Bobolink reproductive response to three hayfield management regimens in southern Ontario

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Abstract
Incidental mortality of bobolinks (Dolichonyx oryzivorus) breeding in agricultural grasslands has long been known to contribute to population declines, though generalized recommendations for conservation that balance bird reproduction and farmer production needs have remained elusive. We evaluated three hayfield management strategies in southern Ontario by tracking hay quality, bobolink breeding success and phenology, and post-breeding dispersal from uncut fields, using sites that were (A) cut along a typical schedule at the manager’s discretion, (B) harvested late, on or after July 15, and (C) harvested early, before June 1, and again after 65 days. First harvests on discretionally managed fields generally occurred during the nestling stage or while fledglings were mostly flightless (mean ± SE = June 23 ± 2.45 SE), likely resulting in very low bobolink reproduction. On late harvested fields, most bobolinks dispersed from breeding sites before 15 July and had high reproductive success; however forage quality declines make this regimen generally infeasible for farmers, as hay protein content generally dropped below 10% in late June. No bobolinks (re)nested on early cut fields in the 65 days interim between harvests, in contrast to success with this strategy in Vermont. In southern Ontario, a modest delay in first harvest may be the most appropriate strategy to balance needs of breeding bobolinks and farmers, translating to small declines in hay quality and substantial increases in reproductive success. Our work highlights the need for geographically refined agro-ecosystem management approaches for supporting grassland birds due to regional differences in hay maturation timing, breeding bird phenology, and habitat availability.

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1. Introduction

Grassland is among the most threatened habitat worldwide due to anthropogenic activity (White, Murray, & Rohwedder, 2000). Populations of grassland birds in North America have declined precipitously in the past half-century, especially in recent decades (Sauer et al., 2014). Historical population declines were a result of replacing native grasslands with non-native grasses for livestock forage and other crops; as native grasslands were destroyed, many grassland bird species adopted non-native hayfields and pastures as surrogate habitats (Bent 1958; Martin & Gavin 1995; Askins 1999). Recent declines in grassland bird populations have been attributed to hazards they experience when they are treated as pests on agricultural fields during migration and over-wintering (Bent 1958; Martin & Gavin 1995; Renfrew & Saavedra 2007), use of pesticides across their range (Renfrew & Saavedra 2007; Mineau & Whiteside 2013), a net loss of habitat (Bollinger, Bollinger, & Gavin, 1990; Askins 1993; Herkert 1997; Di Giacomo, Di Giacomo, & Contreras, 2005), and the intensification of management on the agro-ecosystems where they breed (Bollinger et al., 1990; Martin & Gavin 1995).

Most conservation and management efforts for grassland birds in North America focus on agricultural land-use on the breeding grounds. Shifts in the agriculture industry, such as shifts in beef demand (Nocera & Koslowsky 2011), increased mechanization and productivity for growing forage crops, and greater economic benefits of growing row crops (Sargeant, Leslie, Shoukri, Martin, & Lissimore, 1998; Agriculture and Agri-Food Canada, 2005; Eilers et al., 2010), have decreased the area of land used for hayfields and pastures in favor of monoculture crops and other human development, and an increasing amount of land has been left fallow (Askins 1993; Herkert 1997). In the last half-century, hay harvests have become more frequent and happen earlier, commonly overlapping with the nesting period of many grassland birds and inducing complete nest failure (Bollinger et al., 1990; Perlut, Strong, Donovan, 2007;
periods. June & 124 dispersal, plots harvest Delaying provide are treated complete harvest and hay composition, and all were seeded from one to over 15 years prior to study. Hay harvested from our study sites was used mainly for feeding beef-cattle (five farms) and sheep (two farms). Bobolinks were present on all study sites. Each farm contained an experimental and control plot, consisting of one large subdivided hayfield or two separate fields in close proximity. On control plots, we requested that participating farmers harvest the hay on a typical schedule at their own discretion. This regimen consisted of a first harvest in early to mid-June, then a second harvest after 35–40 days. Farmers volunteered to harvest experimental plots on one of two alternative management schedules: a late first harvest on or after 15 July, or a first harvest as early as possible and not later than 1 June, followed by 65 days before a second harvest. Across four farms in 2011 and six in 2012, there were four hayfields managed with an early harvest regimen (two different fields in each year; mean = 6.6 ha, range 2.0–13.5 ha), ten with typical management (four sites in 2011 and six in 2012; mean = 7.1 ha, range 4.3–13.5 ha), and six with late harvest management (two sites in 2011 and four in 2012; mean = 7.3 ha, range 3.0–13.5 ha). The same three farms participated in both years though there were changes to the management regimens and hayfields studied, and a total of seven different farms participated across both years.

