An Assessment of the Potential for Grassland Bird Conservation in a Fragmented Landscape

AN ASSESSMENT OF THE POTENTIAL FOR GRASSLAND BIRD CONSERVATION IN A FRAGMENTED LANDSCAPE

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Abstract

Grassland bird populations have declined precipitously in the last century due to changing land use patterns across North America. New York's Adirondack Park experienced farmland abandonment and reforestation over the last century, but still supports breeding grassland bird populations. The long-term viability of these populations relies on the adoption of financially viable haying timelines that maintain grassland habitats and allow birds to fledge from actively managed fields. Consequently, addressing this issue requires knowledge of the distribution of grassland birds relative to management and landscape patterns as well as understanding the values and financial requirements of landowners. My research was designed to quantify (1) patterns of occupancy, colonization, and extinction in relation to landscape composition and haying intensity throughout the breeding season, and (2) landowner perspectives on adopting recommended haying timelines. I used a multi-season occupancy model using data from 118 sites that were sampled during three seasons in the summer of 2023, and interviewed twenty land managers throughout the study area.

The multi-season occupancy model compared occupancy, colonization, and extinction patterns of Bobolinks (*Dolichonyx orizyviorus*), Savannah sparrows (*Passerculus sandwichensis*), and Eastern meadowlarks (*Sturnella magna*) to landscape composition and haying patterns. I found that initial occupancy was associated with the percentage of open habitats in the landscape for all three species, with Bobolinks and Eastern meadowlarks most influenced by the landscape within 2.5 km, and Savannah sparrow occupancy closely associated with openness in the landscape within 250 m. Extinction and colonization trends were weak for all species, which may have been influenced by weather abnormalities during the summer of 2023.

I used semi-structured interviews to determine if two suggested haying timelines developed for Vermont's Champlain valley were feasible in the economically and geographically divided farming communities of the Adirondacks. Almost half of the participants (45%) managed some or all their fields on grassland-bird friendly timelines. Delaying the first cut into July is the preferred bird-friendly management timeline for most farmers. While the participants noted that they can make small changes to accommodate breeding birds, they must produce hay that will meet their livestock's nutritional requirements. Financial compensation was the most desired form of support for farmers to prioritize grassland bird conservation.

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Thank you to David and Rhonda Brunner of Ausable Forks, David and Cynthia Johnston of Westport, Colin and Laurie Powers of Wadhams, and Liz Kamb and Nick Mellet of Lake Placid, for making space for me on your farms and in your homes.

This research was conducted on the unceded lands of the Haudenosaunee. The Haudenosaunee stewarded and managed these lands and waters for millennia and were essential in maintaining the balance that allowed our diversity of species to thrive.

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Introduction

Significant, long-term declines in grassland bird populations have been recorded continent-wide [1] due to the intensification of haying and the abandonment and development of agricultural lands [2,3]. Over 99% of the original tallgrass prairie and over 80% of the shortgrass prairie in North America have been lost [4,5], making them among the most endangered natural systems on the continent [6]. As a result, obligate grassland birds have suffered the greatest declines of birds in any habitat type [1], with 74% of species in decline and an overall population loss of 53% in the last 50 years [1]. Natural communities in the Northeast that supported grassland birds (coastal prairie and interior river valleys) were the first to be developed after European colonization [2]. The clearing of forests in the Northeast for pasture in the early 1800's created habitat for Bobolinks (*Dolichonyx oryzivorus*) and other grassland birds. The Adirondack Region, which is now largely forested [7], supported an agricultural community in the late 1800's and early to mid-1900's that provided wool, milk, butter, and hay to domestic and international markets [8,9]. Now, Bobolinks rely on hayfields and pasturelands in the Northeast for breeding habitat; however, they are experiencing widespread habitat loss as the dairy industry has declined in the Adirondacks [8]. Hay harvests are occurring earlier and more frequently due to climate change [10] and intensifying management patterns [11], which further decreases habitat quality for grassland birds on remaining fields [12].

Obligate grassland songbirds such as Bobolinks, Eastern Meadowlarks (*Sturnella magna*), Savannah Sparrows (*Passerculus sandwichensis*), and Grasshopper Sparrows (*Ammodramus savannarum*), require open, grass-dominated habitats. Bobolinks are edge sensitive and typically nest at least 100 m from forest edges [13], which makes them vulnerable to fragmentation. In parts of the Northeast, remaining agricultural lands have become habitat islands for many species, including Bobolinks [14]. The complexity surrounding grassland bird conservation in the Northeast stems from the fact that the form of disturbance that is necessary to maintain open grassland habitats (agricultural management) is also the largest threat to ground nesting grassland birds. The timing of haying is the greatest determinant of habitat quality and nesting success for Bobolinks in the Northeast [15-17]. Studies conducted in New York and Vermont [12,14,16] documented that mean birth and survival rates were lowest in fields that were cut before 11 June, followed by rotationally grazed fields, fields cut between 21 June and 10 July, and fields cut after 1 August. It is uncommon for Bobolinks to have two successful broods in a season; but they can renest if a nest fails early in the breeding season [18]. Due to their hemispheric migration, they return to their breeding grounds later and leave earlier than short-distance migrants like Savannah Sparrows, who are more likely to have more than one brood in a single season [16].

The nutritional content of hay declines each day that harvest is delayed after it reaches a peak in early June [19], which can result in measurable financial implications for farmers [20]. Regional climate variations shift rates of grass growth and breeding phenology, making the development of regionally specific haying guidelines essential [17,19]. Researchers in Vermont identified two suggested haying timelines that would allow Bobolinks to complete a full breeding cycle on the hayed fields [21]. Financial compensation is necessary to enable farmers and landowners to widely adopt recommended haying timelines: [11,22] however, several incentive programs have been developed and tested in Vermont with varying success [21,23,24]. The Bobolink Project [24] utilizes a payment for ecosystem services model to compensate farmers per acre for following one of two recommended haying timelines: (1) Completing a first cut before the end of May and delaying the second cut for 65 days, and (2) delaying the first cut until August 1. Both timelines have shown roughly the same rate of reproductive success [16,21].

Several studies have found that land managers are willing to engage in conservation activities for grassland birds [11,22], which can be further encouraged through extension and education efforts which connect hay makers with information, support, and funding [22]. Since land managers are highly heterogenous even within small geographic areas, researchers often group similar farmers into homogenous "types", which allow for a more nuanced understanding of farmers' perspectives on a range of issues [25]. A typology was used to categorize land managers based on a range of economic, ideological, and social indicators, to streamline the development of outreach and incentive programs in Iowa [26], and they have been used in Europe to inform outreach and policy [25]. Typologies categorize farmers based on a range of factors, which are often unique to the study, but can include value orientations, occupation status, and demographics like age, education level, and farming experience [25]. A regional understanding of landowner perspectives and perceived barriers, and how they vary across landowner types, will help to inform programming that provides targeted outreach [26], sufficient support [11], and is respectful of value conflicts [27].

I used this approach to better understand how landowners might improve habitat quality for grassland birds in the Champlain Valley and High Peaks region of the Adirondack Park. Separated by Lake Champlain, the Vermont side of the Valley differs geographically and socioeconomically from that of New York. The 2017 Census of Agriculture [28,29] showed striking economic differences between the agricultural communities in Essex County, NY and Addison County, VT. The average farm acreage in both counties was similar but mean annual farm income was $1,950 in Essex County versus $199,557 in Addison County. This staggering difference in farm income suggests that Adirondack farmers are using less intensive management practices on similar acreages compared to farms in Vermont. Other studies have linked smaller farms with higher reliance on off-farm income and greater flexibility in adopting conservation practices [30]. Troy et al. [11] found that smaller farms are more likely to delay haying for grassland birds, which suggests that while less intensive and more isolated, the farms in the

Adirondack region could show potential to serve as a refuge for grassland species. Additionally, our study area is divided by several ridges of the High Peaks and hayfields sit at elevations between 37 and 640 m, which leads to variation in growing season duration, and could cause misalignment with the haying timelines that were developed for Vermont farmers.

To address this question, I designed a study to: (1) assess whether farmers in the Adirondacks can follow bird-friendly haying timelines developed in Vermont, (2) develop a typology to streamline program development and outreach strategies, (3) identify key opportunities, limitations, and perceived barriers that allow or prevent farmers in the Adirondacks from following recommended haying timelines, and (4) identify the types of support that are most needed.

Methods

Twenty semi-structured interviews (SSI) were conducted between July 2023 and January 2024. Interviews lasted between 16 and 76 minutes with an average duration of 35 minutes. Landowners, farmers, and haymakers were invited to participate using a snowball sampling method [31]. I began with existing contacts who connected me with their contacts, which continued until I reached my target sample size of 20, based on available time and resources. Interview participants engaged with this research voluntarily, consented to being recorded, and were compensated $50 for their participation. To protect the privacy of participants, no identifying information was recorded. Each interview was assigned a number (1-20) based on the order in which they were conducted, which served as the identifier throughout the coding process. Farm demographics including town, farmer age, tenure on the property, ownership of land, and percentage of household income derived from farming were collected.

Interviews were recorded using the Voice Memos app on an iPad (Apple iPad 9th generation) and were transcribed using Otter.ai [32]. Informal conversations with staff from local organizations in the summer of 2022 steered the development of research questions that would be beneficial for organizations that work to support farmers. Examples include the level of trust that farmers have in various local, state, and federal organizations, their willingness to alter haying timelines, and the types of support that are most helpful. A codebook was created that included 31 inductive and deductive codes [33,34], which were organized by research question. The primary researcher and research assistant coded two interviews (10%) in a practice round in which 100% agreement was reached. Five additional interviews (25%) were then coded to test for inter-coder reliability (ICR). These interviews scored 100% ICR, and the primary investigator coded the remaining 13 interviews using the agreed-upon codebook.

To better understand and compare the different types of landowners present in the sample, I developed a qualitative typology using land ownership, active engagement in land management, and main marketable products as the criteria for categorization (Table 2). I also created codes that describe a landowner's relationship with the natural world (Table 3), which were later compared to similar categories developed under the Value-belief-norm theory [35], which has been used to successfully explain a variety of pro-environmental behaviors [22].

Results

Demographics and the North Country Hay Economy

The twenty participants ranged from 30 to 78 years old. While one participant has been on their property for only one year, another could trace their family's occupancy of the land to when they settled as sheep farmers during the Civil War. The details of their farming operations and the community relationships upon which they depend varied substantially (Table 1). Most participants owned their land, with less than half partially or fully renting the land that they farm. The economic breakdown among participants showed that 70% made less than a quarter of their income from farming and only 20% relied on farming for all their income.

Table 1. Mean, median, and range for key landowner demographics from a sample of 20 landowners, farmers, and haymakers in the Champlain Valley of New York.

Category	Mean	Standard Deviation	Median	Range
Age	57	15	61	30-78
Land Tenure	26	27	15	1-100
Acreage in Hayfield and Pasture	199	244	107	13-1000

While there were some participants in their thirties, the mean and median ages were 57 and 61, and the oldest participant was 78. The duration of land tenure varied widely but was skewed toward more recent entries into farming, with nine farmers stewarding their land for 15 years or less. While 14 of the participants had childhood or family connections to farming, nine returned to farming or relocated to the Adirondacks after working in other careers, which may explain the disconnect between age and amount of time farming, as well as the low reliance on farming for overall household income (Figure 2).

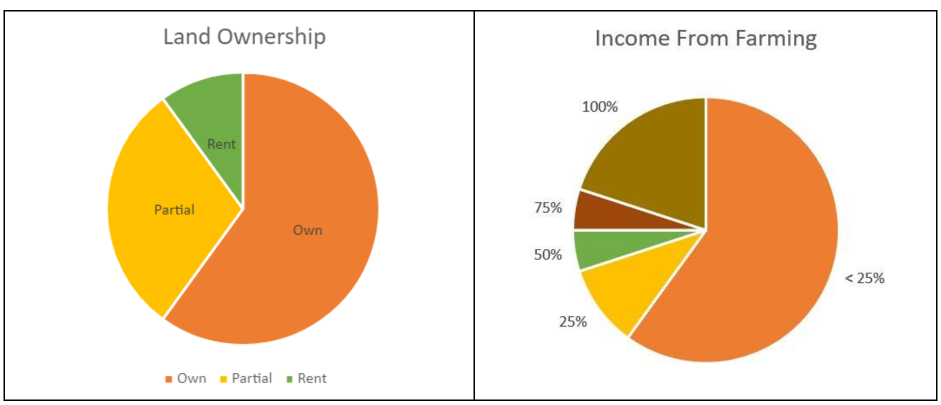

Figure 1 (left) displays the land ownership status of interview participants (N = 20). "Rent" represents farmers who rent all of their land, "own represents farmers who own all of their land, and "partial" represents people who own some of their land and rent some from another landowner. Figure 2 (right) shows the percentage of household income that participants derive from farming. Farmers were asked to put themselves in one of the five categories.

Landowner Typology

I identified four types of participants, based on land ownership, active engagement in the land's management, and main marketable products (Table 2), which are described below.

Table 2: Typologies with defining attributes that were used to categorize interview participants.

Category	Sample size	Attributes
Landowner	5	• Hay is the main marketable product. • Land is owned but managed by someone else.
Hay Producer	5	• Hay is their main marketable product. • Land may be owned, rented, or a combination of both, but is managed by the individual.
Hay Consumer	2	• Diversified animal products are the main marketable products • Land is owned and/or rented and managed by the individual. • Hay is purchased.
Self-supplier	8	• Diversified animal products are the main marketable products. • Land is owned and/or rented and managed by the individual. • Hay is produced on property.

Landowners

Landowners derived the lowest proportion of their income from farming and had the oldest average age. Every landowner managed their land for wildlife in some way, and they had the highest levels of concern for the environment and appreciation for the Adirondacks.

Hay Consumers

Only 2 of 20 participants were categorized as consumers. This group had the youngest average age, derived the highest proportion of their income from farming, had the lowest land tenure, and the lowest amount of open acreage. One of the two consumers indicated that they manage their land in some way for wildlife, and both had a formal education in the natural sciences. One hay consumer made all their income from their dairy and creamery operation, and the other made less than a quarter of their income from selling diversified products, including meat and breeding stock.

Hay Producers

Producers derived the second highest proportion of their income from farming, managed the most acreage, and had the longest tenure managing their land. They had the lowest willingness to manage lands for wildlife, and the lowest concern for the environment. Every producer had a childhood or family connection to farming, and they showed consistent concern about farmland preservation. Producers most frequently mentioned the difficulty in making a living from farming.

