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Breeding bird use of intensively managed rotational grazing pastures, native prairies and savannas: A comparison

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**BREEDING BIRD USE OF INTENSIVELY MANAGED ROTATIONAL
GRAZING PASTURES, NATIVE PRAIRIES AND
SAVANNAS: A COMPARISON**

An Abstract of a Thesis

Submitted

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

Jennifer Marie Hurley O'Hara

University of Northern Iowa

May 1998

ABSTRACT

Intensively managed rotational grazing is a grazing method in which livestock are moved through a series of paddocks over a three to six week rotation. Vegetation in resting paddocks is allowed to regrow, renew energy reserves, and rebuild plant vigor to provide nutritious forage for livestock. Consequently, vegetation in the paddocks is in different stages of growth which creates a mosaic of vegetation heights across the pasture landscape. I hypothesized that the mosaic of vegetation heights resembles the native tallgrass prairie grazed by bison prior to European settlement. The mosaic may be attractive and beneficial to breeding grassland birds. Several species of Neotropical migrant grassland birds have experienced severe declines in the past 30-40 years due to loss of habitat and intensified agricultural practices. Intensive rotational grazing as a sustainable alternative to conventional row crop agriculture and continuous grazing systems may provide better breeding habitat for grassland birds.

To test my hypothesis, I assessed and compared bird use in six rotational grazing pastures, two native prairies, and one native savanna in Northeast Iowa. I conducted early morning bird counts using a fixed width transect method. Each site was censused six times between May and August 1996. Bird abundance and species richness were compared between pastures and native grasslands. I also assessed vegetation structure and landscape level features at each site to determine what features might attract grassland birds.

Each study site is unique in its management, vegetation, adjacent habitat, and landscape scale feature. Thus, each site was considered and analyzed individually. I also

tested for differences between native and grazed sites. T-tests showed no significant difference between grazed pastures and native sites for total species richness, grassland species richness, woodland species richness, Neotropical migrant grassland species richness, Shannon-Weaver index of diversity, total grassland species abundance, bobolink abundance, dickcissel abundance, meadowlark abundance, and grasshopper sparrow abundance. The comparisons allow me to conclude that rotationally grazed pastures are acting as native grassland analogs and are a good alternative to conventional farming in human dominated landscapes.

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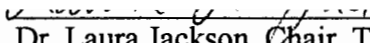
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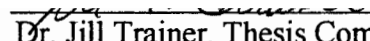
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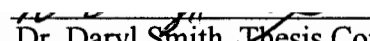
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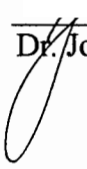
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Date



Dr. John W. Somervill, Dean, Graduate College

DEDICATION

For my mom, Marilyn Ann Stephenson Hurley, who, in her life, taught me to be curious about the world of nature, to see beauty in the smallest creatures and the grandest landscapes, and most of all, to love.

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CHAPTER 1

INTRODUCTION

Problem

Iowa was once dominated by the tallgrass prairie ecosystem. Undisturbed native habitat was virtually eliminated from the landscape by 1900 due to settlement and agriculture. Today, more than 99.9% of the original 28 million acres of Iowa prairie is gone. The remaining patches exist as small isolated fragments scattered across the agricultural landscape. These “islands” include prairie preserves, railroad right of ways, and roadsides (Smith 1992).

The first drastic loss of habitat post-settlement reduced grassland bird populations but few species were extirpated because they were able to adapt and colonize the agricultural grasslands which included pastures, hay fields, and mixed grain fields, as these replaced native prairies. Some grassland species, including the horned lark (*Ermophila alpestris*) and vesper sparrow (*Pooecetes gramineus*), adapted easily to the conversion from prairie to farmland because of their ability to colonize and breed in cultivated habitats. The opening of the landscape produced a pattern of food and cover that was also beneficial to many species of upland gamebirds, including the greater prairie chicken (*Tympanuchus cupido*) (Herkert 1991).

From 1900-1950, species such as the dickcissel (*Spiza americana*) and upland sandpiper (*Bartramia longicauda*) experienced declines across the prairie region for unknown reasons, but most grassland species populations stayed the same or experienced only slight declines (Fretwell 1986)

Since the 1950s, however, grassland bird populations have undergone a more drastic decline due to the loss of agricultural grassland habitat to corn and soybean crops and to intensified agricultural practices (Best and Hill 1983, Best et al. 1990, Warner 1994, Paine et al. 1995, Best et al. 1995).

Widespread and local human activities have altered the natural landscape at rates that far exceed the ability of many species to adapt to the changes. Homogenous, specialized farms lack the food, shelter, nest sites, or the necessary interspersion of habitat needs to attract and sustain Neotropical migrants (Rodenhuse et al. 1993). Neotropical migrant (NTM) songbirds are species that nest in the temperate region and spend their winters in tropical South America, Central America, the lowlands of Mexico, and the West Indies.

A major concern is the effect of fragmentation of the landscape on the population and distribution of Neotropical migrants. Fragmentation modifies the structure of habitat patches and landscape patterns by altering patch size, shape, and the distance between patches. Species that need undisturbed grassland habitat experience declines in the total amount of potential habitat and species that require large blocks of habitat find fewer large blocks available. Despite the fact that the average territories of species such as the bobolink, savanna sparrow (*Passerculus sandwichensis*), and grasshopper sparrow (*Ammodramus savannarum*) are typically less than 2.5ha, these species are rarely encountered in areas less than 10ha (Diamond 1975). The area between patches also increases, thus creating barriers to movements of individuals from one patch to another.

Fragmentation often results in increased species richness because of a greater number of edge species (Whitcomb et al. 1981). These species increase because fragmentation creates a higher ratio of edge to interior habitat, providing edge species with more habitat than prior to fragmentation. Small grasslands are usually dominated by such non-prairie species as red-winged blackbirds (*Agelaius phoeniceus*) and common yellowthroats (*Geothlypis trichas*), and support few prairie interior species. The edge-to-interior ratio increase may also lead to lower reproductive success for nesting grassland birds. Levels of nest predation and brood parasitism are higher in edge habitats than in interiors (Burger 1988, Johnson and Temple 1990).

According to recent analysis of North America Breeding Bird Survey data from the past three decades, some Neotropical migrant species have experienced severe population declines (Peterjohn et al. 1995). The declines have been associated with the loss of winter habitat as well as fragmentation and loss of breeding habitat in North America (Faaborg et al. 1993, Freemark et al. 1995).

Meadowlarks (*Sturnella* sp.), bobolinks (*Dolichonyx oryzivorus*), dickcissels, and some species of sparrows, all migrants, have experienced declines of 25-65% in the past 30-40 years (Robbins et al. 1989, Robbins et al. 1993). Some of the formerly most abundant species such as the bobolink have shown declines as high as 90% in some areas (Herkert 1991). In Illinois, the relative abundance of grassland birds has declined 85-90% and sixteen species have been extirpated, are threatened, or are endangered. Warner (1994) concluded that these declines are the result of intensive farming, increased use of

fertilizers and chemicals, and fewer livestock, forage crops, small grains, pastures, and natural areas.

In order to encourage survival, successful reproduction, and subsequent increased numbers of grassland birds, it is necessary to identify the habitat requirements of these species and promote farmland management practices that encourage and sustain Neotropical migrant grassland birds. Far too little is known about the habitat requirements of most Neotropical migrant bird species. Without these data, farmers and other landowners are unable to effectively manage their land for these birds.

The questions that remain are: What cues do grassland birds use to select the breeding habitat as they fly over a landscape dominated by agriculture? What are the consequences of the modern agricultural landscape for the survival and reproductive success of grassland birds? What structural characteristics of a native prairie are important or necessary for grassland birds and can we incorporate these characteristics into our farming systems in a sustainable and profitable way to attract birds and increase their numbers?

A growing number of farmers are investigating sustainable farm systems that are economically sound, are healthy for livestock and the environment, and that also encourage wildlife. Intensively managed rotational grazing (IMRG) is a management practice whereby livestock move through a series of paddocks on a three to six week cycle (Figure 1). IMRG has many benefits for the farmer, the livestock, the environment, and for wildlife (Chan-Muehlbauer et al. 1994).

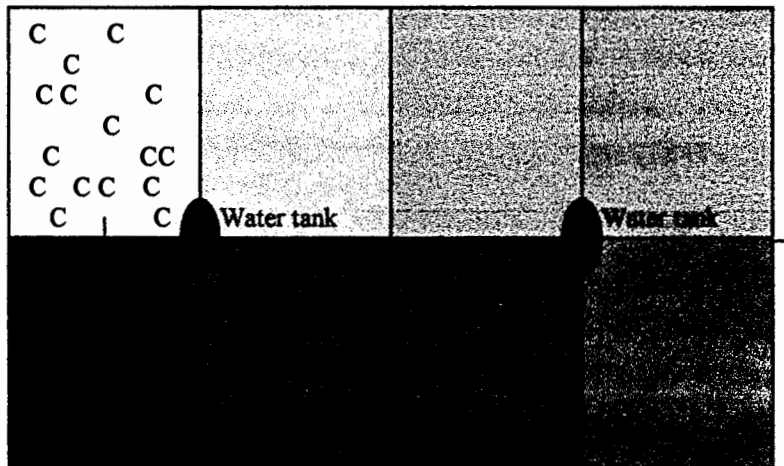


Figure 1. Diagram of a pasture using rotational grazing. Paddocks are separated by electric fencing. Cows (C) move in the direction of the arrow to a paddock that has not been grazed for 3-6 weeks. Water tanks are placed in locations where they are accessible from several paddocks.

For the farmer, there are fewer inputs, so it is economically beneficial (Chan-Muelbauer et al. 1994). Affordable electric fencing separates paddocks. Pesticide, fertilizer, and feed costs are minimized. Therefore, the farmer attains maximum profitability. He or she is obliged to be observant of soil and vegetation processes in the pasture and must adjust management accordingly. Daily contact with the animals and the land give the farmer greater knowledge of the farm system. Rotational grazing requires less time, effort, and expense than feeding animals in confinement. It reduces veterinary costs and improves conception rates. On selected dairy farms, IMRG reduced the need for purchased grain concentrates and increased the milk production to grain ratio. Although annual herd average of milk production decreased slightly, profitability increased significantly (Murphy 1990).

The benefits to the livestock are numerous. The animals are free roaming as opposed to being confined like those in a large-scale operation. Through much of the year, animals feed on grasses and forbs that have not been sprayed with pesticides. Little or no fertilizers are used in the pastures. Vegetation in “resting” paddocks regrows and plant vigor is rebuilt to provide more nutritious feed for the animals (Voison 1988).

Benefits for the environment include year-round ground cover which reduces soil erosion. As stated, pesticide and fertilizer use is minimized. At the landscape scale, conversion from a conventional row crop based dairy or a continuous grazing system to an IMRG system adds more “bird friendly” habitat to the landscape. The benefits to wildlife and namely Neotropical migrant (NTM) grassland birds prompted this study of bird use in IMRG pastures compared to bird use in native grassland habitats.

I hypothesized that the mosaic of vegetation heights created by rotational grazing resembles the native prairie grazed by bison before settlement. This mosaic may be attractive and beneficial to breeding NTM grassland birds. IMRG as a sustainable alternative to conventional row crop agriculture and continuous grazing systems may provide better breeding habitat for grassland birds.

