslands) have declined as a result of agricultural intensification in recent decades. This decline could be mitigated to some degree by offering payments to farmers to restore some ecological services on their farms. Indeed, payments for ecosystem services, such as the Alternative Land Use Services (ALUS) program (www.alus.ca), are increasingly common around the world (see, Whittingham 2011). However, the actual effectiveness of these kinds of incentives is sometimes questioned (e.g., Kleijn and Sutherland 2003; Whittingham 2011).

The recent listing of two grassland birds in 2009 and 2010 – the Bobolink and Eastern Meadowlark – as threatened species under Ontario's *Endangered Species Act* has focussed attention on what could be seen as an inherent conflict between conservation interests and normal agricultural practices in hayfields, pastures, forage crops and edge habitats. A recovery strategy for these two species in Ontario has been prepared (McCracken *et al.* 2013), and the provincial government has adopted a special exemption for normal agricultural practices. Merging the interests of farmers and grassland birds will allow creative solutions, engage people on the land, and take advantage of a farmer's most basic skill – the ability to propagate living things – and apply this skill to at risk species. Such a paradigm-shift engages farmers as active participants in the recovery of endangered species.

In Norfolk County, the ALUS program has successfully engaged more than 150 farm families in the restoration of upwards of 1200 acres of natural cover on marginal or sensitive farm lands, including several projects that should benefit grassland birds. Overall, the ALUS program is demonstrating the ability of farmers to produce wildlife habitat and food at the same time. In the Norfolk region, we are also fortunate to have many other restoration activities underway on hundreds of additional acres of former agricultural lands that are held by other conservation organizations, including Nature Conservancy of Canada (NCC), Long Point Region Conservation Authority (LPRCA), Long Point Basin Land Trust (LPBLT), and Ducks Unlimited Canada (DUC).

Whenever possible, site management plans that call for habitat restoration efforts and/or best-management practices should incorporate a biological monitoring framework as a tool to: 1) evaluate the progress and effectiveness of management approaches; 2) provide feedback information that is necessary for informing adaptive management frameworks; and 3) learn more about which kinds of management actions work best under which conditions. Indeed, Ferraro (2011) went so far as to question whether such payments are warranted in the absence of measuring environmental and social effects. Ideally, such an assessment would include an assessment of what might have happened in the absence of the incentive program.

The main goal of the studies in Norfolk County was to gain a greater understanding of the extent to which grassland species of breeding birds, and in particular Bobolink and Eastern Meadowlark, nest in a) working agricultural lands (e.g., hayfields and pastures); b) various kinds of site restoration projects implemented on retired farmlands; and c) old agricultural fields – all relative to monoculture row and grain crops.

The region of focus was Norfolk County, although some fieldwork also occurred nearby in extreme western Haldimand County and southern Brant County. The project extended over 3 years, because a) birds do not respond immediately to habitat change that stems from site restoration work, b) habitat quality (and sometimes habitat type) at the site level itself changes over short time periods in early-successional conditions, and c) because of affects from annual weather conditions. There are also annual background fluctuations in regional (and even continental) bird populations in response to a variety of external factors.

Year #1 (2011) of our study was mostly a pilot year needed to identify and select a representative cross-section of suitable study areas, and to collect initial data that could be used to gain a better understanding of the kinds of sample sizes required. Information from year #1 fed into the design of more extensive surveys that were conducted in 2012 (year #2) and 2013 (year #3).

Primary Research Questions

1. Compared to traditionally-managed agricultural landscapes, to what extent do ALUS projects and other habitat restoration activities enhance on-site breeding populations for Bobolink and related species of high conservation concern in terms of their effects on levels of species abundance and diversity?
2. What specific kinds of conservation projects (ALUS, other site restoration initiatives, including tree planting projects) bring the most and least benefits to Bobolink and other grassland birds of high conservation concern? In particular, there is an untested perception that reforestation projects benefit grassland birds because they outwardly resemble grassy fields in their earliest stages of restoration.
3. To what extent would any beneficial effects be predicted to result in increased populations of Bobolink and related bird species of high conservation concern if ALUS and/or other types of conservation projects were rolled out at larger regional scales and/or had greater uptake among landowners within the region?
4. Where exactly do grassland species at risk (Bobolink and Eastern Meadowlark) currently occur within the Norfolk County study area? What kinds of habitats are they mostly using and to what extent does the regional population occur in traditionally managed agricultural lands versus other kinds of open habitats?
5. In the Norfolk study region, what proportion of sites that Bobolinks and Eastern Meadowlarks occupied in the breeding bird atlas (2001-2005) are still being used? If they are no longer occupied, have there been obvious changes in habitat characteristics (e.g., conversion from grasslands to some other land use)?
6. How can information from this study be used to better inform future conservation efforts on agricultural lands (e.g., best management practices)?

METHODS

Sampling Design: Habitat

A key part of the sampling strategy was to obtain a good representative cross-section of open field habitats, according to their size, ownership, and management regime. Selection of study sites was based on information provided by ALUS, NCC, LPRCA, and BSC staff, plus information contained from within roadside surveys that had been previously conducted during the Ontario Breeding Bird Atlas project from 2001-2005. For many survey sites (especially off-road sites), reconnaissance visits were made in advance of actual surveys to scout potential fields for study, locate potential point count locations, and to locate access points. For ALUS projects, these included a visit with the landowner to explain the project, gain some information on recent and past site management, and to reconnoitre the property.

Distances between bird sample stations were not less than 200 m, in order to reduce double counting of most bird species. All stations were georeferenced (UTM NAD83) to an accuracy of ~5 m using a Garmin 12 GPS unit.

The following habitat attributes were recorded:

- Roadside- or interior-field count type
- Roadside presence within 100 m (Y or N)
- Grassland field area (ha)
- Longest distance open-line of sight (sight horizon distance) that is not broken by forest cover > 10 m wide
- Number of forested sides, number of hedgerows and number of fencelines occurring within each of the four cardinal compass directions within a 200 m radius
- Presence/absence of rural outbuildings within 200 m
- Presence/absence of nest boxes within 200 m
- Presence/absence of livestock within 200 m
- Presence/absence of hay/pasture/idle field/restoration habitat
- Age of field treatment (if applicable)
- Proportion of grass cover within 100 m (coded in 5 categories)
- Percent bare ground within 100 m
- Percent shrub/tree cover within field within 100 m
- Presence/absence of wetland influences within 100 m
- Remarks (e.g., notes on hayfield cutting).

All sample stations at restoration sites were also photographed and date stamped. In the future, this photo reference library will allow visual assessment of habitat change as succession proceeds and restoration projects mature.

Intensive Bird Surveys (two visits)

For intensive surveys, the number of stations that were surveyed twice during the course of the breeding season totalled 89 in 2011, 131 in 2012, and 90 in 2013. Most of these stations were sampled in at least two years. All visits were conducted from 21 May to 8 July, during the morning (0558 to 1028 h EDT) under favourable weather conditions and by the same experienced observer (Jon McCracken).

Point counts at these sites were 5 minutes in duration. Birds were recorded within two distance bands: < 100 m and > 100 m. Fly-overs and obvious transients were not counted, with the exception of swallows and swifts that were foraging above the fields.

On ALUS properties, species not detected on point counts were also recorded. This was merely for site inventory purposes for the interest of ALUS landowners; these additional records were not included in any analyses.

Atlas Point Count Stations (Single-visit Surveys)

This component of the project was completed in 2012 (year #2). Precise roadside point count stations at which Bobolink and/or Eastern Meadowlark were detected during the last Ontario breeding bird atlas project (2001-05) in Norfolk County and environs were extracted from the atlas database and mapped on two large maps (see Appendix 1a, b). Roadside point locations for the Atlas project had previously been randomly selected. Each location was individually coded and precise UTM coordinates were presented in the map legends for easy reference. In total, 212 occurrence records of the two target species were mapped. Of these, 195 sites were resurveyed in 2012.

These bird surveys followed the same protocol as was used during the Atlas period. These were single-visit, 5-minute counts made in the morning, under suitable weather conditions, at the height of the breeding season, with birds again being recorded within two distance bands (<100 m and >100 m). The main difference was that a single observer (S.A. Mackenzie) was used in 2012, while over a dozen observers were used during the Atlas period. Surveys were completed between 0528 and 1033 h EDT (80% were completed before 0900 h and only 2% were done after 1000 h).

All surveys were conducted between 24 May and 15 June. This date range was selected to maximize the window during which breeding was occurring, yet earlier than most haying operations were expected to occur. Because grassland birds abandon hay fields immediately after being cut, this reduced the likelihood that false negatives would be recorded. Nevertheless, at least partial hay-cutting occurred at 6 (3.1%) of the 195 sites surveyed in 2012. Survey results from these sites were left in the habitat analysis, but not in the change analysis. Because the survey window from the Atlas period was considerably longer than our surveys in 2012, there would have been considerably more false negatives in the earlier period. Because of this bias, the actual rate of site abandonment between the two time periods would likely be even greater than the values reported later in this report.

In addition to birds, broad habitat characteristics were also recorded within a 100-m radius, as per Table 1. Elements of grass-dominated habitats (i.e., pasture, hay, old grassy field) were encountered at 99 samples in 2012 (18.6% of total). Corn, soy, grain and other crops were encountered at 270 samples (50.8% of total). Sites containing forest cover (5.8% of total encounters) were low, as would be expected because the samples were originally derived from a dataset drawn entirely from a pool of Bobolink/meadowlark records. As such, the values in Table 1 are not representative of the overall habitat makeup of the Norfolk County region, but rather represent a sample that is heavily biased towards agricultural lands that held grassland components during the Atlas period from 2001-05.

In addition to the 195 Atlas point count locations sampled, another 35+ points were deliberately targeted for surveys in 2012 because they contained expanses of grassland that were likely to hold one or both target species. Field protocols were identical. Results from these additional points were not included in the change analysis comparing results between the present day versus those from the Atlas period. However, these data were used in several investigations of species' habitat associations.

Table 1. Habitat types recorded within 100 m of Atlas point stations sampled in 2012 and number of stations that supported each one. Totals exceed the total number of stations surveyed (n=195) because most stations had more than one habitat type present. Grassland habitats are highlighted in green.

Bare ground	Corn	Soy	Grain	Other Crop	Pasture	Hay (alfalfa)	Hay (grass)	Old Field (grass dominated)	Old Field (shrub dominated >25%)	Tree restoration	Grass restoration	Forest	Rural Buildings	Other	Total
37	89	81	56	44	**25**	**11**	**27**	**36**	10	3	0	31	74	7	**531**

Data management/analysis
All data were transcribed to Excel worksheets. Each station was uniquely coded by a combination of landowner type, field name and an alpha/numeric code.

In any given year, when two visits were made to point count stations, the **maximum** number of individuals of each species counted was used for analysis. Hence, if 2 Bobolinks were counted at station A-10 on visit #1 and 4 were counted on visit #2, then the value used was 4. Using the maximum count statistic is preferred over using average or total counts, because the maximum count gives a closer approximation of the actual numbers of birds occurring at a sample station. For all analyses, we also pooled counts from the two distance bands.

Each bird species was assigned to one of five habitat guilds: forest, grassland, shrub, generalist, and aerial.

RESULTS AND DISCUSSION

Sampling Coverage for Intensive Surveys (two visits)
In total, 135 individual points were sampled intensively at 83 unique properties from 2011 to 2013. Most stations were located in Norfolk County, but about a dozen were located in western Haldimand County.

Forty-six points were located on private properties registered with ALUS; 45 were on restoration properties owned by various ENGOs (Nature Conservancy of Canada, Long Point Region Conservation Authority, Ducks Unlimited Canada, Bird Studies Canada, Long Point Basin Land Trust); and 44 were on private lands (a mix of hayfields, pasture, wheat-clover, fallow fields, and restoration).

The number of points per individual field ranged from 1-10. Roadside locations accounted for 42 survey stations. The remainder were situated in field interiors.

Field sizes ranged from 1 to 74 ha in size, and averaged 18.1 ha, with a median of 10.4 ha. The majority (46%) were very small to small (<10 ha). About 43% were medium to large (10-50 ha); and 11% were very large (> 50 ha). Most of the conservation lands were in small category.

Types of field management included working lands of various description (e.g., hay, pasture, wheat, corn, soy) and non-working lands (e.g., habitat restoration projects of various ages, old fields). A breakdown of management regimes is provided in Table 2.

Table 2. Types of field-management elements that were intensively sampled from 2011 to 2013.

Management Regime Elements	**No. of Sample Stations [1]**
A) Working lands	
• Hay elements	34
• Pasture elements	17
• Non-forage crop elements (wheat-clover; soybean)	12
TOTAL	**63**
B) Non-working Lands	
• Restoration elements (prairie and/or forest)	91
• Idle/fallow field elements	22
TOTAL	**113**

[1] The area around 40 sample stations encompassed elements of both working and non-working lands, so the combined total of these two categories exceeds the actual total number of sample stations.

For fields involving habitat restoration projects (n = 91 stations), the time since active restoration began ranged from 0 yr (i.e., essentially bare ground) to 20 yr, with a median age of 4 yr. Of these sample stations, 58% were located at sites that had prairie restoration elements and 42% had forest restoration elements. About 20% had a mixture of both (e.g., savannah restoration).

Overview Results from Bird Surveys

Because both intensive and extensive surveys were conducted in 2012, pooled data from this year were used to construct an overview of the region's species assemblage. In total, 97 species were recorded across all 339 point count stations sampled in 2012 (Table 3). Of the total count of 10,854 individuals, the most abundant was the generalist guild of species (36.2% of observations), followed by shrub birds (25.7%), forest birds (19.1%), grassland species (10.9%), and aerial insectivores (8.1%). Overall, Song Sparrow was the most numerous bird species, followed by American Robin, Red-winged Blackbird, European Starling, Chipping Sparrow, and American Crow. Similar species rankings were found by Boutin *et al.* (1999) for corn and soy fields in southwestern Ontario.

Nine species at risk were encountered in the 2012 surveys – in numbers and frequencies that appear to generally represent their population status in the overall region (Table 3). Barn

Swallow was the most frequently encountered species, followed by Bobolink, Eastern Meadowlark, Wood Thrush, Bank Swallow, Eastern Wood-Pewee, Chimney Swift, Red-headed Woodpecker, and Golden-winged Warbler. All are considered Threatened in Ontario. Bobolinks were encountered at 101 (28%) of the point count stations. Meadowlarks are much less common in the Norfolk County region and were encountered at 56 (15%) of the point count stations.

Table 3. Frequency of occurrence and total of maximum counts of birds encountered at point count stations in 2012. Listed in decreasing order of frequency of occurrence. Species in bold and marked with * are Species at Risk.

Species Code	Species Name	# of Pts	% frequency	Total Abundance	% total abundance	Guild
SOSP	Song Sparrow	314	86.7	768	7.1	shrub
AMRO	American Robin	293	80.9	808	7.4	generalist
RWBL	Red-winged Blackbird	262	72.4	1179	10.9	generalist
EUST	European Starling	200	55.2	939	8.7	generalist
CHSP	Chipping Sparrow	182	50.3	309	2.8	forest
AMCR	American Crow	171	47.2	298	2.7	forest
AMGO	American Goldfinch	171	47.2	321	3.0	shrub
COGR	Common Grackle	170	47.0	580	5.3	shrub
SAVS	Savannah Sparrow	167	46.1	337	3.1	grassland
BARS	***Barn Swallow**	154	42.5	373	3.4	aerial
BHCO	Brown-headed Cowbird	144	39.8	248	2.3	generalist
BAOR	Baltimore Oriole	141	39.0	175	1.6	forest
NOCA	Northern Cardinal	141	39.0	168	1.5	shrub
YWAR	Yellow Warbler	138	38.1	250	2.3	shrub
MODO	Mourning Dove	133	36.7	207	1.9	forest
COYE	Common Yellowthroat	115	31.8	164	1.5	generalist
KILL	Killdeer	110	30.4	163	1.5	grassland
REVI	Red-eyed Vireo	103	28.5	152	1.4	forest
BOBO	***Bobolink**	101	27.9	251	2.3	grassland
HOLA	Horned Lark	94	26.0	196	1.8	grassland
CEDW	Cedar Waxwing	93	25.7	278	2.6	shrub
INBU	Indigo Bunting	93	25.7	118	1.1	forest
VESP	Vesper Sparrow	92	25.4	129	1.2	grassland
HOWR	House Wren	88	24.3	104	1.0	forest
TRES	Tree Swallow	81	22.4	165	1.5	aerial
WAVI	Warbling Vireo	80	22.1	107	1.0	forest
HOSP	House Sparrow	76	21.0	244	2.2	generalist
FISP	Field Sparrow	75	20.7	129	1.2	shrub
GCFL	Great Crested Flycatcher	75	20.7	82	0.8	forest
GRCA	Gray Catbird	73	20.2	81	0.7	shrub
BLJA	Blue Jay	67	18.5	83	0.8	forest
EAME	***Eastern Meadowlark**	56	15.5	78	0.7	grassland
WIFL	Willow Flycatcher	51	14.1	58	0.5	shrub
EAKI	Eastern Kingbird	50	13.8	53	0.5	shrub
BCCH	Black-capped Chickadee	41	11.3	46	0.4	forest
BRTH	Brown Thrasher	37	10.2	39	0.4	shrub
NOFL	Northern Flicker	37	10.2	37	0.3	forest

Species Code	Species Name	# of Pts	% frequency	Total Abundance	% total abundance	Guild
RBGR	Rose-breasted Grosbeak	36	9.9	42	0.4	forest
WOTH	***Wood Thrush**	34	9.4	36	0.3	forest
EABL	Eastern Bluebird	33	9.1	36	0.3	generalist
EATO	Eastern Towhee	31	8.6	33	0.3	forest
BANS	***Bank Swallow**	27	7.5	311	2.9	aerial
OROR	Orchard Oriole	27	7.5	30	0.3	shrub
EAWP	***Eastern Wood-Pewee**	24	6.6	27	0.2	forest
TUVU	Turkey Vulture	21	5.8	46	0.4	forest
DOWO	Downy Woodpecker	20	5.5	21	0.2	forest
SCTA	Scarlet Tanager	19	5.2	19	0.2	forest
CAGO	Canada Goose	18	5.0	206	1.9	generalist
HOFI	House Finch	16	4.4	23	0.2	generalist
GRSP	Grasshopper Sparrow	15	4.1	16	0.1	grassland
RTHA	Red-tailed Hawk	14	3.9	14	0.1	forest
RBWO	Red-bellied Woodpecker	13	3.6	14	0.1	forest
ROPI	Rock Pigeon	11	3.0	40	0.4	generalist
WITU	Wild Turkey	11	3.0	13	0.1	generalist
PUMA	Purple Martin	9	2.5	16	0.1	aerial
WBNU	White-breasted Nuthatch	9	2.5	9	0.1	forest
CHSW	***Chimney Swift**	8	2.2	11	0.1	aerial
GTBH	Great Blue Heron	8	2.2	8	0.1	forest
AMRE	American Redstart	7	1.9	7	0.1	forest
BBCU	Black-billed Cuckoo	7	1.9	7	0.1	shrub
BWWA	Blue-winged Warbler	7	1.9	8	0.1	shrub
BWHA	Broad-winged Hawk	7	1.9	8	0.1	forest
HOWA	Hooded Warbler	7	1.9	7	0.1	forest
NOMO	Northern Mockingbird	7	1.9	7	0.1	shrub
OVEN	Ovenbird	7	1.9	9	0.1	forest
CSWA	Chestnut-sided Warbler	6	1.7	6	0.1	shrub
EAPH	Eastern Phoebe	6	1.7	6	0.1	generalist
PIWO	Pileated Woodpecker	6	1.7	6	0.1	forest
AMKE	American Kestrel	5	1.4	5	0.0	grassland
GRHE	Green Heron	5	1.4	5	0.0	forest
RHWO	***Red-headed Woodpecker**	5	1.4	5	0.0	forest
RBGU	Ring-billed Gull	5	1.4	7	0.1	generalist
SPSA	Spotted Sandpiper	5	1.4	5	0.0	generalist
WODU	Wood Duck	5	1.4	8	0.1	forest
BGGN	Blue-gray Gnatcatcher	4	1.1	4	0.0	forest
HAWO	Hairy Woodpecker	4	1.1	4	0.0	forest
MALL	Mallard	4	1.1	7	0.1	generalist
VEER	Veery	4	1.1	6	0.1	forest
DICK	Dickcissel	3	0.8	3	0.0	grassland
NRWS	Northern Rough-winged Swallow	3	0.8	5	0.0	aerial
PIWA	Pine Warbler	3	0.8	3	0.0	forest
SWSP	Swamp Sparrow	3	0.8	3	0.0	generalist
UPSA	Upland Sandpiper	3	0.8	5	0.0	grassland
GWWA	*** Golden-winged Warbler**	2	0.6	2	0.0	shrub

