AVIAN STUDIES IN MONTANE MEADOWS: SONGBIRD ABUNDANCE AND NESTING SUCCESS

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✦ INTRODUCTION

The loss of biological diversity has become a global concern during the last decade (Wilson, 1988; Reid and Miller, 1989). The need to predict those species of concern and areas of high species richness is even more pressing as we enter an era of potential global climate change. Prerequisites to good decision-making with regard to the management of biological diversity are adequate floral and faunal inventories for the lands in question and a rigorous understanding of species-habitat relationships (e.g., Noss, 1983; Davis et al., 1990; Scott et al., 1990; Scott et al., 1993). The emergence of landscape ecology as a discipline has been instrumental in helping scientists understand spatial patterns of species distribution (Noss, 1983; Urban et al., 1987; Turner, 1989). Once these relationships are understood, it may be possible to predict species diversity based upon landscape level habitat analysis using geographic information systems (GIS) and remotely sensed data (Urban et al., 1987; Turner, 1989) at fine-scale resolutions (e.g., 20 - 50 meter sampling sites). Conversely, such analyses can help optimize sampling strategies or allow us to test hypotheses regarding the spatial correspondence of species diversity "hotspots" among taxonomic groups (e.g. Prendergast et al., 1993).

The debate over global climate change has created renewed interest in documenting baseline variability in biodiversity. Goals of the Committee on Earth Sciences (1989) regarding the U.S. Global Change Research Program focus on the development of sound scientific strategies for monitoring and predicting environmental change. Key priorities, as noted by the committee, are as follows:

> *"Systematic sampling and monitoring are essential to document critical natural versus human-induced change in the structure and function of globally relevant biological systems on various time scales." (Committee on Earth Sciences, 1989).*

Montane meadow communities can function as early indicators of environmental change because they are highly sensitive to variations in precipitation and temperature. The composition and condition of meadow communities are closely linked to the environmental conditions within a site. Different meadow communities occupy specific sites based on narrowly defined adaptations to gradients of temperature and moisture. Short-term changes in environmental conditions are manifested as changes in vegetation condition, while long-term, directional shifts in temperature and moisture regimes will also drive changes in species composition and diversity of animal communities. Because of this sensitivity to abiotic conditions, meadow communities are excellent indicator areas of directional environmental change.

One of the more visible and diverse communities found in these montane meadows is the songbird community, and it is most diverse in the willow habitats of the Greater Yellowstone Ecosystem. We have been collecting data on bird communities in montane meadows for the past decade. During that time, it has become obvious to us that habitat type, vegetation structure, and landscape context play major roles in determining local songbird distribution and abundance. The abundance of some of the willow-dependent songbirds can vary significantly between different sites within the same habitat type (Saveraid et al., 2001). We have posited that this variation is explained in part by the height of the vegetation. However, we have not directly assessed these relationships. Berger, et al. (2001) examined the effects of herbivory on songbirds in the Greater Yellowstone Ecosystem and found them to be significant. However, we wanted to conduct a more fine-scaled approach to this investigation with an emphasis on comparing local patch-level effects (e.g., vegetation structure) to larger-scale landscape effects (e.g., patch size and adjacent habitat). We suspected that the combination of patch size and vegetation structure may explain local species diversity and abundance patterns better than simply vegetation structure alone.

Our goals for the 2002 field season were two-fold:

1. To continue our long-term inventory and monitoring of songbird biodiversity in montane meadows of the Greater Yellowstone Ecosystem.

2. To conduct pilot research that would allow us to begin to sort out the relative effects of habitat type, vegetation structure, and landscape context on nesting success of a willow-dependent songbird, the Yellow Warbler (*Dendroica petechia*).

