Land-Use Change and Amphibian Diversity in the Bolivian Chiquitano Dry Forest (1985-2023)

Petersik Julius, Bachelor Thesis

Abstract

Tropical dry forests are among the ecosystems most affected by land-use change (LUC), yet existing knowledge of these systems remains relatively limited. This is especially true for amphibians, the most imperilled vertebrate class, and their largest order, anurans. This thesis assesses how geographic patterns of anuran diversity in the Bolivian Chiquitano Dry Forest changed between 1985 and 2023 in response to different LUC types, which species and ecomorphs were identified as winners or losers, and the extent to which they are covered by the 2023 protected area (PA) network. Drawing on time-calibrated probability-of-occurrence outputs from presence-background species distribution models for the 58 species that met the minimum occurrence threshold, probabilities of occurrence were summed per pixel to derive taxonomic richness (TR). At the species level, expected range sizes were quantified as the summed probability of occurrence multiplied by pixel area. Rarity-weighted richness (RWR) was calculated by weighting each species by the inverse of its 1985 expected range size. The occurrence dataset identified 65 species within the Chiquitano, suggesting that the previously reported species richness of 49 was an underestimation. TR and RWR were initially continuously distributed along natural environmental gradients. Both metrics declined and became increasingly spatially heterogeneous, with fragmentation of richness hotspots preceding the quantitative decline. By 2023, TR and RWR distribution no longer followed natural conditions but instead reflected land-use change history. Losses were driven predominantly by cropland conversion, which coupled tightly to TR and RWR loss, whereas pasture conversion showed weak positive effects. Of the 58 species, 65% contracted their expected ranges, with the strongest contractions exceeding the strongest expansions. Among ecomorphs, Arboreal and Fossorial species declined most, whereas Aquatic species were the only consistently expanding group. Protected-area coverage was structured by habitat association, with forests being better represented than savannas. Regions outside PAs were most affected by habitat loss. LUC, and cropland conversion in particular, has substantially reduced and spatially reorganised anuran diversity in the Chiquitano, and has eroded exceptional ecomorphological richness. The remaining habitat cores are increasingly confined to isolated reserves within forest PAs, highlighting the need for a broader protected-area strategy beyond the current forest-focused reserve system in this rapidly transforming frontier region.

