XV WORLD FORESTRY CONGRESS
Building a Green, Healthy and Resilient Future with Forests
2–6 May 2022 | Coex, Seoul, Republic of Korea

Prioritizing areas for bird conservation at western Trans-Mexican Volcanic Belt

Alejandra Galindo Cruz[1], Francisco Javier Sahagún Sánchez[2], Verónica Carolina Rosas-Espinoza[3]

[1]Maestría BIMARENA, Universidad de Guadalajara, Guadalajara, Jalisco, México. alegalindo1@gmail.com, alejandra.galindo@posgrado.ecologia.edu.mx
[2]Departamento de Políticas Públicas, Centro Universitario de Ciencias Económico Administrativas, Universidad de Guadalajara, Anillo Periférico Norte No. 799, CP. 45100, Núcleo Universitario Los Belenes, Zapopan, Jalisco México.
[3]Departamento de Ecología, Centro Universitario de Ciencias Biológicas y Agropecuarias, Universidad de Guadalajara Las Agujas, Zapopan Jalisco, 45220, México.

Abstract

Ensure the maintenance of wildlife populations and ecosystems in Mexico, demands to identify essential regions that are priority and representative for the most significant ecosystems and species. In the present study, we determined priority areas in order to carry out conservation actions for birds at the western Transmexican Volcanic Belt. For this purpose, we modeled the distribution of 121 priority bird species at the national level; then, we determined the connectivity of the vegetation cover where the species potentially distributed and used a complementarity approach considering all species, the connectivity index, and representativeness in the natural protected areas, with allowed the identification of those areas with a high concentration of species richness, high concentrations of endemicity and high levels of landscape connectivity that were excluded from actual protection decrees. The results show three optimal areas as relevant conservation sites, with different ecological characteristics, the sites with temperate forest cover and tropical forest in the north and south center of the study area stand out. The information generated will help complement a network of Protected Areas that favors the conservation of bird diversity and their ecosystems in this study area.

Keywords: Biodiversity conservation; governance; landscape management

Introduction, scope and main objectives

The transformation and loss of ecosystems reduce the viability of wild populations and can cause local or total extinction of species in specific regions (Primack et al. 2001; Kattan 2002). In Mexico, protected areas (PA) are crucial to guarantee priority species and ecosystem conservation. However, in many cases, these areas do not represent regional biodiversity and conserve few species in relation to their surface (Ceballos 2007; Margules and Sarkar 2009).

Throughout the country, it is possible to identify areas of interest for bird conservation (Arizmendi and Márquez 2000). One of them is the Trans-Mexican Volcanic Belt (TMVB) which hosts 66% of Mexican bird species. At the eastern and western extremes, the Nearctic and the Neotropical regions converge, which has generated a mosaic of complex ecological affinities, leading to a significant concentration of endemism (Escalante et al. 1993; García-Trejo and Navarro-Sigüenza 2004; Navarro-Sigüenza et al. 2007).

In the western region of the TMBV, the coexistence of different natural ecosystems (temperate forests, tropical forests, grasslands, wetlands, among others) is critical to favor the persistence of biological diversity and the maintenance of ecosystem services. Unfortunately, land use change processes occur in the area, which leads to connectivity loss in the landscape matrix (Villavicencio-García et al. 2009; Sánchez-Cordero et al. 2012). The above demand actions that guarantee the maintenance of the connectivity of the different landscape units as a primary criterion in territorial management and as a measure to mitigate some effects of the current fragmentation rate (Margules and Sarkar 2009).

The objective of this work was to identify priority areas where optimal conditions exist to implement conservation actions for priority bird species based on the analysis of the actual and potential distribution of the species and the evaluation of landscape connectivity for the western region of the Trans-Mexican Volcanic Belt. The information generated will be helpful to support actions aimed at recognizing essential sites for conservation in the area.

Methodology

1- Study area

We carried out this study in the western region of the Trans-Mexican Volcanic Belt (Ferrari et al. 2012; Fig. 1), with 2 406 424 ha extension and altitude ranging from sea level up to 4 260 m high. It compresses two climatic domains, one in the lowlands of the western extreme, which holds tropical forests, grasslands, and wetlands, and the second domain at the center of the study area that comprehends the temperate zones (Suárez-Mota et al. 2014).

