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Regional population viability of grassland songbirds: Effects of agricultural management

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ABSTRACT

Although population declines of grassland songbirds in North America and Europe are well-documented, the effect of local processes on regional population persistence is unclear. To assess population viability of grassland songbirds at a regional scale (~150,000 ha), we quantified Savannah Sparrow *Passerculus sandwichensis* and Bobolink *Dolichonyx oryzivorus* annual productivity, adult apparent survival, habitat selection, and density in the four most (regionally) common grassland treatments. We applied these data to a female-based, stochastic, pre-breeding population model to examine whether current grassland management practices can sustain viable populations of breeding songbirds. Additionally, we evaluated six conservation strategies to determine which would most effectively increase population trends. Given baseline conditions, over 10 years, simulations showed a slightly declining or stable Savannah Sparrow population (mean bootstrap $\lambda = 0.99$; 95% CI = 1.00–0.989) and severely declining Bobolink population (mean bootstrap $\lambda = 0.75$; 95% CI = 0.753–0.747). Savannah Sparrow populations were sensitive to increases in all demographic parameters, particularly adult survival. However for Bobolinks, increasing adult apparent survival, juvenile apparent survival, or preference by changing habitat selection cues for late-hayed fields (highest quality) only slightly decreased the rate of decline. For both species, increasing the amount of high-quality habitat (late- and middle-hayed) marginally slowed population declines; increasing the amount of low-quality habitat (early-hayed and grazed) marginally increased population declines. Both species were most sensitive to low productivity and survival on early-hayed fields, despite the fact that this habitat comprised only 18% of the landscape. Management plans for all agricultural regions should increase quality on both low- and high-quality fields by balancing habitat needs, nesting phenology, and species' response to management.

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1. Introduction

Over the last 40 years, grassland bird populations have declined more rapidly than any other North American bird guild (Bollinger and Gavin, 1992; Knopf, 1994; Peterjohn and Sauer, 1999; Sauer et al., 2005); similar declines have been observed in Europe (Chamberlain et al., 2000; Donald et al., 2001, 2006). Although these trends are regularly cited, it is unclear how local processes occurring within an agricultural field affect regional population persistence. For example, in agricultural regions of the northeastern United States, population declines generally have been attributed to two divergent processes: the abandonment of farmland and subsequent forest succession; and, modernized grassland management, which involves cutting and harvesting hay throughout the growing season, as well as rotational grazing at varying intensities. Within an agricultural landscape, individual fields vary in management intensity, increasing variation in demographic rates among fields (Bollinger and Gavin, 1989; Perlut et al., 2006). However, it is unclear how variation in the composition of the landscape with respect to management-defined habitats affects regional population persistence.

Grassland management has changed dramatically over the last 40 years, including earlier first harvest dates and more frequent harvests in North America (Bollinger et al., 1990; Troy et al., 2005) and Europe (Vickery et al., 2001). In the northeastern United States, an increasing proportion of dairy farmers have advanced their initial cutting date from ~1 July to late-May or early-June – a vulnerable time in the breeding cycle, when most birds are in the later part of the incubation or early nestling stage (Perlut et al., 2006). Eggs and nestlings of ground-nesting birds are vulnerable to being crushed by the harvest machinery, and nests that survive hay-harvest are likely to be depredated (Bollinger et al., 1990; Perlut et al., 2006). Additionally, recent increases in harvesting frequency (Troy et al., 2005) result in a shorter window of opportunity (~35 days) for birds to renest in between haying events. Along with decreased reproductive success, intensive management causes significant, deleterious effects on adult apparent survival, φ, defined as the joint probability that a bird survives and returns to a particular area (Perlut et al., 2008). Birds breeding in intensively managed fields have ~25% lower apparent survival than those in less-intensively managed fields (Perlut et al., 2008). Modern hayfield management clearly presents a variety of threats to grassland bird populations.

Quantifying these events and how they occur across a region (>150,000 ha) is critical in maintaining or restoring grassland bird populations. More than 70% of the world's temperate grasslands are devoted to agriculture or other human uses (Hannah et al., 1995), which leaves agricultural habitats as the primary breeding habitat for many species in North America (Rodenhouse et al., 1995) and Europe (e.g. Freemark and Kirk, 2001; Wilson et al., 2005). This pattern is particularly evident in the northeastern United States, where agricultural regions maintain large, but steadily declining populations of grassland birds. Although the need for conservation is clear, we know surprisingly little about the sensitivity of population persistence to key life history parameters or the distribution of management activities across a landscape (but see Bollinger et al., 1990; Wells, 1997; Fletcher et al., 2006).

To determine population viability across dynamic agricultural regions, conservation biologists must identify how individual fields within the landscape are managed, identify how birds select among management-defined habitat types (density and recruitment), and finally, determine annual productivity and survival within each habitat. Moreover, to reverse declining population trends, optimal conservation strategies need to be identified, evaluated, and implemented. Potential strategies include increasing the total amount of grassland habitat within the breeding landscape, increasing habitat quality without decreasing total breeding habitat, increasing the "attractiveness" of high-quality fields for new breeders, and increasing overwinter survival through improvements in non-breeding habitat quality.

During the 2002–2006 breeding seasons, we collected landscape management data and estimated demographic parameters of Bobolinks (*D. oryzivorus*) and Savannah Sparrows (*P. sandwichensis*), obligate grassland species breeding in the Champlain Valley of Vermont and New York, USA. We applied these data to a female-based, stochastic, pre-breeding, population model (sensu Donovan and Thompson, 2001) to examine whether current grassland management practices throughout the Champlain Valley can sustain viable populations of breeding songbirds. A key assumption of the model is that birds could disperse among fields within the region, but the region itself was demographically closed. The research objectives were to: (1) model population growth for Bobolinks and Savannah Sparrows breeding in the Champlain Valley, and (2) assess six alternative landscape-level conservation strategies, targeted at different phases of the annual cycle and breeding ground habitat management, in terms of their efficacy in reversing or dampening population declines.

2. Materials and methods

2.1. Study area and experimental design

The Champlain Valley is a significant dairy farming region in the northeastern US (Fig. 1), and is surrounded by the Green Mountains to the east and the Adirondack Mountains to the west. The Champlain Valley contains 146,000 ha of managed grassland (US Department of Agriculture, 2007), which can be grouped into four general treatment-types:

1. *early-hayed* (*EH*): hayed between 27 May and 11 June and generally again in early- to mid-July;
2. *middle-hayed* (*MH*): hayed between 21 June and 10 July;
3. *late-hayed* (*LH*): hayed after 1 August, typically after most birds have ended their reproductive season;
4. *rotationally-grazed pastures* (*RG*): fields in which cows were rotated through a matrix of paddocks and moved after all of the grass in a paddock was grazed to a farm-specific height. Each paddock is thereby given a multiple week "rest" between grazing events.

2.2. Champlain valley agricultural management trends

To assess the relative proportion of each of the four treatment-defined habitat types within the Champlain Valley, we