12-2018

Vegetation Characteristics and Bird Communities Associated with Singing Painted Buntings in Northwest Arkansas

Lauren Kristina Thead
University of Arkansas, Fayetteville

Vegetation Characteristics and Bird Communities Associated with
Singing Painted Buntings in Northwest Arkansas

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science in Biology

by

Lauren K. Thead
Mississippi University for Women
Bachelor of Science in Biology, 2009

December 2018
University of Arkansas

This thesis is approved for recommendation to the Graduate Council.

Steven J. Beaupre, Ph.D.
Thesis Director

Steven L. Stephenson, Ph.D.
Committee Member

Michelle Allayne Evans-White, Ph.D.
Committee Member

Abstract

It has been shown that bird communities are affected by the species composition and physical structure of plant communities. Within avian communities, the bird species that are the most localized in distribution tend to be the most affected by habitat changes. My research analyzed plant and bird communities found with the Painted Bunting (*Passerina ciris* Linnaeus), a locally common but declining species throughout much of its range. First, I describe vegetation characteristics associated with singing male Painted Buntings in northwest Arkansas. I categorized field sites with singing male Painted Buntings as either managed for wildlife or unmanaged, based on land-use practices, and collected measurements of the structure and composition of all woody vegetation, forbs, and graminoids. Contrary to my hypothesis, there was no difference in vegetation structure and composition between managed and unmanaged sites, although two measures of profile diversity were higher in managed sites than in unmanaged sites. Second, I describe the bird communities associated with these same breeding male Painted Buntings. I collected data on bird populations and calculated bird diversity, evenness, and richness for both managed and unmanaged sites. The results did not support the hypothesis that managed sites would show higher bird diversity, evenness, and richness; no differences were found between bird communities at different site types. Northern Mockingbird (*Mimus polyglottos* Linnaeus) was the only species to differ in population size between site types, being more abundant in unmanaged sites. Concluding observations synthesize the results of my research to provide a summary of Painted Bunting ecology in northwest Arkansas. Quantitative studies of both vegetation and avian communities in Painted Bunting habitat are limited, so my work should provide a point of reference for further investigations of Painted Buntings in the Ozark region.

Acknowledgments

This research was supported by a grant from the Arkansas Audubon Society Trust. Dr. Kimberly G. Smith advised me during my field research. I thank Joseph C. Neal for helping with field site selection, Ross Shiery for assisting with surveys of both birds and vegetation in 2014, and Dr. Douglas A. James for providing some of the field tools used for vegetation data collection. I also thank Dr. Erin A. Thead for aiding me with the statistical analysis of the data, Sheila A. Thead and Dr. Larry G. Thead for their advice and support, and my current committee—Dr. Steven J. Beaupre, Dr. Steven L. Stephenson, and Dr. Michelle Allayne Evans-White—for their guidance during the writing of this thesis.

Table of Contents

General Introduction

The species composition and physical structure of plant communities can have profound effects on associated bird communities (e.g., Lack 1933; Kendeigh 1941; MacArthur and MacArthur 1961), and birds that show strong localization in their distributions tend to be more significantly affected by changes in habitat (e.g., Wiens and Rotenberry 1981; Strong and Bock 1990). This ecological principle is applicable to the Painted Bunting (*Passerina ciris* Linnaeus), a small Neotropical migratory songbird in the family Cardinalidae (Lowther et al. 1999). This species has two distinct breeding populations that are isolated from each other geographically (Thompson 1991). The western population extends from eastern New Mexico through Texas, Oklahoma, and Louisiana, to western Mississippi, and north to Kansas and the southern edge of Missouri. The eastern population occurs along the Atlantic Coastal Plain from southern North Carolina to northeast Florida and Georgia. These populations appear to be isolated on the wintering grounds, as well, with western individuals found in western Mexico and Central America, and eastern individuals in southern Florida, the Bahamas, and Cuba. Although still fairly common throughout much of its range, the Painted Bunting declined an average of approximately 3.5% per year from the late 1960s to the late 1990s (Meyers 2011), with Atlantic Coastal Plain populations experiencing the most significant population declines (Brittain et al. 2010). However, populations in the Ozark region of the United States appear to be slightly increasing (USGS c2012).

On both their breeding and wintering grounds, Painted Buntings can be found in a variety of habitats characterized by an abundance of low-growing, scrubby vegetation and small patches of woodland (Lowther et al. 1999). Vegetation characteristics of western Painted Bunting breeding habitat have been examined in relatively few studies, notably in southern Oklahoma

(Parmelee 1959), northeast Texas (Kopachena and Crist 2000), eastern Texas (Conner et al. 2004), northwest Arkansas (Shugart and James 1973), and south-central Louisiana (Vasseur and Leberg 2015).

Studies on bird communities associated with Painted Bunting breeding habitat have been conducted by Brittain et al. (2010) in the Altamaha River Estuary, Georgia, and by Shugart and James (1973) at Pea Ridge National Military Park, Arkansas. Bird community composition may change over time, particularly if relatively rapid, anthropogenic habitat alterations, such as habitat fragmentation, occur (e.g., Wilcove et al. 1986; Herkert 1994). Painted Buntings are likely affected by habitat fragmentation (Lowther et al. 1999), in part because it increases an area's favorability to the Brown-headed Cowbird (*Molothrus ater* Boddaert), which is known as a brood parasite due to its behavior of depositing its eggs in the nests of other passerines (Lowther 1993). Both Parmelee (1959) and Vasseur and Leberg (2015) examined the effect of cowbird parasitism on Painted Bunting breeding success. Parmelee observed that Painted Buntings in Oklahoma may have developed certain adaptive behaviors to cope with cowbird parasitism, but Vasseur and Leberg noted nest failures in south-central Louisiana populations that may have been related to brood parasitism by cowbirds.

The purpose of this research was twofold. First, I describe the vegetation characteristics associated with singing/breeding male Painted Buntings in the northwest region of Arkansas. Second, I describe the bird communities associated with these breeding male Painted Buntings. Although the study by Shugart and James (1973) focused on habitats in northwest Arkansas and is therefore the most directly comparable to my own research, it concentrated on land at Pea Ridge National Military Park, where Painted Buntings were observed only in an early-stage clonal persimmon (*Diospyros virginiana* L.) plot. At my field sites in Washington and Crawford

Counties in Arkansas, clonal persimmon plots were not present, and breeding Painted Buntings were found in a far wider variety of habitat types. Thus, my research should provide a useful reference point for further studies of Painted Bunting habitat in the Ozark region.

In Chapter I, the vegetation characteristics associated with singing male Painted Buntings in the northwest region of Arkansas are described. Each selected habitat was categorized according to apparent land-use practices. Managed sites were any habitats that were maintained for wildlife use, while unmanaged sites were usually located within or near areas of human development. Methods modified from James and Shugart (1970), James (1971), Rotenberry and Wiens (1980), and Wiens and Rotenberry (1981) were used in sampling all woody and herbaceous vegetation at the field sites. Principal component analysis, performed with R version 3.4.2 (R Core Team 2014) and XLSTAT (XLSTAT 2017) was then used to determine the extent to which the variables were correlated, so that they could be reduced. To determine whether managed and unmanaged sites were differentiated, XLSTAT was used to perform a MANOVA on the reduced data set, and pairwise *t*-tests were conducted on the individual variables. I hypothesize that vegetation structure and composition differ between managed and unmanaged habitat types, due to land-use practices.

Chapter II describes the bird communities associated with singing male Painted Buntings in northwest Arkansas. Bird populations were surveyed using transect methods developed by Hutto et al. (1986), and measures of diversity and evenness were calculated using methods adapted from Hill (1973). Species richness measures were recorded for two different scales of observation. Pairwise *t*-tests were performed on the data to determine whether managed and unmanaged sites were differentiated. I hypothesize that bird community diversity, evenness, and richness are higher in managed than in unmanaged sites, due to increased habitat fragmentation at sites left unmanaged for wildlife. I conclude with a synthesis of my work and suggestions for its use in conservation management of Painted Buntings and their habitat.

Literature Cited

Brittain, R. A., V. J. Meretsky, and C. B. Craft. 2010. Avian communities of the Altamaha River Estuary in Georgia, USA. Wilson Journal of Ornithology 122:532-544.

Conner, R. N., J. G. Dickson, J. H. Williamson, and B. Ortego. 2004. Width of forest streamside zones and breeding bird abundance in eastern Texas. Southeastern Naturalist 3:669-682.

Herkert, J. R. 1994. The effects of habitat fragmentation on Midwestern grassland bird communities. Ecological Applications 4:461-471.

Hill, M. O. 1973. Diversity and evenness: a unifying notation and its consequences. Ecology 54:427-432.

Hutto, R. L., S. M. Pletschet, and P. Hendricks. 1986. A fixed-radius point count method for nonbreeding and breeding season use. Auk 103:593-602.

James, F. C. 1971. Ordinations of habitat relationships among breeding birds. Wilson Bulletin 83:215-236.

James, F. C., and H. H. Shugart, Jr. 1970. A quantitative method of habitat description. Audubon Field Notes 24:727-736.

Kendeigh, S. C. 1941. Birds of a prairie community. Condor 43:165-174.

Kopachena, J. C., and C. J. Crist. 2000. Macro-habitat features associated with Painted and Indigo Buntings in northeast Texas. Wilson Bulletin 112:108-114.

Lack, D. 1933. Habitat selection in birds with special reference to the effects of afforestation on the Breckland avifauna. Journal of Animal Ecology 2:239-262.

Lowther, P.E. 1993. Brown-headed Cowbird (*Molothrus ater*), The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, New York, USA. [accessed 2012 March 13]. http://bna.birds.cornell.edu/bna/species/047doi:10.2173/bna.47.

Lowther, P. E., S. M. Lanyon, and C. W. Thompson. 1999. Painted Bunting (*Passerina ciris*), The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, New York, USA. [accessed 2012 March 13]. http://bna.birds.cornell.edu/bna/species/398.

MacArthur, R. H., and J. W. MacArthur. 1961. On bird species diversity. Ecology 42:594-598.

Meyers, J. M. 2011. Population densities of Painted Buntings in the southeastern United States. Southeastern Naturalist 10:345-356.

Parmelee, D. F. 1959. The breeding behavior of the Painted Bunting in southern Oklahoma. Bird-Banding 30:1-18.

R Core Team. 2014. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. [accessed 2017 August 15]. http://www.R-project.org/.

Rotenberry, J. T., and J. A. Wiens. 1980. Habitat structure, patchiness, and avian communities in North American steppe vegetation: a multivariate analysis. Ecology 61:1228-1250.

Shugart, H. H., Jr., and D. James. 1973. Ecological succession of breeding bird populations in northwestern Arkansas. Auk 90:62-77.

Strong, T. R., and C. E. Bock. 1990. Bird species distribution patterns in riparian habitats in southeastern Arizona. Condor 92:866-885.

Thompson, C. W. 1991. The sequence of molts and plumages in Painted Buntings and implications for theories of delayed plumage maturation. Condor 93:209-235.

USGS Patuxent Wildlife Research Center, North American Breeding Bird Survey Results and Analysis 1966-2012, Painted Bunting BBS Trend Map 1966-2010. c2012. United States Department of the Interior, Washington, D. C., USA. [accessed 2012 March 17]. http://www.mbr-pwrc.usgs.gov/bbs/tr2010/tr06010.htm.

Vasseur, P. L., and P. L. Leberg. 2015. Effects of habitat edges and nest-site characteristics on Painted Bunting nest success. Journal of Field Ornithology 86:27-40.

Wiens, J. A., and J. T. Rotenberry. 1981. Habitat associations and community structure of birds in shrubsteppe environments. Ecological Monographs 51:21-41.

Wilcove, D. S., C. H. McLellan, and A. P. Dobson. 1986. Habitat fragmentation in the temperate zone. M. E. Soulé, editor. Conservation Biology. The science of scarcity and diversity. Sinauer Associates, Sunderland, Massachusetts, USA.

XLSTAT. 2017. Data analysis and statistics with Microsoft Excel. Addinsoft, New York City, USA. [accessed 2017 September 29]. https://www.xlstat.com/en/.

Chapter I: Vegetation Characteristics Associated with Singing Painted Buntings (*Passerina ciris*) in Managed and Unmanaged Habitats in Northwest Arkansas

Abstract

Multiple studies have shown that birds are affected by the plant communities that they inhabit. Bird species with more localized distributions tend to show stronger associations with particular habitat features, including vegetation, than species that are more widely distributed. The Painted Bunting (*Passerina ciris*) is a fairly common but declining species throughout much of its range in eastern and central North America, and although several quantitative studies have been conducted on breeding habitat in the eastern portion of its range, relatively few studies have focused on habitat in the western portion, including that of Arkansas. A more detailed understanding of the habitat preferences of this species will help establish a baseline for future research on its Arkansas populations, and might aid in conservation efforts. In this study, I determined vegetation characteristics associated with breeding male Painted Buntings in northwest Arkansas. Field sites were separated into two categories—those managed for wildlife and those left unmanaged—and measurements for both woody and forb/graminoid vegetation were collected on 11.3-m-radius circular plots, resulting in a set of 17 variables. I used principal component analysis to determine the extent to which the variables were correlated with one another. Habitats with high values of the first component displayed sparse ground cover, tall trees, and high forb and graminoid horizontal heterogeneity. Habitats with high values of the second principal component were characterized primarily by high tree species diversity, relatively high vertical vegetation heterogeneity, and a large number of medium-sized trees. A MANOVA, which I performed on reduced data to determine whether vegetation structure and composition differed between managed and unmanaged sites, indicated that there was no

significant difference between site types. Measures of vertical profile diversity of forb/graminoid vegetation were lower in unmanaged sites than in managed sites, which suggests that other factors—potentially including composition of forb/graminoid plants, levels of human interference, and soil and water characteristics—may differ between site types.

