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ASSESSING THE VALUE OF SHADE COFFEE FOR BIRD CONSERVATION IN THE COLOMBIAN ANDES AT A LOCAL, REGIONAL, AND NATIONAL LEVEL

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Abstract. There is a growing interest concerning the value of shade coffee for bird conservation in tropical regions, but most of the research to date has come from landscapes retaining high levels of forest cover and from coffee grown under traditional shade. Most of Colombia's coffee production takes place in technified coffee farms, located in highly transformed rural landscapes, and coinciding with high levels of bird diversity and endemism. We analyzed Cenicafé's Conservation Biology Program's bird database (1997-2007) to assess the value of shade coffee for bird conservation at a local, regional, and national level. We then compared those findings with similar data from patches of natural vegetation. At a local level, shade coffee had similar or higher species richness than natural vegetation, but its contribution in terms of forest species is limited by how much its structure resembles that of native habitat. At a regional level we found comparable levels of species similarity when we compared sites within the shade coffee or the natural vegetation cover types. At the national level, shade coffee plots had an impoverished bird community; patches of natural vegetation had more variation in species composition among regions and harbored more species of conservation concern. Most species (60%) were recorded in both cover types, but there were many more species found exclusively in natural vegetation (107) than in shade coffee (42). Promoting coffee grown under diverse and complex shade, and preserving natural vegetation remnants, emerge as complementary, rather than supplementary, conservation strategies for birds in the Colombian Andes.

Key Words: birds, Colombia, conservation, patches of natural vegetation, shade coffee.

EVALUACIÓN DEL VALOR DE LOS CAFETALES BAJO SOMBRA PARA LA CONSERVACIÓN DE LAS AVES EN LOS ANDES COLOMBIANOS A ESCALA LOCAL, REGIONAL Y NACIONAL

Resumen. Existe un interés creciente respecto al valor del café cultivado bajo sombra para la conservación de las aves en las regiones tropicales, pero hasta ahora la mayoría de las investigaciones provienen de paisajes que retienen altos niveles de cobertura boscosa y de cafetales con sombríos tradicionales. La mayor parte de la producción cafetera en Colombia ocurre en cultivos tecnificados, en paisajes rurales altamente transformados, y que coinciden con altos niveles de diversidad y endemismo de aves. Analizamos la base de datos del Programa de Biología de la Conservación de Cenicafé (1997-2007) para evaluar el valor del café bajo sombra para la conservación de las aves a escala local, regional y nacional. Después comparamos estos hallazgos con datos similares correspondientes a parches de vegetación natural. A escala local, el café bajo sombra tuvo niveles similares o mayores de riqueza de especies que la vegetación natural, pero su contribución de especies de bosque está limitada por la semejanza estructural a los hábitats nativos. A escala regional encontramos niveles semejantes de afinidad de especies al comparar diferentes cafetales bajo sombra o diferentes remanentes de vegetación natural. A nivel nacional el café bajo sombra presentó una comunidad de aves empobrecida; los parches de vegetación natural tuvieron más variación en la composición de especies entre regiones y albergaron más especies de prioridad de conservación. La mayoría de las especies (60%) se registraron en ambos tipos de cobertura, pero encontramos más especies exclusivas de vegetación natural (107) que de café bajo sombra (42). Promover el café sembrado bajo sombríos diversos y complejos, y preservar los remanentes de vegetación natural, emergen como estrategias de conservación complementarias, más que suplementarias, para las aves en los Andes Colombianos.

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INTRODUCTION

Few agricultural production systems have received as much attention from a biodiversity conservation perspective as coffee. Since the mid-1990's, numerous studies evaluated, praised, or criticized the value of shade coffee as a habitat for birds, especially in Mexico and Central America (Perfecto et al. 1996, 2003, Wunderle and Latta 1996, Greenberg et al. 1997a, 1997b, Calvo and Blake 1998, Tejeda-Cruz and Sutherland 2004, Komar 2006). Studies are becoming more complex in their analyses and approaches (Daily et al. 2001, Perfecto et al. 2005, Philpott et al. 2007, Sekercioglu et al. 2007), but most have been conducted in traditional shade coffee plots and in landscapes that still contain important remnants of native forest habitats.