2- Species selection

We selected terrestrial birds species that had at least part of their distribution in the study area and that, in addition: 1) were listed in NOM-059-SEMARNAT-2010 (DOF 2010), 2) that were a priority for conservation (DOF 2014), or 3) that were endemic to Mexico as stated by Berlanga et al. (2017) and added those endemic lineages proposed by Navarro-Sigüenza and Peterson (2004), this resulted in a list of 121 bird species.

3- Species distribution models

To model the distribution of the species, we used the MaxEnt algorithm (Phillips et al. 2006). We used information from the total area of distribution for each species. We used the climatic variables proposed by Cuervo-Robayo et al. (2013) and selected the ones that were not correlated (this selection was unique for each species). Once we have the final model of each species, we cut them to fit the study area.

4- Integral connectivity index

For the connectivity analysis, we used the cartographic information on land use and vegetation from the national forest inventory (Series VI) of the National Institute of Statistics and Geography [INEGI] (2016). Because the bird species have a certain affinity with respect to the existing vegetation type (Stotz et al. 1996), the different types of ecosystems and their different variants were unified by biotic similarity in the following classes: temperate forests (BF), tropical forests (TF), wetlands and riparian (W), grasslands (Gr), agriculture (Ag), bare soil without vegetation (BS) and urban area (UA).

To estimate connectivity between patches, we used the "Conefor sensinode 2.6" program (Saura and Torné, 2009), with which we obtained an Integral Index of Connectivity (IIC; Saura and Pascual-Hortal 2007), as dispersion factor, we selected a linear constant of 1 000 m to the closest edge, and from the resulting values we defined the following scale: Very Low, Low, Medium, High, Very High connectivity.

5- Priority areas for conservation determination analysis

We applied Boolean algebra to demarcate complementary polygons for the existent PAs considering 1) the areas that host the highest species richness and that, in turn, were not represented within the PAs, 2) areas that present high landscape connectivity, and 3) areas with exclusive presence of restricted distribution taxa. We identify those areas that present a high concentration of species richness, high concentrations of endemicity, and high levels regarding the connectivity of the landscape.