Species Code	Species Name	# of Pts	% frequency	Total Abundance	% total abundance	Guild
COHA	Cooper's Hawk	2	0.6	2	0.0	forest
LEFL	Least Flycatcher	2	0.6	2	0.0	forest
NOHA	Northern Harrier	2	0.6	2	0.0	grassland
AMWO	American Woodcock	1	0.3	1	0.0	shrub
BEKI	Belted Kingfisher	1	0.3	1	0.0	generalist
CCSP	Clay-colored Sparrow	1	0.3	1	0.0	grassland
CLSW	Cliff Swallow	1	0.3	1	0.0	aerial
MAWR	Marsh Wren	1	0.3	1	0.0	generalist
MOWA	Mourning Warbler	1	0.3	2	0.0	forest
RBNU	Red-breasted Nuthatch	1	0.3	2	0.0	forest
RTHU	Ruby-throated Hummingbird	1	0.3	1	0.0	forest
WEME	Western Meadowlark	1	0.3	1	0.0	grassland
YBSA	Yellow-bellied Sapsucker	1	0.3	1	0.0	forest

Comparison of Agricultural Lands and Conservation Lands

Primarily for the interest of ALUS program participants, Figure 1 presents summary information on abundance and species richness relative to those found in ENGO and private properties that were also sampled intensively. Although there were few statistically significant differences between the various landowner categories, ALUS properties had somewhat higher overall bird densities and numbers of species than other properties. There are a variety of possible explanatory variables (e.g., presence of hay/pasture, presence of rural buildings, presence of nest boxes, age and type of restoration project, field size). It is also plausible that ALUS participants (mostly farmers), have more experience in actively growing crops, and are better at establishing natural habitats than non-farmers.

Generally, bird species richness was similar across all habitat types and across habitat guilds, regardless of whether a field was in high-intensity agriculture (corn, soy, and grain crops), low-intensity agriculture (pasture/hay), or in conservation land (Figure 2). Species richness in the high-intensity agricultural category was inflated somewhat by the inclusion of grain crops in this category, which have a greater species richness than row crops like corn and soy that have relatively depauperate bird communities. At the same time, species richness was artificially depressed somewhat for lands in the conservation category, because most of these sites were still in their very early stages of restoration and had not yet reached their full species complement. As such, a more accurate assessment of biodiversity could be made in a few years time, once restoration sites are at least 5 years old.

In the meantime, there were, however, often substantial differences in the response of individual species to individual treatments (Figure 3). At one extreme, Grasshopper Sparrow, Field Sparrow, and Eastern Towhee were much more highly associated with restoration habitats than traditional agriculture (Figure 3). The same graph shows the other extreme, with species like Killdeer, Barn Swallow, and Horned Lark showing close associations with agricultural habitats. The two extremes support the need to have both kinds of management approaches on the landscape in order to fully retain the region’s biodiversity.

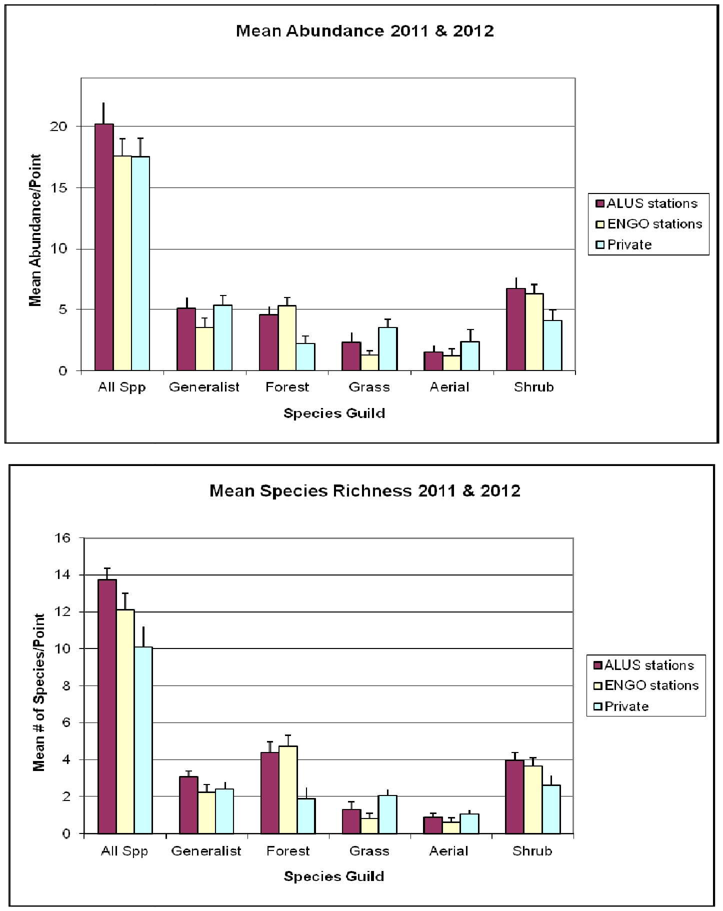


Figure 1. Summary abundance (upper graph) and species richness (lower graph) statistics (means plus 95% confidence intervals) across the various bird guilds and across different broad categories of land ownership, based on intensive surveys conducted in 2011 and 2012.

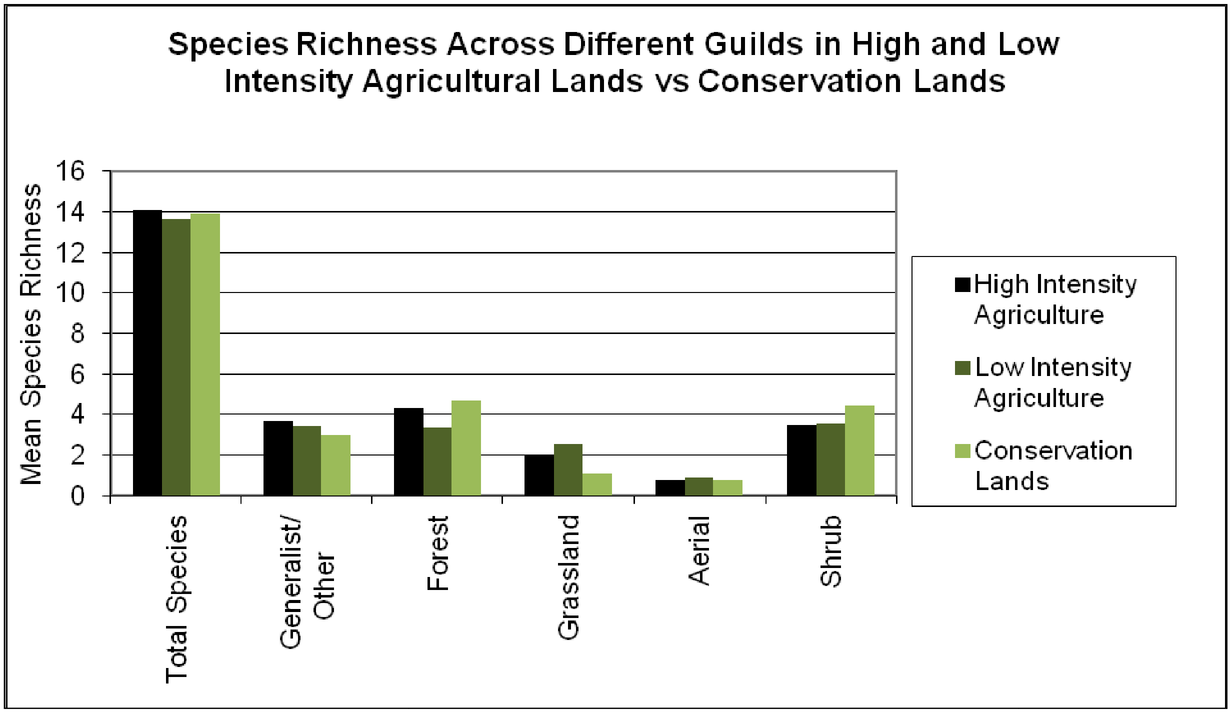


Figure 2. Comparison of bird species richness in agricultural lands vs conservation lands in 2012 (n = 339 sample stations). High intensity agriculture includes row crops and grains; low intensity agriculture includes hay and pasture.

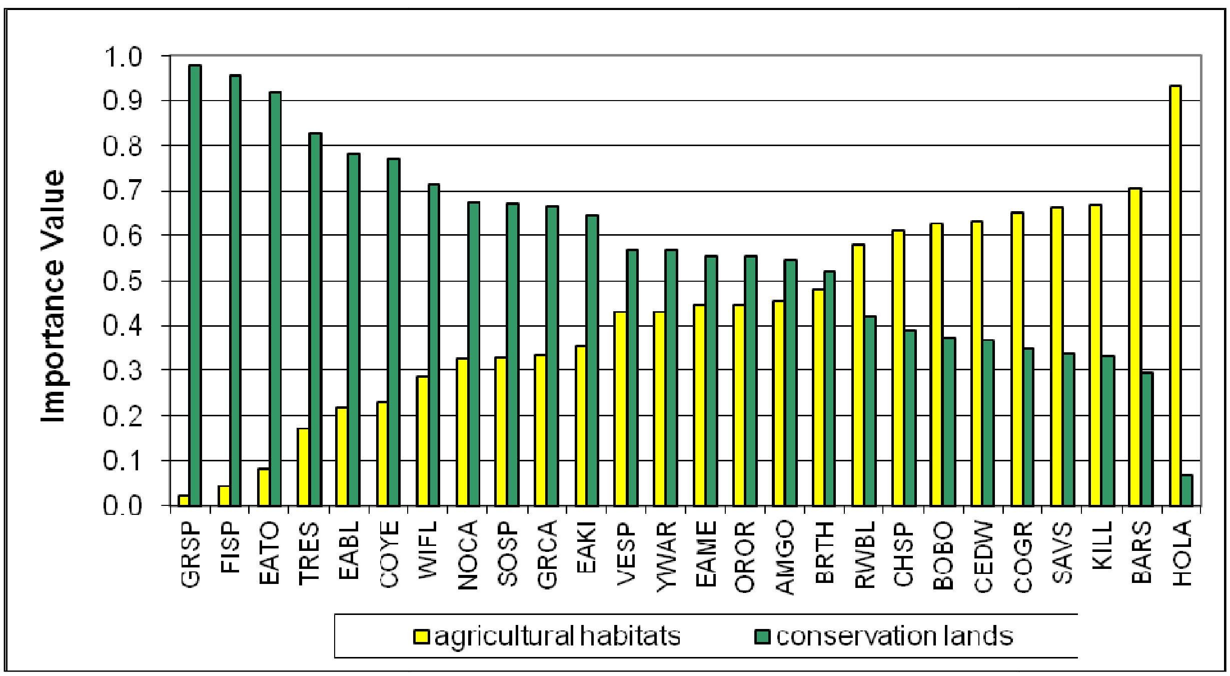


Figure 3. Relative importance of agricultural habitats vs conservation lands for different species of birds in 2012 (n= 339 sample stations). Species codes are provided in Table 3.

<u>Grassland Bird Community:</u> Overall, the grassland bird community in the Norfolk region was dominated by Savannah Sparrow, followed by Killdeer, Bobolink, Horned Lark, Vesper

Sparrow, and Eastern Meadowlark (Table 4). Seven other grassland species were rare to uncommon.

Presence of the three grassland-obligate species (Bobolink, Eastern Meadowlark, Savannah Sparrow) was most clearly associated with agricultural hay and pasture (Figure 4). Other grassland species (Vesper Sparrow, Horned Lark, and Killdeer) were most closely associated with fields that had bare ground cover, which were predominantly agricultural fields (Figure 5). Though recorded in small numbers, Grasshopper Sparrow occurred mostly in conservation lands (Figure 6).

Table 4. Frequency of occurrence and total of maximum counts of grassland birds encountered at point count stations in 2012. Listed in decreasing order of frequency of occurrence.

Species Name	# of Pts	% frequency	Total Max Abundance	% total abundance
Savannah Sparrow	167	46.1	337	3.1
Killdeer	110	30.4	163	1.5
Bobolink	101	27.9	251	2.3
Horned Lark	94	26.0	196	1.8
Vesper Sparrow	92	25.4	129	1.2
Eastern Meadowlark	56	15.5	78	0.7
Grasshopper Sparrow	15	4.1	16	0.1
American Kestrel	5	1.4	5	0.0
Dickcissel	3	0.8	3	0.0
Upland Sandpiper	3	0.8	5	0.0
Northern Harrier	2	0.6	2	0.0
Clay-colored Sparrow	1	0.3	1	0.0
Western Meadowlark	1	0.3	1	0.0

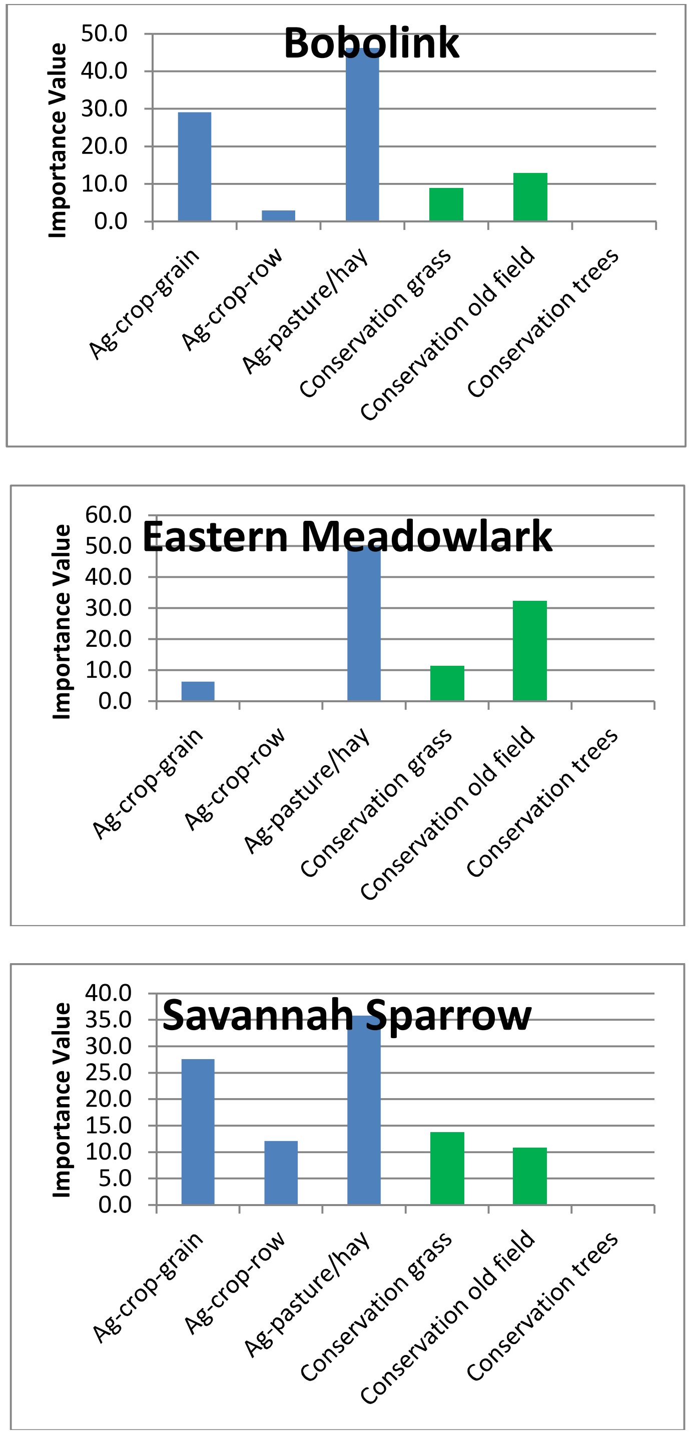


Figure 4. Relative importance of agricultural habitats vs conservation lands for three grassland obligate species: Bobolink (top), Eastern Meadowlark (middle) and Savannah Sparrow (bottom) in 2012 (n= 339 sample stations).

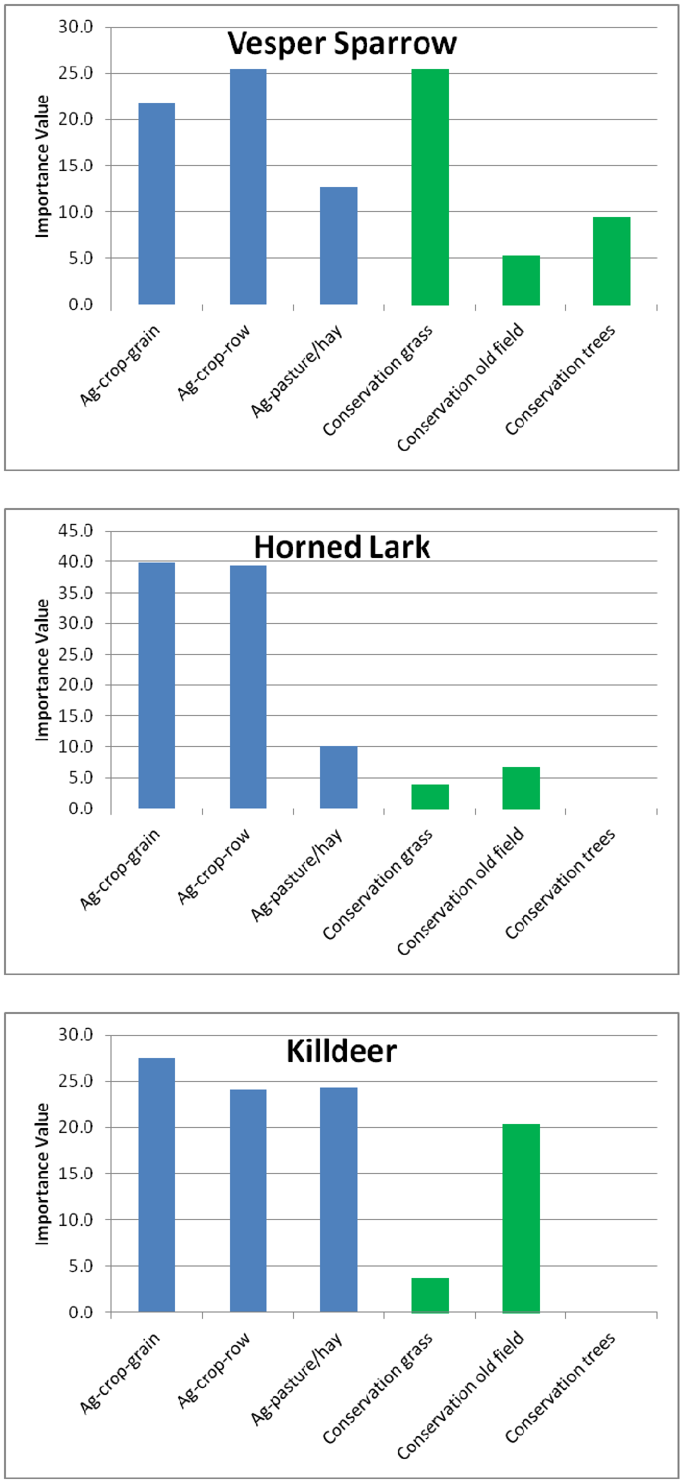


Figure 5. Relative importance of agricultural habitats vs conservation lands for Vesper Sparrow (top) Horned Lark (middle) and Killdeer (bottom) in 2012 (n= 339 sample stations). These "grassland" species do not require grass, and are often associated with open field habitats that have bare ground.

