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Conservation value of silvopastures to Neotropical migrants in Andean forest flocks

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ABSTRACT

In the face of continued loss of Andean forests, shade agroforestry is a promising approach where agricultural production and conservation can co-occur to support environmental and socioeconomic needs. Agroforestry systems provide habitat for a diverse avifauna, including several migratory species of concern. Unfortunately, shaded crops continue to be converted to sun monocultures and pastures which provide fewer ecosystem services, reduce habitat complexity, and support less biodiversity. Silvopastoral systems, which combine grazing pastures and trees, have recently been drawing worldwide attention. In an effort to evaluate the conservation value of little-studied silvopastures to Andean birds, we compared mixed-species flock communities associated with different forested habitats. In January–February of 2011–2013, species composition, flock size, and individual foraging heights were recorded for 446 flocks at 9 study areas in Antioquia, Colombia. We sampled shade-coffee, shade-cardamom, secondary forest, and silvopasture at ~1,150–1,850 m elevation and measured vegetative structure in each habitat. Less structurally-complex silvopastures supported smaller, less diverse flocks with fewer Neotropical migrants and resident forest specialists. Further, fewer male Blackburnian Warblers flocked in silvopastures compared to other habitats, which is consistent with other studies showing that overwintering male migrants tend to occupy the highest quality habitats. Although forest birds may be better served by silvopastures than conventional treeless pastures, our findings suggest that silvopastoral systems are less suitable for flocking birds than other forested habitats. However, agroforestry remains an important complementary approach to other strategies to maintain Andean forests and improve the conservation potential of degraded land.

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1. Introduction

With ever-growing demands on the environment, society is challenged to find ways that conservation can occur within working landscapes. This is especially true in biodiversity hot spots such as the northern Andes mountains of South America, where deforestation and agricultural development have left little forest intact. Agroforestry is a strategy that can reduce habitat loss for forest species while producing high yields and supporting rural livelihoods (Perfecto and Vandermeer, 2010). However, not all approaches are comparable in terms of ecological value. Market pressures can provoke conversion from more to less environmentally-friendly practices, usually a quick transformation that can take decades to reverse. For example, in Colombia >60% of all shade coffee plantations were converted to structurally simple sun coffee (Perfecto et al., 1996; Rice and Ward, 1996), and rangelands doubled from 1960 to 1995 (Murgueitio et al., 2011). The conversion of agroforestry systems to land uses with less vegetative complexity, such as pasture for cattle grazing, is one example where socioeconomic pressures, including a volatile coffee market and changing demographics, may diminish the ability of land to meet conservation needs (Camargo et al., 2005).

Shade agroforestry is widely known to support diverse bird communities, including migratory birds that are more numerous in shaded crops than large-scale commercial agriculture (Perfecto et al., 1996; Moguel and Toledo, 1999; Rice and Greenberg, 2000; Roberts et al., 2000; Pomara et al., 2003; Komar, 2006; Bhagwat et al., 2008). Although shade plantations may lack resident forest specialists, they usually harbor diverse and abundant populations of migrant species (Greenberg et al., 1997a, 2000; Wunderle and Latta, 2000). In fact, abundance of many Neotropical migrants is

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often greater in shade-coffee compared to primary forest (Greenberg et al., 1997c; Petit et al., 1999; Johnson and Sherry, 2001; Tejeda-Cruz and Sutherland, 2004; Bakermans et al., 2009). Thus, trends in agroforestry conversion may have serious consequences for migratory species such as the Cerulean Warbler (*Setophaga cerulea*), whose steady population decline may be linked to loss of forest cover in the Andean coffee-growing region.

Among the most striking features of agroforestry systems is their ability to support a diverse group of resident birds, many of which associate closely with Neotropical migrants in mixed-species foraging flocks. This phenomenon is particularly common and widespread in the Andes, where flocks are distinctive because of the participation of diverse foraging guilds using multiple strata, the high representation of tanagers (Thraupidae), and for being among the largest recorded mixed-species flocks, frequently with 10–20 species and upwards of 30 individuals (Moynihan, 1979; Remsen, 1985; Bohórquez, 2003; Arbeláez-Cortés et al., 2011). Mixed-species flocks are important features of Andean forest ecosystems, and in agricultural landscapes as many as 85% of species within the local bird community may participate when migrants are present (pers. obs.). As many migrant species forage almost exclusively in flocks, overwinter survival is thought to be influenced by these flocking systems.