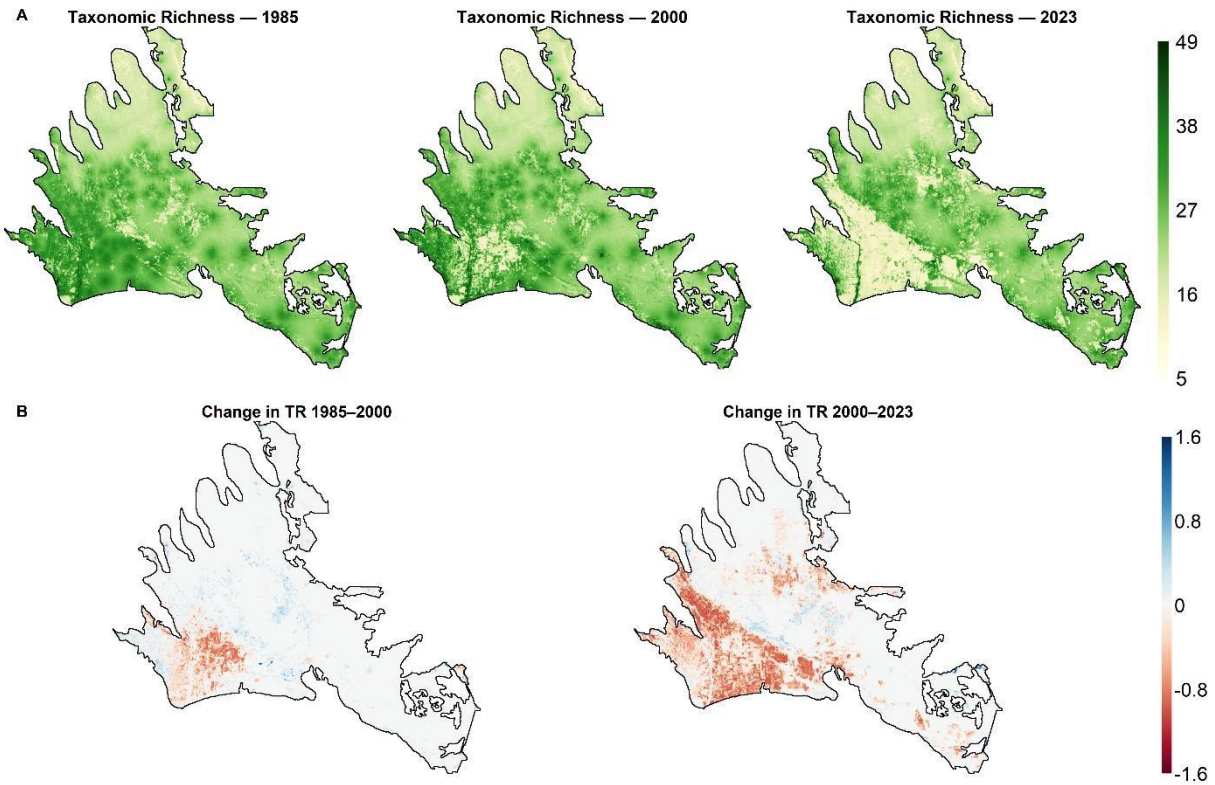

Figure 1 | Spatial patterns and temporal change of Anuran taxonomic richness (TR) in the Chiquitano between 1985 and 2023. (A) TR represents the sum probability of occurrence ($p(\text{occ})$) values across the 58 modelled species per 1 km² pixel, for each of the three timesteps. (B) Shows proportional change in TR between time intervals, expressed as log-ratio.

