DISTRIBUTION OF BIRDS ALONG THE MISSOURI AND MADISON RIVER CORRIDORS

2008 Report

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Executive Summary

Riparian habitats comprise an extremely small physical area (<1%) of the western United States. Although riparian systems are restricted in area, these areas harbor a wide diversity of birds and other wildlife. In 2002, we began investigating vegetation and land use associations of breeding birds along the Madison and Upper Missouri Rivers with the intent to continue long-term monitoring every third year thereafter. Understanding how these factors influence avian populations will help in implementing habitat restoration and conservation strategies focused on the river system.

*In 2008, we re-visited 104 of the randomly selected sites surveyed from 2004-2005. We also added 6 new sites and 17 points in riparian patches with a high composition of Russian olive (*Elaeagnus angustifolia*) as part of a before-after/control-impact study of the removal of the invasive species. In all, we detected 9,435 birds consisting of 113 species using riparian habitats along the river corridor. This represents 46% of the 245 bird species known to breed in Montana, which speaks to the critical importance of riparian habitats to Montana's bird populations.*

Using bird data collected from 2004 to 2008, we refined our previous habitat models of species occurrence, evaluated year effects, and examined the relationship between persistence and local habitat quality. In all, 18 of the 27 species evaluated showed a decline in occurrence from 2004 to 2008. Local vegetation structure again appears to be a critical factor in bird distributions along the river system. However, landscape connectivity was selected in the final model for more species than any other metric.

Russian olive encroachment was not significantly associated with the probability of occurrence of any single species. However, species richness, and the abundance of species grouped by nesting and foraging strategy had a strong negative relationship with Russian olive cover.

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Introduction

Riparian habitats in the western United States comprise an extremely small physical area, amounting to less than 1% of the West (Knopf et al. 1988), yet as much as 90-95% of cottonwood-willow riparian habitats have been lost in the West (Johnson and Carothers 1981). Although riparian systems are restricted in area, these areas harbor a wide diversity of birds, as well as other plants and animals (Mosconi and Hutto 1982, Bock and Strong 1990, Saab et al. 1995). In fact, these areas have been referred to as the "aorta of an ecosystem" (Wilson 1979).

Although riparian areas contain a high diversity of wildlife, these systems have been severely stressed by a variety of anthropogenic factors, including river damming and changes in hydrology, deforestation and habitat loss, human recreation, grazing, and other disturbances, and these potential impacts arise from both local and landscape-scale changes (Johnson 1992, Rood and Mahony 1995, Scott et al. 1997, Miller et al. 2003, Scott et al. 2003, Sweeney et al. 2004). Results from our previous surveys indicate that while local scale vegetation structure best explains bird distributions along the Missouri and Madison rivers, large-scale human impacts, including habitat fragmentation and loss, had a greater influence on bird distributions than local scale disturbances, such as invasive plants and livestock grazing (Fletcher and Hutto 2008). However, these initial results are from a single snapshot in time, and may not reflect bird-habitat relationships across years. Locations that consistently have birds present are generally of higher quality than locations that are occupied only sporadically (Sergio and Newton 2003, Aldridge and Boyce 2007). By measuring persistence (e.g. site occupancy) across years, we can evaluate annual variation in bird distributions. Differences in habitat characteristics associated with points where birds are detected in none, one, or all years, may be a better indicator of high quality habitat for a given species than standard modeling approaches that combine bird data across years.

The impacts of invasive exotic species on native biota and ecosystems have become a major concern for land managers. Along the Missouri and Madison rivers, anthropogenic alterations of flood regimes, clearing of riparian woodlands, and overgrazing by livestock have promoted the invasion and proliferation of Russian olive (*Elaeagnus angustifolia*). Russian olive has spread rapidly throughout riparian habitats in the Western United States, outcompeting native vegetation, interfering with natural plant succession and nutrient cycling, and taxing water reserves. Because Russian olive is capable of fixing nitrogen in its roots, it can grow on bare, mineral substrates and dominate riparian vegetation where overstory cottonwoods have died (Shafroth et al. 1995, Simons and Seastedt 1999).

Previous research into the influence of Russian olive encroachment on riparian birds is sparse and contradictory. Although the tree produces a large crop of fruit utilized by many birds, lower bird numbers and species richness have been found in Russian olive stands than in native riparian vegetation (Knopf 1986, Brown 1990). However, along the Columbia River, short distance migrants were more abundant in Russian olive, while more Neotropical migrants were found in native vegetation (Hudson 2000). In New Mexico, nest densities for several species were highest in Russian olive stands, and nest success rates were equivalent to native riparian habitats. Yet, Russian olive supported no cavity nesters and had higher nest parasitism rates for sensitive species including the Willow Flycatcher (Stoleson & Finch 2001).

In 2008, the BLM initiated a Russian olive removal program along the lower Missouri in an effort to restore the native riparian vegetation communities. To evaluate the success of habitat restoration efforts, it is critically important to understand the effects on habitat function, since changes in habitat from restoration may or may not result in changes in the functional properties of the restored area (Palmer et al. 2005). Birds can be a good tool for evaluating habitat changes since birds are a diverse group that uses a wide range of habitat types and their distribution and abundance is often correlated with the quality, quantity, and condition of habitat. The most direct way to evaluate restoration is to use a before-after-control-impact (BACI) design (Palmer et al. 2005), which compares the temporal changes in communities with restoration activities against temporal natural variation in control areas. A BACI design provides a robust way to determine exactly what is gained from restoration activities.

Continued long-term monitoring as well as understanding how human-related disturbances like the invasion of Russian olive influence avian populations will help in implementing habitat restoration and conservation strategies focused on the river system. In 2008, we had the following objectives:

1) Continue long-term monitoring in order to examine changes in bird distribution over time relative to habitat, human settlement, and human land use practices;
2) Examine the influence of Russian olive encroachment on riparian bird communities and vegetation along the Lower Missouri River section.
3) Establish a BACI study to determine the response of bird communities and vegetation to riparian floodplain restoration associated with Russian olive removal.

OBJECTIVE 1: LONG-TERM MONITORING

Methods

Study Area & Site Selection

We re-visited long-term monitoring sites established in 2004/ 2005 (Fig. 1). Survey points were located throughout the Madison and Upper Missouri Rivers stretching from Varney Bridge south of Ennis to Fred Robinson Bridge at James Kipp Recreation Area. The river was stratified into three geographical sections: the Madison River, the Missouri between Three Forks and Great Falls ("Upper Missouri" hereafter), and between Great Falls and Fred Robinson Bridge ("Lower Missouri" hereafter). Riparian patches were randomly selected from within each section, and points were established by overlaying a 150 x 150 m grid on selected patches (for details see Fletcher & Hutto 2008).

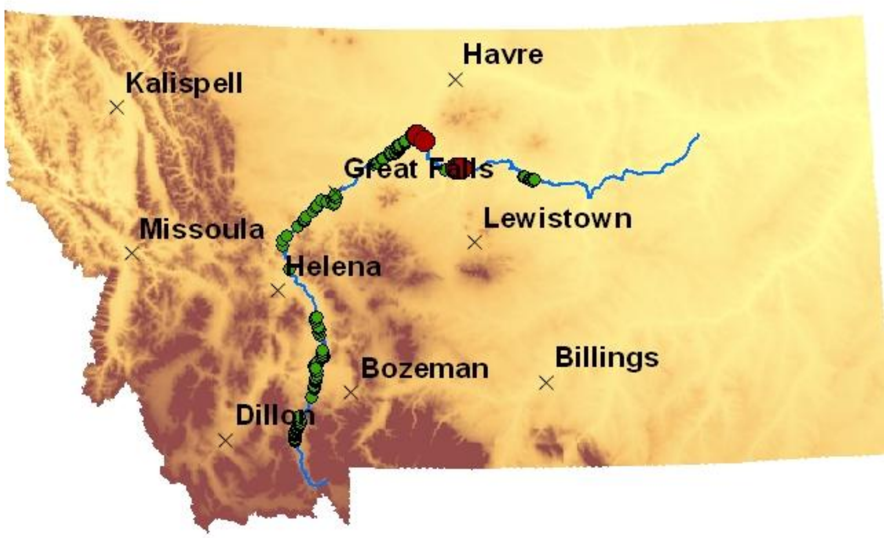

Figure 1. Longterm monitoring points re-visited in 2008 (green points), and new Russian Olive restoration points (red).

Bird Surveys

In 2008, we continued our long-term monitoring surveys for birds using a standard 10 minute point-count protocol (Hutto et al. 1986). Surveys were conducted between sunrise and 5 hours after sunrise and were not conducted during high wind velocities (≥ 20 km/hr) or during consistent precipitation. During surveys, observers recorded all birds seen or heard within a 50 m radius, how individuals were detected (song, visual, or call), sex of individuals, and distances of birds from the center point. Distances (m) to birds were estimated using a rangefinder.

Habitat & Land Use Metrics

Local Vegetation & Disturbance. Point counts allow for estimating densities of birds across different land use categories and habitat conditions. Therefore, we also measured a variety of plant/habitat metrics at each point-count station after completing bird surveys. Vegetation was measured at four sampling locations within the point-count area: plot center and at three locations 25 m from the center, at 0°, 120°, and 240° (Figure 2). At each sampling location we measured vegetation composition and structure at two scales: 5m-radius subplot and 11.3m-radius plot. Within the 5m sub-plot, we recorded ocular estimates for: shrub cover (by species) and height of shrubs > 1m, sapling cover (by species), ground cover structure, and exotic species cover (by species). Ground cover categories included woody stems, grass, forb, sedges/rushes, course woody debris, water, rock, litter, and bare ground. We also counted the number of cow pies and ungulate mounds within each 5m plot.

