

Effects of Alpine Shrub Cover on Territorial Male White-Crowned Sparrows Densities

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Abstract

Avian populations at high elevation are well-adapted to extreme and variable abiotic conditions. Species have adapted efficient foraging strategies, as well as well-timed nest incubation patterns. These behavioral traits are essential in order for parents to meet their metabolic needs while simultaneously having a successful reproductive season. Alpine vegetation structure can be seen as a determinant for a species' success, or overall abundance due to gap structure and efficient foraging opportunities. Alpine environments consist largely of fragmented vegetation due to steep elevation gradients. Yet, alpine bird populations historically have preferred dense and protective vegetative structures. This study investigates the relationship at singing male white-crowned sparrow densities and percent willow (*Salix* spp.) cover between three alpine sites located across the Elk Mountain Range, Colorado. Post-migratory sparrow males pair with a female, breed, and establish delineated territory borders by singing. For the mountain white-crowned sparrow (*Zonotrichia leucophrys oriantha*; MWCS), space availability between willow thickets may act as a driving factor in the species' overall abundance. A negative correlation between number of singing males and percent willow cover indicates alpine populations of MWCS actually prefer fragmented willow cover. Possible explanations for this finding could include (1) greater accessibility to dietary resources between willow thickets, (2) greater solar exposure and thermal warming for a nest not nestled in a dense willow's canopy cover, or (3) an overall decrease in predatory risk and edge effects within alpine environments. This study holds important climate change implications. By analyzing changes in vegetation structure over time we can determine if vegetative health is ultimately affecting the adaptability of mountain white-crowned sparrow populations.

Introduction

Alpine avian populations are adapted for more extreme and variable abiotic conditions, as well as steep elevation gradients (Martin and Wiebe 2004; Bears et. al 2009). At higher elevations ambient temperatures can fluctuate by almost 30°C, storms are more frequent, and delays in plant emergence significantly decrease plant productivity (Bears et. al 2003; Korner 1999). In additions, dominant vegetation within alpine zones are often fragmented and narrow due to environmental determinants like altitude, rainfall, edaphic conditions, aspect, and slope (Tambe and Rawat 2010). A study of alpine belts in the Central Caucasus found increased fragmentation within traditionally continuous vegetative cover in alpine meadows (Kikvidze 1993).

Birds have adapted phenotypes and behaviors advantageous for coping with the challenging abiotic conditions in high elevation environment. Horned larks (*Eremophila alpestris*) in alpine British Columbia compensate for a shorter reproductive timeline by increasing parental care and energy investment in the few offspring they produce within a breeding season (Camfield and Martin 2009). This increase in nest attention often translates into alpine nestlings having greater survival rates, a phenomenon known as the trade-off hypothesis (Bears et. al 2009). Arctic geese oftentimes delay travel to summer breeding sites, minimizing overall energy costs (Sandercock et. al 2005; Cooke et. al 1995). White-tailed ptarmigans (*Lagopus leucura*) optimize their foraging efficiency by decreasing the number of recesses taken from nest incubation (Wiebe and Martin 2000). Himalayan snowcocks (*Tetraogallus himalayensis*) prefer foraging on steep terrain in order to decrease potential risk of predation (Bland and Temple 1990). Given these adaptations high survivorship and greater abundances of avian communities may occur at higher elevations.

Vegetation fragmentation can also reduce bird population abundances. Prairie passerines in southern Saskatchewan occurred in greater numbers within contiguous patches of vegetation (Davis 2004). The bird species were more sensitive to areas with greater ratio of edge to interior habitat. Forest and grassland birds often require large habitats with ample space for territory establishment in order the successfully breed and reproduce (Hobson and Bayne 2000). Willow ptarmigan (*Lagopus lagopus*) densities showed a positive relationship with respect to willow cover and a negative relationship with thicket fragmentation (Ehrich et. al 2012). Similarly, foliage diversity within Yellowstone National Park significantly increased sparrow and warbler diversity and abundance (Baril et. al 2011). However, total density of woodland songbirds in Asheville, NC was highest within vegetation gaps; results indicated greater space availability allowed for increased foraging and breeding pair recruitment (Greenberg and Lanham 2001).