Objectives

The objectives of my study were 1) to assess and compare bird use of native prairies and savannas and IMRG pastures focusing on NTM grassland birds, 2) to assess vegetation structure in native areas and IMRG pastures to determine what structural features might attract grassland birds, 3) to determine if any landscape level features

correlate with grassland bird use, and 4) to determine if IMRG as a management practice can attract and sustain grassland birds.

Literature Review

Habitat Selection by Birds--Definition

Habitat is broadly defined as the physical and biotic factors that make up a place where an animal might live (Partridge 1984). The term habitat is applied both to broad landscape vegetation types, and to detailed descriptions of immediate physical environments used by species. It follows, therefore, that habitat selection implies a choice made by an animal to inhabit or utilize a particular area based on innate or learned behavioral responses to various components of the environment. It is important to remember that any human description of where an animal occurs is somewhat artificial. We attempt to describe a species' habitat from a human perspective by correlating features of the environment to the presence or relative abundance of the organism in question. When we do so, we hope that our description has some relevance to those factors that the species actually uses and requires for its survival.

History of Habitat Selection Theory

Studies of avian-habitat relationships essentially began with Aristotle and continued into the early twentieth century. Early ornithologists and naturalists including Gilbert White, Alexander Whitsen, John J. Audubon, and Joseph Grinnell made basic associations between specific birds and particular habitats (Cody 1985). Differences in habitats used by related species were the focus of these early studies of habitat selection. Charles Darwin's ideas about natural selection caused ornithologists to consider the

evolutionary basis for relationships between birds and their habitats. Ornithologists then became interested in the processes that were responsible for the distribution and abundance of birds. Joseph Grinnell was among the first to pose testable hypotheses about factors that potentially influence the habitat distribution and abundance of birds.

David Lack (1933), who approached the subject from an ecological perspective, hypothesized that species were drawn to ancestral habitats, but that where birds were more abundant than could be accommodated in the preferred habitat, some species would expand into other habitat types. Lack also noted that some species had strong preferences for specific habitats (specialists) whereas other species were more flexible in their selection (generalists).

Svårdsen (1949) examined the role of competition in habitat selection. He observed that intraspecific population pressure tends to broaden habitat use, whereas interspecific competition limits habitat use. Ecologists during this qualitative natural history era made a permanent impact on how ornithologists approach habitat analysis and set the stage for quantitative habitat analysis.

Robert MacArthur ushered in the era of the new ecology with rigorous quantitative methods to describe, predict, and test ecological patterns (MacArthur and Pianka 1966). The new science introduced the idea that multidimensional ecological niches can be quantitatively described using multivariate statistics that could be analyzed with ease using new digital computers. The quantitative methods also allowed for the development of new models of habitat selection. The purpose of the new models was to shed more light on how birds might behave when selecting habitat when faced with

competition and other pressures such as limited habitat or small patch size. An examination of several models will bring us to the application of the theory in recent studies.

Models of Habitat Selection

The theory of habitat selection is related to the optimal foraging theory which states that the proportion of time spent foraging in a given habitat will vary according to the relative rewards of foraging (MacArthur and Pianka 1966, Rosenzweig 1981). Habitat selection theory expands on this to state that an organism selects against a patch if it's fitness while using the habitat is less than while using another patch, taking into account the ratio of search time to foraging time. The model assumes a constant environment except while the individual is foraging, during which time resources would be depleting. The model also assumes that an animal has perfect knowledge of costs and rewards and that the animal does not interact with any other animals. These assumptions are obviously unreasonable in the real world, but the basic model provides a starting point for other models.

The model of density-dependent habitat selection for a single species states that as density increases in a uniform patch, the fitness of individuals within the patch decline. Fretwell (1972) provided a graphical depiction of this theory (Figure 2).

Animal density (n_A), the number of animals in a given habitat, is plotted against fitness (W_A) for one species in four different habitat patches. The model assumes that individuals can perceive habitat fitness levels and will always choose the best habitat available to them at the time. As the best of the habitats fills, the quality of this habitat

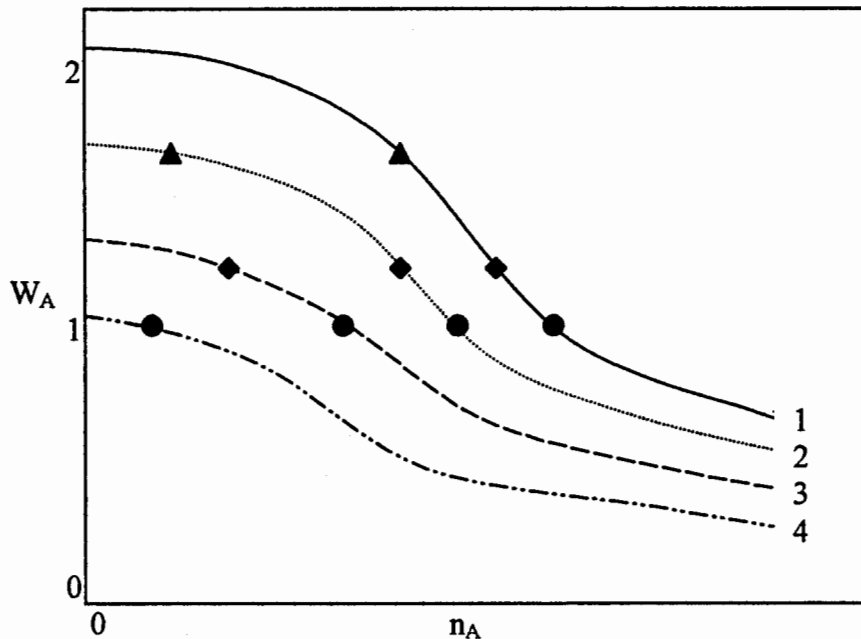


Figure 2. Fretwell's ideal free distribution. Fitness (W_A) as a function of animal density (n_A) in four habitats ($A = 1,2,3,4$). Total density is spread among habitats so that the fitness of all individuals is equal. The different symbols show the distribution at three different total densities (adapted from Rosenzweig 1991).

declines, until eventually the two habitats reach a point where they are of equal quality.

The fitness curves decline due to the action of intraspecific competition operating within the habitats. When actual fitness in one habitat declines below a certain point, the habitat loses its advantage and it is better for individuals to settle in the next best unused habitat.

The lesser habitat is now better because it has not yet been used. As density continues to increase, new individuals settle in subsequent habitats in a way to keep the habitats fairly equal in quality and fitness (Figure 3A). This is termed the "ideal free distribution"

because animals are free to settle where they prefer and they have the ability to determine the best available sites. Figures 3B and 3C represent a modification of the original model

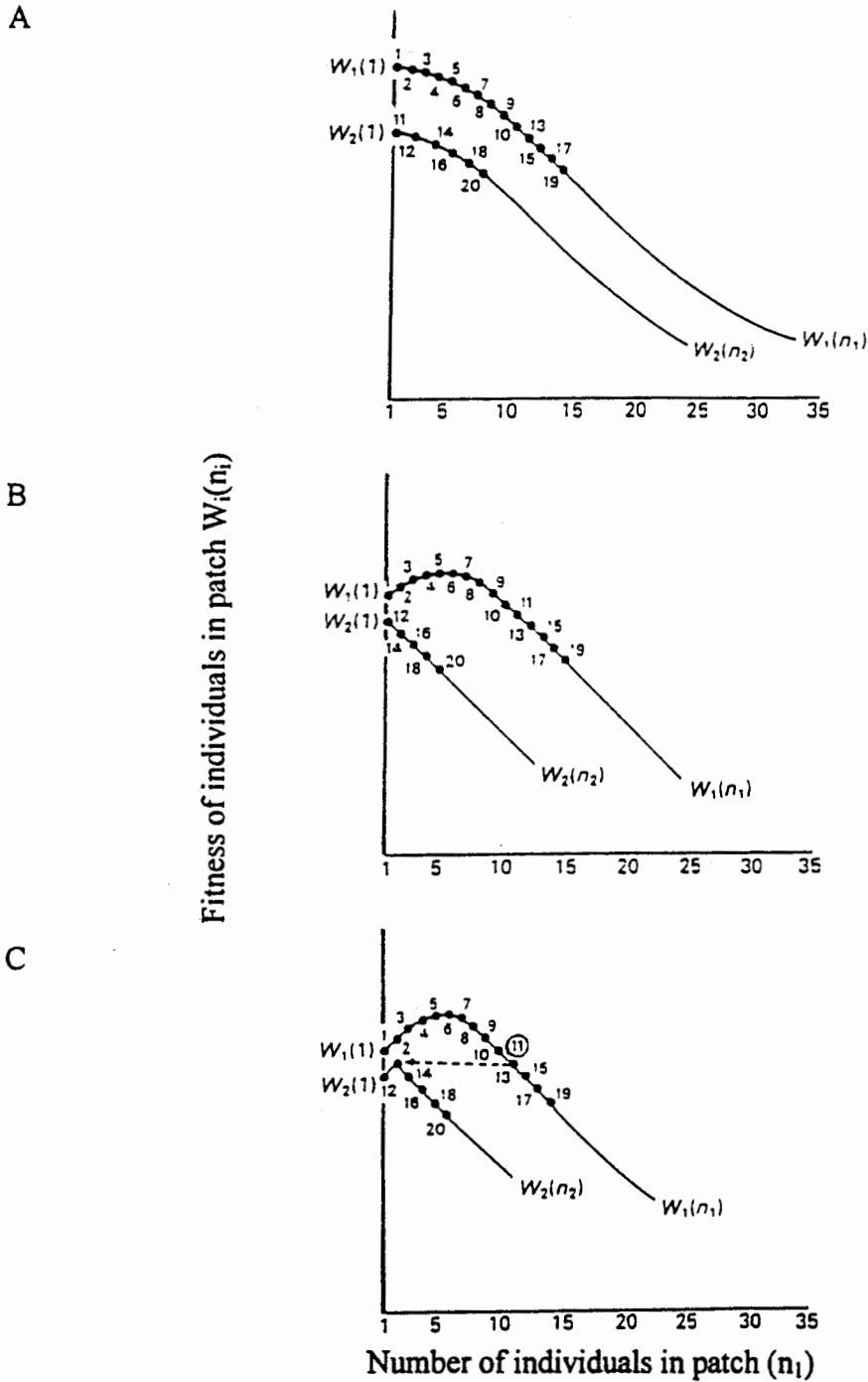


Figure 3. Fitness in groups lacking dominance structure. Each individual, in numerical sequence, chooses the habitat where its fitness will be greater. A. Ideal free distribution B, C. Modification of the ideal free distribution when there is an advantage, up to a point, of being in a larger group (from Krebs and Davies 1984).

which graphs the fitness-density relationship if there is an advantage, up to a certain point, of being in a larger group. Fitness increases up to individual number six, and then begins to decline. After individual 11 settles, it is more beneficial for individual 12 to settle in the lesser habitat patch W_2 .

These models assume that we can relate habitat choice to fitness consequences and that fitness is influenced by population densities through interaction among species. Finally, the models assume that density correlates perfectly with the density of resources. This assumption is not always true, but field tests have shown that this model provides good predictions (Rosenzweig 1991). Information on resource density has shown to be a reflection of how many consumers are present in a habitat. The ideal free distribution model errs in that it assumes that there is no cost in time or energy to travel between patches (Rosenzweig 1981).

A modification of the ideal free distribution theory is the ideal-despotic distribution developed by Fretwell (1972). Territorial species violate the “free” assumption of the ideal free distribution model because dominant individuals establish themselves in a disproportionately high share of the best locations. Therefore, there is a risk incorporated in the model for unsettled individuals. Surprisingly, this model results in species abandoning habitat selection and becoming more opportunistic in their habitat choice as density rises.

