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Impacts of Man-Made Structures on Avian Community Metrics in 4 State Parks in Northwestern Arkansas

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Running Title: Impacts of Man-Made Structures on Avian Community Metrics

Abstract

Avian community metrics often differ between areas with no human disturbance and areas with high levels of human disturbance. However, the relationships between avian community metrics and smaller-scale disturbances are not as clear. Our goal was to investigate if avian abundance, richness, evenness, and diversity differed in areas with and without small-scale human developments. We used fixed-radius 50-m avian point counts to compare points which contained a man-made structure (n = 47), such as a picnic area, road, or campsite to those that did not contain a man-made structure (n = 181) at 4 state parks in Arkansas during 18 May – 7 August 2015. We used paired t-tests to compare points at the park scale and one-way ANOVAs or Kruskal-Wallis tests to investigate differences among the hiking and biking trails within parks. At the park scale, avian abundance (t_3 = -1.44, P = 0.246), richness (t_3 = -0.86, P = 0.453), diversity (t_3= 2.02, P = 0.137), and evenness (t_3 = -0.37, P = 0.733) did not differ between points containing man-made structures and points without man-made structures. Species richness ($F_{1,11}$ = 5.03, P = 0.047) and diversity (χ^2_1= 4.20, P = 0.040) were higher at points with man-made structures (Simpson's D mean = 0.13 ± 0.01SE; S mean = 8.99 ± 0.70SE) at Pinnacle Mountain than points without man-made structures (Simpson's D mean = 0.18 ± 0.03SE; S mean = 7.17 ± 0.47SE); abundance ($F_{1,11}$ = 1.43, P = 0.257) and evenness ($F_{1,11}$ = 0.16, P = 0.695) did not differ among points. Within the 3 remaining parks, abundance ($F_{1,7\text{-}9}$ = 0.11 – 2.59, P = 0.152 – 0.748), richness (χ^2_1 = 0.300 – 1.68, P = 0.195 – 0.584), diversity (χ^2 = 0.300 – 1.05, P = 0.305 – 0.584; $F_{1,7}$ = 1.82, P = 0.219) and evenness ($F_{1,7\text{-}9}$ = 0.35 – 4.28, P = 0.077 – 0.570) did not differ between points with and without man-made structures. Given the results of our analyses both at the park scale and within parks, it appears that small-scale man-made disturbances may have limited or no impact on avian community metrics.

Introduction

Human interference can impact avian abundance, assemblages, diversity, and species evenness (Burger 1981, McGarigal and McComb 1995, Trzcinski et al. 1999, Crooks et al. 2004, La Sorte and Boecklen 2005, Brown 2007, Ferenc et al. 2014). Non-consumptive use of natural resources, such as hiking, biking, and birdwatching, has been shown to reduce avian reproductive success (Miller et al. 1998, Kangas et al. 2010), increase predation on avifauna (Desgranges and Reed 1981), and have overall negative impacts on bird communities (Askins et al. 1990, Knight and Gutzwiller 1995). Urban development also tends to have negative impacts on avian community dynamics, with larger urban areas having decreased diversity, lower species richness, and lower species evenness when compared to more rural areas (Burger 1981, Friesen et al. 1995, Aurora et al. 2009, Crooks et al. 2004, Ferenc et al. 2014, Verma and Murmu 2015). As with urbanization, forest fragmentation can also have negative impacts on avian community metrics, with fragmented forests having less diversity, lower species richness, and lower avian abundance than continuous forests (Brown 2007). However, other studies have found that fragmentation has negligible impacts on avian abundance, and that habitat loss, even on a small scale, is a more important contributing factor to reductions in species richness and abundance (McGarigal and McComb 1995, Trzcinski et al. 1999).

