

**The effect of willow proximity on species richness and
abundance of birds nesting in aspen (*Populus tremuloides*)
woodlands.**

Jessica R. Glass

Rocky Mountain Biological Laboratory

REU Program, Summer 2009

Principle Investigator: Chris Floyd

“The effect of willow proximity on species richness and abundance of birds nesting in aspen (*Populus tremuloides*) woodlands.”

Abstract:

Riparian zones are widely recognized as important sources of high species diversity. High levels of food resources and habitat complexity in riparian zones attract large numbers of avian species, particularly in arid regions. However, less is known about the importance of riparian proximity in wet montane regions. The landscape near the Rocky Mountain Biological Laboratory (RMBL) in Gunnison Co., Colorado is a wet, montane area with valleys that encompass large riparian regions surrounded by willow shrubs (*Salix subcoerulea*, *S. pseudocordata*, *S. brachycarpa*.) and aspen (*Populus tremuloides*) groves. These willows provide food and nesting resources to a variety of bird species that nest in aspen woodlands, including the Red-Naped Sapsucker (*Sphyrapicus nuchalis*), a keystone species. As one travels further from riparian areas, elevation quickly increases, leading to variation in microhabitat. The impacts of elevation and willow proximity distance on bird diversity may be hard to disentangle. We investigated the effects of riparian proximity on the species richness and abundance of breeding birds in aspen groves. To control for elevation, we conducted bird censuses at from three different elevations (high, medium and low, 20 point counts each). Willow patches were categorized as “minor” ($< 6500 \text{ m}^2$) and “major” ($\geq 6500 \text{ m}^2$) patches. Distance from major willow patches had a large effect on avian species richness at low elevations ($P = 0.017$), a marginally significant effect at medium elevations ($P = 0.08$) and no effect on

species richness at high elevations ($P = 0.95$). Our results stress the importance of preserving willows around riparian regions, particularly at low elevations, where habitat destruction caused by development and grazing is most prominent.

Introduction

In ecosystems worldwide, riparian areas are central in supporting environments that are diverse and rich in vegetation, thus providing habitat for a large variety of animal species (Naiman & Decamps 1997). The presence of water brings variation in nutrient cycling and microclimatic differences, which make the surrounding habitat more heterogeneous, supporting a larger number of species (Naiman & Decamps 1997, Gregory et al. 1991, Scott et al. 2003). Greater abundances of insects, birds and mammals are fostered by the shrubby vegetation and complex array of plant species that accompany these areas (Naiman et al. 1993, Maisonneuve & Rioux 2001, Palmer & Bennet 2006, Matos et al. 2009). In addition to providing heterogeneity, streams nurture the surrounding vegetation, providing habitat refuges from surrounding development (Naiman et al. 1993).

Throughout the western United States, riparian vegetation encompasses less than 1% of the landscape (Knopf et al. 1988). Unfortunately, riparian areas are facing increasing destruction from cattle grazing and other human-influenced activities (Fleischner 1994, Goodwin 1997, Miller et al. 2003). As more species of breeding birds are found in riparian zones than upland habitat, this may have profound impacts on their populations (Knopf et al. 1988). In northern Colorado, for example, 82% of bird species

appear in riparian zones (Knopf 1985). Domestic livestock have steadily grazed many of Colorado's valleys and riparian areas for decades. Grazing has been demonstrated to negatively impact avian species richness and abundance, and restoration of plant species is slow after grazing is restricted, which affects nesting and foraging conditions (Dobkin et al. 1998, Scott et al. 2003). Human development creates fragmentation of willow habitat, which affects territory size and proximity to resources. Destruction of riparian zones also leads to more invasive plant species, which create imbalances in the native flora and fauna (Miller et al. 2003). Birds are particularly influenced by spatial and temporal variability in habitat and resources (MacArthur 1964, Anderson et al. 1983, Mosley et al. 2006, Olchenowski 2008). In arid regions, riparian areas are well known to play a key role in sustaining high levels of avian species richness and abundance (Szaro & Jakle 1985, Woinarski et al. 2000, Schneider & Griesser 2009). However, results have been ambiguous when examining the relationship between species richness and riparian habitat in areas where confounding factors may interfere, such as upland forests that extend continuously from a water source, or regions that have fewer limitations in resources and precipitation amounts (Whitaker & Montevecchi 1997, Bub et al. 2004, Shirley 2005, Palmer & Bennett 2006).

