Grassland bird breeding use of managed grasslands on National Wildlife Refuges within Region 5 of the U.S. Fish and Wildlife Service

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Background

Populations of many species of North American grassland breeding birds have declined significantly over the last half-century (Peterjohn and Sauer 1999, Vickery and Herkert 2001, Sauer et al. 2003), in response to habitat loss and degradation, eliciting concern among national bird conservation organizations for this guild (Vickery et al. 1995, PIF 2001, Berger 2004). Declining trends and relatively low population levels for several grassland birds in the Northeast (New England and New York) and Mid-Atlantic states, consistent with the national picture, have recently prompted interagency bird conservation partnerships, such as Partners in Flight (PIF) and the National Bird Conservation Initiative (NABCI), to list these species and their associated habitats as conservation and restoration priorities for several PIF physiographic areas (Fig. 1) in FWS Region 5 (Table 1).

Since most of the northeastern and mid-Atlantic pre-settlement (before 1600 A.D.) landscape was forested and contained few, widely-scattered, grassland complexes (Patterson and Sassman 1988, Tyndall 1992, Mehrhoff 1997, Askins 1997), avian ecologists have concluded that late twentieth-century declines in grassland bird populations probably represent a return to pre-colonial levels in these regions (Askins 1999, Norment 2002). As a result, some experts discourage allocating conservation resources to grassland habitats in these regions at the perceived expense of species that historically may have been more abundant, such as forest-dependent birds (Whitcomb 1987, Craig 2002a, b). Other ecologists maintain that grassland conservation in the eastern U.S. has global importance, given the massive extent of conversion of Midwestern prairie ecosystems to intensive farming operations (Norment 2002), continental declines in grassland bird populations (Peterjohn and Sauer 1999, Vickery et al. 1999, Vickery and Herkert 2001, Sauer et al. 2003), and the degree to which the Northeast supports certain subspecies (Wells and Rosenberg 1999) and a relatively high proportion of the global population of some grassland species, including Bobolinks and Henslow's Sparrows (Wells and Rosenberg 1999, Rosenberg 2000).

Despite debate on this issue, several federal agencies have devoted substantial resources to grassland bird conservation in the Northeast and Mid-Atlantic, developing educational materials, supporting or conducting management activities, and in some cases, acquiring habitats. The U.S. Fish and Wildlife Service (FWS) has managed and acquired open lands on National Wildlife Refuges in Region 5, and provided financial support for grassland restoration on private lands through the Partners for Fish and Wildlife Habitat program. USDA Natural Resources Conservation Service (NRCS) and Farm Services Agency (FSA) have provided considerable financial and technical assistance to private landowners (largely farmers) in the region to "protect, restore and enhance" grassland habitats, through voluntary cost-share programs such as the Conservation Reserve Program (CRP), Wildlife Habitat Incentives Program (WHIP), and the newly-created Grassland Reserve Program (GRP).

It is conceivable that conserving grassland habitats on National Wildlife Refuges, and through USDA cost-share programs, makes sense from a purely practical standpoint. The refuge system has traditionally maintained expertise and equipment necessary to manage a range of early successional habitats ("disturbance-dependent" habitats), such as moist soil units, farmed and mowed lands, and fire-manipulated ecosystems. Such intensive management capability often does not exist on other public or publicly supported conservation areas, so although FWS may not control large grassland acreages, what it does control can be manipulated fairly precisely. USDA, in contrast, has the potential to affect grassland restoration and management on a scale that dwarfs the holdings of most conservation agencies in the East, through its strong influence upon, and support of, conservation practices on private farms in the region. Additionally, these practices have a high likelihood of being implemented in less densely forested, agricultural landscapes – where grassland breeding bird populations have persisted.

Nevertheless, it also has been argued that by promoting grassland bird habitat in the Northeast and mid-Atlantic, conservation agencies are violating sustainable management principles– by attempting to "freeze" eastern ecosystems in a perpetually disturbed state that must be maintained through intensive management treatments, such as mowing, burning, and herbicide applications (Norment 2002). Some conservationists also oppose conserving the anthropogenic grasslands (e.g., abandoned hayfields and pastures) to which grassland bird species appear to have become adapted in the region, because they are populated with introduced grasses (Dickerson *et al.* 1998). Others have suggested that human-created grasslands provide less optimal habitat for grassland breeding birds than naturally occurring grasslands (Herkert et al. 1993, Jones and Vickery n.d., Haas and Titus 1998, Askins 2000).

Despite expending significant resources for grassland habitat restoration and management, neither FWS nor USDA has a comprehensive regional plan for targeting grassland management efforts in the Northeast/Mid-Atlantic. Avian ecologists have called for such regional plans (Vickery et al. 1999, Norment 2002) for several reasons: first, to justify grassland bird conservation as a logical priority in Region 5, in spite of the associated ecological problems cited above; and second, to determine where costly establishment and management actions are most likely to boost grassland bird populations while minimizing forest fragmentation. Some grassland bird scientists recommend that federal conservation agencies formulate a regional grassland bird plan in concert with the Bird Conservation Plans developed through PIF, but caution against wholesale adoption of PIF grassland acreage targets (Norment 2002). The reasoning is that although current Bird Conservation Plans set grassland habitat protection and restoration targets for six physiographic regions in the Northeast and mid-Atlantic, the documents are not detailed enough to account for landscape effects, specific site limitations, and the capacity of wildlife managers to enhance and maintain grassland bird populations on grasslands currently controlled or influenced by FWS and USDA.

Understanding the capacity of wildlife managers to enhance or maintain grassland bird communities requires recognizing that what constitutes appropriate habitat for grassland birds, such as plant community or structure, and what management practices are most effective for promoting their health, may vary by physiographic region (Johnson and Igl 2001) or bird species (Delisle and Savidge 1997). One reason that acceptable grassland bird habitat may vary across Region 5 is that the ecosystems to which birds have become adapted naturally differ along a warm-season/cool-season latitudinal gradient (MacFadden et al. 1999). Grasslands or abandoned fields naturally populated with warm-season grasses generally occur in southern states (south of Pennsylvania) or on xeric, coastal sites. In contrast, agricultural grasslands are more widespread in the northern parts of Region 5, especially at mesic and wet sites, or at higher elevations, and are dominated by non-native cool-season grasses (Dickerson et al. 1998). Appropriate breeding habitat in Region 5 likely also varies by bird species. As demonstrated by studies in the Midwest, different grassland species often have different plant community preferences, or may respond differently to grassland disturbances (Herkert *et al.* 1993).. Southern, and coastal grasslands in Region 5 are physiognomically similar to mid-western prairies (Niering and Dreyer 1989, Latham et al. 1996, Mehrhoff 1997), and were historically maintained by fire (Tyndall 1992, Dunwiddie et al. 1997, Askins 1997), so birds using these sites may be adapted to fire disturbance. Northern, or inland grasslands are agricultural in origin; these systems were historically maintained with grazing or haying practices, and the bird communities of these habitats may be less adapted to the effects of fire.

Goals and Justification

Overall Purpose and Approach

The overall purpose of this project is to understand the likely capacity of FWS land managers (and by broad inference, USDA and other land managers) to affect grassland bird populations in Region 5. This involves three components: (1) to establish information about grassland bird species distribution and habitat use to support decisions about regional priorities for management; (2) to determine how vegetation structure and composition affect grassland bird use; and (3) to determine, in turn, how the choice of dominant grass community (fallow field vs. planted warm-season grass) and management technique (mow vs. burn) affect the vegetation structure and composition.

These questions should be asked in a sequential manner, both at the regional and local levels (Fig. 2). First, should grassland breeding birds be a focus of management? The controversy over this question might be diminished by considering what conditions might suggest a positive response. Presumably, if it can be demonstrated that abundance and productivity have the potential to be high, that is, if healthy populations could be maintained or established, then management for this guild would be warranted. Likewise, if local populations are a substantial portion of the global population (for one or more species), or if regional biodiversity is important, then grassland bird management should be a focus. The peripheral benefits of managing for grassland birds (on native grass, lepidopterans, etc.) might also favor such management focus. In this study, we seek to provide some partial information to answer this question, by looking at current and potential bird density and considering biodiversity within this guild. Second, if grassland birds are determined to be a management focus, then it becomes important to understand how habitat affects grassland breeding bird abundance, use, and productivity. The habitat effects can occur at the local scale (i.e., vegetation composition and structure in the field) or the landscape level (landscape context); in this study, we investigate the former, while controlling for the latter. Third, once the effect of habitat on the birds is understood, then the manager needs to know how management decisions affect the habitat. In the context of grassland birds, some important management variables include the type of grass maintained or planted in the field and the disturbance regime used to maintain it. Fourth, in addition to knowing what management techniques are most effective, the manager will want to know what methods are most efficient. This framework (Fig. 2) is used to structure the presentation and interpretation of the results from this study.

This study focused attention on some aspects of this framework than others. More specific objectives of the study are outlined below.

Objective 1: Grassland Bird Abundance and Diversity in Existing Habitats

A variety of factors may contribute to occupancy of habitats by grassland breeding birds on public conservation lands. In addition to vegetation community and management history, such factors include local physical variables (patch size, shape, etc.) and landscape metrics (landscape composition and edge-density characteristics). There is value in simply examining grassland bird species distribution and abundance in comparably-sized grassland habitats among Refuges in Region 5. This information will contribute to understanding the capacity of FWS land managers (and potentially other land managers) to affect grassland bird populations on existing grasslands. In particular, do grassland fields in the Northeast support high densities of grassland dependent birds during the breeding season? Is the grassland bird community that uses these fields rich and diverse? Do grassland bird abundance and diversity differ by physiographic region? This information can be used to support decisions about regional priorities for management, since FWS and USDA would prefer to direct resources for grassland bird conservation to areas that make the most important contribution. **An initial purpose of this project is to describe how grassland bird communities differ among comparably sized and managed NWRS grasslands from different physiographic regions.**

Objective 2: Effects of Grassland Structure and Plant Species Composition

There is mounting empirical evidence that certain grasslands in the Northeast and mid-Atlantic may provide better grassland bird habitat because of structural characteristics. Bollinger (1995) reported that abandoned, weedy, cool-season fields in the Northeast resemble the structure of midwestern prairies. Norment et al. (1999) reported that grassland bird abundance was higher in structurally diverse cool-season grasslands such as fallow fields and lightly grazed pastures than non-structurally diverse warm-season grasslands. In Rhode Island, Paton et al. (1999) found grassland birds breeding in fields in which planted big bluestem (*Andropogon gerardi*) was mixed with shorter cool-season grasses such as timothy (*Phleum pratense*) and smooth brome (*Bromus inermis*); tall fields (>1 m) dominated by big bluestem and tall forbs, such as goldenrod (*Solidago* spp.), generally did not contain breeding grassland birds.

In the southern part of the Region, species such as Grasshopper Sparrow (*Ammodramus savannarum*) and Henslow's Sparrow (*Ammodramus henslowii*) can be highly productive in naturally occurring warm-season grasslands, such as fields of broomsedge (*Andropogon virginicus*) (Robbins and Blom 1996; Brian Watts, College of William and Mary, pers. com.), possibly because these grasslands are generally shorter and less dense than planted warm season fields dominated by switchgrass and big bluestem. Fallow, naturally-established warm-season grasslands in the south may be the structural equivalent of fallow, cool-season fields in the northern part of Region 5. **We sought to determine if Region 5 grassland bird populations respond to grassland structure, or plant species composition, and if the effects vary by bird species or physiographic region.**

Objective 3: Effect of Warm-season and Cool-season Grasses

Recent studies in the Northeast suggest that grasslands with low height-density and heterogeneous structure may provide better habitat for grassland breeding birds than tall, dense grasslands (Norment 1999). In Region 5, most extant grasslands are of agricultural origin and dominated by introduced and native cool-season grasses, especially in cooler regions (MacFadden et al. 1999). However, where NRCS and FWS have actively established grasslands for wildlife habitat, these fields are densely planted mixtures of tall, warm-season grasses, using grassland planting prescriptions that were developed in the Midwest to create nesting cover for waterfowl and pheasants, or to provide livestock forage.

Avian ecologists have suggested that northeastern grassland-breeding birds have adapted to agricultural cool-season grasslands (Hurley and Franks 1976, Vickery and Dunwiddie 1997), adjusting to structurally different habitats from their midwestern counterparts (Bollinger 1995, Norment 1999). It appears that anthropogenic grasslands in the Northeast may have higher grassland bird productivity (higher Mayfield survival probabilities, lack of cowbird parasitism) than often is the case in the Midwest (Bollsinger n.d., Jones 2000, Norment et al. *in preparation*) (Table 2). For example, Bobolinks (*Dolichonyx oryzivorus*) have shown higher productivity in cool-season grasslands in New York than in comparably sized midwestern prairie habitats (Bollinger and Gavin 1989). The same pattern may hold for bird density as well (Table 3). Norment (1999) found that grassland bird abundance and species richness in New York were consistently higher in cool-season grasslands than in comparably sized warm-season grasslands dominated by switchgrass. Bollinger (1995) found higher densities of species such as Henslow's Sparrow, Grasshopper Sparrow, and Upland Sandpiper (*Bartramia longicauda*) in the largest, oldest (>10 yr) cool-season fields than in smaller, younger fields.

In contrast, Daves (1997) found greater abundance of Grasshopper Sparrows in warm-season grasslands than in cool-season grasslands on active hayfields in Pennsylvania, but found no significant differences for Savannah Sparrow (*Passerculus sandwichensis*), Eastern Meadowlark (*Sturnella magna*), or Bobolink (*Dolichonyx oryzivorus*). In Nebraska, total bird abundance did not differ between comparably sized (20 to 40 ha) cool-season and warm-season grasslands (Delisle and Savidge 1997): of eleven species studied, two differed in abundance by grassland type, Sedge Wren (*Cistothorus platensis*) preferred warm-season grasslands, while Bobolink abundance was higher in cool-season grasslands.