1. Introduction

Ecological associations between plant community types and bird communities have been observed in a number of studies (e.g., Lack 1933; MacArthur 1961). In research on prairie bird populations in Iowa, Kendeigh (1941) found that different species displayed strong affinities for specific habitat types. Additionally, bird species with more localized distributions often show stronger associations with habitat features than species with wider distributions, as noted by Wiens and Rotenberry (1981) in a study of birds in Great Basin shrubsteppe environments, and by Strong and Bock (1990) in a study of birds in the Huachuca Mountains of Arizona. Habitat preferences of breeding Painted Buntings (*Passerina ciris*) were the main focus of my study. The Painted Bunting (Fig. 1.1) is a species of relatively high conservation priority (Meyers 2011). The Cornell Lab of Ornithology strongly encourages submission of sighting reports (particularly summer records from eastern North America and winter records) on eBird, the Lab's online bird database (eBird News 2008). According to Breeding Bird Survey data, Painted Buntings declined an average of approximately 3.5% per year throughout most of their range during the first 30 years of the survey (Meyers 2011). A notable exception is the Ozark region, where most breeding Painted Buntings in Arkansas occur, and where population change per year has averaged +1.5% (USGS c2012). The reasons for the widespread population declines and local increases are not entirely known. It is likely, however, that the declines result from a combination of habitat loss and fragmentation on both breeding and wintering grounds, human development leading to deaths during migration, and commercial trapping on the wintering grounds in Central America (Lowther et al. 1999). The somewhat limited distribution of Painted Bunting populations suggests that the species may show a strong affinity for particular habitat features, and quantifying those features may aid in conservation efforts.

Breeding habitats utilized by Painted Buntings are usually open areas with dense, scrubby vegetation, such as overgrown fields, prairies, riparian thickets, and woodland edges, where the buntings can find the small seeds and arthropods that comprise their diet (Lowther et al. 1999). Overall, studies quantifying the vegetation characteristics of Painted Bunting habitat in south-central and western North America are few. Breeding birds in the western population are often quite common in overgrown agricultural areas, as noted by Parmelee (1959) in a study that examined the behavior of breeding Painted Buntings in southern Oklahoma. He observed that Painted Buntings were commonly found in scattered fragments of woodland in overgrown fields, as well as wooded fringe habitat along rural roads, with the main determining factors for nest site selection being sufficient vegetation for concealment and support of the nest, several singing perches for breeding males, and a feeding ground consisting of a grassy field with scattered shrubs. The preference of the species for highly open breeding habitat was also noted by Conner et al. (2004) in a study in eastern Texas, and by Kopachena and Crist (2000) in a study in northeast Texas. Additionally, Kopachena and Crist (2000) noted that Painted Buntings are likely to be found in wooded areas of otherwise open habitat. In the only study in northwest Arkansas, at Pea Ridge National Military Park, Shugart and James (1973) found that Painted Buntings have fairly narrow habitat preferences; the species was observed only in an early tree stage plot, which was referred to as a clonal persimmon (*Diospyros virginiana* L.) plot and contained small clusters of shade intolerant tree species, including persimmon. About 83% of the canopy on this plot was open to broom sedge and forbs. Similarly, Vasseur and Leberg (2015) noted in their study of the effects of vegetation on Painted Bunting nest success that breeding densities were higher in patchy, largely open habitats—such as sites containing linear patches of mature trees—than at the edges of mature forests and in scrub-shrub habitats. The open quality of Painted Bunting habitat during the breeding season, combined with habitat fragmentation across the range of the species, is likely a contributing factor to the high rate of nest parasitism by cowbirds—a significant factor in Painted Bunting population declines (Lowther et al. 1999). The Brown-headed Cowbird (*Molothrus ater* Boddaert), the only cowbird species occurring in Arkansas, has expanded its range partly as a result of woodland habitat fragmentation in eastern North America; historically, it was restricted to short-grass plains in the western portions of North America (Lowther 1993).

The effect of habitat on Painted Bunting breeding behavior has been examined in a number of studies, primarily for the eastern population. For example, Springborn and Meyers (2005) found that habitat had affected the size of home ranges of Painted Buntings on Sapelo Island, Georgia. Buntings maintained larger home ranges in managed pine-oak forests than in unmanaged maritime shrub, and frequently traveled farther outside their core home range to forage, indicating that for the eastern population of the Painted Bunting, maritime shrub contains more essential resources and is higher quality breeding habitat than managed pine-oak forest. Although similar studies have not been conducted in northwest Arkansas, the research of Shugart and James (1973) suggested that clonal persimmon plots are a preferred habitat type for Painted Buntings in that region. In a study on the settlement pattern of male Painted Buntings on a 90-ha site on St. Catherines Island, Georgia, males occupying edge habitats displayed more aggressive behaviors and settled on territories one to two weeks earlier than males occupying forest interior habitats, which were less energetically costly to defend but of significantly poorer quality (Lanyon and Thompson 1986).

The purpose of my study was to quantify vegetation characteristics of Painted Bunting (*Passerina ciris*) habitat in northwest Arkansas. This was intended to establish a reference point for Painted Bunting habitat research in the state. My main research objective was to determine the effects of vegetation on the breeding territory site preference of male Painted Buntings (i.e., which specific combinations of vegetation factors are significant in breeding site selection). Another goal was to determine whether differences existed between breeding territories at sites actively managed for wildlife and at sites left unmanaged. Determining how vegetation structure and composition on Painted Bunting territories are affected by management practices may provide insight into how to optimize those practices.

2. Materials and Methods

2.1. Study Area

I selected several sites in Crawford County and Washington County in northwest Arkansas for surveying birds and sampling vegetation (Fig. 1.2). Sites were chosen based on ease of access and presence of male Painted Buntings during the breeding season and were separated into two categories based on whether or not they were actively managed for wildlife. Management practices consisted of land being set aside for public outdoor activities, such as hiking, wildlife observation, and hunting.

The sites managed for wildlife included Frog Bayou Wildlife Management Area (GPS coordinates 35.48, -94.13), Callie's Prairie at Lake Fayetteville (36.15, -94.12), West Side Wastewater Treatment Facility (36.06, -94.23), and Kessler Mountain (36.02, -94.20). Portions of land within and surrounding Kessler Mountain (City of Fayetteville, Arkansas; Kessler Mtn

Trails c2006-2017), Lake Fayetteville (Arkansas Department of Parks & Tourism, Lake Fayetteville c2017), and West Side Wastewater Treatment Facility (City of Fayetteville, Arkansas; Woolsey Wet Prairie Sanctuary c2006-2017) are maintained for public recreation. Woolsey Wet Prairie Sanctuary, adjacent to West Side Wastewater, is a wetland restoration project (City of Fayetteville, Arkansas; Woolsey Wet Prairie Sanctuary c2006-2017), as is Frog Bayou WMA, which contains forested habitat and moist soil units (Arkansas Department of Parks & Tourism, Frog Bayou Wildlife Management Area c2017). Unmanaged sites included the University of Arkansas Crop, Soil, and Environmental Science Farm (36.09, -94.17); W. Willoughby Rd., Fayetteville (36.02, -94.17); Razorback Rd., Fayetteville (36.05, -94.18); and S. Olympic Pl., Fayetteville (36.05, -94.18). Frog Bayou WMA, the only study site in Crawford County, is within the Arkansas Valley ecoregion, while all other sites are located in Washington County and within the Boston Mountains ecoregion (U.S. Environmental Protection Agency 2012). Most of these sites contain a variety of forest edge, prairie, and overgrown field habitat types. Photographs of habitats are shown in Figs. 1.3 through 1.10.

2.2. Study Design

I identified male Painted Buntings at each of the sites and took measurements of vegetation within 11.3-meter-radius circular plots centered on their singing perches, which I determined through observation in the field. This method of survey plot placement was shown by James (1971) to be highly effective in quantifying habitats of breeding birds. To facilitate mapping, I recorded GPS coordinates for all plots. Vegetation sampling on each 11.3-m plot involved recording all woody plant species and measuring percent canopy cover, percent ground cover, vegetation height, plant stem count, and forb/graminoid structure, using modifications of methods developed by James and Shugart (1970) and Rotenberry and Wiens (1980). For the purposes of this study, trees were counted only if their diameter at breast height (DBH) measured at least 7.62 cm. Smaller trees were categorized with woody shrubs. Vegetation sampling occurred at various times from late May to late August, 2014 and 2015.

In accordance with James and Shugart's (1970) methods, each circular plot was transected by two right-angle lines, dividing it into four quadrats and creating four transects in the four cardinal directions (N, S, W, and E). Within these plots, I estimated canopy cover by noting presence or absence of vegetation as seen through a cardboard sighting tube at 10 points along each transect line. Ground cover was estimated in a similar manner, with presence or absence of green vegetation (i.e., forbs or graminoids) noted at each of 10 points for each transect. Estimates of woody shrub or small tree stems in each plot were made by walking, arms outstretched, along each transect and counting the number of stems that came into contact with the observer's arms. A clinometer was used to estimate canopy height based on the height of the tallest tree within each quadrat in a given circular plot. The DBH of all trees at least 7.62 cm DBH was measured using a forester's diameter tape, and each of these trees was placed into one of 8 size classes: A (7.62-15.24 cm), B (15.24-22.86 cm), C (22.86-38.1 cm), D (38.1-53.34 cm), E (53.34-68.58 cm), F (68.58-83.82 cm), G (83.82-101.6 cm), or H (>101.6 cm). All larger trees were identified to species, and, where possible, woody stems were also identified.

To determine the vertical and horizontal structure of the forbs and graminoids, I placed a Wiens pole, a 5-mm-diameter rod marked in 10-cm height intervals (Wiens 1969), at 10 different points along each transect and counted the number of stems crossing the stick for each interval. I measured forb and graminoid vertical cover using methods developed by Rotenberry and Wiens (1980). The average maximum height (in centimeters) of the vegetation (MAXHGT) and the average number of contacts over the entire height of the stick (TOTHITS) comprised the vertical vegetation measures. The horizontal vegetation structure was represented by the average number of vegetation contacts in the first decimeter interval (HIT-10). Measures of horizontal heterogeneity were also calculated, including the coefficient of variation of the maximum vegetation height (CVMAXHGT), the coefficient of variation of the total hits (CVTOTHIT), and the heterogeneity index of the total contacts within samples (HITS-HI). Vertical vegetation heterogeneity was represented by profile diversity indices, including PD-10, which was calculated from the average proportion of contacts in each of the height intervals, and PD-30, which used the proportions of contacts in the intervals of 0-10 cm, 10-30 cm, and >30 cm (Wiens and Rotenberry 1981). Descriptions of the 17 vegetation variables adapted from James and Shugart (1970), Rotenberry and Wiens (1980), and Wiens and Rotenberry (1981) are found in Table 1.1.

2.3. Statistical Analysis

Principal component analysis was used to reduce the number of vegetation variables by determining the extent to which they were correlated. To standardize the diverse measurements of the raw data, the PCA was conducted on the correlation matrix. Prior to conducting the principal component analysis, the variables D (38.1-53.34 cm), E (53.34-68.58 cm), F (68.58-83.82 cm), and G (83.82-101.6 cm) were combined into one category: number of trees >38.1 cm DBH. This was done to simplify the data because most of the vegetation sites had values of 0 for the larger tree categories E, F, and G. Principal component analyses were conducted using R version 3.4.2 (R Core Team 2014) and XLSTAT (XLSTAT 2017) in Microsoft Excel (2013). A Pearson correlation matrix was used to identify variables that showed high correlations ($r \geq 0.9$) and could therefore be reduced in preparation for further analysis. A MANOVA was then conducted on the correlation matrix of the reduced data to determine if there was a separation between managed and unmanaged sites.

I conducted *t*-tests ($\alpha = 0.05$) to determine which individual vegetation measurements differed between managed and unmanaged sites. These were performed using Microsoft Excel (2013). A Šidák correction (Šidák 1967) was used to correct for experiment-wise error.