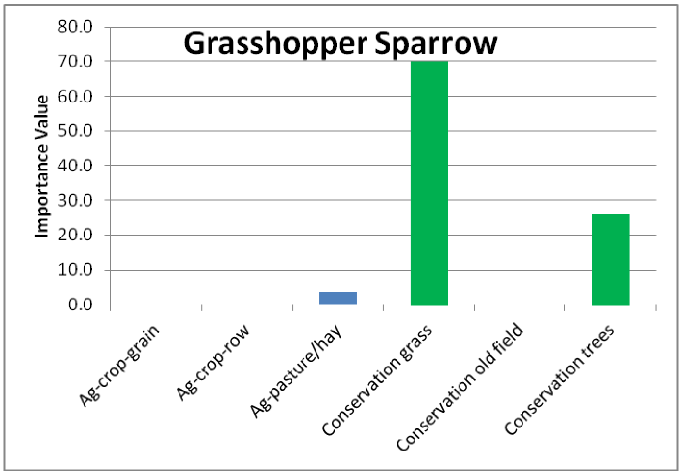


Figure 6. Relative importance of agricultural habitats vs conservation lands for Grasshopper Sparrow in 2012 (n= 339 sample stations). This "grassland" species does not require grass, and is often associated with open field habitats that have bare ground.

Aerial Forager Bird Community: Because they forage over open habitats, species in this guild were most commonly found as associates of the grassland bird community. By far, the most common species were Barn Swallow and Tree Swallow (Table 5). With the exception of Bank Swallow, all members of this guild rely heavily on artificial structures for nesting (e.g. barns, chimneys, nest boxes). Hence, their occurrence is heavily influenced by the presence of these types of structures, in addition to the amount of suitable foraging habitat.

Barn Swallows were most clearly associated with traditional agricultural habitats (Figure 7), owing to the proximity of barns and other rural outbuildings. Conversely, Tree Swallows were most clearly associated with conservation lands (Figure 7), owing to a greater amount of nest box provisioning.

Table 5. Frequency of occurrence and total of maximum counts of aerial forager birds encountered at point count stations in 2012. Listed in decreasing order of frequency of occurrence.

Species Name	# of Pts	% frequency	Total Max Abundance	% total abundance
Barn Swallow	154	42.5	373	3.4
Tree Swallow	81	22.4	165	1.5
Bank Swallow	27	7.5	311	2.9
Purple Martin	9	2.5	16	0.1
Chimney Swift	8	2.2	11	0.1
Northern Rough-winged Swallow	3	0.8	5	0.0
Cliff Swallow	1	0.3	1	0.0

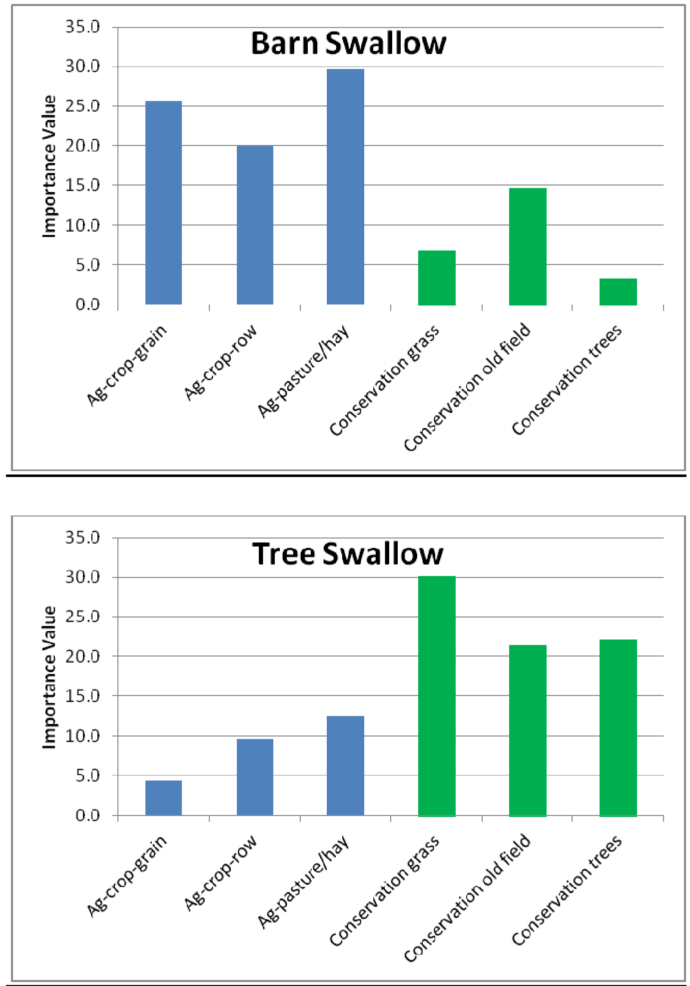


Figure 7. Relative importance of agricultural habitats vs conservation lands for Barn Swallow (top) and Tree Swallow (bottom) in 2012 (n= 339 sample stations). Barn Swallow occurrence is closely associated with presence of barns and other rural outbuildings, whereas Tree Swallows are closely associated with presence of nest boxes.

Shrubland Bird Community: Overall, the shrubland bird community was strongly dominated by Song Sparrow. American Goldfinch, Common Grackle, Northern Cardinal, Yellow Warbler, Cedar Waxwing, Field Sparrow and Gray Catbird were the next most common species (Table 6).

All else being equal, several shrubland species (Song Sparrow, Northern Cardinal, Field Sparrow, and Gray Catbird) appeared to benefit from conservation lands more so than from traditional agriculture (Figure 8). A few of the shrubland species (American Goldfinch, Common Grackle, and Brown Thrasher) appeared to benefit most by agriculture (Figure 9). Several others had fairly even associations between agricultural and conservation lands (Figure 10)

Table 6. Frequency of occurrence and total of maximum counts of shrubland birds encountered at point count stations in 2012. Listed in decreasing order of frequency of occurrence.

Species Name	# of Pts	% frequency	Total Max Abundance	% total abundance
Song Sparrow	314	86.7	768	7.1
American Goldfinch	171	47.2	321	3.0
Common Grackle	170	47.0	580	5.3
Northern Cardinal	141	39.0	168	1.5
Yellow Warbler	138	38.1	250	2.3
Cedar Waxwing	93	25.7	278	2.6
Field Sparrow	75	20.7	129	1.2
Gray Catbird	73	20.2	81	0.7
Willow Flycatcher	51	14.1	58	0.5
Eastern Kingbird	50	13.8	53	0.5
Brown Thrasher	37	10.2	39	0.4
Orchard Oriole	27	7.5	30	0.3
Black-billed Cuckoo	7	1.9	7	0.1
Blue-winged Warbler	7	1.9	8	0.1
Northern Mockingbird	7	1.9	7	0.1
Chestnut-sided Warbler	6	1.7	6	0.1
Golden-winged Warbler	2	0.6	2	0.0
American Woodcock	1	0.3	1	0.0

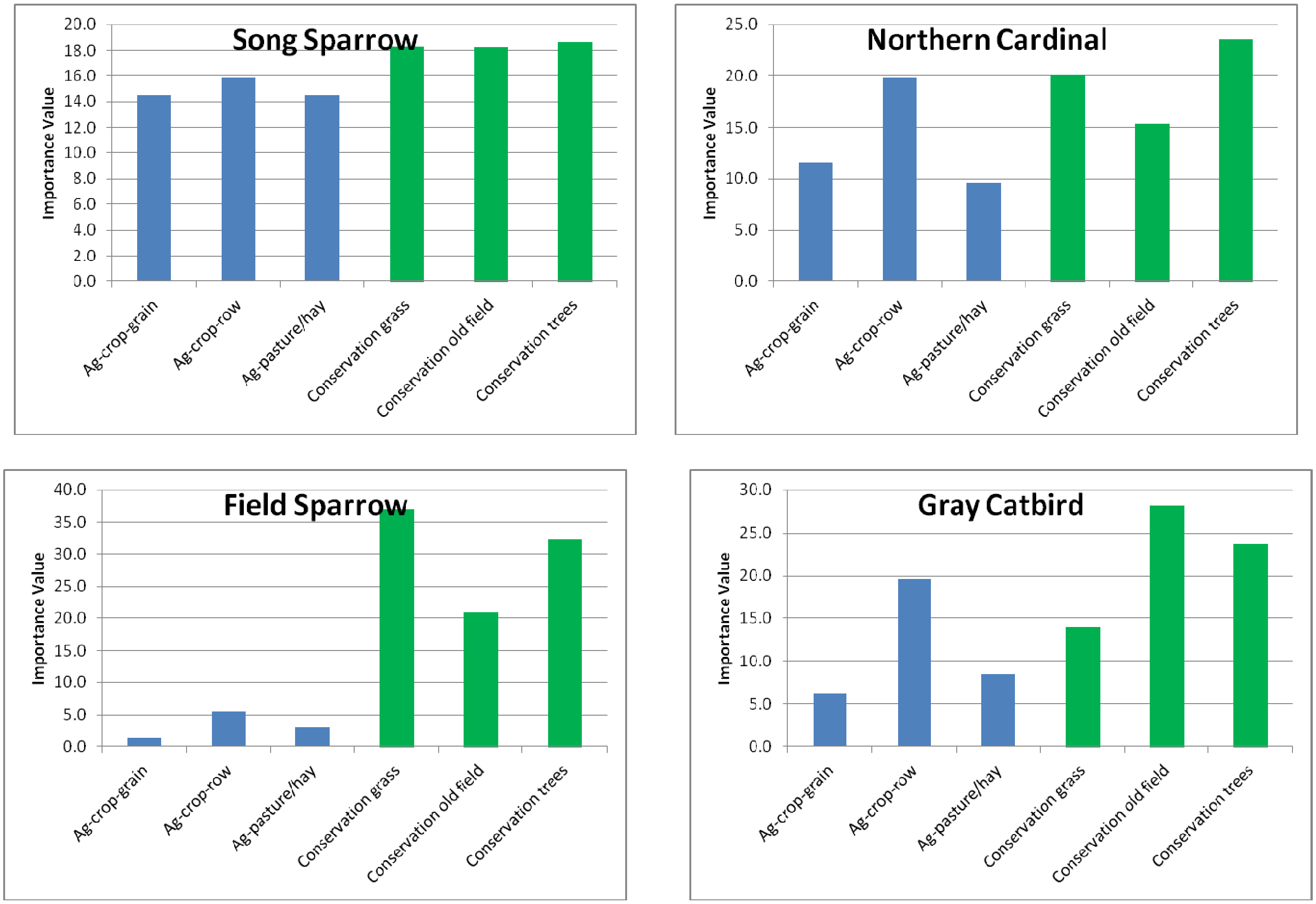


Figure 8. Relative importance of agricultural habitats vs conservation lands for Song Sparrow (top left) Northern Cardinal (top right), Field Sparrow (bottom left) and Gray Catbird (bottom right) in 2012 (n= 339 sample stations). These are all open-country species associated with shrubs.

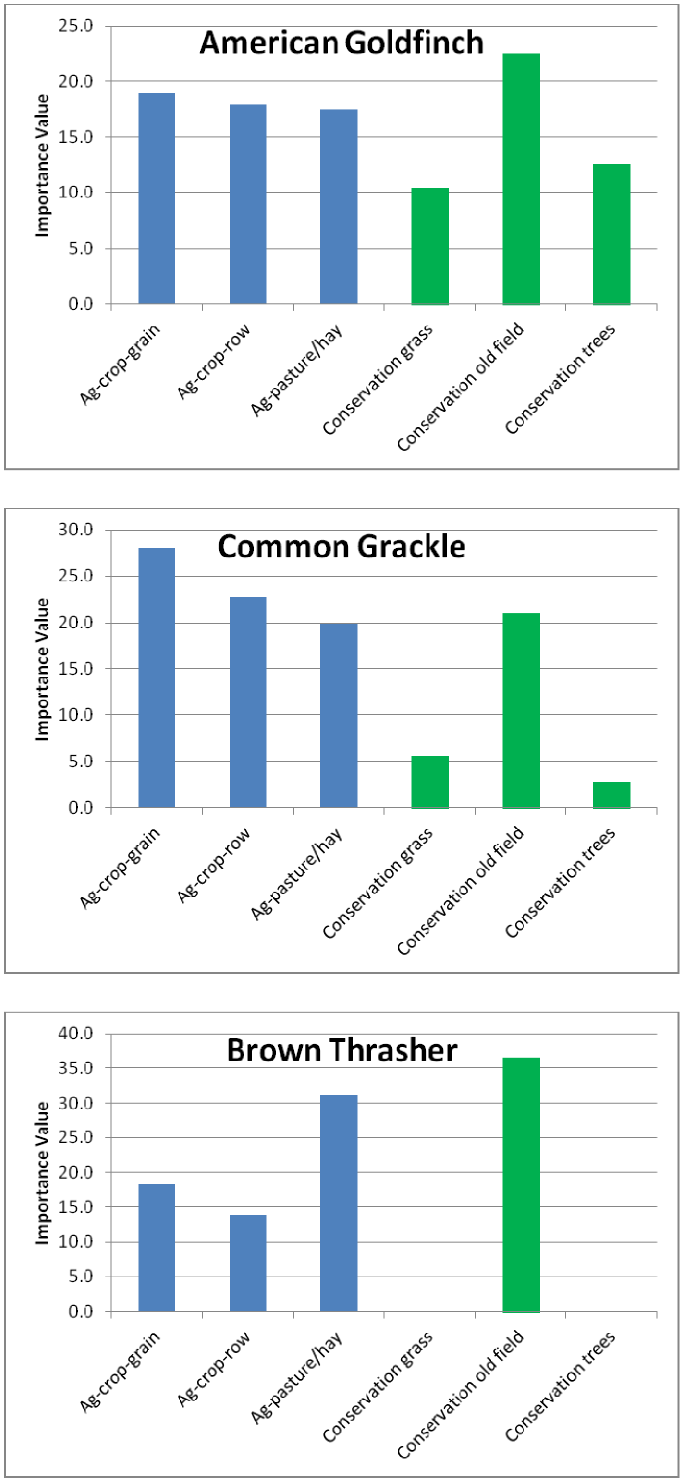


Figure 9. Relative importance of agricultural habitats vs conservation lands for American Goldfinch (top), Common Grackle (middle) and Brown Thrasher in 2012 (n= 339 sample stations). These are open-country species associated with shrubs in agricultural lands.

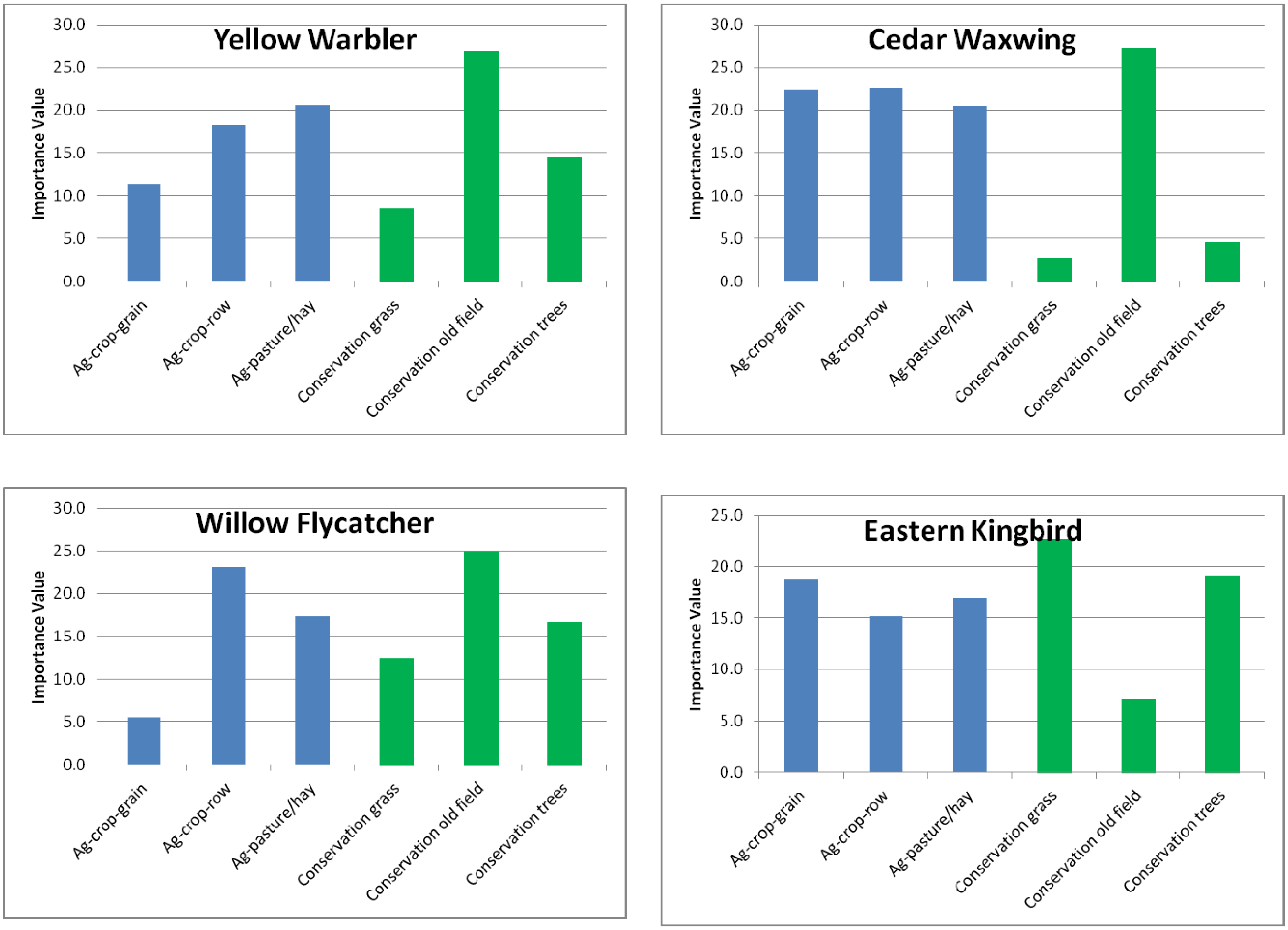


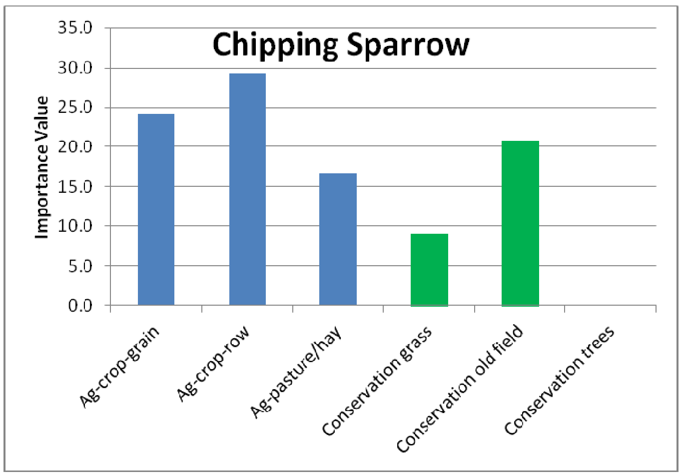
Figure 10. Relative importance of agricultural habitats vs conservation lands for Yellow Warbler (top left) Cedar Waxwing (top right), Willow Flycatcher (bottom left) and Eastern Kingbird (bottom right) in 2012 (n= 339 sample stations). These are all open-country species associated with shrubs, but with no clear association with agricultural or conservation lands.