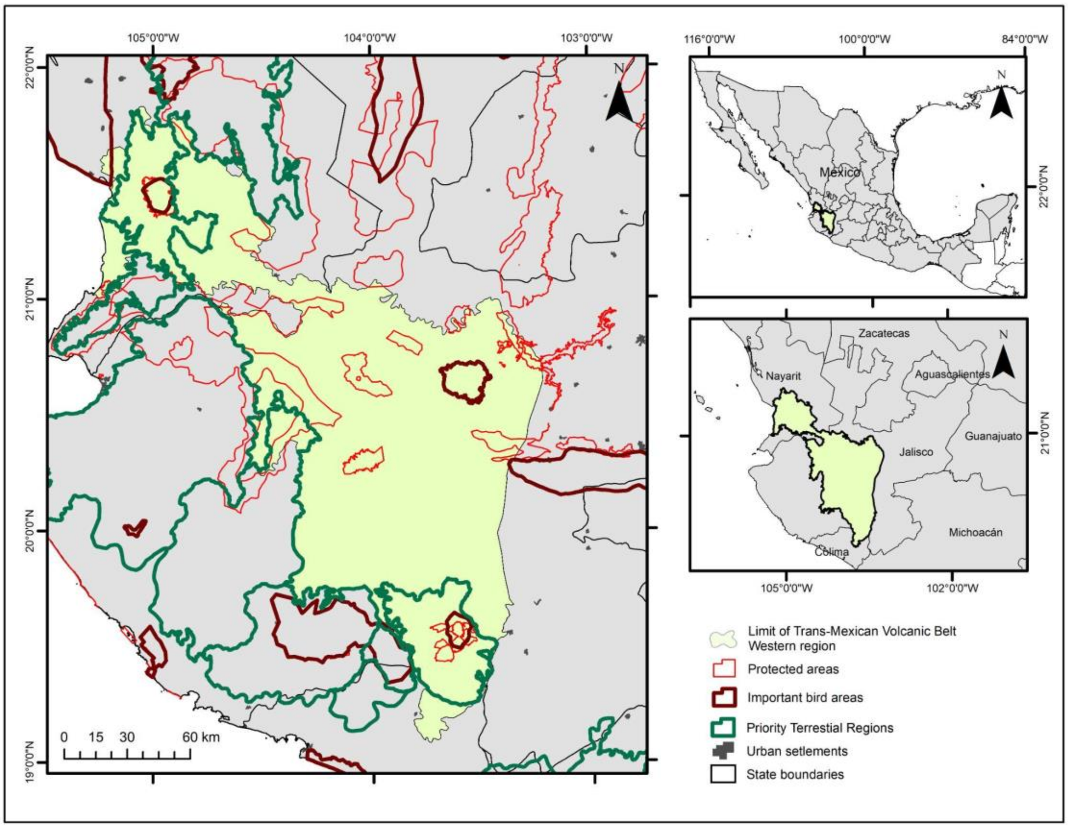

Fig. 1: Location of the western region of the Trans-Mexican Volcanic Belt (TMVB)

Results

Of the 121 species, 47 (39%) presented at least 10% of their potential distribution within the PAs in the study area. Of these, 33 have an affinity for tropical forests, six for grasslands, five for temperate forests, and three for wetlands or riparian vegetation. The consensus map shows a higher concentration of species richness in the tropical extreme, with a marked decrease in areas where there are temperate forests and agricultural zones (Fig. 2).

Of the species with low representativeness of their potential range (< 10%) in the PAs of the study area, 36 are endemic to Mexico, 22 have a risk category assigned by NOM-059-SEMARNAT-2010, and five are considered as priority for conservation. Thus, only two of the above species (*Amazona finschi* and *Cyanocorax beecheii*) have the three characteristics.

According to the IIC, the areas of vegetation covered with the lowest connectivity between vegetation are in the northwestern section of the study area in Nayarit state. These areas compress tropical ecosystems towards the coast and temperate ecosystems towards the center and east of the study area. On the other hand, the central region of the study area, located in Jalisco state, shows high connectivity between patches of different vegetation covers (Fig. 2).

We identified three potential areas to be considered as conservation priorities (Fig. 2). The first proposed area is located in the northwestern part of the study area (Sector A), where secondary vegetation of medium sub-deciduous and sub-evergreen forest predominates. The second area (Sector B) is in the center east of the study area. The primary vegetation of this sector is pine forest, oak-pine, and oak forest. Finally, the third area (Sector C) is located southeast of the study area and shows a mosaic of tropical and temperate forests. In the three sectors, there is medium or high connectivity and a significant concentration of species.

Based on the resulting priority areas for conservation and considering the PAs of the study area, 112 species would have at least 10% of their distribution ranges covered within the study area, and only ten species would not reach the established target (Table 1).

