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Research article

Exploring the effects of non-consumptive recreation, trail use, and environmental factors on state park avian biodiversity

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ABSTRACT

State parks serve an important dual role in conservation by balancing wildlife management and recreation activities by park visitors. However, research in recreation ecology on the collective impacts of non-consumptive recreation, environmental factors, and trail design has been sparse. We modeled the influences of non-consumptive trail use, vegetation communities, habitat structure, climate, and trail design on avian communities in four Arkansas State parks. Our results suggested that non-consumptive trail use, environmental factors, and trail design may have collective influences on avian communities. Trailside vegetation structure and aspects of trail design had stronger effects on park avian communities than non-consumptive trail use. Our findings suggest that trail design and environmental factors may play a larger role in shaping avian communities in areas where non-consumptive trail use rates are low. In order to manage the coexistence of flora and fauna with human recreation effectively, park managers should employ decision frameworks that collectively consider the effects from anthropogenic and environmental variables.

1. Introduction

State parks offer protected habitat to many resident and migratory animals. Parks may also serve as the only available location for many people to experience outdoor recreation and to observe wildlife (Reed and Merenlender, 2008; Rodriguez-Prieto et al., 2014). As such, state parks demand management strategies that protect the plant and wildlife communities within the park while also promoting outdoor recreation. This dual conservation role is accomplished through a mutually beneficial process between park managers and park visitors. State parks provide visitors the opportunity to participate in wildlife education, viewing, and guided outdoor activities, which then provides funding for conservation and data collection on park biotic communities.

Outdoor recreation has been recognized as an important factor that influences biotic communities and the surrounding quality of habitat within state parks (Leung and Marion, 2000). The two main types of recreation activities, consumptive and non-consumptive use, (Reed and Merenlender, 2008), can affect park biota both directly and indirectly (Knight and Cole, 1995). Consumptive use activities are those that directly affect biotic populations and result in the removal of plants and animals from the environment, such as hunting, fishing, and firewood collection (Knight and Cole, 1995; Leung and Marion, 2000). Comparatively, non-consumptive use activities do not actively remove organisms from the environment and incorporate a broader scale of activities including trail use, bird watching, and hiking. Non-consumptive activities have historically been considered benign when compared to consumptive uses (Miller et al., 1998). However, there is a growing body of evidence suggesting that non-consumptive activities have greater, more widespread negative effects on park avian communities (Hammitt et al., 2015; Taylor and Knight, 2003). For example, nonconsumptive recreation can occur year-round as opposed to consumptive recreation that is often bound to specific seasons (e.g., deer season, waterfowl season, archery season). Further, while some state parks permit hunting and angling, nonconsumptive activities such as hiking, biking, and camping are more widespread in state parks. Thus, non-consumptive recreation and may not be compatible with the dual role of balancing outdoor recreation with conservation (Reed and Merenlender, 2008).

The effects of non-consumptive use on park avian communities occur via three primary routes of influence: 1) habitat modification; 2) effects on physiological health and behavior; and 3) effects on community structure (Cole and Landres, 1995). Repeated use of park trails without managing the frequency or intensity of foot traffic can adversely alter habitat via the clearing of near-trail vegetation for firewood (Cole, 1993) and reductions in seed production and vegetation biomass (Campbell and Gibson, 2001). These reductions in vegetation

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biomass can have an impact on bird foraging success and remove protective trailside cover important to many bird species (e.g., ground nesting birds). High rates of trail use also lead to increased levels of avoidance behaviors in birds, which may increase physiological stress through the interruption of courtship behaviors and displacement from familiar territories (Miller and Hobbs, 2000). For example, avoiding park trails can alter nest locations (Safina and Burger, 1983), reduce song occurrence (Knight and Gutzwiller, 1995), decrease reproductive success and productivity (Sekercioglu, 2002), and displace migration and movement corridors (Knight and Swaddle, 2007). Furthermore, effects at the individual or population levels may alter reproductive rates and foraging behaviors of several species at once, which then manifest into community-scale effects on metrics such as diversity, evenness, richness, and composition (Harrison and Cornell, 2008). For example, avian community richness and diversity generally have a negative relationship with high rates of trail use (Hammitt et al., 2015), though this relationship can vary depending on the type of trail activity, focal species of the study, and the spatial scale of observation (Larson, 2015; Rodriguez-Prieto et al., 2014; Torn et al., 2009).

Additional factors such as climate, slope, canopy cover, and aspects of trail design are also important determinants in the structure and dynamics of avian communities in protected areas (Camille et al., 2000). Total precipitation and temperature range can influence individual fitness, resource availability, and place selective morphological and behavioral pressures on individuals (Camille et al., 2000). Slope alignment and canopy cover can indirectly affect biotic community structure by increasing trailside vegetation susceptibility to water runoff, soil erosion, and light attenuation (Miller et al., 2009). Trail width, incision depth, and trailside vegetation may also serve as additional determinants of avian community structure by influencing trail user behavior (Dale and Weaver, 1974; Marion and Leung, 2001).