✦ METHODS

Remotely Sensed Data Analysis

Landsat Thematic Mapper data were used to identify a moisture gradient in montane meadows of the Greater Yellowstone Ecosystem (Debinski, 1994; Jakubauskas and Debinski, 1995). Six meadow types were defined, ranging from extremely hydric (M1) to extremely xeric (M6) meadows. Field investigations confirmed the moisture gradient predicted for the meadows (Jakubauskas et al., 1998; Kindscher et al., 1998; Debinski et al., 2000). M1 and M2 meadows are sedge (*Carex* spp.) marshes and willow (*Salix* spp.) thickets with some standing water. M3 meadows are medium moisture meadows characterized by a diversity of flowering plants (forbs). M4 meadows are of medium moisture with cinquefoil (*Potentilla spp.*) and mixed herbaceous vegetation (and are not present in the Teton landscape), while M5 meadows have a mixture of sagebrush (*Artemesia tridentata*) and herbaceous vegetation. M6 meadows are characteristically xeric, rocky, and dominated by sagebrush.

Birds as Indicators

Birds are good ecological indicators because they are ecologically diverse and use a wide variety of food and other resources. Therefore, they reflect the condition of many aspects of the ecosystem and often respond to spatial and temporal variation in a species-specific fashion (Steele et al., 1984; Taper et al., 1995). They are also conspicuous, ubiquitous, intensively studied, and often appear to be more sensitive to environmental changes than other vertebrates (Morrison, 1986). Because they have short generation times, changes in the environment will be manifested quickly in terms of local abundance and distribution pattern.

Bird Surveys

Our sample sites were stratified by meadow type, with five examples of each of five meadow types in the Tetons (a total of 25 core sites). Sample plots are currently marked with rebar stakes and are re-flagged each season. We collected bird abundance data as we have done during each of the past years, from early June to mid-July. We surveyed birds two times per season at each of the Teton sites during the summer field season. Birds were surveyed between 0530-1030 hrs using point counts in 100 m diameter circular plots. Two observers were present for each 15-minute survey.

During our pilot nest study in 2002, we established standards in nest searching, monitoring, and recording for the Yellow Warbler. We conducted searches near singing males until a female was detected or flushed. She was then followed and observed until we found the nest. Nest locations were determined with a GPS and recorded in UTM coordinates. We monitored nests every 3 - 4 days until each nest's fate was realized and the resultant data were used to calculate daily and periodic survival probability for the group of nests at each site (Table 1, Mayfield 1961; Mayfield 1975). In order to minimize observer effects, we avoided creating "dead end" trails that lead to nests and used a mirror pole for identifying nest contents at a distance.

Table 1. Nest survival probability (Mayfield estimates) of Yellow Warbler nests in M1 meadows, Grand Teton National Park, 2002.

Site	N	Incubation	Nestling	Total
T1B	3	1.0000	0.6798	0.6798
T1C	4	1.0000	0.6887	0.6887
T1CC	3	1.0000	1.0000	1.0000
T1D	4	0.4491	0.1592	0.0715
T1E	4	1.0000	0.2149	0.2149
T1I	3	1.0000	1.0000	1.0000
T1K	5	0.5016	0.5517	0.2767
T1M	3	0.5646	1.0000	0.5646
ALL SITES	**29**	**0.7626**	**0.6426**	**0.4900**

✦ DATA ANALYSIS

We performed simple linear regressions to test for the effects of landscape context on nesting success. Within each site, our sample of nests formed a cluster, and a combined buffer zone was created from individual circles of 100-meter radii centered on each nest (Fig. 1). To quantify features in the vicinity of each cluster, we measured the amount of each feature (meters for line-features or hectares for polygon-features) that fell within this zone. We found a significant relationship between nesting success and the total length of waterways within the buffer zone (Fig. 2, F = 18.83, df = 1,6, P = 0.005). We tested for, but found no correlation between nesting success and the following variables: patch area, distance-to-edge, length of patch edge within the buffer, area of forest cover within the buffer, and the area of willow cover.

Figure 1. Length of waterways within a combined 100-meter buffer zone formed by the union of individual nest-centered circles (red triangles are nests) in Grand Teton National Park, 2002.