However, the bulk of the world's coffee production comes from farms with modern technified production systems, in densely populated, and highly transformed rural landscapes. This is the case for most of the areas where coffee is produced in Colombia, one of the most important coffee producers in the world and the country with the highest bird species richness. The relationship between shade characteristics and coffee production is a complex one (Soto-Pinto et al. 2000), and although growing coffee under shade might be the favored or required system in some parts of Colombia—for example, in regions with prolonged soil moisture deficits—it is not an economically viable system in areas with high annual cloud cover, where increasing shade cover reduces incoming sunlight and ultimately leads to a decrease in production (Farfán-Valencia 2007).

Assessing the value of shade to biodiversity conservation is an issue of importance as part of an effort to ensure the maintenance of ecosystem services and sustainable development in coffee producing landscapes. The Conservation Biology Program in Cenicafé (National Center for Coffee Research, a part of the National Coffee Growers Association) was created more than 10 years ago to generate and disseminate information on the state of biodiversity in the coffee-growing regions of Colombia. This work led to searching for conservation strategies that provide benefits for both the natural and human communities living in these regions.

Several of the projects executed during this time used birds as biodiversity indicators in different landscape types and coffee production systems. Recently, we finished building the Conservation Biology Program's (BDC) database that includes all the available data. The aim of this paper is to analyze the evidence collected to date in the BDC database and in some individual projects, to examine the value that shade coffee may have for bird conservation in the Colombian Andes. To do this we analyze data at local, regional and national levels, and compare them with similar data from patches of natural and semi-natural vegetation.

We are expanding the results from our presentation at the 4th International Partners in Flight Conference titled "Migratory Birds in the Coffee Producing Regions of Colombia" to include resident species. This type of analysis is important for an alliance such as Partners in Flight because understanding the best strategies for conservation of local birds in Latin America improves the chances that strategies for conservation of Neotropical migrants will work as well.

METHODS

Study Area

Our study areas, regions where coffee is grown in Colombia, are generally restricted to altitudes between 1000 and 2000 m, in which coffee crops occupy about 29% of the total area (FNC 2009). Other productions systems include cattle pastures, and food crops like maize, beans, sugar cane, bananas, and other fruits and vegetables. It is also one of the most densely populated regions of Colombia (Rodríguez et al. 2004). In this assessment we examined results of bird studies carried out in more than 40 municipalities located throughout these regions. These include study sites in the three Andean mountain ranges and the Sierra Nevada de Santa Marta (Fig. 1), in five different ecoregions (No. 12: Cauca Valley montane forests, No. 22: Cordillera Oriental montane forests, No. 41: Magdalena Valley montane forests, No. 51: Northwestern Andean montane forests, and No. 64: Santa Marta montane forests—according to the classification of Olson et al. 2001). Soil, climate, topographic and cultural conditions vary significantly among these sites, resulting in a diversity of coffee production systems. In regions like the Sierra Nevada, Santander, and Cundinamarca coffee is grown under shade, whereas in parts of Caldas, Risaralda, Quindío, and Huila it is grown under full solar exposure. Shade characteristics range from heterogeneous in Santander to very homogeneous in regions like Valle and Antioquia (Sánchez-Clavijo et al. 2007).