We have seen that high population densities erode habitat selection in single-species situations according to ideal free density-dependent distribution models. What happens when a competing species is present? Svårdsen (1949) hypothesized that

interspecific competition restores habitat selection because a species must retreat to its most optimal habitat, whereas intraspecific competition causes the selection of a greater variety of habitats (Figure 4).

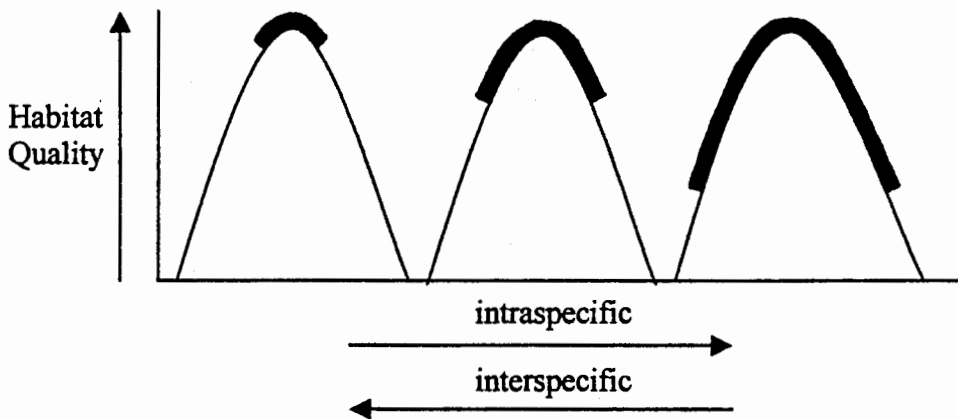


Figure 4. Competition or population pressure and the amount of variation in habitats taken. Strong interspecific pressure forces species to retreat to their adaptive peak habitat. Intraspecific population pressure causes plasticity in habitat choice. The range of habitats used on each slope is represented by thick black bars (adapted from Svärdsen 1949).

Rosenzweig (1981, 1991) developed an approach called isoleg analysis for modeling the mechanism of habitat selection with competition between species. First, Rosenzweig relaxed the assumption of *distinct preferences* where each species has a unique habitat preference (Figure 5A). There is greater evidence supporting the idea of *shared preference* niche organization (Figure 5B) which allows for variance in ability to utilize poor habitat among species. Some species have broad niches, i.e., the ability to utilize poorer habitats, whereas species with high, steep niche curves are limited to where they can profitably live. Species with limited niches have the advantage that they can

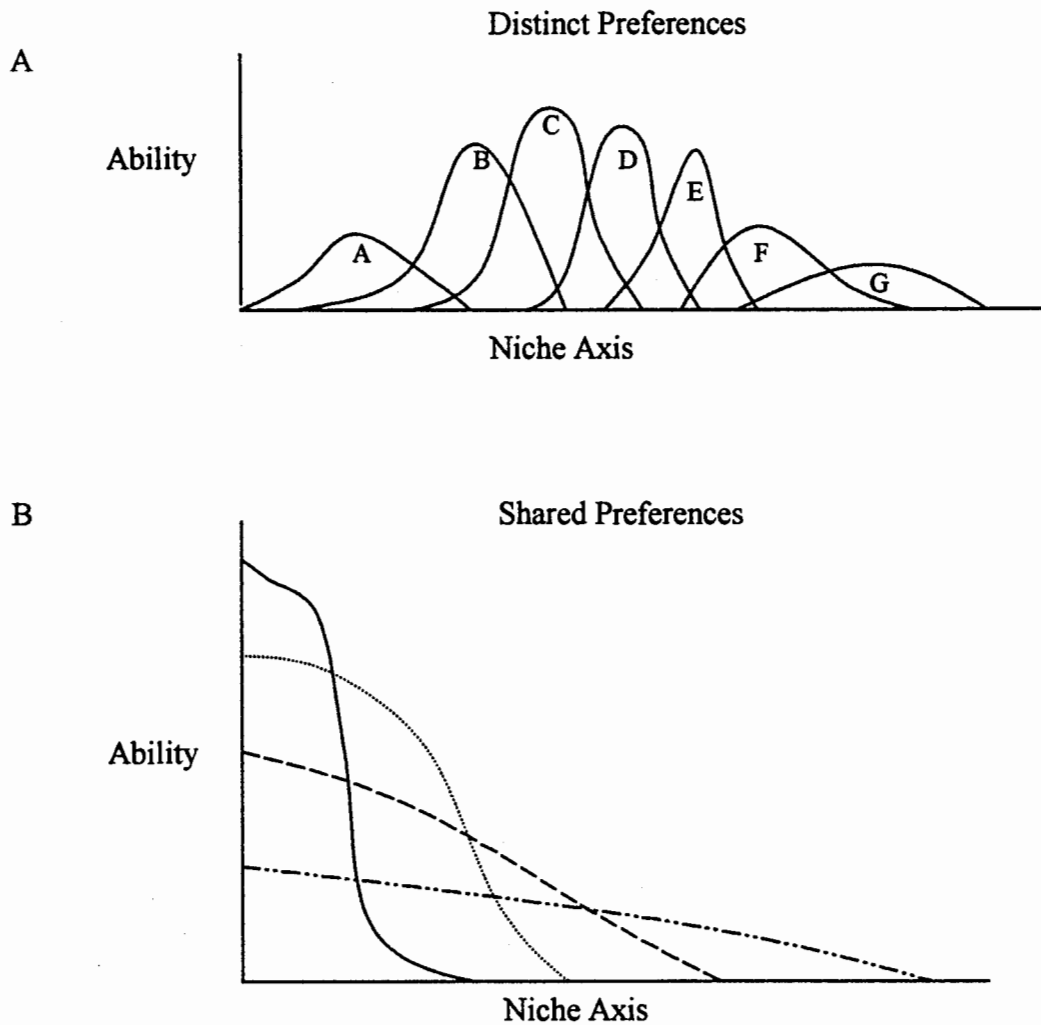


Figure 5. Two types of niche organization. Each curve represents the habitat utilization ability of a different species (adapted from Rosenzweig 1991).

dominate the preferred niche, but may have a disadvantage in regions with little high quality habitat such as in the agricultural Midwest.

Assuming shared preference, Rosenzweig developed isoleg graphs (Figure 6A) to plot the density of a dominant species (x axis) versus the density of a subordinate species (y axis) in two habitats when Habitat 1 is preferred by both species. The isoleg model

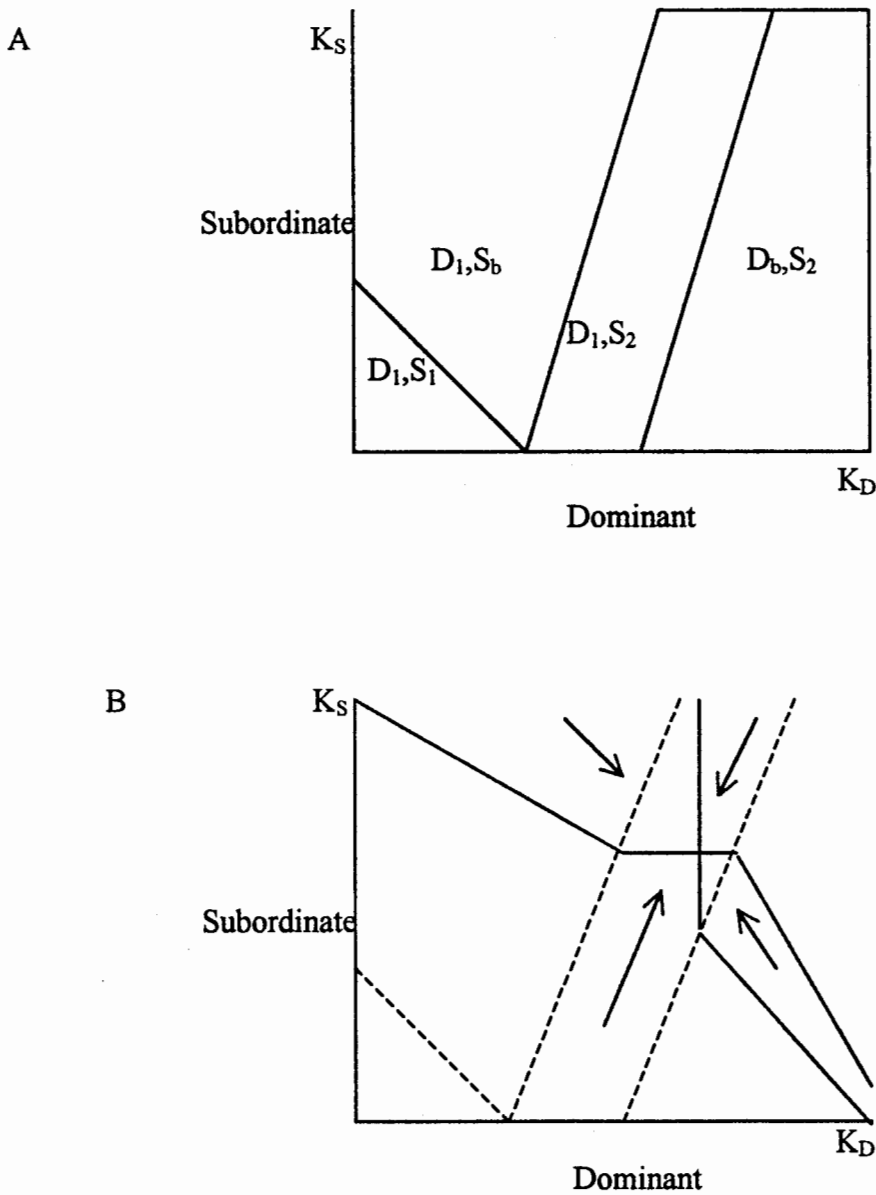


Figure 6. Isolegs and isoclines of a shared-preference competition. Each graph is a state space with the densities of the dominant and subordinate species on the x and y axis respectively. K 's are carrying capacities. A. Spaces are coded based on habitats used. D_1S_b means that the dominant species uses Habitat 1 while the subordinate uses both habitats. Regions are separated by isolegs (lines). B. Solid lines are isoclines of population dynamics. Equilibrium occurs in regions where the two species should not overlap in their use of habitats (adapted from Rosenzweig 1991).

maps how the dominant and subordinate species should behave at each point. In each area, behaviors are predicted to be uniform over broad regions of the state space and change sharply as borders, the “isolegs,” are crossed. As the density of a species increases, each species chooses Habitat 1, 2, or both, denoted by subscripts 1,2, and b. Figure 6B represents an example where interaction results in an equilibrium (arrows pointed to equilibrium) where the subordinate species chooses the poorer habitat (2) and the dominant species chooses the better habitat type (1).

The shared preference isoleg system was tested in two species of hummingbirds, the dominant blue-throated hummingbird (*Lampornis clemenciae*) and the subordinate black-chinned hummingbird (*Archilochus alexandrii*). Their behaviors fit those predicted by the isoleg paradigm (Rosenzweig 1981). Blue-throated hummingbirds were dominant in areas with rich sucrose solutions. As densities of both species in the preferred habitat increased continuously, the proportion of habitat used by each species changed discontinuously.