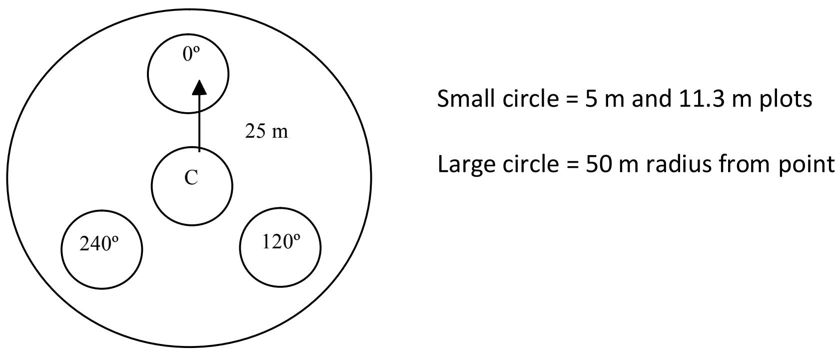

Figure 2. Vegetation sampling circle showing the arrangement of 5m and 11.3m plots.

Within the 11.3m plot, we counted trees by species and size class, and estimated grazing and browsing intensity. Canopy cover of the tallest vegetation layer was estimated by averaging 4 densiometer readings (one in each cardinal direction). For more details, see vegetation data form (Appendix B).

Patch. Using aerial photographs taken in 2005 (1 m. resolution), we calculated four metrics to quantify patch structure: patch size, patch width, shape (shape = circumference/circumference of a circle of the same area; Laurance and Yensen 1991), and the average distance to edge from each point within a patch. Patch size and width were incorporated based on the known strong relationship of patch width and avian species diversity in riparian systems (but see Rodewald and Bakermans 2006), which are thought to vary primarily from anthropogenic habitat loss and fragmentation. Both distance to edge and the shape index provide measures related to the potential for edge effects (Laurance and Yensen 1991, Fletcher et al. 2007). Patch width and shape were retained for analysis after evaluated correlation

Landscape. We calculated measures related to the potential loss (habitat amount) and fragmentation (configuration of forest for a given amount of habitat remaining) of riparian forests surrounding patches and the potential impact of human development within 1 km of each patch. Estimating metrics within 1 km for riparian systems is warranted based on strong correlations from other investigations on birds using riparian forests in the western U.S. (Saab 1999). To quantify riparian forest structure surrounding patches, we estimated the total area of riparian forest to reflect habitat loss (Fletcher and Koford 2002), the distance to the nearest riparian patch and its size to reflect potential connectivity (cf. Moilanen and Nieminen 2002), and patch density (No. of riparian patches/area of riparian forest) and edge density (length of riparian edge/area of riparian forest) to reflect configuration/fragmentation of remaining riparian forest habitat (Fletcher and Koford 2002). For indices of development, we calculated the density of roads and the area of buildings (e.g., homes, businesses, etc.).

Table 1. Explanatory variables considered in the analysis of bird distributions in riparian forests, Montana, 2004 - 2008.

	Variable/scale	Description
	Year Effect	Year of survey
Local		
	Grass ground cover	Percent cover of grasses
	Forb ground cover	Percent cover of forbs
	Litter ground cover	Percent cover of litter
	Shrub cover	Percent cover of total shrubs
	Shrub diversity	Simpson's diversity index for shrub cover
	Canopy cover	Average canopy cover, based on a densiometer
	Canopy height	Maximum canopy height (m)
	Deciduous trees	Total number of deciduous trees
	Conifer trees	Total number of conifer trees
	Tree diversity	Simpson's diversity index for trees
	Snags	Total number of snags
	Grazing index	Fecal counts of cattle
	Invasive cover	Percent cover of invasive exotics
	Variable/scale	Description
	Invasive diversity	Simpson's index of diversity for invasive exotics
Patch		
	Width	Maximum width (m) of each riparian patch
	Shape	Patch irregularity index (perimeter/perimeter of a circle of equal area)
Landscape		
	Forest area	Total area (%) of riparian forest surrounding patch
	Forest patch density	Number of patches/forest area surrounding patch, measure of fragmentation.
	Distance to nearest patch	Minimum distance (m) to the nearest riparian forest patch; measure of connectivity
	Area of nearest patch	Area (ha) of the nearest riparian forest patch; measure of connectivity
	Development	Total area (%) of houses/buildings surrounding patch

Analysis

To evaluate year effects, we compared data collected at the same points in 2004 and 2008. We developed occurrence models for all species detected in ≥ 10% of the point samples in each year (27 Species). We excluded the Yellow Warbler (*Dendroica petechia)*, which occurred at every point sampled in 2004 and 2008. We chose to model occurrence because we were interested in understanding the importance of within-site variation for the entire breeding bird community, and for all but the most common species, density estimates are probably not accurately estimated for individual points within patches. Because average detection probabilities for songbirds ($p = 0.974$) were consistently high, and because the movement of some individuals (Fletcher, unpublished data) suggests that populations are not closed within the breeding season (a necessary assumption of most current methods (MacKenzie et al. 2002)), we did not adjust for detection probability in occurrence models.

Rather than developing models that were directly comparable to our previous analyses (Fletcher et al 2005), we chose to refine our modeling methods and add new measures of habitat and land use as published in Fletcher and Hutto (2008). We used a logistic regression model and a hierarchical structure by considering points within patches as correlated sampling units:

$$\text{Logit}(y_{ij}) = \alpha + X_{ij} + Y_j + Z_j + y_j$$

where y_{ij} is the detection/non-detection of a species at point *i* in patch *j* (compiled across the two visits within a year), X_{ij} represents the local measures for each point, Y_j is the measure describing patch, Z_j is a measure describing the surrounding landscape structure for each patch and y_j is a random site effect (Thogmartin and Knutson 2007). Because we were compiling data from 2004 and 2008, we considered data from separate years as a repeated measure of the same location, to account for lack of independence. We also included "year" as a fixed effect in the model to test for significant differences in bird distributions associated with year. Models were fit by directly maximizing an approximation of the marginal likelihood (i.e., the likelihood integrated over random effects) using the software SPSS (Pan 2001; SPSS 2006).

We examined the relationship between persistence and habitat quality using data on bird species occupancy in 2004 and 2008, and measures of local vegetation structure and composition. To determine if persistence was associated with distinct habitat characteristics we used discriminant analysis in SPSS (SPSS 2006).

Prior to model development, we screened explanatory variables within each spatial scale for strong correlations and removed variables with correlations where $r > 0.5$. At the local scale, we dropped woody ground cover from analyses because it was highly correlated ($r = 0.6$) with total shrub cover (Table 1). At the patch scale, area and width were highly correlated ($r = 0.7$) as was area and distance from edge ($r = 0.69$) and width and distance from edge ($r = 0.82$). We dropped area and distance from edge from further analyses, thereby retaining patch width (Table 1), which has been commonly used as a patch measure in other investigations on riparian birds. At the landscape scale, patch density and edge density were highly correlated ($r = 0.87$) as was road density and the area of buildings/houses ($r = 0.88$); for further analyses we dropped edge and road density (Table 1).

Results

Bird Surveys. Four technicians conducted bird surveys from May 27 – July 10, 2008 at 224 points distributed among 104 sites established in 2004-2005 (see Appendix A for point locations). Throughout the season, we detected a total of 9,435 birds along the Madison and Missouri Rivers, representing 113 species (Appendix C, Table 1). The five most frequently detected species were Yellow Warbler, House Wren, Least Flycatcher, American Robin, and Brown-headed Cowbird, respectively (Fig. 3). We recorded 113 of the 245 bird species known to breed in Montana; 34 of these are listed as the Montana Partner's in Flight (PIF) priority species.

Weather during the spring and summer of 2008 was unseasonably wet and cool, with precipitation levels higher than average. At the time of surveys, several points were inundated with water, so we surveyed as closely as possible to the original point.

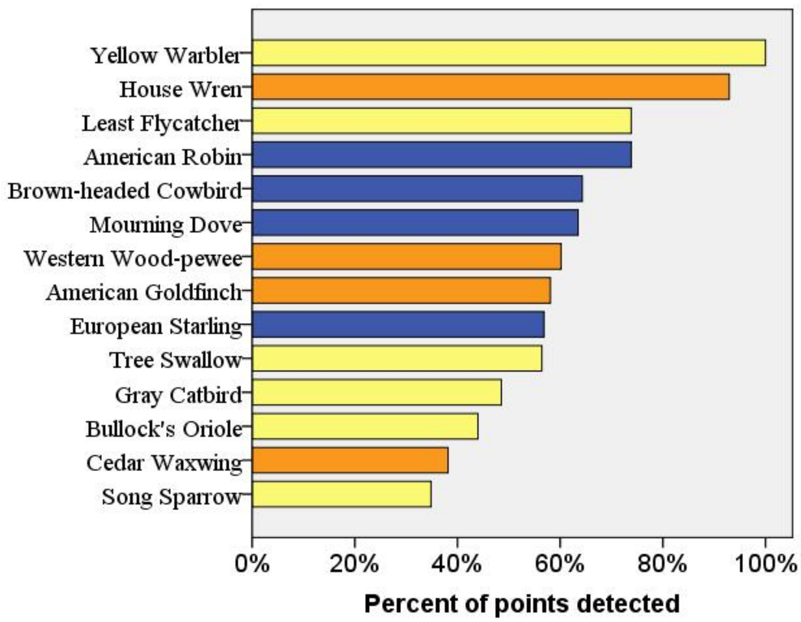

Figure 3. Percentage of points where bird species were detected (bars represent riparian obligates in yellow, riparian associates in orange, and riparian users in blue).