It is currently unknown if typical, commercial warm-season (summer flowering) grass plantings provide habitat equivalent to cool-season (spring flowering) grasslands or fallow fields. **We sought to determine if Region 5 grassland bird populations respond differently to these grassland establishment techniques, and if the effects vary by bird species or physiographic region.**

Objective 4: Effects of Fire vs. Mowing

It is unknown if mowing and prescribed fire can be used as equivalent tools for maintaining grassland breeding bird habitat in Region 5. Fire alters the structure of grasslands by temporarily reducing woody species cover, decreasing litter, and removing dead, aboveground vegetation (DeBano et al. 1998), potentially creating more attractive grassland bird nesting habitat. Many wildlife managers in Region 5 currently prefer to establish warm-season grasses because of perceived ease of maintenance with prescribed fire. Warm-season grasses emerge late in the spring, creating a wide window of opportunity for conducting dormant-season prescribed burns; and burns stimulate warm-season grass productivity. Species such as Grasshopper Sparrow respond positively to reductions in litter (Herkert 1994, Johnson 1997). However, some grassland birds that prefer dense vegetation, such as Henslow's Sparrows, have been found to abandon sites the breeding season following fire (Herkert 1994).

In contrast, recent studies have shown that dormant-season burns may fail to increase cool-season grass cover (Howe 1995, Mitchell and Malecki 2003) and often fail to reduce shrub cover (Euler 1974, Mitchell and Malecki 2003). In addition, aggressive, tall forbs, such as goldenrod, have been reported to increase in cool-season grasslands following dormant season burns (Swan 1966, Swan 1970, Mitchell and Malecki 2003), making them potentially less attractive to grassland breeding birds. No studies have measured the response of grassland breeding birds to fires in cool-season grasslands.

Although labor intensive, mowing can also be used to control woody invasion and dense forbs in grasslands. A disadvantage of mowing is the accumulation of thatch; this may contribute to site abandonment by grassland breeding birds that nest in early seral stages of grasslands, characterized by shallow litter layers, such as Vesper Sparrow (*Pooecetes gramineus*) and Grasshopper Sparrow (Rudnicky et al. 1997). The usual, infrequent, late-season mowing regime used by wildlife managers to reduce nest disturbance may accumulate a deep litter layer and discourage use of grasslands by these species. **We sought to determine if Region 5 grassland bird populations, and plant communities, respond differently to prescribed fire in warm season grasslands, prescribed fire in cool season or fallow fields, and mowing in cool season or fallow fields, and if the effects vary by bird species or physiographic region.**

Methods

Study Areas

This study was conducted from May 2001 to October 2003 at 13 National Wildlife Refuges within FWS Region 5: Rachel Carson NWR, in Wells, ME; Missisquoi NWR in Swanton, VT; Iroquois NWR in Basom, NY; Montezuma NWR in Seneca Falls, NY; Erie NWR in Guys Mills, PA; Wallkill NWR in Sussex, NJ; Supawna Meadows NWR in Pennsville, NJ; Bombay Hook NWR in Smyrna, DE; Prime Hook NWR in Milton, DE; Eastern Neck NWR in Rock Hall, MD; Patuxent NWR in Laurel, MD; Canaan Valley NWR in Davis, WV; and Eastern Virginia Rivers NWR in Warsaw,VA (Fig. 1). At least two "fallow" fields per Refuge were selected as experimental units; these were abandoned agricultural fields or old pastures that had been maintained by mowing and/or burning and were generally dominated by a mixture of *non-native* grasses, the plant community depending on the latitude (cool-season grasses in the north, warm-season grasses in the south). At five Refuges (Iroquois, Montezuma, Erie, Bombay Hook, and Eastern Virginia Rivers), a third field was included in the study; these fields were planted warm-season grasslands, generally dominated by *Andropogon* spp. purchased as a part of a grass seed mix. We selected grassland units 12-16 ha in size, with an effective grassland area in the surrounding landscape of at least 25 ha (i.e., each field was part of, at a minimum, a 25 ha complex of non-woody vegetation, such as farm fields or pastures).

Bird Censuses

Bird abundance and diversity was measured using fixed radius, double-observer point counts (Nichols et al. 2000), with the two observers acting independently, to allow the estimation of detection probability, assumptions about which are frequently criticized in standard point counts (Ralph et al. 1995). Approximately 5 survey points were located within each field, at least 50 m from field edges and 200 m from one another. Survey points were permanent over the course of the study, located each year with GPS receivers, and marked with short wire flags that did not allow for perching.

Birds were surveyed between May 15 and July 15 each year, during the peak breeding period for each Refuge (as pre-determined by each Refuge). Surveys were conducted for two “bouts”, with 5 days of consecutive surveys per “bout”, and the two bouts separated by a 2 week interval in an effort to sample over a range of peak activity periods. Data were collected between 0600 and 1000 hrs, using 5-minute observation periods at each survey point, and were collected for two distances, 0-50 m and 50-100 m from the survey point. The species of all individuals seen or heard was recorded. No attracting devices of any kind were used.

Full analysis of the detection probabilities has not yet been completed. Preliminary analysis of a portion of the data (from Canaan NWR) showed that the detection probabilities differed by observer and species, but that the combined detection probability (the probability that a bird would be detected by at least one of the observers) was quite high (>0.95). In the analysis presented here, the total number of birds detected by at least one of the observers was used as the measure of abundance at a point. A full analysis of detection probability will be completed in the future.

The number of birds of each species detected at each point was averaged over the ten visits in a season to calculate the average use of the field. The average daily use was divided by the sampling area (the area of the fixed radius circle) to estimate a density. The density in each field was determined by taking an average across points, weighting by the sampling areas (some points were fixed at 50-m, some were fixed at 100-m). The abundance in each field was found by multiplying the weighted average density by the area of the field.

Vegetation Sampling

Spring vegetation characteristics of study fields were measured between May and June. Vegetation surveys did not precede initial avian surveys by more than 2 weeks, and did not extend beyond final avian surveys by more than 2 weeks. Late summer vegetation characteristics of study fields were measured between late August and October (2002 and 2003 only), during the peak of warm-season grass growth (as determined by refuge staff). Vegetation sampling points were randomly located in each grassland unit, at a density of one point per 3 ha, and were permanent over the course of the study.

At each point, height-density was estimated from 4 visual obstruction readings at 4 regularly-spaced points within 25 m of the sampling point, using a Robel pole (Robel et al. 1970). Percent frequency vegetation and average litter depth were estimated at each sampling point, as measured along a permanent 30-m transect set in a random direction. Percent frequency was estimated by recording occurrence of vegetation category interceptions along a 4 mm diameter metal rod inserted vertically in the vegetation, and perpendicular to the transect, at 50 regularly spaced points per transect. Vegetation frequency categories included: shrub >0.5 m, shrub <0.5 m, live graminoid, live forb, dead vegetation, bare ground. At 20 regularly spaced points along each transect, litter depth was measured to the nearest 0.5 cm. Total number of plant species and dominant species were estimated, per point, from three 1-m^2 quadrats, randomly placed along each 30-m transect. In each quadrat, the total number of plant species encountered was first recorded, and then cover per plant species was subsequently visually estimated, using a modified Mueller-Dambois and Ellenberg (1974) scale (Table 4). If the sum of the midpoints of the cover classes for each species exceeded 50%, only species in cover classes B_1, B_2, C, D, or E were recorded as “dominant,” and species in class A (less than 5%) were omitted. In addition, we noted the presence of noxious weeds of concern to Region 5 Refuges (Table 5), and estimated the cover class. All plants were identified to species, where possible, except graminoids, which could occasionally only be identified to genus, or merely identified as cool-season or warm-season grasses. Plants were identified in the field using Gleason and Chronquist (1999), and nomenclature was updated later according to USDA Plants National Database (USDA 2004). For late summer sampling, only total number and dominant species were measured.

Prescribed Fire Information

With the exception of one study field, all burn treatments were conducted between February 15, 2002, and April 24, 2002, that is, during the dormant season for most grasses and woody plants at the study areas. The plot at Rachel Carson NWR was burned on Sept. 27, 2001, prior to the average first killing frost for York County, Maine; therefore, this is not considered to have been a dormant season burn for most vegetation at that site. Standard fire weather condition information was collected for each prescribed burn using a belt weather kit, and/or a Kestrel 3000® Pocket Weather™ Meter, immediately prior to the start of test-fire for each prescribed burn: temperature, relative humidity, wind speed and direction, and 1 hour fuel moisture. The following fire behavior characteristics were measured once the flaming front had reached a steady state, for the prescribed burn treatment: rate of spread and flame length. In addition, percent-area-burned information was collected immediately after prescribed burns were declared out, as measured along the permanent, 30-m vegetation sampling transects. Along each transect, at each of 60 systematically spaced points, a 4 mm diameter metal rod was dropped vertically next to the field tape, perpendicular to the ground, and the presence or absence of blackened matter was recorded.

Analysis of the fire weather and percent area burned has not yet been completed. A full analysis, investigating if any of these variables explain variation in bird or plant response, will be completed in the future.

Data Analysis

The overall study is a randomized incomplete block design, with three possible treatments, and 13 blocks (Refuges) in 7 PIF physiographic regions. The three treatments were (1) fallow field, mowed; (2) fallow field, burned; and (3) planted WSG field, burned. Treatment (mow or burn) was randomly assigned to the fallow fields, but because we were working with established fields, the vegetation composition could not be randomly assigned to fields. One year prior to the first field season, no mowing or burning treatments were made to the fields, so data could be collected on the various response variables for the fields in their preexisting conditions. Mowing, where applied, was conducted in late summer/early fall of 2001. Prescribed burns were applied as stated above, under the direction of qualified Refuge personnel, and in accordance with the established Fire Management Plan for the Refuge. (Patuxent NRR has not yet been able to conduct the burn on their field, due to concerns about unexploded ordnance, but anticipate burning in March or April 2004. They have been maintaining both fields in a “pre-treatment” state and have been carrying out all the bird and vegetation measurements on an annual basis.)

In regard to statistical inference, the ultimate population of interest is all conservation grasslands 12-16 ha in size in the Northeast U.S., where “conservation grasslands” is meant to distinguish permanent grasslands managed for conservation purposes from temporary grasslands managed primarily for agricultural or grazing purposes. We do not have a random sample from the population of interest. Rather, we have a nearly complete collection of such fields that are extant and located on FWS Refuge lands. Thus, we can make a legitimate inference to 12-16 ha conservation grasslands on Refuges in the Northeast, including those that may be created in the future. To the extent that conservation grasslands on Refuges are representative of conservation grasslands more generally in the Northeast (for instance, on state and private lands), we can draw a weaker inference to the larger population. The blocked design, where the grasslands are blocked by Refuge, is meant to control for landscape context. While it is prohibitive to design a study that addresses all of these influences, and impossible on refuges, given the limitations of available experimental units, by blocking on Refuge we can at least control for these factors.

Results

These results are preliminary. For the most part, they are presented at the regional level, with means taken over the study fields and Refuges, and standard errors for these means are not shown. Two cautions are important at this point: (1) the regional means may mask important station-specific effects; and (2) the apparent patterns may not be statistically significant. Nevertheless, these results are presented as a report on progress, as a preliminary indication of the direction of the conclusions, and to generate discussion. More detailed results can be expected within six months. Readers of this preliminary report are encouraged to offer suggestions to the authors, both with regard to other analyses that might be valuable, and with regard to interpretation.

Grassland bird density, abundance, and diversity

Grassland bird density differed substantially among Refuges (Fig. 3, Table 6), ranging from 0.04 obligate birds/ha at Eastern Neck NWR (MD) to 4.77 obligate birds/ha at Missisquoi NWR (VT). The highest densities were seen in the St. Lawrence Plain, the Lower Great Lakes Plain, and the Allegheny Plateau, with more moderate densities seen in the other physiographic regions. All of the regions showed the potential to sustain densities of obligate grassland birds that were at least comparable to midwestern densities (compare Tables 3 and 6), although two of the Refuges in the Mid-Atlantic Coastal Plain showed very low densities. Of note, where they existed, planted warm-season grass fields did *not* support much higher densities of obligate grassland birds than their cool-season or fallow counterparts. Only Eastern Virginia Rivers NWR Complex had a warm-season field with slightly higher density than its fallow fields; no obligate grassland birds were detected in the warm-season field at Bombay Hook NWR over the course of the three-year study.

The abundance of grassland birds supported on the fields enrolled in the study shows a similar pattern to the density (Fig. 4, Table 6). These results are affected by the area of the fields, and thus demonstrate a better measure of the relative contributions each Refuge could make to regional conservation efforts. However, this measure is not a complete account, as it does not include those refuge grasslands that were not enrolled in the study. Warm-season grass fields represent a lower contribution across the board, but this is primarily because so much less area is planted in this manner.

The composition of the obligate grassland breeding bird community shows some marked patterns (Fig. 5, Table 7). Most Refuges were dominated by between 1 and 3 species of grassland birds; the most notable exceptions are Canaan Valley NWR (WV), with 4 commonly seen species, and Rachel Carson NWR (ME), with 6. The northern tier of Refuges (in the St. Lawrence Plain, the Lower Great Lakes Plain, and the Allegheny Plateau) showed a similar species composition, dominated by Bobolinks and Savannah Sparrows, with a small number of Eastern Meadowlarks and Grasshopper Sparrows. The Refuges on the Mid-Atlantic Coastal Plain also shows a distinctive community composition, dominated primarily, and in some cases almost exclusively, by Grasshopper Sparrows. The remaining Refuges (Canaan NWR, Wallkill River NWR, and Rachel Carson NWR) did not fit well with the two predominant patterns.

Habitat effects on bird density

Predicting grassland bird density using only local habitat variables (vegetation structure and composition), without controlling for landscape context, is challenging. Using all subsets regression to explore the predictive ability of over a dozen vegetation variables, the best fitting model only explained 11.5% of the variation in grassland bird density across fields and years. The two predictors in this model were the mean measures of ground cover and grass cover in each field (Figs. 6 and 7). Ground cover is the fraction of sampled points at which the ground was covered with plant material or litter. As ground cover increased, the bird density appeared to increase, but this relationship suggests that there are other limiting factors (Fig. 6). That is, to reach the highest densities, the ground cover needs to be high, but high ground cover alone isn't enough to insure high bird densities. A similar pattern is perhaps seen with grass cover (Fig. 7), where grass cover was measured by the fraction of sampled points at which a live grass plant could be found. Bird density has the potential to increase with grass cover, but is not guaranteed to do so—other factors must have a role. Missisquoi NWR (VT) stands out strongly in having much higher obligate densities (primarily Bobolinks) than other sites with similar grass cover. With regard to other vegetation measurements, of note, no relationship could be discerned between bird density and vegetation height-density, without controlling for landscape context.