3. Results

The average habitat values for managed and unmanaged sites are shown in Table 1.1. *T*-tests with a Šidák correction ($\alpha = 3.01 \times 10^{-3}$) showed that profile diversity was significantly different between site types. PD-10 was higher at managed sites than at unmanaged sites, $t(10) = 3.98$, $p = 2.59 \times 10^{-3}$. PD-30 also showed higher values at managed sites, $t(14) = 4.16$, $p = 9.61 \times 10^{-4}$. This indicates that sites managed for wildlife tended to have a considerably higher degree of vertical heterogeneity in forb and graminoid vegetation (Table 1.1).

The individual tree species measuring at least 7.62 cm diameter at breast height (DBH) comprised 18 species (Table 1.2), all of which are commonly found in northwest Arkansas (Hunter 2000). Pairwise *t*-tests did not detect any significant differences between managed and unmanaged sites ($\alpha = 2.85 \times 10^{-3}$). Orchard apple (*Malus pumila* Mill.) and Bradford pear (*Pyrus calleryana* Decne.) were found only in sites not managed for wildlife and were the only nonnative species (Hunter 2000) on the list. The most abundant species in the study sites was eastern red cedar (*Juniperus virginiana* L.), with Bradford pear being the rarest. Trees smaller than 7.62 cm DBH were not recorded individually but were sometimes detected as woody stems along with the shrub stems in a given sample plot. The species composition of small trees at any given study site was generally a combination of saplings of the same species mix as that of the larger tree community and species generally restricted to the forest understory and edge.

Included in the latter category were sumac (*Rhus* spp.), Chinese privet (*Ligustrum sinense* Lour.), and black locust (*Robinia pseudoacacia* L.).

The principal components were derived from the original 17 vegetation variables. The correlations to individual variables are shown in Table 1.3 and Fig. 1.11. The first principal component accounts for 33.5% of the total variance in the data. It has a high positive correlation with average canopy height and horizontal heterogeneity of forbs and graminoids. Woody stem count is also positively correlated with it. It has a high negative correlation with ground cover, density of total vegetation hits, and density of first dm vegetation contacts, and a relatively high negative correlation with PD-30 and maximum height of vegetation. Habitats with high values of this principal component had tall trees, a well-developed shrub layer, relatively few graminoids and forbs, high levels of horizontal structural diversity, and low vertical diversity.

The second principal component accounts for 20.8% of the variance. It is positively correlated with tree species diversity, trees measuring 15.24-22.86 cm DBH, canopy height, average maximum vegetation height, and PD-30. Habitats with high values of this component contained a rich assortment of medium-sized trees as well as forb and graminoid vegetation of diverse vertical structure. As seen in Fig. 1.12, principal component I appeared to account for much of the variation among the unmanaged sites, while principal component II accounted for somewhat more variation on the sites managed for wildlife.

The third principal component accounts for 14.6% of the variance in addition to the first and second components, and is negatively correlated with shrub density and numbers of trees measuring 7.62-15.24 cm DBH. It correlates positively with PD-10. Habitats with high values of this component were mostly open, with few small and medium-sized trees. Forb and graminoid vegetation were highly diverse in vertical vegetation structure.

The fourth principal component accounts for an additional 9.2% of the variance. It represents a high percentage of canopy cover, relatively high canopy height, and high numbers of trees measuring greater than 38.1 cm DBH. Habitats with high values of the fourth component were characterized by large shade trees, as might be found at the woodland edges. Components V-VIII are not easily described, as they do not show significantly high correlation with any of the original variables.

For the MANOVA, the variables SPT, TOTHITS, and HITS-HI were eliminated because of their high correlation ($r \geq 0.9$) with other variables. There was no significant difference between the managed and unmanaged sites, $F(14, 2) = 1.119$, $p = 0.569$; Wilks's $\Lambda = 0.113$.

4. Discussion

Although the PCA results suggest that sites managed for wildlife may be more likely than unmanaged sites to be characterized by variation in tree species diversity, number of medium-sized trees, and both height and structural diversity of graminoids and forbs, the MANOVA results indicate that there is no significant difference between site types in terms of vegetation structure and composition. The measures of vertical heterogeneity, PD-10 and PD-30, were the only individual variables for which significant differences between site types existed. Low measurements of the profile diversity of forbs and graminoids in unmanaged sites suggest that vertical vegetation structure is less varied than in managed sites. The reasons for this could include differences in species composition or species diversity between site types, in levels of development between site types, or in other ecological factors. In Great Basin shrubsteppe environments, different plant species were found to have different vertical heterogeneity values (Wiens and Rotenberry 1981), so it is possible that vertical structure also varies significantly between different species in northwest Arkansas. Species composition and species diversity of forbs and graminoids were not recorded in my study, so further research at these sites might include efforts to identify all herbaceous plants to species. Management and development by humans—including practices such as mowing, application of herbicides, and seeding—were also not measured in the study, but might have had an effect on the structure of herbaceous vegetation at site types. Differences between sites in terms of ecological factors such as soil characteristics, erosion, and water availability could have affected vegetation structure, as well, and would need to be quantified.

In the early-stage clonal persimmon plot surveyed by Shugart and James (1973), trees were at a density of 122 trees per acre, or approximately 301 per ha, and the density of woody stems was 322 per acre or about 796 per ha. Canopy cover was 17%. In comparison, the plots that I sampled, which were mostly mixed-species, mixed-age woodlands, contained per ha an average of 261 trees and 391250 stems, with canopy cover averaging 38%. These particular measurements were not found to be significantly different between managed and unmanaged habitats. I suspect that some of the differences between vegetation measurements recorded at my field sites and those recorded by Shugart and James were due in part to differences in habitat, with much of Pea Ridge being a large grassland. In my survey plots, persimmon, a characteristic tree of early successional stage habitats, was not a dominant species. Painted Bunting territories in my study were located primarily in old field and forest edge, with stands of tall trees providing shelter. Research by Vasseur and Leberg (2015) indicates that relatively extensive canopy cover is correlated with increases in nesting success rates, which may suggest that the higher percentage of canopy cover at my field sites as compared to those of Shugart and James (1973) is beneficial to breeding Painted Buntings in Washington and Crawford Counties.

Literature Cited

Arkansas Department of Parks & Tourism, Frog Bayou Wildlife Management Area. c2017. Little Rock, Arkansas, USA. [accessed 2017 September 15]. https://www.arkansas.com/outdoors/birding/birds/bird-detail.aspx?id=49.

Arkansas Department of Parks & Tourism, Lake Fayetteville. c2017. Little Rock, Arkansas, USA. [accessed 2017 September 15]. https://www.arkansas.com/outdoors/birding/birds/bird-detail.aspx?id=51.

Audubon and Cornell Lab of Ornithology, eBird News, May 14, 2008. We need your Painted Bunting observations! c2008. Cornell Lab of Ornithology, Ithaca, New York, USA. [accessed 2012 March 13]. http://ebird.org/content/ebird/news/we-need-your-painted-bunting-observations.

City of Fayetteville, Arkansas; Kessler Mtn Trails. c2006-2017. Fayetteville, Arkansas, USA. [accessed 2017 September 15]. http://www.fayetteville-ar.gov/facilities/facility/details/Mt-Kessler-Trails-88.

City of Fayetteville, Arkansas; Woolsey Wet Prairie Sanctuary. c2006-2017. Fayetteville, Arkansas, USA. [accessed 2017 September 15]. http://accessfayetteville.org/470/Woolsey-Wet-Prairie-Sanctuary.

Conner, R. N., J. G. Dickson, J. H. Williamson, and B. Ortego. 2004. Width of forest streamside zones and breeding bird abundance in eastern Texas. Southeastern Naturalist 3:669-682.

Hunter, C. G. 2000. Trees, shrubs, and vines of Arkansas. Ozark Society Foundation, Little Rock, Arkansas, USA.

James, F. C. 1971. Ordinations of habitat relationships among breeding birds. Wilson Bulletin 83:215-236.

James, F. C., and H. H. Shugart, Jr. 1970. A quantitative method of habitat description. Audubon Field Notes 24:727-736.

Kendeigh, S. C. 1941. Birds of a prairie community. Condor 43:165-174.

Kopachena, J. C., and C. J. Crist. 2000. Macro-habitat features associated with Painted and Indigo Buntings in northeast Texas. Wilson Bulletin 112:108-114.

Lack, D. 1933. Habitat selection in birds with special reference to the effects of afforestation on the Breckland avifauna. Journal of Animal Ecology 2:239-262.

Lanyon, S. M., and C. F. Thompson. 1986. Site fidelity and habitat quality as determinants of settlement pattern in male Painted Buntings. Condor 88:206-210.

Lowther, P. E., S. M. Lanyon, and C. W. Thompson. 1999. Painted Bunting (*Passerina ciris*), The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, New York, USA. [accessed 2012 March 13]. http://bna.birds.cornell.edu/bna/species/398.

MacArthur, R. H., and J. W. MacArthur. 1961. On bird species diversity. Ecology 42:594-598.

Meyers, J. M. 2011. Population densities of Painted Buntings in the southeastern United States. Southeastern Naturalist 10:345-356.

Parmelee, D. F. 1959. The breeding behavior of the Painted Bunting in southern Oklahoma. Bird-Banding 30:1-18.

R Core Team. 2014. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. [accessed 2017 August 15]. http://www.R-project.org/.

Rotenberry, J. T., and J. A. Wiens. 1980. Habitat structure, patchiness, and avian communities in North American steppe vegetation: a multivariate analysis. Ecology 61:1228-1250.

Shugart, H. H., Jr., and D. James. 1973. Ecological succession of breeding bird populations in northwestern Arkansas. Auk 90:62-77.

Šidák, Z. K. 1967. Rectangular confidence regions for the means of multivariate normal distributions. Journal of the American Statistical Association 62:626-633.

Springborn, E. G., and J. M. Meyers. 2005. Home range and survival of breeding Painted Buntings on Sapelo Island, Georgia. Wildlife Society Bulletin 33:1432-1439.

Strong, T. R., and C. E. Bock. 1990. Bird species distribution patterns in riparian habitats in southeastern Arizona. Condor 92:866-885.

U.S. Environmental Protection Agency, Western Ecology Division, Ecoregions of Arkansas, updated 2012 May 24. [accessed 2015 February 3]. http://www.epa.gov/wed/pages/ecoregions/ar_eco.htm.

USGS Patuxent Wildlife Research Center, North American Breeding Bird Survey Results and Analysis 1966-2012, Painted Bunting BBS Trend Map 1966-2010. c2012. United States Department of the Interior, Washington, D. C., USA. [accessed 2012 March 17]. http://www.mbr-pwrc.usgs.gov/bbs/tr2010/tr06010.htm.

Vasseur, P. L., and P. L. Leberg. 2015. Effects of habitat edges and nest-site characteristics on Painted Bunting nest success. Journal of Field Ornithology 86:27-40.

Wiens, J. A. 1969. An approach to the study of ecological relationships among grassland birds. Ornithological Monographs 8:1-93.

Wiens, J. A., and J. T. Rotenberry. 1981. Habitat associations and community structure of birds in shrubsteppe environments. Ecological Monographs 51:21-41.

XLSTAT. 2017. Data analysis and statistics with Microsoft Excel. Addinsoft, New York City, USA. [accessed 2017 September 29]. https://www.xlstat.com/en/.

Appendices

Figure 1.1. Painted Bunting, adult male at Frog Bayou Wildlife Management Area, approximately 3.22 km outside Dyer, AR. Photographed June 16, 2013, by Lauren K. Thead.

