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BIRD FEEDING BEHAVIOR AS A MEASURE OF RESTORATION SUCCESS IN A CARIBBEAN FORESTED WETLAND

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Comportamiento de forrajeo en aves como medida de éxito de restauración en un humedal Caribeño.

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INTRODUCTION

The goal of a restoration project is to create a resilient ecosystem that will recover naturally from disturbance without human intervention (Urbanska *et al.* 1997). Measures of this goal include the assessment of complexity increase in vegetation structure, species diversity and ecosystem processes (Ruiz-Jaen & Aide 2005a). Some studies argue that, to accurately measure restoration success, a combination of these characteristics must be assessed (Hobbs & Norton 1996, Ruiz-Jaen & Aide 2005a, 2005b; Ruiz-Jaen & Aide 2006). Many restoration projects are concerned with increasing habitat for focal wildlife species, or groups of species, and restoration success of these projects should be assessed on the basis of how wildlife responds (Morrison 2002). Even though invertebrates are often studied to assess restoration success because they represent many functional groups (Holl 1995, Longcore 2003), vertebrates, especially birds, have also been included in restoration success studies because they are important for seed dispersal (Reay & Norton 1999), which is a critical process in restoration. Most restoration studies concerning birds have focused on species diversity and composition, and little is known about the ecological and behavioral consequences, in particular resource use and feeding behavior.

Resource use can differ in forest patches even if they have the same bird species composition. For example, birds may use a forest patch for foraging and nesting, and another forest patch for roosting or just as a stop-over site. If we measure the restoration success of these two patches merely based on bird species richness or composition, we might erroneously conclude that both have reached the same level of restoration, even though one of them may not provide all birds' critical requirements, such as food and breeding sites. Even though some studies have recognized the problematic of measuring restoration success (Sherry & Holmes 1996, Marzluff & Ewing 2001), studies directly measuring differences in resource use characteristics (e.g., foraging behavior) in a restoration success

context are scarce. Given that the goal of most restoration projects is to create suitable habitats for wildlife, measures of restoration success must have information on how wildlife use the site. One important measure of how wildlife uses a forest patch is foraging behavior because it is important to know if birds are using the forest patch for eating (a vital resource), and which kind of food resources they are using. For this reason, I studied bird feeding behavior in a restored forest patch and two reference sites: one that resembles the pre-restored conditions and a forest patch representing the expected outcome of the restoration project in a wetland in Puerto Rico. Puerto Rico's unique land-use history, which includes forest transformation and forest recovery, makes it an interesting place for the study of bird restoration success. If a restoration project is reaching the goal of providing the resource requirements for population viability, we will detect similar foraging behaviors in the restored and reference forests. In contrast, if the restoration project is not yet reaching the goal, we will find similar foraging behaviors between the restored forest and the pre-restored condition site.

METHODS

The study was conducted in the municipality of Toa Baja, in northern Puerto Rico (18°28'N, 66°13'W) where the restored forest and two reference sites are located. Lowland habitats in Puerto Rico were severely modified for agricultural use at the beginning of the 20th century (Dietz 1986). Wetland habitats were mostly modified for sugarcane production. A change in political status in 1952 resulted in a shift in the principal economic activities from agriculture to small scale manufactures and this led to rural-urban migration and the abandonment of much of the agricultural land (Grau *et al.* 2003). Most of these abandoned agricultural lands are now secondary forests (Aide *et al.* 2004) or grasslands.

The restored site (~18 ha) is a grassland dominated by *Typha dominguensis* which colonized the area after the sugar cane plantations were abandoned. Nearly 7000 individuals of *Pterocarpus officinalis* (water dispersed) and *Annona glabra* (animal and water dispersed) were planted between 1997 and 2000. I used a nearby brackish-water forested wetland dominated by *Pterocarpus officinalis* as a reference of the expected outcome of this restoration project (12 ha). For the reference of the pre-restored conditions, I used a nearby grassland (~14 ha) dominated by *T. dominguensis*.

The three sites were visited monthly from December 2004 to May 2005. A single forest type was visited per day just after sunrise (~ 06:40 h in December and 05:50 h in May) for 4 h (24 h total for each forest type). Observations were made by walking slowly through small trails (less than 1 m wide) in the vegetation. When a bird was detected, it was identified and I noted the first behavior, to avoid the problem of autocorrelation (Wagner 1981). This observation was made after 5 s of detection to avoid behaviors caused by the presence of the observer (Wunderle & Latta 1998). The foraging behavior classification I used was adapted from Remsen & Robinson (1990) but, since foraging behaviors were infrequent, I reduced the number of behaviors to nine: perching, perching and calling, foraging in the understory, foraging on tree branch, foraging on leaves (gleaning), foraging on bark, eating seed, eating insect, and eating other animal (Table 1).