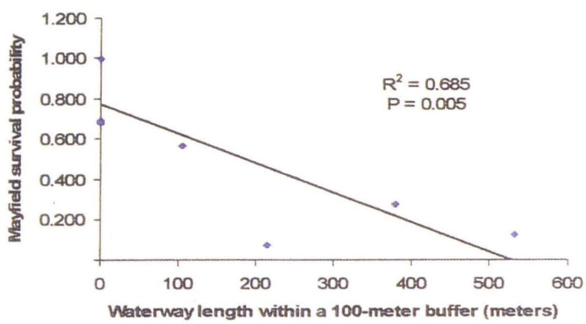

Figure 2. The effect of nearby waterways (i.e., those within 100-meters of the nest cluster) on nesting success in Grand Teton National Park, 2002.

We used the nest coordinates to build a GIS database of nest locations within each willow patch (Fig. 3). Using ArcView GIS 3.x, we calculated the following patch- and landscape-level metrics: 1) distance-to-edge for each nest, 2) individual patch area, and 3) amount of nearby features within 100-meter buffer zones of each nest group. Based on the significance of nearby waterway effects, our future analyses will include calculating waterway length/patch area ratios to use as potential patch-level descriptors of suitable nesting habitat. In addition, multivariate statistical analyses will be used to assess the effects of habitat type, vegetation structure, and landscape context on nesting success for entire guilds of willow-dependent songbirds.

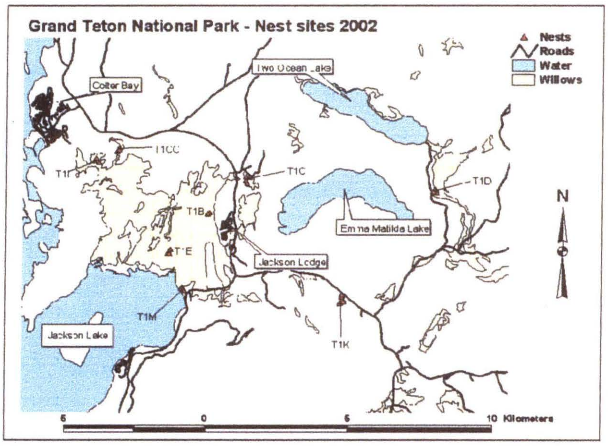

Figure 3. Locations of Yellow Warbler nests and M1 meadows (T1B, T1C, T1CC, T1D, T1E, T1I, T1K, T1M), Grand Teton National Park, 2002.

✦ SUMMARY

The goal of this research is to continue monitoring of long-term, well-established biodiversity inventory and monitoring sites in the Greater Yellowstone Ecosystem, and to add a new habitat-level of investigation to this work. Detecting statistically significant patterns in rare species requires many years of sampling. Our data become more valuable with each additional year's contribution of information. We strongly believe that these montane meadows will be excellent indicators of environmental change. Although much global climate change monitoring has been focused on high latitude or high elevation forest communities, we expect low elevation meadow vegetation to exhibit shifts long before forests do, so they may provide early warning signals for larger ecosystem changes. However, a long-term series of data will be required before we can distinguish the background noise from the signal in changing species distribution patterns. We have some excellent preliminary data on the relationship between habitat type and bird community composition.

We have developed models for predicting several of the most abundant songbird species relative to meadow type (Saveraid et al., 2001). However, the abundances of these species vary significantly from one point in the landscape to another, even within the same habitat type. We would now like to investigate the relative influence of habitat type, vegetation structure, and landscape context on bird communities, with a focus on the willow-dependent Yellow Warbler. We have shown that landscape context can have significant effects on local butterfly species richness (Debinski et al., 2001). The research described here will allow us to begin to separate out the relative effects of patch-level (i.e., vegetation structure) versus landscape-level (i.e., patch size and patch context) effects on local songbird abundance and breeding success. We should emphasize that given the small amount of resources we had for summer 2002, this habitat type/vegetation structure/landscape context analysis was very preliminary. However, we have laid out our methodology here in detail to aid in explaining the significance of the work. We hope to expand this research during future summers.

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