Sources of Information

In this paper we examined the aggregated results from ten projects that involved bird sampling in coffee-producing areas of Colombia; with emphasis on data from shade coffee farms

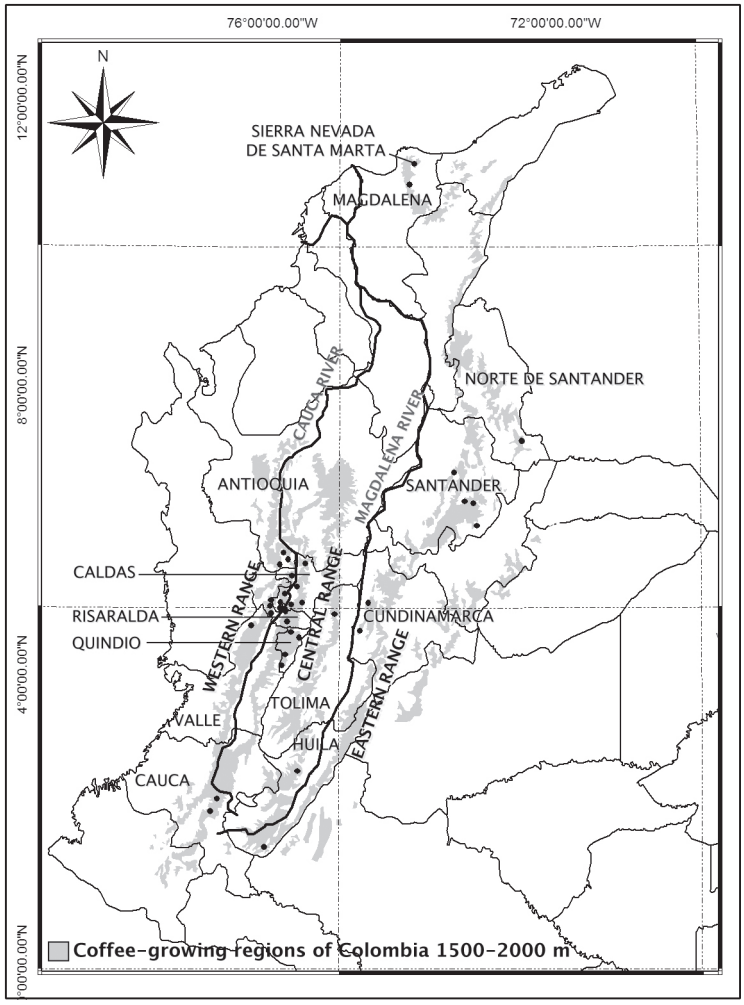

FIGURE 1. Distribution of the coffee-growing region in the Colombian Andes, and location of some of the bird study sites mentioned.

and patches of natural and semi-natural vegetation. Habitats and sampling methods varied according to the research objectives of each project, but all provided useful information for this assessment. Geographical coverage extended from the Sierra Nevada de Santa Marta in northern Colombia to municipalities in the southern departments of Cauca and Huila, from the western to the eastern mountain ranges. The altitudinal range of all sites is 1200-2000m (Fig. 1).

Some of these data have already been published (Botero et al. 1999a, 1999b, Botero and Verhelst 2001, Verhelst et al. 2001, Verhelst et al. 2002, Botero et al. 2005, Sánchez-Clavijo et al. 2008). Additional research is in preparation for publication, with some featured in technical reports issued internally and to financing and supporting institutions.

We focus mainly on the results of the following three projects.

Project ANDES

Cenicafé carried out a plant, bird, and ant community characterization in rural landscapes dominated by shade coffee; as part of the project "Conservation and sustainable use of biodiversity in the Colombian Andes" lead by the Alexander von Humboldt Biological Resources Research Institute. It was carried out between 2003 and 2004 in three distinct biogeographical regions—in the municipalities of El Cairo (Valle), Támesis (Antioquia), and Socorro (Santander) (Fig. 1). In order to get good representation of the regional avifauna and the contribution of each habitat, bird sampling was carried out in

representative cover types within each of eight equal size segments of a large study area (2.5 km^2). Sites were spread out systematically and point counts were repeated during several days (Durán et al. 2004a, 2004b, 2004c).