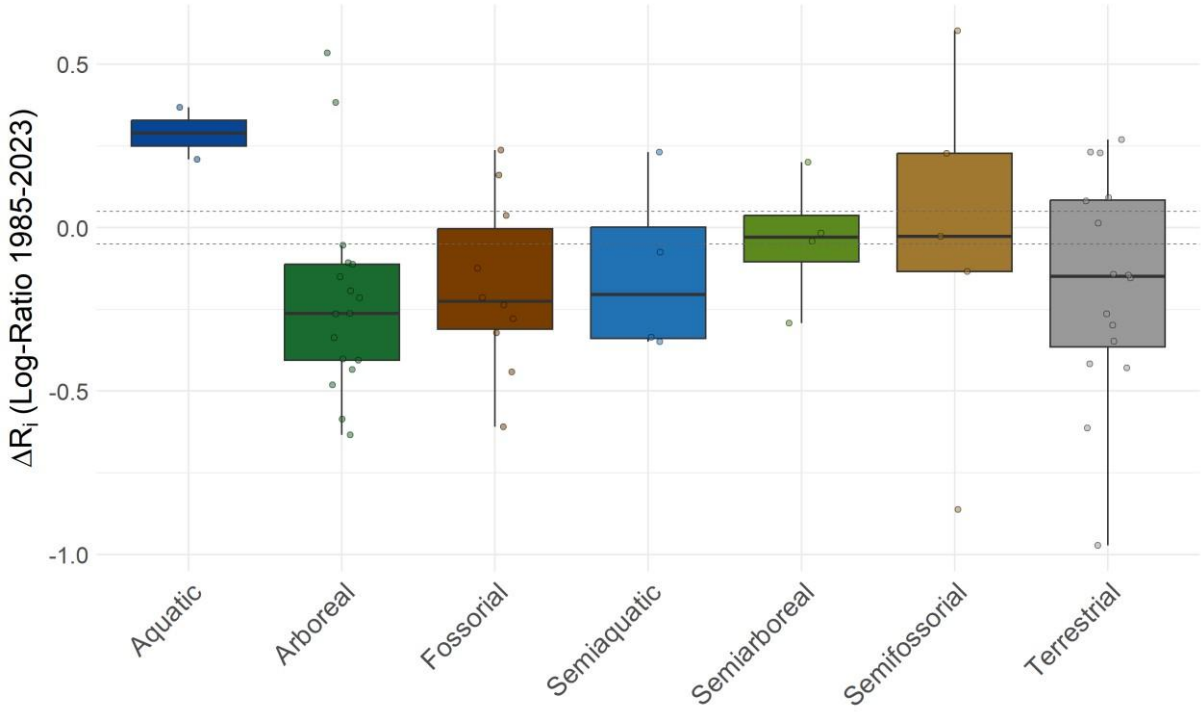

Figure 2 | Distribution of log-ratio expected range size change by ecomorph in the Chiquitano (19852023). Boxplots show the median of ΔR_i change per ecomorph, with individual species shown as points. Dashed horizontal lines indicate ±0.05 threshold of meaningful change.

