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Urban parks can maintain minimal resilience for Neotropical bird communities

César A. Estevo*, Mariana Baldy Nagy-Reis, Wesley Rodrigues Silva

Department of Animal Biology, University of Campinas, Campinas, SP, Brazil

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ABSTRACT

Birds may use urban parks as shelter and refuge, contributing with numerous ecosystem services upon which humans and other organisms depend on. To safeguard these services, it is important that bird communities of urban environments hold some degree of resilience, which refers to the capacity of a system to absorb disturbances and changes, while maintaining its functions and structures. Here we assessed the resilience of the bird community inhabiting an urban park in the Southeast region of Brazil. We classified birds in feeding guilds and identified discontinuities and aggregations of body masses (i.e., scales) using hierarchical cluster analysis. We then calculated five resilience indices for our urban park and for a preserved continuous forest (reference area): the average richness of functions, diversity of functions, evenness of functions, and redundancy of functions within- and cross-scale. The urban park had less species, lower feeding guild richness, and lower within-scale redundancy than the reference area. However, they had similar proportion of species in each function, diversity of functions, evenness of functions, and cross-scale redundancy. The lower species richness and, consequently, the lack of some species performing some ecological functions may be responsible for the overall lower resilience in the urban park. Our results suggest that the bird community of the urban park is in part resilient, as it maintained many biological functions, indicating some environmental quality despite the high anthropogenic impacts of this area. We believe that urban forest remnants with more complex and diverse vegetation are possibly more likely to maintain higher resilience in the landscape than open field parks or parks with suppressed or altered vegetation. We propose that raising resilience in the urban park would possibly involve increasing vegetation complexity and heterogeneity, which could increase biodiversity in a large scale.

1. Introduction

Urban sprawl and expansion are one of the leading causes of forest fragmentation and destruction, triggering species extinctions and decreasing species richness and diversity (e.g., Savard et al., 2000; McKinney, 2002; Marzluff, 2008). Frequently, green areas are maintained within cities to serve as recreational areas for the local community or to protect part of the preexisting natural environment (Loboda and De Angelis, 2005; Mazzei et al., 2007). These urban green areas provide habitat for wildlife, and enable species persistence within urban landscapes (Savard et al., 2000). They serve as shelter and refugee (e.g. Blair, 2004; Franchin and Júnior, 2004), besides contributing for the conservation of some endangered species (Mörtberg and Wallentinus, 2000).

Birds are essential ecosystem service providers (Whelan et al., 2008), including in urban settlements and green spaces, because they can regulate plant population through seed dispersal (Hougner et al., 2006), control insects (Sanz, 2001), and affect nutrient cycle (Fujita and Koike, 2007). In addition, due to their sensitivity to habitat structure (Clergeau et al., 1998; Savard et al., 2000), avian communities are often used as indicators of habitat quality in natural areas (Bradford et al., 1998; Canterbury et al., 2000; O'Connell et al., 2000; Bryce et al., 2002) and in human-dominated landscapes (Glennon and Porter, 2005). Birds may also positively affect people's appreciation of urban landscapes and boost recreational experience in urban parks (Hedblom et al., 2014). As such, birds are arguably key components of the urban fauna.

Within the urban landscape, decreased habitat availability, reduced patch size and vegetation complexity, along with increased edge, amplified non-native vegetation and nest predation are commonly associated with bird declines (Marzluff, 2001). Local extinction within urban parks or urban areas is common, and recolonization is rare, given the dense urbanization surrounding these areas (Borges and Guilherme, 2000; Krügel and Anjos, 2000). It is also expected that certain trophic levels, particularly specialists, solitary, behaviorally inflexible, ground-nesting, highly mobile (e.g. migrants), and aquatic bird species become lost with time in highly isolated forest fragments inserted in urban

* Corresponding author. Present address: Av. Juscelino Kubitschek 901, Paulínia, SP, 13141-130, Brazil.
E-mail address: cesar_estevo@hotmail.com (C.A. Estevo).

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matrixes (Kark et al., 2007; Croci et al., 2008; Møller, 2009; Evans et al., 2011). Consequently, bird diversity is likely to decrease as a function of the urbanization process (Savard et al., 2000). Hence, in face of an increasing human pressure on landscape, it is important that bird communities hold some degree of ecological resilience to safeguard their ecosystem services that benefit the welfare of humans and organisms (Alberti and Marzluff, 2004)

Ecological resilience is the capacity of a system to absorb disturbances and changes, while maintaining its functions and structures (Holling, 1973; Folke et al., 2004; Fischer et al., 2007). In recent years, there has been a growing body of theory on ecological resilience (Holling, 1973; Folke et al., 2004; Allen et al., 2005; Fischer et al., 2007; Karp et al., 2011), and a few studies proposed an empirical method to estimate the resilience of a community or system without its manipulation (Allen et al., 2005; Fischer et al., 2007). Specifically, they proposed a set of indices to assess the relative resilience of a system based upon the quantification of the distribution of ecological functions and the determination of discontinuities generated by processes operating across scales in time and space (Allen et al., 2005). Here, we focused on the ecological functions that birds provide. Aside from their ecosystem services (Sekercioglu, 2006), birds hold well-established feeding guilds (e.g. Poulin and Lefebvre, 1994), which one can use to assess bird's community resilience. Besides, the community resilience is likely to reflect the resilience of the system they live in (Fischer et al., 2007). A previous work using this methodology highlighted that bird communities in species-poor and agricultural sites usually have lower resilience (Fischer et al., 2007), but whether urban parks or urban forest remnants fall into this same patterns remains unknown.