Although large scale fragmentation such as creation of urban and suburban developments has a clear influence on abundance and species composition of avifauna, smaller scale disturbances in natural areas may have less obvious, yet still important, impacts. It has been demonstrated that in locations where human visitation is high, avian survivorship may be lowered, particularly during migration (Burger 1981), thus reducing overall avian abundance in these areas. Human visitation can result in bird avoidance of high-traffic areas and in turn can lower abundance during migration and nesting periods on sites where man-made structures, such as trails, are present (Burger 1981, Gutzwiller et al. 1998, Kangas et al. 2010). Non-consumptive human use of trails and recreational areas can also disturb avian communities and disrupt both feeding and breeding behaviors, particularly among ground-dwelling species (Gutzwiller et al. 1998, Aben et al. 2008, Kangas et al. 2010, Thompson 2015). A study conducted in central Texas focusing on the relationship between golden-cheeked warblers (*Dendroica chrysoparia*) and mountain biking activity showed that warbler territories where mountain biking was present were smaller, and nest success was reduced when compared to sites where mountain biking was not present (Davis et al. 2010). As a result of reduced nesting success, abundance of this species may have been reduced, meaning that man-made biking trails and the associated activity has the capacity to damage populations of individual avian species. Studies in forested settings have also shown that, similar to biking trails, roads have the potential to negatively impact avian abundance and species richness, not only due to increased vehicle traffic, but also due to increased foot traffic along roadways (Polak et al. 2013).

While edge habitat creates areas that allow a variety of species with different habitat requirements to converge, this does not mean that avian communities will be positively affected by edge that is created by man-made structures and openings. Increased predation and human interaction can decrease species abundance, richness, diversity, and evenness (Weatherhead et al. 2010, Cox et al. 2012), but variations in the magnitude of predation and human activity along human-induced edges may impact the degree of change that is observed within avian community metrics. Given that some studies have found that human recreational activities in natural settings have either negative effects or no effect on avian community metrics (Banks and Bryant 2007, Aben et al. 2008, Davis et al. 2010, Kangas et al. 2010, Polak et al. 2013, Wolf et al. 2013, DeLuca and King 2014), we hypothesized that increased human activity may negate the positive effects of increased edge at sites with man-made structures, particularly those that see frequent use. Therefore, we predicted that we would observe a reduction in species richness, diversity, and abundance at points with a man-made structure compared to points with no man-made structure. Although many studies have not investigated species evenness, we predicted that a lower species diversity would also lead to a lower overall evenness, in accordance with Friezen et al. (1995) and Kluza et al. (2000).

Materials and Methods

Four state parks located in close proximity to the Arkansas River in central and west-central Arkansas served as the focus for our study: Mount Magazine State Park, Petit Jean State Park, Mount Nebo State Park, and Pinnacle Mountain State Park. Mount Magazine, Petit Jean, and Mount Nebo are located in the Arkansas River Valley ecoregion, while Pinnacle Mountain is located in the Ouachita Mountain ecoregion (USEPA 2016). Mount Magazine State Park is located in Logan County, south of Paris, AR (15 S 442199, 3895222). The park encompasses 904ha surrounded by the Ozark National Forest and includes Arkansas' highest point in elevation, Mount Magazine (839m). The park is located on top of the mountain, a flat topped plateau rimmed by sandstone bluffs which supports a diverse collection of wildlife and vegetation species adapted to the mountain ecosystem. The park is composed of 8 trails with a combined length of 22.5km and offers 13 cabins and 18 campsites for visitors. Average yearly precipitation for the park is 137cm with the average yearly temperature being approximately 13 ^{o}C (NOAA 2015).

Mount Nebo State Park is located in Yell County, west of Dardanelle, AR (15 S 476945, 3897552). The park encompasses 1,246ha and is centered on Mount Nebo which measures 411m in elevation. The park habitat is mostly comprised of thick oak (*Quercus* spp.) and hickory (*Carya* spp.) dominated forests, characteristic of the Ozark Plateau region, with mixes of sweetgum *(Liquidambar styraciflua)* and red maple (*Q. rubra*) stands throughout the park. The park is composed of 6 trails with a combined length of 22.5km and offers 15 cabins and 44 campsites. Average yearly precipitation for the area is 123cm with average yearly temperatures ranging from 10^{o}C (low) to 23^{o}C (high) (NOAA 2015).

Petit Jean State Park is located in Conway County, west of Oppelo, AR (15 S 505957, 3886563). Petit Jean Mountain, measuring 367.89m, lies between the Ozark and Ouachita mountain ranges in the Arkansas River Valley and serves as the midpoint for the 1,416 ha Park. Habitat of the park is composed mostly of forests dominated by a mix of oak, hickory, and pine (*Pinus* spp.) stands within a series of ponds, streams, and glades, characteristic of the Ozark mountain ecoregion (Keith 1987, Arkansas Forestry Commission 2010). The park offers 8 trails with a combined length of 37km and offers 33 cabins and 125 campsites to visitors. Average precipitation for the area is 127cm with average temperatures ranging from -1°C (low) to 34°C (high) (NOAA 2015).