Another study by Sherry and Holmes (1988) questioned whether the dominant Least Flycatcher (*Empidonax minimus*) restricted American Redstart (*Setophaga ruticilla*) habitat use. Both species are insectivorous and prefer the same habitat. By manipulating and studying changes in flycatcher distribution and abundance, the researchers found both direct and indirect effects of the flycatchers on redstart habitat use. Flycatchers effectively excluded redstarts from preferred habitats by aggressive chases and attacks leading to interspecific territoriality. The aggressive behavior may be an adaptation to increased net food availability. Their findings are not consistent with

Svårdsen's explanation of how interspecific competition shapes a species' niche or pattern of habitat use but were consistent with Rosenzweig's isoleg model which incorporates the effects of interspecific competition and abundance to narrow or broaden the habitat niche of another species. The isoleg model predicts that the subordinate species should become opportunistic in habitat choice sooner when dominants in the preferred habitat are added to the system, as found in the flycatchers and redstarts. Tests of this model in grassland habitat have not been conducted.

Finally, Pulliam and Danielson (1991) designed a model for habitat selection on the landscape level using the concept of source and sink habitats. Their model links breeding site selection to population dynamics in situations with more than one distinct type of habitat. As with the ideal free model (Figure 7A), the distribution of individuals depends on the selective ability of the species. As habitat availability changes, animals may redistribute themselves, controlling their own reproduction and mortality rates to some extent. An alternative to the free model which incorporates differences in individual reproductive success, it is termed the "ideal preemptive distribution" (Figure 7B). In this model, potential breeding sites differ in expected reproductive success and individuals choose the best available sites. Occupied sites are "preempted" or no longer available, but do not influence reproductive success at other sites. An individual settles in whichever habitat has the best available breeding site. The individual using the worst of the occupied sites in Habitat 1 has approximately the same reproductive success as that of the individual in the worst occupied site in Habitat 2. However, average reproductive success is greater in Habitat 1. The model allows the researcher to compare the relative

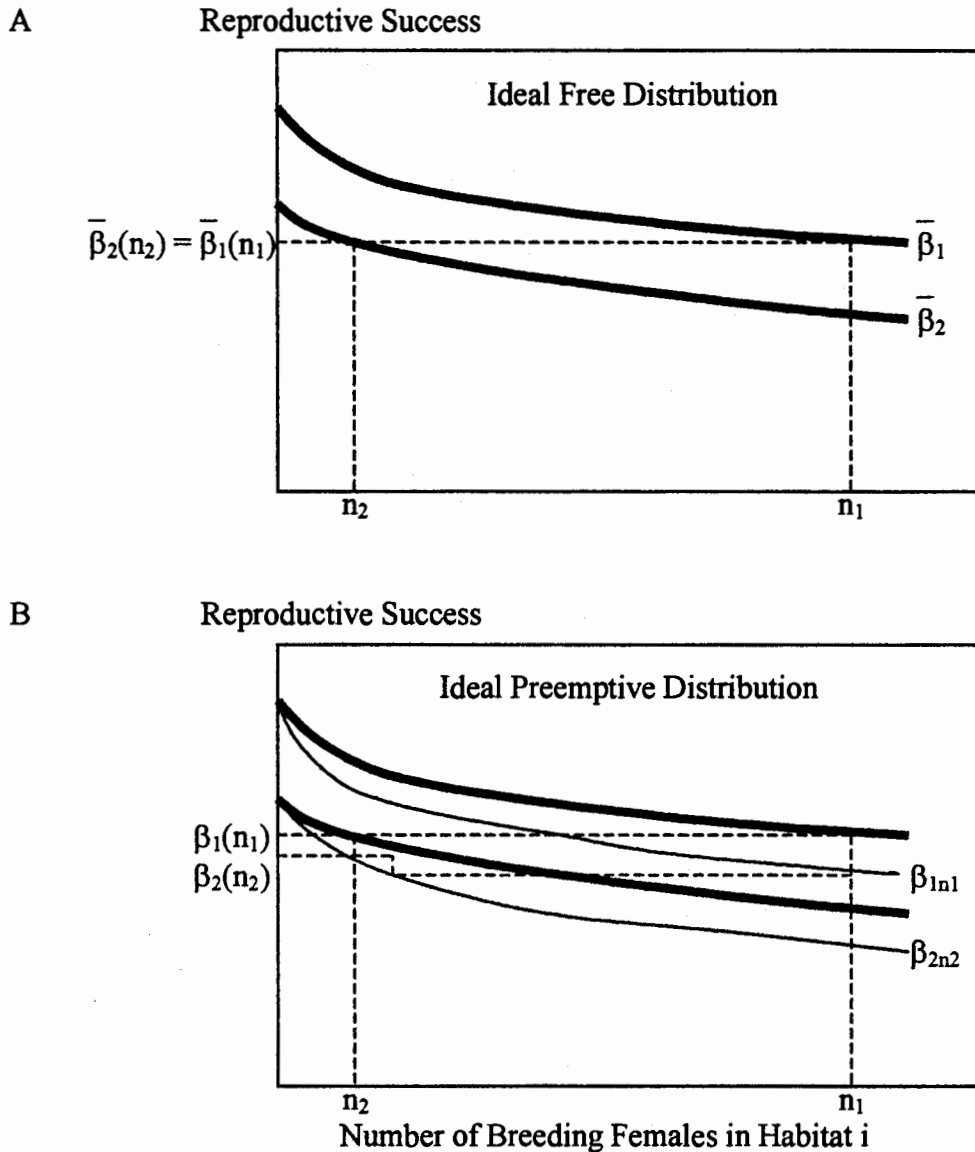


Figure 7. Average reproductive success according to two different models. A. Ideal free model. Average reproductive success $\beta_i(n)$ for each habitat is a decreasing function of the number of females in that habitat (n_i). According to the ideal free model, the number of individuals in each habitat is such that average reproductive success $\beta_i(n_i)$ is equal in both habitats. B. Ideal preemptive model. Each habitat has two curves. The upper curve is the same as in the ideal free distribution (A). The lower curve shows the quality of the worst occupied site, β_{in} , in each habitat as a function of the number of adult females in that habitat. In preemptive distribution, the quality of the worst occupied site in each habitat is the same. When n_1 adults are in Habitat 1, n_2 adults occupy Habitat 2. Average reproductive success is smaller in Habitat 2 than in Habitat 1 (adapted from Pulliam and Danielson 1991).

contribution of different habitat types to a species' population size and growth rate. The model may also be used to predict the effects of habitat loss on a population.

The usefulness of this and other models depends on the extent to which required parameters can be measured in the field. The researcher would need to know the average reproductive success in each habitat and the frequency distribution of breeding site quality in each habitat. Kareiva (1990) stressed that empirical field studies are not tests to see if models and their assumptions are correct, since the models will always be wrong to some extent. Instead, a model can be useful for predicting phenomena that emerge as important in natural situations.

The models have been presented here because they have been instrumental in showing how species might behave. However, many models lack application in real world settings. In the real world of nature, birds are probably influenced by a host of interacting factors such as: natal experience, prior experience in a habitat type or habitat patch, interspecific and intraspecific competition, resource availability, and the presence of predators. Some of these factors have been examined in models and some have been tested in the field. To date, most empirical studies of habitat selection by birds have focused on the relationship between species presence or abundance and vegetation structure and composition. While the models and field studies are important to our understanding of bird habitat use, we are now only beginning to use our knowledge for the conservation of resources and the protection of threatened habitats and species. An examination of applied theory in recent studies will bring us to the impetus and design of the current study.

Empirical Studies of Habitat Selection

A bird must select a habitat where it can successfully forage, establish a territory, attract a mate, nest, and raise young. Nest-site selection presumably dominates other components of habitat selection because it ties a bird, its eggs, and young to a particular site for a relatively long and critical portion of the life cycle (Walsberg 1981). Furthermore, nest-site selection is closely tied to fitness because of the effects on reproductive success (Martin and Roper 1988) which can be affected by predation, environmental stresses, and social factors (Burger and Gochfeld 1988).

Most birds are highly mobile, which allows them to come in contact with a wide range of different habitats. Environments are made up of patches of habitat which differ in their intrinsic quality to a particular species or organism. A general principle in habitat selection is that preferences among environments should coevolve with the qualities of those environments, i.e., organisms should respond positively to environments in which survival and reproductive success have been good (Orians and Wittenburger 1991). This principle may be difficult to assess. What humans define as a good habitat patch may in fact be poor due to undetected factors such as parasites, diseases, or predators. We also do not know the ability of an animal to assess the actual qualities of an environment.

Habitat choice can be seen as a process of hierarchical decisions (Freemark et al. 1995). A bird must decide to explore or pass over a habitat based on general features of the environment. The initial decisions will affect nearly all of an individual's subsequent choices. Exploration then provides information used to decide whether to settle or move on. After the home range and specific site are chosen, the organism must then procure

resources from that site. The fitness of an individual bird will be maximized if it selects an optimal habitat—one that provides all the resources necessary. However, there are constraints on the selection of the optimal habitat. First, there may be a limited amount of time available for searching due to varying resource availability. Second, continued searching may or may not result in an encounter with a better habitat. Longer exploration time may allow an individual to assess a habitat more completely, but future availability of resources may be difficult to predict. Third, there is the possibility of mortality during the search period.

Cody (1981) considered three important influences acting on habitat selection. First, a bird has a fixed morphology and life history that allow it to exploit a certain subset of possible resources and to use certain habitats. For example, wing size and shape affect habitats used (e.g. accipiters and buteos).

Second, the choice is influenced by the presence of competitors; i.e. individuals or species with overlapping food requirements or foraging techniques. Similar species may preclude potential competitors from using resources by using them first or by impeding access to resources by interference competition. The balance between intraspecific and interspecific competition plays a large role in determining habitat use by birds. Interspecific competition may cause species to specialize, while intraspecific competition may induce species to generalize.

Third, the quantity, quality, distribution, and juxtaposition of resources influence actual habitat use. Plant productivity and food levels vary in space and time. The availability of resources is important because various biotic (competition, predators) and

abiotic (weather, fire) factors may render otherwise suitable resources unavailable to the animal. Furthermore, species often require unique resources for different aspects of their life history. For example, breeding birds are constrained by nesting requirements whereas habitat use by migrating or wintering birds is more strongly influenced by the abundance and distribution of food resources.

Vegetation structure and composition are frequently assumed to be the primary proximate factors determining where and how species use resources and have been used frequently as a predictor of bird diversity and identity within a habitat type (MacArthur et al. 1966). Many studies have focused on this idea to determine specific structures or vegetation attributes required by a particular species (James 1971, Cody 1981, Martin and Roper 1981, Yahner 1982, Zimmerman 1982, Hayward and Garten 1984, Loekemoen et al. 1984, Ryan et al. 1984, Giffen et al. 1987, Baltosser 1991, Bergin 1992, Munson 1992, Donazar et al. 1993, Kelly 1993).

In grasslands, Zimmerman (1988) found that male Henslow's sparrows (*Ammodramus henslowii*) established breeding territories in patches with greater coverage of standing dead vegetation, less coverage by woody vegetation, and taller live grasses. Zimmerman hypothesized that standing dead vegetation depresses above ground grass production, which allows a more open substrate for the ground-dwelling species.

Wittenberger (1980) studied the relationship between vegetation, food supply, and polygynous male bobolinks. Some females mated with already mated males. Wittenburger concluded that there must be some benefit for the secondary females (e.g., superior habitat) that outweighs the cost of lost male parental assistance, competition

with other females, and increased predator attraction due to high nest density and activity. Male bobolinks arrived first, established their territories, and settled within 100m of where they bred the previous year. Primary females arrived and paired. Three to eight days later secondary females arrived and paired with already mated males in preferred habitat. Wittenburger measured several attributes in the territories of polygynous, monogamous, and bachelor males including height of vegetation, percentage cover, vegetation biomass, soil moisture, and insect larvae. Preferred territories had higher cover, higher mesic soil surface moisture, and high nestling food (larvae) abundance. These territories presumably offered more food, protection, adequate nesting material, and acceptable nest sites.