Self-suppliers

While six out of the eight self-suppliers made a quarter of their income or less from farming, one made all their income from their agricultural products. The six self-suppliers who made a small proportion of their income from farming had a childhood or family connection to farming. Self-suppliers were the largest sample size (n=8), and showed intermediate values for average age, land tenure, open acreage, and proportion of income from farming. Half of the self-suppliers were willing to manage their lands for wildlife, and half expressed concern for the environment. Two talked about the difficulty of making a living from farming and showed an appreciation for the Adirondacks. Six had a childhood connection to farming, and one had a formal education in natural sciences. Self suppliers were the largest and most diverse group.

Willingness to delay haying for grassland birds

Participants were informed about the two recommended haying timelines that Perlut et al. [21] identified. The first recommendation is to wait until the middle of July for the first cut, and the second is to perform the first cut before the end of May and delay the second cut for 65 days. Next, they were asked if they ever harvest on either timeline and the challenges or opportunities that both would pose for their operation. For each question, answers were grouped into one of four categories: weather-dependent, positive, partial, and negative. Multiple codes were possible and common for the same question. Partial codes were grouped with Positive in the analysis because of the frequency that farmers were able to delay haying on only a portion of their fields. Thus, “positive” represents farmers who have delayed haying or would be willing to on some or all of their fields, “negative” represents farmers who are not willing or able to intentionally delay haying for grassland birds on any of their fields, and “weather-dependent” represented farmers that referenced weather as the main reason that they could or could not follow either timeline. Weather was a common reason why haying on some or all fields was unintentionally delayed, and it was also listed as a main reason why they were not willing to accommodate one or both timelines.

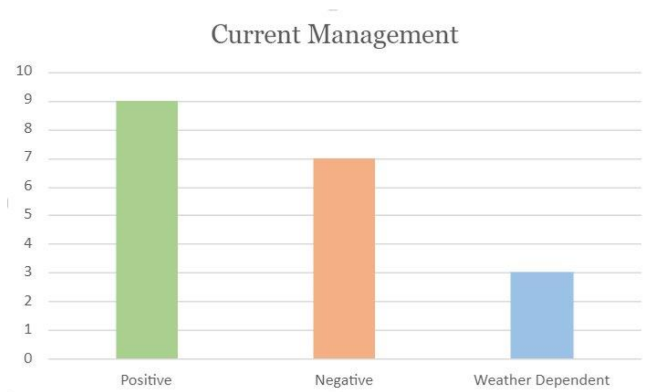

Figure 3. Responses from farmers and landowners as to whether they currently harvest their hayfields on one of two recommended timelines for grassland birds (N=17).

One participant was not able to answer questions about haying timelines because they deferred to the farmer who hays their land, and the two consumers declined to answer because they only pasture their animals. Nine of the remaining participants indicated that they follow one or both haying timelines on all or part of their land. Seven said that they do not follow either timeline and would not change their management timelines to accommodate grassland birds (Figure 3). One farmer was frustrated by the issue, saying:

> "I put five to $10,000 worth of fertilizer on those properties every year. And I'm not going to delay my harvest of hay for the sake of some birds".

Four of the participants intentionally delay their haying and set aside certain fields until they observe that birds have fledged from their nests. Three out of four of these participants were landowners who had long-standing relationships with the farmers who hay their land, and they give permission to hay each year when they feel comfortable.

> "The fields do not get mowed until we have fledged most of the birds out of the fields... there is an emphasis on the bobolinks but I try to take into account the meadowlarks and the little guys that I see that I can't identify but I know where they are and so I know I can mow around them if I need to."

Those who were unable to manage on either of the two suggested timelines cited logistical challenges, inadequate nutritional content, and concerns about missing weather windows. "We get the hay in when it's the most nutritious for the cattle", said one landowner.

Approximately 60% of landowners and self-suppliers responded that they could hay on either timeline on some or all their fields. Conversely, 60% of producers said that they could not follow either timeline.

Can farmers hay before the end of May and wait 65 days?

When asked about completing the first cut in May and delaying a second cut for 65 days, weather became a much more common concern, with eight participants naming it as a primary consideration (Fig. 4). Five participants indicated they can hay in May and wait 65 days on some of their fields or in some years, but three of them said that their delays were because of weather. Of the nine farmers that cannot follow this timeline, five also had concerns about weather, which included not being able to get into their fields in May. Two farmers described logistical challenges on both ends, because fields could be too wet for machinery in May and nutritional content is too low later in the season.

"Trying to mow before May 31, it's gonna be wet... that could be an issue, because he's gotten stuck down there before trying to mow early."

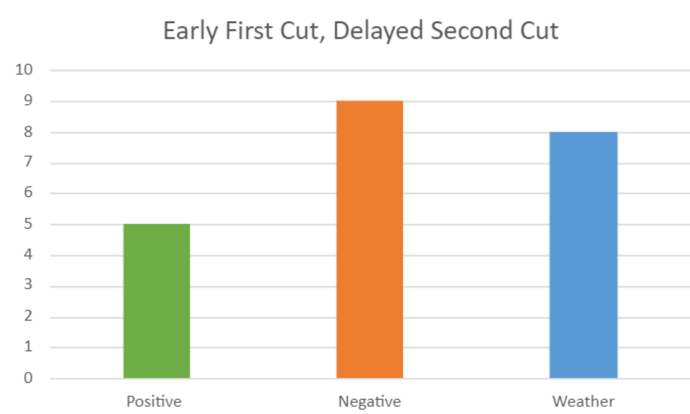

Figure 4: Responses from farmers and landowners as to whether they can harvest hay before the end of May and wait 65 days for their second cut.

Another expressed concern that he doesn't have a market for the hay that could be produced early in the season, saying:

> “that would be a difficult thing for me... you have the ability to make high moisture, silage hay, which I could do at the end of May... and it hasn't worked out too well. Here in this location, I have limited demand for that product.”

Self-suppliers had the most negative response to this timeline, with 60% saying that they could not follow it. Producers gave mixed responses, and cited variations in weather patterns. “Windows to make dry hay within that growing season are few and far between you know, I am still working on some first cut hay right now, that should have been cut six weeks ago.”

Can farmers and landowners delay haying until mid-July?

Delayed first cuts are relatively common, whether they occur for grassland birds or for other reasons (Fig. 5). In addition to the four landowners who delay their first cut for grassland birds, six others regularly get to only a portion of their fields before the middle of July. These delays were due to logistics and weather windows. Haymakers prioritize their most valuable fields, which means that they don’t get their first cut until July on as much as 25-40% of their acreage. One self-supplier said that they would have to designate one field as the “Bobolink Field” each year, which is a strategy that is used by two of the four landowners who give permission to hay when they see fledglings. Farmers who manage pasture in addition to making hay account for a significant portion of the participants that find success with this timeline, because many do not rotate through all their fields before the middle of July. Farmers who pasture livestock also aren’t as limited by weather windows as producers, who need stretches of dry weather to produce dry bales.

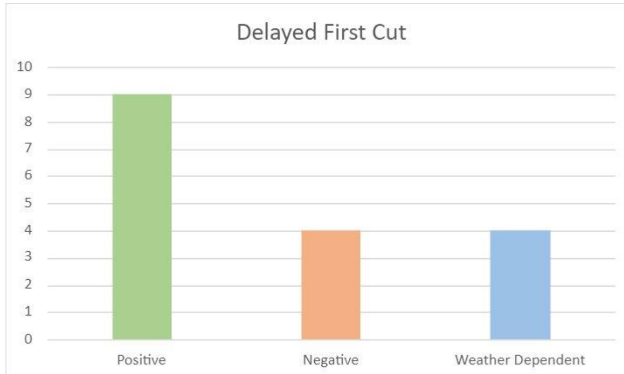

Figure 5: Responses from farmers and landowners as to whether they can delay haying until July 15.

Sixty percent of Landowners and Self-suppliers made positive statements about the delayed haying timeline. Producers were evenly split, with two agreeing that it was feasible, two saying it would not be possible, and one not answering the question.

I also asked participants to explain their main considerations when weighing changes in their management practices and coded their responses into four categories (Table 3).

Table 3. Codebook definitions for the four management consideration categories. Respondents could be placed in more than one category.

Financial	Direct reference to financial constraints, concerns, or profits. Can include needing to secure additional markets or customers for their products. N = 7
Stewardship	Farmer or landowner mentions improving the health of the land, soil, water, pasture, and managing for overall ecological function and biodiversity for the long term. N = 10
Production	Farmer or landowner references capacity limitations like time, labor, or machinery, and the growth and health of the grass for livestock health. N = 8
No Interest in Change	Interviewee states that they have no interest or no need for change. N = 2

Participants who considered stewardship as a main management consideration were the most likely to delay haying for grassland birds, and to delay the first cut until mid-July, but equally as likely as those who prioritize production to take an early cut and wait for 65 days. Across all three haying response categories (willingness to delay for grassland birds, delaying until July, and early cut with a delay), 70% of the participants who valued stewardship were willing and able to delay haying for grassland birds. People who prioritized finances were significantly less likely to delay haying for grassland birds, with an average of 30% willingness across all three response variables. Approximately half of participants who prioritized production delay haying for grassland birds. Finally, the two participants who had no interest in change were not open to either of the two timelines and were not able to delay haying for grassland birds.

Connection to the Natural World

Participants were asked to describe their relationship to the natural world and responses were coded into one of three categories (Table 4).

Table 4. Comparison of the codebook definitions with respect to connection to the natural world and the analogous value-based-norm theory orientation. Respondents could be placed in more than one category.

Our Study	**Value-based-norm theory**
Intrinsic: Connection to the natural world is a fundamental part of life, why they decided to farm; they view themselves as a part of nature. N = 6	*Intrinsic or altruistic:* Value nature for what it is, not what it provides.
Pragmatic: Connection to the natural world is rooted in production, farming, or hunting. N = 10	*Instrumental or egotistic:* The environment is valued for a particular end (product).
Troubled: Expressions of grief and complexity. N = 7	*Relational or biospheric:* Focused on the person's relationship with nature. Centered around expressions of care and concern.

Connection to the natural world varied by typology. Producers and Self-suppliers both aligned most closely with the pragmatic connection to the natural world and rarely spoke of intrinsic connections. Landowners, however, frequently shared sentiments reflecting an intrinsic connection to the natural world. Approximately half of the landowners also shared troubled sentiments, while only one landowner had a pragmatic connection to the natural world. Both consumers shared troubled sentiments, with one also showing pragmatic connections and the other showing intrinsic connections. Correlations between connection to the natural world and willingness to delay haying were largely inconclusive but showed a slight trend toward those with an intrinsic connection being less likely or able to delay haying on their properties.

Participants with pragmatic connections to the natural world considered finances to be the most important management consideration, which was followed closely by production. People with an intrinsic connection to the natural world considered stewardship to be the most important management consideration. Those who had a troubled relationship with the natural world valued production first, with stewardship and finances tied but trailing significantly behind.

Support Needed to Implement Bird-friendly Strategies

An overwhelming majority of farmers (80%) voiced a need for financial support to help them improve management for grassland birds (Figure 6). They cited compensation for added complexity, supplementing the cost of taxes, offsetting lost income, and added costs as primary reasons. One farmer summed up their need for payments by saying:

"if you're going to take on that level of complexity, you should be getting compensated for it", and then later said that they "dream for a day when... you're out there looking for those things, because there's some sort of mechanism to reward you for stewarding the land in a way that attracts (them)."

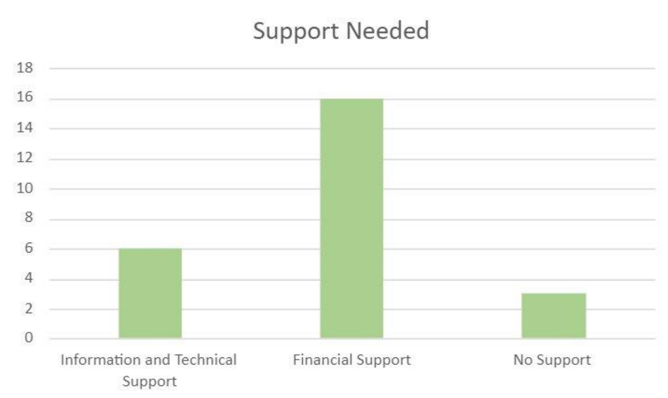

Figure 6. Responses from farmers and landowners about the types of support that farmers need to adopt bird-friendly management timelines.

A quarter of the participants noted the influence of interpersonal relationships and voiced their need for financial incentive to purchase supplemental hay for their customers or make up the lost income for the farmer who hays their land. Of these five participants, three were landowners and two were producers. Landowners typically wished to speak with the farmer who hays their land, stating:

> "I guess I need to clarify my agreements with the farmer, and figure out how that would affect the financial arrangements that I already have"

> "The hay is needed. I guess maybe we'd arrange to buy it elsewhere".

The need for information and technical support were mentioned by 35% of the participants. Requests for information and technical support included identifying the timing and location of breeding populations and technical support when applying for grants and federal programs. A self-supplier stated:

“If you don't support (a program) with a facilitator who actually sits down with the primary potential lendee or grantee, you're going to get nowhere. I can't tell you how many times I've hung up the phone and just ripped up the paper and not even gone to look at that program again, because there's no support”.

The same person mentioned the importance of feeling acknowledged and supported through grant programs:

“it's about the cooperation, and it's about community effort, it's about the prioritization of the many demands we have on our time, and resources, all of us, including the sources of these funds”.

Two landowners said that no form of support would make any difference. For one, the lack of need was because they manage fields for grassland birds and plan to continue regardless, and the other was because they had no interest in altering their practices. All five producers voiced a need for financial support, and two self-suppliers were the only ones to ask for information and technical support alone, wishing for information that could confirm the impact of their choices. As one of them expressed:

“Guidance and knowledge... everything from best practices... tips, and knowledge. I think the more we know about them, the more we can be attentive to the impact of what we're doing.”

Table 5. Type of support needed for implementing bird-friendly timelines by typology.

Participant Type	Financial	Information /Technical	Both	None	Total
Consumer			2		2
Landowner	2		1	2	5
Producer	4		1		5
Self-supplier	4	2	2		8
Total	**10**	**2**	**6**	**2**	**20**

Trust in Conservation Organizations

Once I identified the types of support that would be most helpful, I sought to understand the organizations that may be best positioned to provide it. I created a list of government agencies and NGO's that provide support to farmers or work locally to protect avian diversity. Organizations were identified through literature review and informal conversations with farmers in the Adirondacks. While not an exhaustive list, it covers a range of organizational structures and areas of focus. Farmers were asked to rank their level of trust on a scale of 1 (low) to 10 (high). Organizations were given a zero if the participant had never heard of them. On average, Cornell Cooperative Extension (CCE) scored the highest with 8.4. Next were local Soil and Water Conservation Districts (SWCD) (7.2) and Land Trusts (6.3). The lowest scoring organizations were New York State Department of Environmental Conservation (DEC) (5.7), Audubon (5.2), and the Natural Resource Conservation Service (NRCS) (4.9). NRCS and Audubon both had a high number of farmers who had never heard of them (4 and 5, respectively).

