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Authors: Ramírez-Soto, Aníbal, Rodríguez-Mesa, Rafael, Villa-Bonilla, Bernardino, Sheseña-Hernández, Ixchel, and Ruelas Inzunza, Ernesto

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Using Birds to Assess and Track Forest Restoration

Aníbal Ramírez-Soto[1], Rafael Rodríguez-Mesa[1], Bernardino Villa-Bonilla[1], Ixchel Sheseña-Hernández[1], and Ernesto Ruelas Inzunza[2]

Abstract

We present a simple method to use birds to assess and track the restoration of Tropical Montane Cloud Forests using birds as indicator species. The method is composed of three pieces: a classification of disturbance phases, the collection of species- and assembly-level bird data, and the matching of these two data sets to understand its relationships. We were able to select three species of resident and three species of Neotropical migrants exclusively associated to each of the four habitat phases, as well as some characteristics at the assembly level that help understand the condition of habitats, prescribe restoration intervention plans, and to track its progress over time. The approach described here is intended to be of simple application, aimed for practitioners, and be easily replicated in other places.

Keywords

applied nucleation, Mexico, Sierra de Zongolica, Tropical Montane Cloud Forest, Veracruz

In our recent paper on restoration of Tropical Montane Cloud Forest (TMCF) using applied nucleation, we present a six-prong strategy with elements that we deem critical for its success (Ramírez-Soto et al., 2018).

For reasons of space, we were unable to delve further into the details of some of these key elements. A very important one is the use of biological indicators—in this particular case, birds—to help diagnose, prescribe, and monitor projects based on an intimate knowledge of their local habitat associations.

The rationale behind this approach is simple. Birds, like most other components of biodiversity, are affected by human activities. Their response to different types of disturbance can be observed in two ways: at the species and assemblage levels. This means that the individual bird species that can be recorded in a particular ecosystem, successional stage, or disturbance regime respond in a particular way that is different from the response of other species. This results in each disturbance type having species composites that reflect its ecological characteristics such as availability of food resources and certain microhabitat features (e.g., Stotz, Fitzpatrick, Parker, & Moskovits, 1996).

The factors responsible for shaping the composition of these assemblages are intrinsic to the habitat (e.g., provide certain resources to birds or have a particular structural or floristic composition in itself), extrinsic to it (e.g., are surrounded by contiguous habitats that create a border effect or that supplement the resources needed by birds from a place in close proximity), or combinations of both. Birds in turn respond strongly (e.g., they specialize in a type of habitat that meets certain features) or weakly (e.g., they are generalists able to use a broad range of conditions).

Scientists interested in the use of indicator species have devised ways to identify individual species—as well as sets of them—to determine habitat quality (McGeoch, 1998, 2002). Tejeda-Cruz, Mehltreter, and Sosa (2008) have described this approach in detail and recommend the use of multiple taxa to attain a more robust assessment

[1]Pronatura Veracruz A.C., Programa Ecoforestal, Coatepec, Mexico
[2]Instituto de Biotecnología y Ecología Aplicada, Universidad Veracruzana, Xalapa, Mexico

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Corresponding Author:
Ernesto Ruelas Inzunza, Universidad Veracruzana, Av. de las Culturas Veracruzanas No. 101, Col. Emiliano Zapata, Xalapa, Veracruz 91090, Mexico.
Email: ruelas.uv@gmail.com

of habitat condition, where the redundancy in the indicator species selected strengthens the certainty of being correctly assigned to a given category (Lindenmayer et al., 2002).

Birds serve this purpose well, since they respond much faster to disturbance (or lack thereof) than other indicator species such as plants or insects (Kati et al. 2004; McGeoch, 1998). Given that birds are well known, and possibly one of the easiest and inexpensive taxa to study (e.g., Ralph, Geupel, Pyle, Martin, & DeSante, 1993), how can restoration practitioners use birds to assess the characteristics of habitat patches and use this information to help their endeavors? Can resident and migrant species serve the same purpose? How do indicator species and their assemblages reflect discrete stages along a disturbance continuum?