Forest Bird Community: Because all of our surveys were conducted in open areas, several of the most common forest birds we recorded (e.g., Chipping Sparrow, Indigo Bunting, American Crow, Baltimore Oriole, Blue Jay, Eastern Towhee, House Wren, Mourning Dove) are more closely associated with forest-edge habitats rather than with forest interiors (Table 7). As such, only small numbers of “forest-interior” species were tallied (e.g., Wood Thrush, Veery, Ovenbird, Pine Warbler, Pileated Woodpecker). Chipping Sparrow seemed to have profited from agricultural habitats, while Eastern Towhee was most often associated with conservation lands (Figure 11). Both are forest-edge species.

Table 7. Frequency of occurrence and total of maximum counts of forest birds encountered at point count stations in 2012. Listed in decreasing order of frequency of occurrence.

Species Name	# of Pts	% frequency	Total Max Abundance	% total abundance
Chipping Sparrow	182	50.3	309	2.8
American Crow	171	47.2	298	2.7
Baltimore Oriole	141	39.0	175	1.6
Mourning Dove	133	36.7	207	1.9
Red-eyed Vireo	103	28.5	152	1.4
Indigo Bunting	93	25.7	118	1.1
House Wren	88	24.3	104	1.0
Warbling Vireo	80	22.1	107	1.0
Great Crested Flycatcher	75	20.7	82	0.8
Blue Jay	67	18.5	83	0.8
Black-capped Chickadee	41	11.3	46	0.4
Northern Flicker	37	10.2	37	0.3
Rose-breasted Grosbeak	36	9.9	42	0.4
Wood Thrush	34	9.4	36	0.3
Eastern Towhee	31	8.6	33	0.3
Eastern Wood-Pewee	24	6.6	27	0.2
Turkey Vulture	21	5.8	46	0.4
Downy Woodpecker	20	5.5	21	0.2
Scarlet Tanager	19	5.2	19	0.2
Red-tailed Hawk	14	3.9	14	0.1
Red-bellied Woodpecker	13	3.6	14	0.1
White-breasted Nuthatch	9	2.5	9	0.1
Great Blue Heron	8	2.2	8	0.1
American Redstart	7	1.9	7	0.1
Broad-winged Hawk	7	1.9	8	0.1
Hooded Warbler	7	1.9	7	0.1
Ovenbird	7	1.9	9	0.1
Pileated Woodpecker	6	1.7	6	0.1
Green Heron	5	1.4	5	0.0
Red-headed Woodpecker	5	1.4	5	0.0
Wood Duck	5	1.4	8	0.1
Blue-gray Gnatcatcher	4	1.1	4	0.0
Hairy Woodpecker	4	1.1	4	0.0
Veery	4	1.1	6	0.1

Species Name	# of Pts	% frequency	Total Max Abundance	% total abundance
Pine Warbler	3	0.8	3	0.0
Cooper's Hawk	2	0.6	2	0.0
Least Flycatcher	2	0.6	2	0.0
Mourning Warbler	1	0.3	2	0.0
Red-breasted Nuthatch	1	0.3	2	0.0
Ruby-throated Hummingbird	1	0.3	1	0.0
Yellow-bellied Sapsucker	1	0.3	1	0.0



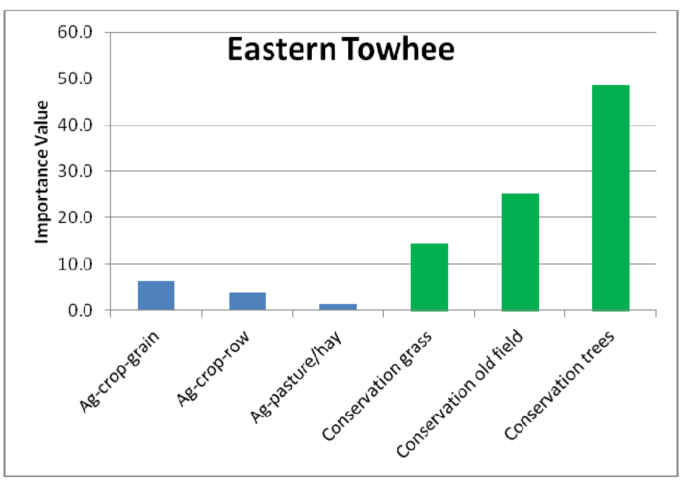


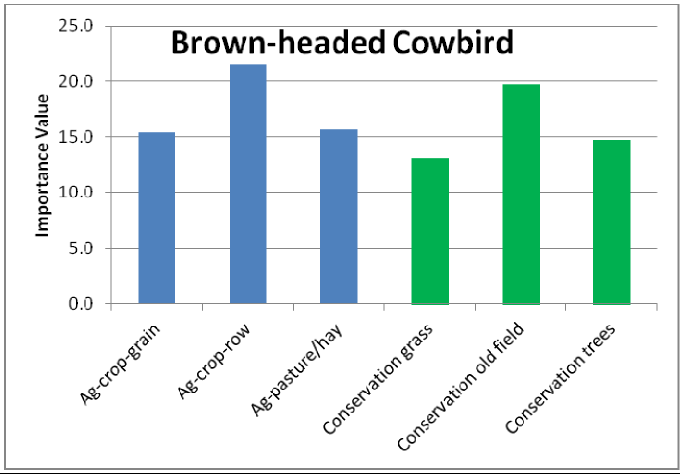
Figure 11. Relative importance of agricultural habitats vs conservation lands for Chipping Sparrow and Eastern Towhee in 2012 (n= 339 sample stations). Both are open-country species associated with forests and forest edge.

Generalist Bird Community: Relatively few habitat-generalist species are of significant conservation concern. Several are associated with wet, marshy areas (Table 8), including two of the most common species recorded (Red-winged Blackbird and Common Yellowthroat). Several others are associated with rural farmland of various description (e.g., American Robin, Brown-headed Cowbird, European Starling, Eastern Bluebird, Wild Turkey, House Sparrow).

Within this guild, only Common Yellowthroat and Eastern Bluebird appeared to fare slightly better in conservation fields than in traditional agriculture habitats (Figures 12 and 13). Red-winged Blackbird appeared to fare better in agriculture than conservation fields (Figure 14).

Table 8. Frequency of occurrence and total of maximum counts of generalist species encountered at point count stations in 2012. Listed in decreasing order of frequency of occurrence.

Species Name	# of Pts	% frequency	Total Max Abundance	% total abundance
American Robin	293	80.9	808	7.4
Red-winged Blackbird	262	72.4	1179	10.9
European Starling	200	55.2	939	8.7
Brown-headed Cowbird	144	39.8	248	2.3
Common Yellowthroat	115	31.8	164	1.5
House Sparrow	76	21.0	244	2.2
Eastern Bluebird	33	9.1	36	0.3
Canada Goose	18	5.0	206	1.9
House Finch	16	4.4	23	0.2
Rock Pigeon	11	3.0	40	0.4
Wild Turkey	11	3.0	13	0.1
Eastern Phoebe	6	1.7	6	0.1
Ring-billed Gull	5	1.4	7	0.1
Spotted Sandpiper	5	1.4	5	0.0
Mallard	4	1.1	7	0.1
Swamp Sparrow	3	0.8	3	0.0
Belted Kingfisher	1	0.3	1	0.0
Marsh Wren	1	0.3	1	0.0



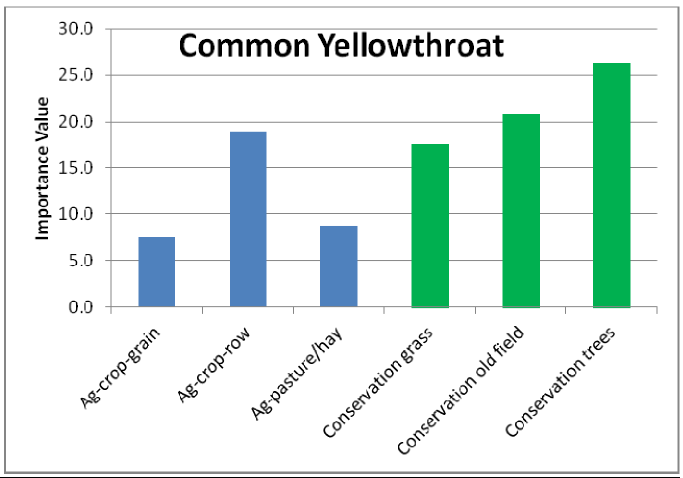


Figure 12. Relative importance of agricultural habitats vs conservation lands for Brown-headed Cowbird (top) and Common Yellowthroat (bottom) in 2012 (n= 339 sample stations). These open-country species are habitat generalists associated with edges, shrubs and grassland.

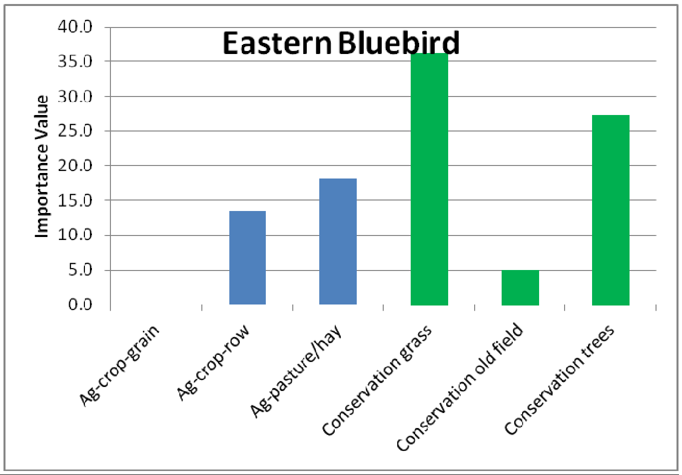


Figure 13. Relative importance of agricultural habitats vs conservation lands for Eastern Bluebird in 2012 (n= 339 sample stations). This is an open-country generalist species associated with grassland and nest box provisioning.

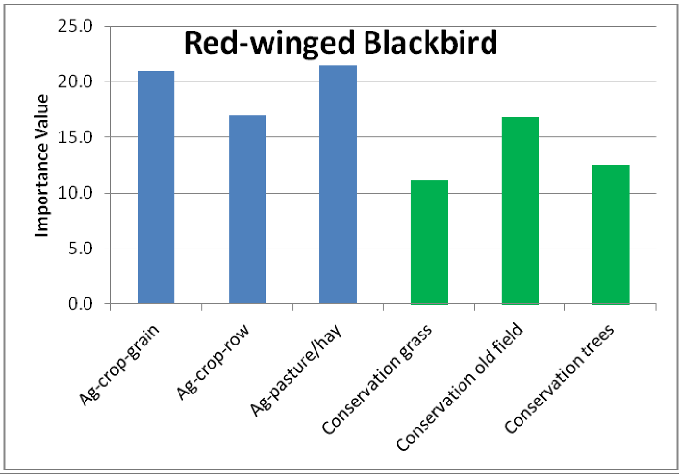


Figure 14. Relative importance of agricultural habitats vs conservation lands for Red-winged Blackbird in 2012 (n= 339 sample stations). This is an open-country generalist species associated with wet shrubby areas and grassland.

Effect of Adjacent Forest Cover on Grassland Bird Occurrence
In an analysis of the intensively surveyed sites, the number of sides of the field that were surrounded by forest (within 200 m of the point count centre) had a strong positive influence on the average abundance of forest birds and shrubland birds, and a strong negative effect on abundance of grassland birds (Figure 15).

The negative effects of woody edges on grassland birds have been reported in many other studies (e.g., Coppendge *et al.* 2001; Ribic and Sample 2001; Bakker *et al.* 2002; Coppedge *et al.* 2008; Renfrew and Ribic 2008). However, not all species within a guild necessarily responded in the same way. Bobolink, Eastern Meadowlark, and Savannah Sparrow showed a strong negative response to forest cover, but this is not apparent for Vesper Sparrow (Figure 16).

A management implication is that habitat restoration projects aimed at grassland-obligate species of birds should be placed within fields that do not have much, if any, forest cover in close proximity (see Conclusions and Recommendations).

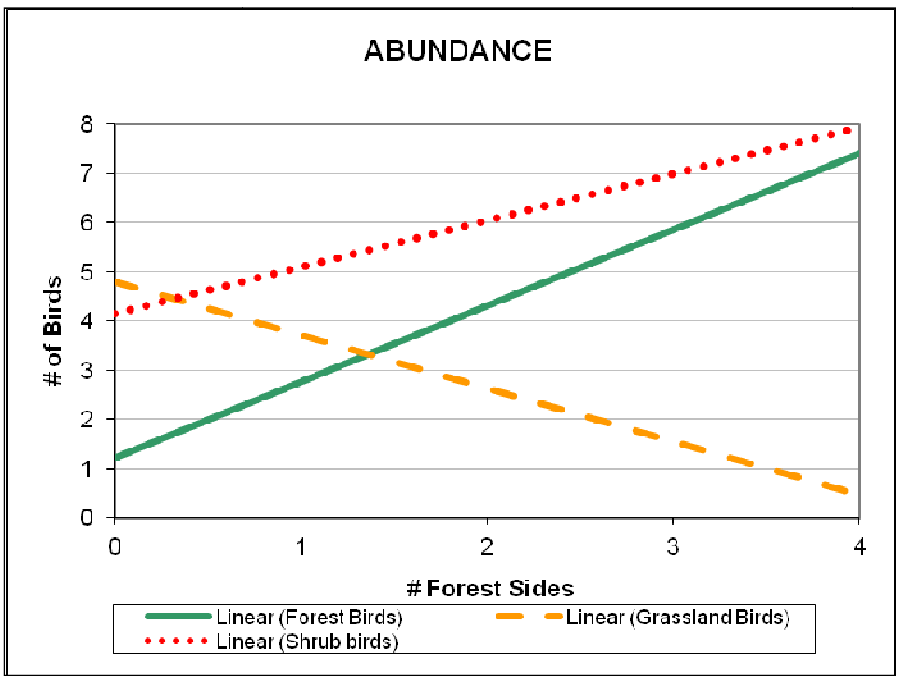


Figure 15. Effect of the proximity of woodland on the average abundance of forest birds, shrubland birds and grassland birds in fields intensively surveyed in Norfolk County from 2011 to 2013. Lines are linear regressions, based on the average count of birds per point count station.

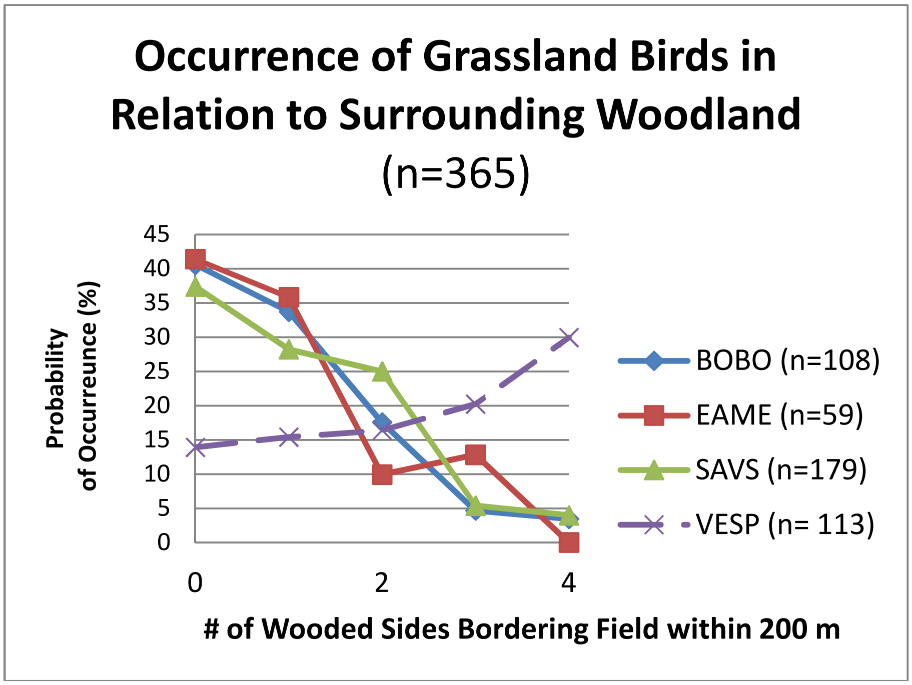


Figure 16. Effect of adjacent forest cover on the probability of occurrence of individual species of grassland birds in Norfolk County.

Other Factors Affecting Occupancy of Grassland Birds

There are several other factors that influence occupancy of grassland birds in fields. Vegetational makeup is important. Not surprisingly, shrubland bird species were positively affected by the amount of shrub cover (Figure 17). Conversely, fields that were more clearly dominated by grasses (as opposed to forbs) were clearly favoured by grassland birds (Figure 18). This is especially true of grassland-obligate species (Bobolink, Eastern Meadowlark, and Savannah Sparrow).

Percent grass cover has been found to be consistently important for grassland birds in other studies (e.g., Renfrew and Ribic 2008). However, in our study, species of grassland birds that are not "obligates" were often more clearly associated with fields that had patches of exposed ground (e.g., Killdeer, Horned Lark, and Vesper Sparrow).

Grassland bird abundance was also positively influenced by field size and horizon distance. The two features are highly correlated themselves, but horizon distance appears to have a stronger influence on grassland bird abundance than field size (see Figures 19 and 20). Hence, a long, narrow field that has a long horizon distance can be better for grassland birds than a field of the same size that is square and has a short horizon distance. Even so, the correlation coefficient (R^2) for field size increases (to about 0.13), when fields greater than 15 ha are excluded, suggesting that there is an upper threshold limit for field size. Hence, field size, while important, is not an overriding determining factor affecting the settlement of grassland birds generally in Norfolk County – at least not after about 15 ha is reached.