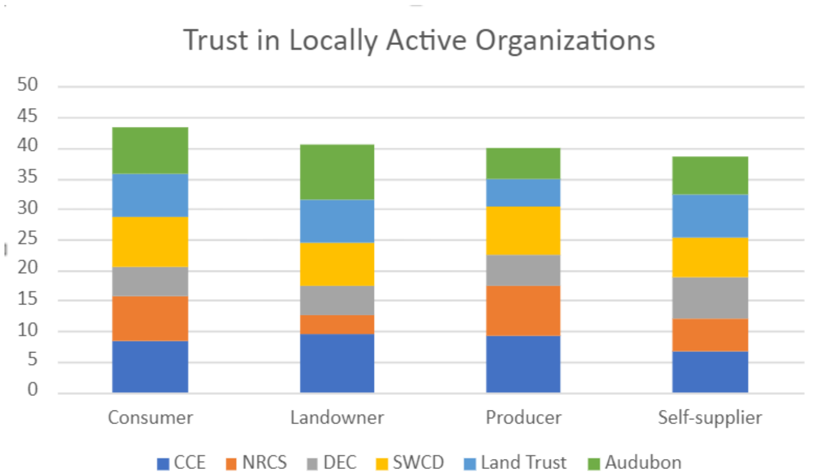

Figure 7. Trust was scored on a 1 to 10 scale by each participant. Trust scores were averaged for each typology and stacked (displayed above). Thicker color bands represent greater trust scores for each typology. Each different color corresponds to an organization (CCE = Cornell Cooperative Extension, NRCS = Natural Resource Conservation Service, SWCD = Soil and Water Conservation District, DEC = New York State Department of Environmental Conservation).

Landowners had the most trust in CCE, and the least amount of trust in the NRCS. Consumers had high levels of trust for CCE, SWCD, NRCS, and Audubon. Producers highly regarded CCE, NRCS, and SWCD, because they received technical support from them. They had the lowest levels of trust in Land Trusts, Audubon, and the DEC. Self-suppliers had moderate levels of trust in all the organizations. They expressed concerns about NRCS because of a perceived lack of capacity, and in Audubon because they felt that their values didn't align with the organization.

Not surprisingly, participants had the most trust in organizations that they typically worked with, or organizations that they felt aligned with their values. Landowners and consumers, who did not rely on their properties for hay production, had the most favorable views of the Audubon Society. Producers highly regarded the organizations that provide technical support to farmers. Self-suppliers varied widely in their views on many of the organizations, but they expressed similar sentiments about wishing for better support and having higher trust in organizations that are represented by trusted members of the community.

Discussion

Almost half of the farmers and landowners in the Adirondacks can utilize one of the two recommended timelines on some or all their land. Landowners and consumers tend to be the most willing to delay haying, but arguably have the least ability to do so, depending on their relationship to the person that rents their land or supplies them with hay. Producers are the least likely to delay haying on their fields and have the greatest concern about production and logistics. Four main barriers to grassland bird conservation exist: 1) lost income from delayed haying, 2) uncertainty and delays attributed to weather, 3) lack of information and technical support, and 4) perceived community barriers.

With almost half of the haymakers already following grassland bird-friendly management timelines, the Adirondacks show potential as a place where outreach, technical assistance, and financial incentive programs can maintain and improve breeding habitat on privately owned land. Troy et al [11] had similar findings when they surveyed 131 dairy farmers in Vermont's Champlain Valley and found that 49% can alter their haying timelines on at least a portion of their land. Another study found a positive correlation between livestock production and willingness to delay haying for grassland species [22], which aligns with our findings that consumers and self-suppliers were much more likely to delay haying than producers. While there is a connection between raising livestock and willingness to delay haying for grassland birds [22], farmers with smaller herds are more likely to delay haying than those with more livestock to manage [11]. This could pose a challenge for grassland bird conservation efforts, because the aggregate amount of land owned or managed by farmers with smaller herds is relatively small. While the participants in Troy's [11] study said that they could delay haying on an average of

29% of their land, that only accounted for 9% of the total acreage in the study. More information should be gathered to assess the minimum acreage that should be protected to maintain viable populations of grassland obligate songbirds. Large-lot landowners could play a crucial role in conservation efforts, and care should be taken to identify and contact property owners who are adjacent to protected lands or bird-friendly fields. Several studies have proposed methods for identifying High-Value Nature farmland [38] and identifying priority parcels for grassland birds [39], which could be adapted for programs in the Northeast, such as the Bobolink Project [24].

Out of the two suggested haying timelines, delaying the first cut into mid-July is the most favorable option among haymakers due to the short growing season and variable summer weather patterns. The 2023 season was unusually wet, which made it difficult for haymakers to follow their typical haying patterns. It is possible that the strain weather posed on farmers in this field season led to an exaggeration of the effects of weather, but while some made direct references to this year being abnormal ("I should have been haying 6 weeks ago"), others made generalized comments that apply in most years (e.g. "I would get stuck"). Most landowners and self-suppliers are open to the idea of delaying cuts in some fields and avoiding areas with the highest level of activity. While they can make small changes to accommodate breeding birds, they must produce hay that will meet their livestock's nutritional requirements.

The "connection to natural world" categories that were derived through inductive and deductive coding mirror the three orientations of value-based-norm theory, which has been used to explain patterns of pro-environmental behavior among diverse stakeholder groups. Gruntorad et al. [22] found positive associations between wildlife knowledge, livestock ownership, and willingness to delay hay harvests for grassland birds, and a negative relationship between hunting and delaying hay harvest. Floress [37] also detected a positive correlation between stewardship attitudes and the willingness of farmers to take action to address water quality issues. However, our analysis showed that people who have an intrinsic connection to the natural world are more likely to prioritize stewardship on their land but are not significantly more likely (even potentially less likely) to delay haying for grassland birds. This could be because landowners closely aligned with intrinsic orientations, and they often weren't the ones making the decisions about haying timelines. Other studies have found that operators (renters) often control decisions about production [30]. By contrast, those with a pragmatic connection to the natural world cared more about production and finance and accounted for all participants who had no interest in change. Finally, participants with a troubled connection to the natural world most frequently considered production, with stewardship and finances trailing behind. These findings largely align with other studies that investigated similar value correlations [25,26,30]. Further examination of our land manager typology with a larger sample size would provide a more robust comparison to studies in other geographies, which primarily relied on surveys to garnish large sample sizes.

The importance of trust in conservation organizations centered around a few themes: perceived capacity, relevance of work to the landowner, past interactions with staff, and familiarity. It quickly became clear that personal relationships with agency staff greatly improve the level of trust that a landowner has with an organization. Other findings suggest the importance of informal and casual outreach that biological technicians can provide while monitoring properties [40]. Additionally, organizations that provide technical support to farmers are the best positioned to approach producers and consumers, while conservation nonprofits are most approachable to landowners. Cornell Cooperative Extension is very active in this region and was the most trusted organization.

The importance of community creates additional barriers and opportunities. While outreach that encourages farmers to learn from each other is a powerful tool [27,36], community relationships can have an adverse effect on willingness to delay haying in two distinct ways. The first example was the frequent occurrence of participants who declined to answer questions without consulting another party or stated a need for financial compensation to benefit someone else. With statements such as "I would need to check with the farmer, they may need supplemental income to offset the losses" (landowner), or "I would need to find somewhere else to buy hay for my customers" (producer), they showed that they heavily consider the needs of others as they make decisions. A more subtle example of community influence was the importance of the appearance of fields that they manage. "I just don't like it, it looks overgrown", said one producer. This highlighted an important and easily overlooked consideration, which is that "what is good may not look good, and what looks good may not be good... the appearance of many indigenous ecosystems and wildlife habitats violates cultural norms for the neat appearance of landscapes" [41]. In the essay *'Messy Ecosystems, Orderly Frames'*, Nassauer [41] explains the importance of embedding cultural "cues to care" into management guidelines, so that conserved and protected landscapes are not perceived negatively by some community members. The low proportion of participants who rely on farming for their household income aligns with the findings of Green et al. [36], who conducted 124 semi-structured interviews in the Virginia Working Lands and had only three participants who relied on farming for their income. With an average farm income of $1,950 in Essex County, farming made up 100% of the household income for only four of the twenty participants in our study. Troy et al. [11] note that large lot landowners who do not farm have increased in the Champlain Valley, so all the farmland that has been retired from agriculture does not necessarily equate to lost grassland habitat. Large-lot landowners may have fewer economic constraints than farmers, but they often rely on neighboring farms to hay their properties, which maintains the open nature of the land and makes them eligible for agricultural tax credits (Howe, pers. obs,). Essex County, NY shares some demographic similarities with the adjacent agricultural county in Vermont (Addison County, VT). In both counties, new farmers account for close to one third of the agricultural community, the average farm size is similar (202 acres in Essex and 237 in Addison), and approximately 73% of farms in both counties are smaller than 179 acres in size. However, census data strongly suggests that Addison County uses much more intensive farming practices and generates more income. While Addison County holds more than three times more agricultural land in total acreage, these farms generate total sales that are 32 times greater than the farms in Essex County. These critical differences have implications for farmers' capacity to incorporate wildlife into their management plans, and potentially on the pressures that obligate grassland species face in this landscape.

The resulting need for financial support aligns with the findings of similar studies [11,20], which documented the financial strain that delayed haying imposes on farmers. Ideally, successful programs would minimize financial barriers to adapting haying timelines and provide education through conservation science programs [36,40]. In addition to financial support, information and technical support were also frequently referenced. Information and technical support include activities such as farm visits, educational programming, and assistance with applications for funding. This type of support can increase knowledge of the conservation impacts that result from altered management plans and lower perceived barriers to financial compensation. Place-based information relevant to their properties and communities increases the likelihood that farmers and landowners will engage in stewardship activities on their land [36]. Gruntorad et al. [22] found that willingness to delay haying for avian populations increased with their knowledge of the species, confirming that outreach efforts will have impacts beyond the ones that are immediately measured. Informal and casual outreach styles, such as conversations with researchers and on-farm demonstrations increase landowners' interest in habitat management and give them opportunities to learn from other land managers in their community [36].

The Adirondacks present a unique opportunity for grassland bird conservation efforts, due to lower-intensity farming and high levels of community connection. Effective outreach strategies would utilize partnerships between technical service providers and conservation nonprofits to appeal to a wider range of land managers. Management recommendations should take aesthetics and production into account to appeal to more pragmatic land managers. Finally, incentive programs should include technical support so farmers can make well-informed and nuanced decisions for their properties and should offer different levels of financial support to account for varying levels of reliance on farm income.

Conclusions and Directions for Future Research

With almost half of the haymakers already following grassland bird-friendly management timelines, the Adirondacks show potential as a place where outreach and financial incentive programs can maintain and improve breeding habitat for grassland songbirds. Out of the two suggested haying timelines, delaying the first cut into mid-July is the most favorable option among haymakers due to the short growing season and variable summer weather patterns. Weather presents a challenge for haymakers in the Adirondacks, which restricts their ability to hay early in the season. However, almost half of the haymakers already delay haying on some fields due to logistics, weather, and concern for breeding birds. Hay production in the Adirondacks is typically limited by weather and logistical constraints like machinery, favorable rental agreements, and health.

Most landowners and self-suppliers are open to the idea of delaying cuts on some fields and avoiding areas with the highest level of activity. While they can make small changes to accommodate breeding birds, they must produce hay that will meet their livestock's nutritional requirements. Financial compensation was the most desired form of support for farmers to prioritize grassland bird conservation. Compensation offsets lost income and serves as an incentive to add complexity to their operations.

Future studies should examine supply and demand for hay in the Adirondacks to understand how hay can be produced and distributed locally while adhering to recommended haying timelines on high-quality habitat. Our study showed that many farmers and landowners are open to adopting best management practices for grassland birds, but significant financial, logistical, and social barriers are present. Understanding the flow of hay through the community and identifying net surpluses or deficits in the system could determine acreage limitations for incentive programs and opportunities to streamline the production and distribution of hay. Additionally, subsequent studies could examine the household finances of farmers. Since most farmers get less than a quarter of their income from farming, understanding how many hours per week are dedicated to other sources of income would add important context. If their other sources of income are passive, it may allow for more flexibility and a greater willingness to take risks. On the other hand, if the other sources of income are from part-time or full-time employment, farmers may have significantly less capacity to consider and adopt altered management timelines. Examining alternative sources of income at the household level will give conservation professionals crucial context about farmers' capacity limitations or ability to take additional risk. To add further context to our understanding of the economics of haying in the Adirondacks, we also need to expand our documentation of grassland bird populations in the Adirondacks; to determine the minimum acreage of high-quality habitat we must protect to preserve healthy populations of our study species. Combining spatial population data with an understanding of landowner values, capacities, and constraints would allow efficient resource allocation for improving grassland bird populations.

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Appendix: Codebook

Research Q: What are the main management considerations that influence how farmers approach change and decision making?

Production and Logistics: Farmer or landowner references capacity limitations like time, labor, or machinery, and the growth and health of the grass for livestock health.

Code for the words: capacity, tools, machinery, time, labor, staff, cost of labor, buying tools for the job, wear on the machinery, milk production, health of cattle, adding more cattle.

Examples: "I guess I'd have to think about the machinery involved. If I have to buy new equipment, that would make it much more difficult."

"We would have to consider how it would affect milk production."

No interest in change: Interviewee states that they have no interest or no need for change. This one is direct.

Examples: "We're not considering change. We have been doing things this way for a few decades now."

"We are happy with the way things are going and aren't considering any changes at the moment."

Finance: Direct reference to financial constraints, concerns, or profits. Can include needing to secure additional markets or customers for their products.

Code for the words: market, money, cost, funding, finances, taxes, payments, financial

Examples: "It has to make financial sense. Our margins are slim so we need to make sure we can stay in business."

"We would have to consider the cost. It takes money to pay taxes on the land and feed the fields."

Stewardship: Farmer or landowner mentions improving the health of the land, soil, water, pasture, and managing for overall ecological function and biodiversity for the long term.

Code for the words: sustainability, soils, water, erosion, native grasses, birds, wildlife, biodiversity, restore

Examples: "We want to protect the birds."

"We're trying to improve the health of the pastures."

Research Q: How do farmers and landowners describe their relationship to the natural world?

Deep and Intrinsic: Their connection to the natural world is a fundamental part of life, why they decided to farm, they view themselves as a part of nature.

Examples: "I like to think of myself as a part of the natural world."