In montane regions, climatic variability and topography are known to influence avian species richness, as environmental conditions change rapidly over short distances (Ruggiero & Hawkins 2008). It is widely acknowledged that species richness is expected to decrease with elevation alone, although attempts to model this decrease suggest that other factors often play a role (Rahbek 1995, Rahbek 1997, Herzog et al. 2005, McCain 2009). In valleys throughout the Rocky Mountains in Colorado, three species of large

willow shrubs (*Salix subcoerulea*, *S. pseudocordata*, and *S. brachycarpa*) are found most frequently along riparian areas, which are most common in the valley bottoms.

Olechnowski (2008) found that different structural characteristics of willow patches in the Greater Yellowstone ecosystem influence avian species richness and abundance. As one travels further away from riparian areas (and thus willows) into sub-alpine aspen groves, there often is a corresponding increase in elevation (C. Floyd and J. Glass, personal observation). In montane regions of the Gunnison Basin in western CO, aspen groves are found at elevations ranging from approximately 2800-3300 m, and distance from these aspens to the nearest willow varies greatly. This high-altitude ecosystem supports a wide array of avian species, with 168 species being recorded in the vicinity of nearby Gothic, CO.

The goal of our study was to examine the effect of riparian proximity on species richness and abundance of breeding birds in aspen woodlands in the Rocky Mountains of Colorado. In our study area, riparian zones are closely associated with willows; thus we also examined the impact of willow proximity. Daily et al. (1993) found that willows, not just riparian areas, play a significant role in the Rocky Mountain ecosystem, particularly to cavity-nesting birds. Unlike previous studies, we controlled for elevation in an attempt to distinguish between the effect of this variable and that of willow proximity. We also investigated the influence of riparian and willow proximity on species abundance, to study how individual species were affected. We hypothesized that species richness and abundance would decrease with greater distances from riparian areas.

To measure the influence of willow proximity, we measured not only the minimum distance to nearest willow, but also the amount of surrounding willow cover

within increasing radii from each study site. In order to distinguish between water and willow availability, we measured the distance to the closest riparian area. We also measured distance to the nearest meadow in order to study edge effects. Meadows are thought to be important to bird communities in aspen groves because of close access to and increased heterogeneity in vegetative and insect resources (Lawler 2002, Dobkin 1995).

Methods

STUDY AREA

This study was centered at the Rocky Mountain Biological Laboratory (RMBL) in Gunnison County, Colorado during the summer of 2009. We chose a total of 60 sites, 20 from three elevations, located in aspen groves (*Populus tremuloides*). Sites were distributed throughout the upper East River Valley, on Mt Crested Butte, in West Brush Creek, on Strand Hill, Washington Gulch and in the Upper East River Valley in Gunnison National Forest. We randomly selected sites from along three categories of elevation: low, 2840-2875 m; middle, 2940-2960 m; and high, 3040-3060 m. All sites were situated at least 30 m from the edge of an aspen grove and at least 130 m apart. Universal Transverse Mercator (UTM) points were randomly chosen using Google Earth 5.0 based on elevation and distance from edge of aspen grove. Sites were located using a handheld GPS unit, and the aspen tree nearest to the GPS point was tagged with both a flag and numbered metal tag. UTM units were then recorded, designating that point as the center of the research site.

AVIAN ABUNDANCE AND WILLOW MEASUREMENTS

Bird density censuses were estimated by conducting 10-min variable circular-plot point counts (Sutherland 2006). A single observer (JG) conducted censuses between approximately 0630 and 1030, with the first count starting one hour after sunrise. Each site was visited twice: once early and once later in the breeding season, between June 29-July 24, 2009. For the second visits, we reversed the order of sites for each region to account for the differences in time of day and travel time between sites. Censuses were not conducted in the rain. Species richness was defined as the total number of species observed over the two visits at each site.