Understanding the collective effects on avian communities from non-consumptive use, environmental factors, and trail design is essential in creating management strategies that fully encompass the diversity of variables influencing park avifauna. Despite the growing pool of literature documenting the effects of non-consumptive recreation on birds (Hammitt et al., 2015; Knight and Gutzwiller, 1995), few studies have addressed the effects of non-consumptive use in state parks or on avian communities (Larson, 2015; Rodriguez-Prieto et al., 2014; Taylor and Knight, 2003). Further, many studies note the possible collective effects of environmental factors and trail design with the effects of non-consumptive use, but few have encompassed all three sources of influence when examining avian communities (Harrison and Cornell, 2008; Monz et al., 2013). Therefore, our goal was to simultaneously examine the effects of non-consumptive trail use, environmental factors, and trail design on the avian communities residing in Arkansas state parks. Approaching recreation ecology with a holistic lens rather than focusing on independent components may provide state park managers with a better understanding on where to focus efforts to mitigate the potential effects of human disturbance on park habitat.

2. Materials and methods

2.1. Study area

We focused on four state parks located in close proximity to the Arkansas River in central and west-central Arkansas: Mount Magazine State Park (MM), Mount Nebo State Park (MN), Petit Jean State Park (PJ), and Pinnacle Mountain State Park (PM) (Fig. 1). Mount Magazine, MN, and PJ State Parks are located in the Arkansas River Valley ecoregion and PM is located in the Ouachita Mountain ecoregion (USEPA, 2016).

Mount Magazine State Park is a 904-ha park located in Logan County, south of Paris, AR (15 S 442199, 38952229) surrounded by the Ozark National Forest. The park is positioned on top of Mount Magazine (839 m above sea level), a flat-topped plateau rimmed by sandstone bluffs which supports a diverse collection of montane wildlife and vegetation species such as Ozark chinquapin (*Castanea ozarkensis*) and maple-leaf oak (*Quercus acerifolia*).

Mount Nebo State Park is a 1246-ha park located in Yell County, west of Dardanelle, Arkansas (15 S 476945, 3897552), centered on top of Mount Nebo (411 m above sea level). Vegetation in the park is mostly comprised of thick oak (*Quercus* spp.) and hickory (*Carya* spp.) dominated forests, with mixes of sweetgum (*Liquidambar styraciflua*) and red maple (*Acer rubra*) stands throughout the park.

Petit Jean State Park is located in Conway County, west of Oppelo, Arkansas (15 S 505957, 3886563). Petit Jean Mountain (368 m above sea level) lies between the Ozark and Ouachita Mountain ranges in the Arkansas River Valley and serves as the midpoint for the 1,416ha park. Vegetation in the park is comprised mostly of forests dominated by a mix of oak, hickory, and pine (*Pinus* spp.) stands within a series of ponds, streams, and glades (USEPA, 2016).

Pinnacle Mountain State Park is an 809-ha park located in Pulaski County, Northwest of Little Rock, Arkansas (15 S 547062, 3855665). The park surrounds Pinnacle Mountain (308 m above sea level) and is composed of a mosaic of habitats including boulder fields, bald cypress (*Taxodium distichum*) swamps, bottomland hardwood forests, two rivers, and upland forests composed of mixes of oak, hickory, and pine stands. The park also has an arboretum that contains woody vegetation from across the state.

2.2. Study design

During 18 May – 7 August 2015, we sampled avifaunal and woody vegetation communities, conducted trail user counts, and recorded environmental and trail conditions in cyclic one-week iterations at each park. We rotated among the four parks so that each park was sampled three times during the study. Sampling took place on trails chosen based on total trail length, diversity of habitat types a trail traversed, and the total area each trail encompassed within the park. We included all trails measuring ≤16 km in length and split trails measuring 8–16 km into two equal portions to accommodate temporal limitations. We used ArcGIS (Environmental Systems Research Institute, Inc., Redlands, CA) to assess the diversity of habitat types represented along each trail (USEPA, 2016) and the total area of the trails within each park, selecting trails that encompassed the majority of the available habitats and area in each park. Applying these criteria resulted in 26 trails included in the study, with six trails each at MM (17.2 km), MN (15.7 km), and PJ (16.9 km) and eight trails at PM (16.7 km) (Fig. 1). Initial sampling locations were located randomly along each trail within the first 250 m of the trailhead. Subsequent sampling locations were then systematically located every 250 m to ensure independence of avifaunal data (Ralph et al., 1995). This methodology resulted in 60 points at MM, 56 points at MN, 59 points at PJ, and 52 points at PM.

2.3. Data collection

Avian point counts began at or within 15min of sunrise each weekday and lasted until approximately 5 h after sunrise. Point counts lasted 5min. Birds observed within 50 m of the survey point were identified to species level and details of sampling location, distance from sampling location, and whether the record was visual or auditory were recorded for each observation. We conducted point counts only during suitable weather conditions for avian activity, defined as mornings with no rain or fog, wind speeds less than13 km/h, and temperatures ranging 18–23 °C (Ralph et al., 1995).

We sampled each avian survey point independently three times per week, once each by three different observers. This methodology resulted in nine visits for each of the 227 points (i.e., three times/week at each point during three independent weeks), with 45min of total observation time collected per point. By utilizing three different observers throughout the week rather than one, as is common in many avian