3. Data collection

3.1. Point counts

Experimental and control plots had one to two point count stations each depending on plot size, at which five-minute, 50 m radius point counts were conducted between 30 min after dawn and 1000 h every 3–6 days from mid-May to 15 July 2012 (no point counts were conducted in 2011), for a total of 12–16 counts per station. We did not conduct counts during periods of precipitation, fog, or winds ≥25 km/h. We limited our point count area to a 50 m radius to ensure adequate detection and to suit field size and topography; low rolling hills on some sites would not allow larger radii due to visual obstruction. Some smaller fields could only support one point count station, as point count centers were spaced at least 150 m apart to avoid potential double counting. We counted all male, female, and fledgling bobolinks, and their observed reproductive activity was recorded (sensu Vickery, Hunter, & Wells, 1992; Nocera et al., 2007). Reproductive activity was classified for each point count station over the season by assigning an ordinal index rank, progressing from 0 when no bobolinks were settled on-site, 1 for male presence >3 weeks, 2 for female presence >3 weeks, 3 for evidence of pairing (such as females carrying nest materials), 4 for adults carrying food to presumed nestlings, and 5 for observed fledglings. This method is useful to examine differences in the overall reproductive activity achieved between management regimens, rather than to estimate the timing of phenological events (Bettis, Simon, & Nocera, 2005). In 2011, field searches were conducted every 3–5 days on early managed fields after first harvest to detect bobolink (re) colonization and reproductive activity.

3.2. Bobolink banding and resighting

Between late May and early June of 2012 we captured male and female adult bobolinks with mist-nets on or near male territories...
and marked them unique to each site with a United States Fish and Wildlife band on one leg (issued by Canadian Wildlife Service) and a color band on the other. We captured and handled all bobolinks according to procedures approved by the Trent University Animal Care Committee (protocol # 12012). From mid-June on, hayfields were searched with a spotting scope (20–60 × 80) every 1–5 days to search for banded males. Resighting effort on a field ceased after two consecutive visits with no banded bobolinks detected.

3.3. Forage sampling

We collected hay samples each week for nutritional analysis from all plots at each farm in 2011 and 2012 beginning in mid-May until the site was harvested. Samples were taken along a transect starting at a random point, with ~5–10 stems of vegetation cut at ~8–10 cm above the ground (approximately harvest height) every two steps until an adequate bundle (~200 g) was collected. Samples were sent to SGS Agri–Food Laboratories, Guelph, ON, and analyzed for crude protein (CP), acid detergent fiber (ADF), and calcium (Ca) and phosphorus (P) content, which are primary indicators of hay nutritional quality. CP is a basic measure of protein that is estimated from the total nitrogen content in hay. ADF is a measure of the cellulose and lignin content of hay which reduces the digestibility of forage as it increases making lower ADF levels more desirable. Calcium and phosphorus are important minerals in bone formation and must be fed to livestock at least 1:1 Ca:P ratio or Ca is mobilized from the bones to maintain normal biological functions (NRC 1996).

All forage samples were analyzed individually. To analyze CP and ADF, all samples were oven-dried for at least 48 h and then ground with a cyclone grinder to pass through a screen with a 1 mm mesh size. A portion of the sample was then loaded into a Near Infrared Reflectance Spectrometer and reflected light from the sample is measured in the infrared region (1100–2500 nm) to estimate CP and ADF content. Calcium and phosphorus concentrations were determined using wet chemistry (reagent-based) techniques (SGS Agri–Food Laboratories, Guelph, ON).

4. Statistical analysis

All statistical analyses were carried out in program R (version 2.15.1; R Development Core Team, 2012).

4.1. Bobolink abundance

To ascertain that initial bobolink abundance did not differ among treatments prior to harvest, we modeled log-transformed adult abundance from point counts in May with a linear mixed effects model, using treatment as a fixed effect, and random effects of date and point count station nested within farm (package ‘lme4’; Bates, Maechler, & Bolker, 2012).