Project FRAGMENTS

Phase 1 of a project titled "Effect of forest fragmentation over the genetic diversity of wild populations of plants and animals in the coffee-growing region" included sampling of birds, plants and bats in 15 forest fragments located in the central coffee growing region of Colombia (Caldas, Risaralda, Quindío, and Antioquia Fig. 1). This project was carried out between 2003 and 2004. Bird assemblages were sampled with transects and mist nets, with the goal of a complete characterization of remnant communities in one of the most disturbed regions of Colombia (Orrego et al. 2004).

CERTIFICATIONS Project

The undergraduate thesis "Evaluating the role of environmental certifications to coffee in biodiversity conservation: focus in bird communities" was carried out in 2006. It was designed to compare plant and bird communities in 13 shade coffee farms according to their environmental certifications status: no certifications, Rainforest Alliance certification, and Rainforest Alliance + Organic certification. This study took place in Santander, where these certifications have been well received by shade coffee farms that still resemble the traditional form (Gómez 2006).

Because we have generalized habitats into broad categories, it is important to clarify that in shade coffee we have included a wide range of shade types, from complex and diverse remnant shade to simple plantations with a single overstory shade species. Under patches of natural and semi-natural vegetation we include forest fragments, tall secondary vegetation patches and riparian vegetation. These are usually small, disturbed and isolated, but in many of the agricultural regions where coffee is grown in Colombia, they are all that remains of the middle-elevation mountain forests that covered the area originally.

It is also important to address the fact that these results were not designed for direct comparisons, and therefore data sets are highly variable in terms of the sampling effort behind them. For this reason, conclusions featured in this paper are approximations to general patterns and explanations, and preliminary species richness values are used as relative, rather than absolute values.

RESULTS AND DISCUSSION

The Local Value of Shade Coffee

Local studies in shade coffee plots have shown high species richness. In the ANDES study, we found 62, 75, and 83 species of birds using shade coffee as habitat in Valle, Santander, and Antioquia, respectively, representing about 70% of the total avifauna found in each of the three regions. In the CERTIFICATIONS study, where sampling effort was higher, total species richness for 13 farms in Santander was 106 species. Remarkably, 21 of these species (20%) were boreal migrants (Table 1). This figure is very high for a South American habitat, and is similar to data from shade coffee plots in Central America (Komar 2006).

Local studies of birds in secondary vegetation remnants show similar or lower levels of species richness. In ANDES, we found only 23 bird species in Valle's secondary forests, and 45 and 59 species, respectively, in Santander and Antioquia's tall secondary vegetation patches. These values represented only 25% to 48% of the species in each region. With higher sampling in the less disturbed forests studied in FRAGMENTS, we found 35 to 75 species per fragment, and a total contribution of 192 species in fragments spread over a wide geographical area (Table 1). Shade coffee plots would appear to make local contributions to bird diversity at higher and similar levels as do forest fragments. However, due to higher sampling efforts (number of sites), and because of higher individual detectability of birds in habitats with open vegetation, the number of individuals (sample size) is much higher for shade coffee than for natural vegetation remnants (Table 1). This may explain the higher species richness we found.

Bird community composition was different between shade coffee and natural vegetation remnants, as has been reported in other studies (Estrada et al. 1997, Daily et al. 2001, Tejeda-Cruz and Sutherland 2004, Gordon et al. 2007). Calculated species similarity (using Jaccard's index of compositional similarity) between the two types of habitats for each region studied in ANDES showed values under 0.5; shade coffee and secondary vegetation remnants shared only 17% of the bird species found in Valle, 39% in Antioquia, and 41% in Santander (Table 1). Differences between regions for this value may be explained by the vegetative characteristics of each cover type, which vary according to management and disturbance history. In Valle, sparse shade is dominated by a single tree species (Sánchez-Clavijo et al. 2007), and therefore its bird community resembled more

TABLE 1. Summary of variables measured for shade coffee plots and patches of natural vegetation at a local, regional, and national scale in Colombia's coffee-growing regions.