"I can't imagine my life without it. It is one of my most important relationships."

Pragmatic: Connection to the natural world is rooted in production, farming, or hunting. The farmer or landowner may describe a harmonious relationship with the natural world in which they describe working with the natural world instead of against it in their practices.

Examples: "We care about the natural world, we try to keep the invasives out of our fields."

"When it's not raining and I can cut hay, I have a great relationship with the natural world".

Troubled: Expressions of grief and complexity.

Examples: “Both gratitude and grief.”

Research Q: Do you manage the landscape in any way to encourage wildlife?

Positive: Farmer or landowner considers wildlife in their management practices, and sometimes or always goes out of their way to protect various species.

Negative: Farmer or landowner will not go out of their way to protect wildlife on their farm. This can include an acknowledgement that wildlife benefits from farming and they do nothing to discourage it.

Research Q: How willing are farmers to delay haying for grassland birds?

Positive: Farmer or landowner is willing to delay haying for grassland birds.

Negative: Farmer or landowner is not willing to delay haying for grassland birds.

Partial: Farmer or landowner sometimes delays haying for grassland birds, or delays haying on part of their property. This can be due to logistics (machinery, time) or due to a desire to protect breeding birds.

Weather Dependent: Weather is listed as a main factor in their ability to delay mowing. (ie. In some years they could delay, but in others they can’t, or shifting weather windows are a concern about delaying).

All Fields are Pasture: Farmer does not make any hay on their property, all of their fields are pasture and they buy hay. If this is the case, use this code and then skip the next two questions unless they talk about altering their grazing rotations for grassland birds.

Research Q: Can farmers delay until after the middle of July?

Positive: The farmer or landowner is able to delay haying into the middle of July.

Negative: The farmer would not consider delaying until after the middle of July.

Partial: The farmer could delay haying on some fields, or in some years.

Weather Dependent: It varies year to year based on the weather.

Research Q: Can farmers hay before the end of May and wait 65 days?

Positive: Farmers or landowners can hay before the end of May and wait 65 days.

Negative: The farmer or landowner would not consider or would not be able to hay before the end of May and wait 65 days.

Partial: The farmer or landowner could use this management timeline in some years, or on some of their fields.

Weather Dependent: Weather is a main factor in their reasoning why this timeline may or may not work out. This can include statements like “We can’t get into the fields before the end of May”.

** on this question, you may find a lot of people that say they cannot use this timeline because of their inability to get a first cut in before the end of May because fields are too wet. I will double code these with *Weather Dependent + Negative* if they decisively say that they cannot. **

Research Q: What type of support is necessary to help farmers delay haying for grassland birds?

No Support Needed: Interviewee either is in no need of support, or has no interest in delaying haying. Support will make no difference.

Examples: "I can’t think of anything that would make a difference to me.”

“I don’t need any support; I just do it.”

Information and Technical Support: Farmer or landowner shares a need for on-farm technical support and better information about when and where grassland birds are nesting on their property.

Example: “To have someone come out and tell me where the birds are nesting and when I could cut would be really helpful.”

Financial Support: Farmer or landowner mentions a need for financial support, supplemental hay, or access to new markets, in order to delay mowing for grassland birds.

Examples: “I’d need some sort of compensation to cover the taxes on the land”.

“Well, if I’m paying to rent land by the acre, you would have to pay me the difference in price to cut bedding hay”.

Subcode **Relationships** if the farmer or landowner mentions needing supplemental hay or financial compensation to fulfill agreements or provide support to a customer or haymaker.

Examples: “I would have to check with Dave, if he was having a hard year, I might need financial compensation that I could pass along to him”.

“I would need to source hay from somewhere else. My customers look to me every year for hay to feed their horses”.

Research Q: What values do farmers in the Adirondacks hold closely?

Preserving Farmland: Farmer or landowner expresses an interest in protecting farmland or open spaces. This includes a mention of concern about the decline of the agricultural community, farmland abandonment, and services that are disappearing.

Community: Farmer or landowner references the communities of the Adirondacks, or the farming community of the Adirondacks, as inspiring them to farm in this region. Farmer or landowner received support from or organization or individual outside of their family to start their farm.

Love for the Adirondacks: The farmer or landowner vacationed in the Adirondacks as a child, came to love the landscape as an adult, or participates in outdoor hobbies and wants to be geographically close to the mountains.

Family, Childhood Connection to Farming: Farmer or landowner grew up on a farm, grew up around farming, or has a family or childhood tie to farming.

Formal Education in Natural Resources: Farmer or landowner talks about their formal education in Biology, Environmental Science, or Natural Resources as a motivator for farming.

Concern for the Environment: Farmer or Landowner discusses invasive species, climate change, biodiversity loss, ecological function of their property, the region, or the Earth.

Difficulty Making A Living Farming: Farmer or landowner states that you can’t make money farming, people won’t pay the true cost of local food, margins are slim, their farm is or has been close to closing, or lack of farming infrastructure and services make it challenging to farm.

CHAPTER 2: THE IMPACT OF HAYING PATTERNS AND LANDSCAPE COMPOSITION ON GRASSLAND BIRD DISTRIBUTION IN A PREDOMINATELY FORESTED LANDSCAPE

Abstract

Grassland birds have experienced significant population declines in recent decades due to changing land use patterns. In the Northeast, grassland-obligate songbirds rely on hayfields and pasturelands for breeding habitat. The open nature of these grass-dominated habitats is maintained by haying and grazing, which often occurs during the breeding season and results in high mortality. The impacts of haying on breeding grassland birds are well documented, but haying intensity varies regionally. In the Adirondack Park, grassland bird populations are highly fragmented, but less intensive hayfield management could reduce conflicts during the breeding season. I used a multi-season occupancy modeling framework within a single breeding season to measure the initial occupancy, colonization, and extinction patterns of three grassland species. We used satellite imagery to detect the timing and intensity of haying by measuring rapid decreases in Normalized Difference Vegetation Index (NDVI). Our findings showed strong associations between initial occupancy and landscape openness for all three species, as well as strong correlations between detection probability and sampling time. Our results failed to display strong trends between haying intensity and colonization and extinction patterns. We believe that this could be because of misalignment between point count data and satellite imagery, due to atmospheric conditions that prevented us from securing high-quality imagery at our planned temporal resolution.

Introduction

Grassland songbird populations have shown continent-wide declines in the last century [1], as intensification of agricultural practices [2,3] and farmland abandonment [3,4] have reduced the quality and availability of high-quality habitat [5]. Grassland birds have declined more than birds in any other habitat type, and Bobolinks have lost 60% of their population over the last 50 years, with an anticipated loss of another 50% in the next 50 years [1].

Natural communities in the Northeast that once supported grassland birds (coastal prairie and interior river valleys) were the first to be developed after European colonization [4]. The clearing of forests in the Northeast for pasture in the early 1800's created habitat for Bobolinks (*Dolichonyx oryzivorus*), Savannah Sparrows (*Passerculus sandwichensis*), and Eastern Meadowlarks (*Sturnella magna*), which now largely rely on agricultural lands for their breeding habitat [4]. Bobolinks and Eastern Meadowlarks are currently noted in New York State as high priority Species of Greatest Conservation Need [6].

The complexity surrounding grassland bird conservation in the Northeast stems from the fact that the form of disturbance necessary to maintain open grassland habitats (agricultural management) is also the greatest threat to ground nesting grassland birds. Farmers pasture open fields and create hay for the winter to support their dairy and livestock operations [7-10]. The timing of haying is the greatest determinant of habitat quality and nesting success for Bobolinks in the Northeast [9,11,12]. Hay reaches its nutritional peak in late May and early June, when many grassland songbirds are in the late incubation stage or have nestlings [9,13]. In the Champlain Valley of New York and

Vermont, haying occurs between 1-4 times per year in each field [2] and if conducted during the breeding season, causes nearly all active nests to fail [9]. In a survey of dairy farmers in Vermont's Chaplain Valley, Troy et al. [14] found that hayfield management practices are shifting, with earlier and more frequent cuts. Another study in Vermont's Champlain Valley discovered that haying dates are shifting forward due to climate change, while Bobolinks are not adjusting their migration and breeding phenology [15].

Studies conducted in New York and Vermont [9,16] documented that mean birth and survival rates were lowest in fields that were cut before 11 June, followed by rotationally grazed fields, fields cut between 21 June and 10 July, and fields cut after 1 August. Responses to mowing vary by species. Shustack et al. [2] found that only 13% of cut fields retained or gained Bobolinks but 71% of fields retained or gained Savannah Sparrows after haying. Savannah Sparrows have a longer nesting season and are more resilient to disturbances during the breeding season. Several studies have found that Savannah Sparrows are more likely to recolonize hayed fields [2] and renest after a nest failure [10].

Ruderal shrubland, grassland, and agriculture make up less than 2% of the total acreage of terrestrial habitats within the Adirondack Park [17], but provide refuge for a diversity of species, including grassland obligate songbirds. Many hayfields in the Adirondacks are smaller and more isolated than those in the adjacent Champlain Valley of Vermont but are managed less intensively [18,19]. The patchy grassland habitats in the Champlain Valley function as islands within the heavily forested landscape of the Northeast [20]. Habitat selection among grassland species is impacted by landscape composition at different spatial scales, which impact species differently with varying levels and types of habitat fragmentation [21]. In Michigan, researchers found that population trends were better explained by land cover patterns than haying intensity, suggesting that reforestation of agricultural lands has a larger impact on grassland bird persistence than the intensification of haying [22]. Other studies have pointed to agriculture as the main driver of grassland bird population declines [3,4,16,23], because haying is a form of disturbance that birds do not recognize as an environmental threat [24]. Bobolinks are heavily impacted by landscape characteristics and occur more frequently with increasing openness at the 2500-meter scale. Savannah Sparrows were impacted by features at only 500 meters [2]. Findings in the Champlain Valley have suggested that high site fidelity, regardless of the nest success in the previous year, may be attributed to the lack of contiguous habitat [20].

While national and regional trends show consistent declines, regional population monitoring is essential to effectively design and prioritize conservation efforts [25], which makes it imperative to understand how populations in different geographic locations are impacted by haying intensity and landscape fragmentation. NDVI has been used successfully in the conservation field to measure relationships between primary productivity and distribution, abundance, and migration patterns for a range of species [26,27].

The objectives of this study were to (1) survey grassland birds in three periods within the breeding season in the Champlain Valley of New York, (2) determine the variables that most explain changes in occupancy patterns within a single breeding season, and (3) explore the effectiveness of monitoring haying using remote sensing and NDVI.

Methods

Study Area

The study area encompassed 786,908 hectares of New York's Champlain Valley and Eastern High Peaks regions. The study area allows for comparison of occupancy patterns across the elevational gradient from an established research site in Lake Placid [29-30], to the New York side of the Champlain Valley, which is adjacent to long-standing reference sites in Vermont [9,10,16,20]. The study area contains portions of Essex, Franklin, and Clinton counties and is largely forested, with a range of habitats that include alpine summits, boreal bogs, ruderal shrubland and grassland, and coniferous and mixed deciduous forest types. Located entirely within the boundaries of the Adirondack Park, the area contains several fragmented and low-intensity farming regions.

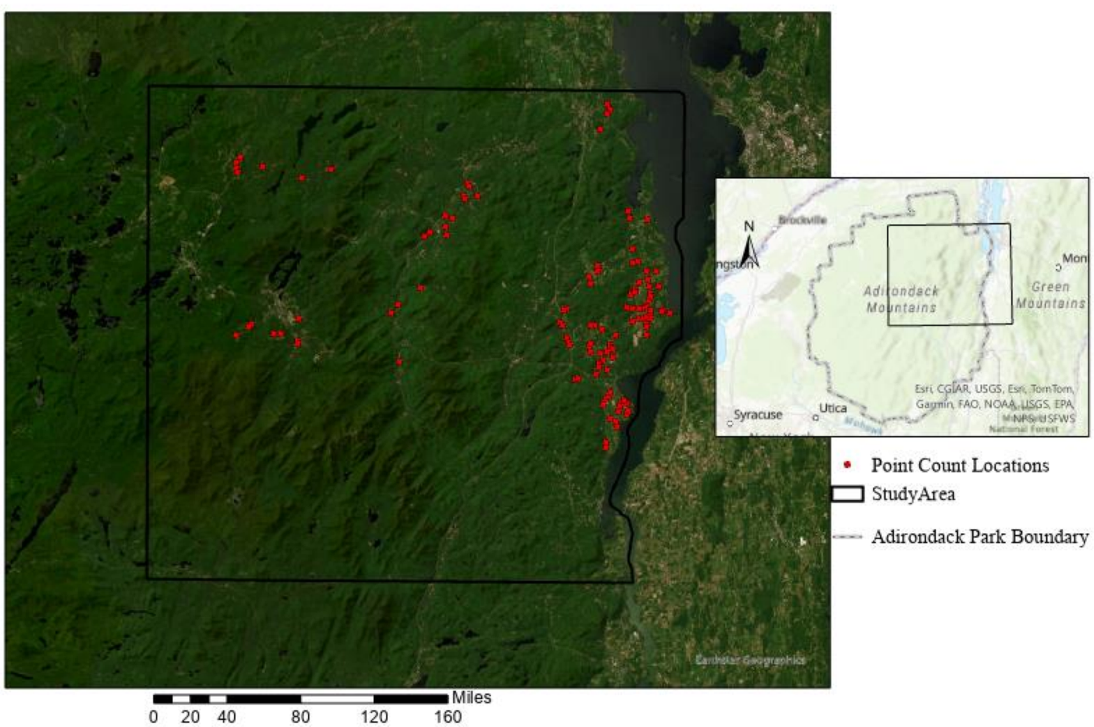

Figure 8: Map of the study site and point count locations (red) in the Adirondack Park of Upstate New York.

Point Count Methods

I identified over 750 hayfields throughout the study area using National Agricultural Statistics Service (NASS) Crop Data Layer (CDL) [31] data and aerial imagery. I selected fields that were 10 acres in size and within 5 meters of a roadway, which resulted in a total of 167 hayfields in the study area that could be sampled from the roadside. I randomly selected 120 point count locations from the 167 fields, ensuring that each point was at least 250 meters from all other points [4]. Point counts were conducted during three distinct periods (hereafter seasons) that corresponded to the phenology of hay cutting and the reproductive cycle; May 15-30, June 10-20, June 30- July 10. During each season, each site was visited once and three point counts (three minutes and 20 seconds each) were conducted during the visit. All the avian species that were detected visually or audibly during each point count were recorded. Detection data for our three species of interest was later translated into binary code, with a 1 representing a detection and a 0 representing a count with no detection.