Mountain white-crowned sparrows (*Zonotrichia leucophrys oriantha*; MWCS) nest in alpine environments with a colder climate, available shrub cover, and open meadows (Morton 2002). Singing males in these habitats indicates a breeding territory as they sing to defend their nesting and foraging grounds. MWCS take advantage of alpine habitats' brief window for resource available. Late snowmelt can be favorable for their reproduction, providing a short-term but abundant access to food used for breeding and offspring survival (Morton 2002). Recent evidence demonstrates that climate change is altering the abundance of shrub cover at alpine zones throughout the rocky mountains of Colorado (Steltzer and Brown, unpublished data). Hence, an understanding of how bird densities respond to vegetative cover in alpine zones may be useful to understand future bird population dynamics in these habitats.

The purpose of this study was to determine the effects of alpine shrub cover on territorial MWCS densities. I hypothesized that willow (*Salix spp.*) cover positively correlate with alpine MWCS densities.

Methods

Study Site

This study was conducted at high elevation (3383 to 3505 meters) sites in the Elk Mountain Range of the Rocky Mountains in Gunnison County, CO. High elevation sites are located in Virginia Basin (38.98124, -106.9732), North Pole Basin (39.02537, -107.0846), and Paradise Divide (38.99055, 107.0609) located in the vicinity of Upper East River Valley in Gothic Colorado (Appendix B). Singing male surveys were conducted from 5 July to 14 July, which is during the high-elevation breeding season.

Survey points were at least 100m apart. To prevent overlap between survey areas (each ~100m in diameter) and represents a single MWCS average territory size (Morton 2002). A sample size of about 10 points within each alpine site was taken.

The most abundant types of alpine vegetation occur in low-growth forms and small sizes; for example shrub cover consisting of willows (*Salix spp.*) and cinquefoil (*Potentilla crantzii*) (Rieben et. al 2004). However, steep elevation gradients and terrain carved by harsh winter climates often fragments willow structures. Patchy vegetative cover at high elevation allows space availability for other plant species; for example, alpine wildflowers: Colorado columbine (*Aquilegia coerulea*), Indian paintbrush (*Castilleja rhexiifolia*), Mountain bluebells (*Mertensia ciliate*), etc. (Duft and Moseley 1989).

Each survey point's proportion of shrub cover was digitized using GIS and ArcMap®. We quantified percent of willow cover for each site by assigning each 50m radius survey area a percent of willow cover. Map projections (created: 6/20/15 using ArcMap Systems®, see Appendix B) indicate all survey points for each high elevation site: Virginia Basin, North Pole Basin, and Paradise Divide. Each point includes a 50m buffer and digitized polygons of non-willow cover within that buffer. Percent willow cover was then calculated based on the area of non-willow cover within the overall area (7833m²) of each survey point.

Bird Surveys

Survey point counts were five minutes in duration; to reduce detectability bias or repeat counts of individual birds. All surveys were conducted from 0600 to 0900 to standardize for peak singing time in the day. Each survey began after the surveyor waited two minutes allowing nearby birds to acclimate to human presence. Only one observer (E.Nault) conducted each survey. Prior to all surveys the observer must practice learning each species' song, as well as pace out 50 meters to assist with accurate determination of distances. Recorded singing male species included MWCS, Lincoln's Sparrow (*Melospiza lincolnii*; LISP), Wilson's Warbler (*Cardellina pusilla*; WIWA), and Fox Sparrow (*Passerella iliaca*; FOSP); although MWCS is the main study subject. Other abiotic variables like Beaufort wind scale (never greater than 4 km/hr), percent cloud cover, temperature (4 to 27°C), and interfering sounds (rivers, vehicles, planes, etc.) were standardized to prevent extraneous variable bias.

Statistical Analysis

Geographic information system mapping displayed a gradient of willow cover (~20% to 90%) between the 28 survey points. Therefore, using Microsoft Excel® programming a linear

regression established a relationship between number of singing males and percent willow cover. Regression analysis was tested without potential outliers.