In addition to species censuses, prevalence of Red-Naped Sapsuckers was estimated (measured as density of aspen trees bearing sap well scars), as was that of the heartwood rot fungus *P. tremulae*, indicated by the presence of fungal reproductive conks. These data were collected to contribute to current knowledge of the important ecological role of sapsuckers and fungus in the Colorado subalpine ecosystem (Daily et al. 1993, Losin et al. 2006). Meadow proximity was also measured, with a meadow being defined as a continuous area of at least 100 m² (10 x 10 m, 8 x 12.5 m, or 5 x 20 m) not containing any aspen trees > 5 cm DBH. Distance to and area of the nearest willow patch, riparian area and meadow were measured using Google Earth 5.0, aerial images (approx. 15 cm/pixel resolution), and/or tape measures. Willow proximity was defined as the distance (m) from the aspen site center to the nearest stem of mature, local, willow species (*S. subcoerulea*, *S. pseudocordata*, *S. brachycarpa*). Riparian areas were defined

as those depicted by a blue line on US Geological Survey topographical maps from 1971. Major riparian areas were the East River, Copper Creek, Washington Gulch Creek, Verzuh Young and Ditch, and Brush Creek. Major willow patches were those with a minimum area of 6500 square meters.

DATA ANALYSIS

We conducted a regression, looking separately at the effect of willow proximity on species richness at each of the three categories of elevation. Analysis of covariance (ANCOVA) could not be used to analyze species richness as affected by willow proximity and elevation, as those two factors were not independent of one another. Regression was also used to examine the effect of riparian proximity on each elevation. Meadow proximity was not affected by elevation and was plotted against species richness using a simple regression. Species abundance was measured by the total number of individuals at each site divided by the number of species present at that site. Analysis of variance (ANOVA) was used to look for a relationship between elevation and willow proximity.

Results

We found that both elevation and proximity to major willow patches affected species richness. At low elevations, proximity to major willow patches strongly influenced species richness ($P = 0.02$, $R^2 = 0.28$, Fig. 1). At medium elevations, proximity to major

willow patches had a marginal effect on species richness ($P = 0.08$, $R^2 = 0.16$), whereas at high elevations, there was no effect ($P = 0.95$, $R^2 = 0.0002$). Elevation significantly affected the proximity of major willows ($P = < 0.001$, $R^2 = 0.26$, Fig. 2).

Distance to willow shrubs had a much smaller effect on species richness than did distance to major willow patches. In both cases, elevation significantly influenced species richness; however, elevation did not affect the proximity of willow shrubs that were too small to be considered a major patch. Species richness was not significantly influenced by distance to riparian area or major riparian area when controlling for elevation. Distance to nearest meadow did not influence species richness ($P = 0.28$, $R^2 = 0.020$) or abundance ($P = 0.19$, $R^2 = 0.030$).

Total species abundance was not affected by elevation, distance to willow, major willow, riparian area or major riparian area. However, at low elevations, the abundances of both Warbling Vireos and Western Wood-Pewees were negatively impacted by major willow proximity ($P = 0.03$, $R^2 = 0.029$, $P = 0.085$, $R^2 = 0.085$, respectively). High elevation sites contained fewer species that rely heavily on willows and fewer cavity-nesting species (Fig. 3).

There was a positive relationship between the prevalence of the heartwood rot fungus and the prevalence of Red-Naped Sapsucker sap wells on aspens at low elevations ($P < 0.001$, $R^2 = 0.66$), but there were no significant effects of the heartwood rot fungus on sap wells at medium or high elevations ($P = 0.997$, $P = 0.28$, respectively). At low elevations, the area of major willow patch positively affected the number of sap wells ($P < 0.001$, $R^2 = 0.753$).