Pinnacle Mountain State Park is located in Pulaski County, Northwest of Little Rock, AR (15 S 547062, 3855665). The park encompasses 809ha centered on Pinnacle Mountain (308m) covering a mosaic of habitats including boulder fields, bald cypress (*Taxodium distichum*) swamps, bottomland hardwood forests, and upland forests composed of mixes of oak, hickory, and pine stands. As a result of the varying habitat types, the park's Arboretum that maintains woody vegetation from across the state, and the 2 rivers that run through the park, the park supports a diverse variety of avian species. Pinnacle Mountain offers 10 trails with a combined length of 30km and offers no camping to visitors. Average yearly precipitation for the park is 127cm with the average temperature being 18°C (NOAA 2015).

Sampling of avifaunal community metrics occurred from 18 May – 7 August 2015. Parks were visited in 1-week increments (Monday- Friday), rotating among the 4 parks so that each park was sampled 3 times during the study. We chose trails within each park based on length, habitat type diversity, and total area of the park that they encompassed. Trails measuring <16km in length were included in the study, with trails 8 – 16km split into 2 equal portions to accommodate temporal limitations of accessing them. Trails fitting the distance criteria above were further categorized by choosing trails that passed through the greatest diversity of habitat types (Arkansas Forestry Commission 2010) and that encompassed the greatest area of park use. We observed these attributes by plotting the trails on a map overlay in ArcGIS (Environmental Systems Research Institute, Inc., Redlands, CA) to discern what habitat areas the trails passed through and by assessing the total coverage of the trail in the park. Applying these criteria to the trails in each park resulted in 7 trails at Mount Nebo State Park, 6 trails at Mount Magazine State Park, 6 trails at Petit Jean State Park, and 8 trails at Pinnacle Mountain State Park to be included in the study. Initial sampling of avian point locations at each state park were located at randomly selected points within 250m of the each major trail's trailhead. We identified subsequent sampling locations systematically at 250m intervals in order to ensure independence of bird count data.

Avian point counts began within a period of 15 minutes before sunrise each weekday and lasted until 4 hours after sunrise (~05:45–10:00hr). We conducted point counts only during suitable weather conditions for avian activity which were defined as: mornings with no rain or fog (although temperate, light drizzle can be tolerated by most species; Cyr et al. 1995, Martin et al. 1997), and wind speeds <13km/hr (Freedmark and Rogers 1995, Petit et al. 1995).

Each point was sampled independently 3 times per week, once each by 3 observers. This methodology resulted in 9 visits per all 228 points (i.e., 3 times per week at each point during 3 independent weeks), with 45 minutes of total observation time collected per point. By utilizing 3 observers throughout the week rather than 1, as is common in many avian surveys, we were able to diminish repeated observer bias and also increase the detection probability at each point. Points along each trail were visited at random times so that no point was visited at the same time throughout the week by any of the 3 observers. Birds sighted/heard at each study point were identified to species level, recorded by their 4 letter alpha codes (Pyle and Desante 2003), and specified in their location relative to the study point, their distance from the study point, and if the spotting was visual or auditory via symbols established by Ralph et al. (1993). Additionally, the presence of man-made campsites, picnic areas, cabins, houses, roads, and other structures within the 50m plot was recorded by 1 observer per point.

Once sampling was complete, we calculated the average community metric values for points containing a man-made structure and points without a man-made structure at each state park. We calculated average abundance (N) for each point by dividing the number of individual birds counted over the 3 observers. By using the average instead of the total number of birds observed, we accounted for the probability that each individual bird was counted 3 times in 1 week, once by each observer. We calculated species richness (S) by totaling the number of species observed by the 3 observers at each point to ensure that all species observed at each point were taken into account. Lastly, using data from all observers at each point, we calculated Simpson's Evenness Index (E) and Simpson's Diversity Index (D). Using the state parks as replicates (n = 4), we used a paired t-test ($\alpha = 0.05$ for all analyses; SAS/STAT software Version 9.3) to determine if avian community metrics differed between points with man-made structures and points without man-made structures. After we analyzed the data at the park level, we analyzed data using one-way ANOVAs or Kruskal-Wallis tests to investigate differences using the trails within each park as replicates.