Table 6: Covariates Used to Develop a Multi-season Occupancy Model for Grassland Birds in the Adirondacks

Covariate	psi	p	gamma	epsilon	Definition
kmopen	1				Percentage of the surrounding landscape at a 2.5 km radius that is in grassland, pasture, or hayfield.
mopen	1				Percentage of the surrounding landscape at a 250 m radius that is in grassland, pasture, or hayfield.
kmpercenthayed			1		Percentage of the fields within the 2.5 km buffer that were hayed during the season
mpercenthayed			1	1	Percentage of the fields within the 250 m buffer that were hayed during the season
time		1			Time at the start of the point count

Spatial Analysis

I created 250-meter and 2.5-kilometer buffers around each roadside point location, which align roughly with the spatial scales used by other studies [2,32]. Three crop types (Grassland/Pasture, Alfalfa, and Non-Alfalfa/Hay), which are representative of hayfields and pasture, were extracted from the 2022 United States Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS) Crop Data Layer (CDL). Zonal statistics were run on the CDL data, which generated the percentage of each buffer area that contained hayfield.

Remotely sensed multispectral imagery was acquired from Planet [33], which provides high-frequency satellite imagery and geospatial data daily for a yearly subscription fee. I used the Normalized Difference Vegetation Index (NDVI) to transform satellite imagery into a binary variable (hayed vs. not hayed). NDVI is calculated from multispectral satellite imagery as (NIR – Red) / (NIR + Red), where NIR is the near-infrared band and red is the red visible light band [34]. Since photosynthetic plants absorb red light and reflect near-infrared radiation, NDVI values are higher (closer to 1.0) with greater plant biomass in the landscape [25]. Abrupt reductions in NDVI are a strong indicator of haying [37]. Terrestrial NDVI values range from 0 to 1, and we considered a field to have been hayed when we observed a reduction of 0.1 or more between two dates.

To effectively measure haying during the breeding season, I needed to secure unobstructed imagery of the whole study area at regular intervals (ideally once per week) from May 15 – July 15. However, the 2023 field season had frequent rain events in June and July, which delayed the first cut for most farmers (Howe, unpublished data) and made acquiring remotely sensed data difficult. In addition, the smoke from wildfires in Canada caused air quality alerts throughout the Northeast [38], with the Air Quality Index registering higher than 150 throughout the study area several times in June [39]. On days with poor air quality, rain, and cloud cover, which occurred frequently during the summer of 2023, visibility was obscured, and satellite data could not be utilized. Instead of using imagery from a single day, I had to mosaic the imagery for several consecutive days to get adequate coverage of the study area, and the temporal resolution did not align perfectly with the point counts. The days that resulted in high-quality imagery were May 23, May 31, June 1, June2, June 5, June 20, June 22, July 4, and July 5. Our mosaiced imagery and resulting periods for comparison were June 1st, 2nd, and 5th to June 20th and 22nd (Season 1), and June 20th and 22nd to July 4th to July 5th (Season 2).

Correlation analysis

Table 7: Correlation analysis

	kmpercenthayed_1	mpercenthayed_1	kmopen	mopen	kmpercenthayed_2	mpercenthayed_2
kmpercenthayed_1	1					
mpercenthayed_1	0.461973579	1				
kmopen	-0.150865244	-0.021321974	1			
mopen	-0.300449223	-0.131065651	0.4497184	1		
kmpercenthayed_2	0.056022825	0.067616544	0.02499275	-0.084755042	1	
mpercenthayed_2	0.078904378	0.089395247	0.303344978	-0.032919293	0.377811368	1

A correlation analysis (Table 7) showed correlations greater than 0.3 (or less than -0.3) for several buffer covariates, which was the threshold that I used as the limit. Percent openness and the proportion of open acres hayed were correlated at both scales. I eliminated models with correlated covariates, resulting in a final model set of 72 unique combinations (Appendix 1). I ran all possible additive models and omitted the ones that did not converge, which resulted in 67 Bobolink models (Appendix 2), 69 Savannah Sparrow models (Appendix 3), and 71 Eastern Meadowlark models (Appendix 4).

Statistical Analysis

Table 8: Model parameters

Name	Symbol	Definition
p	p	probability of detection
psi	y	probability of initial site occupancy in period 1
gamma	γ	probability that a previously unoccupied site becomes colonized between periods t and t+1
epsilon	ε	probability that a previously occupied site goes locally extinct between periods t and t+1

I used a multi-season occupancy modeling framework to examine changes in bird occupancy at point count locations within a single breeding season. The primary input to the occupancy analysis was the encounter history (1 = detected, 0 = not detected). for all three species across all sites and visits. The encounter histories were input into a multi-season occupancy model using the occMod() function in the RPresence package [40,41] in program R [42], which estimates four parameters (Table 8), as well as relevant covariates.

Occupancy covariates included landscape openness (percentage of hayfield in the surrounding landscape at 250 m and 2.5 km spatial scales; Table 6). Time was the detection covariate (Table 6) as the point count protocol ensured that I did not sample on days when wind and precipitation would limit my ability to detect grassland birds. Extinction and colonization covariates included recent haying at the 250 m and 2.5 km spatial scales (Table 6).

The model set contained all possible additive models, which were assessed for each of the three target bird species: Bobolink, Savannah Sparrow, Eastern Meadowlark (Appendix 1), using model selection methods to rank the models. I considered all models with ΔAIC < 4 to show support, but present beta coefficients from all models that collectively make up the 95% model weight. The package ggplot2 [43] was used to generate graphics.

Results

Landscape Mosaic

The mean percentage of hayfield acreage in the surrounding landscape decreased by 50% when comparing the 250-meter buffers to the 2.5 km buffers, highlighting the isolated nature of grassland habitats in forest-dominated landscapes like the Northeast [5,44-46]. Within a 250-meter radius of our point counts, the percentage of the landscape that was composed of hayfield ranged from 9% to 49%, with a mean of 31.1%. Within a 2.5 km radius, the percentages dropped to a range of 1% to 35%, with a mean of 15.1%. The data were non-normally distributed at both spatial scales due to our criteria for site selection, which selected roadside points that were adjacent to fields greater than 10 acres in size.

Bobolink Models

Table 9: AIC Table - Top 10 Bobolink Models

Model	AICc	neg2ll	npar	warn.conv	warn.VC	DAICc	modlike	wgt
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(1)	956.3229	941.3047	7	7	0	0	1	0.3523
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	957.9424	940.6213	8	7	0	1.6195	0.445	0.1567
psi(kmopen)p(time)gamma(1)epsilon(1)	958.6187	945.8619	6	7	0	2.2958	0.3173	0.1118
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(1)	959.0122	943.994	7	7	0	2.6893	0.2606	0.0918
psi(kmopen)p(time)gamma(1)epsilon(mpercenthayed)	960.193	945.1748	7	7	0	3.8701	0.1444	0.0509
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	960.6336	943.3125	8	7	0	4.3107	0.1159	0.0408
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(1)	960.7621	945.7439	7	7	0	4.4392	0.1087	0.0383
psi(kmopen)p(1)gamma(kmpercenthayed)epsilon(1)	961.1238	948.367	6	7	0	4.8009	0.0907	0.0319
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	962.3781	945.057	8	7	0	6.0552	0.0484	0.0171
psi(kmopen)p(1)gamma(kmpercenthayed)epsilon(mpercenthayed)	962.7076	947.6894	7	7	0	6.3847	0.0411	0.0145

Out of the 67 Bobolink models, the top five models (<4 AIC) contained 76.4% of the model weight (Table 9 and Appendix 2 for betas). The model set contained significant model uncertainty, with the top model carrying 0.352 of the total weight. I used model averaging approaches to generate model averaged estimates for p, psi, gamma, and epsilon for each of the 118 sites (Figure 9). Detection probability (the probability of detection on an occupied site) was high but decreased as a function of time in which the survey was conducted (Figure 9 top left; see Appendix 2 for beta estimate). Detection probability ranged from a high of 93% to a low of 76% at 09:40, the latest count in our dataset. Betas for time in all the top models did not span zero. Initial site occupancy during the first season was strongly associated with the percent openness in the 2.5km radius landscape (Figure 9 top right), and the betas for kmopen in all the top models did not span zero. Bobolink occupancy reached 50% at 4% openness, which is equivalent to 78.5 hectares. At 35% openness (687 hectares), bobolink occupancy reached 95%. Patterns of occupancy shifted as the breeding season progressed. Overall, between 25-35% of previously occupied sites were abandoned, though this pattern was only weakly associated with the percentage of hayed land within 250 meters of the point count location (Figure 9 bottom left). -The probability of localized extinction remained constant despite the haying intensity in the surrounding landscape (Figure 9 bottom left).

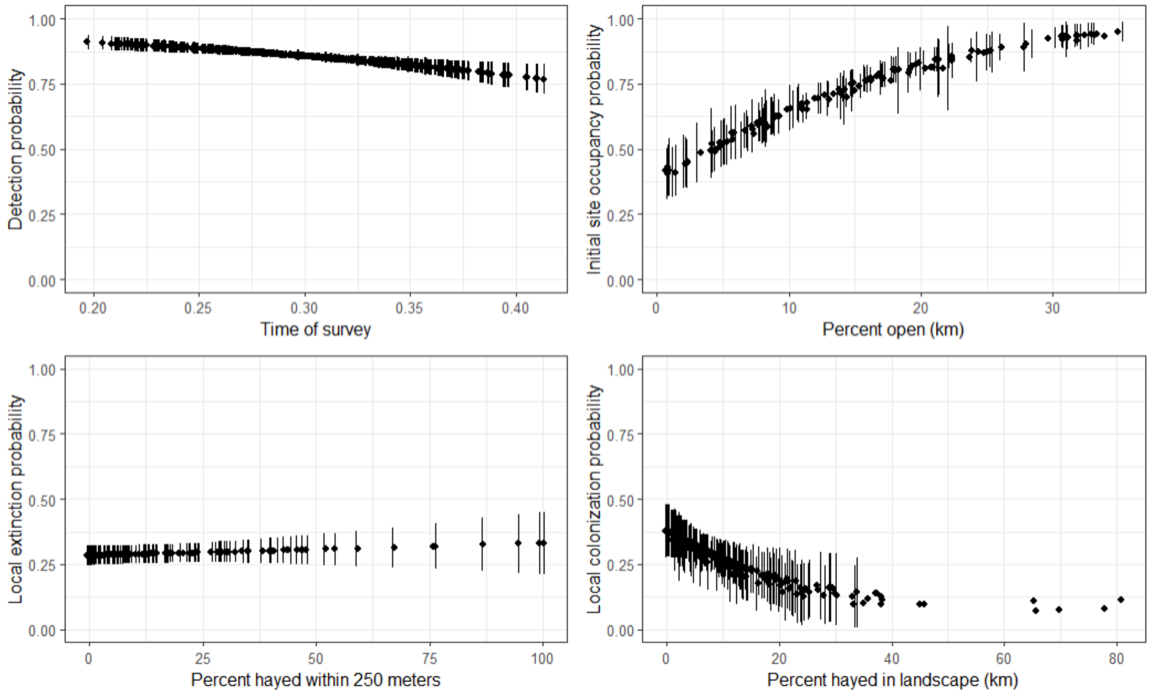

Figure 9: (top left) detection probability compared to time, (top right) initial site occupancy compared to landscape openness at 2.5 km, (bottom left) local extinction probability compared to haying within 250 meters, (bottom right) local colonization probability compared to haying within 2.5 km.

Savannah Sparrow

Table 10: AIC Table – Top 10 Savannah Sparrow Models

Model	AICc	neg2ll	npar	warn.conv	warn.VC	DAICc	modlike	wgt
psi(mopen)p(time)gamma(1)epsilon(mpercenthayed)	1092.874	1077.856	7	7	0	0	1	0.3116
psi(mopen)p(time)gamma(1)epsilon(1)	1093.515	1080.759	6	7	0	0.6414	0.7257	0.2261
psi(mopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	1094.602	1077.281	8	7	0	1.7283	0.4214	0.1313
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	1095.176	1077.855	8	7	0	2.3017	0.3164	0.0986
psi(mopen)p(time)gamma(mpercenthayed)epsilon(1)	1095.208	1080.19	7	7	0	2.3339	0.3113	0.097
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(1)	1095.776	1080.758	7	7	0	2.9019	0.2343	0.073
psi(kmopen)p(time)gamma(1)epsilon(mpercenthayed)	1099.355	1084.336	7	7	0	6.4806	0.0392	0.0122
psi(kmopen)p(time)gamma(1)epsilon(1)	1100.017	1087.261	6	7	0	7.1434	0.0281	0.0088
psi(mopen)p(mpercenthayed)gamma(1)epsilon(mpercenthayed)	1100.491	1085.473	7	7	0	7.6175	0.0222	0.0069
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	1101.07	1083.749	8	7	0	8.1958	0.0166	0.0052

The top 6 models (<4 DAIC) contained 93.8% of the model weight. The model set contained significant model uncertainty, with the top model carrying 0.316 of the total weight. I used model averaging approaches to generate model averaged estimates for p, psi, gamma, and epsilon for each of the 118 sites (Figure 10). Detection probability was high but decreased slightly as a function of time in which the survey was conducted

(Figure 10 top left; see Appendix 3 for beta estimates). Betas for time in all the top models did not span zero. Detection probability ranged from a high of 91% to a low of 70% at 09:40, the latest count in our dataset. Initial site occupancy during the first season was associated with openness in the 250-meter radius (Figure 10 top right). Savannah Sparrow occupancy reached 50% at 22% openness within a 250-meter radius; at 49% openness at the same scale, occupancy reached 90%. Betas for mopen in all the top models did not span zero. Patterns of occupancy shifted as the breeding season progressed. Between 10-20% of previously occupied sites were abandoned, though this pattern decreased slightly as mowing increased within 250m of the point count location (Figure 10 bottom left). Between 50-60% of previously unoccupied sites were colonized in subsequent seasons (Figure 10 bottom right).

