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Short communication

Bird community shifts related to different forest restoration efforts: A case study from a managed habitat matrix in Mexico

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ABSTRACT

Although increased attention is being paid to animals when studying restoration processes, little is known on the effects that different restoration efforts have on birds. In this study we evaluated the variation of bird communities in a managed landscape that includes cropfields and two different restoration strategies. To evaluate possible differential effects of both restoration strategies (plus former-state and natural-state comparisons as controls), we compared their bird communities. After five growing seasons, bird species richness was highest in native forest remnants and lowest in cropfields. Although species richness values from the restoration treatment did not show differences in relation to those from the forest treatment, values for the reforestation treatment did. Bird densities were highest in the forests and alike in cropfield, reforestation, and restoration treatments. However, bird communities recorded in the restoration treatment were fairly even when compared to the reforestation treatment, and highest bird species composition similarity was recorded between the restoration and forest treatments. These results suggest that the studied restoration treatment attracts a higher number of bird species in relation to former states and thus enhance bird richness. Also, we demonstrate that restoration efforts that include more actions can affect more ecosystem components. In this study, nurse plants not only offered a quick growing structural vegetation component that enhanced habitat structure, but also provided abundant food resources for birds. Given the scarcity of comparable habitat matrices to replicate our study, our results should be taken with caution as they are not generalizable to all Mexican temperate forest conditions. Although further studies need to address whether restoration practices using *Lupinus elegans* positively affect bird primary population parameters (e.g., survival, reproduction), our results show that restoration practices that include nurse plants can promote rich bird communities after only 5 years from the implementation of restoration measures.

1. Introduction

Ecological restoration has focused largely on the vegetation component of ecosystems. However, increased attention is being paid to the animal component in restoration processes (Majer, 2009). A large proportion of the existing knowledge of the effects that restoration activities have on wildlife has focused on birds (e.g., Passell, 2000; Gabbe et al., 2002; Hamel, 2003; Twedt et al., 2006; Gaines et al., 2007).

Previous studies addressing relationships between restoration activities and their ornithological component have drawn several main conclusions: (1) bird species richness and abundances are often enhanced by restoration practices (Passell, 2000; Twedt et al., 2002; Hamel, 2003; Gaines et al., 2007; Aerts et al., 2008; Farwig et al., 2008), (2) bird species composition can shift in restoration treatments (Brawn, 2006; Farwig et al., 2008), and (3) restoration processes can be accelerated by frugivore birds (Aerts et al., 2006). Although some studies have recorded significantly higher bird species richness in restored areas with fast-growing tree species in the short-term (e.g., 3–7 years; Passell, 2000; Hamel, 2003), a recently published article reports no shifts in avian colonization processes in a 5–6 year fast-growing tree restored area (Twedt, 2006).

However, few studies have focused on the effects that different restoration efforts have on bird communities (e.g., Hamel, 2003; Farwig et al., 2008). In this study we evaluated bird community shifts related to different forest restoration efforts using cropfields as former-state control and native forests as natural-

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state control. Restoration strategies used in this study include the use of a nitrogen-fixing legume (*Lupinus elegans*) as a nurse plant plus reforestation, and the other one only includes reforestation efforts. We predicted that bird species richness and densities would rise gradually from cropfields to native forests, with fairly even bird communities in native forests, and highly dominated bird communities in cropfields. Also, we expected bird composition to change as habitat structure changed, with differences between the restoration and reforestation scenarios due to the presence of the resources offered by the legume and the plant species that established below it (e.g., flowers, fruits, perches).

2. Materials and methods

2.1. Study area

The study area is located in the Comunidad Indígena de Nuevo San Juan Parangaricutiro, Northeast Michoacán, Mexico (2750 masl). Native pine and oak–pine forests dominate the area, and at elevations ≥2800 masl, fir (*Abies religiosa*) become abundant. The forests of the indigenous community (11,694.5 ha) are managed for timber production under sustainable forestry practices. Our surveys were performed in a middle-slope hillside with cropfields abandoned at least 8 years ago. The surrounding landscape consists of a matrix of cropfields with dispersed pine–oak–fir forest patches. Despite being abandoned almost a decade ago, our study site still showed a low number of plant species, only forbs and weeds were present, and no tree species were recorded at the beginning of the restoration and reforestation efforts in 2004.

We considered four habitat treatments for this study: (1) native forests – natural-state control, (2) cropfields – former-state control, (3) restoration – including the use of a nitrogen-fixing nurse plant, and (4) reforestation. Native forests are dominated by pine trees (i.e., *Pinus pseudostrobus, P. montezumae*) and, in lesser amount, oaks (*Quercus crassipes*) and firs (*Abies religiosa*). The most common plant species recorded in this treatment, other than trees, were: *Bidens aurea*, *B. bigelovi*, *B. serrulata*, *Commelina tuberosa*, *Conyza schiedeana*, *Crusea longiflora*, *Dalea touinii*, *Festuca amplisima*, *Gnaphalium attenuatum*, *G. americanum*, *Hypericum philonotis*, *Jaegeria hirta*, *Lopezia racemosa*, *Lupinus elegans*, *Muhlenbergia minutisisima*, *Oenothera pubescens*, *Phacelia platycarpa*, *Phaseolus* sp., *Sabazia humilis*, *Salvia mexicana*, *Tagetes micrantha*, and *Tithonia tubiformis*.