Results

A total of 28 point counts ($n=28$) were conducted between all three high elevation sites: North Pole Basin, Virginia Basin, and Paradise Divide. Out of all species recorded (MWCS, LISP, WIWA, FOSP) MWCS were most abundant. Paradise Divide had the greatest overall abundance of MWCS; 40 total sparrows were found across 11 point counts. North Pole Basin had 38 sparrows at 10 point counts. Virginia Basin had 14 sparrows for seven point counts.

Polygon digitizing to calculate area of willow cover within each 50 m survey buffer (total area = 7833 m²) resulted in a relatively even distribution of willow cover (Figure 1, Appendix A). Virginia Basin had the greatest average willow cover at 68.17%. North Pole Basin had an average willow cover of 47.48%, and Paradise Divide followed at 39.32%.

Regression analysis indicated a negative trend ($R^2 = 0.1569$), results indicated a significant correlation ($p = 0.0369$) between number of singing males and percent willow cover (Figure 2, Appendix A).

Discussion

Our initial hypothesis of a positive correlation between number of singing MWCS and percent willow cover, was rejected. The linear regression indicates MWCS occur in greater densities within more fragmented willow cover. This result conflicts with preexisting avian literature that show the greatest abundances and diversity of birds occur in areas of contiguous, dense willow cover (Davis 2004; Ehrich et. al 2012; Baril et. al 2011; Hobson and Bayne 2000). Although Fragmented vegetation can enhance optimal foraging strategies through increased accessibility to plants, seeds, and accompanying insects (Greenberg and Lanham 2001). Gap spaces between willows may allow for a quick transition from nest to foraging which reduces the duration of recesses taken from nest by incubating parents. Another justification may involve variable fluctuation in ambient temperatures that may occur within alpine environments (Camfield and Martin 2009). Females may be more inclined to build nests in more fragmented willows that experience greater solar exposure and maintain the thermal requirements of MWCS eggs. Therefore, a greater abundance of males would occur in areas more inhabited by their female partners and respective nests. Last, predation risk may be decreased in areas of steeper elevation gradients (Bland and Temple 1990). Edge effects and exposure to disturbances may be less applicable at high elevation sites which are typically less traversed by humans, and less inhabited by avian predators.

Within a larger context, a long-term study of willow cover at high elevation may provide insights in climate change and its relative effect on vegetation cover within this area. A study of climate change occurring in the Rocky Mountain Range of Colorado since the 1970s uses a NDVI (Normalized Difference Vegetation Index) and categorizes areas of alpine vegetation as either greening or browning (Steltzer and Brown, unpublished data). By conducting a more in-depth vegetation analysis including measures of percent willow cover, average height, shrub species composition, and neighboring wildflower species; we could monitor changes in vegetation between successive years. Ultimately if results indicate whether vegetation is greening or browning, we can determine if mountain white-crowned sparrows are in fact, resistant to vegetative loss.