Discussion

The species richness of breeding birds in aspen groves was negatively related to proximity of major willow patches at low and medium elevations. At high elevations there was no effect of willow proximity on species richness. As expected, sites at higher elevations were further from willows than those at low or medium elevations, with the closest major willow patch to a high elevation site being > 100 m away. Birds nesting at high elevations are presumably getting food sources from somewhere else and are not relying on willows. Few species that are known to be dependent on willows (e.g. Red-Naped Sapsuckers, Yellow Warblers, Wilson Warblers) were recorded at high elevation sites (Fig. 3). Overall, there were fewer cavity nesters at high sites than at low or medium sites. Exclusively aspen-nesting species such as House Wrens, Warbling Vireos and Western Wood-Pewees were present at all elevations, though the abundances of Warbling Vireos and Western Wood-Pewees decreased at low elevations with distance to major willows.

Total abundances were not affected by distance to major willow patches. One might predict that in closer proximity to willows and riparian areas, more abundant resources would invoke less competition and more individuals could be found. This, however, was not the case. Territoriality and nest-choice selection may be preventing more species from occupying sites closer to willows. Perhaps males, with more resources close by, are able to maintain larger territories, thus preventing more individuals from occupying these areas.

In this Rocky Mountain ecosystem, aspen groves in close proximity to riparian areas support a high number of species that rely on willow patches. One species in particular, the Red-Naped Sapsucker (*Sphyrapicus nuchalis*), plays a vital role, functioning as a double keystone species by providing nest holes for secondary cavity nesting birds and by supplying a food source for a wide array of birds, insects and mammals by drilling sap wells in aspen and willows (Daily et al. 1993). Daily et al. (1993) found that sapsucker prevalence was inversely correlated to distance from willows, indicating that willows were the most important determinants of sapsucker presence. They also found that abundances of secondary cavity nesters were higher in sites with greater sapsucker prevalence, reinforcing the sapsucker's role as a keystone species. However, the distribution of non cavity-nesting bird species was not affected by sapsucker presence or distance from willows, supporting the contention that willows, because of their sap resources, were more important than riparian zones in determining avian species richness and abundance (1993). As neither proximity to riparian nor major riparian areas significantly affected species richness in our study, our results confirm the importance of willows in this environment to both cavity and non-cavity nesting birds.

Our results emphasize the importance of conserving riparian zones and surrounding habitat, particularly at low and medium elevations. Our findings partly contradict those found by Knopf et al. (1985), who argued that riparian communities at low and high elevations should be protected most, and conservation efforts should be less focused on medium elevations. Major willow proximity for medium elevation sites ranged from 115-920 meters. 115 meters is a negligible distance for a migratory bird and would presumably not deter species that rely on willows from commuting to their food

source. Since total bird abundance was not affected by major willow proximity or elevation, this may imply that less dominant birds, even those that depend on willows, are being pushed up to higher elevation sites because of competition at lower sites.

The local ecosystem around the Rocky Mountain Biological Laboratory is predominantly wet and aspen groves often adjoin willows and riparian areas directly. Studies in other habitats with these characteristics have shown a lesser impact of riparian areas on avian species richness and abundance (Whitaker & Montevicchi 1997, Shirley 2005). The complexity and individuality of these various habitats and systems puts a constraint on scientists' abilities to create generalized patterns that explain variances in avian species richness and abundance. In this high-altitude region of the Rocky Mountains, where valleys are tightly bound by mountains, the changes in climate and topography that come with rapid increases in elevation might create a higher need for riparian zones, causing our results to coincide with studies on riparian areas in more arid regions.

Our results show that willow patch size played an important role, as only major willows had significant impacts on species richness. This has consequential implications for conservation in this region, where grazing has been occurring for decades, and development in valleys is expanding. Studies have shown that North American aspen groves support higher numbers of bird species and abundances than other montane habitats (Winternitz 1976, Turchi 1995). Preserving aspen woodland habitat that is in close proximity to riparian areas, especially at low and medium elevations, should be a major issue of concern if the high levels of avian biodiversity in this region are to be maintained.

Acknowledgements

We thank The National Science Foundation for providing funding through the Research Experiences for Undergraduates Program. We also thank the Rocky Mountain Biological Laboratory for providing research facilities and living quarters during the study.