Data origin	PROJECT	ANDES						SC CERT.[a]	FRAGS.[b]	BDC DATABASE		
	REGION	Valle		Antioquia		Santander		Santander	Central	Colombia		
	HABITAT (number of sites)	Shade Coffee (16)	Secondary Forest (4)	Shade Coffee (11)	Tall Secondary Vegetation (8)	Shade Coffee (8)	Tall Secondary Vegetation (6)	Shade Coffee (13)	Forest Fragments (15)	Shade Coffee	Natural Vegetation	Total
Species richness	No. species (S)	62	23	83	59	75	45	106	192	320	385	455
	No. individuals (N)	652	87	760	189	636	290	6846	5192	14873	10474	25347
Red List species[c]	Critically endangered (CR)	0	0	0	0	1	1	2	0	2	2	3
	Endangered (EN)	0	0	0	0	0	0	0	1	2	7	7
	Vulnerable (VU)	0	0	1	1	1	0	1	1	5	6	7
	Near threatened (NT)	0	0	0	0	0	0	1	4	2	6	6
Endemic species[d]	Endemic	0	0	0	1	1	1	2	3	11	17	18
	Near-Endemic	3	0	3	1	3	2	5	4	13	12	16
Migrants[e]	Northern hemisphere	6	0	13	6	15	9	21	21	28	26	31
	Southern hemisphere	0	0	0	0	0	0	0	0	0	0	0
Vulnerability indexes	Species high vulnerability[f]	16%	32%	9%	15%	14%	16%	-	-	-	-	-
	Score: vulnerability X dependency[g]	20	31	20	20	26	16	-	-	-	-	-
Similarity measurements[h]	Similarity between sites (mean ± SD)	0.26 ± 0.08	0.20 ± 0.08	0.23 ± 0.08	0.08 ± 0.07	0.33 ± 0.08	0.35 ± 0.07	-	0.27 ± 0.08	-	-	-
	Similarity vs. natural vegetation remnants in the same site (%)	0.17	-	0.39	-	0.41	-	-	-	0.65	-	-
	Highest habitat similarity in the region	Fallow Pastures (0.43)	-	Treed Pastures (0.45)	-	Secondary Vegetation (0.41)	-	-	-	-	-	-

[a]CERTIFICATIONS (Gómez 2006), [b]FRAGMENTS (Orrego et al. 2004), [c]Renjifo et al. 2002, IUCN 2007, [d]Renjifo et al. 2000, [e]Remsen et al. 2008, [f]VI = 1 or 2 (Kattan 1992), [g]Petit & Petit 2003 (modified version), [h]Jaccard's index of compositional similarity.

closely the one found in fallow pastures (43%) than the one found in secondary forests. In Antioquia, shade is also highly monospecific (Sánchez-Clavijo et al. 2007), and the highest similarity found for its bird community was with that of pastures with scattered trees (45%). The highest similarity between communities in shade coffee and those in natural vegetation remnants found in Santander may be explained by this region's complex and diverse shade (Sánchez-Clavijo et al. 2007).

Therefore, the contribution that shade coffee plots can make to the regions' original forest avifaunas seems to be limited by how much its structure resembles that of native habitat, as has been previously reported (Moguel and Toledo 1999, Perfecto et al. 1996, 2005, Tejeda-Cruz and Sutherland 2004; Gordon et al. 2007). As shade in coffee plots loses its vegetative diversity and complexity, it loses its resemblance to forest and becomes more like semi-open habitats with a few trees. Most forest birds find these habitats to be unsuitable and are typically replaced by generalist species.