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Appendix A

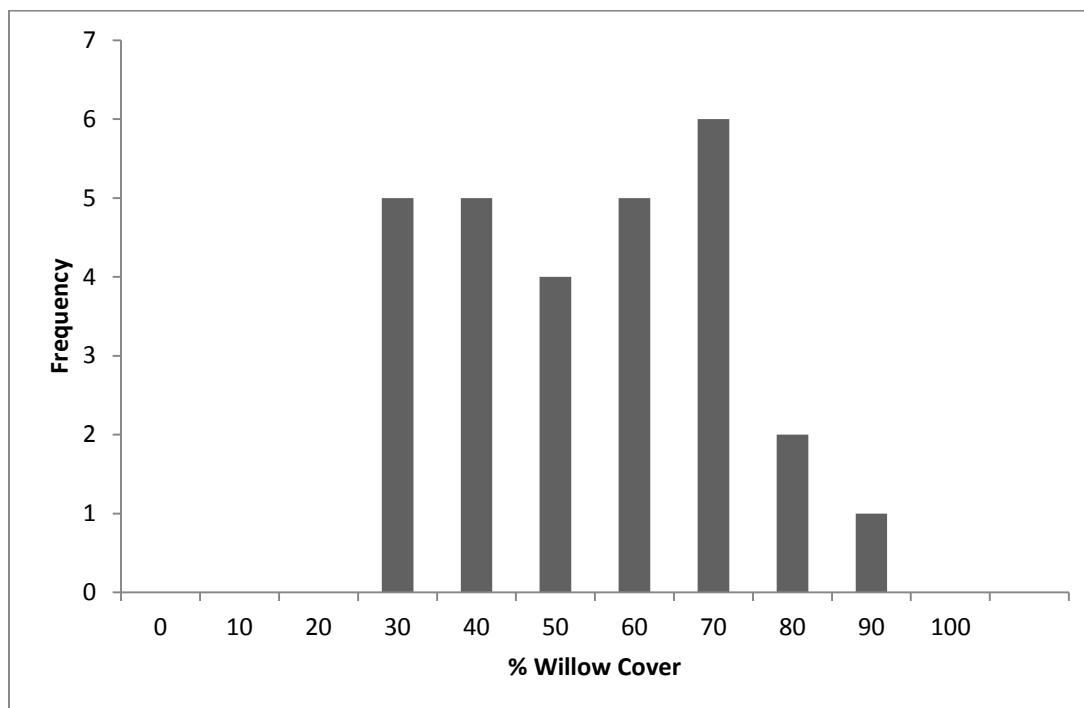


Figure 1. Normal distribution of percent willow cover across all three high elevation survey sites.