Bird Distribution in relation to habitat and land use practices. Predictive models of bird species occurrence were developed based on vegetation and land use factors at local, patch, and landscape scales for 27 species using data from 2004 and 2008 (Appendix C, Table 1). These models are not directly comparable to our previous findings, however many similarities emerged: different species showed positive and negative correlations with local vegetation structure and grazing intensity, and these relationships typically related to species life history traits. We again found more species with positive than negative correlations with invasive species. It is important to remember when interpreting these findings that invasives may be correlated with other vegetation characteristics that are favorable to these bird species, and may not reflect a direct relationship. Also, while these findings may suggest a positive effect of invasives on birds, many studies have documented negative effects of invasives on avian reproductive performance (Schmidt & Whelan 1999; Borgmann & Rodewald 2004).

Local disturbance measures (e.g. invasives and grazing intensity) were relatively more important than landscape scale disturbance (amount of development) in explaining bird occurrence (Fig. 4). However, all of the vegetation measures are potentially influenced by human impacts. Previously, we found that grazing intensity was negatively correlated with shrub and sub-canopy cover (Fletcher et al. 2005). Further, riparian forest fragmentation and connectivity are indirect measures of human disturbance in the landscape, and our findings suggest that bird occurrence may be particularly sensitive to the loss of connectivity of riparian forests along the river corridor.

The influence of patch and landscape scale factors was variable and tended to occur less frequently in models (Fig. 4). The one exception was connectivity, as measured by distance to and size of the nearest riparian patch. Connectivity measures occurred in more species models than any other single variable, and overwhelmingly were predicted to have a positive effect on the probability of species occurrence.

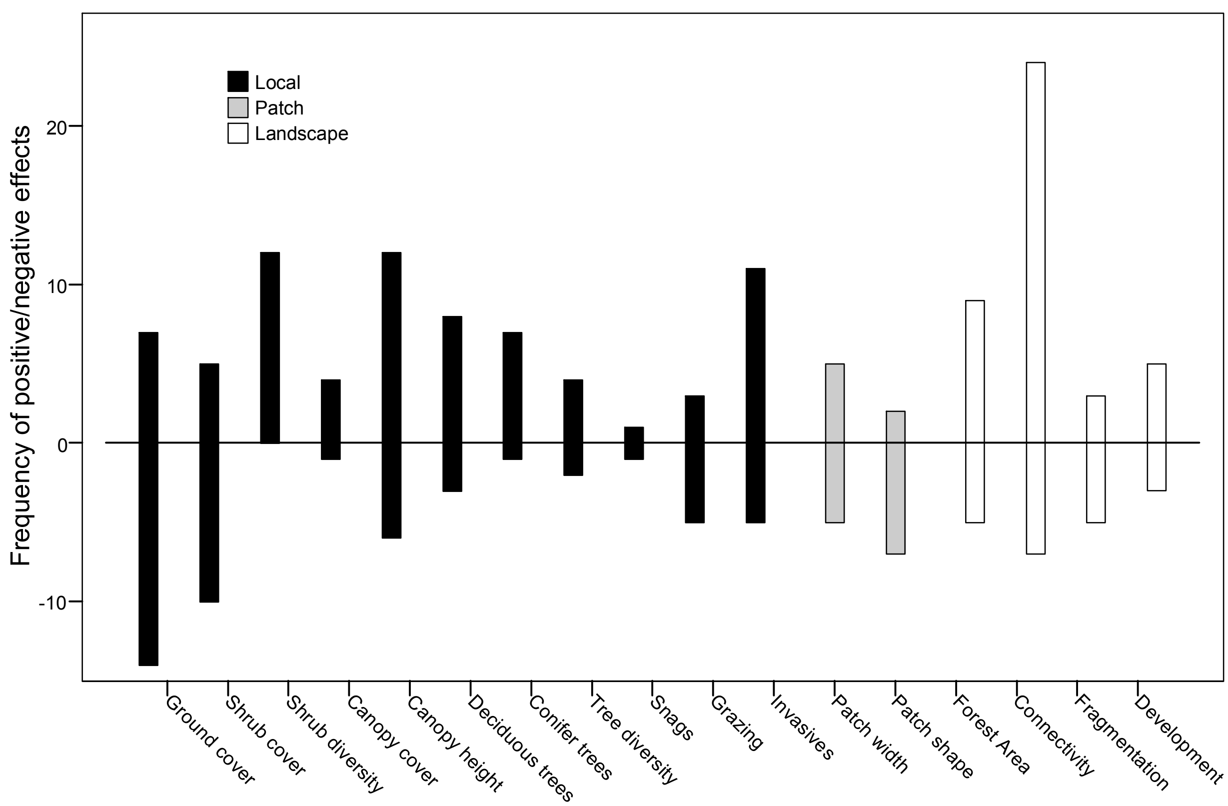

Figure 4. Summary of factors influencing bird occurrence in riparian patches at three spatial scales, 2004 and 2008. Bar length represents the number of species in which the best model contained that factor, and bar positioning shows the number of species with positive or negative correlations.

Year Effects. Nearly all of the 27 species modeled were less likely to occur in 2008 than in 2004. Only two species, the Red-naped Sapsucker and Tree Swallow, were positively correlated with year (Appendix C, Table 2). One likely explanation is that 2008 was an unusually wet and cool summer, which may have negatively influenced breeding bird populations. We will need several more years of data to determine whether this is an overall decline in species occurrence along the river.

Persistence and Habitat Quality. For all the species we examined, persistence (e.g. the number of years a point was occupied) was associated with unique local vegetation characteristics, however for most species there was a high degree of overlap. For example, Song Sparrows occurred at points with greater shrub cover and diversity, lower canopy height, and fewer deciduous trees (e.g. x-axis in Fig. 5), and points that were occupied in all years tended to have more forbs and invasives and lower tree diversity and canopy cover than points occupied once (e.g. y-axis in Fig. 5).

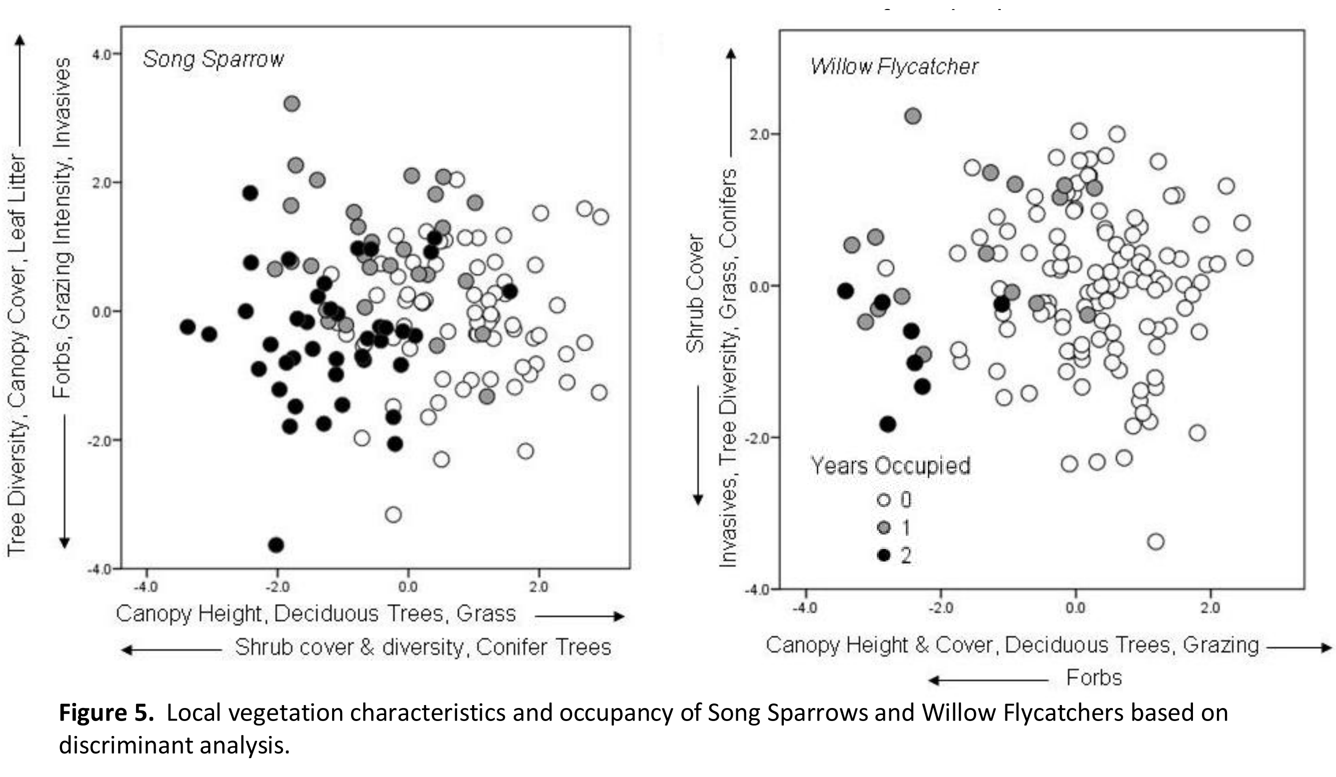

Figure 5. Local vegetation characteristics and occupancy of Song Sparrows and Willow Flycatchers based on discriminant analysis.