Landscape context, however, explains a large portion of the variation in grassland bird density across fields and among years. Using "Refuge" as a predictor for grassland bird density in a general linear model explains 86.2% of the variation. That is, 86.2% of the variation in bird density is explained by *where the field is*, rather than by annual effects, management treatments, or local habitat variables. Adding in a predictor associated with whether the field is a planted warm-season grass field or a fallow field explains a little bit more variation, but beyond that, the local habitat variables explain almost nothing more. Two variables, the mean height-density and the cool-season grass cover, are marginally significant predictors, once landscape context is controlled for, but their contribution to overall predictive power is low.

While these results seem quite strong in implying that local habitat variables are not important relative to landscape variables, considerably more analysis is needed to look at the habitat effects within each physiographic region and within each Refuge. Thus, the reader should bear in mind that these results are preliminary.

Management effects

Of particular interest to managers are the treatment-by-time effects on bird density and vegetation characteristics. That is, how did the variables of interest differ among treatments, and how did those differences change over time (pre-treatment vs. post-treatment)?

The treatment-by-time effects on grassland bird density, averaged across all fields within each treatment category, showed some important patterns (Fig. 8). In cool-season grass and fallow fields, a mowing treatment increased grassland bird density (on average) in the year immediately following treatment, but this increase in density was more than lost in the second year post-treatment. A similar pattern was seen in warm-season grass fields that were burned—the increase in the first year post-treatment was not very great, but the decrease in the second-year was pronounced. In contrast, burning a cool-season or fallow field had no demonstrable effect on grassland bird density, at least on average across Refuges.

The treatment-by-time effects on vegetation characteristics were, in many cases, more pronounced (Figs. 9-14). Vegetation height-density (Fig. 9) decreased sharply the first-year post-treatment in the traditionally managed fields (WSG fields that were burned; and CSG/fallow fields that were mowed), but was not affected in the first year in CSG/fallow fields that were burned. In the second-year post-treatment, all types of fields showed a sharp increase in height-density.

Grass frequency did not differ substantially among treatment types prior to treatment, and the only noticeable effect was a decrease in grass frequency in the first year post-treatment on CSG/fallow fields that were burned (Fig. 10). When the grass cover was broken down by warm-season and cool-season species, however, some stronger patterns were evident. First, cool-season grass cover was higher in CSG/fallow fields than in WSG fields, as expected (Fig. 11), and warm-season grass cover was much higher in WSG fields than in CSG/fallow fields (Fig. 12). Mowing increased cool-season grass cover (Fig. 11) but had no effect on warm-season grass cover (Fig. 12). Burning had no effect on cool-season grass cover (Fig. 11), but sharply increased warm-season grass cover in the first year following treatment in WSG fields (Fig. 12). Of note, however, the positive impact of mowing on cool-season grass cover was longer lived than the positive effect of burning on warm-season grass cover (compare Figs. 11 and 12).

The "warm-season grass fraction" measures the fraction of total grass cover (cool-season plus warm-season) that is composed of warm-season grass species. Warm-season grass cover increased with burn treatments, regardless of the type of field (Fig. 13), that is, burning selected for warm-season grass species over cool-season grass species. Mowing, on the other hand, appeared to select for cool-season grass species.

Finally, litter depth was greatly decreased by burning, whether in planted WSG fields or CSG/fallow fields, in the first year post-treatment, but returned almost to original levels by the second year post-treatment (Fig. 14). Mowing, on the other hand, had no effect on litter depth.

Warm-season grass fields

The treatment-by-time effect averaged over all warm-season grass fields (Fig. 8) masks differing responses on individual fields (Fig. 15). The warm-season grass fields at Montezuma (Avery field) and Erie (field NG-40) showed the trend in bird density that was seen on average: a slight increase in bird density the first season after burning, then a decrease to levels less than or equal to the pre-treatment density. This pattern, however, did not hold on the other three warm-season grass fields: at Bombay Hook (field 101a), no obligate grassland breeding birds were seen during any of the years; at Iroquois (Contaminant field), bird density increased for each of the years following burning; and at Eastern Virginia Rivers (Tayloe field), bird density decreased for each of the years following burning.

The vegetative response to burning in warm-season grass fields was likewise divergent across fields (Fig. 16). On three of the fields (at Erie, Montezuma, and Iroquois), the burn treatment reduced the height-density in the season following the burn, but in the other two fields (at Eastern Virginia Rivers and Bombay Hook), height-density increased in the season immediately following the burn. The response the second-year post-treatment was also mixed.

Discussion

This discussion follows the train of thought in Fig. 2, using the results of this study to provide evidence that can be used to answer the series of questions. At the outset, it is important to note that this interpretation of the data is preliminary; at the end of the discussion, we provide a sense of the additional analyses we anticipate.

Density, diversity, and productivity: informing management goals for grassland birds

It appears the Refuges in the Northeast are able to provide good habitat for grassland breeding birds, and attract reasonable densities, in fields 12-16 ha in size, with an effective grassland area of at least 25 ha. Further, the available evidence suggests that productivity may be as good, or better, in the Northeast than in the Midwest. In this study we observed densities of obligate grassland breeding birds that were comparable to densities seen at midwestern sites (Tables 3 and 6, Figs. 3 and 4). At some of the Refuges, there was also good diversity in the grassland bird community (Table 7, Fig. 5). While we did not study productivity in this project, there are several studies underway of grassland bird productivity on Northeast Refuges (Table 2); these suggest that productivity can be quite good in the Northeast, perhaps even better in some cases than the typical productivity in the Midwest. Taken together, these results provide some insight for answering the first question in Fig. 2: grassland birds cannot be eliminated from management consideration at the regional level based on current abundance, productivity, or diversity levels.

At the station-level, the best places for grassland birds appear to be the Refuges in the St. Lawrence and Lower Great-Lakes Plains, and Allegheny Plateau, with the special situations at Rachel Carson NWR and Canaan Valley NWR also meriting attention. The Mid-Atlantic Coastal Plain, however, is more problematic to interpret. First, diversity is quite low in this area, with Grasshopper Sparrows being the primary obligate grassland species observed. Although this does not necessarily argue against grassland management, it does tie the management objectives to a small number of species. Second, most of the study fields in this physiographic region only recently came out of agricultural production, so the grasslands are not yet well established. On the other hand, it may be that the landscape in southern New Jersey and the Delmarva peninsula does not provide a hospitable matrix of habitats for grassland birds. Further study of these fields as they become more established will certainly help resolve this uncertainty.

So, this study provides information that tends to support the objective of managing for grassland birds, particularly for three physiographic regions, but it does not definitively resolve the question of whether Refuges should focus efforts on this bird guild. While the bird densities observed were respectable, the absolute number of obligate grassland birds supported by Refuge fields is fairly small, since Region 5 Refuges do not maintain extensive areas of grassland habitat. Several questions arise that deserve debate in the context of setting management goals for grasslands. (1) Do the birds that use these fields form an important component of a larger metapopulation on the landscape? Thus, do the Refuges have a larger impact than the small numbers suggest? (2) Do these Refuge fields, managed for breeding grassland birds, provide important habitat for grassland birds at other times of the year? (3) Are there peripheral benefits of managing for grassland birds that further justify such management? For instance, to what extent are native grassland plants or grassland-dependent invertebrates supported by managed grasslands, and how important are these plants and animals in setting station and regional goals? (4) What are the alternative management options for these grassland fields? What alternative types of upland habitat could be maintained on these lands, and which trust species would that benefit? (5) How should Refuges prioritize the multiple upland habitats and bird species, including grasslands and grassland dependent birds, included in national conservation plans, such as Partners in Flight plans? We hope it is clear that studies like this can provide data that inform such discussions, but ultimately, the management objectives need to be set as expressions of social values. Regional- and station-level objectives regarding managed grasslands need to be considered in the larger context of what benefit Refuges can serve on the landscape.

Habitat effects on grassland breeding bird use of fields

The remainder of this discussion assumes that there is an interest in managing for grassland birds. Given that interest, the next question is how habitat variables affect use of fields by grassland birds (Fig. 2). Our preliminary analysis suggests that although there is some effect of local (field-level) habitat variables (Figs. 6 and 7), the bulk of the variation across the Region in grassland bird density is explained by landscape variables. That is, the landscape context of each Refuge appears to play a much more important role in determining grassland use than the local characteristics of each field. Other authors have found that landscape variables, such as the proportion of grassland cover or total woodland edge density in the immediate landscape, are important predictors of grassland bird density (Fletcher and Koford 2002). This suggests two possible (and not exclusive) strategies: first, focus efforts in those areas where the landscape context supports grassland birds (e.g., Missisquoi, Iroquois, and Eastern Virginia Rivers, and others); and second, begin to understand the factors in the landscape context that matter, and seek to change them. Regarding the second point, for example, it may be that the landscape context for grassland birds on the Delmarva will improve over the next decade as more land is removed from active agricultural production and as existing fields mature. The primary point is that the decision to manage for grassland birds needs to be made with attention to the surrounding landscape.

Management effects

Given that a Refuge wants to manage for grassland birds, and that the landscape context has been appropriately considered, how can management actions improve the habitat? The two primary management tools available are grassland establishment techniques (seed mixtures, planting techniques and weed control measures), and the disturbance methods used to maintain fields in a state of early succession. In this study, planted warm-season grass fields did *not* attract a demonstrably higher density of obligate grassland birds than their cool-season or fallow counterparts (Fig. 3, Table 6). Further, the burning treatment prescribed for warm-season grass fields produced only minor and short-lived beneficial effects (see Figs. 8, 9, and 14). There are a number of reasons to question these conclusions (see “Planted warm-season grass fields” below), but on the face of it, warm-season grass fields, *as they have been created in Region 5*, do not appear to be achieving the desired results with regard to grassland birds, at least not yet.

It may be that cool-season grass and fallow fields, especially if mowed rather than burned, are a more effective way to manage for grassland birds. Burning cool-season grass fields in the spring does not appear to be an effective management option. Such management increases height-density of the grass over time (Fig. 9), reduces grass cover in the short-term (Fig. 10), shifts the grass community toward greater warm-season grass cover (Fig. 13), and has no effect on grassland bird use (Fig. 8). Alternatively, mowing cool-season grass fields affects the vegetation in a manner similar to burning warm-season grass fields: it temporarily decreases vegetation height-density (Fig. 9), increases grass cover (Fig. 11), maintains the grass community (Fig. 13), and has a positive, though not permanent, impact on grassland bird use (Fig. 8).

In short, for the types of fields currently found on Region 5 Refuges, and for the management methods as currently practiced, our preliminary results suggest two tentative conclusions: (1) there is not yet evidence that we know how to establish warm-season grass fields that are superior habitat for grassland birds; and (2) mowing cool-season and fallow fields on a regular, though not necessarily annual, cycle may be an effective way to maintain habitat for obligate grassland birds.

Planted warm-season grass fields

There has been considerable attention given to the planting of warm-season grass fields in the Northeast, with some controversy over whether this is an appropriate practice. On average, our results suggest that the five warm-season grass fields on Region 5 Refuges are not demonstrably better than their local fallow counterparts. But, careful consideration of each of these fields separately clouds this conclusion to some extent. The pattern of response by grassland birds to treatment of these fields varies considerably by Refuge (Fig. 15), as does the vegetative response

(Fig. 16). The field at Iroquois (Contaminant field) showed the expected vegetative response—reduced height-density for one year, with a return to pre-treatment levels—and a positive bird response over two years. However, this field contains almost no warm-season grass (warm-season grass cover < 5%, compared to ~20% at Montezuma and 60-80% at Bombay Hook). Here is a case where the planted warm-season grass did not become established. The warm-season grass field at Montezuma (Avery field) has higher cover in warm-season grass and showed mostly expected vegetative response to treatment, but does not attract very high densities of grassland birds. We suspect that this is because the vegetation is too rank, in ways not captured by our data, for grassland bird use. The field at Bombay Hook (field 101a) has the best-established community of warm-season grass, but attracts no obligate grassland birds, perhaps because it is quite small (8.2 ha), surrounded by trees on three sides, and is crossed with old ditches. The field at Eastern Virginia Rivers (Tayloe), like the others, is still in the process of becoming established, which may explain the monotonic increase in height-density, and the monotonic decrease in grassland bird use. The field at Erie (NG-40), like the field at Iroquois, does not appear to have a lot of warm-season grass cover, but showed a strong and expected vegetative response to burning; it's not clear why grassland bird use declined so sharply in the third year of the study.

The point of this discussion of the individual warm-season grass fields is twofold. First, as we proceed with more detailed analysis of all the fields, we may find that there are important individual differences that reflect context, history, and other unmeasured habitat variables. Second, the warm-season grass fields in Region 5 are not created equally, and it's not clear that any of them yet represent the intended ideal plant community for this habitat type.

Future analyses

As mentioned at several points in this report, the analysis to date is preliminary. There are a number of fairly extensive additional analyses we intend to undertake. First, we have not yet formally accounted for detection probability in the point count analysis. Not only are we interested in getting more accurate estimates of bird density, we are interested in understanding what factors affect detectability. We hope this leads to some recommendations for standardized regional protocols for measuring bird density in grasslands. Second, we will undertake some analysis of the vegetation methods. For instance, there is a suggestion in some of the preliminary data that height-density in a field may be very sensitive to the timing of measurement, and we wish to understand how that variable might affect our conclusions. Further, some of the vegetation measurements may not be robust to differences in observers. We need to understand these aspects of the methods to understand our results and to be able to make recommendations about standardized protocols for vegetation measurement. Third, so far, we have only analyzed the response of obligate grassland birds, but the majority of species using these fields are grassland generalists. So we do not yet have a full picture of the contribution these fields make for birds. We will conduct analyses similar to those contained in this report, looking at this larger suite of bird species. Fourth, there are more specific vegetation variables that we have not yet analyzed, in particular, cover by plant species, and proportions of native and non-native species. These analyses will allow us to ask such questions as how *Solidago* spp. responded to fire, whether and how the plant community changed with treatment or over time, etc. Fifth, as noted earlier, we will break all of these results down by Refuge to offer more site-specific analyses. It will be important both to look for common trends across Refuges and to identify significant departures from general trends.

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Table 1. Refuges participating in the Regional Grassland Breeding Bird study, corresponding Partners in Flight (PIF) Physiographic Regions, ranking of grassland habitats as priorities in PIF bird conservation plans, and current PIF grassland objectives.