While vegetation structure and composition must be important to birds, we cannot conclude that it is the only factor considered in habitat selection. The physical structure and characteristics of a habitat other than vegetation have also been found to be important to birds (Hilden 1965, Walsberg 1981). Physical environmental factors such as energy flow, the substrate, topography, climate, and weather may also determine habitat suitability.

Social facilitation may also attract or repel an individual to or from a particular habitat. Habitat choice may also be largely based on a bird's experience in its natal habitat (Bedard and LaPointe 1984). We do not fully understand the degree to which a free choice is made as opposed to imprinting or simply returning to natal habitat. Young birds may be influenced by the habitat and territory choices made by older males that return to breeding sites earlier. Males often return to sites or habitat/nest types in which

they were previously successful. Furthermore, they will switch sites after unsuccessful breeding attempts, e.g. eastern bluebirds (*Sialis sialis*) (Cody 1985). Unfortunately, few studies on experience and natal circumstances in habitat selection have been conducted.

Not only are there a vast number of possible influences, particular features of a habitat may predominate at some times and not at others depending on varying requirements over space and time. Orians and Wittenburger (1991) examined the importance of temporal and spatial scales in habitat selection. Individuals may have requirements that are found in different places in the environment. Thus the composition and physiognomy of the landscape on a large scale may be an important factor in habitat selection.

Some species of birds are very sensitive to patch size. Small habitat patches have greater perimeter to area ratios and less core habitat area. This can affect many variables including vegetation, predation rates, and parasitism. Burger and Faaborg (1994) conducted a grassland nesting study using artificial nests in habitat patches with different areas and proximity to woody cover to determine the effects of fragment size and isolation on the nesting success of grassland birds. They found that predation rates were highest in smaller prairies, but proximity to woody cover was also an important factor affecting predation rates. Nests located less than 60 meters from a wooded area were predated three times more than nests located farther away. Woody edges along small prairies may allow edge and woodland predators to penetrate prairie interiors, lowering nesting success. Open ground nesters were particularly vulnerable and thus may be most

sensitive to reduced habitat area. Consequently, area sensitive species may avoid nesting in small fragments even though suitable nesting habitat is present.

The large number of published reports that describe habitat selection among birds attests to the enormous variation observed and to the biological importance of this topic. Researchers have tried to determine what attracts birds to habitats. While this is important and necessary for a complete understanding of birds in grassland ecosystems, few studies address the conservation issue at hand. An understanding of the responses of birds to changes in habitat characteristics is important for conservation and management, especially in light of current habitat degradation. Information regarding habitat components that are vital for threatened species can aid in land management decisions. Habitat selection studies can help us manage habitats in order to increase the abundance of threatened species.

Faced with decreasing numbers of NTM grassland birds in a landscape dominated by agriculture, it is important to determine what sorts of agricultural practices will provide needed grassland habitat. Intensively managed rotational grazing is a good candidate. This practice appears to mimic the physical structure of the patchwork of grazed and ungrazed prairie that is believed to have existed prior to European settlement. I predicted that species richness, species composition, and abundance of grassland species would be similar in IMRG pastures and native prairies and savannas in the same region. Comparison of agricultural practices with natural ecosystems is a fruitful method of determining the positive and negative impacts of these practices on biological

diversity, and offers directions for future research in ecological restoration at the landscape scale.

I propose that IMRG is a way for farmers throughout the Midwest to have successful, profitable, and sustainable systems, while creating habitat for birds. IMRG creates a more diverse farm and a more diverse biological base than conventional row crop systems. Instead of a large monoculture field entirely at the same growth stage treated with fertilizers and pesticides, IMRG pastures are green fields where livestock eat unsprayed forage and create a field of varying vegetation heights. IMRG is also better than continuous grazing systems because the grass is not grazed down to a short equal level throughout the growing season.

To determine bird use in native and grazed habitats, I conducted early morning bird counts to determine species richness and abundance. I also measured vegetation and landscape features to determine any correlations with bird species richness or abundance.

CHAPTER 2

MATERIALS AND METHODS

Intensively managed pastures were located on privately owned farmland in Fayette, Chickasaw, Howard, and Clayton counties in Northeast Iowa. All pasture sites were working dairy or beef cattle pastures. Pasture sites were identified through contact with farmers in the group Practical Farmers of Iowa. Native prairie and savanna sites were located in Howard and Chickasaw counties in Northeast Iowa (Table 1). I searched for native sites that were similar in size and location to grazed sites. Because there are very few native prairie patches left, the choice was limited. The native sites included in this study were used as a standard of comparison for the grazed pastures.

The method used to make observations and record data on bird activity is described in Ralph et al. (1993). However, the sampling and recording procedures were modified slightly to conform to the study design, patch size, and configuration.

Birds were censused using fixed-width transects positioned within prairies, savannas, and IMRG pastures. Transect endpoints were marked with flags and semi-permanent plastic stakes. Transects were placed randomly within the pastures and prairies but were at least 50 meters from field edges or different habitat types. Pasture transects ran across several paddocks in different stages of vegetation growth. All transects were at least 200 meters long (range = 207-773m).

I conducted bird counts between 30 minutes before sunrise and 0900h when birds were most actively vocalizing. Two sites were censused per morning. Each site (one transect per site) was censused six times between 13 May and 23 August 1996.

Table 1. Site locations, habitat types, and transect directions.

Site	County	Latitude	Longitude	Habitat Type	Transect Direction
Natvig pasture	Howard	43°13'30"N	92°11'00"W	Grazed savanna	N/S
Daubendiek prairie	Chickasaw	43°11'30"N	92°17'00"W	Native prairie	N/S
Frantzen pasture	Chickasaw	43°11'30"N	92°21'30"W	Grazed grassland	E/W
Borlaug savanna	Howard	43°13'30"N	92°11'00"W	Native savanna	N/S
Stewart2 pasture	Fayette	42°45'00"N	91°52'30"W	Grazed grassland	E/W
Koether1 pasture	Clayton	43°00'30"N	91°17'30"W	Grazed grassland	E/W
Koether2 pasture	Clayton	43°01'00"N	91°17'00"W	Grazed grassland	E/W
Stewart1 pasture	Fayette	42°40'00"N	91°53'30"W	Grazed grassland	N/S
Hayden prairie	Howard	43°26'30"N	92°22'30"W	Native prairie	E/W

Daubendeik prairie was censused only five times. Starting time was alternated by site so that each site was sampled first three times (starting approximately 30 minutes before sunrise) and second three times. The transect starting point also alternated from one end of the transect to the other to decrease observer bias. Censuses were not conducted on rainy, foggy, or windy days due to decreased visual and audio detection.

I slowly walked transect midlines (approximately 100m every 10 minutes) and identified all birds seen and heard within 50m of the midline. Data were recorded on preprinted data forms. Only birds observed perched on the ground, vegetation, or fenceposts within the transects were included in the analysis of census results. Birds seen flying overhead during counts, but not alighting within transects were excluded. Thus, I focused only on birds actually using the study habitats. Bird species, number of individuals, and activity were recorded for each observation. The information was later entered into a database for descriptive and inferential statistical analysis.

Because feeding and nesting habits influence habitat use patterns in birds, I classified all species on the basis of food type, food substrate, and nest substrate. This approach allowed me to evaluate the degree to which these life history attributes explain differences in habitat use. Categories in the food type and food substrate guilds were patterned after De Graaf et al. (1985). Nest substrates were patterned after De Graaf and Chadwick (1984). Food type designations are based on major foods in the diet (e.g. seeds, insects) during the breeding season. Food substrates refer to the places where food items are found or taken (e.g. ground, air). Nest substrate refers to the habitat type where a species most often nests.

Bird abundance was calculated to determine the number of observations of each bird species per census count expressed as the number of birds per 100 hectares of habitat. These values were then used to compute means for the entire census period for each study site to give a relative value with which to compare bird use of IMRG pastures and native grasslands.

Species richness or the mean number of species occurring on each site (all censuses combined) was determined as well as the total number of species associated with each habitat type (IMRG pasture or prairie). Species richness was also broken down into pre-determined categories of birds (grassland, NTM grassland, woodland, and other) based on nesting and feeding substrates to focus the comparisons. Species richness was compared between pastures and prairies. A Shannon-Weaver index of diversity was also calculated for each site. Descriptive ($\bar{x} \pm SD$) and inferential (t-test) statistics were computed using pastures or prairies as experimental units. Statistical significance was set at $P \leq 0.05$.

Vegetation data were collected at each site during early to mid spring in 1997 when grassland birds were arriving, selecting habitat, and establishing nests. Data were collected along the randomly placed bird transects at set intervals. Sites less than five hectares had at least ten vegetation sample plots while sites greater than 10 hectares had 20 vegetation sample plots.

At each point, height/density was measured using a pole marked at 10cm intervals held in the middle of the sample point. Readings were taken from the four cardinal directions at four meters from the pole. The measurement recorded was the point on the pole at which the height numbers were obscured by the vegetation. This gave an average value of the height/density at each site to give a measure of the actual height of the vegetation.

Maximum height of live and dead vegetation, and litter layer depth were recorded at each sampling point to give mean values for each site. Percent cover was visually

estimated at each point using a 0.25m² frame. Bare ground, litter layer, live vegetation, and dead vegetation percent cover were estimated. Live vegetation was broken down into percent cover of grasses, forbs, and legumes.

Landscape measurements were obtained using United States Geological Survey 7.5 minute quadrangle maps. I measured area (ha), perimeter length (m), amount of core area (>50 meters from edge, ha), distance to wooded area (m), distance to human habitation (m), distance to edge (m), and distance to road (m).

Vegetation and landscape measurements were analyzed in conjunction with bird species richness and abundance using the Pearson correlation coefficient to determine if correlations with habitat use exist. A Bonferroni test was applied to the correlation coefficients to protect adjusted probabilities for multiple tests (Wilkinson, 1989).

CHAPTER 3

RESULTS

Individual Site Results

Each study site is unique in its management, vegetation, adjacent habitat, and landscape scale features. Therefore, the following section provides individual examinations of each site. The three native sites will be described first. Descriptions of grazed sites, from smallest to largest, follow.

Daubendiek Prairie

Daubendiek prairie is a small (4.7ha) tract of native prairie (Table 2).

Daubendiek has the smallest core area (1.7ha) of all the sites and a high perimeter/area ratio (180). It is bordered on the west by a woody hedgerow, to the south by a row crop field, to the east by dense woody vegetation, and to the north by a gravel road adjoining a wetland.

The prairie has not been managed with fire or grazing and is becoming dominated by woody vegetation. However, many native prairie plants are still found there. Early spring (May 1997) vegetation measurements showed 96% litter layer cover and no bare ground. Of the live vegetation, 11% were grasses, 5.5% forbs, and 0.5% legumes (Table 3). These numbers are indicative of warm season grass dominance and the absence of burning or grazing.

Seventeen bird species were recorded, including eleven woodland species, three grassland species, and two other/generalist species (Table 4). The high number of woodland species can be attributed to the surrounding woody vegetation and close

Table 2. Physical dimensions of each site.