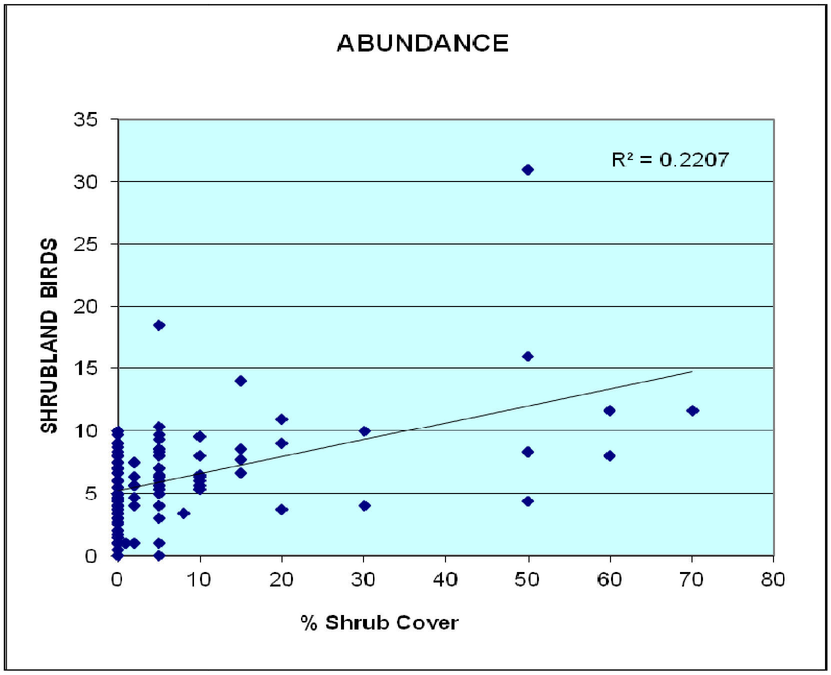


Figure 17. Effect of the amount of shrub cover on shrubland bird abundance in fields sampled intensively from 2011 to 2013 (n = 135 sample points). The regression line is depicted along with the correlation coefficient.

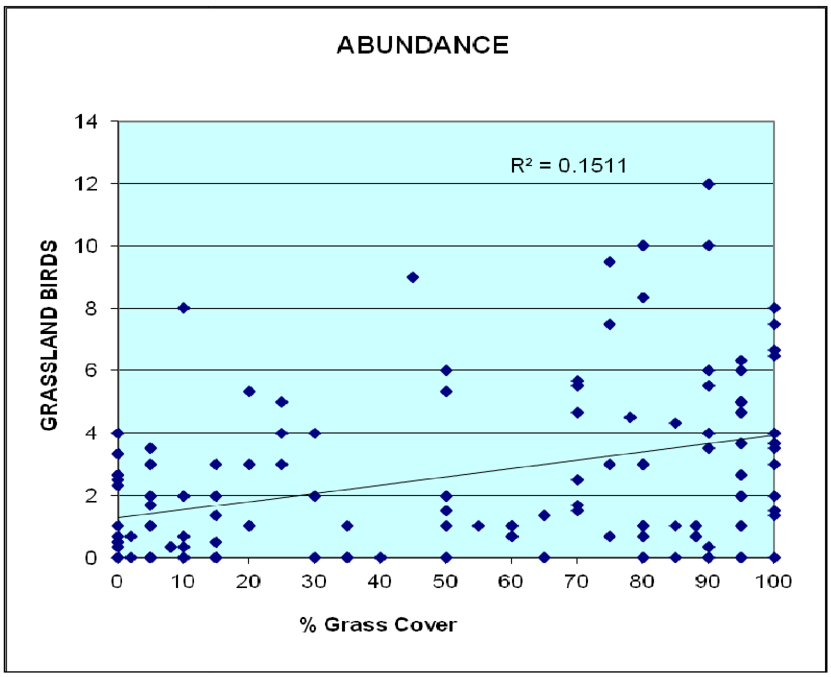


Figure 18. Effect of the amount of grass cover on grassland bird abundance in fields sampled intensively from 2011 to 2013 (n = 135 sample points). The regression line is depicted along with the correlation coefficient.

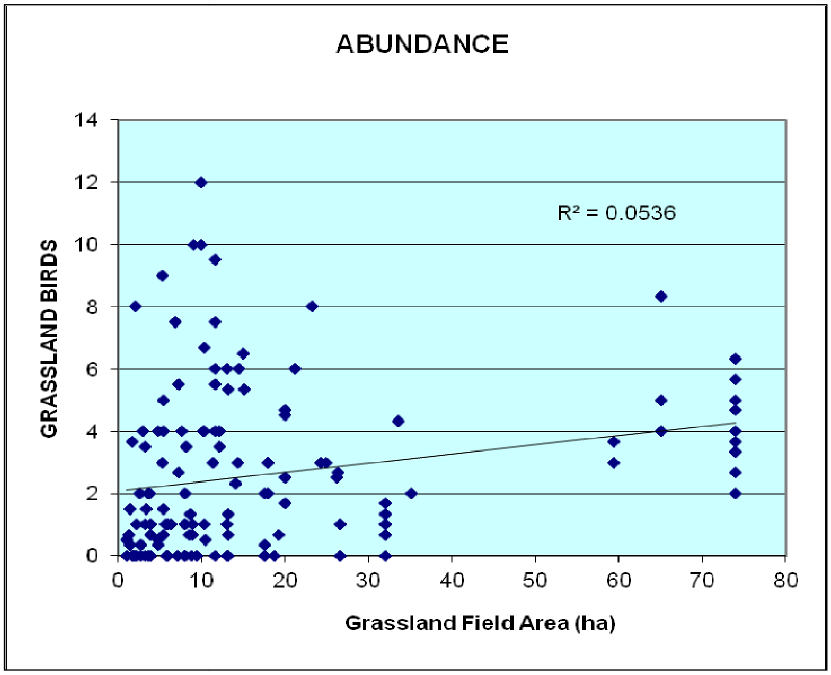


Figure 19. Effect of field size on average grassland bird density in intensively surveyed fields in 2011-2013 (n = 135 sample points). The regression line is depicted along with the correlation coefficient.

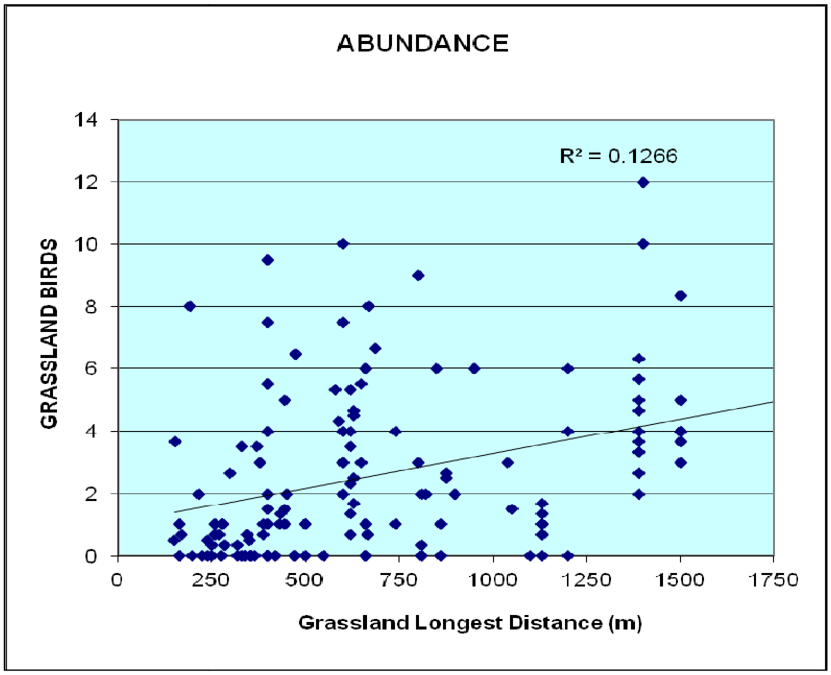


Figure 20. Effect of horizon distance on average grassland bird density in intensively surveyed fields in 2011-2013 (n = 135 sample points). The regression line is depicted along with the correlation coefficient.

Bobolink, Meadowlark and Savannah Sparrow Detailed Site Characteristics

Bobolink:

When corrected for the relative amounts of habitat sampled (ignoring field size forest cover, and other attributes) , pasture and grass-dominated hay were the most important habitats for Bobolinks, followed by grass-dominated old fields and alfalfa hay (Figure 21). Presence of grain crops, which are commonly grown in rotation with tobacco, corn and soy in Norfolk County, was also somewhat important to Bobolinks (Table 9; Figure 21). These habitats tended to be large wheat fields that had an underplanting of red clover or alfalfa, though one field also had a long, narrow, grassed-waterway running through it, which could be an important habitat component worthy of promoting at other agricultural sites. In the Norfolk region, Bobolink occupancy in grain crops seems to largely depend on whether the field has been underseeded with a legume, which probably enhances the amount of nesting cover. It should be noted that the survey sample of grain field sites was biased towards those for which Bobolink presence was already known; dozens of wheat fields that were checked casually did not have Bobolinks. None of these had been underseeded with a legume.

Of the 108 stations where Bobolinks were found during the course of the 3-year study, 17 (15.8%) were situated in grassland habitat-restoration situations (12 at ALUS sites and 5 at other restoration sites). Greatest densities were in hayfields (up to 10 territorial males at some point count locations). This preference for hay is also apparent in Figure 21 (grass and alfalfa combined), and is consistent with results from other studies (e.g., MacDonald 2014).

Restoration sites seldom held more than a single territorial pair of Bobolinks, but there were notable exceptions. The main exception was an ALUS grass restoration field located southeast of Renton, which had up to 6 territorial males at a single survey point. This property was only about 12 ha in size, but supported at least 10 pairs of Bobolinks in both 2011 and 2012. The vegetation here was dominated by grass and there was no surrounding forest cover. Hayfields and pasture were also present in the vicinity of this particular field, and it was obvious that the ALUS site served as a post-mowing refuge for many Bobolinks (dozens) that moved in after the surrounding fields had been cut in mid to late June. This same ALUS property also held at least two pairs of meadowlarks, multiple pairs of Savannah Sparrows, plus Grasshopper Sparrow, and many other species of interest. It also provided habitat for the first-ever documented nesting of Dickcissel (a grassland-obligate species associated with western North America) for Norfolk County.

Eastern Meadowlark:

Meadowlark presence was mostly related to grass-dominated old fields, closely followed by grass-dominated hay and pasture (Figure 21). Unlike Bobolinks, grain crops were rarely occupied by meadowlarks, and alfalfa was never occupied.

Of the 60 stations where Eastern Meadowlarks were found during the course of the 3-year study, 10 (16.7%) were situated in some sort of habitat restoration situation (including 3 at ALUS sites). Like Bobolink, meadowlarks were most clearly associated with working lands, especially pasture and hay (grass-types only, not alfalfa; see Figure 21). Meadowlarks appear to have a greater capacity to occupy fields that have some tree or shrub cover than Bobolinks, as evidenced by the relatively greater importance of old fields and conservation lands that had reforestation projects associated with them (Figure 21).

Meadowlarks usually have much larger territories than Bobolinks and tend to nest singly rather than in loose colonies like Bobolinks. As such, only 15 of the 60 sites held more than a single pair of meadowlarks (maximum of 4 territorial males).

Savannah Sparrow:

The Savannah Sparrow is another obligate grassland-bird species. It is not considered area-sensitive, so will occupy smaller patches of grassland than Bobolinks or Eastern Meadowlarks, and is therefore more widespread. As such, Savannah Sparrows were present at 91 of the 195 sites surveyed in 2012 – much more frequently than either Bobolink (43 sites) or Eastern Meadowlark (20 sites).

Savannah Sparrow occupancy was closely associated with pasture and hay (both grass and alfalfa types) – similar to sites occupied by Bobolinks (Table 9; Figure 21). However, they were also recorded commonly at sites that did not have significant amounts of grass cover. A relatively large proportion of sites (15.9%) fell into the “other habitat” category (Table 9), which is dominated by corn, soy and other row crops. While Savannah Sparrows probably did not directly nest in these crops, they will nest in narrow, grassy roadside verges adjacent to agricultural fields. This attribute also partly accounts for the relatively large proportion of Savannah Sparrow detections that were recorded at sites that contained grain crops (Table 9; Figure 21).

Table 9. Habitat types at Atlas point count stations where Bobolinks, Eastern Meadowlarks and Savannah Sparrows occurred in 2012. More than one habitat type could be recorded at individual points, so totals exceed actual number of point count stations at which a species was detected. It is important to also refer to Figure 21, which gives a graphical depiction incorporating a correction factor for relative proportions of each habitat type that were available within the sample pool.

Species	**Grain[1]**	**Pasture**	**Hay (alfalfa)**	**Hay (grass)**	**Old field (grass dominated)**	**Old field (shrub >25% cover)**	**Other Habitat[2]**	**Total**
Bobolink	23 (35.9%)	13 (20.3%)	4 (6.2%)	14 (21.9%)	8 (12.5%)	2 (3.1%)	0	64
Eastern Meadowlark	2 (7.4%)	4 (14.8%)	0 (0.0%)	8 (29.6%)	11 (40.7%)	2 (7.4%)	0	27
Savannah Sparrow	32 (28.3%)	18 (15.9%)	9 (8.0%)	18 (15.9%)	16 (14.2%)	2 (1.8%)	18 (15.9%)	113

[1] Grain was mostly winter wheat.
[2] Other Habitat was mostly field crops (primarily corn, soy, tobacco, and asparagus).

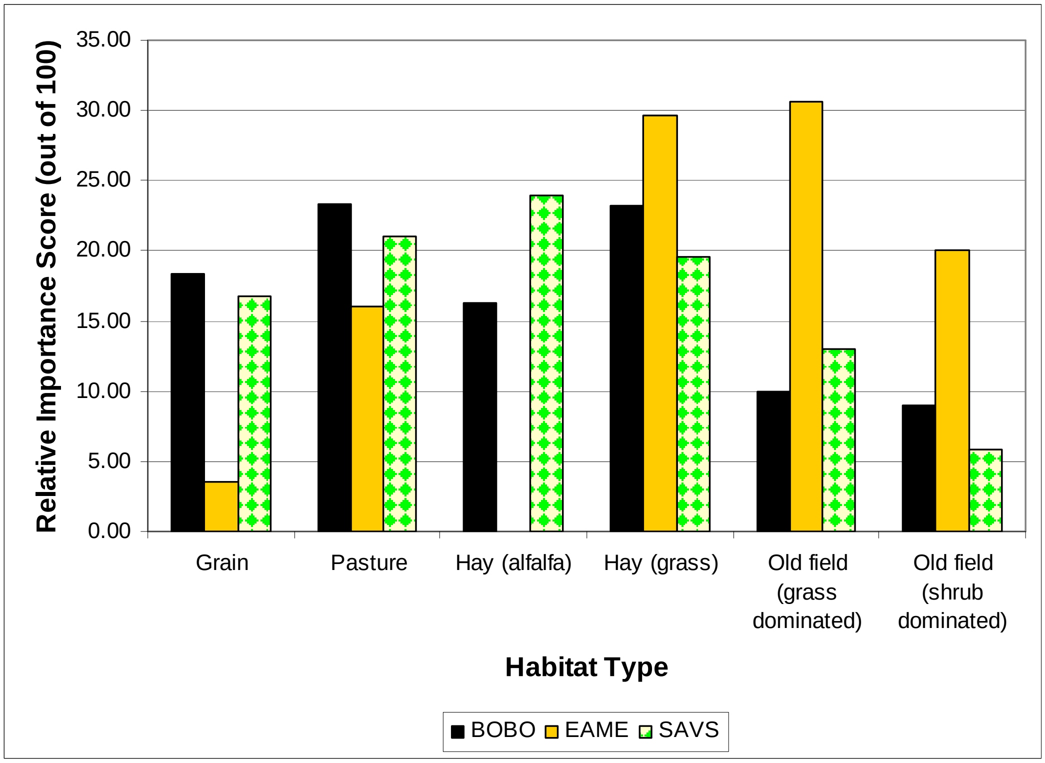


Figure 21. Graphical depiction of the relative importance of agricultural habitat types to Bobolinks, Eastern Meadowlarks and Savannah Sparrows in the Norfolk County region in fields sampled in extensive, singe-visit surveys in 2012. Importance is expressed as a function of the proportion of encounters of each species in each habitat type relative to the proportions of each habitat type present within the overall sample pool. Restoration sites were not sampled sufficiently during these extensive surveys and are not included here.

Bobolinks appeared to favour larger fields to a greater degree than Eastern Meadowlarks (Figure 22), which would make them more area sensitive. Likewise, the longest distance to the horizon break was greater for Bobolinks (Figure 23), again recognizing that field size and horizon distance are strongly positively correlated. As noted in the previous section on grassland birds in general, the degree to which forest cover surrounds a field had a strong negative effect on occupancy of both Bobolinks and Eastern Meadowlarks (Figure 24). Because they are both grassland obligate species, it was not surprising to find that occupancy of both species was also highly related to percent grass cover (Figure 25).

Other features that could affect site occupancy are illustrated in Figure 26. Some of these features are strongly inter-related. For example, presence of livestock and rural buildings are correlated with presence of hay and pasture. Some features (e.g., presence of nest boxes and wetlands) have no real effect on occupancy of either of the two species, but can influence occupancy of other species that do nest in them.

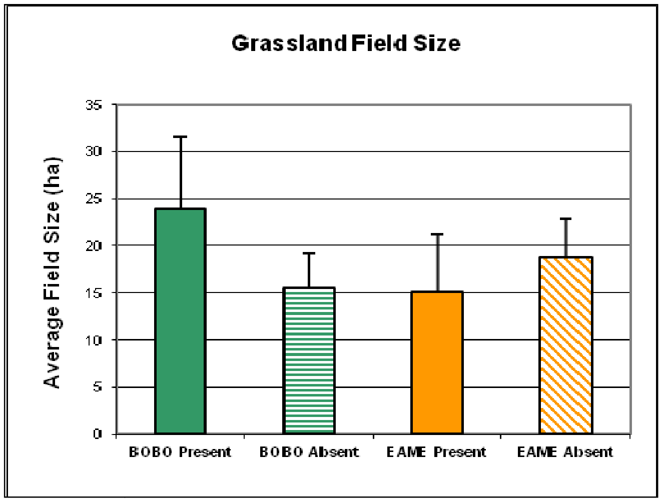


Figure 22. Relationship of size of fields to occupancy of Bobolink and Eastern Meadowlark in Norfolk County from 2011 to 2013. Bars are 95% confidence intervals.