The goal of this article is to present a case study and recommend restoration practitioners with a simple way to use birds as a tool to determine habitat condition. Although this work is based on our experience using birds (and other ecosystem elements) in restoring TMCFs of eastern Mexico, its logic could be applied to habitats and bird species elsewhere. Because this work is aimed at practitioners, we avoid complex data collection or analytical procedures and propose a simple, pragmatic, and realistic way to address this issue.

Here, we distill our experience doing so to three different pieces: (a) a categorical assessment of habitat condition, (b) a local understanding of patterns of habitat use by individual bird species as well as sets of them, and, ultimately, (c) the use of information on bird-habitat associations to determine the severity of its disturbance, design-specific intervention portfolios, and track the progress of restoration efforts.

Habitat Disturbance Classification

Here, we use data gathered in the TMCFs of the Sierra de Zongolica, Veracruz, Mexico, to illustrate this case study. The Sierra de Zongolica is located in central Veracruz, Mexico, in the borderlands with the State of Puebla. Its elevational range varies from 80 to 3,000 masl, and it used to be covered with seven vegetation types (now a patchy mosaic of forest remnants, agricultural fields, and other land uses). As expected, its wide variation in elevations results in a broad range of lowland, mid-, and high-elevation habitats (Figure 1).

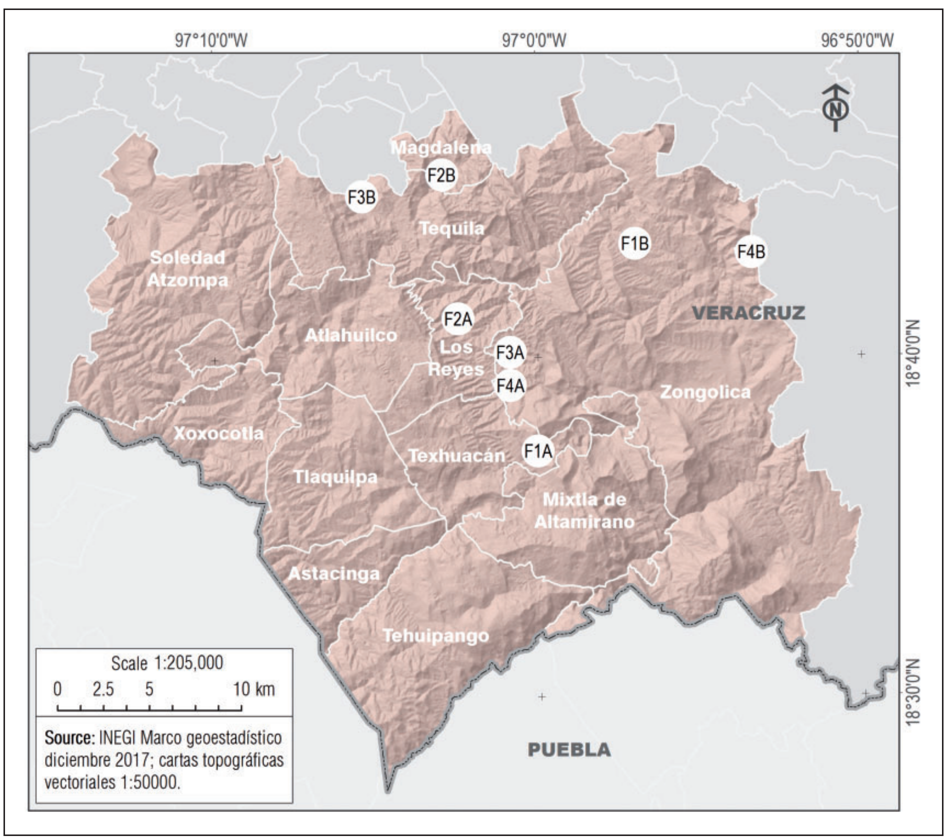

Figure 1. The Sierra de Zongolica, where this project took place. Plot labels: F1A = plot 1a, F1B = plot 1b, etc. Source: INEGI (2017). Source: INEGI Marco geoestadístico diciembre, 2017; cartas topográficas vectoriales 1:50,000.