Giving the importance of green areas in urban environments, we aim to assess the relative potential resilience of urban parks. To do this, we estimated the empirical resilience indices proposed by Allen et al. (2005) to assess the degree of resilience of an urban park in relation to a continuous Atlantic Forest remnant (a reference area) in the Southeast region of Brazil.

2. Methods

2.1. Study sites

We studied the bird community of two sites: an urban park ("Parque Natural Municipal Guapituba Alfredo Kimklert Junior"; 54 ha; 23°41′47.55″S, 46°27′01.81″W) and a reference area ("Parque Estadual Intervales"; 38000 ha; 24°18′29.33″S, 48°16′26.30″W; Fig. 1), both located within the Atlantic Forest domain in the Southeast region of Brazil (198 km apart).

The urban park is located at the municipality of Mauá, São Paulo. Approximately half of the urban park extension (approx. 25 ha) is closed for visitation, and research is the only activity allowed. The rest of the park is open to public visitation, and it has a few infrastructures (e.g., public restrooms, gym equipment, and administrative buildings). The vegetation at the park is composed of Atlantic Forest native plant species, which resembles a native forest in structure, as well as exotic plant species (mainly *Eucalyptus* sp. and exotic palm trees). Average temperatures are around 20 °C, and average annual rainfall of 1400 mm (CEPAGRI, 2016).

At the reference area, annual rainfall ranges between 1000 mm and 2000 mm, and average temperature of 20 °C (Fenton et al., 1999). Vegetation is composed of Atlantic Forest native plant species and it consists mainly of primary forest (see Aleixo and Galetti, 1997 for more details).

2.2. Bird survey

We surveyed the bird community of the urban park using 13 point counts spaced 200 m apart (Vielliard et al., 2010). From February to November 2013, we sampled each point count 17 times (n = 221 visits) for 15 min each, recording all species seen or heard within an unlimited observation radius. We started each survey at sunrise, and finished about 3 h later. We derivate a species accumulation curve using the "specaccum" function in R software with the "random" method (R Development Core and Team, 2008) to assess the efficiency of sampling effort, which reached stabilization after approx. 30 days (Fig. S1). Data on the bird community of the reference area were collected using a similar methodology and were obtained by Aleixo and Galetti (1997).

2.3. Theoretical foundation

We applied the theoretical framework developed by Holling (1992), Peterson et al. (1998), and Allen et al. (2005) to analyze the bird community function and resilience. This framework considers the distribution of ecological functions (e.g., feeding guilds) across multiple scales (Peterson et al., 1998; Allen et al., 2005).

Ecological systems are marked by processes operating across different scales that generate discontinuities in structural features of the system. These discontinuities result in patterns in the system such as aggregations of animal body mass and denote the transition of one scale to another (Allen et al., 2005). Maintenance of these patterns and aggregations indicate some self-organization of the system (Peterson et al., 1998; Allen et al., 2005). A theory suggests that resilience is identified as the functions that the elements of the system provide at different scales (Holling 1992). Therefore, if one can identify the discontinuities that mark the number of aggregations within the system, and describe their ecological functions and distribution within and across scales, it is possible to assess the relative degree of resilience of a system (Holling, 1992; Peterson et al., 1998; Allen et al., 2005).

2.4. Indices of resilience

The relative resilience of a system can be determined by identifying discontinuities and aggregations within the system, and by the quantification of functions both within and across each aggregation (i.e., within- and cross-scales, Fig. 2). Animal body masses can be used to identify discontinuities and define aggregations in ecological systems, besides being a measure that integrates different ecological aspects of a species (Holling 1992; Forys and Allen, 2002; Allen et al., 2005). Feeding guilds can help to understand species' functions, which makes birds reasonable candidates, as they have well-established feeding guilds and provide many ecosystem services.

Five metrics can be used to assess the relative resilience of a system, according to Allen et al. (2005): richness of functions, diversity of functions, evenness of functions, and redundancy of functions within and across scales. Richness of functions, for instance, denotes the range of functional traits of a species (Mason et al., 2005), while diversity of functions represents the diversity of traits and niches of species (Cadotte et al., 2011). Redundancy is the capacity of a species to perform similar roles or functions in communities and ecosystems (Walker, 1992); within-scale redundancy occurs when species of similar body mass perform similar functions, while cross-scales redundancy occurs when functions are performed by species of different body mass (Allen et al., 2005; Fig. 2). For instance, one species may assume the role of another species in case of local extinction (Touchton and Smith, 2011). When the reinforcement of a function occurs at different scales, it is more likely that the loss of that function can be offset by a similar species that interacts with the environment at the same or at a different scale. Therefore, the combination of within- and cross-scale redundancy can add to ecological resilience (Peterson et al., 1998; Allen et al., 2005).

We predict that the urban park would maintain less bird species than the preserved forest, but supporting species performing different ecological functions. Consequently, the bird community in the urban park would have similar levels on some of the resilience indices analyzed, indicating that the community has some degree of resilience.