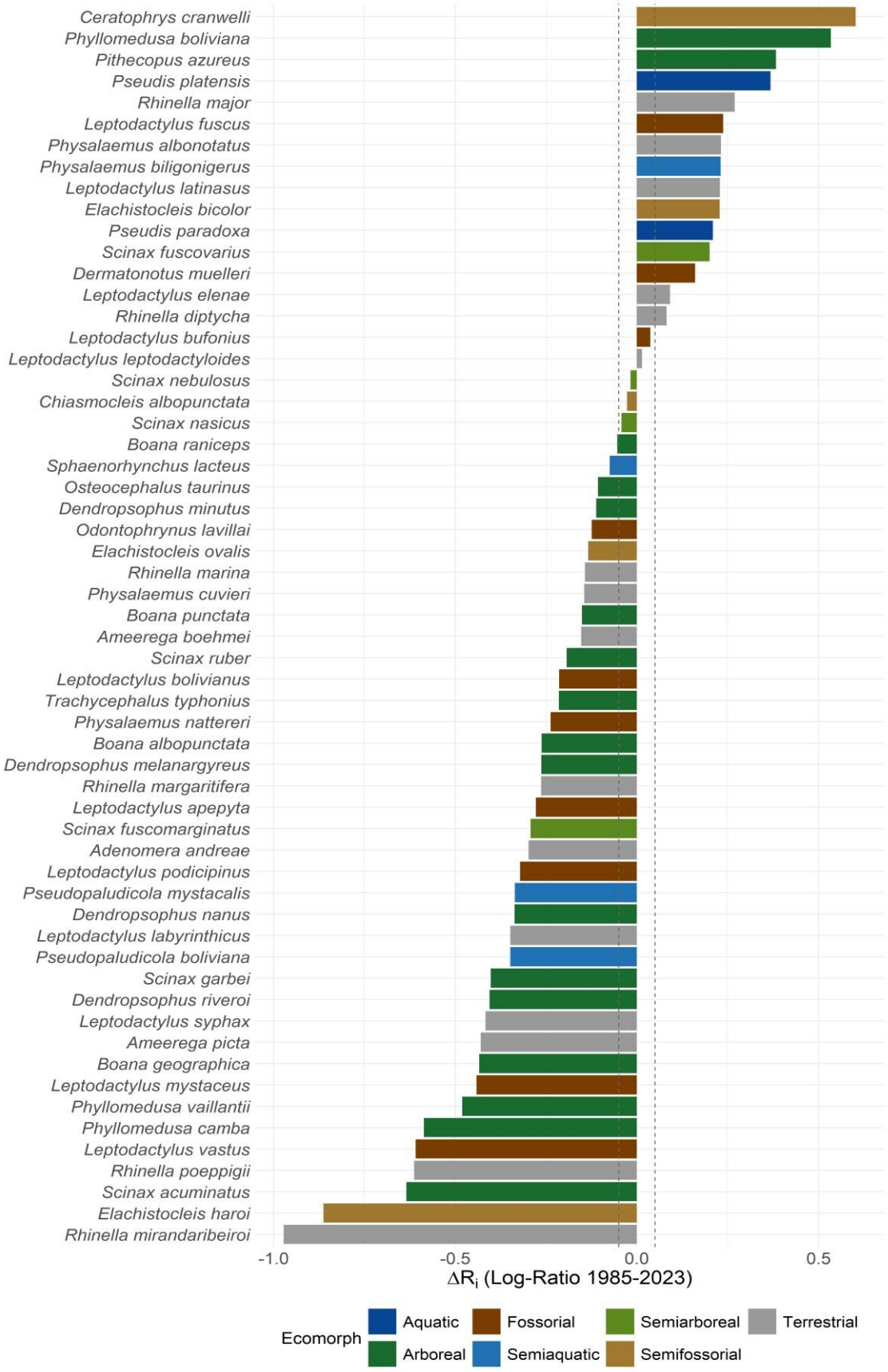

Figure 3 | Winners and losers among the modelled anuran species in the Chiquitano (1985-2023). Bars represent the log-ratio change in expected range size (ΔR_i) per species, coloured by ecomorph. Dashed vertical lines indicate the ±0.05 threshold of meaningful change.

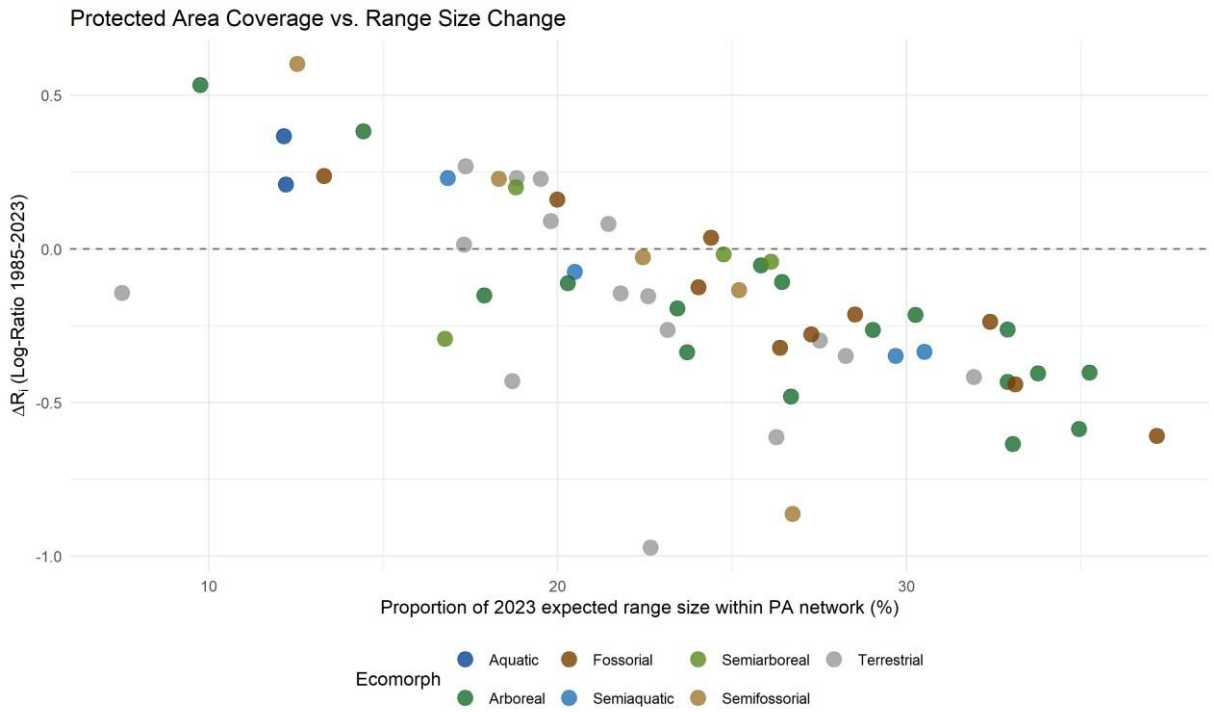

Figure 4 | Relationship between protected area (PA) coverage and expected range size change per species. Each point represents a species, coloured by ecomorph. The x-axis shows the proportion of each species' 2023 expected range size falling within the PA network; the y-axis shows the logratio change in expected range size between 1985 and 2023.