Though shade crops such as coffee and cacao are only grown on a small proportion of global agricultural land, expansive rangelands have great potential to be developed into sustainable systems incorporating trees and shrubs, known as silvopastoral systems. An alternative to conventional cattle grazing, silvopastures have been little studied compared to other agroforestry. Silvopastoral systems are receiving worldwide attention for their economic and conservation potential in agricultural landscapes, including Andean regions (Murgueitio et al., 2011; Cubbage et al., 2012). Planting trees in rangelands may partially mitigate negative environmental impacts of grazing such as deforestation, erosion, and water pollution and provide more ecosystem services such as increased nutrient recycling, soil fertility, and carbon sequestration compared to conventional pastures (Nair, 1989; Murgueitio and Calle, 1999; Chará and Murgueitio, 2005; Ibrahim et al., 2006; Haile et al., 2010). Furthermore, the shade trees in silvopastures provide marketable saw-timber, firewood, fruits, and seeds (Bellefontaine et al., 2002). Although they exhibit less structural complexity compared to many other agroforestry systems, silvopastures provide perches, shelter, foraging, and corridors for a wide variety of resident and migratory birds (Harvey et al., 2005; Fajardo et al., 2009; Rice and Greenberg, 2004). Greenberg et al. (1997b) found that *Acacia pennatula* groves used for grazing in Mexico had the highest density and diversity of many migratory bird species compared to other habitats. Though not as biodiverse as forests, silvopastures in Colombia support many species and individual birds (Fajardo et al., 2009), but little is known of the relative value of silvopastures to foraging flocks and migrant birds.

In this study we compared relative habitat use of silvopasture, shade-coffee, shade-cardamom, and secondary forest by mixed-species flocks and overwintering migratory birds, with the ultimate aim of informing agroforestry management in the Andes. Specifically, we examined how vegetative structure and flocking bird communities differed among these habitats. Reductions in habitat complexity resulting from land conversion, such as forest lost to pasture or silvopasture, are likely to render habitat less suitable for flocks by impacting resource availability. Simplification of habitat and loss of floristic diversity diminish wintering migrant diversity (Rappole and Morton, 1985; Lynch, 1992) and can reduce functional diversity of the avian community, such as fewer forest understory specialists (Sekercioglu, 2012). Loss of vegetative strata reduces foraging substrates, which could reduce the likelihood of certain species occurring and/or joining flocks. Therefore, we predicted that complex secondary forest would have the largest and most diverse flocks showing greater vertical distribution of individuals compared to structurally simple silvopastures, which were expected to have the least diverse flocks. Because sex segregation can indicate habitat quality, with males occupying the best habitats on the wintering grounds (Sherry and Holmes, 1996; Latta and Faaborg, 2002), we hypothesized that proportion of males of migrant species would be greatest in the most structurally-complex habitats and lowest in silvopastures.

2. Material and methods

2.1. Study areas

Mixed-species foraging flocks were studied in the northern Andes of Colombia, Antioquia Department (5°49′N, 75°49′W). The Colombian Andes are comprised of three mountain chains which divide near the Ecuadorian border: the Cordillera Occidental, or western chain, Cordillera Central in the center, and Cordillera Oriental, the eastern chain. Our study areas were located near the towns of Andes, Betania, Ciudad Bolívar, Jericó, Monserrate (Jardín municipality), Palermo (Támesis municipality), Salgar, and Támesis in the western chain and Fredonia in the central chain. The nine study areas are premontane moist forest in the Cauca River Valley between ~1,150 and 1,800 m in elevation (Holdridge, 1967). Annual temperature fluctuates between 19 and 23 °C. The landscape was a heterogeneous mix of native forest remnants and ravines, shaded and open crops, developed areas, and pastures. The primary land uses are cattle grazing, cultivation of coffee and plantain, and smaller amounts in other crops.

In each study area, we established replicate study plots approximately 10 ha in size. Study plots were delineated by visually identifiable boundaries and hard transitions between habitat types. We studied the most common forms of tree cover available to birds in the region: secondary forest ($n = 31$ plots), shade-coffee ($n = 44$), shade-cardamom ($n = 11$), and silvopasture ($n = 40$). Secondary forest plots were typically remnants in riparian areas or ravines (Fig. A1). Shade-coffee plantations in the study area were highly-managed with a homogeneous overstory of shade trees such as *Inga* spp., *Tabebuia* spp., *Cordia alliodora*, *Albizia* spp., and *Persea* spp. (Fig. A2). Cardamom, a highly-shaded agroforestry system, was grown on moist slopes and often in ravines with a near-closed canopy. Cardamom is a low-growing, leafy plant that grows in the understory of a diverse canopy of native forest trees (Fig. A3). Silvopastures were represented by fence rows, scattered overstory trees, and clumps (some former shade-coffee trees) in pasture grazed by cattle (Fig. A4). Composition of remnant trees in silvopastures was similar to shade trees found in coffee plantations.

2.2. Flock surveys

During January and February 2011–2013, transects were systematically walked in each plot to search for flocks from 0700 to 1200 and 1500 to 1700 h COT, which are known to be peak activity periods for birds in our system. Transects were not used to estimate density of birds at a site, but rather to standardize our efforts to encounter flocks. Transect length (0.5–1.0 km) necessarily varied among survey sites based on site area and topography. To facilitate our ability to observe flocks, transects were established in areas relatively easy to traverse, such as on an established trail, secondary road, or path through a farm. Each plot contained 1–2 transects ($n = 164$ transects total) such that the total area traversed was comparable among sites. Surveys were conducted in favorable weather (e.g., no rain, heavy fog, or strong wind) under conditions not expected to affect flock behavior or our observation ability.

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