In June 2004, three coniferous species were used to restore a 1.15 ha crop-hillside, planted in equal amounts and spaced 2 m from each other, in a 4500 m^2 area: *P. pseudostrobus*, *P. montezumae*, and *Abies religiosa*. An additional restoration resource was used in this hillside: a nitrogen-fixing nurse plant (*L. elegans*), seeded in 32 patches of 64 m × 64 m. Natural establishment of other plant species was allowed. This area was considered as the restoration treatment for this study. Dominant plant species that established in this treatment, other than the planted trees, were: *Bacharis heterophylla*, *Bidens aurea*, *B. bigelovi*, *B. serrulata*, *Commelina tuberosa*, *Conyza coronopifolia*, *C. schiedeana*, *Crataegus mexicana*, *C. longiflora*, *D. touinii*, *Drymaria malachioides*, *F. amplisima*, *G. attenuatum*, *G. americanum*, *H. philonotis*, *J. hirta*, *L. elegans*, *Mulenbergia macroura*, *O. pubescens*, *P. platycarpa*, *Prunella vulgaris*, *S. humilis*, *Salvia elegans*, *S. mexicana*, *Senecio salignus*, *S. stoechodiformis*, *T. micrantha*, *Taraxacum officinale*, and *T. tubiformis*.

The rest of the hillside was planted only with pine tree species (i.e., *P. pseudostrobus*, *P. montezumae*). Trees were also spaced 2 m away from each other, and natural establishment of other plant species was also allowed. An area of 4500 m^2 was selected as the reforestation treatment. Dominant plant species that established in this treatment, other than the planted trees, were: *Bidens aurea*, *B. serrulata, C. tuberosa*, *Cyperus* sp., *Dalea touinii*, *H. philonotis*, *S. humilis*, and *Trifolium mexicanun*.

Finally, the closest agricultural lands to both restoration and reforestation treatments were used as the cropfield treatment. Cropfields are used in the study area for subsistence and are divided in parcels smaller than 2 ha. Many were abandoned and used for cattle grazing more than 10 years ago but several are still planted with corn (*Zea mays*).

By 2009, the restored/reforested hillside was covered by a canopy of young trees. A random sample of 100 trees at both treatments showed that the height of *P. montezumae* pines, the most abundant tree species in both treatments, was statistically higher in the restoration treatment ($F_{1,98} = 31.7$, $P < 0.0001$). Also, total plant species richness increased from 18 to 60 in a four-year period (2004–2008) in the restoration treatment, while the reforestation treatment still had low plant species richness ($n = 19$) by 2008.

2.2. Bird surveys

We surveyed bird communities from August 2008 to June 2009 using point counts (5-min, 25 m radius; following Ralph et al., 1993), recording all birds seen or heard, from 0700 to 1000 h. We used limited-radius point counts for assuring that all birds recorded were actively using the surveyed area and not nearby sites with different habitat attributes. To calculate bird densities, we measured the distance from the observer to the recorded birds inside the point counts using a rangefinder (Bushnell Yardage Pro). We surveyed two point counts replicates in the four described treatments. Point counts were established in the restored plot and adjacent cropfields, reforestation plots, and a nearby native forest patch. In order to assure the independence of point count replicates, we located them at least 200 m away from each other (as recommended by Huff et al., 2000). Thus, we surveyed eight point counts (two replicates per treatment), during the same day and under similar weather conditions, in August and October 2008, and January, March, April, and June 2009 in order to record year-round seasonal variations.

2.3. Data analysis

To contrast bird species richness values, we used a rarefaction analysis. For this we computed the statistical expectation of bird species richness for each treatment using EstimateS (Sobs [Mao Tao] ± 95% confidence intervals; Colwell, 2005). Such expectation is calculated based on the repeated re-sampling of all pooled samples (Gotelli and Colwell, 2001), allowing the comparison of the statistically expected species richness of the bird community recorded at each treatment using a comparable computed accumulated abundance (Moreno, 2001; Magurran, 2004).

To calculate bird densities, we computed bird individuals/ha (mean ± 95% confidence intervals) using Distance 5.0 (Thomas et al., 2005). This software calculates the probability of detection of individuals at increasing distances from the observer, considers detection rates by concentric surveyed area, and estimates the number of bird individuals that exist within a surveyed area (Buckland et al., 2001). To determine if species richness and bird density values were statistically different among the surveyed treatments, we compared their 95% confidence intervals. If confidence intervals did not overlap, we considered the data to be statistically different with an $\alpha < 0.01$ (following Payton et al., 2003; M. Payton pers. com.).

To assess differences in the evenness/dominance of the bird communities recorded at the different studied treatments, we used a species rank/abundance plot approach (=Whittaker plot; as recommended by Magurran, 2004). Rank/abundance plots are often