Refuge	PIF Physiographic Area	Priority Habitats, Ranked in Order of Regional Priority	Grassland Habitat Objectives
Rachel Carson NWR	(09) Southern New England	1. Maritime marshes 2. Beach dune 3. Mature deciduous and 4. mixed forest 5. Early successional shrub/pitch pine barren ***6. Grassland agricultural***	"Roughly 10,000 – 15,000 ha (45,000 ac) of grassland habitat is needed to support the entire grassland habitat-species suite"
Canaan Valley NWR	(12) Mid-Atlantic Ridge and Valley	1. Early succession shrub 2. Mature deciduous forest ***3. Grasslands*** 4. Northern hardwood/spruce-fir forests	"Roughly 10,000 ha of suitable grassland habitat is required to support entire habitat -species suite (e.g., 8,500 pairs of Bobolinks); protection and management of any sites supporting Henslow's Sparrow should be a high priority."
Iroquois NWR, Montezuma NWR	(15) Lower Great Lakes Plain	***1. Grasslands/agricultural*** 2. Scrub-shrub 3. Hardwood forest	"Roughly 160,000 ha of grassland habitat is required to support entire habitat-species suite (e.g., 140,000 pairs of Bobolinks); of this 8,000 ha should be maintained in patches large enough to support 600 pairs of Upland Sandpipers, and 1,000 ha should be managed specifically to support 500 pairs of Henslow's Sparrows"
Wallkill River NWR	(17) Northern Ridge and Valley	1. Scrub-shrub 2. Hardwood forest ***3. Grasslands***	"Roughly 13,000 ha of pastureland are required to support 12,000 pairs of Bobolinks and other grassland species; at least 1,000 ha should be in patches large enough to support 50+ pairs of Upland Sandpipers and potentially Henslow's Sparrow."
Missisquoi NWR	(18) St. Lawrence Plain	***1. Agricultural grassland*** 2. Shrub-early successional 3. Riparian-deciduous mixed forest 4. Freshwater wetland	"Roughly 775,000 ha of suitable grassland habitat is required to support the entire habitat-species suite (e.g., 680,000 pairs of Bobolinks), with 100,000 ha maintained in large enough patches to support 7,600 pairs of Upland Sandpipers, and 1,000 ha to support 500 pairs of Henslow's Sparrows in NY"
Erie NWR	(24) Allegheny Plateau	***1. Grasslands*** 2. Disturbance/scrub-shrub 3. Mature deciduous and mixed forest 4. Mountaintop coniferous	"Roughly 30,000 ha of grassland habitat is required to support entire habitat-species suite (e.g., 275,000 pairs of Bobolinks); of this, 1,200 ha should be suitable to support 2,500 pairs of Henslow's Sparrow, and 3,300 ha should be in patches large enough to support 250 pairs of Upland Sandpipers"
Bombay Hook NWR, Prime Hook NWR, Eastern Neck NWR, Eastern Virginia Rivers NWR, Patuxent NRR, and Supawna Meadows NWR	(44) Mid Atlantic Coastal Plain	1. Pine savannah 2. Barrier and bay islands 3. Salt marsh 4. Forested wetland 5. Mixed upland forest ***6. Early successional*** 7. Pine plantation 8. Fresh/brackish emergent wetland	"Maintain enough open grasslands (in combination with high-marsh habitat) to support 200 pairs of Henslow's Sparrows and 100,000 pairs of Grasshopper Sparrows across the planning unit." [no acreage goals]

Table 2. Estimates of grassland bird productivity from the Northeast and the Midwest.

Species	Location	Daily Survival	Nest Survival	Cowbird Parasitism (%)	Source
EAME	Iroquois NWR	0.988	0.74	0	C.J. Norment, unpubl. data
EAME	Canaan NWR	0.959	0.35	0	K.A. Warren, unpubl. data
EAME	Midwest	0.920	0.21	31	Several
BOBO	Iroquois NWR	0.980	0.62	0	C.J. Norment, unpubl. data
BOBO	Fort Drum, NY	--	0.53	0	Bollsinger et al. n.d.
BOBO	Canaan NWR	0.978	0.58	0	K.A. Warren, unpubl. data
BOBO	Midwest	0.962	0.40	24	Several
SAVS	Iroquois NWR	0.985	0.70	0.9	C.J. Norment, unpubl. data
SAVS	Fort Drum, NY	--	0.59	1.1	Bollsinger et al. n.d.
SAVS	Canaan NWR	0.953	0.33	0	K.A. Warren, unpubl. data
SAVS	Midwest	0.918	0.71	33	Several
GRSP	Delmarva	0.973	0.56	--	D.E. Gill, unpubl. data

Table 3. Bird density estimates from other grassland bird studies. The methods by which the densities were estimated include point-centered count (PC), transect (T), Breeding Bird Survey (BBS), and spot-mapping (SM). The densities are given as individuals per hectare, unless otherwise noted.

Location	Species	Density (birds per ha)	Habitat	Method	Source
NY	BOBO	0.84	Cool Season	PC	Bollsinger n.d.
NY	BOBO	0.91 (males)	Hayfield	T	Bollinger and Gavin 1992
NY	EAME	0.03	Cool Season	PC	Bollsinger n.d.
NY	SAVS	0.68	Cool Season	PC	Bollsinger n.d.
MidW	BOBO	0.33 (males)	Mixed-grass	BBS	Bollinger and Gavin 1992
MidW	BOBO	0.26 (males)	Tall-grass	BBS	Bollinger and Gavin 1992
MidW	SAVS	1.40 (pairs)	Grassland	SM	Potter 1974
IA	All	1.62	CRP	SM	Patterson and Best 1996
IL	BOBO	0.12	Ungrazed grass	?	Graber and Graber 1963
IL	BOBO	1.09 – 1.23	Hayfield	?	Graber and Graber 1963
IL	BOBO	0.005 – 0.013 (males)	Prairie	T	Herkert 1994
IL	EAME	0.11 – 0.13 (males)	Prairie	T	Herkert 1994
IL	GRSP	0.02 – 0.42 (males)	Prairie	T	Herkert 1994
IL	HESP	0.0 – 0.02 (males)	Prairie	T	Herkert 1994
MO	All	1.8 – 1.66 (males)	Tall-grass	T	Winter and Faaborg 1999
ND	All	0.75 – 1.90	Mixed-grass	T	George et al. 1992
ND	All	0.63 (males)	Prairie	SM	Renken and Dinsmore 1987
ND	All	0.50 (males)	Hayfield	SM	Renken and Dinsmore 1987
ND	SAVS	0.12 – 0.27	Grassland	PC	Scheiman et al. 2003
NE	All	1.92 – 3.83	CRP	T	Delisle and Savidge 1997
WI	All	2.51 (pairs)	Tall-grass	SM	Wiens 1969
WI	BOBO	0.18 (pairs)	Tall-grass	SM	Wiens 1969
WI	SAVS	0.70 (pairs)	Tall-grass	SM	Wiens 1969
WI	*Sturnella* sp.	0.27 (pairs)	Tall-grass	SM	Wiens 1969

Table 4. Modified Mueller-Dambois and Ellenberg scale, used for the vegetation cover measurements.

Class	***Cover***	***Midpoint***
A	1 – 5 %	2.5 %
B_1	5 – 15 %	10.0 %
B_2	15 – 25%	20.0%
C	25 – 50 %	37.5 %
D	50 – 75 %	62.5 %
E	75 – 100 %	87.5 %

Table 5. Invasive plants of management concern to National Wildlife Refuges, Region 5. Plants are listed alphabetically by scientific name. Only plants likely to be found in open fields are listed.

Scientific Name	**Common Name**	**Likely Distribution in Region 5**
Ampelopsis brevipedunculata	porcelain-berry	throughout
Celastrus orbiculata	Asian bittersweet	throughout
Centaurea biebersteinii	spotted knapweed	throughout
Cirsium arvense	Canada thistle	throughout
Coronilla varia	crown-vetch	throughout
Elaeagnus angustifolia	Russian olive	throughout
Elaeagnus umbellata	autumn olive	throughout
Euphorbia esula	leafy spurge	ME to MD
Lepidium latifolium	perennial pepperweed	coastal MA and NY
Lespedeza cuneata	Chinese lespedeza	NY, MA and south
Lonicera japonica	Japanese honeysuckle	throughout
Lonicera morrowii	Morrow’s honeysuckle	throughout
Lonicera tartarica	tartarian honeysuckle	throughout
Lythrum salicaria	purple loosestrife	N. England, NY, PA, NJ
Microstegium vimineum	Japanese stilt grass	NY, CT and south
Polygonum cuspidatum	Japanese knotweed	throughout
Polygonum perfoliatum	mile-a-minute weed	PA, MD, WV, DE, VA
Rhamnus spp.	buckthorn	throughout
Robinia pseudoacacia	black locust	Considered invasive north of PA
Rosa multiflora	multiflora rose	throughout
Sorghum halepense	johnsongrass	throughout except ME
Trifolium lappaceum	burdock	throughout
Vincetoxicum nigrum	black swallow-wort	NJ, PA and north

Table 6. Grassland breeding bird density and abundance on study fields at each Refuge.

	Obligate Density /ha		**Obligate Abundance**	
	CS/Fallow	**WSG**	**CS/Fallow**	**WSG**
Bombay Hook	0.19	0.00	4.65	0.00
Canaan	1.09		50.02	
Erie	1.75	1.57	45.78	19.38
Eastern Neck	0.04		0.84	
Eastern VA Rivers	1.04	1.75	76.72	35.89
Iroquois	2.06	1.96	63.54	32.17
Missisquoi	4.77		120.40	
Montezuma	1.16	1.02	29.20	19.17
Prime Hook	0.19		10.14	
Patuxent	0.64		14.31	
Rachel Carson	1.41		46.66	
Supawna	0.03		0.85	
Wallkill	0.69		17.90	

Table 7. Grassland breeding bird species composition at each Refuge.

	BOBO	**GRSP**	**SAVS**	**EAME**	**HOLA**	**VESP**	**SEWR**	**UPSA**	**DICK**	**NOHA**
Bombay Hook	16.0%	78.0%			6.0%					
Canaan	28.4%	18.4%	38.5%	14.7%						
Erie	31.7%	26.6%	36.1%	3.6%	0.2%	1.5%	0.1%		0.2%	
Eastern Neck		100.0%								
Eastern VA Rivers	0.9%	97.2%		1.4%	0.2%				0.2%	0.1%
Iroquois	79.4%	3.2%	16.0%	1.3%						
Missisquoi	72.9%	0.3%	25.4%	1.5%						
Montezuma	54.3%		43.0%	0.3%			2.4%			
Prime Hook	3.2%	44.0%		10.1%	41.5%		1.3%			
Patuxent		77.3%		22.7%						
Rachel Carson	19.1%	16.5%	41.9%	11.0%		8.2%		3.4%		
Supawna	85.7%				14.3%					
Wallkill	84.7%	6.9%		8.3%						

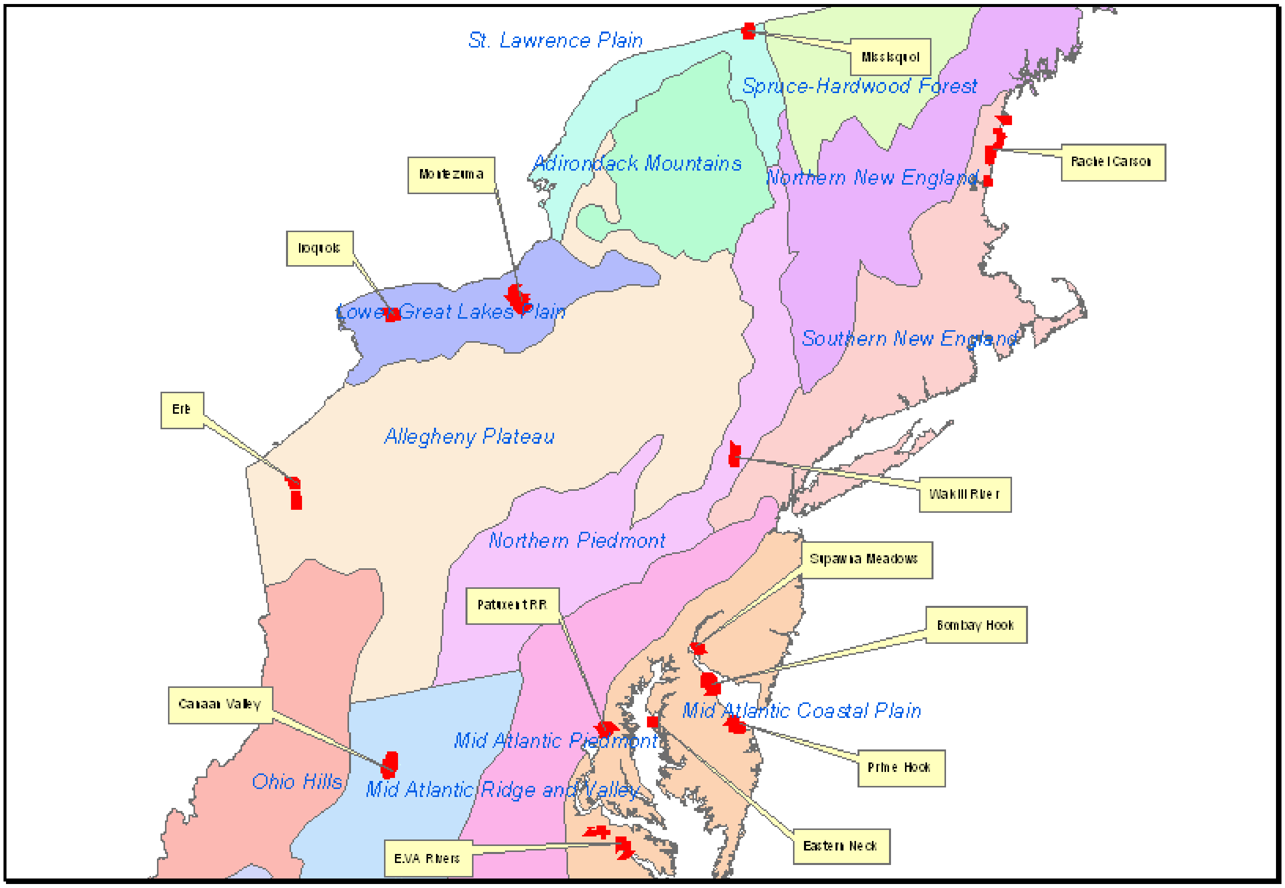

Figure 1. PIF physiographic regions in FWS Region 5. National Wildlife Refuges participating in the current study are highlighted (note, refuges are not mapped to scale—acreages are exaggerated for display purposes).