Site	Site Area (ha)	Transect Area (ha)	Perimeter (m)	Perimeter/Area Ratio	Core Area (>50m from edge) (ha)
Natvig pasture	4.1	2.5	840	207	2.3
Daubendeik prairie	4.7	2.1	840	180	1.7
Frantzen pasture	8.5	4.0	1340	158	4.7
Borlaug savanna	8.7	2.8	1180	136	4.1
Stewart2 pasture	16.2	6.0	1540	95	9.3
Koether1 pasture	51.1	4.2	2950	58	41.8
Koether2 pasture	55.2	4.4	3240	59	37.2
Stewart1 pasture	64.8	6.0	3150	47	48.6
Hayden prairie	97.2	7.7	4780	49	77.9

proximity to a dense stands of trees. The low number of grassland species could be due to the small area, as many grassland species are area sensitive. The large perimeter to area ratio (180) may also be a factor that deterred grassland birds. High amounts of edge may increases the rates of brood parasitism and predation. Of the NTM grassland species I focused on, only the savanna sparrow was recorded at this site. This species was

Table 3. Percent cover of three major vegetation types, litter layer, and bare ground at each site, April 1997. Values represent means from multiple sample points at each site.

Site	% Cover Grass	% Cover Legumes	% Cover Forbs	% Cover Litter Layer	% Cover Bare Ground
Natvig pasture	28.0	3.0	21.0	70.5	2.5
Daubendiek prairie	11.0	0.5	5.5	96.0	0.0
Frantzen pasture	37.3	6.0	5.8	54.5	11.3
Borlaug savanna	10.7	0.0	5.7	100.0	0.0
Stewart2 pasture	50.8	8.8	11.3	19.5	24.0
Koether1 pasture	54.3	8.8	12.8	51.8	4.0
Koether2 pasture	47.8	9.8	14.3	27.8	11.5
Stewart1 pasture	40.0	18.6	7.5	41.6	19.8
Hayden prairie	2.9	0.0	3.3	99.5	0.0

recorded at every site, which suggests that it can easily adapt to habitat patches that are small and have woody vegetation; i.e., they have broader, less specific habitat requirements. Species such as bobolinks, dickcissels, meadowlarks (Eastern and Western combined), and grasshopper sparrows were not found at Daubendiek, which suggests that this prairie site does not meet the habitat requirements of these species.

Table 4. Bird species richness at each site (totals over all censuses). Categories based on nesting and feeding substrates.

Site	Total number of species	Grassland species	Woodland species	Other species	NTM grassland species
Natvig pasture	21	2	17	2	2
Daubendiek prairie	17	3	11	3	2
Frantzen pasture	19	9	7	3	7
Borlaug savanna	29	5	19	5	5
Stewart2 pasture	14	7	4	3	6
Koether1 pasture	18	7	8	3	6
Koether2 pasture	23	5	15	3	5
Stewart1 pasture	18	8	6	4	6
Hayden prairie	17	10	3	4	7

Hayden Prairie

Hayden prairie, in contrast to Daubendiek, is a large (97ha), black soil, native tallgrass prairie. It has been managed using fire and has many native grasses and forbs. Hayden prairie has the second lowest perimeter to area ratio (49) of the nine study sites and has the greatest amount of core area (77.9ha). Like Daubendiek prairie, Hayden

prairie had a large percent cover of litter layer (99.5%). There was no bare ground in the early spring of 1997. Live grasses covered only 2.8% while live forbs covered only 3.2%. Hayden prairie had the deepest litter layer (9.9cm) and the highest height/density measure (9.6) (Table 5). All of these measures indicate warm season grass dominance and the absence of grazing.

Table 5. Structural characteristics of the vegetation at each site. Values are means obtained from multiple sampling points at each site. Data collected May 1997.

Site	Maximum Height Live Vegetation (cm)	Maximum Height Dead Vegetation (cm)	Litter Layer Depth (cm)	Height/Density Measure
Natvig pasture	19.2	16.4	3.5	4.4
Daubendiek prairie	15.0	23.0	3.5	3.3
Frantzen pasture	15.6	16.8	1.2	2.3
Borlaug savanna	21.0	28.1	5.5	4.3
Stewart2 pasture	20.6	10.2	0.8	3.1
Koether1 pasture	22.1	15.2	1.3	4.4
Koether2 pasture	24.7	6.3	0.7	4.4
Stewart1 pasture	18.2	20.0	1.5	2.9
Hayden prairie	24.8	62.8	9.9	9.6

Over six census periods, seventeen species were recorded at Hayden prairie. Ten grassland species (seven NTM grassland species), three woodland species, and four other/generalist species were recorded (two unknown species included in the OTHER category).

Bobolinks, dickcissels, meadowlarks, grasshopper sparrows, and savanna sparrows were all recorded at Hayden prairie. However, meadowlarks were found in very low abundance in comparison to the large grazed pastures (Table 6,7). Meadowlarks do not nest close to other meadowlarks, as bobolinks and other species will. Perhaps the meadowlarks at Hayden prairie were outcompeted by bobolinks and red-winged blackbirds, which exhibit aggressive behavior while nesting. Savanna sparrows were also less abundant than at smaller grazed sites. Hayden prairie was the only site where a Northern Harrier (*Circus cyaneus*) was recorded.

Borlaug Savanna

The Borlaug site was the only native savanna censused. Borlaug was grazed prior to 1988. The savanna is an 8.7ha habitat patch with a small core area (4.1ha) and a fairly large perimeter to area ratio (136) (Table 2).

The savanna is bordered on one side by a gravel road. Two sides are bordered by cultivated small grains and one side gradually becomes dense woods. The savanna has an open area with few trees and an area with characteristic oak trees (*Quercus macrocappa*).

Borlaug savanna had 100% litter layer cover, no bare ground, 10% live grass cover and 5.7% live forb cover (Table 3).

Borlaug savanna had the highest species richness with 29 species recorded over six census periods. Five grassland species, all neotropical migrants, were recorded . In

Table 6. Abundance (number of birds per census per 100 ha of habitat) of five Neotropical migrant grassland bird species at each site.

Site	Bobolink	Dickcissel	Meadowlark (Eastern and Western)	Grasshopper sparrow	Savanna sparrow
Natvig pasture	0.0	0.0	0.0	0.0	52.5
Daubendiek prairie	0.0	0.0	0.0	0.0	9.7
Frantzen pasture	16.5	12.4	8.3	8.3	206.8
Borlaug savanna	35.7	0.0	29.8	11.9	47.6
Stewart2 pasture	38.7	8.3	60.8	35.9	229.4
Koether1 pasture	96.4	4.0	52.2	12.1	180.7
Koether2 pasture	103.4	0.0	23.0	3.8	141.7
Stewart1 pasture	36.2	16.7	30.7	44.6	234.1
Hayden prairie	207.0	4.3	2.2	19.4	21.6

Table 7. Mean numbers of birds observed per census per 100ha on nine sites in Iowa during the breeding season. Food type, substrate and nest substrate are also given (from De Graaf and Chadwick 1984, De Graaf et al. 1985).

	Food type, sub- strate ^c	Nest sub- strate ^d	NAT (6) ^e SP ^b	DAU (5) NP	FRA (6) GP	BOR (6) NS	STE2 (6) GP	KOE 1 (6) GP	KOE 2 (6) GP	STE 1 (6) GP	HAY (6) NP
Savanna sparrow	O,G	G	52.5	9.7	206.8	47.6	229.4	180.7	120.5	234.1	21.6
Song sparrow	O,S	G,S	19.7	77.3	33.1	35.7	19.4	16.1	46.0	11.2	23.7
Bobolink	O,G	G			16.4	35.7	38.7	96.4	111.1	36.2	206.9
Grasshopper sp.	O,G	G			8.3	11.9	35.9	12.1	7.7	44.6	19.4
Meadowlark (E,W)	I,G	G			8.3	29.8	60.8	52.2	23.0	30.7	2.2
Dickcissel	O,G	G			12.4		8.3	4.0		16.7	4.3
Killdeer	I,G	G			28.9		33.2	4.0		5.6	
Ring-necked pheas.	O,G	G		9.7						2.8	32.3
Horned lark	O,G	G			41.4						
Northern bobwhite	O,G	G			8.3						
Sedge wren	I,G	G									19.4
Mallard	O,G	G									2.2
Northern harrier	C,G	G									6.5
Red-wing blackbird	O,G	S	19.7	125.6	90.9	71.4	71.9	72.3	237.6	11.2	131.5
Comm. yellowthroat	I,S	S	45.9	86.9	8.3	53.6			19.2	2.8	92.7
Brown thrasher	O,G	S	13.1		4.1	11.9			3.8		
Field sparrow	O,G	S	19.7	19.3		41.7			7.7		
Gray catbird	O,G	S		57.9		11.9		12.1	23.0		
Chipping sparrow	O,G	S	13.1			11.9					
Indigo bunting	O,S	S				11.9					
Yellow warbler	I,S	S							3.8		
House wren	I,S	Sn	19.7	9.7		41.7		4.0	23.0		
Black-cap chickadee	I,S	Sn		9.7		17.9					
Eastern bluebird	I,G	Sn	39.4			5.9					
Northern flicker	I,G	Sn	6.7			5.9					
Red-bellied woodp.	I,B	Sn	13.1			11.9					
Red-headed woodp.	I,A	Sn	39.4						3.8		
Wh-breast nuthatch	I,B	Sn	6.7								
American robin	V,G	T	177.2	19.3	28.9	65.5	8.3	56.2	23.0	13.9	2.2
American goldfinch	O,S	T	13.1	86.9			22.1	4.0	30.7		32.3
Common grackle	O,G	T	19.7	28.9	8.3	11.9			3.8	2.8	
Blue Jay	O,G	T	19.7	28.9		83.3			7.7		

(table continues)

	Food type, sub- strate ^c	Nest sub- strate ^d	NAT (6) ^a SP ^b	DAU (5) NP	FRA (6) GP	BOR (6) NS	STE2 (6) GP	KOE 1 (6) GP	KOE 2 (6) GP	STE 1 (6) GP	HAY (6) NP
Eastern peewee	I,A	T	13.1	9.7		17.9			3.8		
Baltimore oriole	O,T	T				23.8	2.8		11.5		
Eastern kingbird	I,A	T						20.1	3.8	8.4	
Cedar waxwing	F,S	T	6.7		4.1						
Mourning dove	G,G	T		2.8.9		17.9					
Red-tailed hawk	C,G	T			8.3			4.0			
Rose-br. grosbeak	O,T	T		9.7	4.1						
Barn swallow	I,A	B			20.7		47.0	12.1	23.0	22.3	
Br. headed cowbird	O,G	P				5.9	35.9	8.0		2.8	2.2
House sparrow	G,G	B			4.1					2.8	
Eastern phoebe	I,A	B	26.3								
Unknown 1									3.8		2.2
Unknown 2											2.2

a Total number of transect counts

b Habitat types: GP = grassland pasture, SP = savanna pasture, NP = native prairie, NS = native savanna

c Food types: C = carnivore (vertebrates), O = omnivore (a variety of plant and animal foods), I = insectivore (insects), G = granivore (seeds, nuts), V = vermivore (earthworms), F = frugivore (fruits). Food substrates: A = air, T = upper canopy of trees, S = shrubs or lower canopy of trees, B = bark of trees, G = ground or lower herbaceous vegetation

d Nest substrate: G = ground or herbaceous plants, S = shrubs, vines, or brambles, Sn = snag (dead tree), T = tree, B = buildings, P = nest parasite

addition, 19 woodland species and five other/generalist species were noted. Bobolinks, meadowlarks, grasshopper sparrows, and savanna sparrows were present. Dickcissels were not found within the transect area.