FIGURE 1.

The relationship between distance to major willow patch and species richness was examined for 60 sites at three different elevations (high, medium, low). At high elevations (A), there was no effect of major willow proximity on species richness ($P = 0.95$, $R^2 = 0.0002$). At medium elevations (B), there was a marginal effect ($P = 0.08$, $R^2 = 0.16$). At low elevations (C), there was a strong effect on species richness ($P = 0.02$, $R^2 = 0.28$). At low and medium elevations, species richness decreased as distance to major willow patch increased.

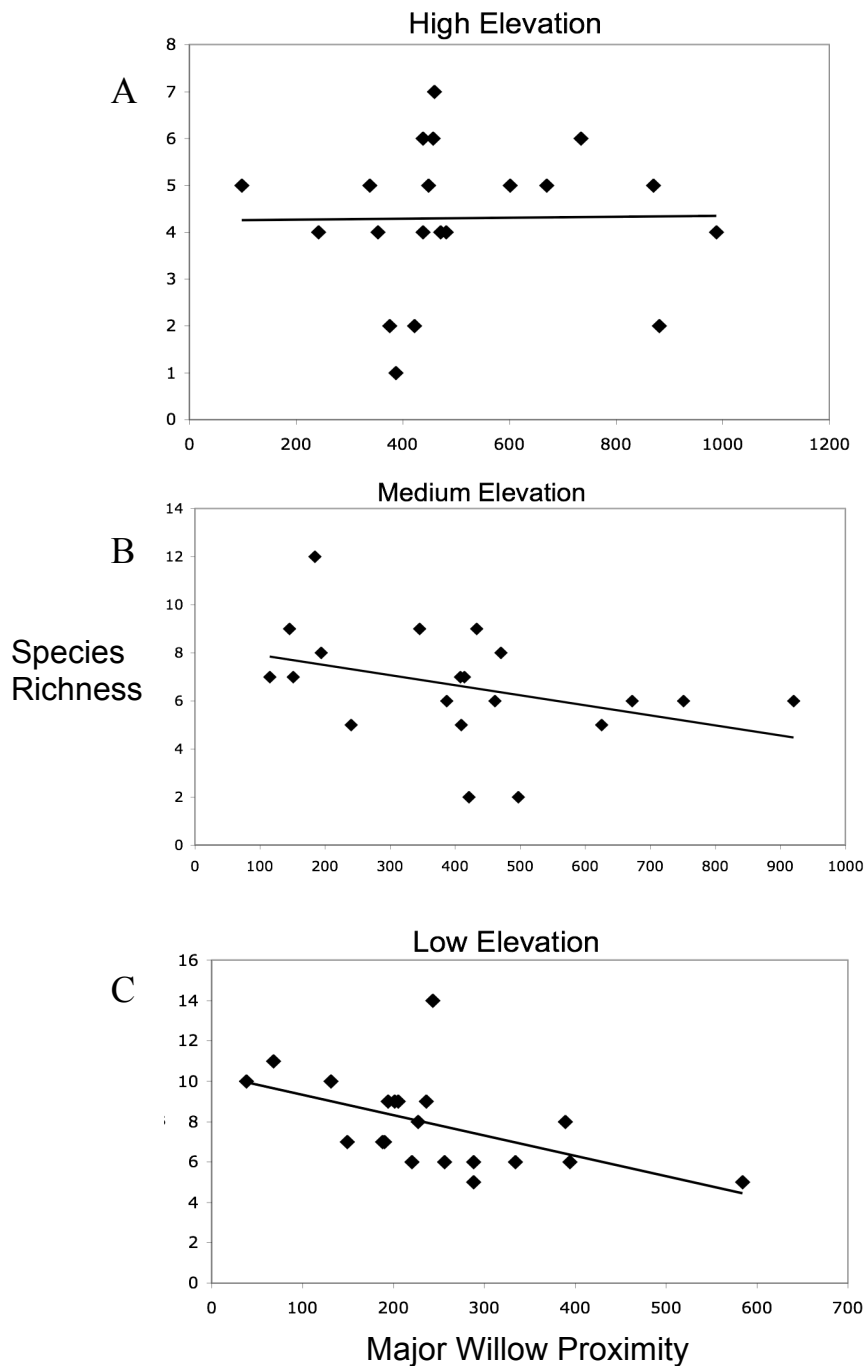


FIGURE 2.