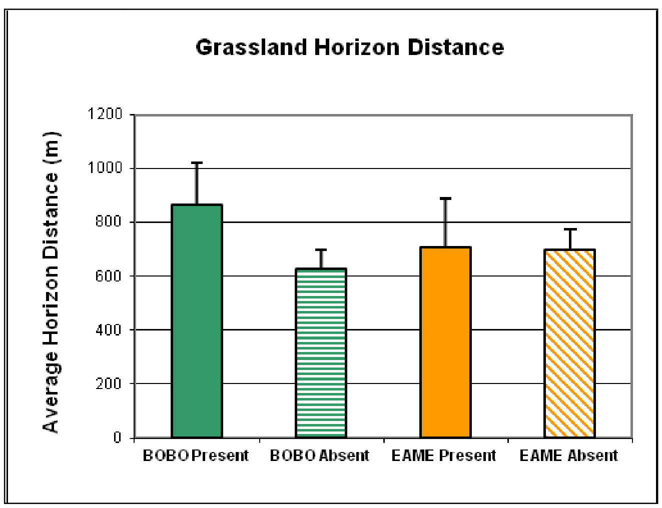


Figure 23. Relationship of longest distance to the horizon-break on occupancy of Bobolink and Eastern Meadowlark in Norfolk County from 2011 to 2013. Bars are 95% confidence intervals.

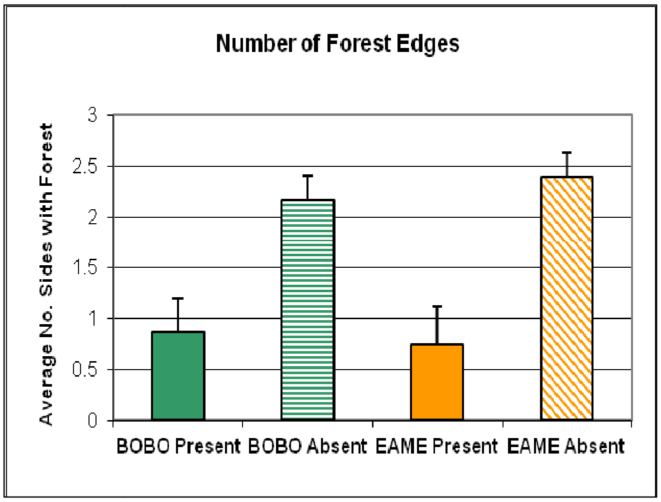


Figure 24. Relationship of the number of sides of a field (within 200m) to occupancy of Bobolink and Eastern Meadowlark in Norfolk County from 2011 to 2013. Bars are 95% confidence intervals.

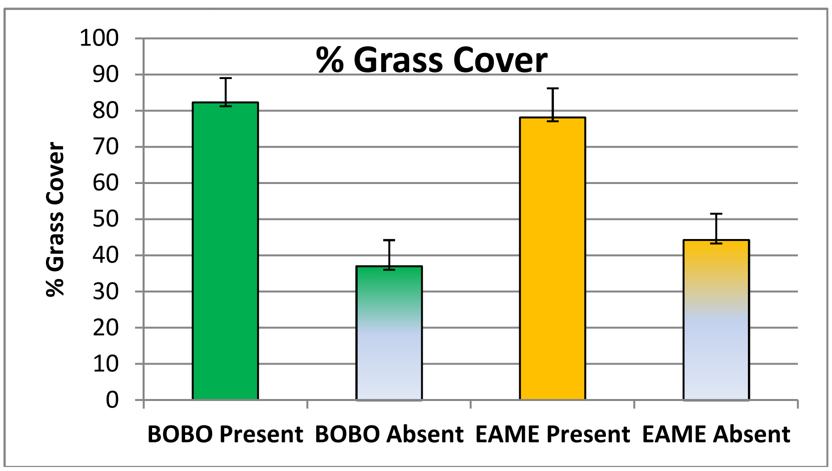


Figure 25. Relationship of the amount of grass cover within a field to occupancy of Bobolink and Eastern Meadowlark in Norfolk County from 2011 to 2013. Bars are 95% confidence intervals.

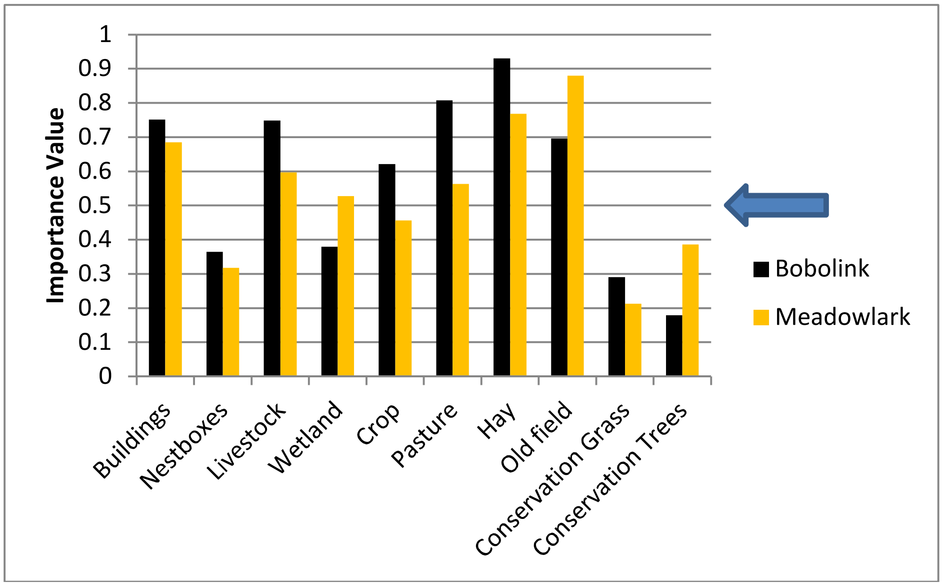


Figure 26. Relationship of the presence of various features affecting site occupancy of Bobolink and Eastern Meadowlark in Norfolk County from 2011 to 2013. Bars that extend above the blue arrow (importance value > 0.5) have the greatest positive effect on species occupancy.

Apparent Loss of Grassland Cover in Norfolk County Region

There are several ways to estimate or infer change in the extent of regional grassland cover. One way is to simply examine the proportion of sites for which no kind of grassland (i.e., pasture, hay, old grassy field) was recorded as being present within 100 m of the point count stations in 2012. All of these stations would presumably have had some sort of suitable habitat (predominantly grass cover) present during the Atlas period, so the change in bird occurrence between the two periods can be used to infer broad changes in habitat composition.

Of the 195 stations sampled for this component of the project in 2012, no grassland was recorded at 120 (61.5%) of them. Assuming that this alone represents the amount of grassland loss, this figure (61.5%) is comparable to others obtained from bird survey results for Bobolink (68.8% decline in occupancy and a 58.6% decline in population size) and Eastern Meadowlark (75.9% decline in occupancy and a 74.3% decline in population size; see Tables 10 and 11).

Also of interest are the number of point count stations that were apparently newly occupied in 2012. These accounted for about 26% of Bobolink sites and 15% of Eastern Meadowlark sites (Table 10). Because these sites had been formerly occupied by one of the target species during the Atlas, they do not represent newly created grassland since then. Instead, they indicate either some change in the existing grassland condition (e.g., conversion from pasture to hay) or had merely been “false negatives” from the Atlas period (i.e., birds were actually present during the Atlas but not detected then).

Table 10. Change in Bobolink and Eastern Meadowlark frequency of occurrence in the Norfolk County region during two time periods.[1]

Species	# Point count occurrences during Atlas period	# Sites that remained occupied in 2012	# Sites newly occupied in 2012	Total sites occupied in 2012	Total % change in occupancy (2002 to 2012)	Annual % rate of change in population size (2002 to 2012)
Bobolink	138	32	11	43	-68.8%	**-6.9%**
Eastern Meadowlark	83	17	3	20	-75.9%	**-7.6%**

[1] Bird records include counts from all point count distance bands.

Table 11. Change in Bobolink and Eastern Meadowlark abundance estimates in the Norfolk County region during two time periods.

Species	Total count of birds during Atlas period[1]	Total count of birds in 2012[1]	Total % change in population size 2002 to 2012	Annual rate of change in population size from 2002 to 2012	Average annual rate of population change for southern Ontario according to BBS (2002-2012)[2]
Bobolink	222	92	-58.6%	-5.9%	-4.1% (-5.5 to -2.6)
Eastern Meadowlark	105	27	-74.3%	-7.4%	-2.9% (-3.4 to -2.4)

[1] Bird records include counts from all point count distance bands.
[2] 95% credible intervals are given in parentheses.

Comparison to Breeding Bird Survey (BBS) trend results

For the 10-year period from 2002-2012, BBS results for southern Ontario (known as "Bird Conservation Region 13") showed an average annual population change of -4.1% and -2.9% for Bobolink and Eastern Meadowlark, respectively (Table 11). These average annual values correspond to overall 10-year changes of –34.2% (95% CI = -43.2 to -23.2) and –21.0% (95% CI= -29.2 to -21.6), respectively.

Population declines are even stronger in our study of the Norfolk County region than the overall southern Ontario BBS trends, particularly for Eastern Meadowlark (Table 11). This suggests that the rate of habitat turnover in the local Norfolk region has been greater than the provincial average over the past decade.

How much Habitat is Needed to Restore Grassland Bird Populations?

The Norfolk County region is characterized by good agricultural soils (Classes 1 to 3) and is thus heavily dominated by non-forage crops. In addition, tobacco was formerly one of the most important crop types in the region, which meant that there was also more grain (especially rye) grown in rotation. Bobolinks frequently nest in grain when there is a shortage of grass cover, so they likely would have been more widespread during the Atlas project (2001-05), at a time when tobacco was on the decline but still far more widespread than at present. For example, according to agricultural statistics from OMAF, tobacco acreage in Haldimand-Norfolk fell from 21,000 acres in 2003 to 12,214 acres in 2012 – a decline of about 42% (source: http://www.omafra.gov.on.ca/english/stats/crops/index.html).

The results reinforce the suggestion that grassland habitat loss has been the primary factor affecting the size of breeding populations of the two species in the Norfolk County region, rather than some other external factor. Hence, breeding populations should rebound if the amount of grassland habitat can be increased.

Recovering populations of Bobolinks and meadowlarks to levels they had been just 10 years ago could mean increasing the amount of suitable habitat in the Norfolk region by at least 30%, based on the most conservative estimate of population loss from the Breeding Bird Survey. Even greater amounts (~60%) would be needed, based on results from our own study of how occupancy has changed within the Norfolk study area.

Estimating how much habitat would need to be replaced is tricky, because we lack good information on breeding densities that occur within each habitat type. Nevertheless, a rough estimate can be derived by simply assuming that the average size of the 212 sites that had been occupied by one or both species during the Atlas was about 20 ha (about 50 acres). This corresponds to the average size of site that was occupied by at least one species of grassland bird over the 3 years of our recent study. Assuming a reduction of at least 30% in site occupancy, this translates to a loss of at least 1300 ha (~3200 acres) of habitat.

While replenishing 3200 acres of lost habitat seems achievable, most of the regional habitat loss has been pasture and hay. In our study, hay and pasture both tended to have higher densities of Bobolink and meadowlark populations than restoration projects that focus on native tallgrass vegetation, perhaps because the latter tended to be smaller and/or be surrounded by forest cover. Hence, restoration efforts that are focussed on planting native grass would likely need to encompass more than the 3200 acres of lost hay and pasture. Under the current ALUS payment configuration (~$150/acre/year), such an acreage target would cost the program ~$500,000 to achieve, including the ongoing costs associated with grassland maintenance.

In order to maximize benefits for Bobolink and Eastern Meadowlark, efforts directed at promoting traditional, cool-grass hay (accompanied by late cutting) and pasture for beef cattle are an important consideration. However, as discussed later in this report, it is important to note that hayfields are clearly population sinks for grassland birds if they are cut during the height of the breeding season, which is the normal practice. As such, the lower population densities of grassland birds that occur in tall-grass restoration sites are offset somewhat by the greater levels of breeding success that these sites enjoy. This means that restoration efforts aimed at tall-grass prairie could bring more benefit to grassland birds than efforts that simply increase the amount of cool-season hay harvested at traditional times. A balanced strategy is needed that includes hay (late season), pasture and tall-grass prairie.

Co-occurrence of Bobolink, Eastern Meadowlark and Savannah Sparrow

Understanding the extent to which there is overlap between the occurrence of different species is important for conservation and management purposes. For one thing, species that occur together require less habitat than species that have little or no overlap in their habitat needs.

In both the Atlas and recent time periods, the degree of overlap between occurrence of Bobolink and meadowlark within the Norfolk County region was greater at sites that were occupied by the meadowlark:Bobolink combination (range 30.1% to 45%) than those that were occupied by the Bobolink:meadowlark combination (range 18.1% to 20.9%; see Table 12). Both of these values are less than was found in a larger analysis of Atlas results from across Ontario, where values ranged from 37.7% to 57.3% overlap. This is probably because Eastern Meadowlarks are generally scarcer in the Norfolk region than in many other parts of southern Ontario.

In the Norfolk region, no change was seen in the proportion of sites that supported the Bobolink/meadowlark combination between the Atlas period and 2012 (18.1% vs 20.9%). However, the proportion of sites that supported the meadowlark/Bobolink combination increased in 2012 over that seen during the Atlas period (45.0% vs 30.1%). This at least partly reflects the greater proportional decline in the local occurrence of Eastern Meadowlarks compared to Bobolinks.

Bobolink and/or Eastern Meadowlark co-occurred at 41 (45%) of the sites where Savannah Sparrows were recorded. Conversely, neither of the two other target species was detected at the remaining 50 (55%) sites where Savannah Sparrows were present and had presumably persisted since the Atlas period. Persistence of Savannah Sparrows at sites that were apparently abandoned by Bobolinks and Eastern Meadowlarks suggests that at least some form of grass cover also persisted at these apparently “abandoned” sites. However, the grassland patch sizes at some Savannah Sparrow sites may simply have shrunk to the point that they were no longer large enough to support Bobolinks or meadowlarks in 2012.

Table 12. A comparison of co-occurrence of Bobolinks and Eastern Meadowlarks at the Norfolk County region point count stations sampled during two time periods.

Species Combination	Atlas Period (2001-05)	2012
BOBO/EAME	25 of 138 BOBO sites had EAME = **18.1% overlap**	9 of 43 BOBO sites had EAME = **20.9% overlap**
EAME/BOBO	25 of 83 EAME sites had BOBO = **30.1% overlap**	9 of 20 EAME sites had BOBO = **45.0% overlap**

Other Management Options: Modifying Hay-cutting Date

In 2013, the ALUS program supported a test side-project to modify the timing of cutting at one hayfield property in Norfolk County. In discussions with the landowner (a small, speciality beef-cattle operation), it was agreed that the exterior portions of his field would be cut early on the normal schedule, leaving interior portions uncut to a later date. The thought here was that these interior portions would act as "refugia" for Bobolinks and other grassland birds, while still allowing the landowner to take at least some early-season hay.

In actual fact, the owner left one field entirely uncut for most of the duration of the breeding season, and cut the perimeters on a normal schedule. Hence, roughly 50% of his hayfields were left uncut until late in June/early July.

Hayfields at this property were in a rectangular configuration, totalling about 8 ha (20 acres), and had a maximum horizon distance of 1400 m. The property was visited 7 times by McCracken from 30 May to 7 July 2013, using a combination of both point counts and line transects. The maximum counts of territorial male Bobolinks on line transects were 26 birds on 27 June and 20+ birds on 13 July. The maximum count of females was 12 birds on 5 July. Bobolinks are polygynous, which is why more males were present than females. This is also why the count of females is a better reflection of the actual number of nests than the count of males. Either way, this site clearly supported good densities of nesting Bobolinks.

Numbers of Bobolinks at this site built up in the latter half of June, apparently reflecting resettlement of an influx of failed breeders that had been disrupted by hay-cutting operations elsewhere in the county. These birds would have been in search of suitable uncut nesting habitat in order to carry out a potential renesting attempt. A similar phenomenon was witnessed at another ALUS grassland site that was left uncut, and is probably a common phenomenon that has not hitherto been adequately documented. As more and more tall-grass prairie restoration projects in the region mature over the next few years, their importance to act as refuge sites can be expected to increase.

Determining nest success for grassland birds is a labour-intensive endeavour. Counts of fledged young at this particular site indicated that 3-5 nests out of a potential pool of about 12 nests (~25-42% of nests), which would otherwise have been destroyed by hay-cutting, successfully fledged young.

In addition to being a proven means for enhancing bird nesting success (e.g., Nocera *et al.* 2005), delayed mowing can also benefit plant and invertebrate species richness (see Humbert *et al.* 2012). However, the practice is most feasible for certain kinds of hay landowners (especially beef and horse operations, and potentially sheep), but is still most likely to be implemented when financial support is available. In the Norfolk County instance, this particular landowner was able to source and purchase early-season (high-protein) hay for his livestock from elsewhere as a result of a particularly well-thought out financial contribution provided by the ALUS program.

Regional relationships between grassland bird population densities and landuse
Using atlas data, we examined correlations between average regional densities of Bobolinks and Eastern Meadowlarks (average # per atlas point count from 2001-05) and for a selection of four agricultural statistics available for all southern Ontario municipalities (for 2005): 1) percent of landbase in hay, 2) pasture, and 3) overall “open area;” and number of cattle per acre. As shown in Figure 27, the relationships were all curvilinear, indicating that the birds exhibit a threshold effect, such that peak densities occur at certain habitat parameter thresholds and then stabilize or even decline. The latter pattern is most apparent in the case of Eastern Meadowlark.

Statistical output for provincial species-habitat models is summarized in Tables 13 and 14. The provincial model that best explained the relationship between log Bobolink abundance and habitat included a quadratic relationship with percent cover by pasture (Table 13). This model had a 74% chance of being the best-fit model in the set, giving it strong support. The evidence ratio indicated it was 2.96 times better than the second-best model, which explained 69.8% of the variation in Bobolink abundance. Pasture was significantly positively related to log Bobolink abundance (parameter estimate = 0.539, SE = 0.067, P < 0.001), while $pasture^2$ was significantly negatively associated with log Bobolink abundance (parameter estimate = -0.028, SE = 0.005, P < 0.001).

The model that best explained the relationship between log Eastern Meadowlark abundance and habitat included a quadratic relationship with both hay and pasture. The model containing a quadratic relationship with pasture also had some support (delta AICc < 2; Table 14). The best-fit model had a 56% chance of being the best model in the set, indicating moderate support, but it was only 1.31 times better than the model containing only pasture, indicating pasture likely had an important influence on Eastern Meadowlark abundance. Hay was significantly positively related to Eastern Meadowlark abundance (parameter estimate = 0.04, SE=0.01,P=0.024), while hay^2 was significantly negatively associated with meadowlark abundance (parameter estimate = - 0.002, SE=0.001, p=0.030). Pasture was positively associated with meadowlark abundance (parameter estimate = 0.03, SE=0.02, P=0.175), while $pasture^2$ was negatively associated with abundance (parameter estimate = -0.001, SE=0.00, p =0.604).