The Regional Value of Shade Coffee

When we examined variation between samples within particular sites, high levels of variation indicated high beta diversity—communities between similar sites are different and each holds a conservation value of its own. Low levels of variation indicated low beta diversity—communities are very homogeneous among sites and each one can be replaced by another. We expected bird communities in anthropogenic habitats to vary less than those in natural and semi-natural habitats (Daily et al. 2001; Petit and Petit 2003). However, regional studies show that shade coffee plots and natural vegetation fragments located within the same region have similar, low levels of species similarity, so that any patch may have an important value for the conservation of birds in the region.

Results from ANDES show that variation in bird community composition among shade coffee plots located in the same study area is significant. In the three locations communities in different plots shared less than 50% of the species (Table 1), indicating that even though the communities in shade coffee are different from those in patches of natural vegetation, they do not represent a completely homogeneous set of species adapted to disturbed habitats.

The same holds true in data from FRAGMENTS. No two forests shared more than half their species, and patterns didn't relate to patch size or proximity to each other (Table 1). The high heterogeneity between the avifaunas

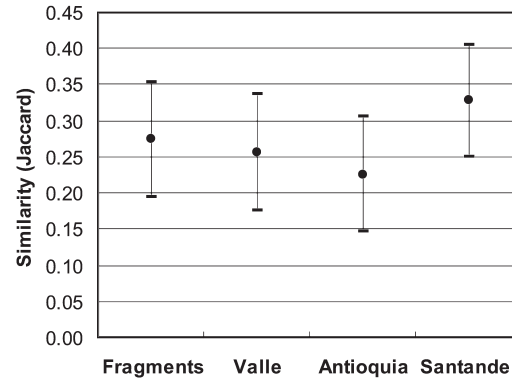

FIGURE 2. Average similarity between forest fragments in the central coffee-growing region of Colombia, and shade coffee plots in Valle, Antioquia, and Santander.

of different patches enhances each fragment's conservation importance. It may indicate that after the process of fragmentation took place survival in each fragment was differential, or it can also be a result of differences in habitat factors that we did not measure such as altitude and vegetation composition. From these two projects, we see little difference in the variation in species composition between communities in different shade coffee plots or different patches of natural vegetation (Fig. 2).

The National Value of Shade Coffee

Analyses at a national level show more differences between the birds found in shade coffee and those found in natural vegetation remnants, especially when considering species conservation priorities. We utilized two ways to assess the value of shade coffee for bird conservation at this level. The first used information on the rarity of each species at a national scale to analyze local and regional results. The second took results from the BDC database that covers a wide geographical area of the coffee-growing regions of Colombia.

In ANDES we calculated the vulnerability of all species based on their geographical distribution, habitat preferences and local abundance, following the methods described by Kattan (1992), and the rarity categories of Rabinowitz et al. (1986). Between 9% and 16% of the bird species in shade coffee plots were highly vulnerable. This shows that the value of shade coffee to bird conservation doesn't arise solely from its supporting of a large number of individuals and species, but that it does harbor species of conservation importance (Table 1). Fifteen to 32% of the species in natural vegetation patches

were highly vulnerable species. In Valle and Antioquia the percentages were twice or nearly twice those found for shade coffee. In Santander it was only 2% higher, probably because vegetation structure of the two cover types is relatively similar (Table 1).

We coupled this analysis with measures of habitat dependency using a modified version of the index created by Petit and Petit (2003), and concluded that a considerable proportion of species found in shade coffee depend strongly on it. This is especially true in cases like Santander where there is no longer much suitable habitat for forest associated species (Table 1). The dependence of species on their habitat was higher for forests than for shade coffee in Valle, the same for both cover types in Antioquia, and higher for coffee in Santander (Table 1). This reflects the differences in habitat quality determined by the internal characteristics and management of cover types in each region. From this perspective, conservation importance is highest in those habitats that showed the least disturbance.

Information in the BDC database shows that out of a total of 455 species of birds seen or heard in the coffee growing regions of Colombia (and for which we had a described habitat), 320 (70%) have been recorded in shade coffee, and 385 (85%) have been recorded in patches of natural vegetation. Sampling efforts have probably been similar for both habitat types, but since the results come from different projects we have no way of measuring that accurately.