Discriminant analysis results tended to mirror habitat associations found in logistic regression models, suggesting that either method may be adequate in many cases. Evaluating persistence may be most useful for understanding habitat requirements of rare species, where presences are too few to model using standard regression approaches. For example, the Willow Flycatcher was detected on < 10% of points and yet is a species of high conservation priority. Discriminant analysis of persistence and local vegetation revealed that Willow Flycatchers occurred more often at points with more forb cover, lower canopy height and cover, fewer deciduous trees, and lower grazing intensity (e.g. x-axis, Fig. 5). Points occupied all years had higher shrub cover, fewer invasives, and fewer conifers than sites occupied for a single year. If occupancy rates are associated with habitat quality, meaning species are more likely to occupy the highest quality locations through time, then this approach can help management for habitat most likely to support bird populations by focusing on factors correlated with persistence. At the other end of the scale, this analysis reveals thresholds of habitat quality below which the species is unlikely to occur.

Next Steps

Long-term Monitoring. Completion of a 3rd long-term monitoring survey in three years (2011) will provide initial population trend information for riparian birds along the river system. A third monitoring session will also permit more detailed examination of the relationship between persistence and habitat quality, which will provide further insight into the influence of land use and disturbance on bird communities.

Gis-based Maps. While these models are useful for understanding factors influencing habitat use by breeding birds, it would be valuable to provide links between habitat-relationship models and GIS databases. Digitized National Wetland Inventory (NWI) maps will finally be available for the entire Madison-Missouri river system this summer (2009). Once NWI GIS layers are completed for the river system, GIS-based analyses on how local and landscape factors can influence bird distributions should be conducted. Given that information, it will be important to revisit habitat models to determine what factors best explain species distribution, and whether GIS-only models can adequately predict bird distributions. Results thus far continue to suggest that managing local habitat structure will be critical for maintaining bird diversity, yet we have not had adequate GIS layers to evaluate all potential landscape influences.

GIS-only models can then be used to develop maps of predicted bird distributions for riparian areas across the entire river system. The Avian Science Center is currently developing a web-based interactive tool for accessing GIS-based maps. This will allow managers and land planners to utilize maps from their desktop. Uses of this tool include evaluating potential restoration and conservation options, delineating areas of conservation priority, and determining where avian “hotspots” likely occur (e.g. areas with high diversity or abundance of key species) for the river system. GIS-based models can also be used for interpreting the potential implications of different restoration and land management scenarios. By working with land managers, we can estimate how different land use approaches may influence bird diversity, and we can forecast the influence of potential landscape change on the bird community.

Steps for Predictive Species Map development:

1. *Determine if NWI layer is sufficient for predicting species distributions.* To do this we will need to re-evaluate habitat models at multiple spatial scales to determine whether GIS-only models adequately predict bird distributions.
2. *Validate habitat models.* Once NWI GIS layers are integrated into species-environment models, these models should be validated to better ensure the accuracy and reliability of using such models in management strategies. Model validation could be easily implemented along the river system by surveying new sites for birds and determining whether models adequately predicted observed distributions (see Fielding and Bell 1997). We anticipate that this could be done with 1 field season and 2 technicians, which could complement long-term monitoring efforts.
3. *Develop interactive web site.* The final predictive maps and associated tools for summarizing and delineating areas of interest can be made available as an interactive online tool easily used by land managers, biologists, and planners on their desktop.

Objectives 2-3: Russian Olive Removal Study

Methods

Study Area & Site Selection

In designing a BACI study to evaluate Russian olive removal, it is critical to establish a sufficient number of control sites as well as gather information prior to restoration activity (e.g. "before"). For the Russian olive restoration project, we visited known restoration sites (e.g. Council Island) and searched the Lower Missouri for additional sites with Russian olive to serve as control sites. We will use established long-term monitoring points in the Lower Missouri without Russian olive as reference sites. In future years, additional restoration sites will be surveyed prior to restoration activities.

Bird Surveys

(See Objective 1 methods)

Habitat Metrics

In addition to the local scale vegetation measures collected for long-term monitoring sites (see Objective 1 methods), we also measured Russian olive tree density and height, and estimated cover within 50 m of each survey point.

Analysis

We only included bird and vegetation data from points in the Lower Missouri section to avoid geographic influences, and because the Russian olive removal project is focused on the Upper Missouri River Breaks National Monument (UMRBNM). For species with >75 detections in the section, we evaluated the relationship between individual bird species abundance and the amount of Russian olive using linear regression. For species detected on at least 10% of points, we modeled the relationship between occurrence and Russian olive using logistic regression. We also examined the influence of Russian olive on total species richness, and total abundance of species grouped by life history traits. We assigned bird species to one of four nesting guilds (ground-nesters, shrub-nesters, canopy nesters, and cavity-nesters) based on primary nesting habitat. We also grouped bird species by foraging strategy into four foraging guilds (ground-foragers, bark-foragers, foliage-foragers, and aerial-foragers). Birds were assigned to guilds using the species accounts of Ehrlich et al. (1988) and Martin (1995). All species were included in guilds except waterbirds, which were rarely detected and require unique habitats for nesting and foraging.

We evaluated the structure and composition of the riparian vegetation in areas with and without Russian olive using discriminant function analysis.

After restoration, we will assess the change in bird communities in restored areas relative to natural variation in control and reference sites based on changes in bird density and diversity using standard approaches (Michener 1997) (Table 2).

Table 2. General sampling of restored and reference sites for evaluating restoration.

Site	Pre-restoration		Post-restoration	Measured effects
Restored sites	Habitat A	⇨	Habitat B	Restoration + temporal variation
Control sites (similar to pre-restoration conditions)	Habitat A	⇔	Habitat A	Temporal variation in A
Reference sites (representing goals of restoration)	Habitat B	⇔	Habitat B	Temporal variation in B
Adjacent sites within landscape (representing goals of restoration)	Habitats A/B	⇨	Habitat B* (with landscape change)	Non-target/spatial extent of restoration effects on nearby areas

Results

Site Selection. Six sites and 17 points containing Russian olive (RO) were added for the Russian olive study (Table 3; see Appendix A for point locations). A total of 49 points had some Russian olive present; only 10 of these points are on public land within the Upper Missouri River Breaks National Monument, 22 are on private land within the UMRBNM, and the remaining 17 are located further upstream.

It was difficult to find patches of Russian olive within the Upper Missouri River Breaks National Monument that met existing site selection criteria (e.g. 50 m wide), so most new sites were established in patches that were at least 30 m long and a little as 15 m wide. We searched carefully for patches of Russian olive between Coal Banks Landing and Fred Robinson Bridge and are confident we surveyed all patches on public land (and most patches on private land) in this section. We can also document that there are virtually no Russian olive plants between river mile 95 (downstream from Judith Landing) and Fred Robinson Bridge. In order to add more sites with Russian olive, we suggest searching the following sections: just upstream from Canyon Ferry Reservoir, up to 10 miles upstream from Great Falls, and the section between Fort Benton and Coal Banks Landing. However, sites selected in these river sections are unlikely to be on BLM lands.

Table 3. Number of sites, points, and points with Russian olive (RO) on each section of the Madison and Missouri Rivers.

River Section	Sites	Points	RO
Madison River	35	64	2
Upper Missouri River	34	89	15
Lower Missouri River	41	88	32
Total	**110**	**241**	**49**

Russian Olive Distribution & Growth. Russian olive was scattered evenly or in clumps on over half of points, with only 8 points distributed in linear strips. The mean number of trees per plot was 49 and mean cover was 35.1% (Fig. 6). Council Island had a mean of 63 trees per plot and 22.5% cover. Plants were generally encountered (44 of 49 pts) as a large shrub (DBH < 8 cm) or a mix of shrubs and small trees (a plant with a DBH of ≥ 8 cm was considered a tree). The height of Russian olive plants ranged from 1 to 8 m, with a mean of 4.2 m (Fig. 7).

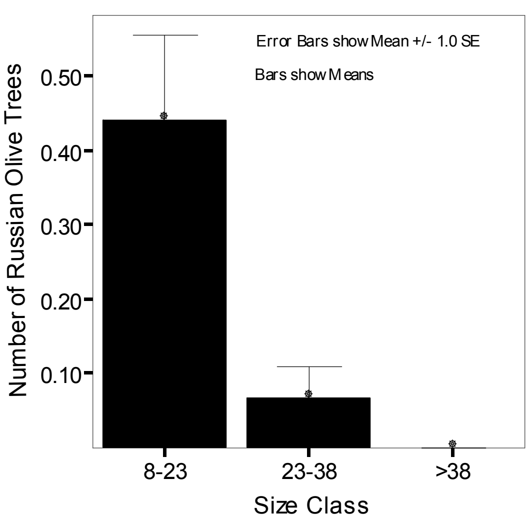

Figure 7. Mean number of Russian Olive trees by size class , where 1 is 8-23 cm; 2 is 23-38 cm; and 3 is >38 cm DBH.