4.2. Bobolink reproductive activity

To assess reproductive activity among treatment types, we performed a Kruskal–Wallis non-parametric rank sum test on the final reproductive activity ranks achieved at point count stations before hay was harvested, and necessary multiple comparison tests were conducted (R package ‘pgirmess’; Giraudoux 2012).

4.3. Fledgling appearance

To characterize the increase in fledglings observed over the breeding season, we calculated the mean ratio of the number of fledglings to adults from point counts each week from all sites prior to harvest, beginning with the last week no fledglings were observed until 15 July (sensu Nocera et al., 2005). The fledgling to adult ratio controls for the effects of displaced adult bobolink emigrating from non-study fields. From visual estimation, we chose to fit an exponential function to describe these data and assessed the fit by inspecting plots of the residuals.

4.4. Bobolink dispersal

The mean date of bobolink dispersal was calculated to estimate the timing of departure from uncultivated harvested fields, presumably after breeding, to examine how dispersal timing coincides with typical and delayed harvest timing to indicate bobolink reproductive success indirectly. In 2012 only, for each color–banded individual resighted, dispersal date was estimated as the mean of the last date spotted on-site and the date of the second visit in which the bird could not be located.

4.5. Forage quality

For all measures of forage quality, we used two-sample Kolmogorov–Smirnov tests to confirm that no unexpected influences caused measurements taken over the same periods in 2011 and 2012 to differ in distribution and that measurements could be pooled for analyses.

From visual examination, we fit exponential and quadratic curves to arc sine square-root transformed proportions of the dependent variables CP and ADF distributed by the independent variable Julian date, for samples taken before first harvest. We assessed the fit visually, and with residual and proportion of total sum-of-squares. We used piecewise linear regression to further characterize this relationship and identify the date at which the values of CP and ADF content changed markedly.

We used a linear regression to describe the change in the ratio of percentage calcium to phosphorus content with Julian date, from samples taken before harvest. We estimated the R² statistic of the regression and assessed the linear fit by graphically examining the residuals.

5. Results

The average first harvest dates in 2011 and 2012 were 1 June ± 1.11 days SE (range 29 May–4 June; n = 4) on early harvest sites, and 23 June ± 2.45 days SE (range 13 June–8 July; n = 10) on control plots cut at the discretion of participating farmers.

5.1. Bobolink abundance

Initial bobolink abundance in May 2012 was the same among fields under early, typical, and late treatment regimens, as indicated by a likelihood ratio test of the linear mixed effects model with and without the fixed effect of treatment (χ² = 0.85, df = 2, p = 0.65). Subsequent mean weekly adult bobolink abundance, over the period 14 May to 15 July, differed between treatment types (Fig. 1). No bobolinks were detected attempting to nest in early harvest fields after the first cut in either year.

5.2. Bobolink reproductive activity

The mean reproductive activity rank achieved on point count sites among treatment types (conducted in 2012 only) was 3.0 ± 0 SE (n = 2) on early harvested sites (evidence of pairing at all stations), 3.7 ± 0.26 SE (n = 10) on control harvested sites (evidence of nestlings on average), and 5.0 ± 0 SE (n = 8) on late harvested sites (fledglings observed at all stations) (Fig. 2). A Kruskal–Wallis non-parametric rank sum test indicated that final reproductive activity ranks between treatments differed (H = 12.29, df = 2, p < 0.01), with multiple comparison tests identifying differences (p < 0.05) in the
Fig. 1. Weekly mean adult bobolinks observed during point counts on hayfields managed with early (dotted line), typical (solid line), and late (dashed line) first harvest dates, from 14 May to 15 July 2012. Early harvested fields were cut 29 and 30 May (n = 2); typical fields were cut between 13 and 30 June (mean 20 June, n = 6), and late fields were harvested on or after 15 July 15 (n = 4). No Bobolinks were detected attempting to breed following harvest on early treatment fields. Bobolinks were observed on one early treatment field after the first harvest but were not nesting. In the first two weeks of July, mixed post-breeding flocks ranging from 20 to 35 young and adult bobolinks were observed during three separate point counts but were not included in adult weekly means. Lines are fit with a loess curve with span = 0.65.

