PROGRESS REPORT

30606-1 Relationships between the landscape and mangrove bird assemblages in the central coast strip of Veracruz, Mexico

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Study area and landscape characterizing

The field work covered three mangrove fragments in the central portion of the "Planicie Costera de la Región del Sotavento" physiographic province in the state of Veracruz, Mexico (Fig. 1). The choice of these fragments was: 1) Arroyo Moreno "AM", 2) Mandinga "MAN" and 3) Laguna Grande "LG" because of their relative structural homogeneity and because they are mixed forests with three mangrove species: *Rhizophora mangle* (red mangrove), *Avicennia germinans* (black mangrove) and *Laguncularia racemosa* (white mangrove). We took fragments as focal points and adjusted 2 km and 4 km radii to delimit landscape contexts and characterize them at three nested spatial scales: local vegetation, patch, and landscape. We classified a subscene of a Landsat 8 Level-2 multispectral image (30m spatial resolution, April 2019) with 5 land use classes: 1) mangrove, 2) agricultural, 3) urban settlements, 4) water, and 5) secondary vegetation. We extracted landscape contexts and calculated landscape metrics at the patch (area) and landscape scales (Shannon diversity, percentage of land use classes and number of fragments) using ArcMap Ver. 10.5 and FRAGSTATS Ver. 4.2.1 software. At the local vegetation scale, we established 20x20m plots where we measured diameter at breast height (DBH), and estimated mangrove structural variables such as basal area and tree height. All variables were considered as predictor variables.

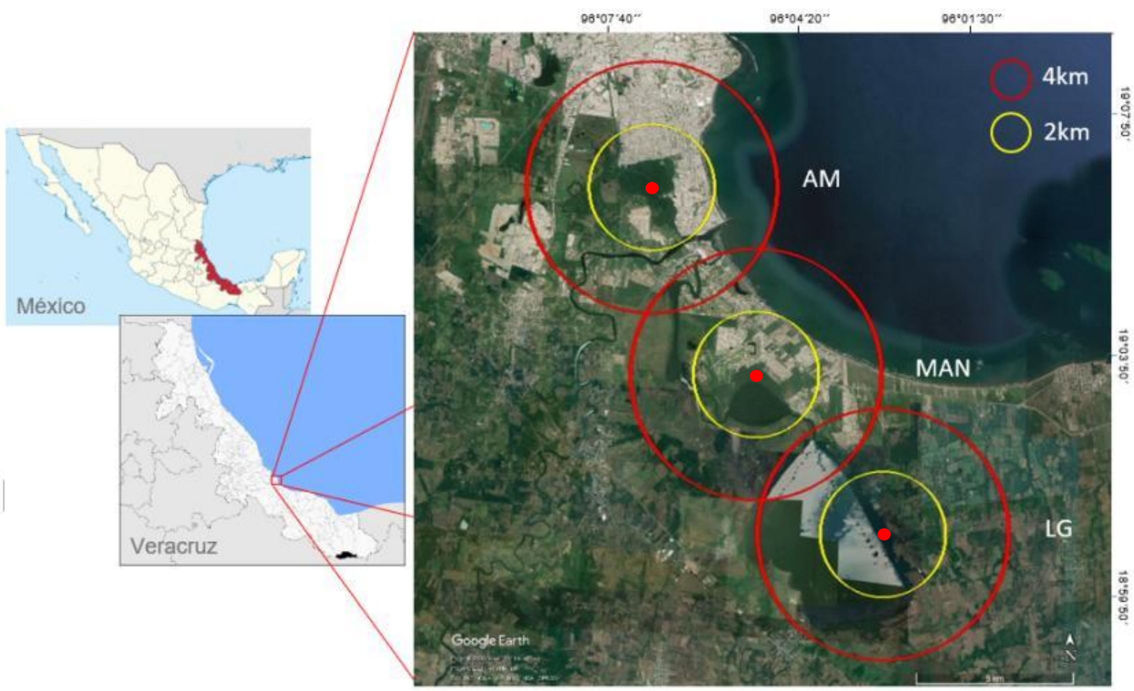

Figure 1. Geographic location of the study area in the central coastal portion of Veracruz, Mexico. Focal mangrove fragments and spatial radius are shown.