The large number of woodland species can be attributed to the presence of oak trees and the adjacent forest. The savanna also appears to be large enough and have enough open area to support area sensitive grassland species.

Natvig Pasture

The Natvig pasture site is a grazed savanna of 4.1ha bordered by a woody fencerow to the west, a cultivated hayfield to the south, another pasture to the north, and a pond and forest to the east. The transect ran North/South through several paddocks and was 254m long. The site has the highest perimeter to area ratio (207), meaning that there is a high amount of edge over interior habitat (Table 2). Consequently, this site has a low amount of core habitat area (2.3ha). Of the pastures, Natvig pasture had the greatest percent cover litter layer (70.5). The understory live herbaceous vegetation was mostly grasses (28%) and forbs (21%) in the spring of 1997 when data were collected (Table 4).

Landscape features measured from the middle of the transect show a short distance (80m) to edge and to woods (100m). While the savanna is characterized by many oak trees, I measured the distance to the nearest ungrazed stand of trees for the measurement to woods (Table 8).

Over six censuses, I recorded 21 bird species at the Natvig site. Most of these (17) were woodland nesters, while only two were grassland nesting species. The OTHER category includes common generalist species. Of five NTM grassland species that I chose to look at (bobolink, meadowlark, savanna sparrow, grasshopper sparrow, dickcissel), only the savanna sparrow was found on the Natvig pasture. Song sparrows were also recorded. These results can be attributed to the oak trees within the pasture, nearby woods, and the small area of the pasture. Area sensitive grassland species were not attracted to this site.

Table 8. Landscape features of each site obtained from United States Geological Survey 7.5 minute quadrangles. Distances measured from the center of the transect.

Site	Distance to edge (m)	Distance to woods (m)	Distance to human habitation (m)	Distance to road (m)	Distance to water (m)
Natvig pasture	80	100	200	280	480
Daubendiek prairie	70	220	700	120	200
Frantzen pasture	160	260	280	240	160
Borlaug savanna	180	80	240	120	20
Stewart2 pasture	160	1800	180	200	300
Koether1 pasture	400	250	380	450	100
Koether2 pasture	400	40	360	600	20
Stewart1 pasture	400	480	480	330	260
Hayden prairie	420	400	440	380	500

Frantzen Pasture

The Frantzen pasture (8.5ha) is bordered to the east by a gravel road, to the north by a farm road, and to the west and south by a stream and brush. The pasture has a small core area (4.7ha) and a large perimeter to area ratio (158) (Table 2).

The Frantzen pasture had the lowest height/density measure (2.3) of all the sites. The percent cover of live grasses, forbs, and legumes in the Frantzen pastures were lower than in the other grassland pastures, while the litter layer coverage was a little higher (Table 3).

Nineteen species were recorded with nine grassland species and seven woodland species. Despite the factor that it is the smallest grassland pasture, the Frantzen pasture had the same number NTM grassland species as Hayden prairie (7). This pasture was the only site where horned larks were recorded (Table 7). The birds were feeding on bare ground in cattle lanes between the paddocks. In addition, seven woodland nesting species and three other/generalist species were recorded using the pasture. Bobolink, meadowlark, and grasshopper sparrow abundances were low compared to other pasture sites, while dickcissel and savanna sparrow abundances were high (Tables 7, 8).

Stewart 2 Pasture

The Stewart 2 pasture is a 16.2ha rectangular pasture, bordered to the north and south by cultivated crops, to the west by cultivated small grains and to the east by a homestead.

The percent cover of the litter layer at Stewart 2 was the lowest level recorded (19.5), while the percent cover of bare ground was the highest (24). Litter layer depth (0.8) and the height/density measure (3.1) were also low. This pasture experienced a winter kill which accounts for these values. Stewart 2 was the farthest from a stand of woods (1800m) but was the closest to an inhabited home (180m) (Table 8).

Stewart 2 had the lowest total number of species recorded (14). However, six NTM grassland species were recorded, a value comparable to the larger sites. Meadowlarks had the highest abundance at Stewart 2 (60.8 birds/100ha). The abundance of savanna sparrows was also high (229.4 birds/100ha) (Table 6).

Koether 1 Pasture

The Koether 1 site is a 51.5ha pasture bordered to the north by homes, to the east by grain and row crops, to the south by a woodland, and to the west by more cultivated fields. Vegetation measurements were unremarkable except that the site had a low percent cover of bare ground (4.0) for a pasture.

Koether 1 had eighteen species of birds. Seven grassland species were recorded. All five NTM grassland species I focused on (Table 6) were in the mid range for abundance compared to the pasture and native sites.

Koether 2 pasture

Koether 2 is a 55.2ha pasture bordered to the north by a large stand of woods, and to the east, south, and west by cultivated fields.

Vegetation measurements show that Koether 2 had the lowest maximum height of dead vegetation, the lowest litter layer depth, and a low percent cover of litter layer, suggesting that the pasture had been grazed down more than other pastures the previous autumn (Tables 3, 5).

Two landscape features make the Koether 2 pasture interesting. First, the distance to woods is only 40m because of a finger of the woods which comes into the pasture.

Second, the distance to water is only 30m because the transect passed a farm pond (Table 8).

The total number of birds recorded was 23, the second highest. Five grassland species, all Neotropical migrants, were recorded while 15 woodland species were recorded. This can be accounted for by the close proximity of a large stand of woods and by the finger of trees that passes into the transect area. Many of the woodland species were recorded in the area near the trees. Dickcissels were not recorded and grasshopper sparrows were recorded in very low abundance compared to the other grassland sites. Bobolinks and savanna sparrows were abundant (Table 6).

Stewart 1 pasture

The Stewart 1 site was the largest grazed pasture (64.8ha) censused with the largest core area of pasture (48.6ha) and the lowest perimeter to area ratio of all sites. The pasture is bordered to the west by a county road and row crops, to the north by row crops, to the east by a stream and trees, and to the south by a homestead and more pasture.

Stewart 1 had a low height/density measure (2.9) and a high percent cover of bare ground. Like the Stewart 2 site, Stewart 1 had experienced a winter kill in 1996/1997 which accounts for the large amount of bare ground (Table 3).

Eighteen bird species were recorded (eight grassland). Dickcissels, grasshopper sparrows, and savanna sparrows were the most abundant at Stewart 1 compared to all other sites (Table 6).

IMRG Pasture and Native Grassland Comparison

T-tests showed no significant difference between IMRG pastures and native sites for total species richness, grassland species richness, woodland species richness, NTM grassland species richness, Shannon-Weaver index of diversity, mean number of species per census, total grassland species abundance, bobolink abundance, dickcissel abundance, meadowlark abundance, and grasshopper sparrow abundance. The only T-test that showed a significant difference between pasture and native sites was savanna sparrow abundance. Savanna sparrows were more abundant on pasture sites.

Vegetation structure in pastures was different from native sites. Generally, standing dead vegetation was shorter, litter layer was shorter and covered less ground, and there was more bare ground and live vegetation on the pasture sites in the spring when data were collected (Tables 3, 5). Vegetation data were collected when birds would be choosing nesting habitat. The difference in vegetation structure between grazed and native sites can be attributed to the fact that pasture sites were grazed while native sites were not.

Vegetation and Landscape Features

Correlation analysis of vegetation or landscape variables and avian species richness and abundance yielded interesting results. Bobolink abundance showed a strong relationship to the perimeter to area ratio (Table 9). Bobolinks also respond positively to a high height/density measure (Table 10). Grasshopper sparrow abundance had a positive correlation with the distance to woods (Table 9).

Table 9. Correlations (r^2) among landscape variables and avian relative abundance. Significant variables ($p < 0.05$) are indicated by (*).

	Bobolink abundance	Dickcissel abundance	Grasshopper sparrow abundance	Meadowlark abundance	Savanna sparrow abundance
Area (ha)	0.879	0.222	0.395	0.052	0.068
Perimeter to area ratio	-0.729*	-0.344	-0.597	-0.507	-0.418
Dist. to human hab. (m)	0.104	-0.020	-0.083	-0.362	-0.311
Distance to road (m)	0.572	-0.028	-0.039	0.136	0.270
Distance to water (m)	0.196	0.115	0.184	-0.373	-0.246
Distance to woods (m)	-0.035	0.391	0.663*	0.611	0.489

Total grassland species abundance calculated for each site showed a negative correlation with the perimeter to area ratio (-0.769) (Table 11). As the perimeter to area ratio increased, the abundance of grassland birds decreased.

Correlations between species richness measures and habitat variables showed a negative relationship between NTM grassland species richness and the perimeter to area ratio (Table 11).

Table 10. Correlations (r^2) among vegetation variables and avian relative abundance. Significant variables ($p < 0.05$) are indicated by (*)

	Bobolink abundance	Dickcissel abundance	Grasshopper sparrow abundance	Meadowlark abundance	Savanna sparrow abundance
Height/density	0.867*	-0.332	-0.066	-0.293	-0.554
Percent cover bare ground	-0.193	0.705	0.726	0.581	0.872*
Percent cover live vegetation	-0.184	0.351	0.286	0.625	0.820
Percent cover litter layer	0.116	-0.448	-0.418	-0.617	-0.867

Table 11. Correlations (r^2) among habitat variables and avian species richness. Significant variables ($p < 0.05$) are indicated by (*).

	Total grassland species abundance	Total species richness	Grassland species richness	NTM grassland species richness	Shannon-Weaver diversity index
Area (ha)	0.510	-0.219	0.621	0.553	-0.690
Perimeter to area ratio	-0.769*	0.196	-0.653	-0.700*	0.629
Dist. to human hab. (m)	-0.193	-0.281	-0.030	-0.233	-0.343
Distance to road (m)	0.380	-0.015	0.200	0.286	-0.485
Distance to water (m)	-0.122	-0.509	0.102	-0.106	-0.303
Distance to woods (m)	0.539	-0.624	0.292	0.301	-0.253
Height/density	-0.009	-0.009	0.301	0.209	-0.173
Percent cover bare ground	0.691	-0.422	0.328	0.398	-0.436
Percent cover live vegetation	0.488	-0.236	0.016	0.167	-0.331
Percent cover litter layer	-0.631	0.333	-0.161	-0.300	0.406

CHAPTER 4

DISCUSSION

Individual Site Analysis

It is obvious that each site is unique and its characteristics affect which species will use that particular site. As a bird returns from its wintering grounds to breed in Iowa, it must search the landscape for a habitat patch that fulfills its unique requirements. For some species, area is important. A species may need a large core area or a long distance from edge or woody vegetation to possibly guard against increased rates of predation or parasitism. Some species prefer tall grasses while others prefer a large amount of bare ground. Clearly, opportunistic or brood parasitic species such as brown-headed cowbirds search for edge habitat.

In taking a broad look at the vegetation and landscape characteristic of the sites included in my study, some trends became clear. Daubendiek prairie is small with a lot of woody encroachment, nearby woods, and a thick cover of vegetation. It makes sense that area sensitive grassland species would not settle in Daubendiek prairie. Savanna sparrows were recorded at Daubendiek but in very low abundance compared to every other site. Song sparrows were also noted, but this is a species that can utilize brushy areas.

Table 7, which separates species into nesting and feeding guilds, shows many of the trends of species presence/absence as well as abundance data. Many woodland species used Daubendiek.