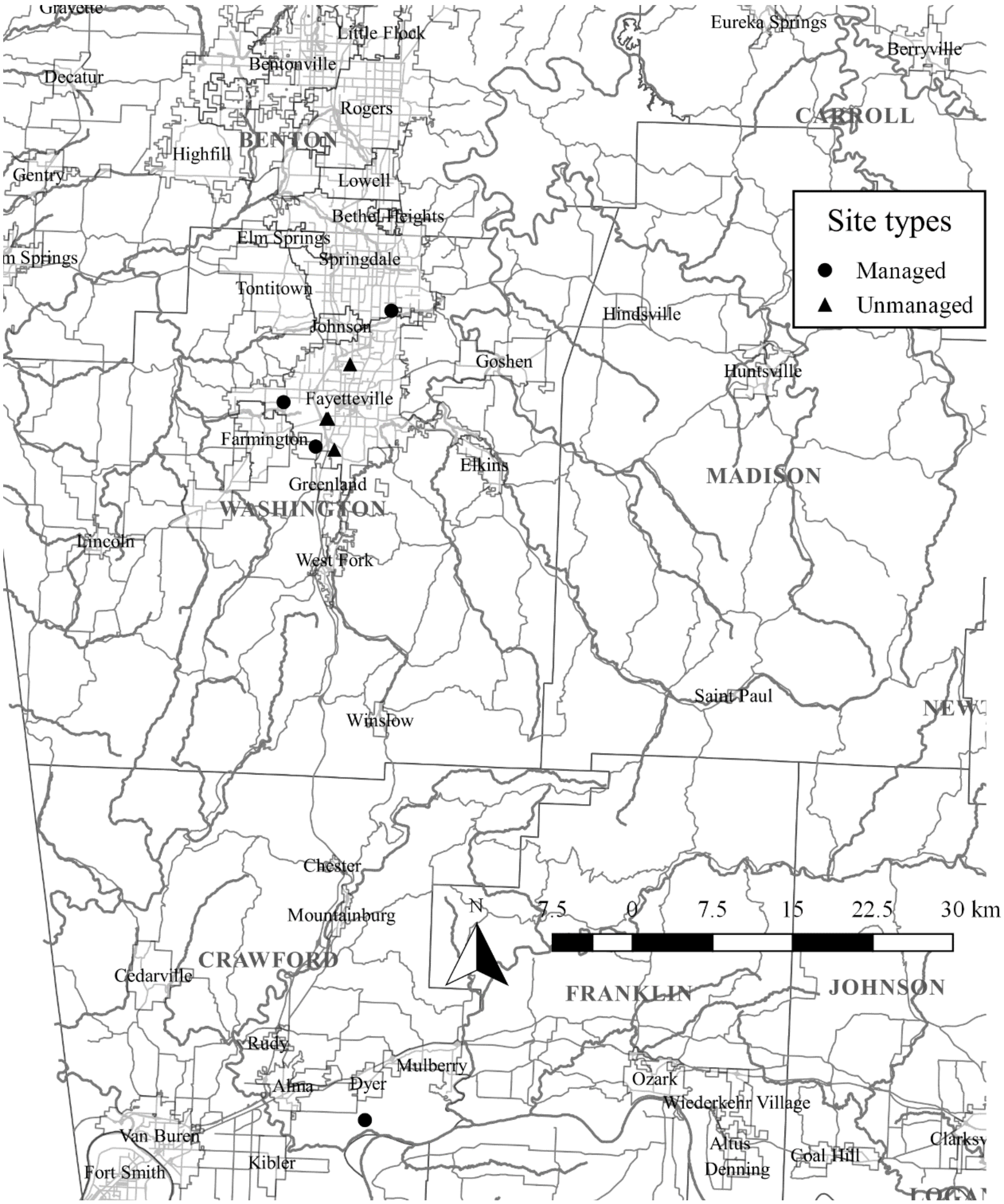

Figure 1.2. Locations of study sites in Washington and Crawford Counties in northwest Arkansas, 2014-2015.

Figure 1.3. Field and woodland edge habitat at Frog Bayou Wildlife Management Area, approximately 3.22 km outside Dyer, AR. Photographed June 11, 2013, by Lauren K. Thead.

Figure 1.4. Field and woodland edge habitat at Callie's Prairie, Lake Fayetteville, in Fayetteville, AR. Photographed June 14, 2014, by Lauren K. Thead.

Figure 1.5. Field and marsh edge habitat at West Side Wastewater Treatment Facility, Fayetteville, AR. Photographed September 20, 2014, by Lauren K. Thead.

Figure 1.6. Vegetation at Kessler Mountain, Fayetteville, AR. Photographed July 16, 2015, by Lauren K. Thead.

Figure 1.7. Field and pine stand at the University of Arkansas Crop, Soil, and Environmental Science Farm, Fayetteville, AR. Photographed June 17, 2014, by Lauren K. Thead.

Figure 1.8. Cedar stand at W. Willoughby Rd., Fayetteville, AR. Photographed July 16, 2014, by Lauren K. Thead.

Figure 1.9. Vegetation at Razorback Rd., Fayetteville, AR. Photographed June 13, 2015, by Lauren K. Thead.


Figure 1.10. Vegetation at S. Olympic Pl., Fayetteville, AR. Photographed June 6, 2013, by Lauren K. Thead.

Table 1.1. Vegetation variable descriptions, average values (means ± 1 SE), and pairwise corrected *p*-values ($\alpha = 3.01 \times 10^{-3}$) for managed (*n* = 9) and unmanaged (*n* = 8) sites from surveys in northwest Arkansas, 2014-2015. Bold-faced variables were shown to be significantly different between unmanaged and managed sites.

Symbol	Description	All sites	Unmanaged sites	Managed sites	Pairwise corrected *p*-values
%GC[a]	Percent ground cover	63.5 ± 5.5	55.6 ± 0.8	70.1 ± 0.8	0.211
S[a]	Number of woody stems per two arms-length transects	15.8 ± 2.4	19.0 ± 3.0	13.0 ± 3.7	0.214
SPT[a]	Number of tree species	2.9 ± 0.4	2.5 ± 0.3	3.3 ± 0.7	0.308
%CC[a]	Percent canopy cover	38.1 ± 4.8	32.9 ± 0.5	42.8 ± 0.8	0.313
CH[a]	Canopy height in m	39.8 ± 4.4	38.6 ± 0.7	41.9 ± 0.6	0.807
T_1[a]	Number of trees 7.62-15.24 cm DBH	5.9 ± 1.3	7.6 ± 2.1	4.4 ± 1.5	0.242
T_2[a]	Number of trees 15.24-22.86 cm DBH	3.2 ± 0.6	2.6 ± 0.4	3.7 ± 1.2	0.388
T_3[a]	Number of trees 22.86-38.1 cm DBH	0.7 ± 0.2	0.3 ± 0.2	1.1 ± 0.4	0.097
T_4[a]	Number of trees >38.1 cm DBH	0.7 ± 0.5	1.0 ± 1.0	0.1 ± 0.2	0.563
MAXHGT[b]	Average maximum height of forb and graminoid vegetation in cm	55.3 ± 5.4	42.8 ± 7.9	66.4 ± 5.2	0.028
TOTHITS[b]	Average total number of contacts	77.5 ± 18.8	57.0 ± 12.4	95.7 ± 33.6	0.306
HIT-10[b]	Average number of contacts in first dm	1.7 ± 0.3	1.7 ± 0.2	1.7 ± 0.5	0.944
CVTOTHIT[b]	Coefficient of variation of average total number of contacts	3.4 ± 0.3	3.9 ± 0.4	2.9 ± 0.2	0.052
CVMAXHGT[b]	Coefficient of variation of maximum height	0.6 ± 0.1	0.7 ± 0.1	0.5 ± 0.1	0.200
HITS-HI[b]	Heterogeneity index of total contacts within samples	22.1 ± 2.4	26.6 ± 4.3	18.1 ± 2.0	0.102
PD-10[c]	**Average proportion of contacts in each dm height interval**	**3.3 ± 0.4**	**2.3 ± 0.2**	**4.3 ± 0.5**	**0.003**
PD-30[c]	**Average proportion of contacts in intervals of 0-1 dm, 1-3 dm, and >3 dm**	**2.3 ± 0.1**	**2.0 ± 0.1**	**2.6 ± 0.1**	**0.001**

[a] From James and Shugart (1970).
[b] From Rotenberry and Wiens (1980).
[c] From Wiens and Rotenberry (1981).

Table 1.2. Number of trees per ha by species (means ± 1 SE) for sites (n = 17) in northwest Arkansas, 2014-2015. Number of trees did not differ significantly ($\alpha = 2.85 \times 10^{-3}$) between unmanaged ($n$ = 8) and managed (n = 9) sites.

Species		All sites	Unmanaged	Managed	Pairwise corrected *p*-values
Eastern red cedar	*Juniperus virginiana* L.	48.9 ± 18.7	41.2 ± 20.6	55.8 ± 31.4	0.702
Shortleaf pine	*Pinus echinata* Mill.	17.4 ± 17.4	37.1 ± 37.1	0.0 ± 0.0	0.351
Loblolly pine	*Pinus taeda* L.	41.4 ± 27.8	88.0 ± 56.2	0.0 ± 0.0	0.161
Red maple	*Acer rubrum* L.	1.5 ± 1.5	3.1 ± 3.1	0.0 ± 0.0	0.351
Silver maple	*Acer saccharinum* L.	2.9 ± 2.0	0.0 ± 0.0	5.5 ± 3.6	0.169
Sugarberry	*Celtis laevigata* Willd.	2.4 ± 1.7	0.0 ± 0.0	4.6 ± 3.1	0.179
Eastern persimmon	*Diospyros virginiana* L.	4.1 ± 3.0	0.0 ± 0.0	7.8 ± 5.4	0.189
Honey locust	*Gleditsia triacanthos* L.	15.0 ± 9.5	9.3 ± 6.5	20.1 ± 17.3	0.347
Black oak	*Quercus velutina* Lam.	6.8 ± 3.4	9.3 ± 6.5	4.6 ± 3.1	0.530
Bitternut hickory	*Carya cordiformis* (Wangenh.) K. Koch	1.0 ± 1.0	0.0 ± 0.0	1.8 ± 1.8	0.347
Osage orange	*Maclura pomifera* (Raf.) Schneid.	8.7 ± 6.0	3.1 ± 3.1	13.7 ± 11.0	0.375
Green ash	*Fraxinus pennsylvanica* Marsh.	16.7 ± 9.4	18.5 ± 18.5	15.1 ± 8.2	0.869
Eastern cottonwood	*Populus deltoides* subsp. *deltoides* Bartram ex Marshall	5.8 ± 5.8	0.0 ± 0.0	11.0 ± 11.0	0.347
Orchard apple	*Malus pumila* Mill.	21.1 ± 15.6	44.8 ± 32.0	0.0 ± 0.0	0.204
Black cherry	*Prunus serotina* Ehrh.	14.5 ± 7.9	18.5 ± 15.3	11.0 ± 7.3	0.665
Bradford pear	*Pyrus calleryana* Decne.	0.5 ± 0.5	1.0 ± 1.0	0.0 ± 0.0	0.351
Winged elm	*Ulmus alata* Michx.	17.4 ± 14.6	0.0 ± 0.0	32.9 ± 27.3	0.262
Slippery elm	*Ulmus rubra* Muhl.	35.1 ± 20.5	12.4 ± 12.4	55.4 ± 36.9	0.295
Total		261.4 ± 41.2	286.2 ± 54.0	239.3 ± 63.3	0.581

Table 1.3. Summary of results of the principal component analysis of mean values of vegetation variables from sites (n = 17) in northwest Arkansas, 2014-2015. Bold-faced values were strongly associated with principal components. Abbreviations for vegetation variables are explained in Table 1.1.

		Component							
		I	II	III	IV	V	VI	VII	VIII
Percentage of total variance accounted for		33.5	20.8	14.6	9.2	6.8	4.3	3.7	2.8
Cumulative percentage of total variance accounted for		33.5	54.3	68.9	78.1	84.9	89.2	92.9	95.7
Correlations to original variables	%GC	**-0.852**	-0.038	-0.152	0.192	0.257	0.062	0.111	0.014
	S	0.520	0.285	-0.564	-0.244	-0.078	-0.444	0.167	-0.010
	SPT	0.117	**0.742**	-0.495	0.030	-0.315	0.158	-0.111	0.065
	%CC	0.312	0.495	0.439	0.530	0.347	0.027	-0.206	-0.026
	CH	**0.618**	0.548	-0.089	0.496	0.035	0.069	-0.106	0.128
	T_1	0.305	0.123	-0.553	-0.153	0.436	0.516	0.268	0.032
	T_2	-0.183	0.482	-0.452	0.039	0.565	-0.363	-0.063	0.222
	T_3	0.175	**0.789**	-0.241	-0.144	-0.473	0.128	-0.079	0.074
	T_4	0.284	0.261	0.199	**0.724**	-0.204	-0.084	0.427	-0.137
	MAXHGT	-0.581	0.561	0.260	-0.171	-0.001	-0.082	0.440	-0.023
	TOTHITS	**-0.727**	-0.366	-0.164	0.308	-0.241	0.046	0.029	0.387
	HIT-10	**-0.666**	-0.466	-0.379	0.337	-0.171	-0.120	0.016	0.132
	CVTOTHIT	**0.834**	-0.395	0.175	-0.008	0.015	0.043	0.170	0.249
	CVMAXHGT	**0.878**	-0.138	0.272	-0.100	-0.007	-0.211	-0.028	0.092
	HITS-HI	**0.860**	-0.281	0.137	-0.111	-0.007	0.059	0.177	0.251
	PD-10	-0.360	0.392	**0.738**	-0.199	0.002	0.051	-0.042	0.251
	PD-30	-0.575	0.590	0.425	-0.270	0.018	-0.027	0.081	0.108

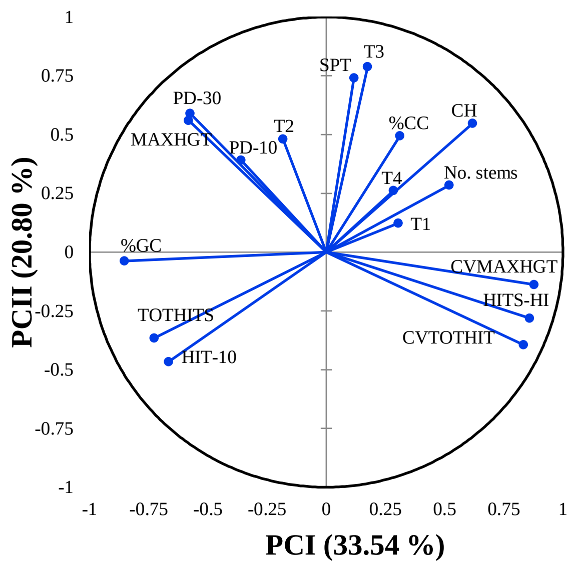

Figure 1.11. Correlation of first and second principal components to 17 vegetation variables used in study. Principal component I is plotted on x-axis and principal component II on y-axis.