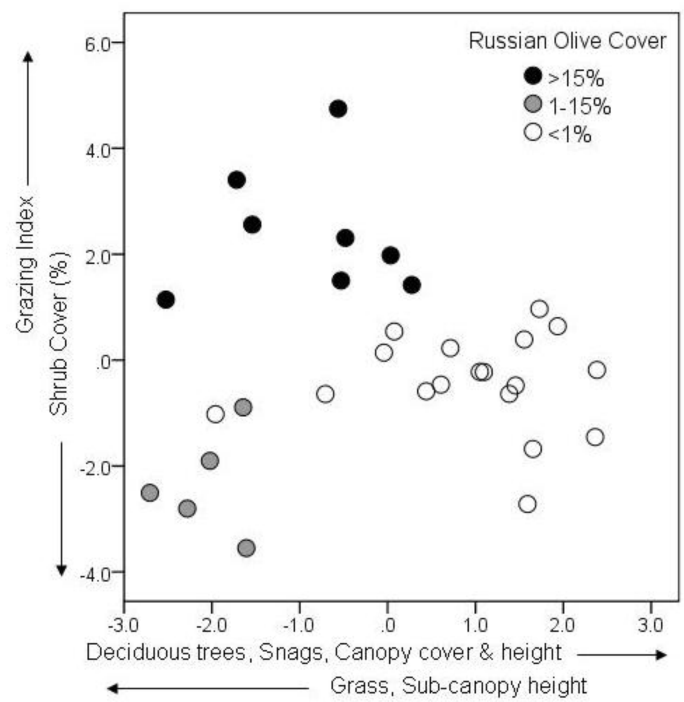

Figure 8. Local vegetation across 3 levels of Russian olive cover in the Lower Missouri River section.

Overall, there were few significant differences in vegetation structure between sites with Russian olive and sites without. However, sites with Russian olive cover tended to have fewer deciduous trees and snags, lower native riparian shrub cover, and more grazing, higher sub-canopy height, and greater grass cover (Fig. 8).

Bird Communities & Russian Olive. We had sufficient data to examine the influence of Russian olive on the abundance of 7 species: American Robin, European Starling, House Wren, Least Flycatcher, Mourning Dove, Tree Swallow, and Yellow Warbler. The abundance of 3 of these species was significantly related to Russian olive metrics. Mourning Dove abundance was positively correlated with Russian olive cover, while Tree Swallow and Yellow Warbler abundance was negatively associated with both cover and tree density (Fig. 9). All species abundances were more highly correlated with percent cover of Russian olive than any other measure. There were no significant relationships between individual bird species occurrence and the amount of Russian olive for the 36 species we evaluated.

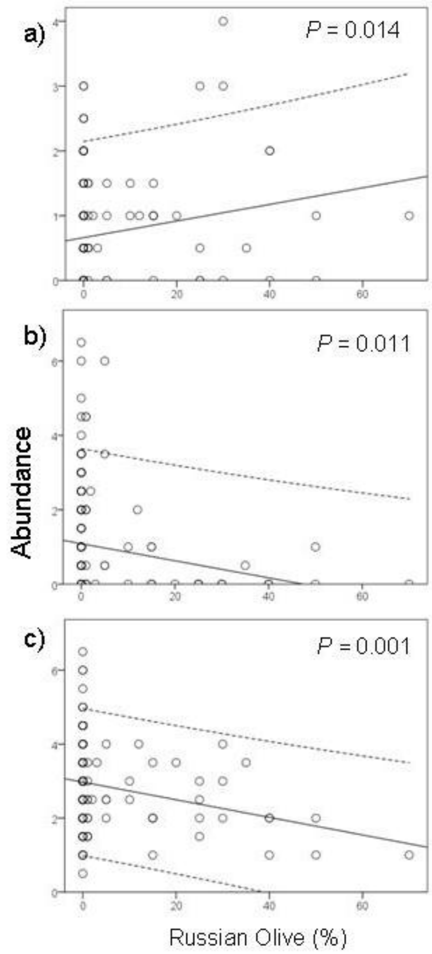

Figure 9. Correlation between abundance and Russian olive cover on the Lower Missouri River for three species: a) Mourning Dove, b) Tree Swallow, and c) Yellow Warbler

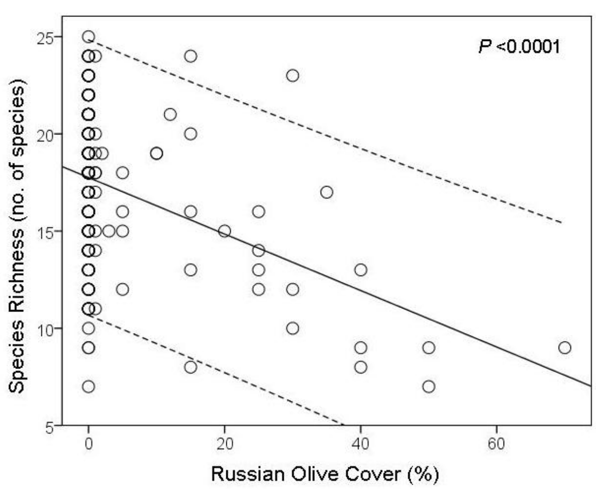

Figure 10. Species richness was negatively associated with Russian olive cover (estimate ± 2 SD)

There was a strong negative correlation with Russian olive cover and species richness (Fig. 10). All nesting guilds, except ground-nesters, were negatively associated with Russian olive cover. Canopy and cavity nesters were also negatively correlated with Russian olive tree density (P = 0.001 and P = 0.004, respectively; Fig. 11). These relationships support our findings that Russian olive stands tended to have fewer large deciduous trees and snags and lower riparian shrub cover. Of the four foraging guilds, only foliage gleaners had a significant negative relationship with Russian olive cover.

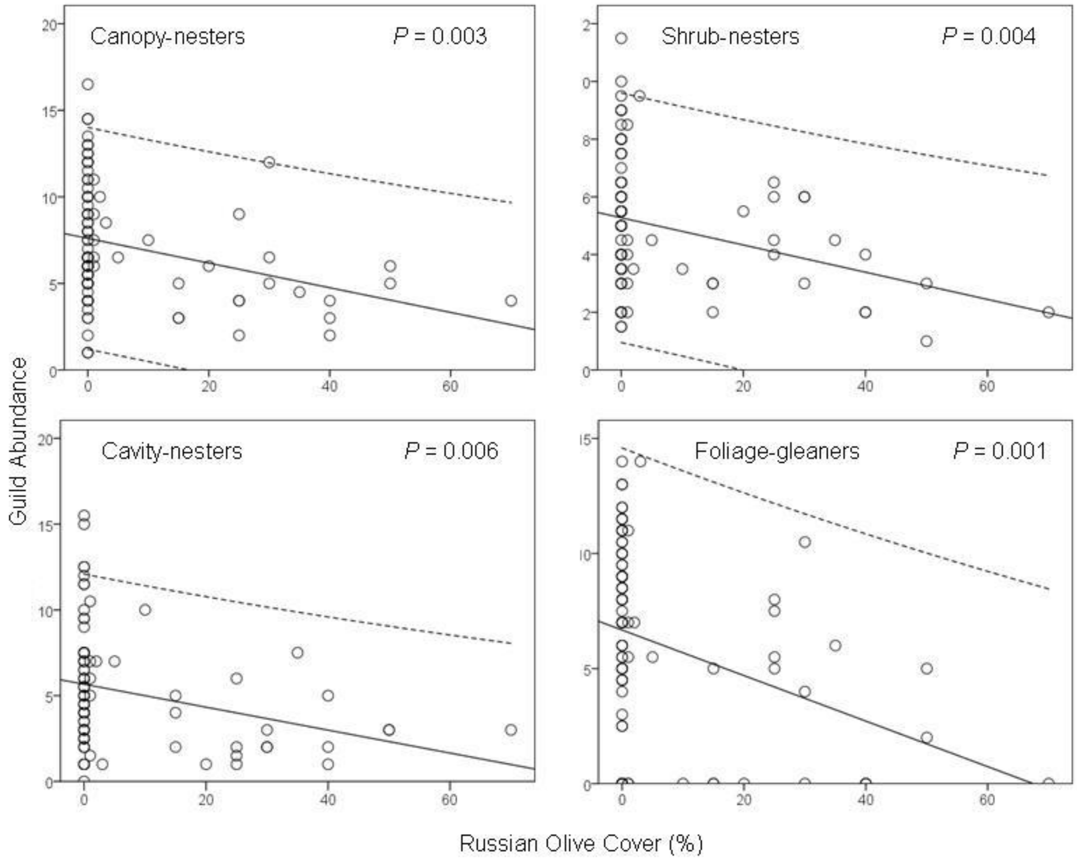

Figure 11. Significant correlations between total abundance of three nesting guilds (canopy, shrub, and cavity) and one foraging guild (foliage-gleaners) and Russian olive cover.

Discussion & Management Implications

The small size and patchy distribution of Russian olive along the lower Missouri River suggests that Russian olive establishment is relatively recent, and is occurring slowly; only rarely did Russian olive stature and density approach that of cottonwood. The fact that little difference in riparian structure was found between riparian stands with and without Russian olive, suggests Russian olive invades riparian habitats of all ages and types along the Missouri River, but stands with few mature Cottonwood may be more vulnerable to invasion. Since cottonwood is unable to reproduce in the shade, once Russian olive forms an understory canopy beneath mature cottonwood, old cottonwood stands will over time be replaced by forests of Russian olive (Lesica & Miles 1999).