Fig. 2. Codes describing bobolink reproductive activity (jittered) achieved inside 50 m radius point count stations on hayfields under early (squares; n = 2), typical (circles; n = 10), and late (triangles; n = 8) harvest regimens in 2012 by the date of the last point count before the first hay harvest. Reproductive activity was classified for each point count station over the season by assigning an ordinal index rank, progressing from 0 when no bobolinks were settled on-site, 1 for male presence >3 weeks, 2 for female presence >3 weeks, 3 for evidence of pairing (such as females carrying nest materials), 4 for adults carrying food to presumed nestlings, and 5 for observed fledglings (sensu Vickery et al., 1992; Nocera et al., 2007). Point counts were conducted every 3–6 days beginning in mid-May. In 2012, early managed sites were harvested on 29 and 30 May, typical sites, on average, were harvested on 21 June ± 2.42 days, and late cut sites were harvested on or after July 15 when point counts ceased.
level of reproductive activity achieved before harvest between control and late harvest regimens, and early and late harvest regimens, although not for control and early harvest regimens.

5.3. Fledgling appearance

The exponential function that describes the weekly increase in the mean ratio of fledglings to adults observed at all count stations prior to field harvest from the week before the onset of fledging to 15 July 2012 (Fig. 3) is represented by:

\[ y = -0.2937 + 0.1839e^{0.4230x} \]

5.4. Bobolink dispersal

The mean date of marked bobolink dispersal from late harvest fields in 2012 was 9 July ± 2.4 days SE (range 26 June to 22 July, n = 10). All individuals included in the dispersal date estimation left the breeding grounds before fields were harvested, as many late harvest fields were not cut immediately on 15 July and re-sighting continued where banded bobolinks were present.

5.5. Forage quality

A total of 97 samples were analyzed for measures of forage quality from 2011 and 2012. A two-sample Kolmogorov–Smirnov test indicated that crude protein content measured in those hay samples over the same period in 2011 and 2012 did not differ in distribution (D = 0.23, p = 0.15) and measurements were pooled for analysis. A negative exponential function best described the change in crude protein content in hay samples over Julian date (Fig. 4), represented by the equation:

\[ y = 0.2926 + 88.0164e^{-0.0449x} \]

As described by the exponential decline, the CP content was 14.6% on 31 May around the time of early harvests, 10.4% at the time of the average first harvest on control sites (23 June), and 9.1% on 15 July during delayed harvests. The CP content dropped below 10% around 28 June, which is considered the threshold of adequate CP for growing or maintaining most beef-cattle (Rayburn 1994; NRC, 1996; Ortega, Soltera-Gardea, Drew, & Bryant, 1997). Piecewise linear regression (Fig. 4) identified 16 June as the breakpoint at which decline in crude protein content slowed markedly.

A two-sample Kolmogorov–Smirnov test indicated that ADF content measured in hay samples over the same period in 2011 and 2012 did not differ in distribution (D = 0.26, p = 0.09) and measurements were pooled for analysis. An exponential function best described the change in ADF content with Julian date (Fig. 5):

\[ y = 0.6903 - 38.3669e^{-0.0411x} \]

The ADF content was 33.1% on 31 May around the time of early harvests, 37.6% at the average first harvest date on control sites (23 June), and 39.4% on 15 July during delayed harvests. The ADF content increased above 35% around 8 June, which is considered the threshold for ideal ADF content (Rayburn 1994). Piecewise linear regression (Fig. 5) identified 1 June as the breakpoint at which the increase in ADF slowed markedly with time.

A two-sample Kolmogorov–Smirnov test indicated that calcium to phosphorus ratios (Ca:P) from hay samples over the same period in 2011 and 2012 differed in distribution (D = 0.30, p < 0.05). How-
ever, these samples were pooled across years because the observed difference in the rate of Ca:P increase with Julian date was small and discrepancies are due to the study fields used and their management, such as the application of lime fertilizer, not the occurrence of stochastic events between years. A least squares linear regression model describes the increase in Ca:P with Julian date in 2011 and 2012 (Fig. 6):

\[ y = -7.2561 + 0.0721x \quad (R^2 = 0.30) \]

Cattle must be fed with at least a 1:1 Ca:P ratio, with ratios of about 2:1 being ideal though up to 7:1 is considered acceptable (NRC 1996). Ca:P ratios were above 1:1 in all samples. On average, Ca:P was 3.6 on 31 May around the time of early harvests, 5.3 at the average first harvest date on control sites (23 June), and 6.9 on 15 July during delayed harvests.