Two hundred seventy eight species, 60% of the birds in our database, use both types of habitats (Fig. 3). This is important because it means in areas where there are no forests left, but where shade coffee is present, a high proportion of bird species richness may still be represented. Likewise, in regions where coffee is grown with total solar exposure, but where there are still forest fragments, numerous species will be present. This overlap conforms to evidence for the utility of these agricultural systems as habitat for birds of conservation importance. This is especially true in regions where natural vegetation is scarce and deteriorated and where some kinds of shade coffee could become the main habitat for forest birds. It also indicates that many of the birds found in our database are generalist species.

Our most pressing priorities should be those species that depend on the presence of forested habitats (Daily et al. 2001, Tejeda-Cruz and Sutherland 2004, Estrada and Coates-Estrada 2005). The 107 species of birds found exclusively in natural vegetation remnants (24% of the species we analyzed) will only persist in our rural landscapes if such habitats are conserved.

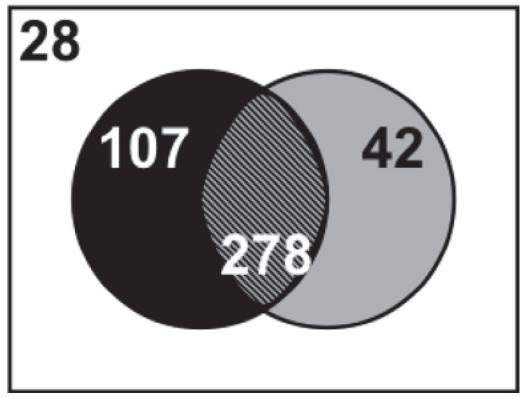

FIGURE 3. Venn diagram explaining the habitats in which birds in the Conservation Biology Program's database have been found; white = number of species that weren't found in either patches of natural vegetation (NV) nor in shade coffee plots (SC); black = number of species found in NV but not in SC; grey = number of species found in SC but not in NV; striped = number of species found in both NV and SC.

The proportion of species found in shade coffee but not in forest remnants is much smaller, and probably composed of open habitat species of a lesser conservation priority (Fig. 3).

The small number of species not included in either of these two habitat types (28) is almost certainly an effect of sampling bias. However, it also suggests that the best conservation strategies are probably those related to shade coffee and patches of natural vegetation, and that conservation efforts should not be focused solely on either strategy, but rather combine both in a complementary fashion.

Natural and semi-natural vegetation remnants harbor more resident species of conservation importance (threatened and endemic) than shade coffee farms. This is especially true for endangered, nearly threatened, and endemic species. Nonetheless, shade coffee does harbor an important proportion of these species, and in addition, more migratory species (Table 1). The fact that no habitat type contains all the threatened, endemic or migratory species further emphasizes our statement that conservation initiatives in these types of rural landscapes should include multiple strategies in order to conserve most priority species.

CONCLUSION

Due to the nature of our data, the patterns discussed in this paper are a general approximation to the issue of evaluating the conservation value of agricultural systems like shade coffee. However, detailed, statistically robust

studies are still needed to assess specific cases, especially at the local and regional levels. As we broadened our analyses to the national level, differences in the conservation value of shade coffee and patches of natural vegetation became clearer. Shade coffee in Colombia is a highly productive and technified agricultural system, yet our investigations show that it does have the high conservation value for birds found in traditional systems of Mexico and Central America. This is especially true considering how little forest habitat is left in regions where coffee is grown in Colombia, where the contribution made by shade coffee farms cannot be replaced entirely by the conservation of those few remaining patches of natural vegetation. However, as has been argued by other researchers on this topic, increasing shade coffee is not as determinant for the conservation of priority species as protecting and restoring remnants of natural vegetation.

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