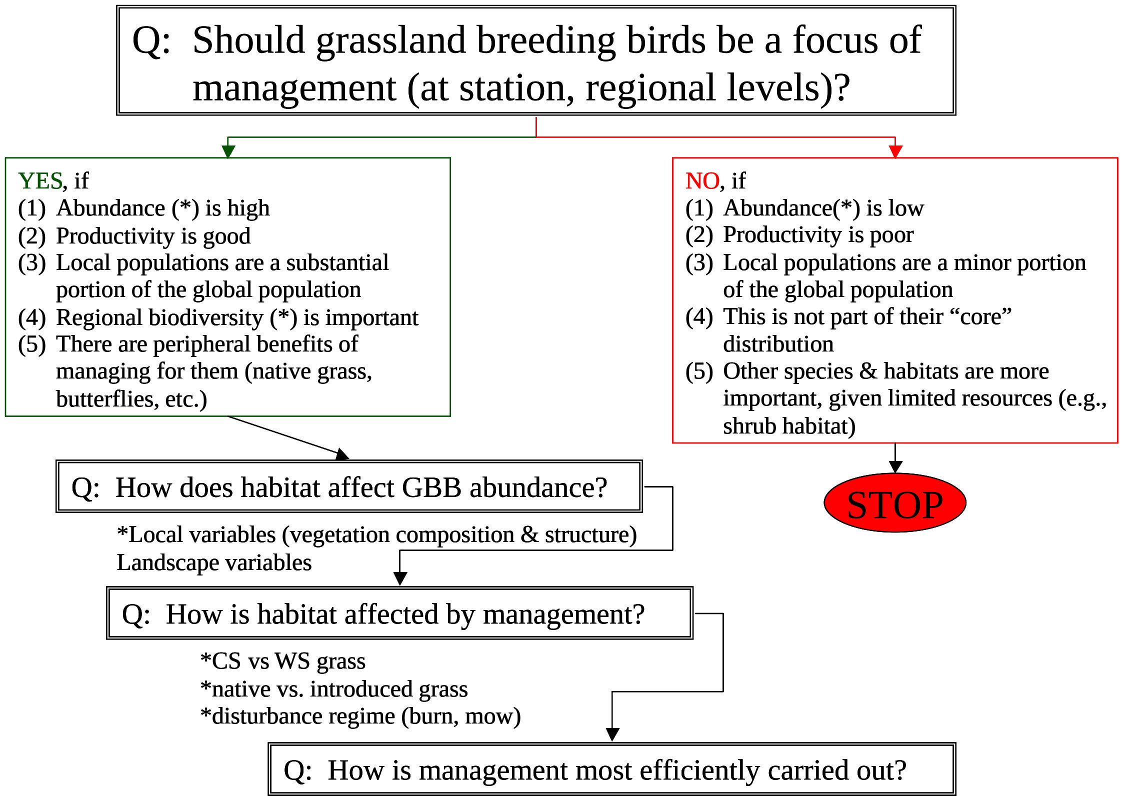

Figure 2. Sequence of questions to identify the role and methods for management of grassland birds. Asterisks (*) indicate elements that are addressed in this study.

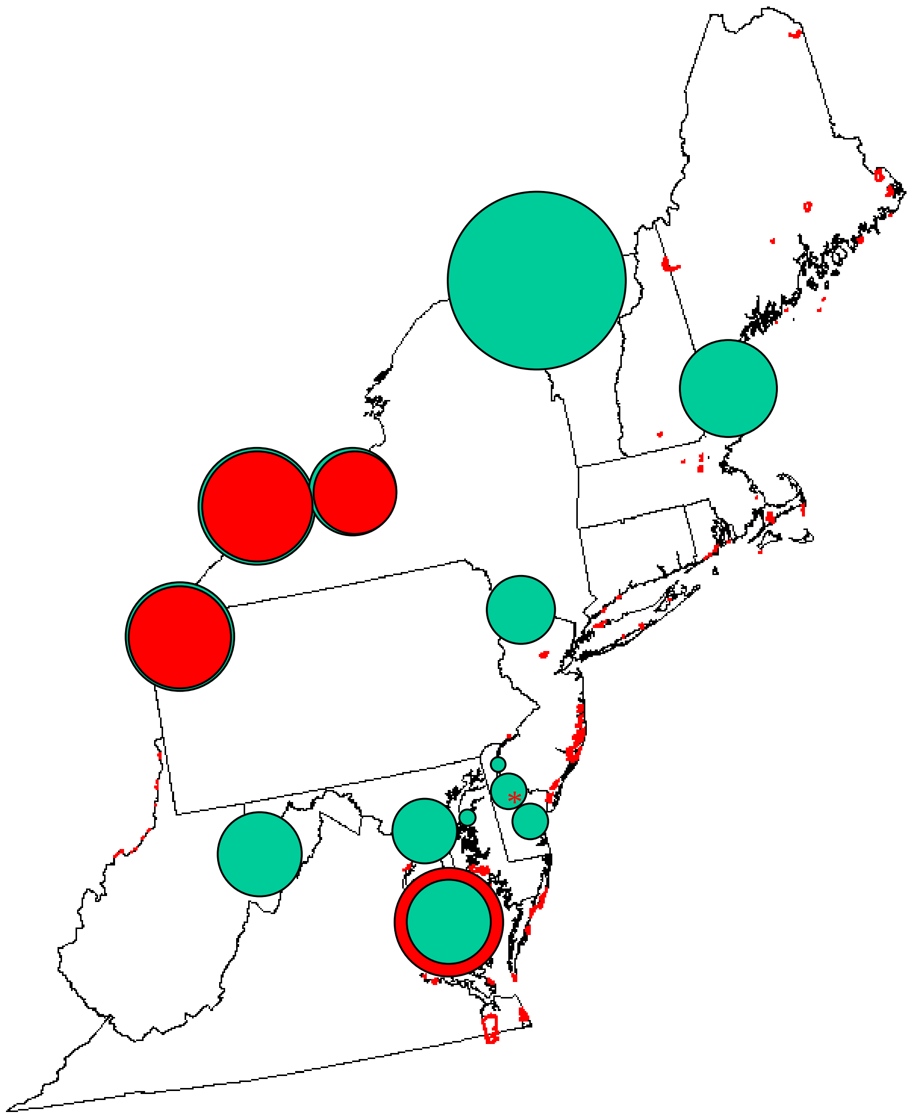

Figure 3. Obligate grassland bird density for each Refuge in the study. The area of each circle is proportional to the density (obligate birds/ha) on cool-season grass or fallow fields (aqua circles) and warm-season grass fields (red circles). The density shown is the sum of the highest annual densities for each field and thus represents a measure of the potential density under good conditions.

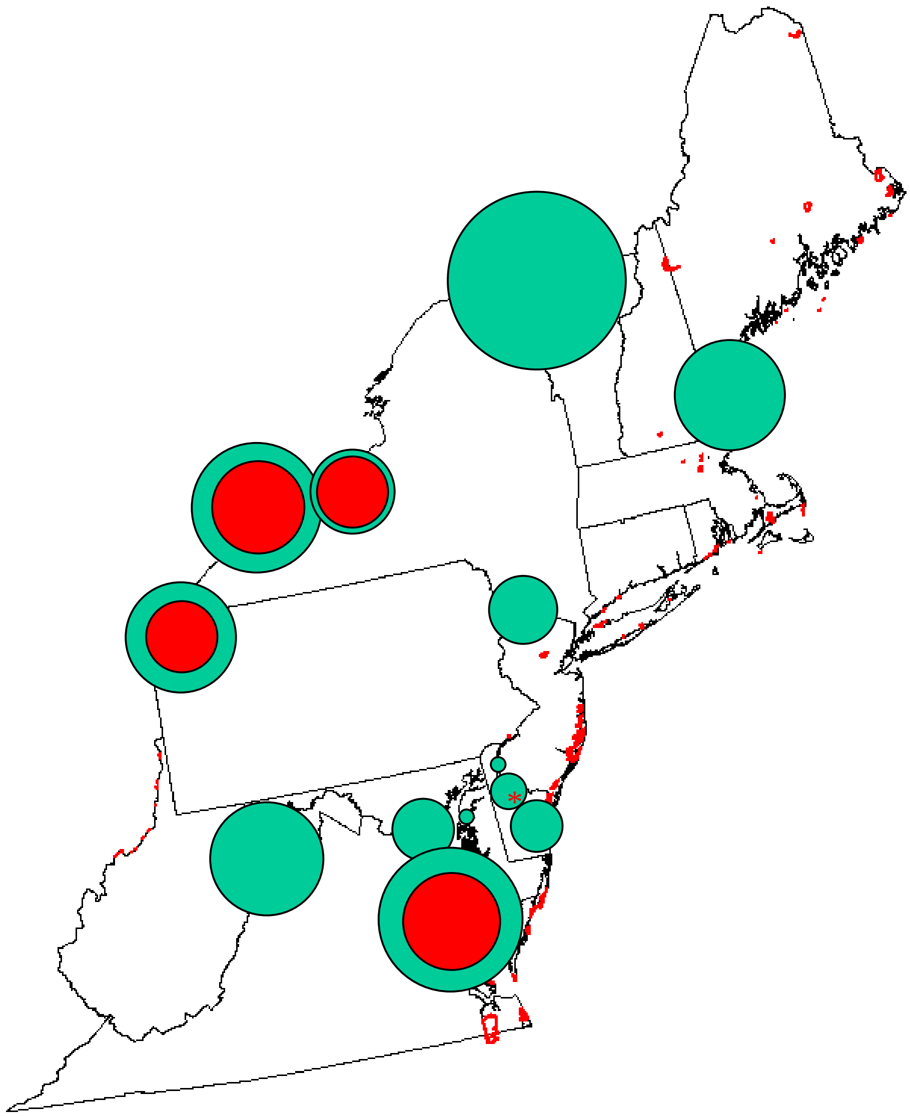

Figure 4. Obligate grassland bird abundance for each Refuge in the study. The area of each circle is proportional to the total number of obligate grassland birds estimated to be using the Refuge fields enrolled in the study; the cool-season grass or fallow fields are shown with aqua circles, and the warm-season grass fields are shown with red circles.

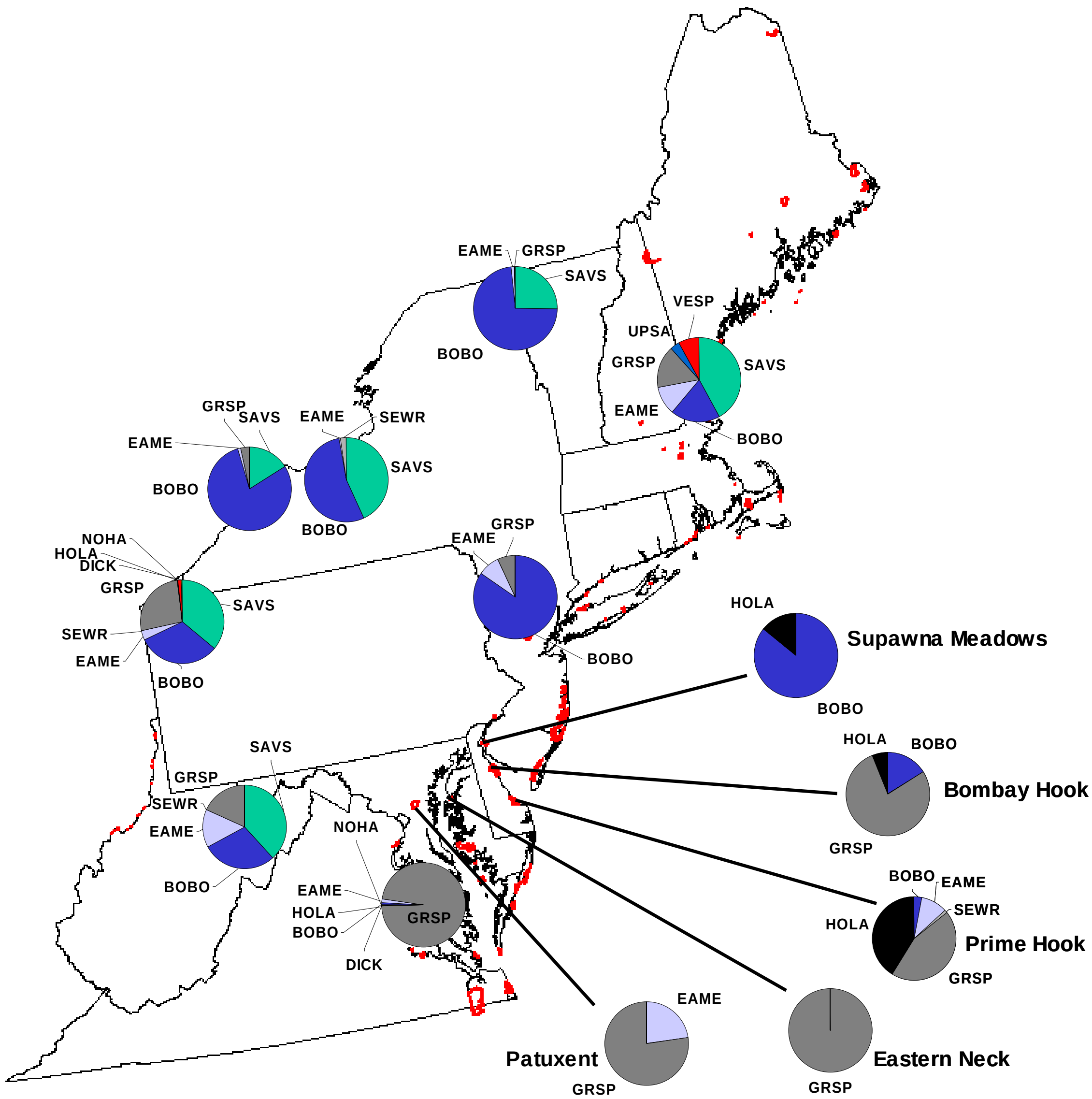

Figure 5. Obligate grassland breeding bird species composition for each Refuge in the study.