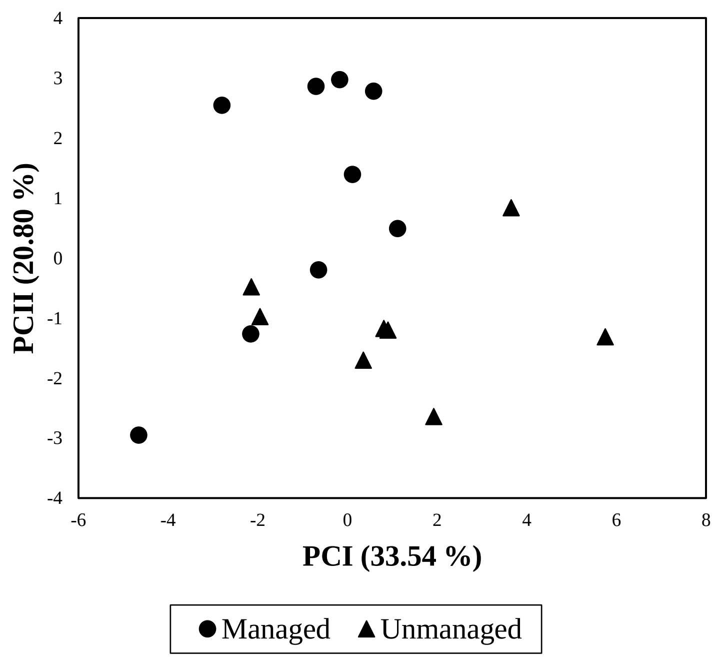

Figure 1.12. Variation in vegetation structure based on principal component factor scores. Principal component I is plotted on x-axis and principal component II on y-axis.

Chapter II: Bird Communities Associated with Singing Painted Buntings in Northwest Arkansas

Abstract

I studied the bird communities associated with breeding male Painted Bunting habitat in northwest Arkansas to gain an understanding of species assemblages in the region and to establish a baseline for further research. Study sites were categorized based on whether or not they were actively managed for wildlife, and 10-minute bird censuses of a visual and auditory nature were conducted on 25-m-radius circular transects. Sites managed for wildlife were not found to have higher community diversity, evenness, and richness than unmanaged sites. One species, Northern Mockingbird, was found to have significantly higher population sizes on unmanaged sites than on managed sites, which suggests that differences in vegetation features—including, potentially, profile diversity, which was found in the previous study to be lower in unmanaged sites—had an effect on its populations. Brown-headed Cowbirds, brood parasites of Painted Buntings and other small songbirds, were among the most frequently detected species in the transects, which suggests that further research to determine their impact on Painted Bunting populations may be needed.

1. Introduction

The bird communities associated with breeding Painted Buntings (*Passerina ciris* Linnaeus) in the characteristic old field and forest edge habitats that they frequent in northwest Arkansas are the focus of this chapter. My research was intended to increase understanding of bird communities in these habitats and to provide a baseline for future research on the Painted Bunting. As previously discussed, although Painted Bunting populations have shown average increases of 1.5% in the Ozark region of Arkansas (USGS c2012), the species as a whole is considered a high conservation concern because it has declined over most of its range (Meyers 2011). There are many reasons for this conservation status, including habitat loss and fragmentation, hazards encountered during migration, and commercial trapping (Lowther et al. 1999). Painted Buntings breeding in the eastern portion of their range, along the Atlantic Coastal Plain from South Carolina and the southern portion of North Carolina, to northeast Florida and Georgia, are considered a more significant conservation concern than western populations (Brittain et al. 2010). Western breeding Painted Bunting populations—which include those found in northwest Arkansas—extend as far west as eastern New Mexico and as far east as central Mississippi (Thompson 1991). The southernmost boundary of their range is northern Mexico, and the northernmost boundaries are central Kansas and the southern edge of Missouri (Thompson 1991).

Habitat fragmentation has been shown to alter bird communities (e.g., Galli et al. 1976; Wilcove et al. 1986; Herkert 1994), most significantly, at least in the case of eastern North American communities, by making an area more enticing to cowbirds, genus *Molothrus* Swainson (Brittingham and Temple 1983; Lowther 1993). Cowbirds are referred to as brood parasites because of their behavior of laying eggs in the nests of other passerine species (Lowther 1993). In Parmelee's study of nesting Painted Buntings in southern Oklahoma, Brown-headed Cowbird (*Molothrus ater* Boddaert) eggs and young were observed in 28.9% of Painted Bunting nests (Parmelee 1959). Research by Wiens (1963) also found prevalent cowbird parasitism in Painted Bunting breeding territory in southern Oklahoma: 71.4% of the nests in the study were parasitized. Cowbird parasitism frequently results in lower rates of both nestling survival and fledging success of the host species (Gates and Gysel 1978; Lowther 1993). Although the cowbird has gradually expanded its range to encompass most of North America, it was historically restricted to short-grass plains (Lowther 1993). Thus, it is possible that some western Painted Bunting populations have been exposed to nest parasitism long enough that they have adapted to cope with it, as observations by Parmelee (1959) indicate. Parmelee observed that Painted Bunting young fledged before or at the same time as the cowbird young in the same nest, suggesting that perhaps competition with cowbirds was not a major detriment, but in one situation, a single cowbird in a nest with two buntings fledged ahead of one of the buntings. However, in their study of the effect of habitat characteristics on Painted Bunting nesting success in south-central Louisiana, Vasseur and Leberg (2015) determined that parasitism by Brown-headed Cowbirds—which was at a rate of at least 23%—probably contributed to nest failures.

Various studies have examined bird communities associated with Painted Bunting habitat in both the eastern and western portions of the breeding range. Recent research by Brittain et al. (2010) on breeding bird communities in the Altamaha River Estuary in Georgia, USA, a site within the eastern range, found Painted Buntings at three of five different habitat types. These three were maritime oak, pine forest, and shrub. Collectively, they contained 47 species of birds. In a study of the changes in breeding bird communities at different ecological successional stages at Pea Ridge National Military Park, Benton County, Arkansas, within the western range of Painted Buntings, Shugart and James (1973) noted breeding Painted Buntings in only one vegetation community type: early successional stage habitat dominated by clonal persimmon trees. An additional 14 species of birds were found in this habitat. The Pea Ridge National Military Park is located well within the Boston Mountains ecoregion (U.S. Environmental Protection Agency 2012), which is also the ecoregion encompassing most of my study sites. Therefore, my study should be reasonably comparable to that of Shugart and James (1973).

The purpose of this study was to determine the bird communities associated with singing male Painted Buntings in northwest Arkansas. I hypothesized that the bird communities would be similar to those previously reported in a clonal persimmon plot by Shugart and James (1973). I expected community diversity, richness, and evenness to be higher in habitats managed for wildlife than in habitats left unmanaged. No previous population studies of the bird communities associated with Painted Buntings had been conducted in Washington and Crawford Counties, where my study sites were located.

2. Materials and Methods

2.1. Study Area

For analysis of bird communities, I used several forest edge, prairie, and old field sites in Crawford County and Washington County, Arkansas. I selected sites based on ease of access and presence of male Painted Buntings during the breeding season. I separated these sites into two categories based on whether or not they were actively managed for wildlife. As described in the previous chapter, wildlife management encompassed a variety of practices.

The sites managed for wildlife included Frog Bayou Wildlife Management Area (GPS coordinates 35.48, -94.13), Callie's Prairie at Lake Fayetteville (36.15, -94.12), West Side Wastewater Treatment Facility (36.06, -94.23), and Kessler Mountain (36.02, -94.20). Unmanaged sites included the University of Arkansas Crop, Soil, and Environmental Science Farm (36.09, -94.17); W. Willoughby Rd., Fayetteville (36.02, -94.17); Razorback Rd., Fayetteville (36.05, -94.18); N. Broyles Rd., Fayetteville (36.07, -94.23); and S. Olympic Pl., Fayetteville (36.05, -94.18). All sites, with the exception of Frog Bayou WMA, are located in Washington County and within the Boston Mountains ecoregion (U.S. Environmental Protection

Agency 2012). Frog Bayou WMA, the only study site in Crawford County, is within the Arkansas Valley ecoregion.

2.2. Study Design

From May to July during the 2014 and 2015 field seasons, I located 15 male Painted Buntings at study sites in northwest Arkansas. Following methods developed by Hutto et al. (1986), I conducted four bird surveys lasting 10 minutes each within each 25-meter-radius circular transect, centered on a breeding male Painted Bunting's singing perch. During the observation periods, birds were detected both visually and aurally. Birds flying over the count area, birds detected in vegetation outside the count area, and birds detected after the 10-minute mark were recorded separately from birds detected within the main survey parameters. It is likely that the allotted time was sufficient for detection of breeding birds present in the transects, because 10-minute point counts generally enable detection of at least 75% of the birds that would be detected in 20-minute counts (Hutto et al. 1986). Breeding territories for the Painted Bunting have not been quantified in Arkansas, but studies in the neighboring states of Oklahoma (Parmelee 1959) and Missouri (Norris 1982; Norris and Elder 1982) suggest that territories in the western *ciris* populations may measure between 1.13 ha and 3.92 ha. However, determining territory sizes for Painted Buntings was not feasible in this study because of the difficulty of tracking the movements of Painted Buntings over extensive areas.

In compliance with the methods of Hutto et al. (1986), the mean number of individuals detected per count and frequency of occurrence, or the proportion of counts on which a species was detected, were calculated from the raw data. Frequency of occurrence was determined for species detected within 25 m and the 10-minute time interval as well as for all species, whether or not they were detected within the transect boundaries and time limit. The detection ratio, or the ratio of detections beyond 25 m or outside the time interval to the total number of detections, was also calculated for each species.

Bird diversity and evenness were calculated using methods described in Hill (1973). Measurements of richness within the 25-m-radius transects as well as over a wider area (i.e., the limit of my ability to detect birds by either sight or sound) were also recorded. Birds detected within transects during the 10-minute periods were included in the calculations of diversity, evenness, and richness within 25 m. The measure of species richness at the local or neighborhood level included the species detected within survey parameters and those detected outside the 25-m transect or outside the time interval. Pairwise *t*-tests with a Šidák correction (Šidák 1967) to account for experiment-wise error were calculated with Microsoft Excel (2013). These were used to detect significant differences in populations of species at managed and unmanaged sites, as well as differences in community diversity, richness, and evenness between managed and unmanaged sites.

3. Results

The mean number of individuals per count, frequency of detection within 25 m, frequency of detection beyond 25 m, and detection ratio for the 77 species detected at the sites are presented in Table 2.1. Several species had high detection ratios, indicating that they were observed almost exclusively outside the transects. These included wading birds, such as Great Blue Herons and Green Herons; raptors, such as Red-tailed Hawks and Red-shouldered Hawks; and vultures, such as the Turkey Vulture. Lower detection ratios are indicative of species that were most frequently found within the time limits and circular transects (Hutto et al. 1986). Therefore, it is appropriate to consider species with low detection ratios as being more representative of the breeding bird communities than are high-detection-ratio species, which may be wide-ranging and spend comparatively little time in the transect circles (Hutto et al. 1986).

The 15 most abundant species across all sites (Table 2.1), from most abundant to least, were Northern Cardinal, European Starling, Indigo Bunting, Carolina Chickadee, Painted Bunting, American Robin, American Goldfinch, Carolina Wren, Northern Mockingbird, American Crow, House Finch, Mourning Dove, Barn Swallow, Brown-headed Cowbird, and Red-winged Blackbird. Most of these species had very high frequencies of detection, as well, with the exception of American Robin, House Finch, Mourning Dove, Barn Swallow, and Red-winged Blackbird, which tended to be found infrequently but in relatively large groups within the transects.

The 17 highest frequencies of detection within 25m, from highest to lowest, were for Painted Bunting, Northern Cardinal, Indigo Bunting, Carolina Chickadee, Carolina Wren, Northern Mockingbird, Blue-gray Gnatcatcher, American Crow, European Starling, White-eyed Vireo, American Goldfinch, Brown-headed Cowbird, Blue Jay, Field Sparrow, Tufted Titmouse, American Robin, and Mourning Dove. The list of the 17 species with the highest frequencies of detection at the local level is somewhat similar, except for its inclusion of Blue Grosbeak and Scissor-tailed Flycatcher and exclusion of American Robin and Field Sparrow. The frequency of detection of Painted Buntings was 1.000 due to the circular transects being centered on singing perches of breeding males of that species.