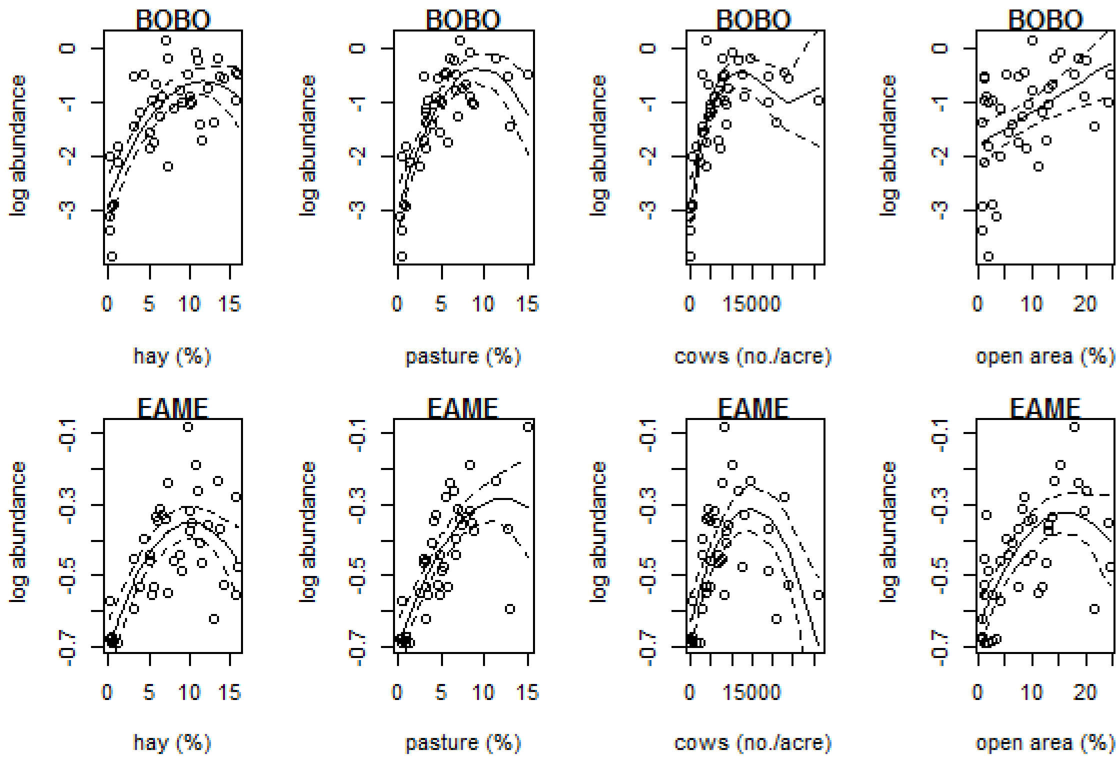


Figure 27. Log mean abundance per county of Bobolink (BOBO) and Eastern Meadowlark (EAME) in southern Ontario between May 16th and June 15th (2001-2005). Solid lines represent predicted values, and dashed lines represent 95% confidence intervals. Habitat variables include percent hay, pasture, and open area per county as well as mean density of cattle (number per acre).

Table 13. Summary output from competing models predicting abundance of Bobolink in southern Ontario between May 16th and June 15th (2001-2005). Linear, quadratic, and cubic relationships between log abundance and percent pasture (pasture), percent hay (hay), percent open area (open), and density of cows (cows) per county were modeled.

Model	K	LL	AICc	Delta AICc	AICc Wt.	Cum. Wt.
Pasture + pasture^2	4	-30.79	70.66	0.00	0.74	0.74
Hay + hay^2 + hay^3 + pasture + pasture^2 + pasture^3	8	-26.23	72.83	2.17	0.25	0.98
Cows + cows^2 + cows^3	5	-33.50	78.67	8.00	0.01	1.00
Hay + hay^2	4	-36.46	82.01	11.35	0.00	1.00
Open	3	-50.82	108.27	37.60	0.00	1.00
Intercept only	2	-55.97	116.24	45.58	0.00	1.00

Table 14. Summary output from competing models predicting abundance of Eastern Meadowlark in southern Ontario between May 16th and June 15th (2001-2005). Linear, quadratic, and cubic relationships between log +0.5 abundance and percent pasture (pasture), percent hay (hay), percent open area (open), and density of cows (cows) per county were modeled.

Model	K	LL	AICc	Delta AICc	AICc Wt.	Cum. Wt.
Hay + hay^2 + pasture + pasture^2	6	42.25	-70.10	0.00	0.56	0.56
Pasture + pasture^2	4	39.32	-69.55	0.55	0.42	0.98
Hay + hay^2	4	36.09	-63.11	6.99	0.02	1.00
Open + Open^2	4	33.08	-57.07	13.02	0.00	1.00
Cows + cows^2	4	31.57	-54.06	16.04	0.00	1.00
Intercept only	2	18.95	-33.59	36.05	0.00	1.00

CONCLUSIONS AND RECOMMENDATIONS

1. Other Environmental Benefits of Habitat Restoration Projects that were not Measured

We did not set out to evaluate the overall Norfolk County ALUS program *per se*, nor the conservation work that is being done by other entities locally. All of these efforts are laudable and have a large number of potential environmental benefits, far beyond those that effect grassland birds. ALUS lands were merely part of the mix of land-management choices we looked at. Having said that, we do feel that the ALUS model is an excellent one, because we saw abundant evidence that farmer managers are a) active on site, b) are highly motivated to bring conservation benefits, and c) have the expertise, tools and other equipment needed to grow and manage vegetation.

Our study also examined only one potential environmental benefit from programs like ALUS. We measured breeding bird attributes, but benefits can also accrue to birds that use restoration fields during migration and/or winter (e.g., Plush *et al.* 2012). In addition to breeding birds, there are obviously numerous other potential environmental benefits (e.g., effects on flora, pollinators and other insects, carbon storage, soil conservation) that were not measured in our study.

2. Other Caveats

Especially when working in open field and agricultural systems, it is important to point out that every year is a bit different, and that "average" survey results can be heavily influenced by seasonal weather conditions. For example, a fairly severe drought was prevalent within our study area (and beyond) in 2012. This undoubtedly affected habitat conditions, planting and harvest schedules, and bird settlement patterns. In addition, many of the restoration sites that we sampled were in their early stages of establishment (<5 years old), which meant that they often had higher amounts of bare ground and/or weedy forb cover than will be apparent later on as these sites mature. Several of the tall-grass prairie sites were also mowed or burned in order to suppress the early invasion of weed cover, both of which temporarily suppressed breeding bird activity. Under these conditions, controlling for all the possible variables that we now better understand to influence grassland bird composition would require substantially larger sample sizes than were possible to obtain during our study in Norfolk County.

3. Grassland Habitat Loss in Norfolk County

Declines of Bobolinks and Eastern Meadowlarks in Norfolk County over the past decade are mostly attributable to the loss of grassland habitats (pasture and hay). This loss is largely the result of conversion to row crops, especially corn and soy. Some of the loss of Bobolink habitat (not meadowlark habitat) here can also be attributed to significant declines in the region's tobacco crop, because of the attendant loss in the acreage of rye as the principal cover crop grown in rotation with tobacco.

4. Effects of Restoration Projects on Biodiversity

It is important to point out that traditional farming (especially pasture and hay) has significant positive effects for a number of bird species. Even corn and soy can benefit some species. Obviously, programs like ALUS are wholly complementary to traditional agriculture – and should not be viewed as some sort of replacement.

Based on our studies, it does not appear to be meaningful to try to give an overall quantitative metric that adequately measures the overall benefit of the ALUS program to birds. Again, this is partly because of differences in the age of conservation treatments that were available to us. In any case, we can conclude that various kinds of habitat restoration projects benefited individual species in different ways, and that no one measure (e.g., species richness or overall abundance) adequately captures this complexity. Indeed, managing strictly for species richness alone is seldom a good management goal, because it often brings the most benefit to widespread, common species that are habitat generalists, at the expense of habitat specialists. For example, species richness can easily be enriched by simply turning a hayfield into a tree restoration project, but it will occur at the loss of grassland species that have much greater conservation needs than the species that replace them.

Various other studies have reached similar conclusions. While some studies have found higher bird abundance and species richness in agro-environmental schemes versus traditional agriculture (e.g., Beecher *et al.* 2002), others have not. Kleijn and Sutherland (2003) reviewed the literature and could not arrive at any consistent conclusions about the benefits of agri-environment programs to birds, either in terms of abundance or species richness, and could draw no conclusions about how effective such programs are in conserving and promoting overall biodiversity on farmland.

At the landscape level, Whittingham (2011) found that overall populations of European farmland birds continued to decline, despite major investments in agri-environment schemes. Herzog *et al.* (2005) found that some European bird species benefited from various kinds of agri-environmental projects, but hardly any benefits were seen for grassland birds. Although they did not include birds in their study, Aviron *et al.* (2009) found that payments for ecological services increased species richness of plant and insect communities, but that populations of threatened and rare species did not show benefits. The authors concluded that while ecological service payment programs can benefit overall biodiversity at the local scale, this mostly reflected positive responses of common species, and that effective conservation of threatened and rare species may require targeted programs operating at the landscape level.

Like us, several other studies have found that response varies considerably among individual species (Herzog *et al.* 2005; Aviron *et al.* 2009; Kirk *et al.* 2011). This feature alone can complicate habitat management decision-making. This is especially the case when researchers fail to provide results of their statistical models in a format this is readily understandable and/or useful to land managers. An example of this failure is evident in the complicated results from the statistical modelling provided by Kirk *et al.* (2011).

5. <u>Tallgrass Prairie Restoration versus Traditional Forms of Grass Agriculture</u>

To entirely offset regional losses of grassland at the acreages needed, efforts directed at promoting traditional, cool-grass hay (<u>with</u> delayed mowing) and pasture for beef cattle should be contemplated in tandem with efforts focussing on restoration of native tall-grass prairie. As part of this mix, it is important to remember that one of the values of tall-grass restoration to birds is that these fields are not cut during the height of the breeding season once they are established, unlike traditional cool-season hay. Even so, we estimate that at least 3200 acres of grassland would likely need to be planted and maintained (with no further net loss), just to recover the region's grassland bird populations to the levels they were at a decade ago.

6. Tree Restoration versus Grassland Restoration

Different kinds of restoration projects (e.g., grass versus tree planting) bring different kinds of benefits to suites of different bird species. Other factors, including size and age of the project and the type of surrounding land cover, also heavily influence bird species composition.

To protect overall biodiversity in Norfolk County, it is necessary to retain grassland species. As such, landowners and conservation organizations should strive to balance the amount of tree restoration here with grassland restoration. There is currently a great deal of imbalance in favour of afforestation, and no apparent coordination of landcover restoration objectives within the ENGO community. Meanwhile, with further losses of grassland, the region's biodiversity can be expected to erode. Achieving even the minimum target level of grassland creation in Norfolk County (at least 3200 acres; see above) poses a significant challenge, and is best attempted in a coordinated fashion among the various nongovernment environmental organizations that operate within the Norfolk County region.

None of the tree restoration projects studied in Norfolk County provided suitable habitat for any obligate-grassland bird species (Bobolink, Eastern Meadowlark, and Savannah Sparrow) that are of greatest conservation concern. This is because grass was seldom a dominant plant used in the restoration efforts and/or because the fields involved were often surrounded by adjacent forest cover. However, these restoration sites did often provide habitat for at least two non-obligate species of grassland birds: Vesper Sparrow and Grasshopper Sparrow, as well as for an entire suite of non-grassland species.

We do not in any way advocate supplanting tree restoration with grassland restoration efforts. This is not an either/or situation. We do, however, strongly advocate trying to achieve an overall matrix of various habitat types on the local landscape – including pastures, hayfields, other agricultural crops, old fields, native prairie, and shrub/tree restoration.

Though they did perform better than tree restoration sites, even the grassland restoration projects had a mixed record in terms of benefiting obligate-grassland species. Very few of them performed as well as well-established hayfields and pastures, but some grassland restoration sites were clearly much better than others. Sites that performed best typically had excellent recruitment of grass following planting (fields did not become dominated by weedy forbs), and had little bare ground cover. In relation to these particular habitat conditions, performance at restoration sites can be expected to improve after several more years of grassland establishment, depending on the extent to which grass reseeds into any bare-soil gaps and the extent to which fields continue to be actively managed to suppress weed cover. It takes 5 years or more to establish a native prairie, and successful establishment depends on an active maintenance regime to periodically suppress weed and shrub cover (see "Effect of Time" below).

7. Recommended Elements of Grassland-bird Habitat Restoration Projects

The following recommendations apply mostly to benefit grassland birds. They do not necessarily apply when it comes to other environmental considerations, including effects on pollinators, carbon sequestration, Wild Turkey brood habitat, etc.

- Don't plant grasslands in fields that have forest cover bordering them on more than one side (within 200 m of the field centre). Where possible, concentrate grassland planting in fields that are surrounded by agricultural lands, preferably where there is hay and/or pasture in the vicinity.

- Plant grasslands in fields that are at least 5 ha in size, and preferably more than 10 ha.
- A general rule of thumb should be to plant grasslands as if you were planting a hayfield or pasture. This includes doing both proper site preparation (e.g, advance weed control) and using appropriate seeding rates. Scrimping at the earliest stages of grassland establishment can be a waste of time, effort and money.
- To minimize coverage of bare soil and weed cover in the initial years of establishment, plant grasslands by liberally sowing seed directly rather than transplanting vegetative plugs. It is important to minimize patches of bare soil for grassland birds.
- For grassland birds, plant grasslands that are dominated by grass mixtures. At least 65% of the seed mixture should be grasses, using a variety of different species that grow to attain different heights (especially moderate heights), with the balance being forbs. Avoid planting a monoculture of one species of grass (especially big bluestem). To maximize utility to grassland-obligate birds, do not just plant warm-season native tallgrass species. Also plant mixtures containing cool-season shorter-grass species.
- Do not plant trees or shrubs in fields targeted for grassland restoration.
- Maintain grasslands through judicious burning and/or mowing. These practices generally should not occur more than once every 5 years, because they remove the thatch layer that grassland-obligate species need for nesting. They should also occur outside the breeding season, preferably after July. Grassland fields may also occasionally need to be re-seeded, particularly in the early years of establishment.
- For fields larger than about 5 ha, consider rotating different management regimes (burning/mowing) and schedules across different sections, so that you don't have the same habitat conditions across an entire field at any one time.
- Tallgrass prairie can be harvested for livestock forage, but only after the breeding season is over (after 10 July), which is probably a typical timeframe because warm-season grasses mature later in the season than cool-season species in traditional hayfields.

8. Effect of Restoration Time

It obviously takes time for habitat restoration projects to take hold (e.g., Dodds *et al.* 2008). Indeed, a common issue in the assessment of the benefits of such projects is establishing an appropriate baseline or benchmark condition upon which legitimate comparisons can be made (e.g., Bohlen *et al.* 2009). Dodds *et al.* (2008) used a "native" condition as their benchmark, but this is not useful if the target species (e.g., Bobolink and Eastern Meadowlark) are heavily associated with anthropogenic agriculture.

The Norfolk study included restoration projects spanning a number of ages, ranging from activities that had just begun to others that had been in progress for 20 years or more. Generally, projects that had been in progress for longer periods had more value to the breeding bird community (in terms of overall species richness and abundance) than those that were younger. That said, bird communities in even the youngest restoration projects were apt to be decidedly different from those in row crops. Being "different" does not necessarily mean being "better" or "worse." Spread across the landscape, retaining a matrix of "different" habitat types sustains overall biodiversity.

Dodds *et al.* (2008) suggested that native grasslands could be effectively restored within a decade, quite unlike some other habitats, like forests that take much longer to mature. When time is of the essence, it needs to be understood that the benefits from planting native grassland to benefit grassland birds are much more quickly realized than planting forest to benefit forest birds.

9. Benefits of Delayed Hay Mowing

Because of exceptionally high rates of nest mortality, virtually all birds that nest in hayfields vacate the site immediately after a field is mowed. Only Savannah Sparrow is apt to persist afterwards and to attempt a second nesting in the remaining short grass. Even so, these second nesting attempts are jeopardized by repeated mowing. As such, hayfields that are mowed during the breeding season are a population sink for grassland birds. While it is not often practical from a farmer's perspective, delaying mowing until after birds fledge from nests is nevertheless a proven method of helping grassland birds, and should be part of the mix of conservation activities aimed at this suite of species.

Where possible, to maximize breeding success, mowing should be delayed until after the main breeding season (approximately 10 July; see MacDonald 2014). For reasonably large acreages (20 acres or more), it is possible to cut different parts of the field at different times, such that a normal, early cut could be accommodated on at least part of the field. Although this concept deserves more study, landowners could choose to do an early cut in a swath around the field perimeter, leaving an uncut swath (at least 25 m wide) in the field centre, which would be harvested later. This central swath would serve as a refuge, allowing at least some birds to escape the mower blade and nest successfully. Determining the best configuration and layout for this sort of "refuge" requires surveying the field's birdlife in advance of any mowing, noting species, general numbers and the locations of any concentrations.

For delayed haying, most farmers will require some sort of incentive payment, such as has been provided by ALUS. Depending on the price of hay, incentives for delayed cuts may be more costly than payments to retire marginal farmland (e.g., $250/acre versus $150/acre), so this cost differential needs to be factored into decision-making. It will also be desirable for the farmer to identify an alternative source of early-season hay in advance, so that livestock nutritional requirements are not unduly compromised. It's also worth noting that the timing of the first cut of hay can be naturally delayed (at least to some extent) because of weather conditions, though probably seldom until 10 July. In addition, drought conditions can also greatly affect the quantity of hay available, and hence its price.

10. Importance of Monitoring

Habitat restorationists should a) fully document their management activities and efforts, and b) monitor their outcomes. We recommend that periodic breeding bird surveys be continued at as many of the Norfolk County restoration project survey sites as possible, in order to fully monitor and document how the bird community changes at each site over the long-term (at least 10 years). The future success of various types of management activities here and elsewhere will be greatly informed by monitoring (birds and habitat), together with good documentation of what specific management activities occurred and when. It is important to learn what works and what does not.

11. Other Research Topics

- One consequence of cutting hayfields late in the season is that they can attract large numbers of Bobolinks (and probably some other species) that had failed their first nestings elsewhere because of early-season mowing. Depending on the time of year, most of these birds also probably fail to breed after they settle in the uncut "refuge" fields, and they may even interfere with the resident birds that occupied the field earlier. However, this post-mowing interaction and the importance of "refuges" has never been studied and should be a priority research item.

- The notion of cutting perimeters of a hayfield early, leaving other central parts to act as refuges to be cut later also deserves research attention to more fully assess its merits.

- It appears that winter wheat and other grain crops (especially rye) have potential to provide reasonably good nesting habitat for Bobolinks and Savannah Sparrows (not meadowlarks), when fields are large (>20 ha or so) and when they are underseeded with clover. The importance of grain crops deserves more study, to determine how frequently they are occupied by grassland birds, obtain precise information on site conditions (e.g., importance of underseeding, presence of grassed strips), what kinds of bird densities are involved, and the extent to which the birds are successfully breeding in relation to grain harvest times. It's also possible that other potential environmental benefits (e.g., nitrogen fixation) are sufficient to qualify legume underseeding for consideration for incentives under the ALUS program.

ACKNOWLEDGEMENTS

Major funding for this project was provided by Alternative Land Use Services (ALUS), with the Ontario Ministry of Agriculture and Food, and additional support coming from The W. Garfield Weston Foundation, Environment Canada, Bird Studies Canada and Delta Waterfowl Foundation.

Thanks also to the Ontario Ministry of Natural Resources for financial support provided through the Species at Risk Research Fund for Ontario, and to NSERC which provided post-doctoral support for Sonya Richmond through Bird Studies Canada. Thanks to Lynn Bishop (ALUS) for administering the project.