Due to the small number of sites with large amounts of Russian olive cover, we had insufficient data to evaluate the influence of encroachment on abundance for most individual species. However, even at this relatively early stage of encroachment, we found strong negative associations between Russian olive and riparian bird species richness, and shrub, cavity, and canopy nesting guilds, and foliage gleaners. Our findings suggest that Russian olive encroachment negatively influences habitat for birds relying on riparian shrub and canopy layers, as well as cavity availability.

Frequent disturbance events have been associated with increases in invasive species (Hobbs and Huenneke 1992). However, in naturally dynamic river systems low disturbance regimes may promote exotic plant invasions. Restoration by removal of Russian olive is important for immediate restoration of stands at risk of complete conversion to Russian olive, but the long-term management for native riparian communities along the entire river system will likely require restoring natural flow regimes.

Next Steps

- We can begin evaluating the short-term effects of Russian olive removal on birds and vegetation in 2010. Short-term effects from restoration have been noted almost immediately in some areas after restoration (Hemesath and Dinsmore 1993, Rood et al. 2003)
- We need to discuss the options for increasing both the number of control and restoration sites versus intensifying survey efforts at a small number of restoration sites in order to better understand the effects of Russian olive removal.

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Appendix A. Survey point locations

Table A-1. All point locations in lat/longs. Projection is set in WGS84. Site numbers with an”*” denote new Russian Olive point locations.

SITE	STRETCH	POINT	LAT	LONG		SITE	STRETCH	POINT	LAT	LONG
1	MA	1	45.22578	-111.75150		64	UM	1	47.42142	-111.50066
2	MA	1	45.23691	-111.75444		64	UM	2	47.41891	-111.49883
2	MA	2	45.23824	-111.75460		65	UM	1	47.41401	-111.42698
2	MA	3	45.23836	-111.75255		65	UM	2	47.41398	-111.42522
3	MA	1	45.24659	-111.75721		65	UM	3	47.41334	-111.42345
3	MA	2	45.24526	-111.75690		65	UM	4	47.41266	-111.42161
4	MA	1	45.26516	-111.75118		66	UM	1	47.43389	-111.35075
5	MA	1	45.27549	-111.75196		66	UM	2	47.43242	-111.34659
5	MA	2	45.27686	-111.75220		66	UM	3	47.43227	-111.34485
6	MA	1	45.30114	-111.75166		67	UM	1	47.38885	-111.33704
6	MA	2	45.30237	-111.75117		68	UM	1	47.40929	-111.30496
6	MA	3	45.30352	-111.75049		68	UM	2	47.40887	-111.30690
7	MA	1	45.31667	-111.74425		68	UM	3	47.40847	-111.30879
8	MA	1	45.32803	-111.74041		68	UM	4	47.40803	-111.31064
9	MA	1	45.33399	-111.73153		68	UM	5	47.40759	-111.31247
10	MA	1	45.34260	-111.72580		69	UM	1	47.45716	-111.30759
10	MA	2	45.34127	-111.72539		69	UM	2	47.45622	-111.30618
11	MA	1	45.34724	-111.72121		69	UM	3	47.45529	-111.30477
12	MA	1	45.35393	-111.71427		69	UM	4	47.45432	-111.30343
12	MA	2	45.35520	-111.71349		70	UM	1	47.48229	-111.31320
12	MA	3	45.35643	-111.71273		71	LM	1	47.76015	-110.80229
12	MA	4	45.35765	-111.71212		71	LM	2	47.75896	-110.80433
13	MA	1	45.36431	-111.70961		72	LM	1	47.77372	-110.75612
14	MA	1	45.37463	-111.70396		72	LM	2	47.77431	-110.75125
15	MA	1	45.38295	-111.70012		73	LM	1	47.80797	-110.69194
15	MA	2	45.38167	-111.70096		73	LM	2	47.80693	-110.69054
16	MA	1	45.39285	-111.69236		74	LM	1	47.81536	-110.66544
16	MA	2	45.39159	-111.69305		75	LM	1	47.85280	-110.57405
16	MA	3	45.39029	-111.69376		75	LM	2	47.85144	-110.57388
17	MA	1	45.40544	-111.69639		76	LM	1	47.86353	-110.58538
18	MA	1	45.41137	-111.69574		76	LM	3	47.86219	-110.58620
19	MA	1	45.44209	-111.70905		76	LM	4	47.86090	-110.58698
20	MA	1	45.62315	-111.54908		76	LM	5	47.85829	-110.58637
21	MA	1	45.70061	-111.51779		77	LM	1	47.87441	-110.58905
22	MA	1	45.71615	-111.52070		78	LM	1	47.86877	-110.56849
22	MA	2	45.71745	-111.52010		79	LM	1	47.86052	-110.51022
23	MA	1	45.72647	-111.51737		79	LM	2	47.85970	-110.51111
23	MA	2	45.72701	-111.51939		80	LM	1	47.87611	-110.50612
23	MA	3	45.72592	-111.52061		81	LM	1	47.89363	-110.46261
24	MA	1	45.76355	-111.51402		82	LM	1	47.90689	-110.45248
24	MA	2	45.76224	-111.51492		82	LM	2	47.90589	-110.45128
25	MA	1	45.77935	-111.51582		82	LM	3	47.90097	-110.45283

25	MA	2	45.77660	-111.51703	82	LM	4	47.90008	-110.45435
26	MA	1	45.78623	-111.51248	83	LM	1	47.90334	-110.46169
27	MA	1	45.79645	-111.50875	84	LM	1	47.90999	-110.47762
28	MA	1	45.80859	-111.50555	84	LM	2	47.90922	-110.48152
28	MA	2	45.80722	-111.50602	84	LM	3	47.90793	-110.48094
28	MA	3	45.80477	-111.50723	85	LM	1	47.91868	-110.49607
29	MA	1	45.82637	-111.49764	86	LM	1	47.92830	-110.48848
32	MA	1	45.90599	-111.52627	86	LM	2	47.92700	-110.48934
33	MA	1	45.91598	-111.52526	86	LM	3	47.92502	-110.49062
33	MA	2	45.91495	-111.52658	87	LM	1	47.93972	-110.46322
33	MA	3	45.91387	-111.52797	87	LM	2	47.94148	-110.46013
33	MA	4	45.91201	-111.52783	88	LM	1	47.95124	-110.37830
34	MA	1	45.91666	-111.51618	89	LM	1	47.97100	-110.36896
34	MA	2	45.91570	-111.51485	89	LM	2	47.97233	-110.36854
35	MA	1	45.91996	-111.50354	90	LM	1	48.00145	-110.25102
35	MA	2	45.91963	-111.50191	91	LM	1	48.01321	-110.24341
36	UM	1	45.93729	-111.49324	91	LM	2	48.01481	-110.24416
36	UM	2	45.93601	-111.49391	92	LM	1	48.03696	-110.18798
37	UM	1	45.99456	-111.44543	92	LM	2	48.03722	-110.18602
37	UM	2	45.99335	-111.44440	93	LM	1	48.02355	-110.12989
37	UM	3	45.99217	-111.44340	93	LM	2	48.02460	-110.13130
38	UM	1	45.99789	-111.41586	94	LM	1	47.71450	-109.83088
38	UM	2	45.99673	-111.41692	95	LM	1	47.71149	-109.70693
39	UM	1	46.00351	-111.41571	95	LM	2	47.71216	-109.70510
40	UM	1	46.01014	-111.42242	95	LM	3	47.71298	-109.70343
40	UM	2	46.01029	-111.42039	95	LM	4	47.71384	-109.70187
40	UM	3	46.00874	-111.42206	96	LM	1	47.73383	-109.65549
41	UM	1	46.03516	-111.42161	96	LM	2	47.73392	-109.65754
41	UM	2	46.03326	-111.42127	97	LM	1	47.73825	-109.63177
42	UM	1	46.05193	-111.42131	98	LM	1	47.74374	-109.55980
42	UM	2	46.05063	-111.42169	98	LM	2	47.74340	-109.55780
43	UM	1	46.18670	-111.47174	98	LM	3	47.74304	-109.55584
44	UM	1	46.22163	-111.48359	99	LM	1	47.74494	-109.51635
44	UM	2	46.22295	-111.48324	99	LM	2	47.74510	-109.51843
45	UM	1	46.24401	-111.47943	100	LM	1	47.65086	-108.76899
45	UM	2	46.24305	-111.47585	101	LM	1	47.64796	-108.74959
45	UM	3	46.24353	-111.47762	101	LM	2	47.64847	-108.74776
46	UM	1	46.25097	-111.49062	101	LM	3	47.64898	-108.74587
47	UM	1	46.26751	-111.49345	102	LM	1	47.63242	-108.70282
47	UM	2	46.26895	-111.49445	102	LM	2	47.63256	-108.70076
47	UM	3	46.27029	-111.49491	102	LM	3	47.63271	-108.69864
47	UM	4	46.27191	-111.49490	102	LM	4	47.63284	-108.69657
48	UM	1	46.32006	-111.53536	102	LM	5	47.63299	-108.69453
49	UM	1	46.33810	-111.52185	103	LM	1	47.62456	-108.67942
49	UM	2	46.33733	-111.52309	103	LM	2	47.62564	-108.68031
49	UM	3	46.33664	-111.52517	104	LM	1	47.61768	-108.65710
50	UM	1	46.35013	-111.52805	104	LM	2	47.61754	-108.65501
50	UM	2	46.34868	-111.52839	104	LM	3	47.61738	-108.65279