The bird community diversity, evenness, richness at 25 m, and local richness were slightly higher in managed habitats than in unmanaged habitats (Table 2.2), but the *t*-tests conducted on these data ($\alpha = 0.01$) did not indicate any significant differences between site types. Therefore, it is not possible to reject the null hypothesis that bird communities are the same in unmanaged and managed sites. Total diversity and evenness values for all circular transects in the study were 23.3 and 32.4, respectively.

The *t*-tests conducted on the 62 species observed within the transects and time limit ($\alpha = 8.27 \times 10^{-4}$) indicated that only Northern Mockingbird showed a significant difference in population size between managed and unmanaged sites, $t(7) = 6.35$, $p = 3.83 \times 10^{-4}$ (Fig. 2.1). Northern Mockingbirds were more numerous in unmanaged sites than in managed sites.

4. Discussion

The hypothesis that sites managed for wildlife populations would contain more diverse breeding bird communities was not supported by the data. Managed and unmanaged sites in the study area displayed roughly equal measures of bird diversity, evenness, and richness. Increasing the number of sites from the relatively small sample of 15 might improve the chances of detecting differences in avian community composition between habitat types. Alternatively, bird communities associated with breeding Painted Buntings might not be greatly affected by either urban sprawl or by management for wildlife conservation purposes.

Northern Mockingbird was the only species whose populations were determined to be significantly different between site types, being higher in unmanaged sites than in managed sites. Typical breeding habitats for Northern Mockingbirds in Arkansas are unforested areas with shrubs and low-growing, dense vegetation (James and Neal 1986). In the previous chapter on vegetation structure and composition within sites, vertical heterogeneity of forb and graminoid vegetation was found to be lower in unmanaged sites than in managed, which may indicate that breeding Northern Mockingbirds are associated with habitats containing high homogeneity in vertical vegetation structure. The 11.3-m-radius vegetation plots were only a fraction of the size of the bird survey plots, however, so they may not accurately represent the vegetation communities found within the bird survey boundaries. Another possible explanation for the difference in Northern Mockingbird abundances is that mockingbirds may have avoided managed sites due to their comparatively close proximity to mature forest tracts. Managed sites at Callie's Prairie at Lake Fayetteville, Frog Bayou Wildlife Management Area, and Kessler Mountain were surrounded by a variety of montane and riparian forest types, while unmanaged sites were located primarily in urban and residential areas.

The lists of the most abundant and the most frequently detected species found at the field sites provide an understanding of bird communities associated with breeding Painted Buntings in northwest Arkansas. The majority of the common species encountered at my field sites are characteristic birds of forest edge environments, as would be expected given the present habitat structure.

Most of the 15 species noted by Shugart and James (1973) in a clonal persimmon plot at Pea Ridge National Military Park were also found in my study, Common Nighthawk (*Chordeiles minor* J. R. Forster) and Blue-winged Warbler (*Vermivora cyanoptera* Olson and Reveal) being the two exceptions. Common Nighthawks are crepuscular (Poulin et al. 2011) and were probably missed as a result of the surveys being conducted from morning to early afternoon. In northwest Arkansas, the Blue-winged Warbler typically occurs during the breeding season in overgrown field habitats with dense stands of saplings, but it is not commonly found in forest edge habitats (James and Neal 1986). Of the 15 most abundant species found in my study sites, only four, including Painted Bunting, Northern Cardinal, American Goldfinch, and Indigo Bunting, were found in the clonal persimmon plot by Shugart and James (1973). Additionally, several of the most frequently detected species in my study were not associated with breeding Painted Buntings in Shugart and James's study.

The eastern focus of the study by Brittain et al. (2010) makes comparisons between it and my Arkansas study less useful, but valuable insights can still be drawn from the data. For example, Painted Bunting was the fifth most abundant species on my sites in Arkansas, and the species with the fifth highest breeding density in shrub habitat in the Altamaha River Estuary (Brittain et al. 2010). In the three habitat types in which Painted Buntings were found, Brittain et al. (2010) observed 47 species, many of which were found at my sites, as well. However, four species—Wilson's Plover (*Charadrius wilsonia* Ord), Willet (*Tringa semipalmata* Gmelin), Common Ground-Dove (*Columbina passerina* Linnaeus), and Boat-tailed Grackle (*Quiscalus major* Vieillot)—were not found at my sites because they either do not occur in Arkansas (e.g., Wilson's Plover and Boat-tailed Grackle), occur rarely (e.g., Common Ground-Dove), or occur only as migrants (e.g., Willet) (James and Neal 1986). Additionally, five species detected in the Altamaha River Estuary study (Brittain et al. 2010) were not detected at any of my sites, even though they are regularly occurring breeding species in Arkansas (James and Neal 1986): Yellow-crowned Night-Heron (*Nyctanassa violacea* Linnaeus), Red-headed Woodpecker (*Melanerpes erythrocephalus* Linnaeus), Yellow-throated Vireo (*Vireo flavifrons* Vieillot), Brown-headed Nuthatch (*Sitta pusilla* Latham), and Hooded Warbler (*Setophaga citrina* Boddaert). This was likely due to the study sites containing unsuitable habitat for these species, as Red-headed Woodpecker, Yellow-throated Vireo, and Hooded Warbler occur mainly in mature forests; Yellow-crowned Night-Heron in wooded swamps and bottomlands; and Brown-headed Nuthatch in pine woods (James and Neal 1986).

Brown-headed Cowbird was the 14th-most abundant species and the 12th-most frequently detected species in my circular transects, outnumbering some of the characteristic species of early successional stage habitat, such as Field Sparrow and Blue Grosbeak. Because of the severe threat that cowbirds pose to nesting Painted Buntings (Lowther et al. 1999), their relative abundance on these breeding territories is concerning, particularly considering that their populations were not lower on habitats managed for wildlife conservation than on those left unmanaged. Further studies on nesting behavior of Painted Buntings at these sites and others would be useful to determine whether habitat differences—in particular, fragmentation of woodlands due to urbanization—affect rates of cowbird parasitism on nests.

The most likely explanation for the differences in bird communities between my sites and the sites sampled by Shugart and James (1973) is that my sites were not close to uniform in vegetation composition, but instead were primarily forest edge habitats, with a mixture of saplings, shrubs, and medium-sized trees adjacent to relatively large expanses of forbs and graminoids. It is possible that habitats utilized by breeding Painted Buntings in Benton County, Arkansas commonly differ in vegetation structure and composition from Arkansas habitats in Washington and Crawford Counties.

Literature Cited

Brittain, R. A., V. J. Meretsky, and C. B. Craft. 2010. Avian communities of the Altamaha River Estuary in Georgia, USA. Wilson Journal of Ornithology 122:532-544.

Brittingham, M. C., and S. A. Temple. 1983. Have cowbirds caused forest songbirds to decline? BioScience 33:31-35.

Galli, A. E., C. F. Leck, and R. T. T. Forman. 1976. Avian distribution patterns in forest islands of different sizes in central New Jersey. Auk 93:356-364.

Gates, J. E., and L. W. Gysel. 1978. Avian nest dispersion and fledging success in field-forest ecotones. Ecology 59:871-883.

Herkert, J. R. 1994. The effects of habitat fragmentation on Midwestern grassland bird communities. Ecological Applications 4:461-471.

Hill, M. O. 1973. Diversity and evenness: a unifying notation and its consequences. Ecology 54:427-432.

Hutto, R. L., S. M. Pletschet, and P. Hendricks. 1986. A fixed-radius point count method for nonbreeding and breeding season use. Auk 103:593-602.

James, D. A., and J. C. Neal. 1986. Arkansas birds: their distribution and abundance. The University of Arkansas Press, Fayetteville, Arkansas, USA.

Lowther, P.E. 1993. Brown-headed Cowbird (*Molothrus ater*), The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, New York, USA. [accessed 2012 March 13]. http://bna.birds.cornell.edu/bna/species/047doi:10.2173/bna.47.

Lowther, P. E., S. M. Lanyon, and C. W. Thompson. 1999. Painted Bunting (*Passerina ciris*), The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, New York, USA. [accessed 2012 March 13]. http://bna.birds.cornell.edu/bna/species/398.

Meyers, J. M. 2011. Population densities of Painted Buntings in the southeastern United States. Southeastern Naturalist 10:345-356.

Norris, D. J. 1982. Habitat ecology of the Painted Bunting on the Ozark Plateau. MS thesis, University of Missouri-Columbia, Columbia.

Norris, D. J., and W. H. Elder. 1982. Distribution and habitat characteristics of the Painted Bunting in Missouri. Transactions of the Missouri Academy of Science 16:77-83.

Parmelee, D. F. 1959. The breeding behavior of the Painted Bunting in southern Oklahoma. Bird-Banding 30:1-18.

Poulin, R. G., S. D. Grindal, and R. M. Brigham. 2011. Common Nighthawk (*Chordeiles minor*), The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, New York, USA. [accessed 2016 March 8]. https://birdsna.org/Species-Account/bna/species/comnig.

Shugart, H. H., Jr., and D. James. 1973. Ecological succession of breeding bird populations in northwestern Arkansas. Auk 90:62-77.

Šidák, Z. K. 1967. Rectangular confidence regions for the means of multivariate normal distributions. Journal of the American Statistical Association 62:626-633.

Thompson, C. W. 1991. The sequence of molts and plumages in Painted Buntings and implications for theories of delayed plumage maturation. Condor 93:209-235.

U.S. Environmental Protection Agency, Western Ecology Division, Ecoregions of Arkansas, updated 2012 May 24. [accessed 2015 February 3]. http://www.epa.gov/wed/pages/ecoregions/ar_eco.htm.

USGS Patuxent Wildlife Research Center, North American Breeding Bird Survey Results and Analysis 1966-2012, Painted Bunting BBS Trend Map 1966-2010. c2012. United States Department of the Interior, Washington, D. C., USA. [accessed 2012 March 17]. http://www.mbr-pwrc.usgs.gov/bbs/tr2010/tr06010.htm.

Vasseur, P. L., and P. L. Leberg. 2015. Effects of habitat edges and nest-site characteristics on Painted Bunting nest success. Journal of Field Ornithology 86:27-40.

Wiens, J. A. 1963. Aspects of cowbird parasitism in southern Oklahoma. Wilson Bulletin 75:130-139.

Wilcove, D. S., C. H. McLellan, and A. P. Dobson. 1986. Habitat fragmentation in the temperate zone. M. E. Soulé, editor. Conservation Biology. The science of scarcity and diversity. Sinauer Associates, Sunderland, Massachusetts, USA.

Appendices

Table 2.1. Relative indices of bird abundance from point counts (*n* = 60) conducted in northwest Arkansas, 2014-2015. Bold-faced names are also mentioned in Shugart and James (1973) as occurring with Painted Buntings.

Species		Mean[a]	f(25m)[b]	f(l)[c]	Detection ratio[d]
Northern Cardinal	***Cardinalis cardinalis* Linnaeus**	**288.333**	**0.933**	**0.950**	**0.018**
European Starling	*Sturnus vulgaris* Linnaeus	226.667	0.417	0.417	0.000
Indigo Bunting	***Passerina cyanea* Linnaeus**	**188.333**	**0.833**	**0.833**	**0.000**
Carolina Chickadee	*Poecile carolinensis* Audubon	186.667	0.750	0.750	0.000
Painted Bunting	***Passerina ciris* Linnaeus**	**115.000**	**1.000**	**1.000**	**0.000**
American Robin	*Turdus migratorius* Linnaeus	113.333	0.350	0.367	0.045
American Goldfinch	***Spinus tristis* Linnaeus**	**106.667**	**0.400**	**0.417**	**0.040**
Carolina Wren	*Thryothorus ludovicianus* Latham	105.000	0.667	0.667	0.000
Northern Mockingbird	*Mimus polyglottos* Linnaeus	100.000	0.517	0.533	0.031
American Crow	*Corvus brachyrhynchos* Brehm	86.667	0.467	0.717	0.349
House Finch	*Haemorhous mexicanus* Müller	85.000	0.300	0.300	0.000
Mourning Dove	*Zenaida macroura* Linnaeus	80.000	0.350	0.450	0.222
Barn Swallow	*Hirundo rustica* Linnaeus	76.667	0.250	0.333	0.250
Brown-headed Cowbird	*Molothrus ater* Boddaert	75.000	0.383	0.383	0.000
Red-winged Blackbird	*Agelaius phoeniceus* Linnaeus	73.333	0.217	0.250	0.133
Blue-gray Gnatcatcher	*Polioptila caerulea* Linnaeus	70.000	0.483	0.500	0.033
Eastern Bluebird	*Sialia sialis* Linnaeus	65.000	0.333	0.350	0.048
Blue Jay	***Cyanocitta cristata* Linnaeus**	**61.667**	**0.367**	**0.383**	**0.043**
Field Sparrow	***Spizella pusilla* Wilson**	**60.000**	**0.367**	**0.367**	**0.000**
Scissor-tailed Flycatcher	*Tyrannus forficatus* Gmelin	56.667	0.333	0.383	0.130
White-eyed Vireo	*Vireo griseus* Boddaert	55.000	0.417	0.433	0.038
Tufted Titmouse	*Baeolophus bicolor* Linnaeus	41.667	0.367	0.400	0.083
Blue Grosbeak	***Passerina caerulea* Linnaeus**	**40.000**	**0.333**	**0.417**	**0.200**

Table 2.1. (Cont.)