The work we describe here is centered on TMCF, on the mid-elevation section. We have done on-the-ground, applied nucleation restoration work with landowners there for 6 years (further described in Lucio-Palacio et al., 2016 and Ramírez-Soto et al., 2018).

In our practice, the first key step is to begin assessing habitat condition data. Most of it is dictated by its agricultural use. Local campesinos have a milpa-based slash-and-burn practice that currently use parcels for periods of 4 to 5 years interspersed with periods of a similar duration during which campesinos let the land rest before planting it again (for a description of the milpa agricultural system, see Ramírez-Soto et al., 2018). When not used for agriculture at the end of a cycle, older age plots have other uses such as the collection of firewood, non-timber forest products, and medicinal plants.

In recent decades, population growth has forced the milpa cycles to be shorter in resting time as well as taking place in smaller sized plots. This situation has also forced people to use areas with substandard quality for milpas. We have seen campesinos using of areas of marginal utility, such as steep hillsides and areas where secondary succession has been arrested due to pesma ferns (*Pteridium* spp.).

We intervene areas that landowners want to restore. We start by classifying our focal areas using the time since agricultural disturbance as the main criterion. Here, we classified habitat plots (two replicates of each, for a total of eight plots of 3 ha each) in four visually distinctive disturbance categories. We estimated the condition or state of each pair of plots by examining three types of evidence of use, such as traces of recent agricultural activity (grooves, harvest remains, burnt stumps, etc.), second-growth vegetation height and species present (based on our local knowledge of plant species and its successional characteristics), and through interviews with landowners. Before assigning plots to a given category, we visited all of them in order to have a comprehensive view of local disturbance stages (Table 1).

We also generated information on the spatial context of these plots. Using a geographic information system, we gathered data on land use attributes that affect habitat condition such as fragmentation of contiguous areas, amount of edge habitat, surrounding land pressure, and proximity to roads, villages, and towns as the most important attributes. This classification works well to characterize plots of 3 to 10 ha.

Bird Habitat Use

Next, we determined the patterns of habitat use of species and assemblage in the aforementioned plots using a combination of data from point counts (10 min, 25 m radius, 250 m apart, see Hutto, Pletschet, & Hendricks, 1986) and mist nets (an array of six nets used in the morning, covering ca. 300 m of linear distance, see Ralph & Dunn, 2004) to determine presence–absence, frequency of occurrence, body condition, sex, age, seasonal status, and other variables that can be associated with habitat quality (Ramírez-Soto et al., in review). During an annual cycle, bird sampling needs about 7 to 8 days of work per plot per year to reach a species accumulation curve asymptote for common birds.

Once we had presence–absence and abundance data for each habitat phase category, we made simple tallies of species per habitat type and method of detection in order to identify species that are exclusive and common, and hence good indicators, of a given habitat association (Table 2).

Table 2. Habitat-Exclusive Birds Represent Between 5% and 20% of All the Birds Sampled per Habitat, Making the Selection of Relatively Common Species an Easy Task.

Habitat phase	Species richness	Exclusive species in point counts	Exclusive species in mist nets
1	92	21	15
2	93	11	10
3	73	7	3
4	81	19	9

Note. Habitat-exclusive birds can be reliably selected from samples of 7 to 8 days per habitat per year, covering a much larger area than detailed habitat assessments, and resulting in a cost effective indicator of habitat condition.

Table 1. A Categorical Classification of Plots (Once Occupied With Tropical Montane Could Forest) for Restoration in the Sierra de Zongolica, Veracruz, Mexico.

Habitat phase	Stage designation	Time since clearing or major disturbance (unassisted, natural, secondary succession)
1	Initial or highly degraded	Between 0 and 3 years since agricultural use
2	Intermediate	Between 4 and 8 years
3	Advanced	Between 9 and 15 years
4	Reference ecosystem in good condition	$>$16 years since last disturbance

Note. It is based on plot attributes, its surroundings, and time since its most recent agricultural disturbance.

Table 3. Common and Easy-to-Record Birds That Can Be Used as Indicators of Habitat Quality in the Sierra de Zongolica, Veracruz, Mexico.