6. Discussion

Our evaluation of three hayfield management strategies showed that an exceptionally early hay harvest regimen, as proposed by Perlut et al. (2011), was entirely unsuccessful in supporting breeding bobolinks in southern Ontario. We found that bobolink breeding was instead supported when the first hay harvest was delayed until 15 July. All regimens we examined carry benefits and risks to both breeding birds and farmers in terms of the compatibility of breeding bobolink success with forage quality and feasibility.

Initial bobolink abundance in May did not differ on plots among treatment types, indicating that sites were comparable in terms of habitat suitability prior to the beginning of the study. At the time of harvest on early cut fields in late May of 2012, all point count stations had evidence of male and female pairing (level 3). However, bobolink abundance was reduced to zero following hay harvest on both early and control fields (Fig. 1) with no bobolinks returning to nest, though a small number of non-resident transients were observed on early cut fields post-harvest in late June and early July. Adult bobolink abundance remained stable on late harvest fields and increased towards the end of June as some small social flocks began to form (Fig. 1). Abundance then decreased in July as birds began to depart from the breeding grounds or occupy the margins of the field in mixed flocks out of point count radii. It is also possible that bobolink abundance detected in point counts could have differed with changes to territory distribution within the 50 m point count radius over the study period, though effects are likely minimal.

Bobolink reproductive activity on control sites at the time of the last point count before harvest did not significantly differ from that on early sites, though ranks ranged from 3 to 5 (mean = 3.7; i.e., closest to a level 4 with evidence of nestlings; Fig. 2). Regardless, realized reproductive success was likely very low, particularly for sites harvested prior to and around the average harvest date, with higher probability of success on sites cut at the end of June. At the time of harvest on control fields, it is likely that most young were still in the nest and those that had fledged were mostly flightless, suggesting direct mortality after contact with mowing equipment. Further, indirect mortality rates from predation are high for those that do escape mowing at that stage (Bollinger et al., 1990; Perlut et al., 2006). Reproductive activity codes differed significantly on late harvest sites with fledglings observed on all point count sites (level 5) well before the 15 July late harvest date, and reproductive
success was likely high as the mean dispersal date (9 July ± 2.4 days SE) occurred prior to mowing. The mean dispersal date was estimated from a sample size of ten male bobolinks and likely forms a conservative estimate, as departure dates for individuals were estimated as the mean between the date last spotted and the second visit when the bird could not be located, with each visit occurring 1–5 days apart.

Fledglings were first observed in mid-June, and the mean fledgling to adult ratio increased each week until 15 July when point counts stopped (Fig. 3). Fledglings remain flightless upon leaving the nest and were increasingly observed in the dense hayfield vegetation as they gained mobility and began to flock towards the end of the period. Bobolink cannot sustain longer flights until about 16 days of age (Martin & Gavin 1995) and relatively few fledglings were observed in point counts around 23 June, the average first harvest date on typical sites (Fig. 3). The phenology described in other nearby regions, with mean fledging dates of 24 June in eastern Ontario and western Quebec (Frei 2009) and 22 June in western New York (Norment, Runge, & Morgan, 2010), overlaps directly with the average first harvest date on control fields in 2011 and 2012, demonstrating the incompatibility of typical management practices and bobolink breeding phenology and the resulting low reproductive success.

No bobolinks returned to nest on early harvested fields after the first cut in either 2011 or 2012 (n = 4), contrary to experiments in Vermont (Perlut et al., 2011) that found increases in breeding success compared to typical management programs. Farmers that harvested early in our study obtained hay of high quality, but with reduced yield. We asked farmers implementing early harvest regimens to cut as early in May as feasible, though it was difficult in both years for farmers to harvest in mid-May due mainly to precipitation and wet fields which created exceptionally muddy conditions that risked substantially damaging fields with harvesting equipment. After it was obvious (by late June) that no bobolinks (re) colonized early cut fields, farmers were relieved of the restriction to leave the field uncut for 65 days to track changes in forage quality during this period. Although suitable for bobolinks prior to the harvest (Fig. 1), vegetation height after the first cut may have limited (re) colonization, as bobolinks likely selected fields with higher vegetation for mid-season (re) nesting attempts if a first attempt failed. Unlike our study where exceptionally muddy conditions prevented access to fields for harvest, in Vermont (Perlut et al., 2011), study fields were cut earlier (16–17, 22, and 25 May) which may have allowed vegetation to grow back faster and provide more attractive habitat when bobolinks were seeking fields to nest. Perlut (2011) used criteria to select participating fields based on size (≥8.1 ha), shape, past use, and hay composition, which may have also increased perceived habitat quality for (re) nesting attempts. It is also possible that suitable breeding sites are less limited in our region or that breeding bobolink density is lower. Latitudinal or climatic differences may account for some discrepancy in study results, for example, the onset of the “warm season” in our study is generally several days later than in the area of the Perlut et al. (2011) study (National Oceanic and Atmospheric Administration online archived data). Our early harvest dates were likely at or past the limit for allowing enough time for vegetation regrowth and bobolink (re) nesting. Farmer involvement was voluntary in our study and there were no monetary incentives as was used in