Bird survey and statistical analysis

We surveyed fixed-width transects of 500 m long and 30 m wide within the focal fragments to record birds in two non-breeding seasons in Mexico (winter January-March 2020 and December 2020-February 2021). There were 7 fixed transects for AM, 5 for MAN, and 6 for LG, with a total of 213 visits. The frequency of the visits was at 15-day intervals and the time of the walks was from 07:00 am to 12:00 noon. We rotated the direction of travel of the transects every three visits and the observers walked them simultaneously in each fragment to significantly reduce redundancy between records. We considered the richness and abundance of birds in diet groups as the response variable for the analysis. As a replacement of the summer 2020 fieldwork by Covid-19, we conducted monitoring in summer 2021 (breeding season May-July) for inventory purposes of birds in breeding season.

We performed a rarefaction curve based on sampling coverage and extrapolation to assess sampling effort, as well as to contrast the magnitudes of diversity differences between fragments. We only used visits from non-breeding seasons for the analysis. Simultaneously, we subjected a Kolmogorov-Smirnov test analysis to identify statistically significant differences between non-breeding seasons as a function of relative bird abundances. We detected no differences between seasons, so we performed the analysis with both seasons. We used iNEXT software in its online version and R Ver. 4.0.4. Finally, we used the Negative Binomial regression (NBN) model as it best fits our count data. We performed simple regressions between 8 predictor variables of the three nested spatial scales and 6 representative diet groups. We considered relationship between variables those models significant ($p<0.05$) as it indicates that the model has significantly reduced the variance and is thus useful for predicting the response variable.

Preliminary results

We obtained a classified image with very good concordance strength (K'=0.96; Fig. 2). Landscape metrics had marked variations between landscape contexts, with urban settlements dominating in the AM context within 2 km radius (45.1%) and agricultural, water, and secondary vegetation in LG (36.02% radius 4 km, 44.66% radius 2 km, and 22.87% radius 2 km, respectively), but discrete variations between spatial radii. The most fragmented land use classes in all landscape contexts and spatial radii were agricultural and secondary vegetation. The patch with the largest area was AM (213.66 ha) and the smallest was MAN (67.77 ha). At the local vegetation scale, AM had on average a higher DBH with 18.81±14.25 cm and heights with 9.04±5.3 m. The MAN fragment had the lowest DBH values with 9.2, basal area of 25.71 and average height of 6.59±3.85.

We recorded a total of 157 bird species associated with mangroves in non-breeding seasons and one breeding season. For the analysis seasons alone (winter) we recorded 116 in AM, 92 in MAN and 110 in LG (Fig. 3). The rarefaction curve had an average coverage estimator value of 97% sample completeness, thus, in statistical terms, subtracting 3% of records if we increase the sampling effort to 150 units (Fig. 4). There were no significant differences between fragments as the confidence intervals of the rarefaction and extrapolation curve vectors overlap.