RESULTS

I obtained bird foraging observations in the reference forest of 16 species, in the restored site of 5 species and in the pre-restored site of 1 species (Table 1). For these, I collected a total of 65 foraging observations in the refer-

TABLE 1: Bird species and total number of observations of nine foraging behaviors in three forest types: reference forest (Rf), restored forest (Rs), and pre-restored conditions (Pr). The foraging behaviors are foraging in understory (FoUn), perching (Per), perching and calling (PerC), foraging in tree branch (FoTB), foraging in leaves (FoLe), foraging in bark (FoBa), eating insect (EaIn), eating seed (EaSe), eating other animal (EaOA).

	FoUn			Per			PerC			FoTB			FoLe			FoBa			EaIn			EaSe			EaOA		
	Rf	Rs	Pr	Rf	Rs	Pr	Rf	Rs	Pr	Rf	Rs	Pr	Rf	Rs	Pr	Rf	Rs	Pr	Rf	Rs	Pr	Rf	Rs	Pr	Rf	Rs	Pr
Butorides virescens				6			2			1									1								
Ceryle alcyon																									1		
Coereba flaveola							7	3					5														
Crotophaga ani				14																							
Dendroica discolor																			1								
Geothlypis trichas					2		1	1																			
Melanerpes portoricensis																2											
Mniotilta varia																4											
Myiarchus antillarum							1																				
Protonotaria citrea													1														
Quiscalus niger				1			2						1														
Seiurus noveboracensis	2		1			1	2																				
Setophaga ruticilla													3														
Tiaris bicolor					1																						
Tiaris olivaceus		1																									
Turdus plumbeus																						2					
Tyrannus dominicensis							1																				
Vidua macroura					1																						
Zenaida aurita	1			1																							
Total	3	1	1	22	4	1	16	4		1			10			6			2			2			1		

ence site, 9 in the restored site and 2 in the pre-restored site. These results not only show the absence of data on bird foraging behavior from the restored and pre-restored conditions sites, but the absence of bird species in general. Eight of the nine observations I made in the restoration site were of perching behavior (four perching and four perching and calling). The other observation was a single Yellow-faced Grassquit (*Tiaris olivaceus*) foraging on the ground. In the pre-restored conditions site, I only observed the Northern Waterthrush (*Seiurus noveboracensis*) perching and foraging on the ground. Observations from the reference site contained all studied foraging behaviors.

DISCUSSION

I observed more feeding behaviors in the reference forest in comparison with the restored and pre-restored conditions sites. Moreover, the reference forest had a richer avifauna, in comparison with the other two sites. This lack of species in the restored and pre-restored condition sites was caused by the lack of forest complexity and vertical structure, which is reflected in the few number of foraging observations in these sites.

The pre-restored conditions site had only one species, which was a migrant. Migrants frequently use a wide array of habitats, including open areas (Blake & Loiselle 1992, Currie *et al.* 2005). The species detected in the restoration site included both migrants, such as the Northern Waterthrush and Common Yellowthroat (*Geothlypis trichas*), and resident species characteristic of open sites such as Black-faced Grassquit (*Tiaris bicolor*), Yellow-faced Grassquit, and Bananaquit (*Coereba flaveola*), and an exotic species, the Pin-tailed Whydah (*Vidua macroura*). This is a common pattern in Puerto Rico in which open areas are dominated by native generalists and exotic species (Raffaele 1989).

The pre-restored conditions site was composed almost exclusively of *Typha dominguensis* grassland, which means that there were few perching sites for birds. The only individual observed perched in this site was located in an isolated small patch of woody vegetation inside the grassland. The other observed behavior in this pre-restored conditions site was of the Northern Waterthrush foraging in the understory. In order to have walking access to this grassland, we made trails less than 1 m wide. The Northern Waterthrush was observed on this trail. Thus the almost total absence of foraging birds inside this site may be result of a lack of vertical structure. This absence of vertical structure and lack of forest complexity may be also responsible for the absence of bird species in general. Vertical structure has been found to be important in the restoration of birds (Holl 1998). A study conducted in Puerto Rico showed that sites with a more artificial perches had a higher diversity and abundance of birds (Shiels & Walker 2003). In our study area, the more developed vertical structure of the restoration site may have attracted more foraging birds than the pre-restored conditions site.

In the restoration site, birds displayed a greater diversity of foraging behaviors than in the pre-restored conditions site. As in the pre-restored conditions site, the restoration site had one individual foraging in the understory. In addition, the other eight observed behaviors were perching, and perching and calling. This behavior was absent from the pre-restored condition site because of the absence of vertical structure. The restoration site had a large amount of small trees (less than 10 cm DBH), which provided some vertical structure in which birds can perch. Even in presence of this vertical structure, we did not observed any actual feeding behavior, which suggest that birds are using this site as stopover.