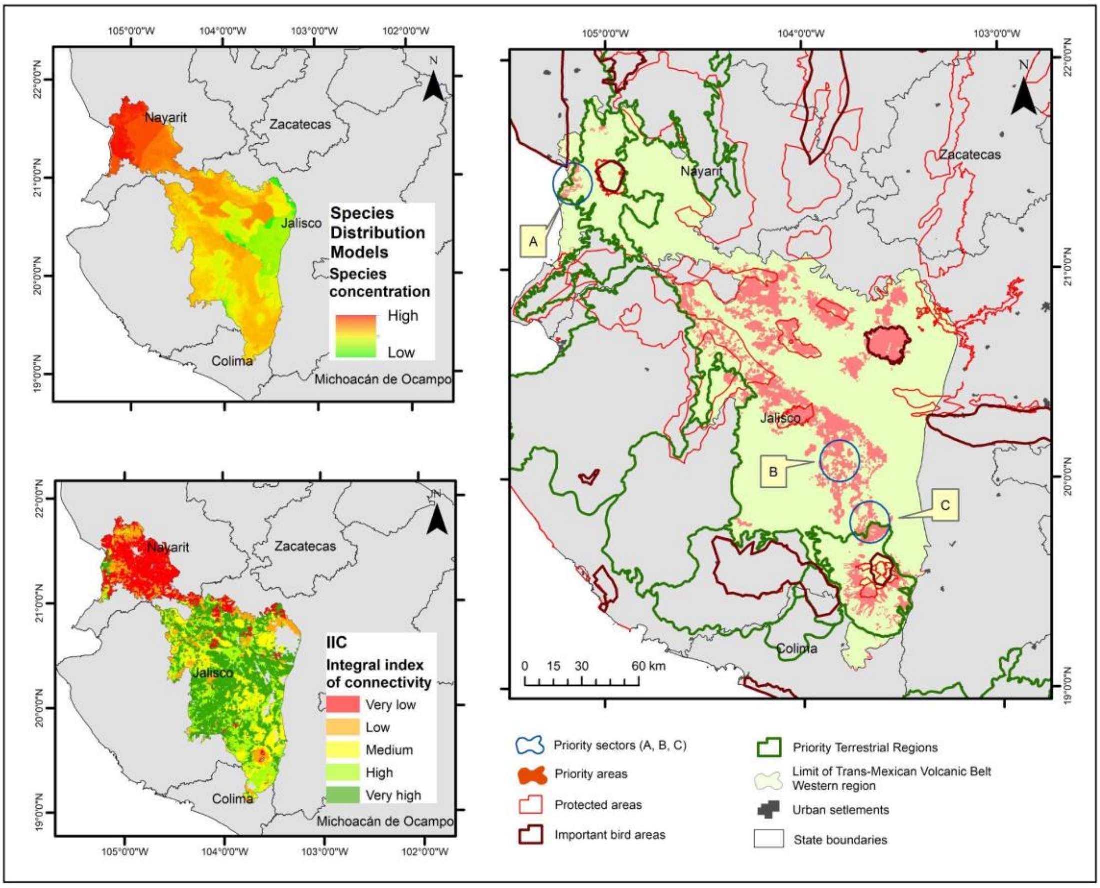

Fig. 2: We present species richness concentration based on the selected bird species SDMs for the TMVB, landscape connectivity on the study area and, priority areas for the conservation of birds of interest in the western region of the TMBV.

Table 1: Species that did not reach the conservation target (10% of their distribution area within the NPAs) for the western region of the TMVB.

Species	Affinity	initial % NPA	final % NPA	NOM	PC	Endemism
Cynanthus doubledayi	TF	0.00	0.00			Si
Falco peregrinus	Gr	2.35	7.47	Pr		No
Amazona albifrons	TF	2.24	9.45	Pr	Si	No
Amazona oratrix	TF	3.76	9.80	P	Si	No
Tityra griseiceps	TF	6.16	9.73			Si
Deltarhynchus flammulatus	TF	6.18	9.76	Pr		Si
Campylorhynchus humilis	TF	0.04	1.47			Si
Geothlypis chapalensis	W	2.15	2.15			Si
Geothlypis melanops	W	6.21	6.21			Si
Passerina leclancherii	TF	4.02	9.33			Si

Discussion

The areas determined as priorities for bird conservation in the present work coincided with several of the existing PAs in the studied region and highlighted the areas that could constitute voids or omissions in the PAs network. The use of species distribution models and landscape connectivity analyzes are relevant as reliable analytical tools to support systematic planning protocols for conservation (Ferrier 2002; Margules and Sarkar 2009; Lechner et al. 2017).

The connectivity loss of ecosystems due to the expansion of anthropogenic activities can influence the viability of the populations of species that inhabit them (Santos and Tellería 2006). The consideration of these results would complement the strategies for conservation in the western region of the TMBV through the integration with technical studies that are part of the justifying inputs for establishing a PA.

Some authors suggest that one way to counteract the problems that arise from fragmentation includes: expanding the area of protected habitats and promoting mechanisms that promote connectivity by counteracting the isolation effect of habitat elements (Fahrig, 2003), therefore considering the inclusion of these areas in the PA network, could favor the maintenance of the connectivity of the landscape and would allow ensuring the biotic continuity between the areas with the current decree in the TMBV in the long term (Sánchez-Cordero et al. 2005).