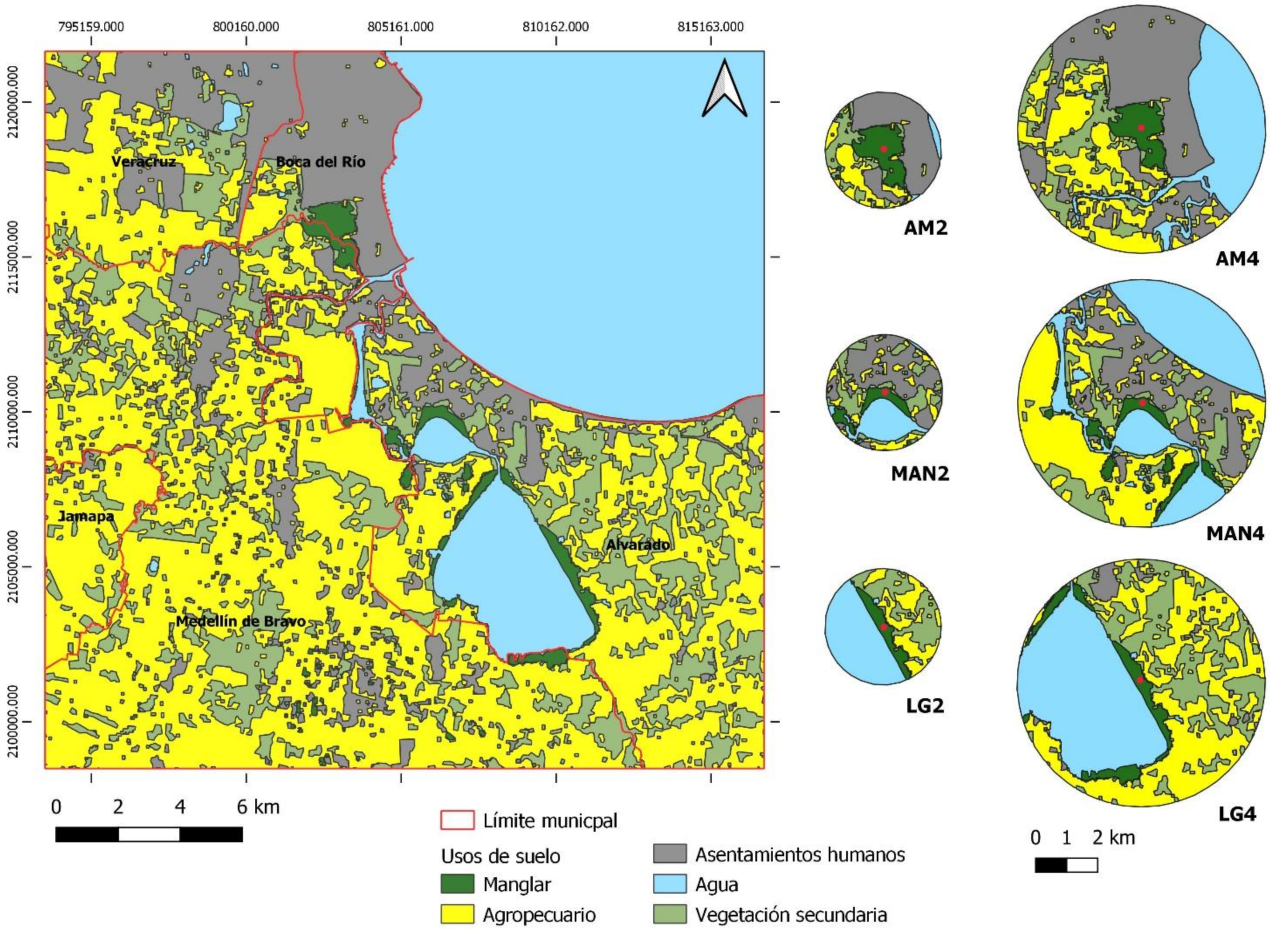

Figure 2. Classified map and landscape contexts with five land use classes in the central coast of Veracruz. AM: Arroyo Moreno, MAN: Mandinga and LG: Laguna grande. Numbers refer to 2km and 4km radius.

We obtained a total of 23 diet type categories. Insectivorous birds dominated with 46.05% of the total, followed by piscivores (8.55%) and carnivores (6.58%). We selected only 13 dietary categories based on a frequency ≥5 records in all transects to minimize spurious relationships arising from underrepresented species, of which we considered 6 groupings as the most important for RBN analysis: 1) carnivores, 2) crustaceans, 3) insectivores, 4) insectivores-frugivores, 5) omnivores and 6) vermivores, this to determine in a general way the associations between variables.