Species		Mean[a]	f(25m)[b]	f(l)[c]	Detection ratio[d]
Eastern Towhee	***Pipilo erythrophthalmus* Linnaeus**	**30.000**	**0.200**	**0.217**	**0.077**
Chimney Swift	*Chaetura pelagica* Linnaeus	26.667	0.033	0.217	0.846
Downy Woodpecker	*Picoides pubescens* Linnaeus	25.000	0.250	0.300	0.167
Brown Thrasher	***Toxostoma rufum* Linnaeus**	**25.000**	**0.217**	**0.267**	**0.188**
Summer Tanager	*Piranga rubra* Linnaeus	25.000	0.183	0.183	0.000
Red-eyed Vireo	*Vireo olivaceus* Linnaeus	21.667	0.183	0.200	0.083
Dickcissel	*Spiza americana* Gmelin	20.000	0.133	0.133	0.000
Fish Crow	*Corvus ossifragus* Wilson	20.000	0.100	0.150	0.333
Common Grackle	*Quiscalus quiscula* Linnaeus	20.000	0.050	0.050	0.000
Yellow-billed Cuckoo	*Coccyzus americanus* Linnaeus	18.333	0.167	0.183	0.091
Common Yellowthroat	*Geothlypis trichas* Linnaeus	18.333	0.167	0.167	0.000
Red-bellied Woodpecker	*Melanerpes carolinus* Linnaeus	16.667	0.150	0.200	0.250
Yellow-breasted Chat	***Icteria virens* Linnaeus**	**15.000**	**0.150**	**0.167**	**0.100**
House Wren	*Troglodytes aedon* Vieillot	15.000	0.150	0.150	0.000
Eastern Meadowlark	*Sturnella magna* Linnaeus	15.000	0.083	0.100	0.167
Bell's Vireo	*Vireo bellii* Audubon	13.333	0.083	0.083	0.000
Black-and-white Warbler	*Mniotilta varia* Linnaeus	10.000	0.067	0.083	0.200
Greater Roadrunner	*Geococcyx californianus* Lesson	10.000	0.067	0.067	0.000
Northern Rough-winged Swallow	*Stelgidopteryx serripennis* Audubon	10.000	0.033	0.033	0.000
Chipping Sparrow	*Spizella passerina* Bechstein	8.333	0.083	0.117	0.286
Red-shouldered Hawk	*Buteo lineatus* Gmelin	8.333	0.083	0.100	0.167
Killdeer	*Charadrius vociferus* Linnaeus	8.333	0.067	0.117	0.429
Great Crested Flycatcher	*Myiarchus crinitus* Linnaeus	6.667	0.050	0.067	0.250
Rock Pigeon	*Columba livia* Gmelin	6.667	0.017	0.050	0.667
Eastern Phoebe	*Sayornis phoebe* Latham	5.000	0.050	0.117	0.571

Table 2.1. (Cont.)

Species		Mean[a]	f(25m)[b]	f(l)[c]	Detection ratio[d]
Eastern Kingbird	***Tyrannus tyrannus* Linnaeus**	**5.000**	**0.050**	**0.050**	**0.000**
Gray Catbird	*Dumetella carolinensis* Linnaeus	5.000	0.050	0.050	0.000
Ruby-throated Hummingbird	*Archilochus colubris* Linnaeus	3.333	0.033	0.067	0.500
Eastern Wood-Pewee	*Contopus virens* Linnaeus	3.333	0.033	0.067	0.500
Northern Flicker	*Colaptes auratus* Linnaeus	3.333	0.033	0.033	0.000
Red-tailed Hawk	*Buteo jamaicensis* Gmelin	3.333	0.017	0.133	0.875
American Kestrel	*Falco sparverius* Linnaeus	1.667	0.017	0.050	0.667
Northern Bobwhite	***Colinus virginianus* Linnaeus**	**1.667**	**0.017**	**0.050**	**0.667**
White-breasted Nuthatch	*Sitta carolinensis* Latham	1.667	0.017	0.050	0.667
Barred Owl	*Strix varia* Barton	1.667	0.017	0.017	0.000
Acadian Flycatcher	*Empidonax virescens* Vieillot	1.667	0.017	0.017	0.000
Northern Parula	*Setophaga americana* Linnaeus	1.667	0.017	0.017	0.000
Yellow-throated Warbler	*Setophaga dominica* Linnaeus	1.667	0.017	0.017	0.000
Prothonotary Warbler	*Protonotaria citrea* Boddaert	1.667	0.017	0.017	0.000
Turkey Vulture	*Cathartes aura* Linnaeus	0.000	0.000	0.267	1.000
Cattle Egret	*Bubulcus ibis* Linnaeus	0.000	0.000	0.150	1.000
Great Blue Heron	*Ardea herodias* Linnaeus	0.000	0.000	0.067	1.000
Great Egret	*Ardea alba* Linnaeus	0.000	0.000	0.067	1.000
Green Heron	*Butorides virescens* Linnaeus	0.000	0.000	0.067	1.000
Black Vulture	*Coragyps atratus* Bechstein	0.000	0.000	0.033	1.000
Pileated Woodpecker	*Dryocopus pileatus* Linnaeus	0.000	0.000	0.033	1.000
Purple Martin	*Progne subis* Linnaeus	0.000	0.000	0.033	1.000
House Sparrow	*Passer domesticus* Linnaeus	0.000	0.000	0.033	1.000
Canada Goose	*Branta canadensis* Linnaeus	0.000	0.000	0.017	1.000
Broad-winged Hawk	*Buteo platypterus* Vieillot	0.000	0.000	0.017	1.000

Table 2.1. (Cont.)

Species		Mean[a]	f(25m)[b]	f(l)[c]	Detection ratio[d]
Belted Kingfisher	*Megaceryle alcyon* Linnaeus	0.000	0.000	0.017	1.000
Pine Warbler	*Setophaga pinus* Wilson	0.000	0.000	0.017	1.000
Orchard Oriole	*Icterus spurius* Linnaeus	0.000	0.000	0.017	1.000
Baltimore Oriole	***Icterus galbula* Linnaeus**	**0.000**	**0.000**	**0.017**	**1.000**

[a] Mean number of individuals per 25-m-radius point count (x100).
[b] Proportion of 25-m-radius counts within which the species was detected.
[c] Proportion of local counts within which the species was detected.
[d] Number of counts (*n*) at which the species was detected only beyond 25 m, divided by the total number of counts at which the species was recorded.

Table 2.2. Average diversity, evenness, richness at 25 m, and local richness for bird communities by site type from point counts (n = 60) conducted in northwest Arkansas, 2014-2015. Values are means ± 1 SE. Pairwise t-tests (α = 0.01) indicated no significant differences between unmanaged (n = 28) and managed (n = 32) sites.

Sites	Diversity	Evenness	Richness 25 m	Richness local
Unmanaged	12.1 ± 0.7	15.7 ± 0.9	22.0 ± 1.7	27.0 ± 2.4
Managed	14.6 ± 1.3	18.5 ± 1.2	24.1 ± 1.2	29.8 ± 1.0

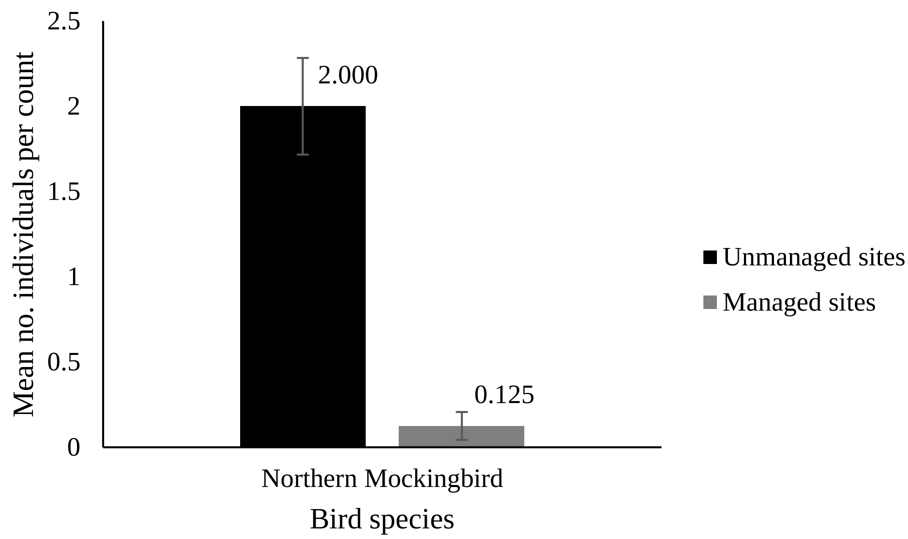

Figure 2.1. Statistically significant contrasts between Northern Mockingbirds found in unmanaged (n = 28) and managed (n = 32) sites in northwest Arkansas, 2014-2015 ($p < 8.27 \times 10^{-4}$). Bars represent means ± 1 SE.

Concluding Discussion

The aim of this thesis was to quantify vegetation characteristics and bird communities associated with breeding male Painted Buntings in northwest Arkansas, a region in which relatively few studies of Painted Bunting habitat and its associated bird populations have been conducted. Because the Painted Bunting is an imperiled species of fairly high conservation priority (Lowther et al. 1999; Meyers 2011), such studies are particularly valuable. In Chapter I, I quantified the structure and species composition of plant communities associated with breeding male Painted Buntings to determine whether vegetation features differed between unmanaged sites and sites managed for wildlife. In Chapter II, I quantified the bird communities associated with breeding Painted Buntings to determine whether differences existed between managed and unmanaged site types. These data should help establish a baseline for Painted Bunting habitat research in Arkansas, and may also provide insight into how to optimize management practices for conservation purposes.

As described in Chapter I, vegetation sampling was conducted within 11.3-meter-radius circular plots centered on breeding male Painted Bunting singing perches at multiple sites in Washington and Crawford Counties, Arkansas (Fig. 1.2). Ground cover; canopy cover; canopy height; plant stem count; and number, species, and DBH of all trees at least 7.62 cm DBH were recorded using methods adapted from James and Shugart (1970). A Wiens pole (Wiens 1969) was used in each circular plot to record the number and position of forb and graminoid stems. Methods developed by Rotenberry and Wiens (1980) and Wiens and Rotenberry (1981) were then used to calculate the vertical and horizontal structure of the forbs and graminoids at the study sites. The original 17 vegetation variables (Table 1.1) were reduced after running a PCA to determine to what extent they were correlated (Table 1.3 and Fig. 1.11), and a MANOVA was performed to identify whether differences existed between managed and unmanaged site types. I used pairwise *t*-tests with a Šidák error correction (Šidák 1967) to identify differences between site types for the 17 individual variables.

There were 18 species of trees measuring at least 7.62 cm DBH at the study sites, the most abundant species being eastern red cedar, and the least abundant being Bradford pear (Table 1.2). While the PCA results suggested that managed and unmanaged sites might be somewhat differentiated (Fig. 1.12), the results of the MANOVA indicated no significant differences between site types in terms of vegetation structure and composition, $F(14, 2) = 1.119$, $p = 0.569$; Wilks's $\Lambda = 0.113$. The only individual variables that differed significantly between site types were two measures of vertical heterogeneity, both of which were higher in managed than in unmanaged sites. Although I am uncertain of the reason for this difference in vertical heterogeneity at my study sites, the variable was shown to differ between plant species in Great Basin shrubsteppe habitats (Wiens and Rotenberry 1981). Therefore, further studies to identify all herbaceous plant species on Painted Bunting territories in northwest Arkansas might be helpful to determine if this is a significant factor. Management practices at the study sites were not quantified, but may have contributed to the detected differences in vertical heterogeneity. A comparison of my research with that of Shugart and James (1973) shows that my study sites had a higher percentage of canopy cover (approximately 38%) than the clonal persimmon plot at Pea Ridge National Military Park (17%). Relatively extensive canopy cover may be beneficial to breeding and nesting Painted Buntings (Vasseur and Leberg 2015).

In Chapter II, I quantified the bird communities associated with Painted Buntings in northwest Arkansas to determine whether these communities differed between site types. I expected that sites managed for wildlife would show higher bird community diversity, richness, and evenness than unmanaged sites. As in the previous chapter, sites were selected in Washington and Crawford Counties, Arkansas. Adapting methods from Hutto et al. (1986), I surveyed birds both visually and aurally in 10-minute point counts on 25-m-radius circular transects, which were centered on the singing perches of breeding male Painted Buntings. All birds detected after the 10-minute mark, in vegetation outside the count area, or flying over the count area were recorded separately. Species variables calculated from these data included mean number of individuals per count, frequency of detection within 25 m, frequency of detection beyond 25 m (which also included flyover birds and those detected after the 10-minute mark), and detection ratio. Community variables of diversity, evenness, richness at 25 m, and local richness (i.e., all species detected both within and outside 25 m) were also determined according to methods developed by Hill (1973). Pairwise *t*-tests with a Šidák correction (Šidák 1967) were used to determine whether measures of diversity, richness, and evenness differed between site types.