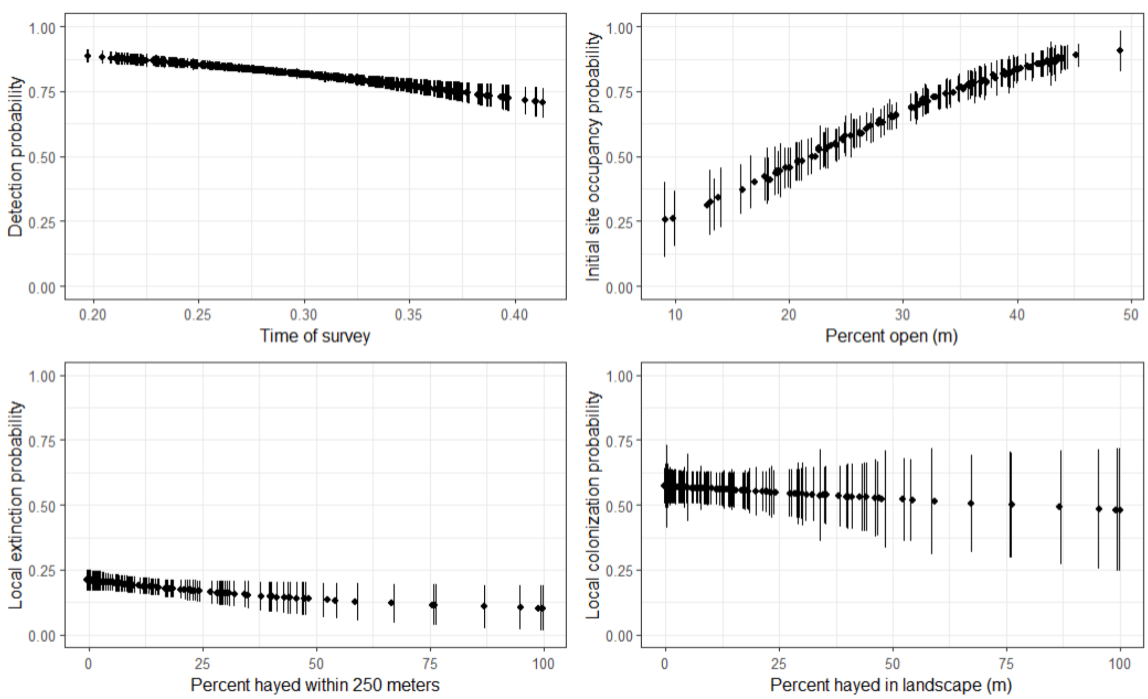

Figure 10: (top left) detection probability compared to time, (top right) initial site occupancy compared to landscape openness at 250 m, (bottom left) local extinction probability compared to haying within 250 meters, (bottom right) local colonization probability compared to haying within 250 m.

Eastern Meadowlark

Table 11: AIC Table - Top 10 Eastern meadowlark Models

Model	AICc	neg2ll	npar	warn.conv	warn.VC	DAICc	modlike	wgt
psi(kmopen)p(time)gamma(1)epsilon(mpercenthayed)	647.7187	632.7005	7	7	0	0	1	0.2731
psi(kmopen)p(time)gamma(1)epsilon(1)	647.7484	634.9916	6	7	0	0.0297	0.9853	0.2691
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(1)	649.6591	634.6409	7	7	0	1.9404	0.379	0.1035
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	649.6599	632.3388	8	7	0	1.9412	0.3789	0.1035
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	649.8655	632.5444	8	7	0	2.1468	0.3418	0.0934
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(1)	649.8657	634.8475	7	7	0	2.147	0.3418	0.0934
psi(kmopen)p(1)gamma(1)epsilon(mpercenthayed)	653.6793	640.9225	6	7	0	5.9606	0.0508	0.0139
psi(kmopen)p(1)gamma(1)epsilon(1)	653.9847	643.449	5	7	0	6.266	0.0436	0.0119
psi(kmopen)p(1)gamma(kmpercenthayed)epsilon(mpercenthayed)	655.4879	640.4697	7	7	0	7.7692	0.0206	0.0056
psi(kmopen)p(mpercenthayed)gamma(1)epsilon(mpercenthayed)	655.6896	640.6714	7	7	0	7.9709	0.0186	0.0051

The top six models (<4 AIC) contained 93.6% of the model weight (Table 11 and Appendix 4 for betas). The model set contained significant model uncertainty, with the top model carrying only 0.273 of the total weight. I used model averaging approaches to generate model averaged estimates for p, psi, gamma, and epsilon for each of the 118 sites (Figure 11). Detection probability was high and decreased rapidly as a function of time (Figure 11 top left; see Appendix 4 for beta estimate). Betas for time did not span zero in all the top models. Detection probability ranged from a high of 89% to a low of 48%. The lowest detection probability occurred around 9:40 AM, during the latest count in our dataset. Initial site occupancy during the first season was strongly associated with landscape openness within a 2.5 km radius (Figure 11 top right). Betas for kmopen did not span zero in all the top models. Eastern Meadowlarks required more open landscapes compared to Bobolinks and Savannah Sparrows, only reaching 50% occupancy at 26% openness. Patterns of occupancy shifted as the breeding season progressed. Colonization of previously unoccupied sites remained constant regardless of surrounding haying, at around 10% (Figure 11 bottom right). Between 20-40% of previously occupied sites were abandoned, and this pattern decreased slightly with haying in the surrounding 250-meter landscape (Figure 11 bottom left).

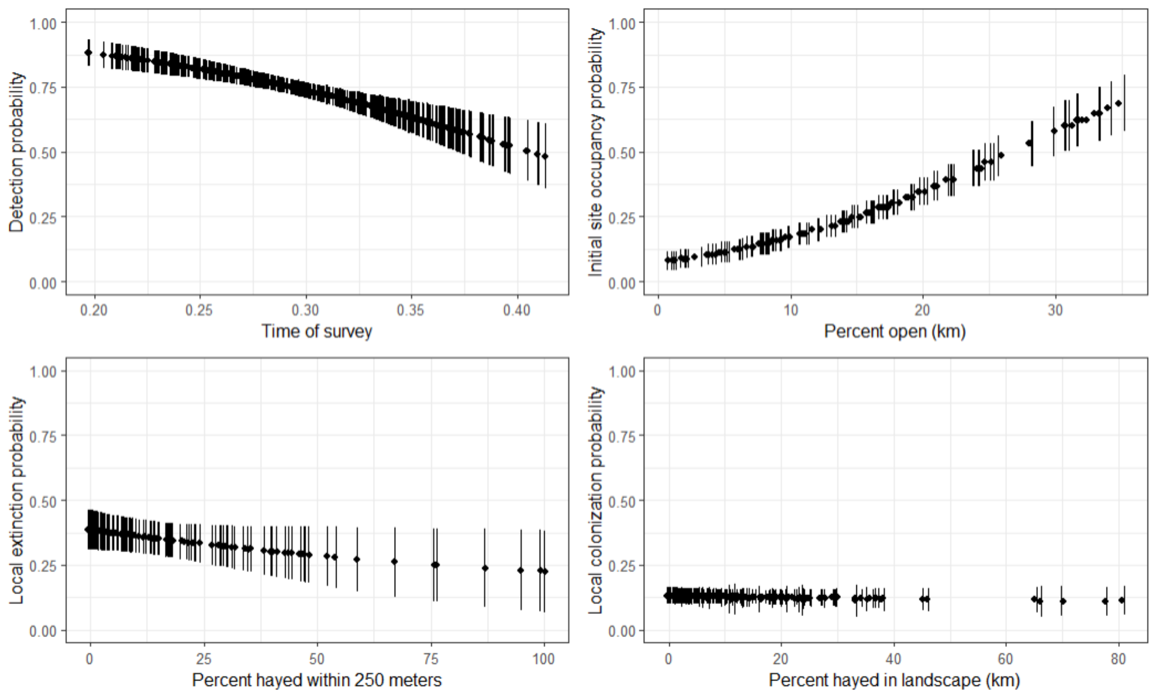

Figure 11: (top left) detection probability compared to time, (top right) initial site occupancy compared to landscape openness at 2.5 km, (bottom left) local extinction probability compared to haying within 250 meters, (bottom right) local colonization probability compared to haying within 2.5 km.

Discussion

Associations between initial occupancy and landscape openness at varying spatial scales were significant for all species. Eastern Meadowlarks required the greatest level of landscape openness, reaching 50% occupancy at 27% openness in the surrounding 2.5 km. By contrast, Bobolinks reached 50% occupancy at 4% openness in the surrounding 2.5 km radius and Savannah Sparrows reached 50% occupancy at 22% openness within a 250 m radius. All three species also showed a significant association between time and detection probability. Eastern Meadowlark detection declined rapidly later in the morning, while the other two remained high through the end of our sampling time.

Bobolink occupancy reached 50% occupancy at an equivalent of 78.5 hectares of open habitat within a 2.5 km radius. At 35% openness, bobolink occupancy reached 95%. Shustack et al. [2] found that at settlement, Bobolinks were influenced by features (proportion of forest to open land) within a 2.5 km radius. Renfrew and Ribic [21], and Wayne [47] found that associations between Bobolink abundance and patch size varied with the percentage of forest in the landscape. In landscapes that were heavily forested at a 1200m radius, the relative abundance of Bobolinks and Savannah Sparrow increased with core area. When the percentage of forest cover in the landscape decreased, there was no trend between relative abundance and core area (Renfrew and Ribic [21]. Guttery [32] found that patch occupancy was positively correlated with the proportion of pasture, idle grass, and hay, and negatively associated with the proportion of cropland and forest in the surrounding landscape.

Savannah Sparrows reached 50% occupancy at approximately 4.3 hectares of open landscape within a 250 m radius. Similar studies linked Savannah Sparrow occupancy with landscape openness at 500 m. Vikery et al. [4] found that Savannah Sparrow occupancy reached 50% occupancy in 10-hectare patches in Maine [4]. Savannah Sparrows are highly adaptable in open habitats in the Adirondacks, being found in fields dominated by forbs and even in boreal bogs (Howe, pers. obs.). Research has demonstrated that they can accommodate smaller fields with higher proportions of forbs [4], which may explain why their initial occupancy was not influenced by features at the 2.5 km radius scale.

Eastern Meadowlarks require the greatest amount of open acreage of the three species. Eastern Meadowlark occupancy reached 50% occupancy at 27% openness in the surrounding 2.5 km radius, which is equivalent to 530 ha of open habitat. In other studies, Eastern Meadowlark have been found to be positively associated with large, open, grass-dominated landscapes [4,48], but have been reported in a diversity of habitats, including cranberry bogs, golf courses, and hedge rows [48,49]. Renfrew and Ribic [21] found that Eastern Meadowlarks were most influenced by patch size and the percentage of grass within a 200m buffer, but that the association shifted with varying levels of openness in the surrounding landscape. When the percentage of grass at a small spatial scale was low, Meadowlark abundance increased with core area, but when pastures were surrounded by more open landscapes, the pattern reversed. Guttery [32] also found that while Eastern Meadowlarks showed no direct association between patch size and occupancy probability, occupancy probability increased with increasing land in hay and pasture between 100m and 1km radii.

The detection of all three species decreased with time. Bobolinks and Savannah Sparrows generally maintained high levels of detection. By 09:40, the probability of detection for Bobolinks and Savannah Sparrows was 76%, and 70%, respectively. By contrast, at 09:40, detection probability for Eastern Meadowlarks was 45%. Reasons for the difference among species are unclear. As Eastern Meadowlarks are detectable at long distances [50], the sharp decrease in detection probability with time of day is presumably a result of decreased rate of vocalizing.

In a study of a fragmented landscape in the Midwest, Scheiman et al. [51] determined that the Bobolinks in their study area had high dispersal rates and low rates of patch extinction from one year to the next. The study categorized the population as a metapopulation, suggesting that patches were connected by immigration and emigration. Similar research in our region could determine whether dispersal distances are above or below the greatest interpatch distances, which would identify habitat main lands and “midlands” [52] that are providing resilience to the population, and the “islands” that are at the greatest risk of extinction.

The relatively weak association between haying and the extinction and colonization parameters could be attributed to a variety of factors. In a survey of hay producers in the Adirondacks, Howe (unpublished data) found that weather during the 2023 field season caused widespread haying delays for farmers. These delays may have disrupted the typical patterns of colonization and extinction that would be expected during a normal hay production year. Second, the lack of significant associations between haying and colonization and extinction rates may be a result of the misalignment between haying data with on-the-ground bird surveys. My initial plan was to secure weekly NDVI imagery, the frequent rains and air quality obstructions caused me to have to create mosaiced imagery from several days and compare mosaiced imagery across 2-3 week intervals. This resulted in haying data that might not be aligned temporally with the point count data, obscuring the effect of haying on colonization and extinction. Third, the relative importance of open habitats may simply overshadow the effects of haying due to the relative high level of fragmentation and isolation of hayfields in the Adirondacks.

We recommend further utilization of multispectral satellite imagery to detect haying, and we believe that the challenges we encountered for this methodology can be mitigated by (1) planning to collect point count and multispectral imagery for over multiple years, and (2) collecting qualitative data from farmers through conversation to identify "normal" and "abnormal" weather and haying patterns. While our study failed to find significant associations between haying intensity and extinction or colonization rates for all species, the analysis brought up other questions, such as the connectivity and resilience of Adirondack grassland bird populations.