Habitat phase	Resident species	Migratory species
1	White-bellied Emerald (*Amazilia candida*)	Chipping Sparrow (*Spizella passerina*)
	Black-collared Seedeater (*Sporophila torqueola*)	Lincoln's Sparrow (*Melospiza lincolnii*)
	Melodious Blackbird (*Dives dives*)	Eastern Phoebe (*Sayornis phoebe*)
2	Rusty Sparrow (*Aimophila rufescens*)	Common Yellowthroat (*Geothlypis trichas*)
	Cinnamon-bellied Flowerpiercer (*Diglossa baritula*)	Olive-sided Flycatcher (*Contopus cooperi*)
	Yellow-bellied Elaenia (*Elaenia flavogaster*)	Blue Grosbeak (*Passerina caerulea*)
3	Sulphur-bellied Flycatcher (*Myiodynastes luteiventris*)	American Redstart (*Setophaga ruticilla*)
	Scaly-throated Foliage-gleaner (*Anabacerthia variegaticeps*)	Summer Tanager (*Piranga rubra*)
	Blue-throated Mountaingem (*Lampornis clemenciae*)	Nashville Warbler (*Oreothlypis ruficapilla*)
4	Blue Ground Dove (*Claravis pretiosa*)	American Dusky Flycatcher (*Empidonax oberlholseri*)
	Slate-colored Solitaire (*Myadestes unicolor*)	Swainson's Thrush (*Catharus ustulatus*)
	Stripe-throated Hermit (*Phaethornis striigularis*)	Orange-crowned Warbler (*Oreothlypis celata*)

We matched habitat quality and bird distributional data to determine its habitat associations. On the habitat side, we use the habitat quality assessments described earlier and for birds, individual-level data. We picked species that were exclusive but also commonly recorded in each habitat phase to avoid using indicator species that do reflect habitat condition but are difficult to detect (and hence complicated to register during the sampling period per habitat type, Table 3).

Indicator species can be informative on their own, but understanding what happens at the assembly level can also be very informative. The bird inventories we collected were enriched with data on sensitivity to habitat disturbance from Stotz et al. (1996) and assigned each species to a diet-type category using the classification of Lopes, Fernandes, Medeiros, and Marini (2017, Figure 2).

Applications

We have used bird-habitat association data to help restore TMCFs in combination with other variables (Ramírez-Soto et al., 2018). As mentioned earlier, birds are easy to survey and provide a quick and spatially efficient way to assess habitat condition.

We have found three applications of this work. The first are initial assessments of habitat disturbance based on birds. Knowing the time and severity of disturbance is a first step in deciding a nucleation-based forest recovery plan. A second application is precisely the selection of tools to prescribe an applied nucleation restoration intervention. Third and last, the use of habitat association data in tracking the progression of forest recovery over time is an application of central importance. For the latter use, having a simple method that provides a quick return is key.

Bird-habitat association data from this case study are good for resident and Neotropical migrant species. Although migratory species are a small proportion of the total number of bird species (about 35% of the total avifauna, Ramírez-Soto et al., in review), our point count and mist net data are sufficient to pick at least three species per habitat phase that are amenable to use as indicators (they all meet the conditions of being relatively common and easy to detect). In terms of the assemblages present per habitat phase, relative abundance of species by diet type and habitat use are also quite informative. In terms of field methods, we recommend using point count data over mist nets, as the total number of species and the number of exclusive species per habitat allows a larger pool to select from (Table 2).

Because birds fly and their habitat use has certain spatial considerations, it is possible that finer grain habitat associations are not possible to obtain from them. The work we show here supports its use for the particular habitat classification scheme and the plot sizes we described, but it is unclear whether it could be scaled up or down.

We recognize this approach is perhaps overly simplistic, but it has been a convenient tool for practitioners in Veracruz whom not always have highly trained technical expertise or time to undertake more complex work. Although methodologically is not as formal and quantitative as the methods proposed by Tejeda-Cruz et al. (2008), this simpler approach may be better suited for practitioners. Its use is straightforward, less expensive, and it allows expanding it to larger areas under restoration whose aim is to recover ecosystem function.