Each class of elevation (high, medium, low) was plotted, using a one-way analysis of variance (ANOVA), against the average distance to major willow patch. The average distance to major willows (m) decreased as elevation increased ($P = < 0.001$, $R^2 = 0.26$).

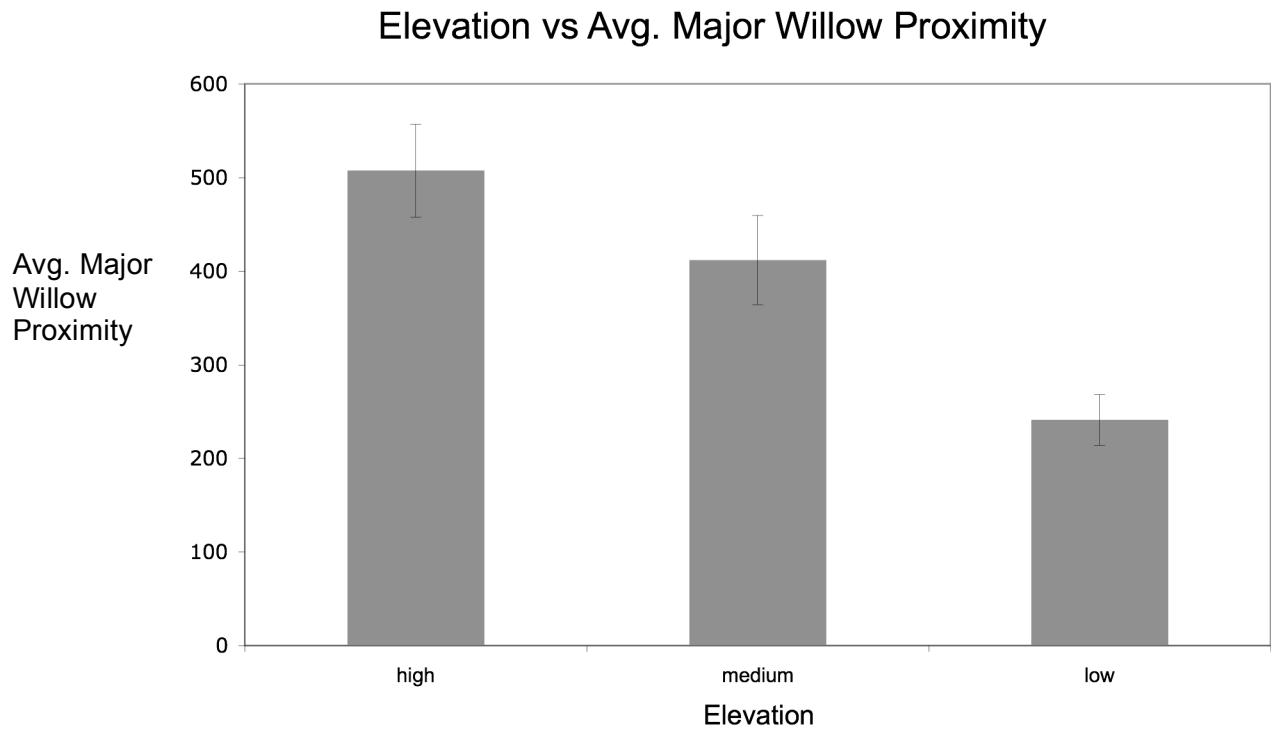


FIGURE 3.

Species abundances from 60 sites at three elevational blocks (high, medium, low). The table displays the number of individuals of each species recorded from both the first and second visits. When a species was seen at the same site twice, the maximum number of individuals seen from one visit was counted.