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Appendix

Appendix 1: Model set

	psi	p	gamma	epsilon		psi	p	gamma	epsilon
1	1	1	1	1	37	1	1	1	mpercenthayed
2	kmopen	1	1	1	38	kmopen	1	1	mpercenthayed
3	mpercenthayed	1	1	1	39	mpercenthayed	1	1	mpercenthayed
4	mopen	1	1	1	40	mopen	1	1	mpercenthayed
5	1	time	1	1	41	1	time	1	mpercenthayed
6	kmopen	time	1	1	42	kmopen	time	1	mpercenthayed
7	mpercenthayed	time	1	1	43	mpercenthayed	time	1	mpercenthayed
8	mopen	time	1	1	44	mopen	time	1	mpercenthayed
9	1	mpercenthayed	1	1	45	1	mpercenthayed	1	mpercenthayed
10	kmopen	mpercenthayed	1	1	46	kmopen	mpercenthayed	1	mpercenthayed
11	mpercenthayed	mpercenthayed	1	1	47	mpercenthayed	mpercenthayed	1	mpercenthayed
12	mopen	mpercenthayed	1	1	48	mopen	mpercenthayed	1	mpercenthayed
13	1	1	kmpercenthayed	1	49	1	1	kmpercenthayed	mpercenthayed
14	kmopen	1	kmpercenthayed	1	50	kmopen	1	kmpercenthayed	mpercenthayed
15	mpercenthayed	1	kmpercenthayed	1	51	mpercenthayed	1	kmpercenthayed	mpercenthayed
16	mopen	1	kmpercenthayed	1	52	mopen	1	kmpercenthayed	mpercenthayed
17	1	time	kmpercenthayed	1	53	1	time	kmpercenthayed	mpercenthayed
18	kmopen	time	kmpercenthayed	1	54	kmopen	time	kmpercenthayed	mpercenthayed
19	mpercenthayed	time	kmpercenthayed	1	55	mpercenthayed	time	kmpercenthayed	mpercenthayed
20	mopen	time	kmpercenthayed	1	56	mopen	time	kmpercenthayed	mpercenthayed
21	1	mpercenthayed	kmpercenthayed	1	57	1	mpercenthayed	kmpercenthayed	mpercenthayed
22	kmopen	mpercenthayed	kmpercenthayed	1	58	kmopen	mpercenthayed	kmpercenthayed	mpercenthayed
23	mpercenthayed	mpercenthayed	kmpercenthayed	1	59	mpercenthayed	mpercenthayed	kmpercenthayed	mpercenthayed
24	mopen	mpercenthayed	kmpercenthayed	1	60	mopen	mpercenthayed	kmpercenthayed	mpercenthayed
25	1	1	mpercenthayed	1	61	1	1	mpercenthayed	mpercenthayed
26	kmopen	1	mpercenthayed	1	62	kmopen	1	mpercenthayed	mpercenthayed
27	mpercenthayed	1	mpercenthayed	1	63	mpercenthayed	1	mpercenthayed	mpercenthayed
28	mopen	1	mpercenthayed	1	64	mopen	1	mpercenthayed	mpercenthayed
29	1	time	mpercenthayed	1	65	1	time	mpercenthayed	mpercenthayed
30	kmopen	time	mpercenthayed	1	66	kmopen	time	mpercenthayed	mpercenthayed
31	mpercenthayed	time	mpercenthayed	1	67	mpercenthayed	time	mpercenthayed	mpercenthayed
32	mopen	time	mpercenthayed	1	68	mopen	time	mpercenthayed	mpercenthayed
33	1	mpercenthayed	mpercenthayed	1	69	1	mpercenthayed	mpercenthayed	mpercenthayed
34	kmopen	mpercenthayed	mpercenthayed	1	70	kmopen	mpercenthayed	mpercenthayed	mpercenthayed
35	mpercenthayed	mpercenthayed	mpercenthayed	1	71	mpercenthayed	mpercenthayed	mpercenthayed	mpercenthayed
36	mopen	mpercenthayed	mpercenthayed	1	72	mopen	mpercenthayed	mpercenthayed	mpercenthayed

Appendix 2: Bobolink Model Beta Coefficients

Model	Parameter	Beta_est	se	lowerCI	upperCI
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(1)	P Intercept	3.534607	0.730577	2.102702392	4.966511608
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(1)	P Slope (Time)	-5.808873	2.359996	-10.43438016	-1.183365836
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(1)	Psi Intercept	-0.465109	0.411317	-1.271275506	0.341057506
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(1)	Psi Slope (Kmopen)	0.102365	0.029331	0.044877296	0.159852704
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(1)	Epsilon Intercept	-0.897844	0.17087	-1.232743046	-0.562944954
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(1)	Gamma Intercept	-0.324629	0.389274	-1.08759202	0.43833402
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(1)	Gamma Slope (Kmpercenthayed)	-0.076256	0.045035	-0.164522978	0.012010978
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	P Intercept	3.536133	0.730941	2.103514965	4.968751035
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	P Slope (Time)	-5.81488	2.361349	-10.44303899	-1.186721005
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	Psi Intercept	-0.465077	0.411322	-1.271253306	0.341099306
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	Psi Slope (Kmopen)	0.102371	0.029333	0.044879376	0.159862624
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	Epsilon Intercept	-0.983023	0.19976	-1.374545406	-0.591500594
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	Epsilon Slope (Mpercenthayed)	0.00674	0.007998	-0.008935792	0.022415792
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	Gamma Intercept	-0.32527	0.389332	-1.088346698	0.437806698
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	Gamma Slope (Kmpercenthayed)	-0.076242	0.045048	-0.164534458	0.012050458
psi(kmopen)p(time)gamma(1)epsilon(1)	P Intercept	3.534274	0.729941	2.103615929	4.964932071
psi(kmopen)p(time)gamma(1)epsilon(1)	P Slope (Time)	-5.812436	2.357996	-10.43402324	-1.190848764
psi(kmopen)p(time)gamma(1)epsilon(1)	Psi Intercept	-0.465469	0.411903	-1.272784045	0.341846045
psi(kmopen)p(time)gamma(1)epsilon(1)	Psi Slope (Kmopen)	0.102677	0.029444	0.04496782	0.16038618
psi(kmopen)p(time)gamma(1)epsilon(1)	Epsilon Intercept	-0.898317	0.170834	-1.233145487	-0.563488513
psi(kmopen)p(time)gamma(1)epsilon(1)	Gamma Intercept	-0.891973	0.271099	-1.423317276	-0.360628724
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(1)	P Intercept	3.534396	0.729883	2.103851607	4.964940393
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(1)	P Slope (Time)	-5.813612	2.357823	-10.43486016	-1.192363838
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(1)	Psi Intercept	-0.467309	0.412007	-1.274827881	0.340209881
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(1)	Psi Slope (Kmopen)	0.102819	0.029481	0.045037302	0.160600698
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(1)	Epsilon Intercept	-0.898504	0.170875	-1.233412846	-0.563595154
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(1)	Gamma Intercept	-0.696463	0.304496	-1.293264193	-0.099661807
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(1)	Gamma Slope (Mpercenthayed)	-0.03584	0.031317	-0.097220192	0.025540192
psi(kmopen)p(time)gamma(1)epsilon(mpercenthayed)	P Intercept	3.536033	0.730304	2.104663462	4.967402538
psi(kmopen)p(time)gamma(1)epsilon(mpercenthayed)	P Slope (Time)	-5.819401	2.359371	-10.44368319	-1.195118814
psi(kmopen)p(time)gamma(1)epsilon(mpercenthayed)	Psi Intercept	-0.46544	0.411925	-1.272798164	0.341918164
psi(kmopen)p(time)gamma(1)epsilon(mpercenthayed)	Psi Slope (Kmopen)	0.102692	0.029448	0.044974981	0.160409019
psi(kmopen)p(time)gamma(1)epsilon(mpercenthayed)	Epsilon Intercept	-0.983695	0.199714	-1.375127247	-0.592262753
psi(kmopen)p(time)gamma(1)epsilon(mpercenthayed)	Epsilon Slope (Mpercenthayed)	0.006758	0.007997	-0.008915832	0.022431832
psi(kmopen)p(time)gamma(1)epsilon(mpercenthayed)	gamma Intercept	-0.892504	0.271184	-1.424014873	-0.360993127
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	P Intercept	3.536256	0.730228	2.105035419	4.967476581
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	P Slope (Time)	-5.820593	2.359147	-10.44443615	-1.196749846
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	Psi Intercept	-0.467279	0.41202	-1.274823361	0.340265361
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	Psi Slope (Kmopen)	0.102829	0.029484	0.045041422	0.160616578
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	Epsilon Intercept	-0.983492	0.199714	-1.374924247	-0.592059753
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	Epsilon Slope (Mpercenthayed)	0.00673	0.007998	-0.008945792	0.022405792
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	Gamma Intercept	-0.697199	0.304569	-1.294143271	-0.100254729
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	Gamma Slope (Mpercenthayed)	-0.035774	0.031285	-0.097091473	0.025543473
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(1)	P Intercept	3.532327	0.731915	2.09779996	4.96685404
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(1)	P Slope (Time)	-5.797435	2.363958	-10.43070754	-1.164162459
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(1)	Psi Intercept	-1.43312	0.74044	-2.884355733	0.018115733
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(1)	Psi Slope (Mopen)	0.078536	0.024626	0.030269927	0.126802073
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(1)	Epsilon Intercept	-0.897723	0.170866	-1.232614206	-0.562831794
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(1)	Gamma Intercept	-0.323807	0.388932	-1.086099712	0.438485712
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(1)	Gamma Slope (Kmpercenthayed)	-0.076167	0.04499	-0.16434578	0.01201178
psi(kmopen)p(1)gamma(kmpercenthayed)epsilon(1)	P Intercept	1.788984	0.113447	1.566631966	2.011336034
psi(kmopen)p(1)gamma(kmpercenthayed)epsilon(1)	Psi Intercept	-0.46134	0.410245	-1.265405425	0.342725425
psi(kmopen)p(1)gamma(kmpercenthayed)epsilon(1)	Psi Slope (Kmopen)	0.101573	0.029083	0.044571367	0.158574633
psi(kmopen)p(1)gamma(kmpercenthayed)epsilon(1)	Epsilon Intercept	-0.898668	0.171056	-1.233931599	-0.563404401
psi(kmopen)p(1)gamma(kmpercenthayed)epsilon(1)	Gamma Intercept	-0.324099	0.387401	-1.083391008	0.435193008
psi(kmopen)p(1)gamma(kmpercenthayed)epsilon(1)	Gamma Slope (Kmpercenthayed)	-0.076285	0.04498	-0.16444418	0.01187418
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	P Intercept	3.534177	0.732312	2.098871855	4.969482145
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	P Slope (Time)	-5.804673	2.365452	-10.44087373	-1.168472273
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	Psi Intercept	-1.433538	0.740506	-2.88490309	0.01782709
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	Psi Slope (Mopen)	0.078557	0.02463	0.030283087	0.126830913
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	Epsilon Intercept	-0.983091	0.199742	-1.374578126	-0.591603874
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	Epsilon Slope (Mpercenthayed)	0.006756	0.007997	-0.008917832	0.022429832
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	Gamma Intercept	-0.32447	0.389006	-1.08690775	0.43796775
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	Gamma Slope (Kmpercenthayed)	-0.076153	0.045003	-0.164357259	0.012051259
psi(kmopen)p(1)gamma(kmpercenthayed)epsilon(mpercenthayed)	P Intercept	1.788756	0.113471	1.566356927	2.011155073
psi(kmopen)p(1)gamma(kmpercenthayed)epsilon(mpercenthayed)	Psi Intercept	-0.461314	0.410248	-1.265385305	0.342757305
psi(kmopen)p(1)gamma(kmpercenthayed)epsilon(mpercenthayed)	Psi Slope (Kmopen)	0.101576	0.029084	0.044572407	0.158579593
psi(kmopen)p(1)gamma(kmpercenthayed)epsilon(mpercenthayed)	Epsilon Intercept	-0.983491	0.199919	-1.37532504	-0.59165696
psi(kmopen)p(1)gamma(kmpercenthayed)epsilon(mpercenthayed)	Epsilon Slope (Mpercenthayed)	0.006716	0.008003	-0.008969592	0.022401592
psi(kmopen)p(1)gamma(kmpercenthayed)epsilon(mpercenthayed)	Gamma Intercept	-0.324625	0.387475	-1.084062045	0.434812045
psi(kmopen)p(1)gamma(kmpercenthayed)epsilon(mpercenthayed)	Gamma Slope (Kmpercenthayed)	-0.076298	0.045002	-0.164500299	0.011904299