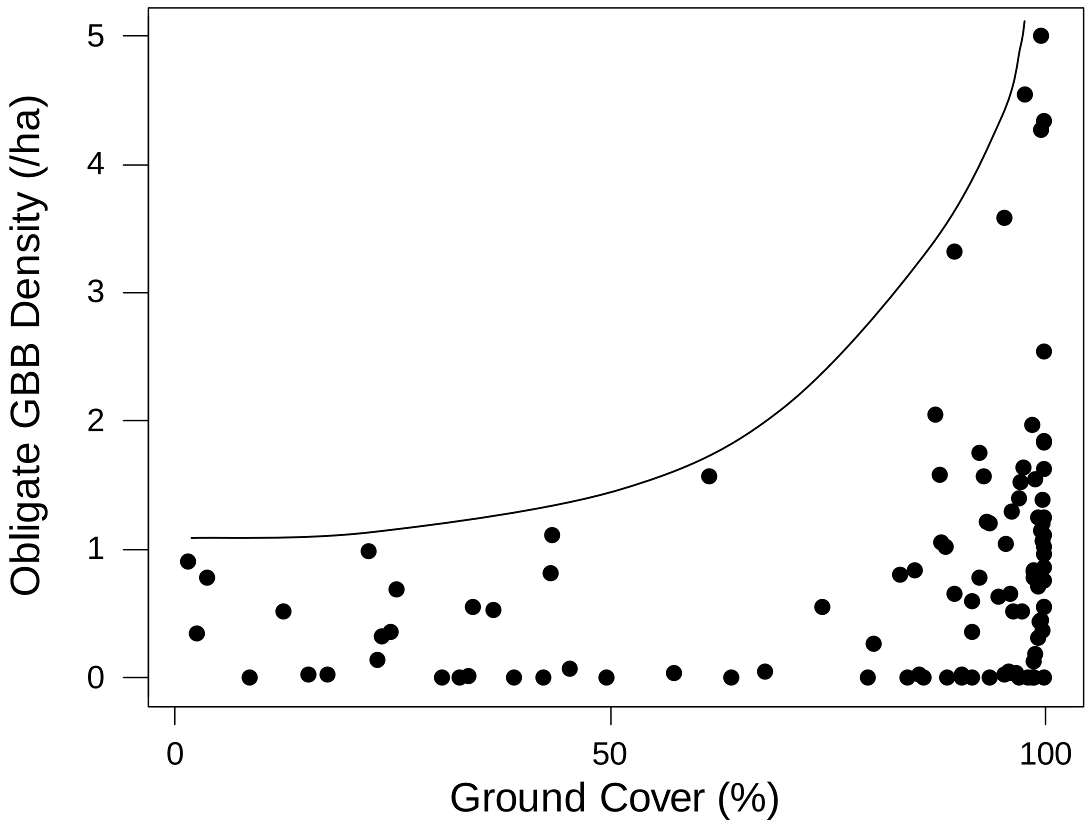

Figure 6. Obligate grassland breeding bird density (birds/ha) as a function of ground cover, for each field in each year of the study. Ground cover is the complement of bare ground, as measured by the frequency of interceptions that touched the ground without intercepting plant material or litter.

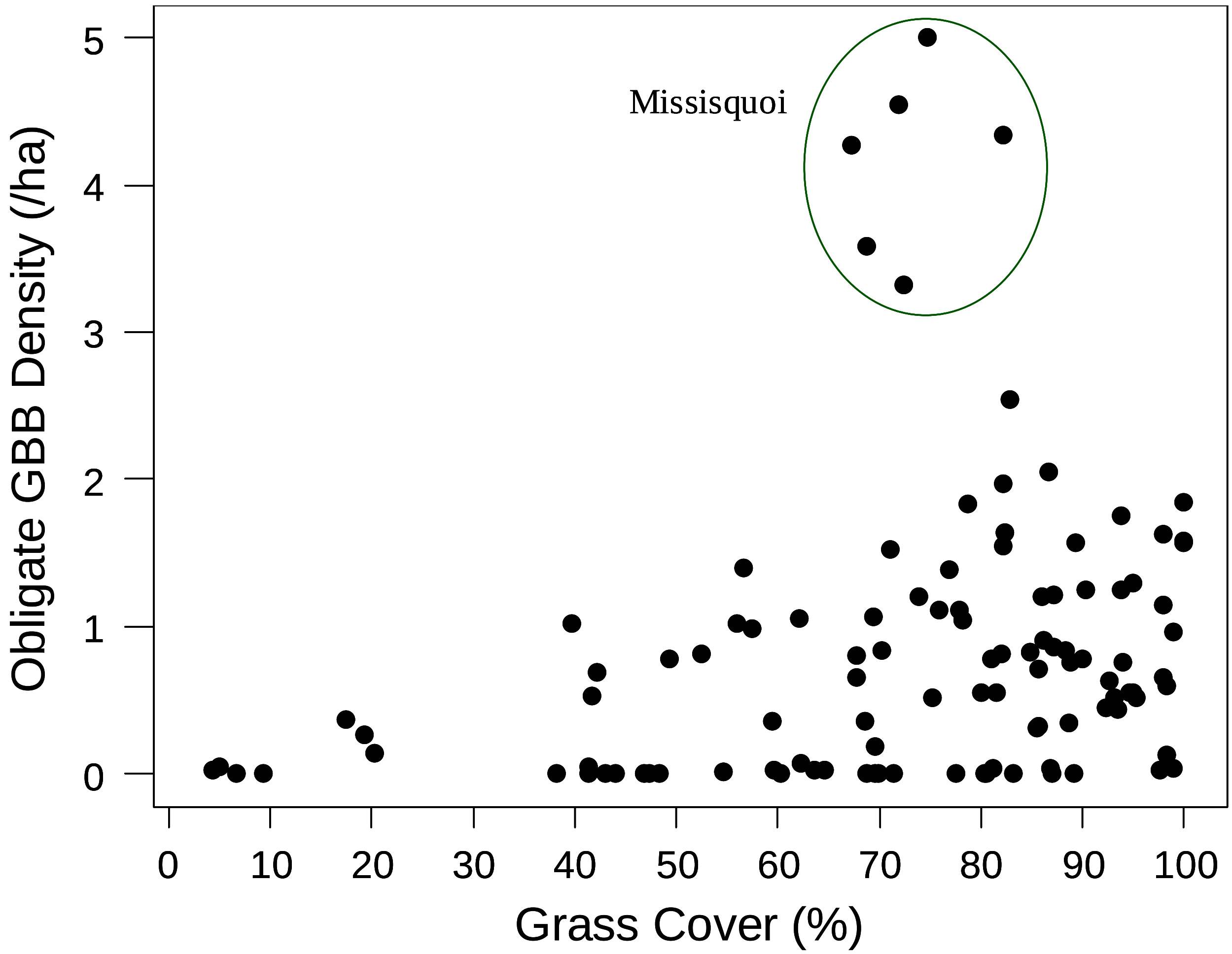

Figure 7. Obligate grassland breeding bird density (birds/ha) as a function of grass cover, for each field in each year of the study. Grass cover was measured as the frequency with which a rod intercepted live grass. The 6 points for Missisquoi NWR (3 yrs X 2 fields) are indicated.

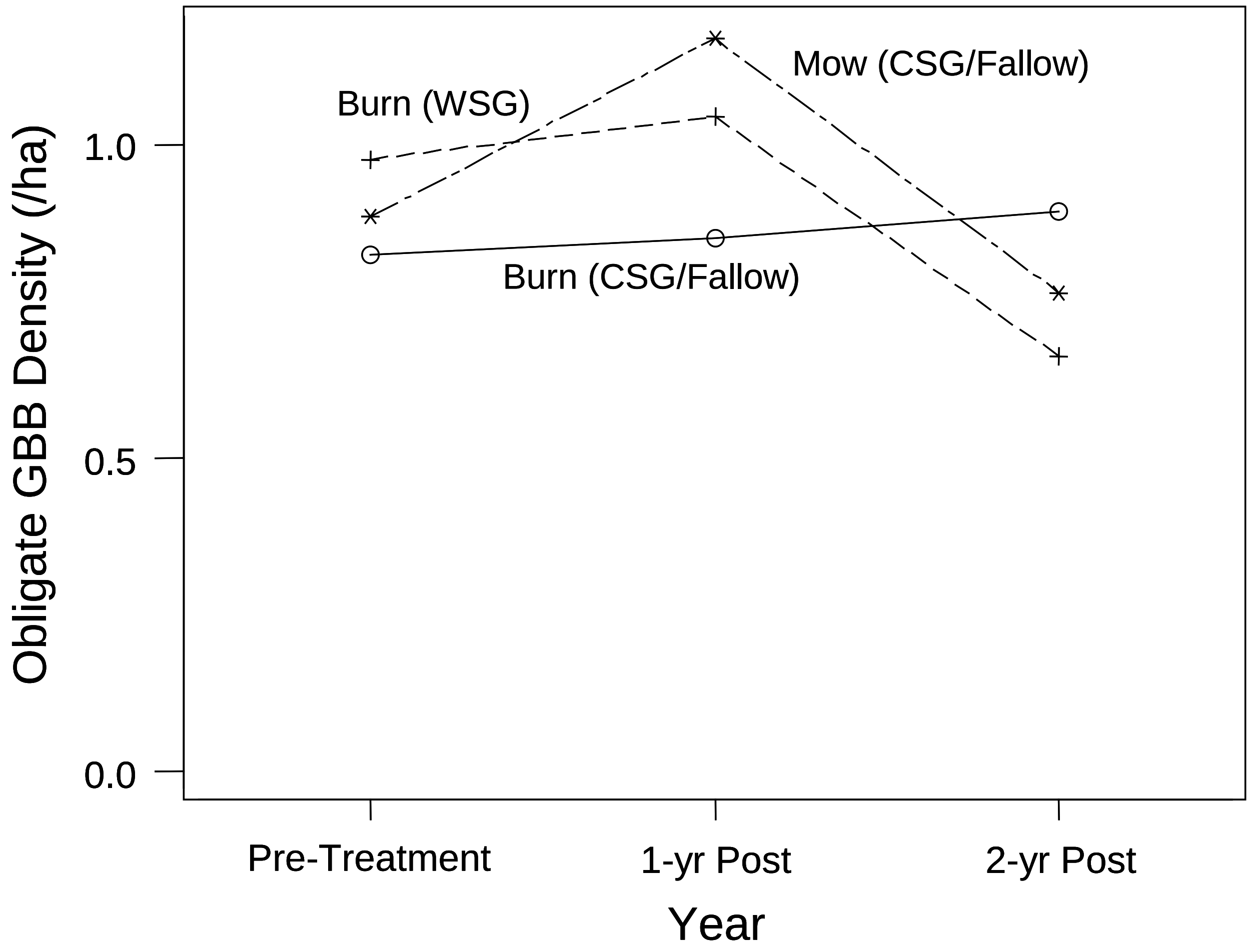

Figure 8. Obligate grassland breeding bird density (birds/ha) as a function of year (pre-treatment, 1-yr post-treatment, 2-yr post-treatment), for the three classes of treatment. These results represent an average over all fields (hence, Refuges) in each treatment category.

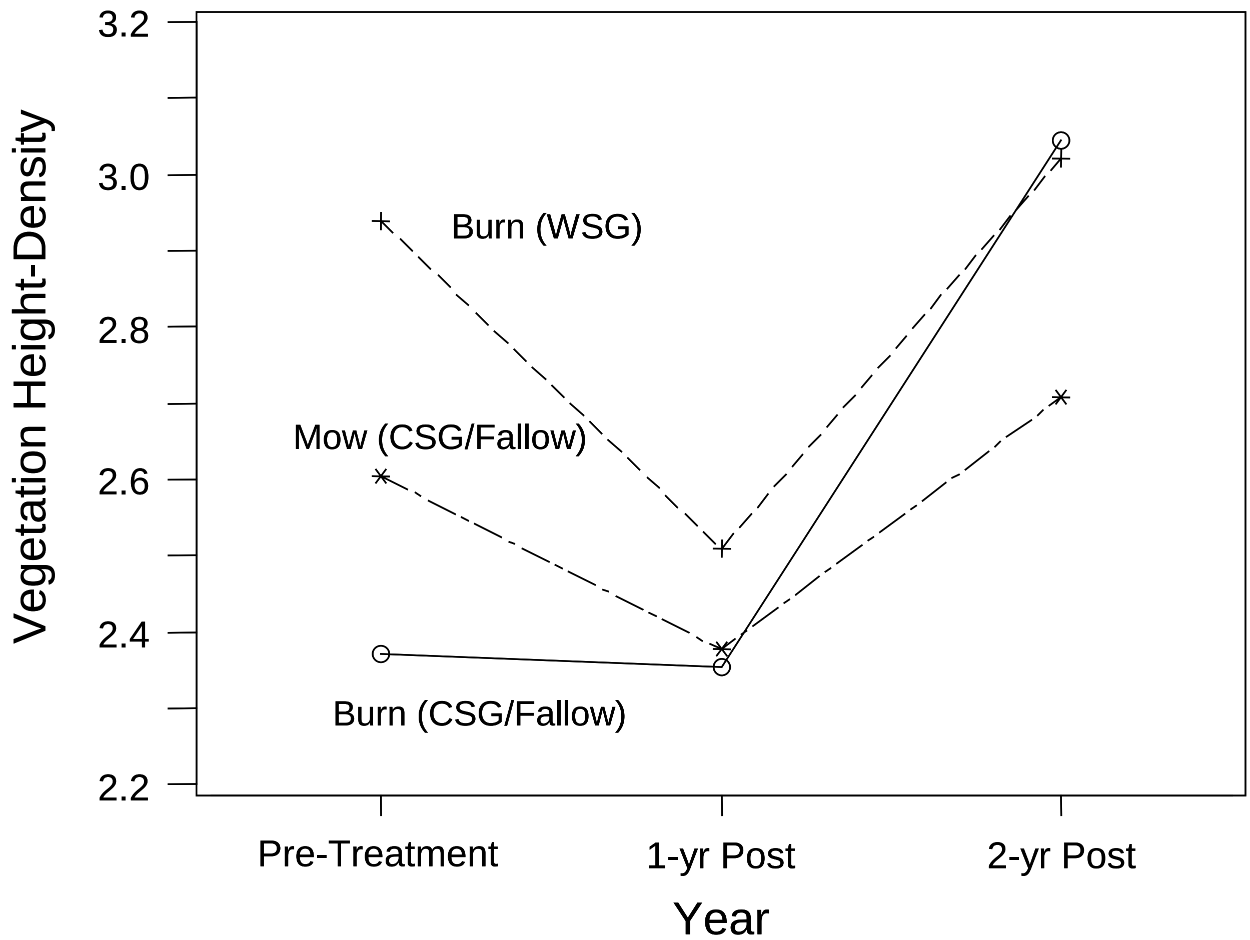

Figure 9. Mean vegetation height-density (Robel measurement) as a function of year (pre-treatment, 1-yr post-treatment, 2-yr post-treatment), for the three classes of treatment. These results represent an average over all fields (hence, Refuges) in each treatment category.