Of the 77 species found at the study sites, the most abundant and most frequently detected included Northern Cardinal, European Starling, Indigo Bunting, Carolina Chickadee, Painted Bunting, American Goldfinch, Carolina Wren, Northern Mockingbird, American Crow, and Brown-headed Cowbird (Table 2.1). The species that were most frequently found within the 25-m transects during the 10-minute point counts showed correspondingly low detection ratios, while species that were seen mostly outside 25 m, such as herons, raptors, and vultures, had high detection ratios. As determined by *t*-tests, no significant differences were detected in species diversity, richness, and evenness between site types (Table 2.2). This may have been due to the relatively small sample sizes in my study, or it could suggest that land management practices do not significantly affect bird communities associated with Painted Buntings in northwest

Arkansas. The *t*-tests also showed that Northern Mockingbird was the only species whose population sizes differed between site types, with higher populations occurring within unmanaged sites (Fig. 2.1). In Chapter I, unmanaged sites were shown to have lower measures of vertical heterogeneity of forbs and graminoids, so it is possible that Northern Mockingbirds were attracted to this habitat feature. In Arkansas, mockingbirds tend to be found in open areas with low-growing shrubs and other low, dense vegetation (James and Neal 1986). The close proximity of most of the managed sites to mature forest tracts may also have contributed to mockingbirds' decreased presence on them.

Multiple similarities exist between the bird communities quantified in my study and those quantified in the research of Shugart and James (1973), at Pea Ridge, and Brittain et al. (2010), in the Altamaha River Estuary. There are several key differences, as well, which are probably related to the particular locations and habitat types sampled. Prior to my research, there had been no studies quantifying the vegetation characteristics and bird communities associated with breeding Painted Buntings in Washington and Crawford Counties, Arkansas, which apparently have characteristically different habitat from the territories of Painted Buntings in both the Atlantic Coastal Plain and near the Arkansas-Missouri border.

Finally, the prevalence of Brown-headed Cowbirds—common brood parasites that frequently target Painted Bunting nests (Parmelee 1959; Wiens 1963; Lowther 1993), sometimes causing nest failure (Vasseur and Leberg 2015)—at my study sites is potentially a cause for concern. I suggest that further research should be done on the nesting habits of Painted Buntings in northwest Arkansas to examine both the impact of cowbird parasitism on their populations and the effect of land management practices on Brown-headed Cowbirds.

Literature Cited

Brittain, R. A., V. J. Meretsky, and C. B. Craft. 2010. Avian communities of the Altamaha River Estuary in Georgia, USA. Wilson Journal of Ornithology 122:532-544.

Hill, M. O. 1973. Diversity and evenness: a unifying notation and its consequences. Ecology 54:427-432.

Hutto, R. L., S. M. Pletschet, and P. Hendricks. 1986. A fixed-radius point count method for nonbreeding and breeding season use. Auk 103:593-602.

James, D. A., and J. C. Neal. 1986. Arkansas birds: their distribution and abundance. The University of Arkansas Press, Fayetteville, Arkansas, USA.

James, F. C., and H. H. Shugart, Jr. 1970. A quantitative method of habitat description. Audubon Field Notes 24:727-736.

Lowther, P.E. 1993. Brown-headed Cowbird (*Molothrus ater*), The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, New York, USA. [accessed 2012 March 13]. http://bna.birds.cornell.edu/bna/species/047doi:10.2173/bna.47.

Lowther, P. E., S. M. Lanyon, and C. W. Thompson. 1999. Painted Bunting (*Passerina ciris*), The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, New York, USA. [accessed 2012 March 13]. http://bna.birds.cornell.edu/bna/species/398.

Meyers, J. M. 2011. Population densities of Painted Buntings in the southeastern United States. Southeastern Naturalist 10:345-356.

Parmelee, D. F. 1959. The breeding behavior of the Painted Bunting in southern Oklahoma. Bird-Banding 30:1-18.

Rotenberry, J. T., and J. A. Wiens. 1980. Habitat structure, patchiness, and avian communities in North American steppe vegetation: a multivariate analysis. Ecology 61:1228-1250.

Shugart, H. H., Jr., and D. James. 1973. Ecological succession of breeding bird populations in northwestern Arkansas. Auk 90:62-77.

Šidák, Z. K. 1967. Rectangular confidence regions for the means of multivariate normal distributions. Journal of the American Statistical Association 62:626-633.

Vasseur, P. L., and P. L. Leberg. 2015. Effects of habitat edges and nest-site characteristics on Painted Bunting nest success. Journal of Field Ornithology 86:27-40.

Wiens, J. A. 1963. Aspects of cowbird parasitism in southern Oklahoma. Wilson Bulletin 75:130-139.

Wiens, J. A. 1969. An approach to the study of ecological relationships among grassland birds. Ornithological Monographs 8:1-93.

Wiens, J. A., and J. T. Rotenberry. 1981. Habitat associations and community structure of birds in shrubsteppe environments. Ecological Monographs 51:21-41.

Complete Literature Cited

Arkansas Department of Parks & Tourism, Frog Bayou Wildlife Management Area. c2017. Little Rock, Arkansas, USA. [accessed 2017 September 15]. https://www.arkansas.com/outdoors/birding/birds/bird-detail.aspx?id=49.

Arkansas Department of Parks & Tourism, Lake Fayetteville. c2017. Little Rock, Arkansas, USA. [accessed 2017 September 15]. https://www.arkansas.com/outdoors/birding/birds/bird-detail.aspx?id=51.

Audubon and Cornell Lab of Ornithology, eBird News, May 14, 2008. We need your Painted Bunting observations! c2008. Cornell Lab of Ornithology, Ithaca, New York, USA. [accessed 2012 March 13]. http://ebird.org/content/ebird/news/we-need-your-painted-bunting-observations.

Brittain, R. A., V. J. Meretsky, and C. B. Craft. 2010. Avian communities of the Altamaha River Estuary in Georgia, USA. Wilson Journal of Ornithology 122:532-544.

Brittingham, M. C., and S. A. Temple. 1983. Have cowbirds caused forest songbirds to decline? BioScience 33:31-35.

City of Fayetteville, Arkansas; Kessler Mtn Trails. c2006-2017. Fayetteville, Arkansas, USA. [accessed 2017 September 15]. http://www.fayetteville-ar.gov/facilities/facility/details/Mt-Kessler-Trails-88.

City of Fayetteville, Arkansas; Woolsey Wet Prairie Sanctuary. c2006-2017. Fayetteville, Arkansas, USA. [accessed 2017 September 15]. http://accessfayetteville.org/470/Woolsey-Wet-Prairie-Sanctuary.

Conner, R. N., J. G. Dickson, J. H. Williamson, and B. Ortego. 2004. Width of forest streamside zones and breeding bird abundance in eastern Texas. Southeastern Naturalist 3:669-682.

Galli, A. E., C. F. Leck, and R. T. T. Forman. 1976. Avian distribution patterns in forest islands of different sizes in central New Jersey. Auk 93:356-364.

Gates, J. E., and L. W. Gysel. 1978. Avian nest dispersion and fledging success in field-forest ecotones. Ecology 59:871-883.

Herkert, J. R. 1994. The effects of habitat fragmentation on Midwestern grassland bird communities. Ecological Applications 4:461-471.

Hill, M. O. 1973. Diversity and evenness: a unifying notation and its consequences. Ecology 54:427-432.

Hunter, C. G. 2000. Trees, shrubs, and vines of Arkansas. Ozark Society Foundation, Little Rock, Arkansas, USA.

Hutto, R. L., S. M. Pletschet, and P. Hendricks. 1986. A fixed-radius point count method for nonbreeding and breeding season use. Auk 103:593-602.

James, D. A., and J. C. Neal. 1986. Arkansas birds: their distribution and abundance. The University of Arkansas Press, Fayetteville, Arkansas, USA.

James, F. C. 1971. Ordinations of habitat relationships among breeding birds. Wilson Bulletin 83:215-236.

James, F. C., and H. H. Shugart, Jr. 1970. A quantitative method of habitat description. Audubon Field Notes 24:727-736.

Kendeigh, S. C. 1941. Birds of a prairie community. Condor 43:165-174.

Kopachena, J. C., and C. J. Crist. 2000. Macro-habitat features associated with Painted and Indigo Buntings in northeast Texas. Wilson Bulletin 112:108-114.

Lack, D. 1933. Habitat selection in birds with special reference to the effects of afforestation on the Breckland avifauna. Journal of Animal Ecology 2:239-262.

Lanyon, S. M., and C. F. Thompson. 1986. Site fidelity and habitat quality as determinants of settlement pattern in male Painted Buntings. Condor 88:206-210.

Lowther, P.E. 1993. Brown-headed Cowbird (*Molothrus ater*), The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, New York, USA. [accessed 2012 March 13]. http://bna.birds.cornell.edu/bna/species/047doi:10.2173/bna.47.

Lowther, P. E., S. M. Lanyon, and C. W. Thompson. 1999. Painted Bunting (*Passerina ciris*), The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, New York, USA. [accessed 2012 March 13]. http://bna.birds.cornell.edu/bna/species/398.

MacArthur, R. H., and J. W. MacArthur. 1961. On bird species diversity. Ecology 42:594-598.

Meyers, J. M. 2011. Population densities of Painted Buntings in the southeastern United States. Southeastern Naturalist 10:345-356.

Norris, D. J. 1982. Habitat ecology of the Painted Bunting on the Ozark Plateau. MS thesis, University of Missouri-Columbia, Columbia.

Norris, D. J., and W. H. Elder. 1982. Distribution and habitat characteristics of the Painted Bunting in Missouri. Transactions of the Missouri Academy of Science 16:77-83.

Parmelee, D. F. 1959. The breeding behavior of the Painted Bunting in southern Oklahoma. Bird-Banding 30:1-18.

Poulin, R. G., S. D. Grindal, and R. M. Brigham. 2011. Common Nighthawk (*Chordeiles minor*), The Birds of North America Online (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, New York, USA. [accessed 2016 March 8]. https://birdsna.org/Species-Account/bna/species/comnig.

R Core Team. 2014. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. [accessed 2017 August 15]. http://www.R-project.org/.

Rotenberry, J. T., and J. A. Wiens. 1980. Habitat structure, patchiness, and avian communities in North American steppe vegetation: a multivariate analysis. Ecology 61:1228-1250.

Shugart, H. H., Jr., and D. James. 1973. Ecological succession of breeding bird populations in northwestern Arkansas. Auk 90:62-77.

Šidák, Z. K. 1967. Rectangular confidence regions for the means of multivariate normal distributions. Journal of the American Statistical Association 62:626-633.

Springborn, E. G., and J. M. Meyers. 2005. Home range and survival of breeding Painted Buntings on Sapelo Island, Georgia. Wildlife Society Bulletin 33:1432-1439.

Strong, T. R., and C. E. Bock. 1990. Bird species distribution patterns in riparian habitats in southeastern Arizona. Condor 92:866-885.

Thompson, C. W. 1991. The sequence of molts and plumages in Painted Buntings and implications for theories of delayed plumage maturation. Condor 93:209-235.

U.S. Environmental Protection Agency, Western Ecology Division, Ecoregions of Arkansas, updated 2012 May 24. [accessed 2015 February 3]. http://www.epa.gov/wed/pages/ecoregions/ar_eco.htm.

USGS Patuxent Wildlife Research Center, North American Breeding Bird Survey Results and Analysis 1966-2012, Painted Bunting BBS Trend Map 1966-2010. c2012. United States Department of the Interior, Washington, D. C., USA. [accessed 2012 March 17]. http://www.mbr-pwrc.usgs.gov/bbs/tr2010/tr06010.htm.

Vasseur, P. L., and P. L. Leberg. 2015. Effects of habitat edges and nest-site characteristics on Painted Bunting nest success. Journal of Field Ornithology 86:27-40.

Wiens, J. A. 1963. Aspects of cowbird parasitism in southern Oklahoma. Wilson Bulletin 75:130-139.

Wiens, J. A. 1969. An approach to the study of ecological relationships among grassland birds. Ornithological Monographs 8:1-93.

Wiens, J. A., and J. T. Rotenberry. 1981. Habitat associations and community structure of birds in shrubsteppe environments. Ecological Monographs 51:21-41.

Wilcove, D. S., C. H. McLellan, and A. P. Dobson. 1986. Habitat fragmentation in the temperate zone. M. E. Soulé, editor. Conservation Biology. The science of scarcity and diversity. Sinauer Associates, Sunderland, Massachusetts, USA.

XLSTAT. 2017. Data analysis and statistics with Microsoft Excel. Addinsoft, New York City, USA. [accessed 2017 September 29]. https://www.xlstat.com/en/.