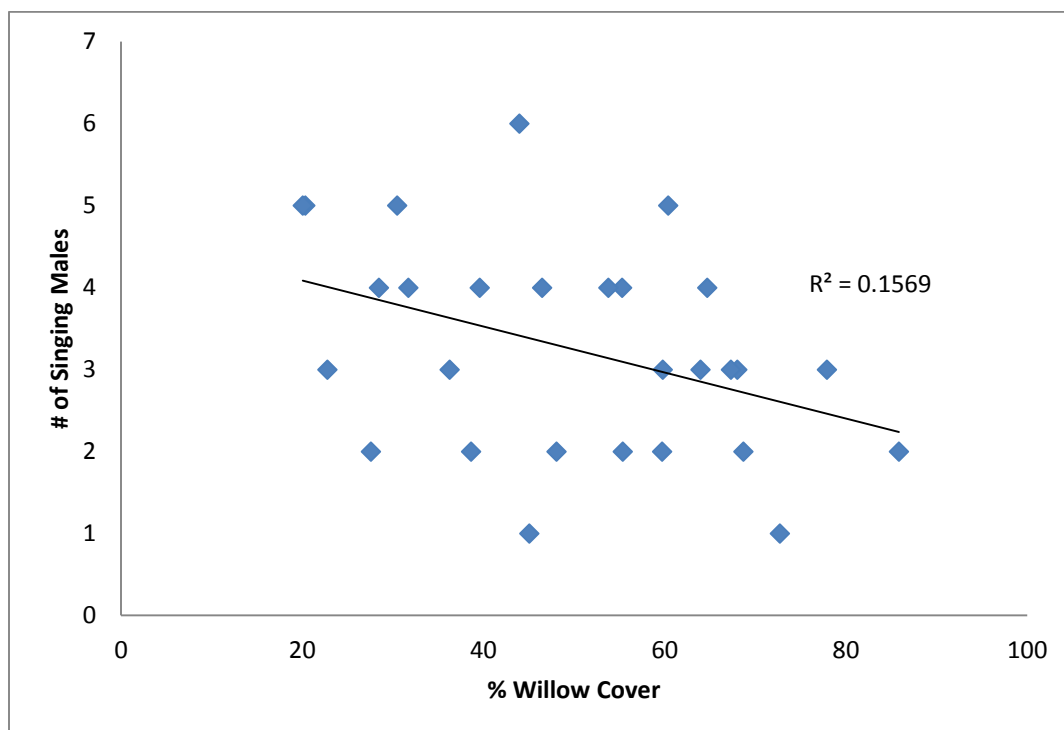


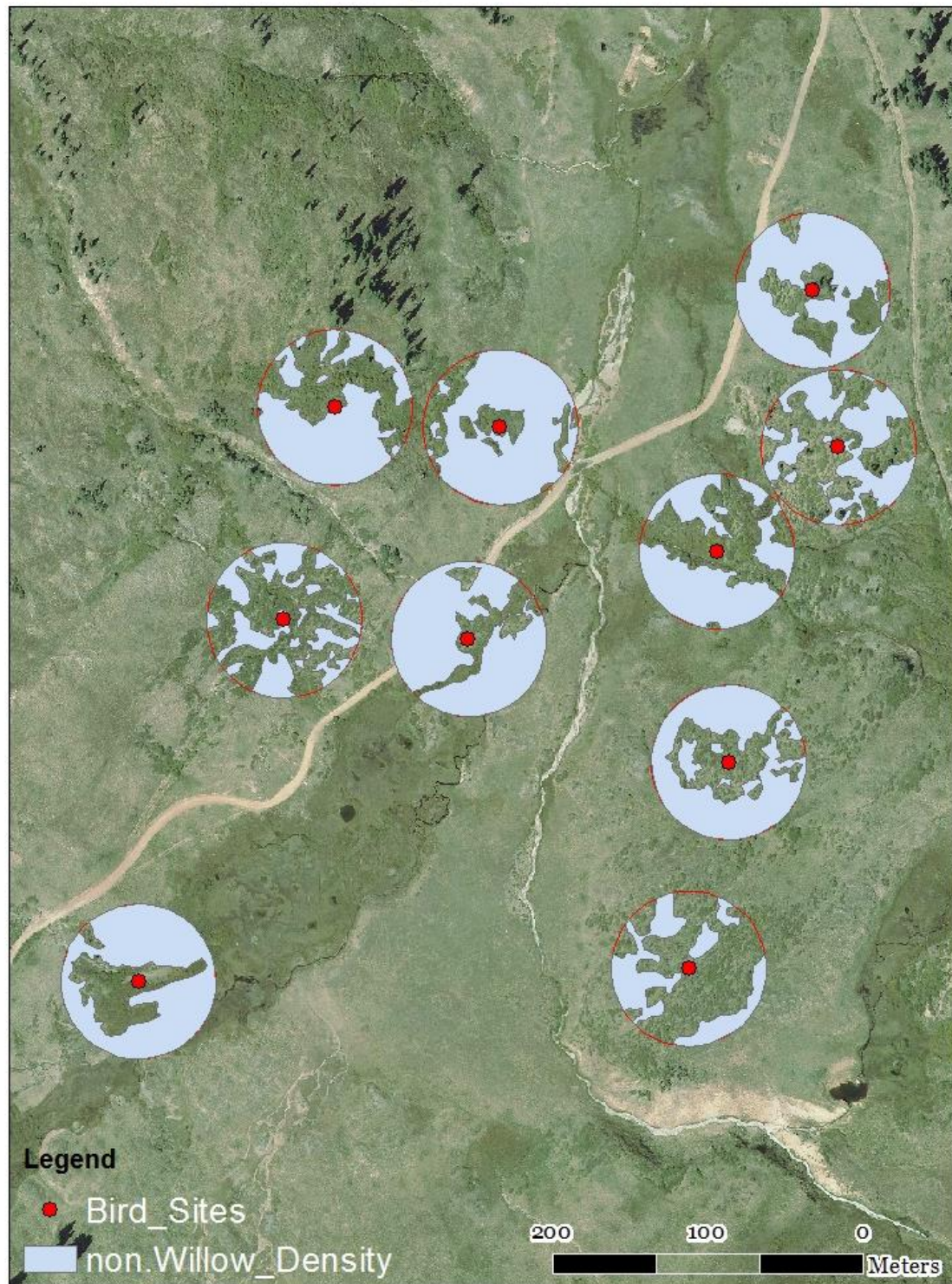
Figure 2. Linear regression results indicating a correlation between number of singing males and percent willow cover.

Appendix B

North Pole Basin Bird Survey



Paradise Divide Bird Survey



Virginia Basin Bird Survey