Results

In total, we located 47 man-made structures across the 4 state parks. Of these structures, approximately 41% were roads, 17% were small homes or cabins, 9% were parking lots, 7% were campgrounds, 6% each were bridges, power line structures, and small sheds or storage buildings, and 4% each were picnic areas/benches, and miscellaneous small concrete structures. At the park scale, neither avian abundance (t_3 = -1.44, P = 0.246), richness (t_3 = -0.86, P = 0.453), diversity (t_3= 2.02, P = 0.137), nor evenness (t_3 = -0.37, P = 0.733) differed between points containing man-made structures and those without man-made structures (Table 1).

Subsequent analyses within the 4 parks largely failed to reveal differences in avian community metrics at points with and points without a man-made structure, with the only differences occurring at Pinnacle Mountain. Within that park, we observed 9 total man-made structures at our 53 points, consisting of 33% powerline structures, 22% roads, and 11% each of bridges, parking lots, picnic areas, and small concrete structures. Species richness ($F_{1,11}$ = 5.03, P = 0.047) and diversity (χ^2_1 = 4.20, P = 0.040) were higher at points with man-made structures than points without man-made structures; abundance ($F_{1,11}$ = 1.43, P = 0.257) and evenness ($F_{1,11}$ = 0.16, P = 0.695) did not differ among points at Pinnacle Mountain (Figure 1).

Table 1. Comparison of mean (±SE) avian Simpson's Diversity (D), Simpson's Evenness (E), species richness (S), and abundance (N) at points with (W) and without (WO) a man-made structure at 4 state parks in Northwestern Arkansas, 2015. There were no differences between points for any metrics (*paired* t_3 = -0.86 – 2.02 P = 0.137 – 0.733).

Park	D	E	S	N
Pinnacle				
W	0.12±0.01	0.96±0.01	5.19±0.44	9.22±0.74
WO	0.19±0.02	0.97±0.01	3.86±0.41	6.86±0.62
Magazine				
W	0.19±0.01	0.90±0.01	4.98±0.51	6.61±0.54
WO	0.22±0.02	0.88±0.02	4.88±0.54	5.83±0.47
Petit Jean				
W	0.16±0.02	0.92±0.01	5.07±0.38	8.03±0.65
WO	0.20±0.03	0.95±0.02	3.64±0.44	6.61±0.77
Nebo				
W	0.18±0.02	0.96±0.00	3.86±0.28	6.84±0.47
WO	0.17±0.01	0.93±0.01	4.79±0.31	7.62±0.44

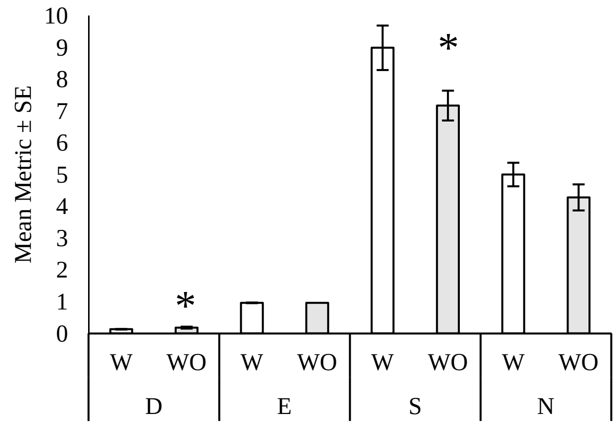

Figure 1. Comparison of mean (±SE) avian Simpson's Diversity (D), Simpson's Evenness (E), species richness (S), and abundance (N) at points with (W) and without (WO) a man-made structure at Pinnacle Mountain State Park, Arkansas, 2015. Asterisks indicate significance at P = 0.05.

At Mount Magazine, 12 total structures were located within our 60 points, and consisted of 67% roads, 17% parking lots, 8% campgrounds, and 8% small sheds or storage buildings. Avian abundance ($F_{1,9}$ = 0.11, P = 0.748), richness (χ^2_1 = 0.300, P = 0.584), diversity (χ^2_1 = 0.300, P = 0.584), and evenness ($F_{1,9}$ = 0.76, P = 0.407) did not differ among points with and without man-made structures (Figure 2).