Appendix 3: Savannah sparrow Beta Coefficients

Model	Parameter	Beta Estimate	Standard Error	Lower CI	Upper CI
psi(mopen)p(time)gamma(1)epsilon(mpercenthayed)	P Intercept	3.14301	0.632522	1.903289661	4.382730339
psi(mopen)p(time)gamma(1)epsilon(mpercenthayed)	P Slope (Time)	-5.514475	2.107962	-9.646004601	-1.3829454
psi(mopen)p(time)gamma(1)epsilon(mpercenthayed)	Psi Intercept	-2.00484	0.741271	-3.457704463	-0.55197554
psi(mopen)p(time)gamma(1)epsilon(mpercenthayed)	Psi Slope (Mopen)	0.090914	0.024444	0.04300464	0.13882336
psi(mopen)p(time)gamma(1)epsilon(mpercenthayed)	Epsilon Intercept	-1.24031	0.229001	-1.689143712	-0.79147629
psi(mopen)p(time)gamma(1)epsilon(mpercenthayed)	Epsilon Slope (Mpercenthayed)	-0.020382	0.01375	-0.047331505	0.006567505
psi(mopen)p(time)gamma(1)epsilon(mpercenthayed)	Gamma Intercept	0.264445	0.248847	-0.223286158	0.752176158
psi(mopen)p(time)gamma(1)epsilon(1)	P Intercept	3.15352	0.633018	1.912827518	4.394212482
psi(mopen)p(time)gamma(1)epsilon(1)	P Slope (Time)	-5.555937	2.110708	-9.692848662	-1.41902534
psi(mopen)p(time)gamma(1)epsilon(1)	Psi Intercept	-2.005018	0.741392	-3.458119618	-0.55191638
psi(mopen)p(time)gamma(1)epsilon(1)	Psi Slope (Mopen)	0.090937	0.024451	0.043013921	0.138860079
psi(mopen)p(time)gamma(1)epsilon(1)	Epsilon Intercept	-1.441827	0.200952	-1.835685683	-1.04796832
psi(mopen)p(time)gamma(1)epsilon(1)	Gamma Intercept	0.262672	0.249078	-0.225511909	0.750855909
psi(mopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	P Intercept	3.147082	0.632981	1.906462037	4.387701963
psi(mopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	P Slope (Time)	-5.528835	2.109867	-9.664098332	-1.39357167
psi(mopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	Psi Intercept	-2.004447	0.741165	-3.457103707	-0.55179029
psi(mopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	Psi Slope (Mopen)	0.09089	0.024438	0.0429924	0.1387876
psi(mopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	Epsilon Intercept	-1.240062	0.229074	-1.68903879	-0.79108521
psi(mopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	Epsilon Slope (Mpercenthayed)	-0.020406	0.013753	-0.047361385	0.006549385
psi(mopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	Gamma Intercept	0.376449	0.290477	-0.192875458	0.945773458
psi(mopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	Gamma Slope (Mpercenthayed)	-0.016473	0.02181	-0.059219815	0.026273815
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	P Intercept	3.143065	0.632547	1.903295661	4.382834339
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	P Slope (Time)	-5.514634	2.108048	-9.646332158	-1.38293584
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	Psi Intercept	-2.004807	0.741265	-3.457659703	-0.5519543
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	Psi Slope (Mopen)	0.090912	0.024444	0.04300264	0.13882136
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	Epsilon Intercept	-1.240296	0.229004	-1.689135592	-0.79145641
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	Epsilon Slope (Mpercenthayed)	-0.020383	0.01375	-0.047332505	0.006566505
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	Gamma Intercept	0.270921	0.310751	-0.338139768	0.879981768
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	Gamma Slope (Kmpercenthayed)	-0.00067	0.019418	-0.038728581	0.037388581
psi(mopen)p(time)gamma(mpercenthayed)epsilon(1)	P Intercept	3.157516	0.633472	1.915933695	4.399098305
psi(mopen)p(time)gamma(mpercenthayed)epsilon(1)	P Slope (Time)	-5.56982	2.112579	-9.710398754	-1.42924125
psi(mopen)p(time)gamma(mpercenthayed)epsilon(1)	Psi Intercept	-2.004694	0.741252	-3.457521223	-0.55186678
psi(mopen)p(time)gamma(mpercenthayed)epsilon(1)	Psi Slope (Mopen)	0.090911	0.024443	0.0430036	0.1388184
psi(mopen)p(time)gamma(mpercenthayed)epsilon(1)	Epsilon Intercept	-1.441922	0.201015	-1.83590416	-1.04793984
psi(mopen)p(time)gamma(mpercenthayed)epsilon(1)	Gamma Intercept	0.37385	0.290416	-0.195354901	0.943054901
psi(mopen)p(time)gamma(mpercenthayed)epsilon(1)	Gamma Slope (Mpercenthayed)	-0.016403	0.021822	-0.059173334	0.026367334
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(1)	P Intercept	3.15356	0.633041	1.912822439	4.394297561
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(1)	P Slope (Time)	-5.556041	2.110783	-9.693099659	-1.41898234
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(1)	Psi Intercept	-2.004988	0.741386	-3.458077859	-0.55189814
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(1)	Psi Slope (Mopen)	0.090935	0.02445	0.043013881	0.138856119
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(1)	Epsilon Intercept	-1.441826	0.200954	-1.835688603	-1.0479634
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(1)	Gamma Intercept	0.268391	0.310776	-0.340718767	0.877500767
psi(mopen)p(time)gamma(kmpercenthayed)epsilon(1)	Gamma Slope (Kmpercenthayed)	-0.000593	0.019445	-0.0387045	0.0375185
psi(kmopen)p(time)gamma(1)epsilon(mpercenthayed)	P Intercept	3.14106	0.630994	1.904334486	4.377785514
psi(kmopen)p(time)gamma(1)epsilon(mpercenthayed)	P Slope (Time)	-5.506312	2.102721	-9.62756943	-1.38505457
psi(kmopen)p(time)gamma(1)epsilon(mpercenthayed)	Psi Intercept	-0.273434	0.389441	-1.036724334	0.489856334
psi(kmopen)p(time)gamma(1)epsilon(mpercenthayed)	Psi Slope (Kmopen)	0.07022	0.024966	0.021287539	0.119152461
psi(kmopen)p(time)gamma(1)epsilon(mpercenthayed)	Epsilon Intercept	-1.237154	0.22895	-1.685887754	-0.78842025
psi(kmopen)p(time)gamma(1)epsilon(mpercenthayed)	Epsilon Slope (Mpercenthayed)	-0.020463	0.01376	-0.047432104	0.006506104
psi(kmopen)p(time)gamma(1)epsilon(mpercenthayed)	Gamma Intercept	0.268488	0.248908	-0.219362715	0.756338715
psi(kmopen)p(time)gamma(1)epsilon(1)	P Intercept	3.150407	0.63138	1.912924939	4.387889061
psi(kmopen)p(time)gamma(1)epsilon(1)	P Slope (Time)	-5.543015	2.104977	-9.668694108	-1.41733589
psi(kmopen)p(time)gamma(1)epsilon(1)	Psi Intercept	-0.272105	0.38936	-1.035236577	0.491026577
psi(kmopen)p(time)gamma(1)epsilon(1)	Psi Slope (Kmopen)	0.070119	0.02494	0.021237498	0.119000502
psi(kmopen)p(time)gamma(1)epsilon(1)	Epsilon Intercept	-1.43949	0.200879	-1.833205605	-1.04577439
psi(kmopen)p(time)gamma(1)epsilon(1)	Gamma Intercept	0.26657	0.249086	-0.221629589	0.754769589
psi(mopen)p(mpercenthayed)gamma(1)epsilon(mpercenthayed)	P Intercept	1.558422	0.106293	1.350091548	1.766752452
psi(mopen)p(mpercenthayed)gamma(1)epsilon(mpercenthayed)	P Slope (Mpercenthayed)	-0.003664	0.005144	-0.013746055	0.006418055
psi(mopen)p(mpercenthayed)gamma(1)epsilon(mpercenthayed)	Psi Intercept	-2.011568	0.739	-3.459981385	-0.56315462
psi(mopen)p(mpercenthayed)gamma(1)epsilon(mpercenthayed)	Psi Slope (Mopen)	0.090776	0.024341	0.043068517	0.138483483
psi(mopen)p(mpercenthayed)gamma(1)epsilon(mpercenthayed)	Epsilon Intercept	-1.229778	0.227263	-1.675205295	-0.7843507
psi(mopen)p(mpercenthayed)gamma(1)epsilon(mpercenthayed)	Epsilon Slope (Mpercenthayed)	-0.020685	0.013798	-0.047728583	0.006358583
psi(mopen)p(mpercenthayed)gamma(1)epsilon(mpercenthayed)	Gamma Intercept	0.263134	0.2469	-0.220781108	0.747049108
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	P Interrcept	3.146041	0.63157	1.908186546	4.383895454
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	P Slope (Time)	-5.524262	2.105119	-9.650219423	-1.39830458
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	Psi Intercept	-0.274104	0.389478	-1.037466853	0.489258853
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	Psi Slope (Kmopen)	0.07027	0.024978	0.02131402	0.11922598
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	Epsilon Intercept	-1.23679	0.229026	-1.685672712	-0.78790729
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	Epsilon Slope (Mpercenthayed)	-0.020492	0.013765	-0.047470904	0.006486904
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	Gamma Intercept	0.381909	0.290749	-0.187948569	0.951766569
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	Gamma Slope (Mpercenthayed)	-0.016665	0.021819	-0.059429454	0.026099454

Appendix 4: Eastern meadowlark Beta Coefficients

Model	Parameter	Beta Estimate	Standard Error	Lower CI	Upper CI
psi(kmopen)p(time)gamma(1)epsilon(mpercenthayed)	P Intercept	4.104738	1.085293	1.977602807	6.231873193
psi(kmopen)p(time)gamma(1)epsilon(mpercenthayed)	P Slope (Time)	-10.249339	3.591691	-17.288924	-3.209753996
psi(kmopen)p(time)gamma(1)epsilon(mpercenthayed)	Psi Intercept	-2.541003	0.506228	-3.533191648	-1.548814352
psi(kmopen)p(time)gamma(1)epsilon(mpercenthayed)	Psi Slope (Kmopen)	0.095497	0.025421	0.045672756	0.145321244
psi(kmopen)p(time)gamma(1)epsilon(mpercenthayed)	Epsilon Intercept	-0.351196	0.318769	-0.975971759	0.273579759
psi(kmopen)p(time)gamma(1)epsilon(mpercenthayed)	Epsilon Slope (Mpercenthayed)	-0.018666	0.013847	-0.045805621	0.008473621
psi(kmopen)p(time)gamma(1)epsilon(mpercenthayed)	Gamma Intercept	-1.918382	0.239057	-2.38692511	-1.44983889
psi(kmopen)p(time)gamma(1)epsilon(1)	P Intercept	4.139873	1.084413	2.014462576	6.265283424
psi(kmopen)p(time)gamma(1)epsilon(1)	P Slope (Time)	-10.375431	3.593874	-17.4192946	-3.331567395
psi(kmopen)p(time)gamma(1)epsilon(1)	Psi Intercept	-2.537638	0.505818	-3.529023063	-1.546252937
psi(kmopen)p(time)gamma(1)epsilon(1)	Psi Slope (Kmopen)	0.095325	0.025384	0.045573274	0.145076726
psi(kmopen)p(time)gamma(1)epsilon(1)	Epsilon Intercept	-0.596334	0.278906	-1.142979715	-0.049688285
psi(kmopen)p(time)gamma(1)epsilon(1)	Gamma Intercept	-1.923952	0.240269	-2.394870587	-1.453033413
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(1)	P Intercept	4.126304	1.085348	1.999061009	6.253546991
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(1)	P Slope (Time)	-10.324179	3.59682	-17.37381666	-3.274541341
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(1)	Psi Intercept	-2.537801	0.50556	-3.528680392	-1.546921608
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(1)	Psi Slope (Kmopen)	0.095146	0.025361	0.045439353	0.144852647
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(1)	Epsilon Intercept	-0.594359	0.27886	-1.140914557	-0.047803443
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(1)	Gamma Intercept	-1.803122	0.31392	-2.418393894	-1.187850106
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(1)	Gamma Slope (Kmpercenthayed)	-0.011406	0.020373	-0.051336346	0.028524346
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	P Intercept	4.090606	1.0868	1.960517142	6.220694858
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	P Slope (Time)	-10.197234	3.596445	-17.24613667	-3.148331328
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	Psi Intercept	-2.54097	0.505982	-3.532676497	-1.549263503
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	Psi Slope (Kmopen)	0.095317	0.0254	0.045533915	0.145100085
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	Epsilon Intercept	-0.348923	0.318672	-0.973508643	0.275662643
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	Epsilon Slope (Mpercenthayed)	-0.018721	0.013865	-0.045895901	0.008453901
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	Gamma Intercept	-1.796232	0.3125	-2.408720745	-1.183743255
psi(kmopen)p(time)gamma(kmpercenthayed)epsilon(mpercenthayed)	Gamma Slope (Kmpercenthayed)	-0.011572	0.020368	-0.051492546	0.028348546
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	P Intercept	4.113881	1.085528	1.986285216	6.241476784
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	P Slope (Time)	-10.281627	3.591936	-17.32169219	-3.241561805
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	Psi Intercept	-2.543484	0.506451	-3.53610972	-1.55085828
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	Psi Slope (Kmopen)	0.095679	0.025439	0.045819476	0.145538524
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	Epsilon Intercept	-0.350106	0.318641	-0.974630884	0.274418884
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	Espsilon Slope (Mpercenthayed)	-0.018724	0.013861	-0.045891061	0.008443061
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	Gamma Intercept	-1.863527	0.275318	-2.403140364	-1.323913636
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(mpercenthayed)	Gamma Slope (Mpercenthayed)	-0.006585	0.017316	-0.040523736	0.027353736
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(1)	P Intercept	4.148415	1.084546	2.0227439	6.2740861
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(1)	P Slope (Time)	-10.404831	3.593798	-17.44854565	-3.361116352
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(1)	Psi Intercept	-2.540111	0.506028	-3.531907655	-1.548314345
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(1)	Psi Slope (Kmopen)	0.095493	0.0254	0.045709915	0.145276085
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(1)	Epsilon Intercept	-0.595862	0.27877	-1.14224116	-0.04948284
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(1)	Gamma Intercept	-1.870962	0.276751	-2.413383993	-1.328540007
psi(kmopen)p(time)gamma(mpercenthayed)epsilon(1)	Gamma Slope (Mpercenthayed)	-0.006325	0.017285	-0.040202977	0.027552977
psi(kmopen)p(1)gamma(1)epsilon(mpercenthayed)	P Intercept	1.067301	0.150225	0.77286541	1.36173659
psi(kmopen)p(1)gamma(1)epsilon(mpercenthayed)	Psi Intercept	-2.521247	0.499897	-3.501027116	-1.541466884
psi(kmopen)p(1)gamma(1)epsilon(mpercenthayed)	Psi Slope (Kmopen)	0.092261	0.024797	0.043659773	0.140862227
psi(kmopen)p(1)gamma(1)epsilon(mpercenthayed)	Epsilon Intercept	-0.327531	0.315883	-0.946650303	0.291588303
psi(kmopen)p(1)gamma(1)epsilon(mpercenthayed)	Epsilon Slope (Mpercenthayed)	-0.019984	0.014427	-0.0482604	0.0082924
psi(kmopen)p(1)gamma(1)epsilon(mpercenthayed)	Gamma Intercept	-1.903048	0.233645	-2.360983785	-1.445112215
psi(kmopen)p(1)gamma(1)epsilon(1)	P Intercept	1.070074	0.149886	0.776302838	1.363845162
psi(kmopen)p(1)gamma(1)epsilon(1)	Psi Intercept	-2.519935	0.499653	-3.499236885	-1.540633115
psi(kmopen)p(1)gamma(1)epsilon(1)	Psi Slope (Kmopen)	0.092132	0.02477	0.043583692	0.140680308
psi(kmopen)p(1)gamma(1)epsilon(1)	Epsilon Intercept	-0.574863	0.277453	-1.118660887	-0.031065113
psi(kmopen)p(1)gamma(1)epsilon(1)	Gamma Intercept	-1.901645	0.233351	-2.359004556	-1.444285444
psi(kmopen)p(1)gamma(kmpercenthayed)epsilon(mpercenthayed)	P Intercept	1.067386	0.150174	0.773050369	1.361721631
psi(kmopen)p(1)gamma(kmpercenthayed)epsilon(mpercenthayed)	Psi Intercept	-2.521491	0.499786	-3.50105356	-1.54192844
psi(kmopen)p(1)gamma(kmpercenthayed)epsilon(mpercenthayed)	Psi Slope (Kmopen)	0.092208	0.024785	0.043630293	0.140785707
psi(kmopen)p(1)gamma(kmpercenthayed)epsilon(mpercenthayed)	Epsilon Intercept	-0.32738	0.315984	-0.94669726	0.29193726
psi(kmopen)p(1)gamma(kmpercenthayed)epsilon(mpercenthayed)	Epsilon Slope (Mpercenthayed)	-0.020127	0.014509	-0.048564117	0.008310117
psi(kmopen)p(1)gamma(kmpercenthayed)epsilon(mpercenthayed)	Gamma Intercept	-1.77194	0.303414	-2.366620512	-1.177259488
psi(kmopen)p(1)gamma(kmpercenthayed)epsilon(mpercenthayed)	Gamma Slope (Kmpercenthayed)	-0.012883	0.020395	-0.052856465	0.027090465
psi(kmopen)p(mpercenthayed)gamma(1)epsilon(mpercenthayed)	P Intercept	1.035467	0.16231	0.717345246	1.353588754
psi(kmopen)p(mpercenthayed)gamma(1)epsilon(mpercenthayed)	P Slope (Mpercenthayed)	0.004032	0.008156	-0.011953466	0.020017466
psi(kmopen)p(mpercenthayed)gamma(1)epsilon(mpercenthayed)	Psi Intercept	-2.518889	0.499865	-3.498606397	-1.539171603
psi(kmopen)p(mpercenthayed)gamma(1)epsilon(mpercenthayed)	Psi Slope (Kmopen)	0.092146	0.024786	0.043566333	0.140725667
psi(kmopen)p(mpercenthayed)gamma(1)epsilon(mpercenthayed)	Epsilon Intercept	-0.326928	0.315735	-0.945757229	0.291901229
psi(kmopen)p(mpercenthayed)gamma(1)epsilon(mpercenthayed)	Epsilon Slope (Mpercenthayed)	-0.020041	0.014445	-0.04835268	0.00827068
psi(kmopen)p(mpercenthayed)gamma(1)epsilon(mpercenthayed)	Gamma Intercept	-1.903179	0.233718	-2.361257863	-1.445100137