50	UM	3	46.34860	-111.53036
50	UM	4	46.34720	-111.53022
51	UM	1	46.35160	-111.51527
51	UM	2	46.35275	-111.51350
51	UM	3	46.35434	-111.51280
52	UM	1	46.78612	-111.90179
53	UM	1	47.00058	-112.00395
54	UM	1	47.04706	-111.99331
55	UM	1	47.09076	-111.94918
55	UM	2	47.09166	-111.94771
56	UM	1	47.17923	-111.80624
56	UM	2	47.17897	-111.80834
56	UM	3	47.18147	-111.80676
57	UM	1	47.23254	-111.73285
57	UM	2	47.23117	-111.73318
58	UM	1	47.23638	-111.71549
58	UM	2	47.23702	-111.71368
59	UM	1	47.24647	-111.70368
60	UM	1	47.27211	-111.69566
61	UM	1	47.31950	-111.60871
61	UM	2	47.31816	-111.60868
62	UM	1	47.36963	-111.55906
62	UM	2	47.36826	-111.55904
62	UM	3	47.36686	-111.55899
62	UM	4	47.36542	-111.55893
62	UM	5	47.36404	-111.55888
62	UM	6	47.36252	-111.56088
62	UM	7	47.36079	-111.56283
62	UM	8	47.36071	-111.56488
63	UM	1	47.37381	-111.55264
63	UM	2	47.37395	-111.55060
63	UM	2	47.37395	-111.55060

104	LM	5	47.61888	-108.65467
104	LM	6	47.61874	-108.65261
104	LM	7	47.62041	-108.65639
104	LM	8	47.62027	-108.65438
105	LM	1	47.62172	-108.63146
105	LM	2	47.62190	-108.63366
105	LM	3	47.62272	-108.64312
105	LM	4	47.62330	-108.63333
301*	MA	1	45.87027	-111.50612
301*	MA	2	45.87132	-111.50733
301*	MA	3	45.86931	-111.50498
301*	MA	4	45.86813	-111.50322
311*	MA	1	45.88851	-111.51433
311*	MA	2	45.88976	-111.51541
911*	LM	1	48.03125	-110.21901
911*	LM	2	48.03106	-110.21685
912*	LM	1	48.03600	-110.20153
912*	LM	2	48.03495	-110.20296
931*	LM	1	47.98156	-110.11205
931*	LM	2	47.98009	-110.11164
931*	LM	3	47.97870	-110.11121
931*	LM	4	47.97738	-110.11077
951*	LM	1	47.73215	-109.68307
951*	LM	2	47.73260	-109.68103
951*	LM	3	47.73307	-109.67911
961*	LM	1	47.73380	-109.65096
961*	LM	2	47.73381	-109.64877
971*	LM	1	47.73519	-109.61379
971*	LM	2	47.73456	-109.61187
971*	LM	3	47.73381	-109.61012
971*	LM	4	47.73286	-109.60854

Appendix B. Field Data Forms

2008 POINT COUNTS – MISSOURI

GPS: Lat:
Long:

Observer						**Code**	
Visit		Date (mdd)		Sky		**Cover type**	
Section		Time		Wind		**Edge 1**	
Site		**Dist to edge** (if <50m)		Noise		**Edge 2**	
Point				Temp F		**Edge 3**	

Time Int	Species Code	Distance	Cues A V	Abund	Sex M/F/P/U	Loc 1=riparian, 0=non-riparian F = flyover	Comments
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							
9.							
10.							
11.							
12.							
13.							
14.							
15.							
16.							
17.							
18.							
19.							
20.							
21.							
22.							
23.							
24.							
25.							

SPECIES NOT LISTED ABOVE & GREATER THAN 50 METERS – 1 line for each spp. seen > 50 M

	Species Code	Distance
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		

BIRDS seen b/4 or after pt: ______________________________

2008 RIPARIAN VEGETATION MADISON – MISSOURI

Date:_____/_____ 2008 **50 m plot:**

Observer	
Section	
Site	
Point	

Russian Olive present? Y or N	If yes, continue below…
Distribution: Off plot Linear Patchy Even	
Abundance: Scattered Common Abundant # trees: % RO:	
Structure: Trees Shrubs Multi-strata Mixed	
Dominant height(s):	

11.3 m plot:

	Center				**0°**				**120°**				**240°**			
Densiometer																
Canopy height																
Sub-canopy height																
Grazing intensity																
Browse intensity																

Tree counts:

Spp:	**1)**			**2)**			**3)**			**4)**			**5)**		
Dbh:	8-23	23-38	>38	8-23	23-38	>38	8-23	23-38	>38	8-23	23-38	>38	8-23	23-38	>38
C															
0°															
120°															
240°															

5 m plot:

Ground cover (sums to 100%)	**C**	**0°**	**120°**	**240°**	**Shrub cover (includes trees < 10 cm dbh)**	**C**	**0°**	**120°**	**240°**
Grass					Spp 1:				
Forbs					Spp 2:				
Sedges/rushes					Spp 3:				
Woody stems					Spp 4:				
Course woody debris					Spp 5:				
Bare ground					Spp 6:				
Litter					Spp 7:				
Water					Shrub height (m):				
Rock					**Exotic Species**				
Other ( )					Spp 1:				
					Spp 2:				
# Cow pies					Spp 3:				
# Ungulate mounds					Spp 4:				

Comments:____

____

Section: MA = Madison; UM = Upper Missouri; LM = Lower Missouri

Appendix C. Bird Data Tables

Table C-1. Number of individuals for each bird species encountered in 2008 surveys on the Madison and Missouri Rivers. The first column shows the number of birds detected within a 50m radius, the second column shows the total number of birds detected within an unlimited distance, the third column shows the proportion of points at which the species was detected for all species detected on ≥ 10% of points, and the fourth column represents the Partner's in Flight priority level.

Bird species	< 50 m[a]	Total	% of points	PIF priority[b]
American Avocet	0	1		
American Crow	1	21		
American Goldfinch	280	292	58%	
American Kestrel	27	32		
American Redstart	6	7		III
American Robin	354	409	74%	
American White Pelican	51	72		III
American Wigeon	0	2		
Bald Eagle	6	15		II
Baltimore Oriole	1	1		
Bank Swallow	3	3		
Barn Swallow	2	2		
Belted Kingfisher	8	13		
Black-billed Magpie	34	78	11%	
Black-capped Chickadee	77	87	24%	
Black-headed Grosbeak	78	104	27%	
Blue-winged Teal	2	3		
Brewer's Blackbird	38	40		III
Brown Thrasher	8	9		
Brown-headed Cowbird	432	451	64%	
Bullock's Oriole	188	211	44%	
California Gull	61	69		
Canada Goose	11	68		
Caspian Tern	0	1		II
Cassin's Vireo	0	1		III
Cedar Waxwing	234	242	38%	
Chipping Sparrow	1	1		III
Clark's Nutcracker	0	1		III
Clay-colored Sparrow	28	37		III
Cliff Swallow	296	302		
Common Goldeneye	1	1		
Common Grackle	93	97	16%	
Common Merganser	11	13		
Common Nighthawk	43	47		
Common Raven	2	10		
Common Yellowthroat	38	55	12%	
Cooper's Hawk	7	9		
Dark-eyed Junco	2	2		

Double-crested Cormorant	9	16		
Downy Woodpecker	61	72	21%	III
Dusky Flycatcher	2	3		
Eastern Kingbird	111	119	28%	
European Starling	517	533	57%	
Field Sparrow	0	2		
Franklin's Gull	60	60		II
Gray Catbird	230	246	49%	III
Great Blue Heron	18	30		
Great Horned Owl	1	8		
Hairy Woodpecker	1	1		
House Finch	44	50	12%	
House Wren	791	797	93%	
Killdeer	1	25		III
Lark Sparrow	6	6		III
Lazuli Bunting	22	23		II
Least Flycatcher	442	457	74%	III
Long-billed Curlew	1	1		II
Long-eared Owl	1	1		
MacGillivray's Warbler	2	2		III
Mallard	17	32		
Marbled Godwit	10	10		II
Marsh Wren	10	14		
Mountain Bluebird	2	2		
Mourning Dove	305	402	64%	
Northern Flicker	96	170	28%	
Northern Harrier	2	3		III
Northern Rough-winged Swallow	36	37		
Northern Waterthrush	4	8		
Osprey	3	12		
Ovenbird	17	28		III
Pileated Woodpecker	3	3		II
Pine Siskin	1	1		
Prairie Falcon	0	1		
Red Crossbill	2	2		III
Red-breasted Nuthatch	1	2		
Red-eyed Vireo	13	17		II
Red-naped Sapsucker	38	47	13%	II
Red-tailed Hawk	27	50		
Red-winged Blackbird	73	131	15%	III
Ring-billed Gull	5	12		
Ring-necked Pheasant	8	107		
Rock Pigeon	16	19		
Rock Wren	0	4		
Sandhill Crane	1	18		
Savannah Sparrow	3	5		
Sharp-shinned Hawk	2	2		III
Song Sparrow	157	197	35%	III

Sora	0	3		
Spotted Sandpiper	9	42		
Spotted Towhee	63	73	19%	
Swainson's Hawk	2	3		III
Swainson's Thrush	19	21		
Tree Swallow	477	486	56%	
Turkey Vulture	3	4		
Veery	3	3		II
Vesper Sparrow	0	2		
Violet-green Swallow	159	161		
Warbling Vireo	48	66	16%	III
Western Kingbird	119	125	18%	
Western Meadowlark	10	100		
Western Tanager	25	29		
Western Wood-Pewee	215	264	60%	
White-breasted Nuthatch	1	1		
White-crowned Sparrow	1	2		
White-throated Swift	13	16		
Willet	0	1		III
Willow Flycatcher	19	21		II
Wilson's Snipe	3	17		
Wilson's Warbler	2	2		
Wood Duck	1	2		
Yellow Warbler	1294	1297	100%	
Yellow-breasted Chat	61	86	17%	
Yellow-headed Blackbird	0	1		III
Yellow-rumped Warbler	5	10		
Total number of detections	**8148**	**9435**		
Total number of species	**101**	**113**		

[a] Abundance was calculated as the maximum detection across 2 surveys, summed across points and sites.
[b] Partner's in Flight (PIF) Priority levels IIII, with I being species of greatest conservation concern based on threats, population declines, and proportion of range occurring in Montana (Montana Partners in Flight 2000).