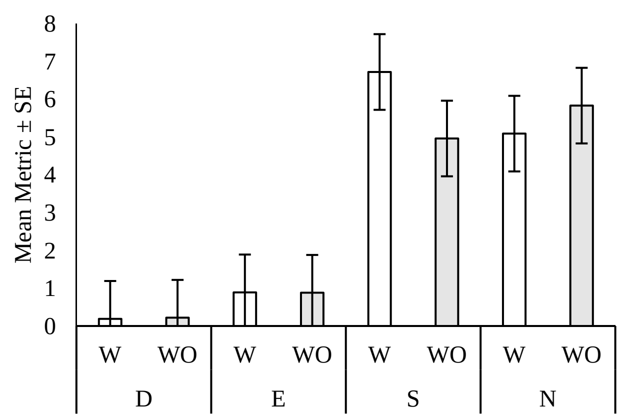

Figure 2. Comparison of mean (±SE) avian Simpson's Diversity (D), Simpson's Evenness (E), species richness (S), and abundance (N) at points with (W) and without (WO) a man-made structure at Mount Magazine State Park, Arkansas, 2015. There were no differences between points for any metrics (χ^2_1 = 0.300, P = 0.584; $F_{1,9}$ = 0.11 – 0.76, P = 0.407 – 0.748).

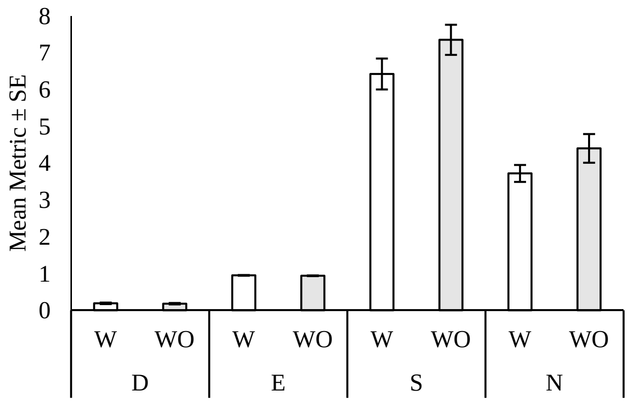

Figure 3. Comparison of mean (±SE) avian Simpson's Diversity (D), Simpson's Evenness (E), species richness (S), and abundance (N) at points with (W) and without (WO) a man-made structure at Mount Nebo State Park, Arkansas, 2015. There were no differences between points for any metrics (χ^2_1 = 1.052 – 1.581, P = 0.209 – 0.305; $F_{1,8}$ = 0.35 – 1.12, P = 0.321 – 0.570).

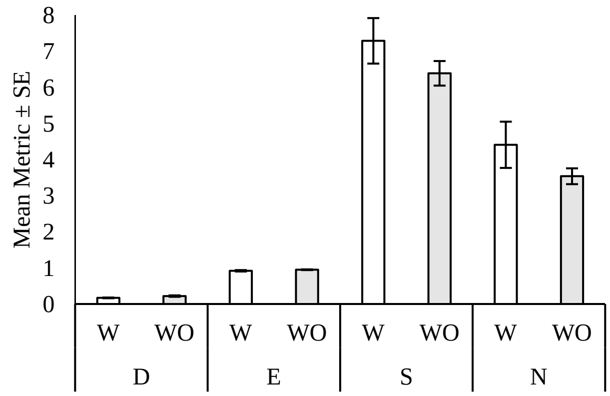

Figure 4. Comparison of mean (±SE) avian Simpson's Diversity (D), Simpson's Evenness (E), species richness (S), and abundance (N) at points with (W) and without (WO) a man-made structure at Petit Jean State Park, Arkansas, 2015. There were no differences between points for any metrics (χ^2_1 = 1.681, P = 0.195; $F_{1,7}$ = 1.82 – 4.28, P = 0.077 – 0.219).

At Mount Nebo, we located 15 structures at our 56 total points, consisting of 53% small homes or cabins, 13% sheds or other utility buildings, 13% campgrounds, and 7% each of parking lots, roads, and picnic areas. Similar to Mount Magazine, abundance ($F_{1,8}$ = 1.12, P = 0.321), richness (χ^2_1 = 1.581, P = 0.209), diversity (χ^2_1= 1.052, P = 0.305), and evenness ($F_{1,8}$ = 0.35, P = 0.570) also did not differ among points at Mount Nebo State Park (Figure 3).