Species	Elevation		
	High	Medium	Low
American Robin	5	14	19
Black-Capped Chickadee	3	15	2
Blue Grouse	0	1	0
Brown Creeper	1	0	0
Cordilleran Flycatcher	0	2	9
Dark-eyed Junco	19	22	29
Downy Woodpecker	2	12	6
Dusky Flycatcher	5	3	4
Fox Sparrow	0	0	1
Green Tailed Towhee	13	3	2
Hermit Thrush	2	1	2
House Wren	21	32	35
Lincoln's Sparrow	2	8	6
Macgillivray's Warbler	2	0	4
Mountain Bluebird	1	0	2
Mountain Chickadee	0	0	2
Northern Flicker	4	11	7
Orange Crowned Warbler	2	0	1
Pine Siskin	2	9	8
Red-Naped Sapsucker	1	2	10
Ruby-Crowned Kinglet	4	1	5
Swainson's Thrush	0	0	4
Tree Swallow	0	0	2
Warbling Vireo	18	23	24
Western Tanager	1	1	4
Western Wood Pewee	4	18	16
White-Breasted Nuthatch	0	1	1
Wilson's Warbler	0	0	2
Yellow Warbler	0	2	7
Yellow-Rumped Warbler	4	10	13

Literature Cited

- Anderson, B.W., Ohmart, R.D., and Rice, J. 1983. Avian and vegetation community structure and their seasonal relationships in the lower Colorado river valley. *The Condor* 85: 392-405.
- Bub, B.R., Flaspohler, D.J., and Huckins, C.J. 2004. Riparian and upland breeding-bird assemblages along headwater streams in Michigan's upper peninsula. *Journal of Wildlife Management* 68: 383-392.
- Daily, G.C., Ehrlich, P.R. and Haddad, N.M. 1993. Double keystone bird in a keystone species complex. *Ecology* 90: 592-594.
- Daily, G. C. 1993. Heartwood decay and vertical distribution of red-naped sapsucker nest cavities. *The Wilson Bulletin* 105: 674-679.
- Dobkin, D. S., Rich, A. C., Pretare, J. A., and Pyle, W. H. 1995. Nest-site relationships among cavity-nesting birds of riparian and snowpocket aspen woodlands in the northwestern great basin. *The Condor* 97: 694-707.
- Fleischner, T. L. 1994. Ecological costs of livestock grazing in western North America. *Conservation Biology* 8:629-644.
- Goodwin, C. N., C. P. Hawkins, J. L. Kershner. 1997. Riparian restoration in the western United States: overview and perspective. *Restoration Ecology* 5: 4-14.
- Gregory, S. V., Swanson, F. J., McKee, W. A., Cummins, K. W. 1991. An ecosystem perspective of riparian zones. *Bioscience* 41: 540-551.
- Herzog, S.K., Kessler, M., and Bach, K. 2005. The elevational gradient in Andean bird species richness at the local scale: a foothill peak and a high-elevation plateau. *Ecography* 28: 209-222.
- Kilham, L. 1971. Reproductive behavior of yellow-bellied sapsuckers I. preference for nesting in fomes-infected aspens and nest hole interrelations with flying squirrels, raccoons and other animals. *The Wilson Bulletin* 83: 159-171.
- Knopf, F. L. 1985. Significance of riparian vegetation to breeding birds across an altitudinal cline. Pp. 105-111 in *Riparian ecosystems and their management: reconciling conflicting uses* (R. R. Johnson, C. D. Ziebell, D. R. Patten, P. F. Ffolliot, and R. H. Hamre, tech. coords.). U.S. Department of Agriculture, Forest Service General Technical Report RM-120.
- Knopf, F. L., Johnson, R. R., Rich, T. Samson, F. B., and Szaro, R. C. 1988. Conservation of riparian ecosystems in the United States. *The Wilson Bulletin* 100: 272-284.