As for the direct application of the data we provide here, it is possible that its use is only good for the Sierra de Zongolica and its surroundings (a region of ca. 94,000 has with restoration plots of 3–10 ha), but the mechanism for developing similar classifications for other localities is entirely replicable in other places in the tropics.

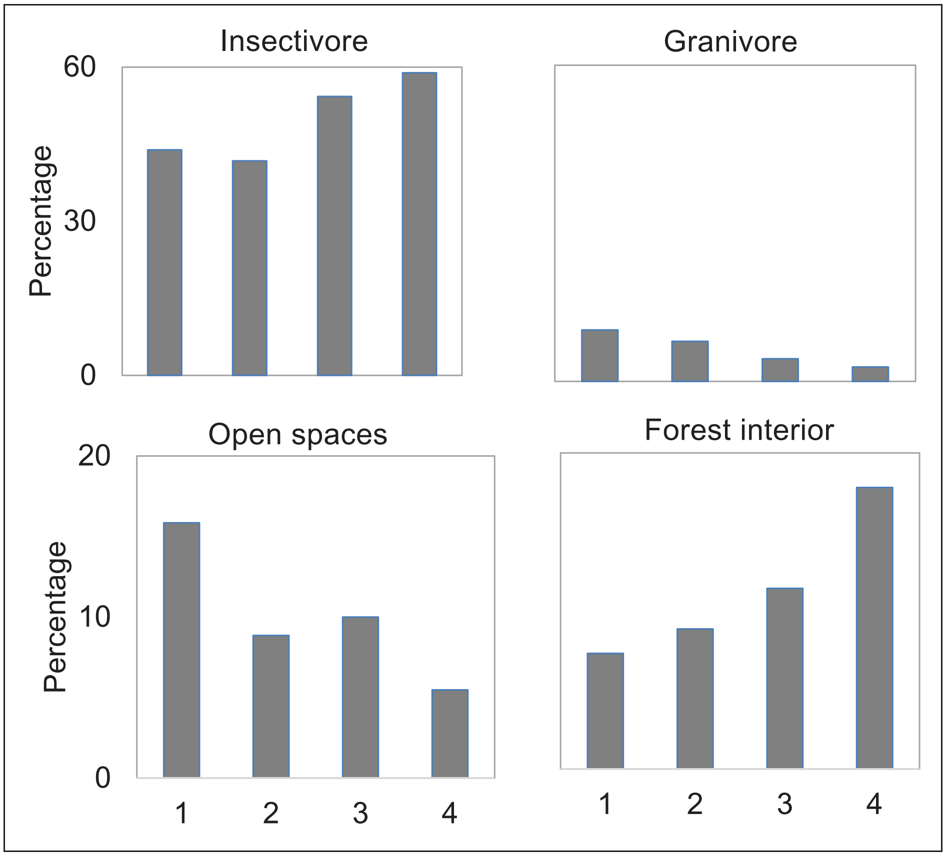

Figure 2. Two simple assemblage-level indicators of habitat condition: diet types and habitat use. The proportion of insectivores in the total species assemblage recorded in each phase increases with plot age while granivores decrease. As it is expected, species associated with open spaces decrease with plot age, while forest interior species increase. Numerals in the x-axis are habitat phases as described in Table 1.

Last, having indicators of multiple taxa has been recommended in the literature as a way to make its informative value more precise and robust (e.g., Kotze & Samways, 1999; Kremen, 1992). We have made some progress along these lines and done trials of the use of other components of the local biodiversity such as flora, amphibians, reptiles, and arthropods. However, to this date, the quickest and simplest has been the use of birds.

Our next steps are devising ways to scale up these efforts through the use of tools such as citizen science (that could also help us strengthen our community relationships). We are also interested in coming up with concurrent methods for other focal taxa and to develop other simple, low-cost field implementation mechanisms for restoration practitioners.

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ORCID iD

Ernesto Ruelas Inzunza http://orcid.org/0000-0001-7651-5308

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