Implementing actions to conserve habitats in the proposed priority sectors would help maintain species with restricted distribution, such as *Phaetornis griseoventer* y *Thalurania ridgwayi*, and support the protection of endangered species, such as *Amazona oratrix*, *Cyanocorax beecheii* and, *Amazona finsch*i.

The information generated is helpful to select sites for conservation because, as a whole, it provides additional arguments with better ecological and biogeographic foundations for decision-makers.

Conclusions

This study allows identifying a set of priority areas for the conservation of birds in the western region of the TMBV. The inclusion of the sites defined in the NPA network could favor the survival of a high percentage of endemic species and in the risk category, with high ecological vulnerability. It is urgent to guarantee the representation of that species in the protected areas of the region. In addition, it would ensure the maintenance of the connectivity of the habitats where these species are currently distributed.

Acknowledgements

We thank the Master of Science program in Biosystematics and Management of Natural and Agricultural Resources (BIMARENA) and the National Council of Science and Technology (CONACYT) for the scholarship number 484751. We also thank Ana Luisa Santiago Pérez and her field team for facilitating the acquisition and use of point field data.

References

Arizmendi MC., Márquez VL. 2000. Áreas de Importancia para la conservación de las Aves de México. D.F, México: Sociedad para el Estudio y Conservación de las Aves en México [CIPAMEX].

Berlanga H., Gómez de Silva H., Vargas-Canales VM., Rodríguez-Contreras V., Sánchez-González LA., Ortega-Álvarez R.,Calderón-Parra R. 2017. Aves de México: Lista actualizada de especies y nombres comunes. D.F. México: Comisión Nacional para el conocimiento y uso de la biodiversidad [CONABIO].

Ceballos G. 2007. Conservation priorities for mammals in megadiverse Mexico: the efficiency of reserve networks. Ecological Applications, 17(2): 569-578. doi: 10.1890/06-0134

Cuervo-Robayo AP., Téllez-Valdés O., Gómez M., Venegas-Barrera C., Manjarrez J. Martínez-Meyer, E. 2013. An update of high-resolution monthly climate surfaces for Mexico. International Journal of Climatology, 34(7): 2427-2437. doi: 10.1002/joc.3848

Diario Oficial de la Federación [DOF]. 2010. Norma Oficial Mexicana NOM-059-SEMARNAT-2010. Protección ambiental-especies nativas de México de flora y fauna silvestres-categorías de riesgo y especificaciones para su inclusión, exclusión o cambio-lista de especies en riesgo. https://www.dof.gob.mx/nota_detalle.php?codigo=5578808&fecha=14/11/2019 [accessed 14.11.19]

Diario Oficial de la Federación [DOF]. 2014. Acuerdo por el que se da a conocer la lista de especies y poblaciones prioritarias para la conservación. Recuperado de http://dof.gob.mx/nota_detalle.php?codigo=5334865&fecha=05/03/2014 [accessed 14.11.19]

Escalante P., Navarro-Sigüenza AG., Peterson AT. 1993. A geographic, ecological and historical analysis of the land bird diversity in Mexico. In TP. Ramamoorthy, R. Bye, A. Lot, J. Fa (Eds), Biological diversity of Mexico: Origins and distribution (pp. 281-307). New York: Oxford University Press.

Fahrig L. 2003. Effects of habitat fragmentation on biodiversity. Annual Review of Ecology, Evolution and Systematics, 34(1): 487-515. doi:10.1146/annurev.ecolsys.34.011802.132419

Ferrier S. 2002. Mapping spatial pattern in biodiversity for regional conservation planning: Where to from here? Systematic Biology, 51(2): 331-363. Doi: 10.1080/10635150252899806

Ferrari L., Orozco-Esquivel T., Manea V., Manea M. 2012. The Dynamic history of the Trans-Mexican Volcanic Belt and the Mexico Subduction zone. Tecnophysics, 522-523(1): 122-149. doi:10.1016/j.tecto.2011.09.018

García-Trejo EA., Navarro-Sigüenza AG. 2004. Patrones biogeográficos de la riqueza de especies y el endemismo de la avifauna en el oeste de México. Acta Zoológica Mexicana, 20(2): 167-185.