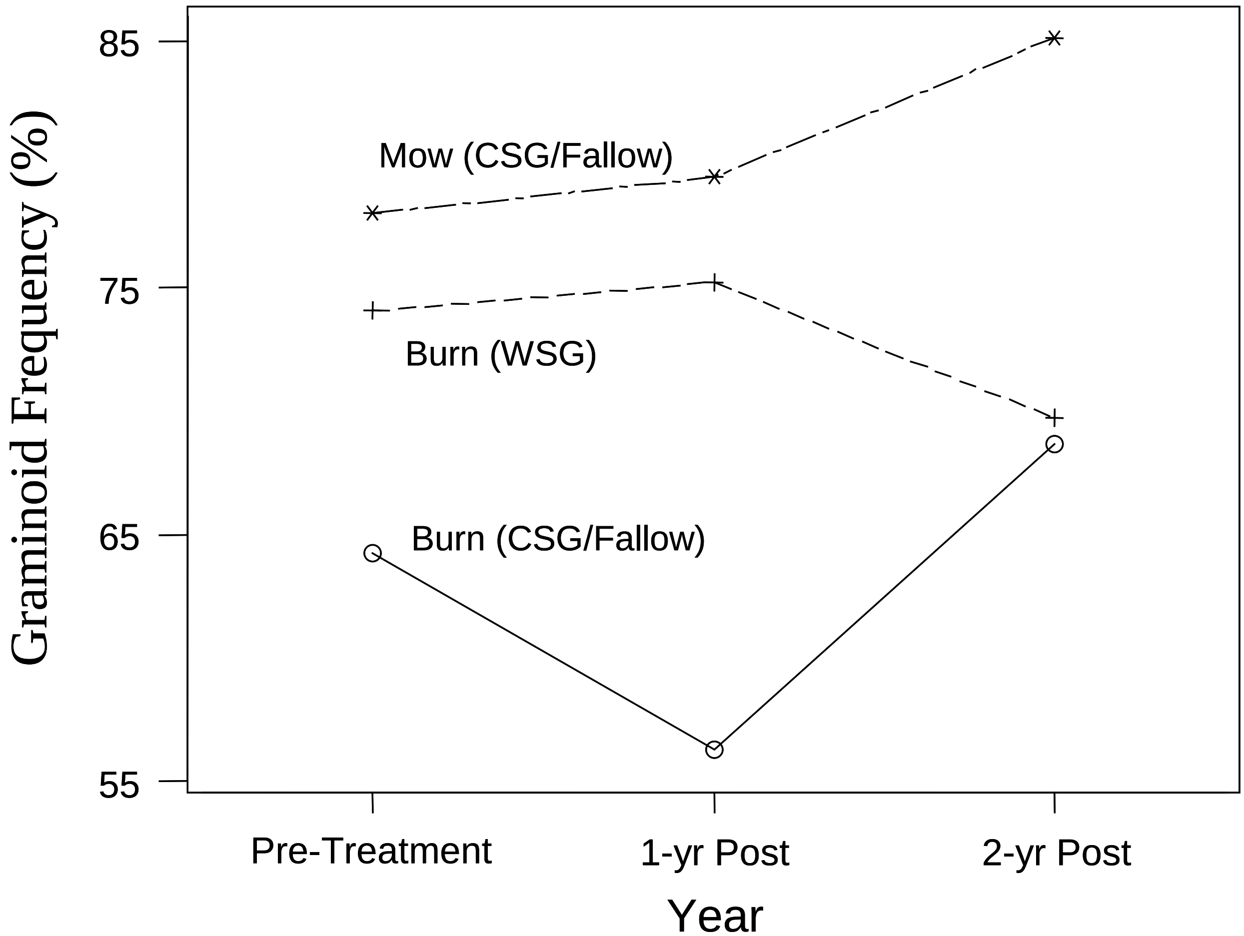

Figure 10. Grass cover (graminoid frequency) as a function of year (pre-treatment, 1-yr post-treatment, 2-yr post-treatment), for the three classes of treatment. These results represent an average over all fields (hence, Refuges) in each treatment category.

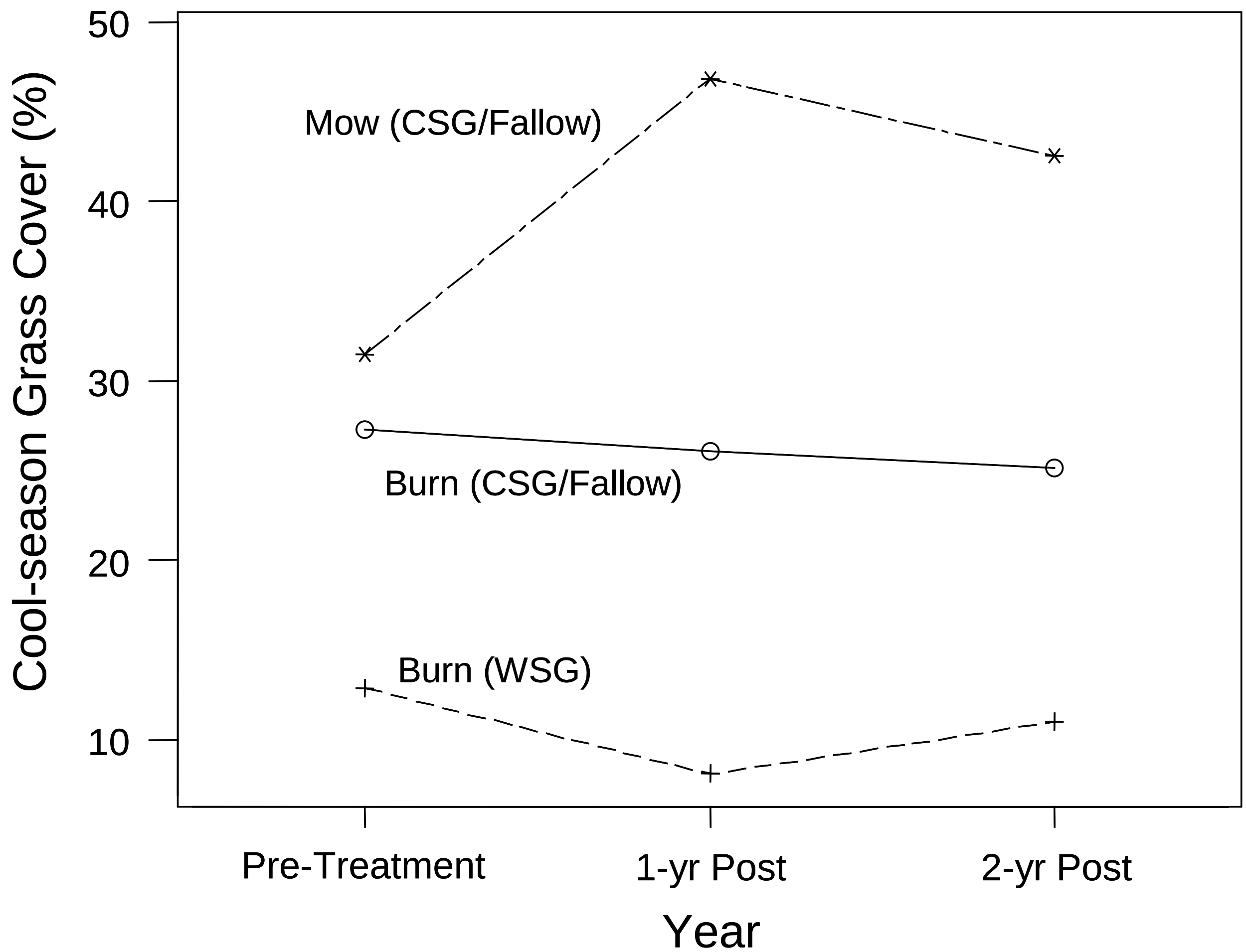

Figure 11. Cool-season grass cover as a function of year (pre-treatment, 1-yr post-treatment, 2-yr post-treatment), for the three classes of treatment. These results represent an average over all fields (hence, Refuges) in each treatment category. Grass cover was measured using the modified Mueller-Dambois and Ellenberg scale (Table 4).

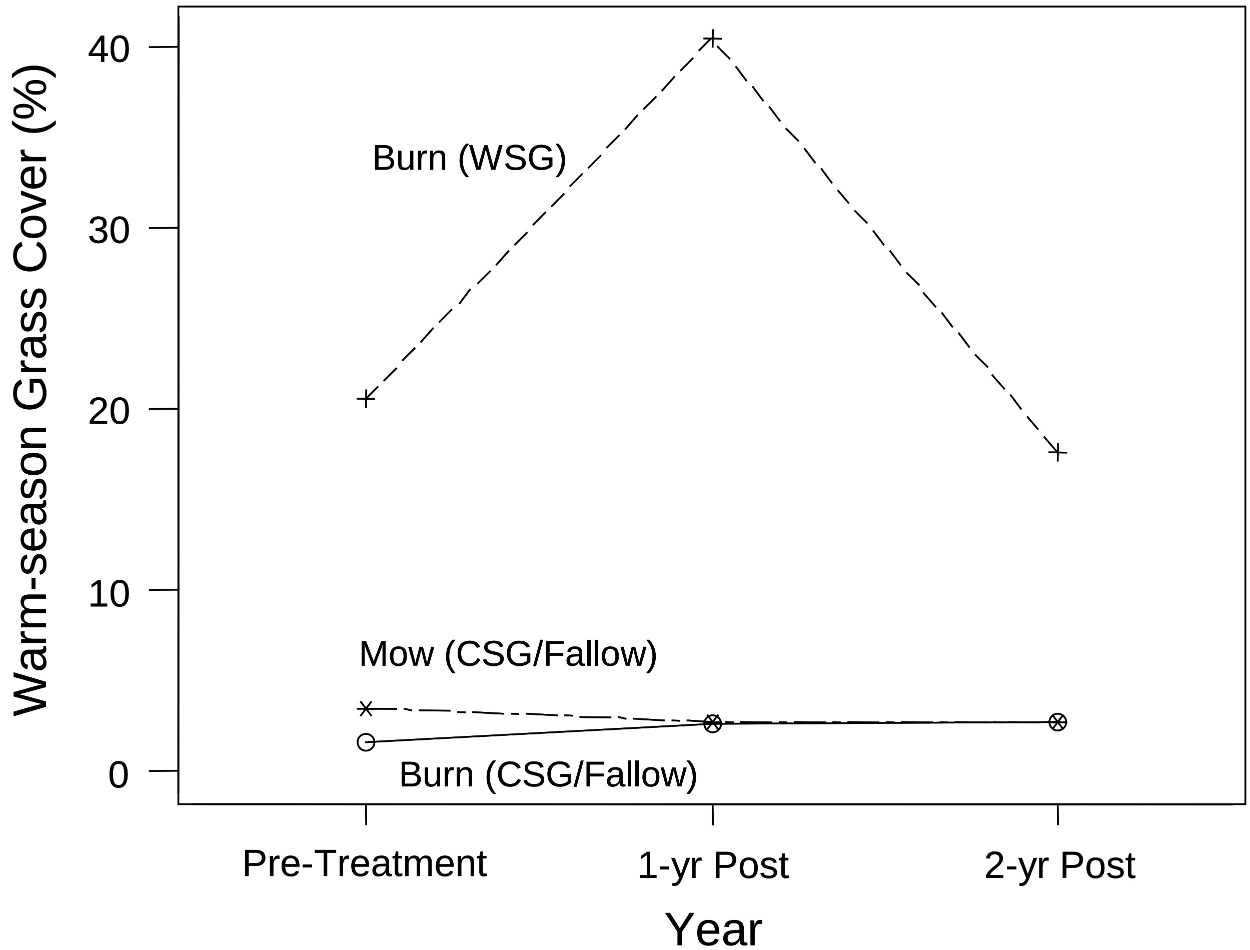

Figure 12. Warm-season grass cover as a function of year (pre-treatment, 1-yr post-treatment, 2-yr post-treatment), for the three classes of treatment. These results represent an average over all fields (hence, Refuges) in each treatment category. Grass cover was measured using the modified Mueller-Dambois and Ellenberg scale (Table 4).