At Petit Jean State Park, 11 total structures were located within our 59 total points, 73% of which were roads, 18% of which were bridges, and 9% of which were other structures, such as small sheds or storage buildings. At Petit Jean we also found no difference in abundance ($F_{1,7}$ = 2.59, P = 0.152), richness (χ^2_1 = 1.681, P = 0.195), diversity ($F_{1,7}$ = 1.82, P = 0.219), or evenness ($F_{1,7}$ = 4.28, P = 0.077) among points with and without man-made structures (Figure 4).

Discussion

Both among parks and within parks at the trail level, we found either no difference or minimal difference in avian community metrics among points with man-made structures and points without man-made structures. These results are somewhat expected given that several studies focusing on the relationship between small scale human development and avian community metrics have found little difference when comparing forested areas without trails and human recreational activity to those where trails, small structures, and human activity were present (Gutzwiller et al. 1994, DeLuca and King 2014, Thompson 2015). One possible mechanism for this lack of differences is the size of the structures themselves. The largest structures within our 50-m plots were small houses, cabins, and powerline structures while studies that have found differences in avian community metrics generally investigated effects of larger structures and urbanized areas (Friesen et al. 1995, Hudson et al. 1997, Ferenc et al. 2014). Because structures in our study were small, the disturbances that they created may not have been large enough to affect avian community composition. Although dividing our structures into categories based on size or type would have been beneficial, given that we had relatively few structures at our study points overall (n =47), subdividing them further in order to perform further analyses would have likely not yielded meaningful results. For example, if we were to logically divide man-made structures into "small", "medium", and "large" categories at each of the 4 parks, we would have very few structures representing each of those categories. As such, the small sample sizes would negate our ability to detect any effects between treatments. Also, the dividing line between each category would be arbitrary, as what constitutes a "small" or "large" structure would be somewhat open for interpretation. Therefore, even if there was a statistical difference in one or more community metric(s) at medium vs. large structures, for example, the difference may have only been caused by our arbitrary categorization rather than by actual differences in the avian communities at the different sizes of structures.

Another potential explanation for overall lack of differences in community metrics is the proximity of the structures in our study to a trail. Because each survey point in our study was centered on a trail, the effects of openings created by trails may have reduced the impacts of structures on avian community metrics. Canopy openings created by trails may have changed avian community metrics when compared to areas of the forest with no trails, which our study did not include. Because recreational trails have been shown to affect avian community metrics and avian behavior (Gutzwiller et al. 1998, Miller et al. 1998, Banks and Bryant 2007, Wolf et al. 2013, Thompson 2015), a study comparing points containing structures and points without structures where no points were located on or near trails could yield results different from our study. However, because human-made structures generally have a road or trail leading to them, it may be difficult to locate enough structures that are independent of trails that could be utilized in a study.

The trails themselves may also be a factor that influenced our findings because human activity is much higher in these areas due to non-consumptive use (e.g., biking, jogging, and hiking) than areas without trails. High levels of human activity can deter birds from areas that may otherwise be occupied and has been shown to cause changes in avian community metrics, particularly abundance (Desgranges and Reed 1981, Knight and Gutzwiller 1995, Gutzwiller et al. 1994, Miller et al. 1998, Davis et al. 2010, Kangas et al. 2010, Thompson 2015). Because trails and human use disrupt avian communities, it is possible that the presence of trails negatively impacted our ability to detect differences between points with and without structures.

A final potential explanation for the lack of differences in avian community metrics within our study points is that the majority of species that we detected were either mid-story or canopy dwelling. Several studies have shown that birds that nest or forage on the forest floor show greater responses to human recreational activity than those that forage or nest farther from the ground (Banks and Bryant 2007, Wolf et al. 2013, Thompson 2015). If understory-foraging or understory-nesting birds would have comprised a greater proportion of birds observed in our study, it is possible that our results would have shown differences in community metrics at points with versus points without a man-made structure. The ability to classify species into different guilds was a shortcoming in our study, compared to previous studies (Gutzwiller et al. 1998, Banks and Bryant 2007, Kangas et al. 2010, Thompson 2015). It is likely that avian guilds are affected differently by human activity and man-made structures (Thompson 2015), therefore running separate analyses for ground-dwelling and canopy-dwelling birds, for example, may have yielded different results in terms of the 4 community metrics in which we were interested. However, given that avian representatives from some guilds, particularly ground-dwelling species, were uncommon at our study sites, and given that our study was focused on the avian community as a whole, we feel that the manner in which we analyzed our data was appropriate.