Table C-2a. Local scale vegetation coefficients of selected best models explaining bird occurrence, 2004-2008.

		Local Vegetation									
Species	Year	Grass	Forb	Litter	Shrub cover	Shrub diversity	Canopy cover	Canopy height	Deciduous trees	Tree diversity	Snags
AMGO	-1.07				0.40				0.46		
AMRO	-0.73				-0.21	0.20		0.37			
BBMA									-0.65		
BCCH	-0.56										
BHCO				-0.50		0.34	0.44	-0.56			
BHGR			0.49		0.25	0.29		0.48			
BUOR	-0.55				-0.26			0.57		0.29	
CEDW	-0.56			-0.55	0.35			-0.32	0.48		
COYE						0.33				-0.40	
DOWO	-0.68		-0.32		-0.62		0.80		-0.91		
EAKI	-1.15				-0.65				-0.73		
EUST	-0.46		-0.56	-0.60	-0.56		0.43	0.79			
GRCA	-0.86	-0.32			0.44			-0.57			
HOFI		0.95				0.62		0.71			
HOWR	-1.64	0.55		-0.53		0.63		1.95			0.53
LEFL	-0.55	0.58				0.74		0.53	1.10		
MODO	-1.58				-0.24	0.29			0.35		
NOFL	-0.67		-0.39		-0.29	0.40		0.28			-0.26
RNSA	-0.97	-1.07	-0.83		-1.37			-0.68	0.85		
RWBL				-1.03	-0.47					-0.51	
SOSP	-0.60	-0.89					0.51	-1.11	-0.65		
SPTO		-0.36									
TRES	-0.81				-0.75	0.33		0.37	0.39		
WAVI	-1.52					0.52		0.67			
WEKI		1.01	-0.81				-0.97	1.00		0.50	
WEWP	-0.84	0.60		0.32		0.39		0.97	0.35	0.45	
YBCH					0.92				0.76	0.50	

Table C-2b. Local scale disturbance, patch, and landscape scale coefficients of selected best models explaining bird occurrence, 2004-2008.

	Local Disturbance				Patch		Landscape				
Species	Conifer trees	Invasive cover	Invasive diversity	Grazing index	Width	Shape	Forest Area	Patch Density	Distance to Nearest Patch	Area of Nearest Patch	Development
AMGO		0.51		0.26							
AMRO	0.59							0.32	-0.41		
BBMA		-0.38			-0.54						0.36
BCCH	0.19						0.54			-0.37	
BHCO	0.12				-0.46				-0.42		
BHGR								-0.74			0.52
BUOR							-0.46	0.20			
CEDW				-0.39			0.32		-0.29		
COYE		-0.39		-0.54		0.42	-0.97	-0.58		-0.89	
DOWO	0.26			-0.40			-0.26		-0.34		
EAKI		0.25						0.47	-0.47	-0.41	
EUST			0.33						-0.20	-0.57	
GRCA			0.47			-0.45	0.40	0.31	-0.43	0.31	
HOFI		0.50			0.56	-0.72			-0.71		0.53
HOWR	1.14	0.86			-0.46		1.75				0.80
LEFL			0.39		0.48				-0.38	0.63	
MODO					0.32						-0.43
NOFL					0.25					-0.49	
RNSA				0.51		-1.27	0.61	0.73	-3.68		
RWBL		-0.43			-1.64	-0.57	0.68		-0.74		
SOSP				0.30	-0.41	-0.49	0.51	0.62	-0.94	0.49	
SPTO	0.17	-0.24		-0.35		0.40	-0.74	-0.45			
TRES						-0.49	0.35	0.37	-0.55		-0.38
WAVI		-0.37			0.38	-0.99		0.38	-0.89		
WEKI		1.27			-0.70			-0.65	0.82	-1.72	
WEWP		0.47	0.27				0.39	0.52	-0.60		0.90
YBCH	-5.87	0.55					-1.29	-1.04	0.52		

Appendix D. Upper Missouri River Breaks National Monument

The Upper Missouri River Breaks National Monument Section (UMRBNM) begins at Fort Benton, MT and runs east to Fred Robinson Bridge at James Kipp Recreation Area. The UMRBNM includes the 149-mile Upper Missouri National Wild and Scenic River. Within the monument, we surveyed a total of 88 points and detected 1,709 birds representing 84 species (Table D-1). The monument section is no doubt a biologically rich riparian habitat providing a refuge for many bird species.

Table D-1. Number of individuals for each bird species encountered in 2008 surveys in the Upper Missouri River Breaks National Monument Section, first within a 50 m radius, then in an unlimited radius, and finally the proportion of points in which we detected the species.

Bird Species	< 50 m	Unlimited	% of points
American Crow	1	9	10%
American Goldfinch	50	54	44%
American Kestrel	9	13	15%
American Redstart	5	5	6%
American Robin	68	77	76%
American White Pelican	2	7	7%
Bald Eagle	1	3	3%
Baltimore Oriole	1	1	1%
Barn Swallow	1	1	1%
Belted Kingfisher	2	3	3%
Black-billed Magpie	6	16	17%
Black-capped Chickadee	17	22	20%
Black-headed Grosbeak	16	23	26%
Blue-winged Teal	0	1	1%
Brewer's Blackbird	15	15	11%
Brown-headed Cowbird	52	60	50%
Brown Thrasher	7	8	8%
Bullock's Oriole	47	53	49%
Canada Goose	4	41	44%
Caspian Tern	0	1	1%
Cedar Waxwing	40	43	31%
Chipping Sparrow	1	1	1%
Clay-colored Sparrow	5	5	6%
Cliff Swallow	8	8	3%
Common Goldeneye	1	1	1%
Common Grackle	22	24	16%
Common Nighthawk	24	25	7%
Common Raven	1	3	3%
Common Yellowthroat	20	31	34%
Cooper's Hawk	2	2	1%
Downy Woodpecker	28	32	34%
Eastern Kingbird	32	33	24%
European Starling	72	77	53%
Field Sparrow	0	2	2%
Gray Catbird	20	22	22%
Great Blue Heron	1	1	1%
Great Horned Owl	1	4	5%

Hairy Woodpecker	1	1	1%
House Wren	102	103	99%
Killdeer	1	9	10%
Lark Sparrow	5	5	5%
Lazuli Bunting	11	12	11%
Least Flycatcher	74	76	76%
Long-billed Curlew	1	1	1%
Long-eared Owl	1	1	1%
Mallard	0	4	5%
Mountain Bluebird	1	1	1%
Mourning Dove	73	91	88%
Northern Flicker	29	58	59%
Northern Rough-winged Swallow	4	4	2%
Osprey	1	3	3%
Ovenbird	10	15	17%
Prairie Falcon	0	1	1%
Red-breasted Nuthatch	1	1	1%
Red-eyed Vireo	8	10	11%
Red-naped Sapsucker	1	3	3%
Red-tailed Hawk	4	7	7%
Red-winged Blackbird	6	16	16%
Ring-billed Gull	0	1	1%
Ring-necked Pheasant	4	48	55%
Rock Pigeon	2	2	2%
Rock Wren	0	4	5%
Sharp-shinned Hawk	1	1	1%
Song Sparrow	4	8	9%
Sora	0	1	1%
Spotted Sandpiper	3	12	14%
Spotted Towhee	37	41	43%
Swainson's Thrush	7	7	6%
Tree Swallow	81	83	35%
Violet-green Swallow	3	3	2%
Warbling Vireo	12	18	20%
Western Kingbird	39	40	25%
Western Meadowlark	7	48	55%
Western Tanager	1	1	1%
Western Wood-Pewee	50	64	72%
White-breasted Nuthatch	1	1	1%
White-crowned Sparrow	1	1	1%
White-throated Swift	12	13	3%
Willet	0	1	1%
Wilson's Warbler	1	1	1%
Wood Duck	0	1	1%
Yellow-breasted Chat	36	46	51%
Yellow-rumped Warbler	4	4	5%
Yellow Warbler	110	110	100%
Total number of detections	**1332**	**1709**	
Total number of species	**74**	**84**	