RBN values showed similar patterns among some bird diet types. For example, carnivorous birds had positive associations with Shannon diversity values, contrary to percentages of land use cover and number of fragments. Carnivores had no relationship with patch area, but negative associations with basal area and height. Crustaceous birds had a very similar pattern.

In contrast, insectivorous birds showed no association with any landscape level and class variable, but did have positive relationships with fragment area, basal area, and average height. Insectivorous-frugivorous birds had a similar pattern of associations. Omnivorous birds had a particular pattern of associations, for example, they only had negative associations with percentages of land uses, but positive relationships with number of fragments. They had no association with patch and local level variables. Finally, vermivorous birds only showed negative associations with the percentages of mangrove and agricultural land uses, as well as positive relationships with the number of fragments of the secondary vegetation class at 2 km radius and patch area.

Figure 3. Bird species present in the mangrove swamp of the central coast of Veracruz, Mexico. A) White Ibis (*Eudocimus albus*), B) Mangrove Warbler (*Setophaga petechia eritachorides*), C) Common Black Hawk (*Buteogallus anthracinus*), Subject to special protection NOM-059-SEMARNAT-2019, D) Crane Hawk (*Geranospiza caerulescens*), Subject to special protection NOM-059-SEMARNAT-2019, E) Green Heron (*Butorides virescens*), F) Lesser Yellow-headed Vulture (*Cathartes burrovianus*), Subject to special protection NOM-059-SEMARNAT-2019, G) Bare-throated Tiger-Heron (*Tigrisoma mexicanum*) Subject to special protection NOM-059-SEMARNAT-2019, H) White-eyed Vireo (*Vireo griseus*), I) Northern Potoo (*Nyctibius jamaicensis*).

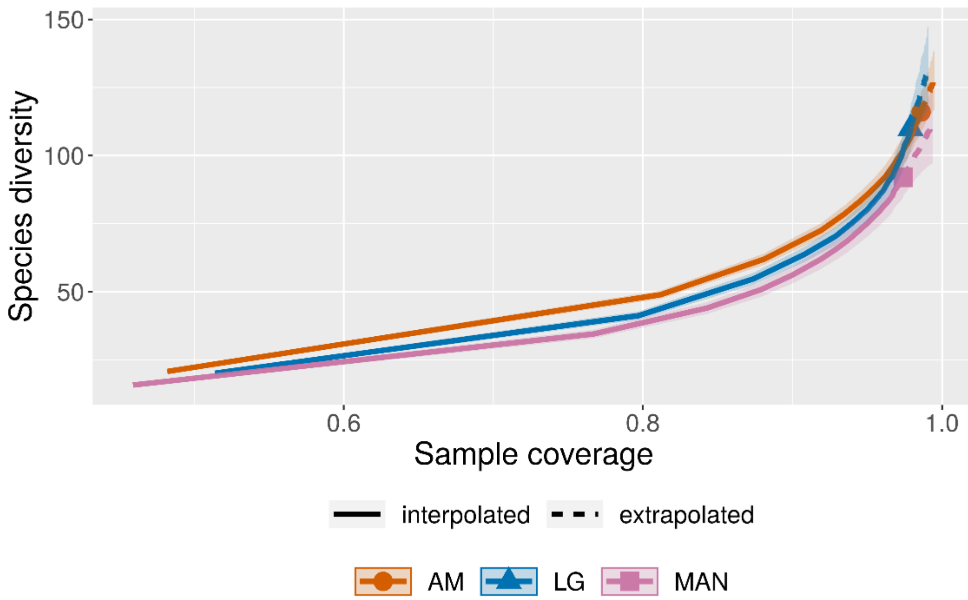

Figure 4. Rarefaction curve and extrapolation using the sampling coverage method, considering the occurrence of birds associated with mangroves in the central coastal strip of Veracruz, Mexico.