Instituto Nacional de Estadística y Geografía [INEGI]. 2016. Conjunto de datos vectoriales de uso del suelo y vegetación escala 1:250 000, Serie VI. INEGI

Kattan G. 2002. Fragmentación: patrones y mecanismos de extinción de especies. In M. Guariguata, G. Kattan (Eds), Ecología y conservación de bosques neotropicales (pp. 560-590). Costa Rica: Ediciones LUR.

Lechner AM., Sprod D., Carter O., Lefroy EC. 2017. Characterising landscape connectivity for conservation planning using a dispersal guild approach. Landscape Ecology, 32(1): 99-113. doi: 10.1007/s10980-016-0431-5

Margules CR., Sarkar S. 2009. Planeación sistemática de la conservación (Trad. VS. Sánchez-Cordero, F. Figueroa). D.F., México: Universidad Autónoma de México [UNAM], Comisión Nacional de Áreas Naturales Protegidas [CONANP], Comisión Nacional para el Conocimiento y Uso de la Biodiversidad [CONABIO].

Navarro-Sigüenza AG., Lira-Noriega, A., Peterson AT., Oliveras de Ita A., Gordillo-Martínez, A. 2007. Diversidad, endemismo y conservación de las aves. In I. Luna JJ. Morrone, D. Espinosa (Eds), Biodiversidad de la Faja Volcánica Transmexicana (pp. 461-483). México: Universidad Nacional Autónoma de México [UNAM].

Navarro-Sigüenza AG, Peterson AT. 2004. An alternative species taxonomy of the birds of Mexico. Biota Neotropica, 4(2): 1-32. Doi:10.1590/S1676-06032004000200013

Pascual-Hortal L., Saura, S. 2006. Comparison and development of new graph-based landscape connectivity indices: towards the prioritization of habitat patches and corridors for conservation. Landscape Ecology, 21(7): 959-967. Doi: 10.1007/s10980-006-0013-z

Phillips SJ., Anderson P., Schapire E. 2006. Maximum entropy modeling of species geographic distributions. Ecological Modelling, 190 (3-4): 231-259. doi: 10.1016/j.ecolmodel.2005.03.026.

Primack R., Rozzi R., Feinsinger P., Dirzo R., Massardo F. 2001. Fundamentos de conservación biológica: perspectivas latinoamericanas. México: Fondo de Cultura Económica.

Sánchez-Cordero V., Cirelli V., Munguía M., Sarkar, S. 2005. Place prioritization for biodiversity representation using species' ecological niche modeling. Biodiversity Informatics, 2(1): 11-23. doi: https://doi.org/10.17161/bi.v2i0.9

Sánchez-Cordero V., Illoldi-Rangel P., Linaje M. 2012. Identificación de áreas prioritarias para la conservación y su conectividad bajo diferentes escenarios de cambio climático: base para el diseño de áreas naturales protegidas. https://www.gob.mx/cms/uploads/attachment/file/168021/2012_identific_areas_prioritarias_cc.pdf [accessed 25.10.19]

Santos T., Tellería, JL. 2006. Pérdida y fragmentación del hábitat: efecto sobre la conservación de las especies. Ecosistemas, 15(2): 3- 12.

Saura S., Torné J. 2009. Conefor Sensinode 2.2: a software package for quantifying the importance of habitat patches for landscape connectivity. Environmental Modelling & Software, 24(1): 135-139. doi: 10.1016/j.envsoft.2008.05.005

Stotz DF., Fitzpatrick JW., Parker III, TA., Moskovits DK. 1996. Neotropical Birds Ecology and Conservation. London: The University of Chicago Press.

Suárez-Mota ME., Téllez-Valdés O., Martínez-Meyer, E. 2014. Dominios climáticos de las áreas naturales protegidas del eje volcánico transversal de México. GeoFocus, 14 (1): 120-143.

Villavicencio-García R., Saura-Martínez de Toda S., Santiago-Pérez AL., Chávez-Hernández A. 2009. La conectividad forestal de las áreas naturales protegidas del estado de Jalisco con otros ambientes naturales, Scientia-CUCBA, 11(1-2): 43-50.