Given that the influence of human activity can have a significant impact over avian community metrics, it would have also been beneficial to account for the amount of recreational usage that each individual man-made structure received. However, given the time available to us and the scope of the project, we were not able to perform the surveys and monitoring necessary to obtain this data. Another issue with this type of analysis would have been the time that some of the structures were used. Campsites, for instance, may have been in use by park visitors 24 hours per day, while some structures, such as the powerline clearcuts, may have not seen any use by park visitors whatsoever.

Pinnacle Mountain avian community metrics were unlike the other parks in this study; both avian species richness and species diversity were higher at points with man-made structures. There are several characteristics of Pinnacle Mountain that may have caused these differences. One explanation for the differences in richness and diversity at Pinnacle Mountain may lie in the structures themselves. At the other 3 parks in our study, the majority of structures consisted of roads, small cabins, and small homes. At Pinnacle Mountain, however, many of the structures that we observed were either powerline clearcuts, parking areas, or were structures directly adjacent to parking areas such as picnic tables. Powerline structures and the large associated clearcuts were a unique feature to Pinnacle Mountain among the 4 parks. The powerline structures themselves were still small enough in size to be included in our study; however, the clearcuts maintained beneath these powerlines were fairly large and continuous, with maintained strips extending throughout the park and out of the park boundaries. These clearcuts, which were located within 3 of our study points at Pinnacle, consisted of early successional vegetation and herbaceous grassland species which may have attracted a different suite of species not seen throughout the more forested sections of the park. Therefore, powerline structures and clearcuts may have created an edge effect with the surrounding forest, resulting in a larger number of species and a higher diversity of species in plots containing one of these structures. An unfortunate shortcoming of our overall study was that no other parks contained powerline clearings or comparable types of clearings that would have allowed us to analyze the impacts of these types of structures further, therefore we can only speculate that these powerline structures were a factor in our findings that points at Pinnacle Mountain containing structures had a higher avian richness and diversity than points not containing structures. Our results suggest that further studies focusing specifically on powerline clearcuts and associated structures would be pertinent.

Due to the Pinnacle Mountain's proximity to Little Rock, AR, visitation at this park is high and parking areas and picnic areas are frequently used by humans. Although this might be expected to have negative effects on community metrics, we observed that human refuse, such as leftover food, concentrated a number of avian species in these areas, which may have contributed to higher diversity and species richness at Pinnacle. Although it is difficult to say for certain why avian richness and diversity were higher at points with structures compared to without structures at Pinnacle Mountain but not at other parks we visited, type of structure and levels of human activity are likely causes.

Another shortcoming of our study was that we did not calculate detection probability. Although we increased detection probability by visiting each park on 3 separate occasions and employing 3 independent observers, it is still not possible to detect all individuals at all point count locations. As we did not account for detection probability in our community metric estimates, we may have introduced a bias in more densely populated areas, possibly causing us to underestimate certain avian metrics, such as abundance and species diversity (Farnsworth et al. 2002, Thompson 2015). It has also been suggested that vegetation density may influence the probability of detection of songbirds (Richards 1981). Although vegetation density may decrease along man-made structures and trails (Loss and Blair 2011, Thompson 2015), DeLuca and King (2014) reported that this does not appear to alter the probability of detecting songbirds visually or aurally. Therefore, we feel justified in not accounting for changes in vegetation when taking detection probability into consideration.

Management Implications

Gaining knowledge about the impacts of man-made structures and campsites in natural areas and the ways in which they affect wildlife is important when considering future construction and placement of such structures. For example, we found that small campsites and other structures generally had no impact on overall avian community composition; however, groups of structures such as neighborhoods or larger individual structures that were not observed in our study sites may have meaningful effects on bird communities. Therefore, further studies that focus on larger structures could be important in deciding whether construction of such sites within state parks could be detrimental to avian communities. Although our study indicated that human structures largely had no effect on avian communities in state parks, it may be beneficial to perform similar studies with different taxa of wildlife. For example, amphibians, which tend to have smaller home ranges when compared to birds (Bellis 1965, Watson et al. 2003, Fellers et al. 2013), may be more greatly affected by small-scale disturbances.

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