The Natvig grazed pasture which is small like Daubendiek, had the same effect on bird habitat choice. Song sparrows and savanna sparrows were again the only grassland Neotropical migrants recorded, while several woodland nesting species were recorded.

Bird use in the Borlaug savanna and the Koether 2 pasture site was also influenced by the presence of trees within the habitat patch and the close proximity to woods. Borlaug and Koether 2 had the highest total number of species (29 and 23, respectively), but were at the low end of the range for grassland species richness. Both sites had a high number of woodland species (Table 4). Species richness is often misinterpreted. Many people think that the more biodiversity, the better. This is simply not true when managing for grasslands. Greater species richness occurs in grasslands when there is a lot of woody edge which creates habitat for opportunistic, generalist, and tree dwelling species. Large, healthy grasslands support more grassland species but fewer total species and relatively low densities of breeding birds when compared to forest patches (Herkert 1991, Martin 1992, Franklin 1993, Herkert 1994).

The larger, more open sites (Stewart 1, Stewart 2, Koether 1, and Hayden prairie) attracted more grassland species (range 7-10) and fewer woodland species (range 3-8) compared to the ranges for the more woody sites just mentioned (grassland species 2-5; woodland 11-19).

The Frantzen pasture is interesting because it is not very large (8.5ha) and yet many grassland species (7 NTM grassland species) were recorded there. However, the savanna sparrow was the only species that had a high relative abundance.

Analysis of Vegetation and Landscape Features

Analysis of correlations between habitat variables and avian species richness show that grassland species richness declined as the perimeter to area ratio increased. Furthermore, grassland species richness had a positive but insignificant correlation with area (0.621). These relationships support the idea that many grassland species are sensitive to small area and to a great amount of edge.

The Shannon-Weaver diversity index had a negative though insignificant correlation with area. As area increased, the diversity index decreased. Smaller sites with more edge had greater numbers of woodland and opportunistic species which is detrimental to grassland birds. As the area of the sites increased, diversity decreased due to fewer woodland and opportunistic species using the grassland habitat interiors. Total grassland species abundance decreased as the perimeter to area ratio increased, supporting the hypothesis that many grassland species require large areas with a small amount of edge.

An in depth analysis of abundance for five grassland species revealed several interesting habitat correlations. Bobolink abundance was strongly related to the perimeter to area ratio and to a high height/density measure of vegetation (Tables 9, 10). Bobolinks prefer large, open grasslands with tall vegetation. Dickcissels, grasshopper sparrows, and savanna sparrows prefer a higher percent cover of bare ground. These species were generally more abundant on grazed sites than on native sites. The shorter, open substrate may provide these species with better feeding and nesting habitat than the native sites which have taller, more dense vegetation and less bare ground. These

findings bring up an interesting question about native grasslands. Prairies such as Hayden prairie are presently managed with fire but are no longer grazed. It is possible that the absence of grazing has a negative effect for some grassland birds in native grasslands habitats.

The analysis of habitat features support the hypothesis that many grassland species need large areas with little edge habitat. While the specific requirements of grassland species differ, the results of this study show that grassland birds are attracted to the landscape and vegetation features of IMRG pastures.

Comparison of Pastures and Native Grasslands

Statistical tests (T-test) comparing native sites to grazed sites showed that there was no significant difference between the two categories for total species richness, grassland species richness, woodland species richness, Neotropical migrant grassland species richness, mean number of species per census, dickcissel abundance, bobolink abundance, meadowlark abundance, grasshopper sparrow abundance, or total grassland species abundance.

The only test that showed a significant difference was the test for savanna sparrow abundance. Savanna sparrows were more abundant on grazed sites (mean 174.2) than on native sites (mean 26.3). As suggested, savanna sparrows may better utilize and be more successful on grazed sites or shorter grasslands. Savanna sparrows may also be outcompeted by other species on native ungrazed grasslands.

Comparisons of grazed sites to native sites allow me to conclude that IMRG pastures are acting as native grassland analogs and are a good alternative to conventional

farming in human dominated habitats. Further studies are necessary but we can move forward confidently with the knowledge that grassland species, some threatened, are using IMRG pastures.

Future Studies and Management of Grassland Birds

Many bird studies in agricultural landscapes have shown that small patch size and habitat fragmentation are primary factors in the decline of Neotropical migrants (Vance 1976, Martin 1980, Opdam et al. 1985, Johnson and Temple 1990, Herkert 1991, Mankin and Warner 1992, Faaborg et al. 1993, Maurer and Heywood 1993). However, most studies have focused on forest species which experienced lower nesting success in small remnants. There is a paucity of studies on the response of prairie bird populations to grassland fragmentation. This is alarming since the tallgrass prairie is among the most depleted and fragmented ecosystem in North America.

Nineteen species of grassland birds exhibit area sensitivity and six species are never found in grassland fragments less than 10 ha (Freemark et al. 1995). Most Neotropical migrants have small territories (<2ha) but may require habitat patches ten or one hundred times their territory size to fulfill feeding needs or to guard against predators and brood parasites (Faaborg et al. 1993).

Small areas may facilitate dispersal to larger areas by acting as stepping stones, but predation and brood parasitism rates in small fragments with woody edges may limit reproductive success, making them population sinks for some species (Burkey 1989, Robinson et al. 1993). Populations in isolated habitat patches have lower growth rates

and are thus more prone to extinction than in connected patches (Fahrig and Merriam 1985, Merriam 1988, Warner 1994).

Large unfragmented habitat patches appear to be the best conservation strategy for grassland birds, but in Iowa, as in many areas, we no longer have large native habitat patches to preserve. Therefore, we must look for conservation and management strategies that are beneficial to grassland birds.

Bock et al. (1993) suggested that grazing livestock can be beneficial for birds in landscapes that historically were inhabited by native grazing ungulates. Livestock grazing may simulate a natural ecological event which the native flora and fauna tolerate or even require by creating a broad mosaic of grassland in various stages of succession. The extent of grazing may be a factor. Upland sandpipers (*Bartramia longicauda*), dickcissels, grasshopper sparrows, bobolinks, and meadowlarks usually respond positively at least to moderate grazing but negatively to heavy grazing in short grasslands. Birds are particularly responsive to changes in the physical structure of habitats in which they nest and forage (Cody 1985) so livestock probably have the greatest negative impact where they most change a habitat's physical structure.

Practices such as intensively managed rotational grazing may impose a mosaic of habitat resembling prehistoric prairie conditions which may be beneficial to sensitive grassland bird species (Chan-Muehlbauer et al. 1994, Paine et al. 1995). However, birds attracted to the pastures risk nest trampling (Page et al. 1978, Koerth et al. 1983). Livestock return to a paddock every 3-6 weeks which may not be enough time for birds to complete their nesting cycle.

Paine et al. (1995) suggest setting aside a refuge paddock in an IMRG farm system to provide an undisturbed area for grassland birds to nest. To attract birds to these areas at the beginning of the season, it would be beneficial to allow the plot to establish standing vegetation in the previous season, because residual cover is more attractive to some threatened grassland species (George et al. 1979).

Having answered the question of whether or not the IMRG pasture system attracts desired grassland species, it is important to determine whether grassland birds are successfully nesting in IMRG pastures and whether their success compares to nesting success in native prairies and savannas. An ideal study would pair native prairies and IMRG pastures within the same geographic region that are similar in size. Because of the enormity of the question, it would be beneficial to pick one key grassland species, such as the bobolink. Bobolinks in both habitat types would be followed from nest establishment to fledging or termination of the nest. It would be interesting to pay particular attention to nesting birds in pasture paddocks when livestock are present. These observations would provide valuable insight into nesting birds' territorial behavior toward grazing livestock. Nesting birds invest a large amount of energy into establishing their nesting territories, attracting mates, building nests, laying eggs, and incubating the eggs. It is possible that birds will deter non-predatory animals from their nests using defensive calls and displays. Previous nest trampling studies in pastures have used artificial nests, which do not account for defensive bird behavior (Burger and Faaborg 1994). The loss of nests to trampling may not be as severe as we suspected.

Studies of nesting success and nest trampling in IMRG pastures will allow us to determine if birds are as successful in IMRG pastures as in native ungrazed grasslands. If birds are not as successful, we could continue to investigate management practices, such as the refuge paddocks, that encourage the success of grassland birds in pastures.

The influence of micro habitat features on bird use needs further investigation. Nesting studies would allow researchers to determine vegetation characteristics that are important to grassland species at the nest territory scale. This information would allow farmers to manage their pastures for grassland birds. For example, if grassland birds respond positively to warm season grasses, these could be integrated into the pasture as forage for livestock and as cover for birds. If large amounts of litter layer attract birds, farmers could adjust fall grazing, if economically feasible, to leave more litter for the following spring.

Freemark et al (1995) supported the idea that Neotropical migrants are affected by factors at the territory scale, but also at the species' regional distribution scale. Habitat selection involves responses to patch structure at a series of hierarchical levels including territory, patch, and landscape scales. To understand how different scale patterns and processes affect grassland birds and their population dynamics, we must bridge local habitat and regional or biogeographical studies (Boecklen and Gotelli 1987, Grumbine 1990). By studying different levels of resolution, habitat attributes that are prerequisites for certain species may become apparent (Thompson et al. 1993). Geographic information systems and multivariate statistical techniques may help us quantify and integrate varieties of factors that characterize complex habitats and reduce many

variables to a few axes. Poorly designed studies, however, may miss important interactions or confound temporal or spatial scales affecting ecological patterns, which could be misleading for management (Orians and Wittenberger 1991).

Using a landscape paradigm for conservation and diversity, we can see regional trends of extinction and colonization, relative abundance of species and habitat types, and spatiotemporal dynamics of the structural components of landscapes (Noss 1983, Barrett 1992). Currently, landscape studies are largely conceptual. Empirical tests of models and theories such as those examined in this paper are needed, but study design is difficult because landscapes cannot be reduced to a set of various land uses or elements (Wiens 1992).

It is difficult to assess what is important to measure in landscape structure. Remote sensing technology may be very helpful. If landscape structures are related to population demographics, computer models could be used to simulate the impact of landscape changes on Neotropical migrant species. Landscape models and theories will be useful in real world situations where the landscape is being converted from row crop fields to IMRG pastures and reconstructed prairies. As grasslands are being created, we can study the immigration, competition, and settling behavior of grassland birds.

Future studies should incorporate the idea of the metapopulation, a spatially structured population made up of distinct subpopulations separated by space or barriers and connected by dispersal (Opdam 1988, 1991). The metapopulation is a demographic unit at the landscape level that is helpful in understanding the effects of fragmentation on a species. The dynamics of the metapopulation are the combined dynamics of the

subpopulation and dispersal flow. Populations in distinct patches may experience extinction and recolonization as the metapopulation pattern of distribution shifts.

Banding studies of grassland birds over time in separate grassland habitat patches within a larger area will further our understanding of settling behavior, site fidelity, and immigration and emigration. These studies, in combination with nesting success studies, will help us to understand if IMRG pastures act as source or sink habitat for grassland species.

While many aspects of bird use of IMRG pastures still need to be examined, I have found that grassland bird abundance and species richness in IMRG pastures is comparable to native grasslands. Based on the analysis of landscape features, the obvious management recommendation for farmers and other land managers is that large grassland tracts must be maintained if grassland species richness is a management goal. Intensively managed rotational grazing is a farming method that allows for large scale structural restoration of grasslands. Although large scale restoration of prairies is not feasible in the human dominated Midwestern landscape, IMRG pastures may provide the structure and area necessary for grassland birds.

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