- Lawler, J. J. and Edwards Jr., T. C. 2002. Composition of cavity-nesting bird communities in montane aspen woodland fragments: the roles of landscape context and forest structure. *The Condor* 104: 890-896.
- Losin, N., Floyd, C.H., Schweitzer, T.E., and Keller, S.J. 2006. Relationship between aspen heartwood rot and the location of cavity excavation by a primary cavity nester, the Red-Naped Sapsucker. *The Condor* 108:706-710.
- MacArthur, R.H. 1964. Environmental factors affecting bird species diversity. *American Naturalist* 98: 387–397.
- Maisonnueve, C. and Rioux, S. 2001. Importance of riparian habitats for small mammal and herptofaunal communities in agricultural landscapes of southern Québec. *Agriculture, Ecosystems and Environment* 83: 165-175.
- McCain, C.M. 2009. Global analysis of bird elevational diversity. *Global Ecology and Biogeography* 18: 346-360.
- Miller, J. R., Wiens, J. A., Hobbs, N. T., and Theobald, D. M. 2003. Effects of human settlement on bird communities in lowland riparian areas of Colorado (USA). *Ecological Applications* 13: 1041–1059.
- Mosley, E., Holmes, S.B., and Nol, E. 2006. Songbird diversity and movement in upland and riparian habitats in the boreal mixedwood forest of northeastern Ontario. *Canadian Journal of Forest Research* 36:1149-1164.
- Matos, H. M., Santos, M. J., Palomares, F., and Santos-Reis, M. 2009. Does riparian habitat condition influence mammalian carnivore abundance in Mediterranean ecosystems? *Biodiversity and Conservation* 18: 373-386.
- Naiman, R. J., and Decamps, H. 1997. The ecology of interfaces: riparian zones. *Annual Review of Ecology and Systematics* 28: 621-658.
- Naiman, R. J., Decamps, H. and Pollock, M. 1993. The role of riparian corridors in maintaining regional biodiversity. *Ecological Applications* 3: 209-212.
- Palmer, G.C., and Bennet, A.F. 2006. Riparian zones provide for distinct bird assemblages in forest mosaics of south-east Australia. *Biological Conservation* 130:447-457.
- Rahbek, C. 1995. The elevational gradient of species richness: A uniform pattern? *Ecography* 18: 200-205.
- Rahbek, C. 1997. The relationship among area, elevation and regional species richness in neotropical birds. *The American Naturalist* 149:875-902.
- Ruggiero, A. and Hawkins, B. A. 2008. Why do mountains support so many species of birds? *Ecography* 31: 306-315.
- Schneider, N.A. and Griesser, M. 2009. Influence and value of different water regimes on avian species richness in arid inland Australia. *Biodiversity and Conservation* 18: 457-471.

- Scott, M. L., Skagen, S. K., and Merigliano, M. F. 2003. Relating geomorphic change and grazing to avian communities in riparian forests. *Conservation Biology* 17: 284-296.
- Shirley, S.M. 2005. Habitat use by riparian and upland birds in oldgrowth coastal British Columbia rainforest. *Wilson Bulletin* 117: 245-257.
- Sutherland, W.J. 2006. *Ecological census techniques: a handbook*. Cambridge University Press, New York, USA.
- Szaro, R.C. and Jakle, M.D 1985. Avian use of a desert riparian island and its adjacent scrub habitat. *Condor* 87: 511- 519.
- Turchi, G. M., Kennedy, P. L., Urban, D. and Hein, D. 1995. Bird species richness in relation to isolation of aspen habitats. *Wilson Bulletin* 107: 463-474.
- Whitaker, D.M. and Montevecchi, W.A. 1997. Breeding bird assemblages associated with riparian, interior forest, and nonriparian edge habitats in a balsam fir ecosystem. *Canadian Journal of Forest Research* 27: 1159–1167.
- Winternitz, B. 1976. Temporal change and habitat preference of some montane breeding birds. *The Condor* 78: 383-393.
- Woinarski, J.C. Z., Brock, C., Armstrong, M., Hempel, C., Cheal, D., and Brennan, K. 2000. Bird distribution in riparian vegetation in the extensive natural landscape of Australia's tropical savannas: a broadscale survey and analysis of a distributional database. *Journal of Biogeography* 27: 843–868.