In contrast, in the reference forest, I not

only observed all behaviors noted in the other two sites, but also other feeding behaviors such as eating seeds, insects, and other animals. The reference forest is a mature forest with tree size ranging from 1 to ~60 cm DBH and, even though this forest is dominated by *Pterocarpus officinalis*, which does not provides fleshy fruit, the vertical structure provided may help birds to perch and capture flying insects and also glean the leaves in search for other types of arthropods.

The use of foraging behavior of birds as a measure of restoration success may be an important tool to study, not only the presence of species, but also resource use which is a more direct measure of how wildlife is using the restoration project. This approach will be important for both points of views of measuring restoration success. Those who argue for an integrated multi-variables approach for measuring restoration success (Ruiz-Jaen & Aide 2006) may find foraging behavior an important tool for measuring ecosystem functioning. Those who argue that restoration projects are made after a need to increase habitat for a focal species or group (Morrison 2002) will find measures of foraging behavior to be a direct way to understand how these focal species are using this restoration sites.

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REFERENCES

Aide, T.. M., & H. R. Grau. 2004. Globalization, migration and Latin American ecosystems. Science 305: 1915–1916.

Blake J. G., & B. A. Loiselle. 1992. Habitat use by Neotropical migrants at La Selva Biological Station and Braulio Carrillo National Park, Costa Rica. Pp. 257–272 *in* Hagan III, J. M., & D. W. Johnston (eds.). Ecology and conservation of neotropical migrant landbirds. Smithsonian Institution Press, Washington, DC.

Currie D., J. M. Wunderle Jr., D. N. Ewert, A. Davis, & Z. McKenzie. 2005. Winter avian distribution and relative abundance in six terrestrial habitats on Southern Eleuthera, The Bahamas. Caribb. J. Sci. 41: 88–100.

Dietz, J. L. 1986. Economic history of Puerto Rico: Institutional change and capitalist develpoment. Princeton Univ. Press, Princeton, New Jersey.

Grau, H. R., T. M. Aide, J. K. Zimmerman, J. R. Thomlinson, E. Helmer, & X. Zou. 2003. The ecological consequences of socioeconomic and land-use changes in postagriculture Puerto Rico. Bioscience 53: 1159–1168.

Hobbs, R. J., & D. A. Norton. 1996. Towards a conceptual framework for restoration ecology. Restor. Ecol. 4: 93–110.

Holl, K. D. 1995. Nectar resources and their influence on butterfly communities on reclaimed coal surface mines. Restor. Ecol. 4: 93–110.

Holl, K. D. 1998. Do bird perching structures elevate seed rain and seedling establishment in abandoned tropical pasture? Restor. Ecol. 6: 253–261.

Longcore, T. 2003. Terrestrial arthropods as indicators of ecological restoration success in coastal sage scrub (California, USA). Restor. Ecol. 11: 397–409.

Marzluff, J. M., & K. Ewing. 2001. Restoration of fragmented landscapes for the conservation of birds: A general framework and specific recommendations for urbanizing landscapes. Restor. Ecol. 9: 280–292.

Morrison, M. L. 2002. Wildlife restoration: techniques for habitat analysis and animal monitoring. Island Press, Washington, D C.

Raffaele, H. A. 1989. The ecology of native and introduced granivorous birds in Puerto Rico. Pp. 541–566 *in* Woods, C. A., & F. E. Sergile (eds.). Biogeography of the West Indies: patterns and perspectives. CRC Press, Boca Raton, Florida.

Reay, S. D., & D. A. Norton. 1999. Assessing the success of restoration plantings in a temperate New Zealand forest. Restor. Ecol. 7: 298–308.

Remsen, J. V., Jr, & S. K. Robinson. 1990. A classification scheme for foraging behavior of birds in terrestrial habitats. Stud. Avian Biol. 13: 144–160.

Ruiz-Jaen, M. C., & T. M. Aide. 2005a. Restoration success: How is it being measured? Restor. Ecol. 13: 569–577.

Ruiz-Jaen, M. C., & T. M. Aide. 2005b. Vegetation structure, species diversity, and ecosystem processes as measures of restoration success. For. Ecol. Manage. 218: 159–173.

Ruiz-Jaen, M. C., & T. M. Aide. 2006. An integrated approach for measuring urban forest restoration success. Urban Forestry Urban Greening 4: 55–68.

Sherry, T. W., & R. T. Holmes. 1996. Winter habitat quality, population limitation, and conservation of Neotrophical-Nearctic migrant birds. Ecology 77: 36-48.

Shiels, A. B., & L. R. Walker. 2003. Bird perches increase forest seeds on Puerto Rican landslides. Restor. Ecol. 11: 457-465.

Urbanska, K. M., Webb, N. R., & Edwards, P. J. 1997. Restoration ecology and sustainable development. Cambridge Univ. Press, Cambridge, U K.

Wagner, J. L. 1981. Visibility and bias in avian foraging data. Condor 83: 263–264.

Wunderle, J. M., & S. C. Latta. 1998. Avian resource use in Dominican shade coffee plantations. Wilson Bull. 110: 271–281.

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