![Figure 5](image-url) Percentage acid detergent fiber (ADF) content in hay samples (n = 97) taken weekly from farms before harvest, between 16 May and 15 July in 2011 and 2012. An exponential function (solid line) describes the increase in ADF over the season \(y = 0.6903 - 38.3669e^{-0.0411t}\), and a piecewise linear regression (dashed line) identified a breakpoint in the rate of ADF increase at 1 June, after which increases in ADF slowed markedly with time. Analyses were performed on arcsine square-root transformed proportions, though true percentages are displayed and fit here.
Vermont to facilitate participation (Perlut et al., 2011). Thus, even if bobolink reproductive success was improved by this strategy such as through earlier harvest dates than those tested in our study, it would likely be infeasible for most farmers in our study area, with or without incentive, due to frequent unsuitable weather in May that renders fields too muddy to access and potential losses in forage yield and quality.

On average, ADF levels increased quickly in May and slowed after 1 June, surpassing the ideal threshold of 35% early in the season around 8 June (Fig. 5). The Ca:P ratio increased linearly over the season but remained just below 7:1 by 15 July, within the range of ideal measurements (Fig. 6). Ca:P increases over the season with hay maturity as it becomes increasingly fibrous and the proportion of phosphorus in the hay decreases as phosphorus is depleted from the soil (NRC, 1996). However, of the parameters measured, CP content is generally considered the most important indicator of overall nutritional quality. Protein requirements vary for certain breeds and are higher (>11%) for pregnant and lactating females, and calves (NRC, 1996). Dairy-cattle generally require CP levels >14% and thus hay is harvested earlier for haylage and more frequently than for beef-cattle operations which require ~10% to grow and maintain most cattle. Compromises in quality proposed by experimental management strategies are suited more for beef farms running cow-calf operations and supporting breeds with lower energy requirements. By the time bobolinks typically dispersed from late harvested fields after breeding, and particularly by the delayed harvest date, CP content had dropped below 10% (Fig. 4). Farmers harvesting control fields around the average date were near the 10% adequacy threshold for CP content (Fig. 4), with hay dropping below this level around 28 June on average. From the mean harvest date on control fields (23 June) until the mean dispersal date on delayed fields (9 July), CP decreased by 1.1%. For hay farmers that tend to take a first harvest in late June, near the average date observed on control fields, waiting until at least early July would translate to relatively small further declines in hay nutritional quality while greatly improving bobolink reproductive success. Work in Nova Scotia (Nocera et al., 2005), found similar patterns and trade-offs in hay maturation and timing of bobolink breeding, however both peak fledging and the maintenance of CP content above necessary levels were about one to two weeks later in comparison.

In southern Ontario, a management strategy implementing an early first hay harvest followed by a delayed second harvest did not improve bobolink reproductive success and may not be feasible for most farmers in the region due to unsuitable climatic processes, especially without monetary incentive. Similarly, despite high reproductive success, a significantly delayed first harvest regimen is not practical for many farmers due to declines in hay nutritional quality over the season. As such, a modest delay in first hay harvest may be the best compromise regimen for our study area to allow potential for some bobolink reproductive success while meeting the needs of most farmers. The success and appropriateness of management strategies can vary regionally, as seasonal forage quality and grassland bird breeding phenology differ among regions (Nocera et al., 2005; Perlut et al., 2011). Future work might explore how the feasibility of these regimens varies latitudinally within the province of Ontario and beyond, to refine suggestions for best management practices to suitable scales and benefit grassland bird reproduction in agro-ecosystems where possible.
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