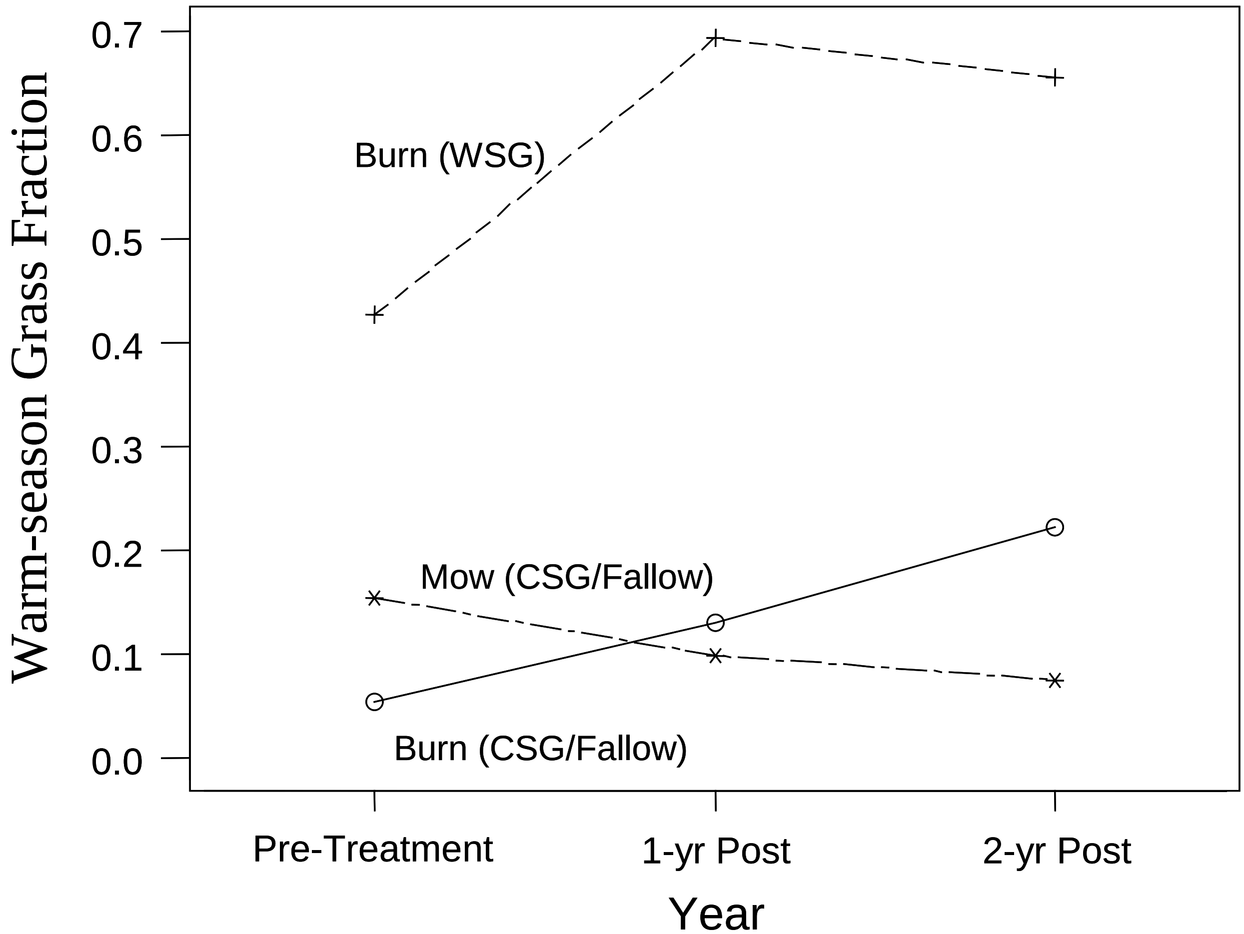

Figure 13. Warm-season grass fraction as a function of year (pre-treatment, 1-yr post-treatment, 2-yr post-treatment), for the three classes of treatment. These results represent an average over all fields (hence, Refuges) in each treatment category. The *y*-axis is the fraction of the grass cover that is composed of warm-season grass species.

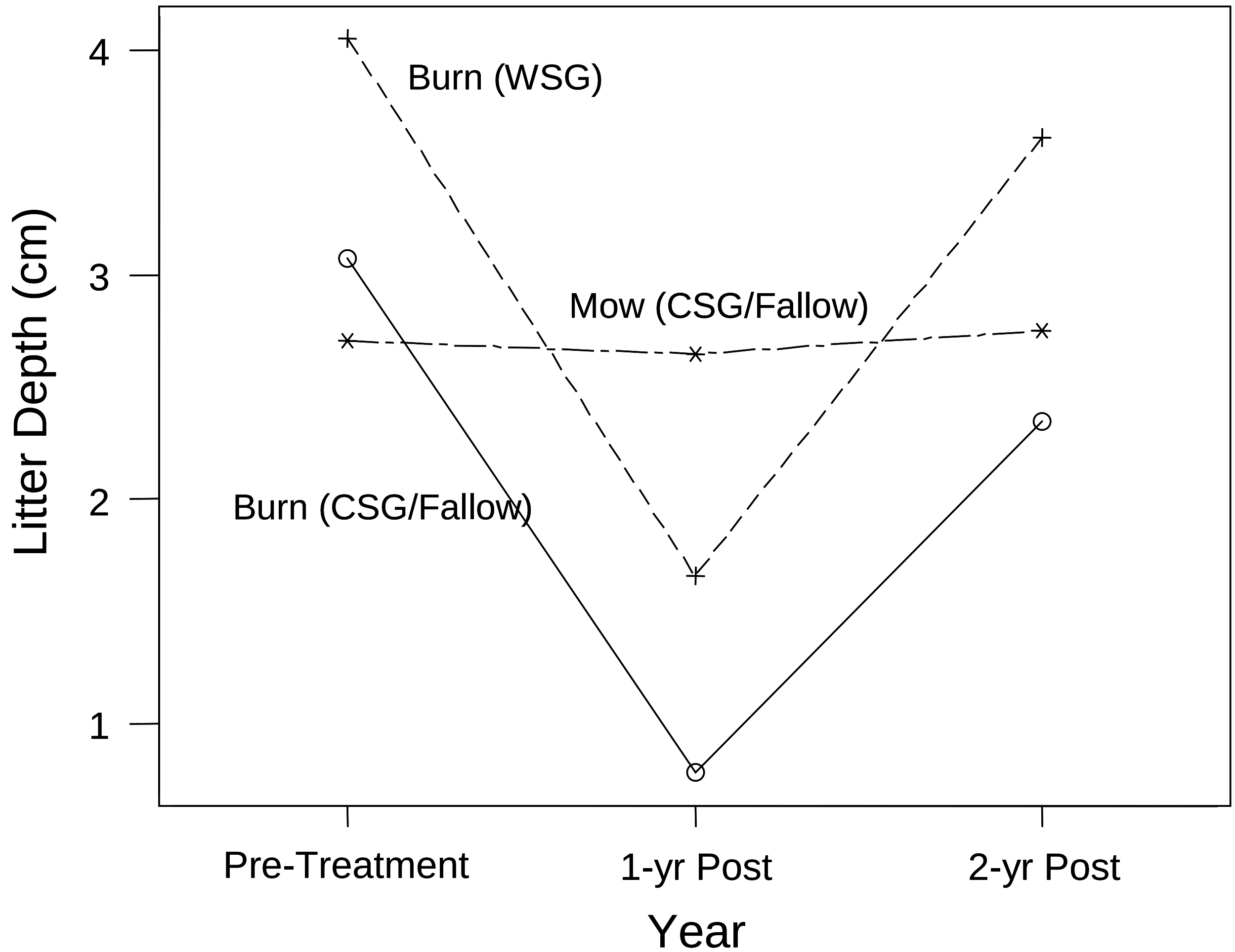

Figure 14. Litter depth (cm) as a function of year (pre-treatment, 1-yr post-treatment, 2-yr post-treatment), for the three classes of treatment. These results represent an average over all fields (hence, Refuges) in each treatment category.

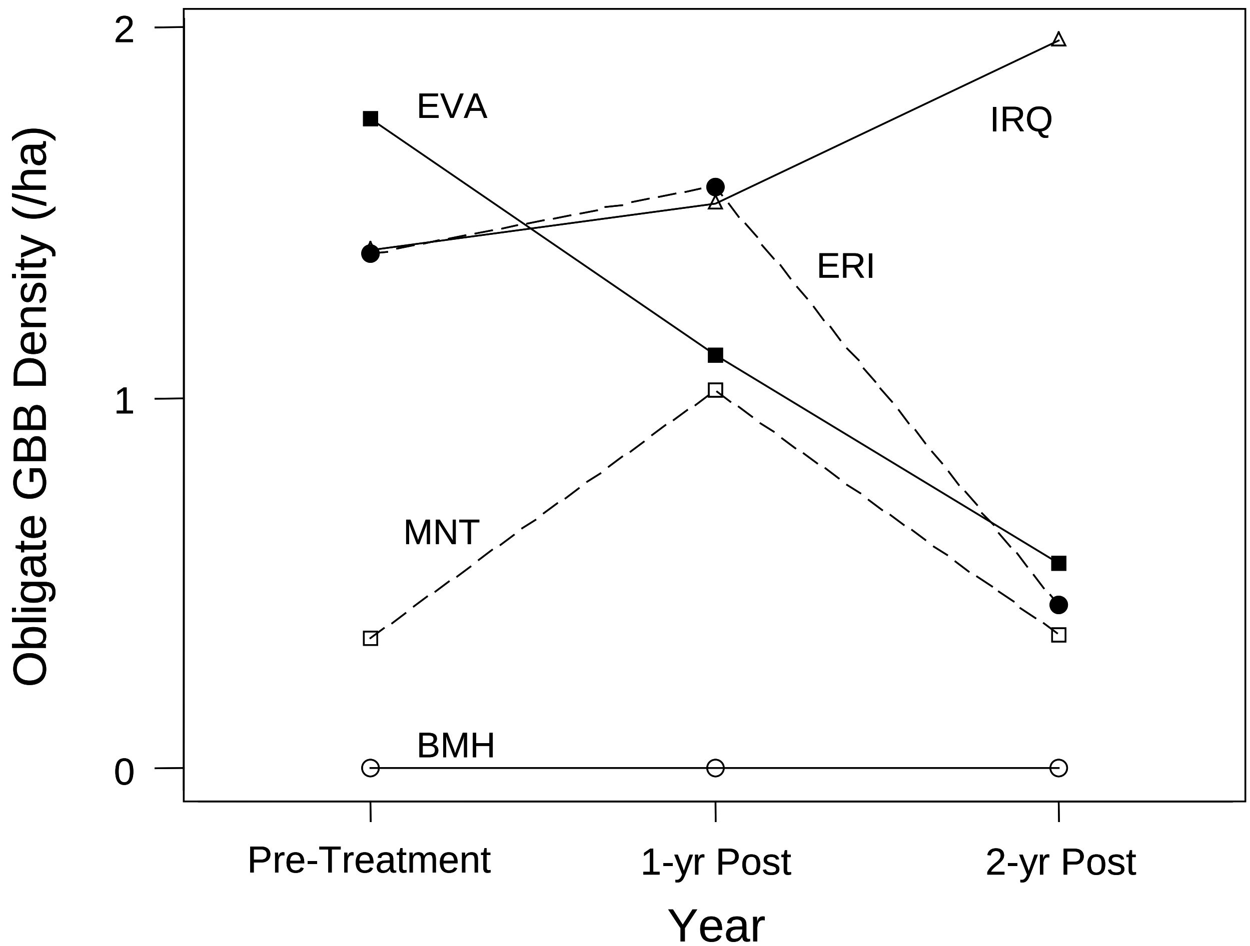

Figure 15. Obligate grassland breeding bird density (birds/ha) as a function of year (pre-treatment, 1-yr post-treatment, 2-yr post-treatment), for the five warm-season grass fields in the study.

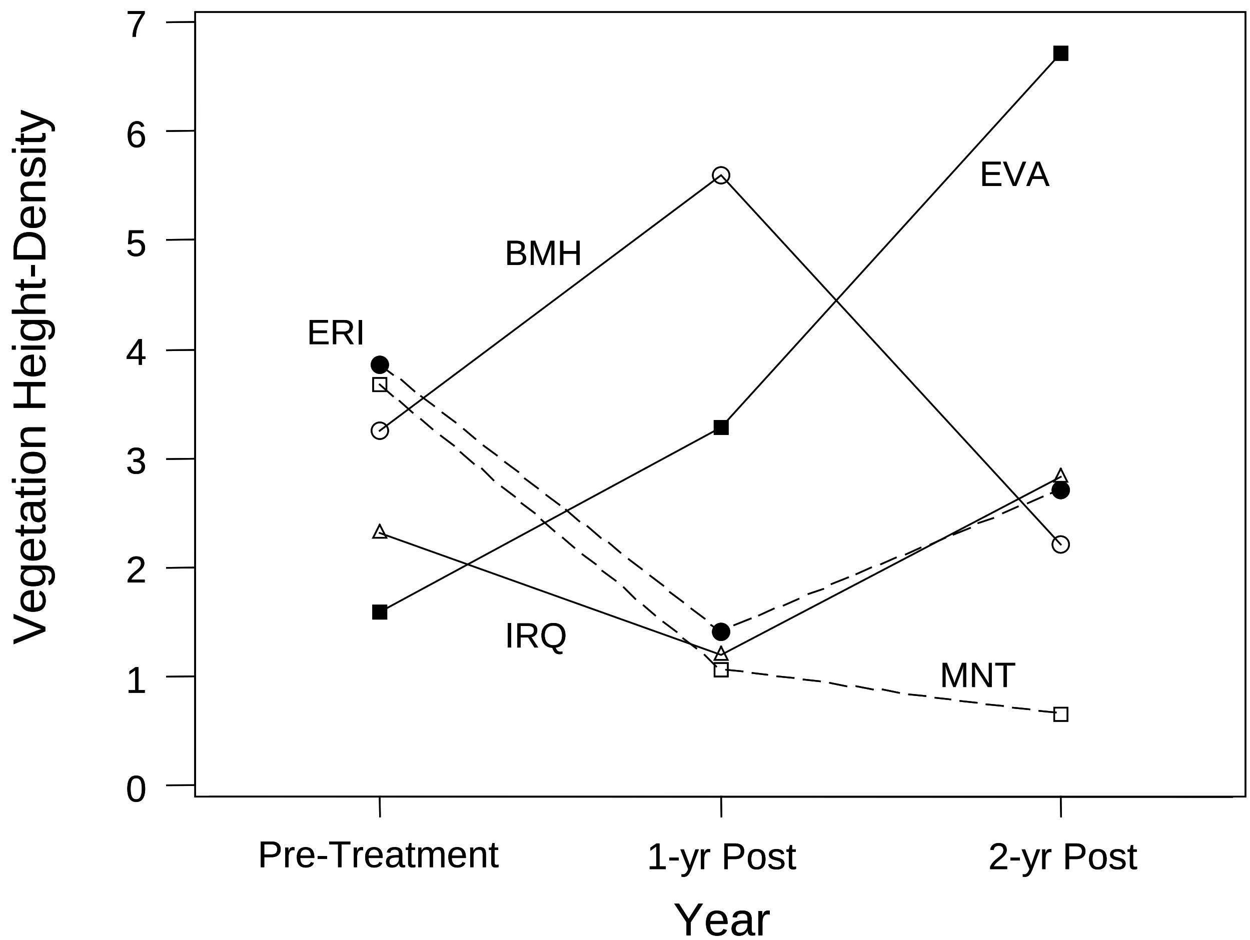

Figure 16. Mean vegetation height-density (Robel measurement) as a function of year (pre-treatment, 1-yr post-treatment, 2-yr post-treatment), for the five warm-season grass fields in the study.