Bryan Gilvesy, Lindsay Bennett, Kristen Thompson and Mark MacNeil (Norfolk ALUS) and Dave Reid were a terrific help in lining up ALUS participants and in supplying information about the ALUS program and ALUS properties. Thanks also to Dave Reid (Norfolk Stewardship Council), Dave Ankney (retired professor, now deceased), Michael and Tom Bradstreet (Nature Conservancy of Canada), and Paul Gagnon (Long Point Region Conservation Authority) for technical input and information about properties. Andrew Couturier and Sandra Marquez (Bird Studies Canada) provided GIS mapping services. Last, many thanks to all the cooperating landowners for allowing access to their properties, sharing important background information, and for the inspirational environmental work they are engaged in.

LITERATURE CITED

Bakker, K.K., D.E. Naugle, and K.F. Higgins. 2002. Incorporating landscape attributes into models for migratory grassland bird conservation. Conservation Biology 16:1638-1646.

Beecher, N.A., R.J. Johnson, J.R. Brandle, R.M. Chase, and L.J. Young. 2002. Agroecology of birds in organic and nonorganic farmland. Conservation Biology 16: 1620-1631.

Bohlen, P.J., S. Lynch, L. Shabman, M. Clark, S. Shukla, and H. Swain. 2009. Paying for environmental services from agricultural lands: an example from the northern Everglades. Frontiers in Ecology and the Environment 7:46-55.

Boutin, C., K.E. Freemark, and D.A. Kirk. 1999. Spatial and temporal patterns of bird use of farmland in southern Ontario. Canadian Field-Naturalist 113:430-460..

Coppedge, B.R., D.M. Engle, R.E. Masters, and M.S. Gregory. 2001. Avian response to landscape change in fragmented southern Great Plains grasslands. Ecological Applications. 11:47-59.

Coppedge, B.R., S.D. Fuhlendorf, W.C. Harrell, D.M. Engle. 2008. Avian community response to vegetation and structural features in grasslands managed with fire and grazing. Biological Conservation 141:1196-1203.

Dodds, W.K., K.C. Wilson, R.L. Rehmeier, G.L. Knight, S. Wiggam, J.A. Falke, H.J. Dalgleish, and K.N. Bertrand. 2008. Comparing ecosystem goods and services provided by restored and native lands. BioScience 58:837-845.

Ferraro, P.J. 2011. The future of payments for environmental services. Conservation Biology 25:1134-1138.

Herzog, F., S. Dreier, G. Hofer et al. 2005. Effect of ecological compensation areas on floristic and breeding bird diversity in Swiss agricultural landscapes. Agriculture, Ecosystems & Environment. 108:189-204.

Humbert, J., J. Pellet, P. Buri, and R. Arlettaz. 2012. Does delaying the first mowing date benefit biodiversity in meadowland? Environmental Evidence 1(9):1-13.

Kirk, D.A., K.E. Lindsay, and R. W. Brook. 2011. Risk of agricultural practices and habitat change to farmland birds. Avian Conservation and Ecology 6(1):5.

Kleijn, D. and W.J. Sutherland. 2003. How effective are European agri-environmental schemes in conserving and promoting biodiversity? Journal of Applied Ecology 40:947-969.

MacDonald, N.M. 2014. The effects of rotational grazing and hay management on the reproductive success of Bobolink and Eastern Meadowlark in eastern Ontario. MSc. Thesis, Trent University, Peterborough, ON. 60 pp.

McCracken, J.D., R.A. Reid, R.B. Renfrew, B. Frei, J.V. Jalava, A. Cowie, and A.R.

Couturier. 2013. Recovery Strategy for the Bobolink (*Dolichoyx oryzivorus*) and Eastern Meadowlark (*Sturnella magna*) in Ontario. Ontario Recovery Strategy Series. Prepared for the Ontario Ministry of Natural Resources, Peterborough, Ontario. viii+ 88 pp.

Nocera, J.J., G.J. Parsons, G.R. Milton, and A.H. Fredeen. 2005. Compatibility of delayed cutting regime with bird breeding and hay nutritional quality. Agriculture, Ecosystems and Environment 107:245-253.

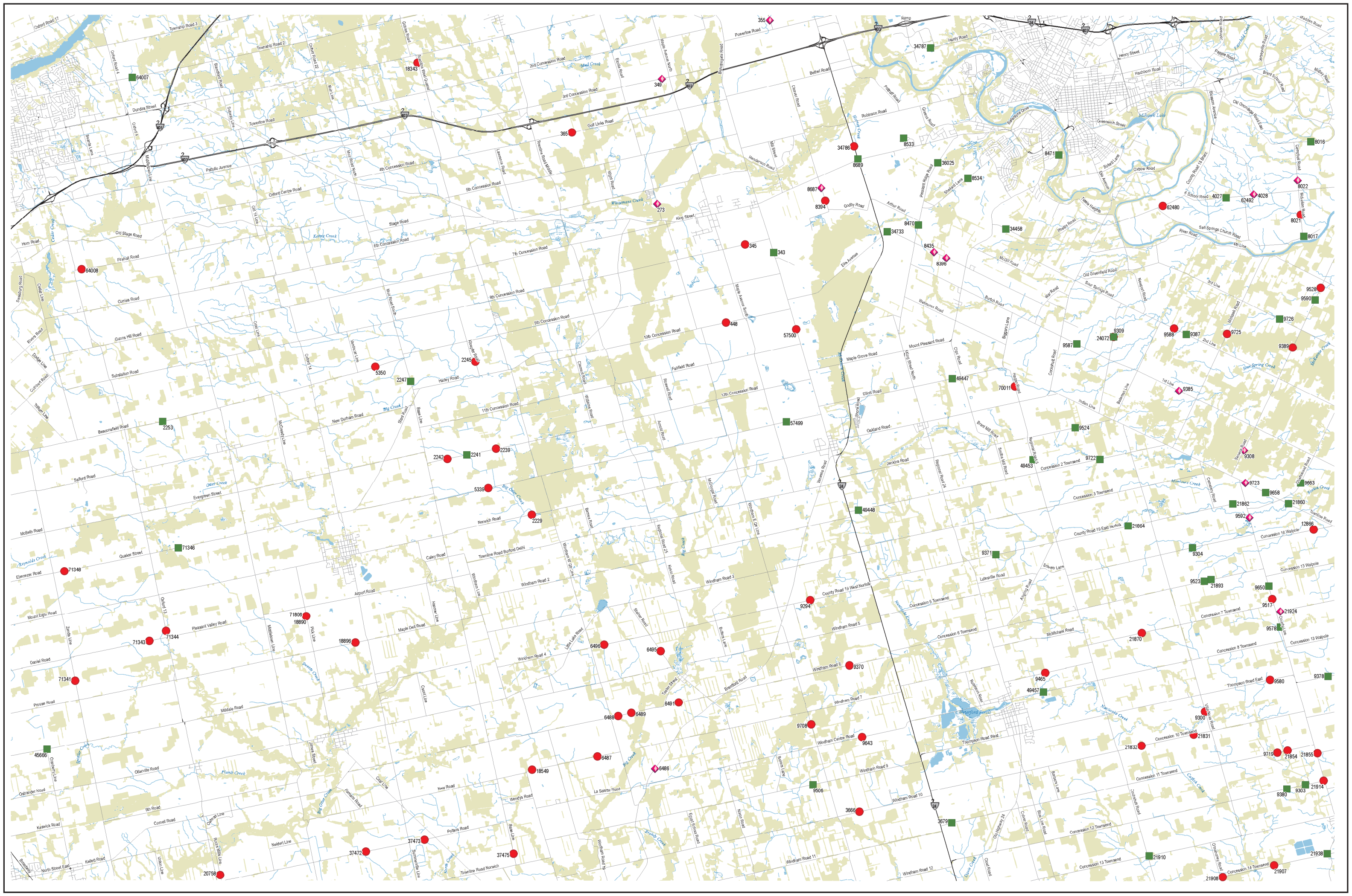
Plush, C.J., C.E. Moorman, and C. Reberg-Horton. 2012. Overwintering sparrow use of field borders planted as beneficial insect habitat. Journal of Wildlife Management 77:200-206.

Renfrew, R.B. and C.A. Ribic. 2008. Multi-scale models of grassland passerine abundance in a fragmented system in Wisconsin. Landscape Ecology 23:181-193.

Ribic, C.A. and D.W. Sample. 2001. Associations of grassland birds with landscape factors in southern Wisconsin. American Midland Naturalist 146:105-121.

Whittingham, M.J. 2011. The future of agri-environment schemes: biodiversity gains and ecosystem delivery? Journal of Applied Ecology 48:509-513.

Appendix 1a. Locations of Bobolink and Eastern Meadowlark point count detections during the Ontario Breeding Bird Atlas (2001-05) for the northern half of the Norfolk study area. Most of these locations were surveyed in 2012.



BOBO/EAME Point Count Detections

Ontario Breeding Bird Atlas 2001-05

Legend

Detections
- Bobolink
- Eastern Meadowlark
- Both
- Waterbody

- Expressway / Highway
- Regional / Local road
- Watercourse
- Wooded area
- Wetland

ID	UTM EASTING	UTM NORTHING	ID	UTM EASTING	UTM NORTHING
273	544416	4772856	9587	560262	4767535
343	548812	4771006	9588	563939	4768119
345	547735	4771308	9590	569264	4769204
349	544588	4777602	9592	566791	4760951
355	548668	4779801	9643	552159	4752635
365	541200	4775554	9650	567518	4758342
448	547018	4768338	9658	567401	4761887
2229	539679	4761058	9663	568718	4762257
2239	538334	4763554	9708	550233	4753108
2241	537224	4763323	9719	567843	4752037
2242	536495	4763174	9722	561135	4763152
2245	537549	4766863	9723	566637	4762262
2247	535103	4766114	9725	565946	4767919
2253	525730	4764594	9726	567931	4768474
3666	552060	4749802	12866	569215	4760485
3679	555543	4749379	18343	535365	4778200
4027	565906	4773076	18549	539694	4751391
4028	566949	4773206	18890	531162	4757207
5339	538039	4762059	18896	533012	4756206
5350	533765	4766661	20758	527903	4747404
6486	544337	4751439	21831	564687	4752724
6487	542162	4751895	21832	562718	4752301
6488	542944	4753431	21854	568228	4752118
6489	543445	4753545	21855	569364	4752016
6491	545234	4753941	21860	568259	4761472
6495	544544	4755885	21862	566154	4761463
6496	542416	4756127	21864	562204	4760629
8016	569103	4775195	21870	562729	4756562
8017	568844	4771609	21893	565331	4758583
8021	568725	4772441	21907	567721	4747771
8022	568608	4773739	21908	565778	4747321
8394	550770	4772968	21910	562998	4748125
8396	555334	4770804	21914	569595	4750981
8435	554871	4771028	21924	567954	4757391
8470	554286	4772043	21938	569722	4748204
8471	559582	4774697	24072	561653	4767803
8533	553727	4775330	34458	557579	4771891
8534	556148	4773810	34733	553107	4771791
8687	550612	4773456	34786	551857	4775028
8689	551999	4774548	34787	554737	4778759
9294	550201	4757817	36025	555016	4774403
9300	565116	4753594	37472	533417	4748286
9303	568898	4750822	37473	535625	4748732
9304	564635	4759802	37475	538990	4748203
9308	566582	4763499	45666	521367	4752169
9309	561653	4767803	49447	555561	4766220
9370	551679	4755339	49448	552017	4761234
9371	557208	4759548	49453	558609	4763138
9378	569760	4754930	49457	559003	4754345
9380	568201	4750668	57499	549289	4764581
9385	564127	4765765	57500	549673	4768083
9387	564403	4767896	62480	563518	4772769
9389	568424	4767393	62492	566949	4773206
9465	559076	4755064	64007	524585	4777646
9506	550299	4750829	64008	522671	4770362
9517	567655	4757858	70011	557932	4765921
9523	565086	4758522	71341	522433	4754768
9524	560202	4764355	71343	525235	4756271
9528	569477	4769666	71344	525861	4756644
9578	567959	4756788	71346	526320	4759802
9580	567567	4754799	71348	522025	4758916
			71806	531162	4757207

Data Sources: Environment Canada, Ontario Ministry of Natural Resources (NRVIS), Bird Studies Canada, Natural Resources Canada.

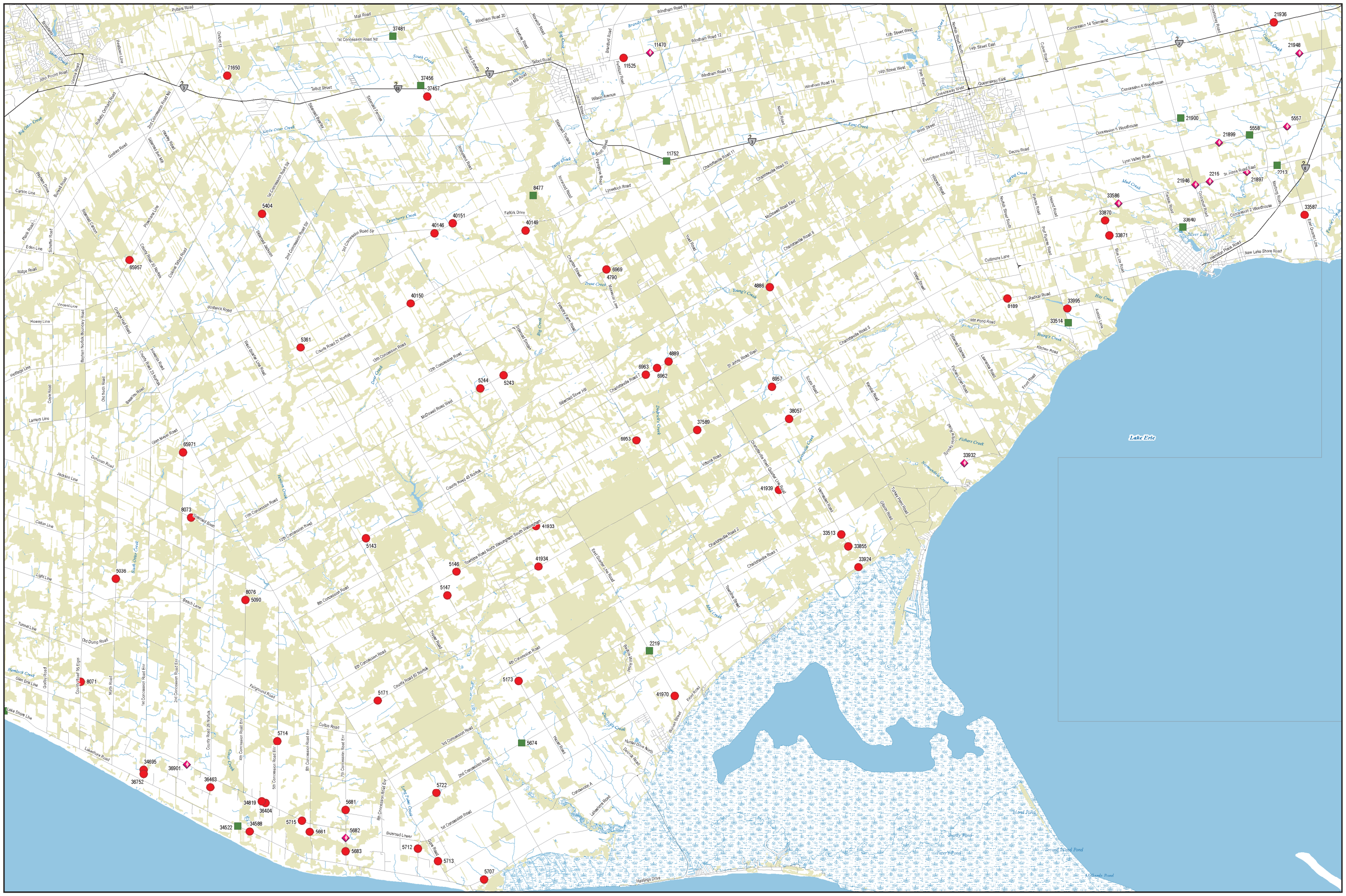
North American Datum 1983
Universal Transverse Mercator Projection
Zone 17

BIRD STUDIES ÉTUDES D'OISEAUX CANADA

1:60,000

0 500 1000 2000 m

Appendix 1b. Locations of Bobolink and Eastern Meadowlark point count detections during the Ontario Breeding Bird Atlas (2001-05) for the southern half of the Norfolk study area. Most of these locations were surveyed in 2012.



BOBO/EAME Point Count Detections

Ontario Breeding Bird Atlas 2001-05

Legend

Detections
- Bobolink
- Eastern Meadowlark
- Both
- Waterbody

- Expressway / Highway
- Regional / Local road
- Watercourse
- Wooded area
- Wetland

ID	UTM EASTING	UTM NORTHING	ID	UTM EASTING	UTM NORTHING
2213	568314	4741090	11752	545149	4741256
2215	565752	4740469	21897	567166	4740832
2219	544500	4722679	21899	566106	4741957
4790	542874	4737134	21900	564657	4742886
4886	549065	4736469	21936	568193	4746516
4889	545230	4733643	21946	565217	4740351
5036	524259	4725400	21948	569160	4745351
5090	529172	4724600	33513	551784	4727079
5143	533746	4726942	33514	560385	4735121
5146	537179	4725673	33586	562294	4739647
5147	536840	4724777	33587	569356	4739208
5171	534198	4720803	33640	564741	4738746
5173	539536	4721539	33855	552044	4726633
5243	538973	4733128	33870	561793	4738997
5244	538090	4732626	33871	561956	4738429
5361	531272	4734184	33924	552433	4725849
5404	529802	4739249	33932	556443	4729801
5557	568691	4742578	33995	560361	4735657
5558	567268	4742237	34522	528879	4716040
5661	531618	4715813	34588	529335	4715824
5674	539656	4719187	34695	525318	4718170
5681	532977	4716647	34819	529801	4716968
5682	532979	4715577	36404	529941	4716904
5683	532981	4715069	36463	527848	4717511
5707	538228	4714013	36752	525315	4718018
5712	535716	4715168	36755	520007	4720404
5713	536477	4714704	36901	526951	4718369
5714	530385	4719253	37456	535826	4744123
5715	531322	4716237	37457	536072	4743689
5722	536416	4717294	37481	534761	4746001
6953	544012	4730657	37589	546313	4731048
6857	549153	4732691	38057	549802	4731471
6962	544795	4733395	40146	536353	4738506
6963	544368	4733149	40149	539802	4738611
6969	542874	4737134	40150	535446	4735849
8071	522924	4721514	40151	537037	4738882
8073	527118	4727727	41933	540201	4727392
8076	529172	4724600	41934	540288	4725873
8189	558079	4736042	41939	549418	4728778
8477	540086	4739946	41970	545462	4720985
11470	544515	4745364	65957	524774	4737508
11525	543524	4745163	65971	526813	4730202
			71650	528488	4744491

Data Sources: Environment Canada, Ontario Ministry of Natural Resources (NRVIS), Bird Studies Canada, Natural Resources Canada.

North American Datum 1983
Universal Transverse Mercator Projection
Zone 17

BIRD STUDIES ÉTUDES D'OISEAUX CANADA

1:60,000

0 500 1000 2000 m