EVIDENCE OF NEOTROPICAL CARNIVORES' CONTINENTAL GEOGRAPHIC RANGE CONTRACTIONS OVER THE LAST TWO DECADES

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THE PROBLEM

The Neotropics is a multicultural region that covers a large range of habitats and climatic conditions from Mexico to Argentina. It is one of the hotspots of the world but also one of the areas that has experienced the most widespread conversion of natural habitat.

The amount of biodiversity data openly available in the region has increased massively over the last decades. **Despite this, data that cover large areas over long-term periods are usually scarce**. In order to be able to model how biodiversity is changing in this region, we urgently need to develop models that can account for this data heterogeneity.

OUR AIM

Use our recently developed **integrated species distribution model (ISDM)** (Grattarola et al. 2023) to (1) estimate the geographic distribution of eight charismatic mammal carnivores in the Neotropics in two time periods, (2) quantify the species occupancy changes, and (3) evaluate how and where do the changes accumulate.

METHODS

We estimated changes in the geographic distribution of species between 2000-2013 and 2014-2021 using an ISDM fitted in JAGS. Our model (1) assumed a Poisson point pattern intensity (scale-free) (**Figure 1**), (2) integrated camera-trap survey data with GBIF point occurences (**Figure 2**), (3) accounted for sampling effort and (4) spatial autocorrelation, and (5) included the species expert maps as a covariate (i.e., distance to the range's edge).

		PO data	PA data	covariates
LC	*Herpailurus yagouaroundi* (jaguarundi)	804	602	npp, elevation, bio7, bio15
LC	*Nasua nasua* (coatí)	1978	1906	nontree, npp, bio10, bio13
LC	*Cerdocyon thous* (crab-eating fox)	3003	1992	urban, tree, bio3, bio4
NT	*Chrysocyon brachyusus* (maned wolf)	475	386	elev, grass, bio2, bio14
LC	*Eira barbara* (tayra)	1740	1837	npp, nontree, bio10, bio17
NT	*Leopardus wiedii* (margay)	549	720	npp, nontree, bio7, bio10
LC	*Leopardus pardalis* (ocelot)	2590	2963	npp, tree, bio10, bio17
EN	*Pteronura brasiliensis* (giant otter)	199	21	npp, elevation, bio7, bio15

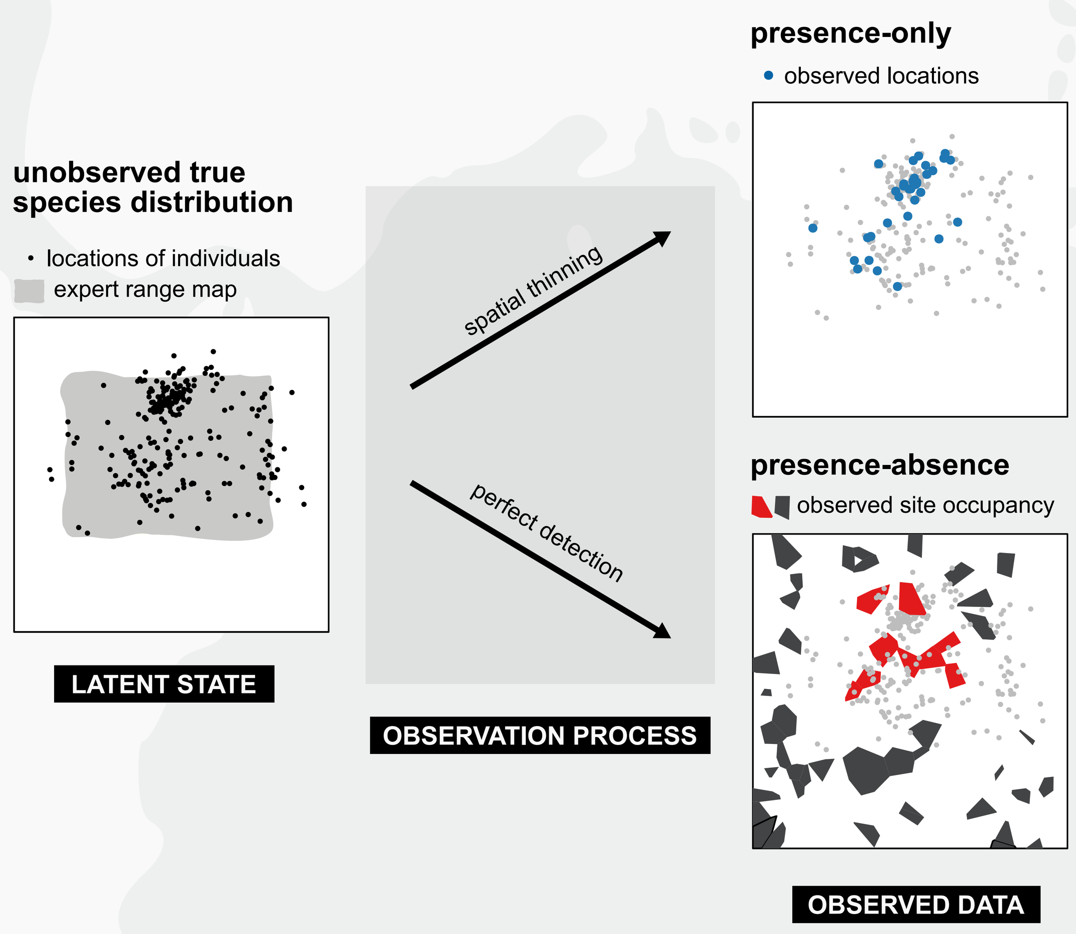

Figure 1. Our model assumes that the true (unobserved) species distribution, i.e., the latent state, can be modelled by a **Poisson point process** conditional on environmental covariates, the distance to the expert range map, time, and spatial splines. This true distribution is then sampled through **two different observation processes**, generating the PO and PA data we observe. The **joint likelihood** of these observed data, given the unobserved true state and uninformative priors, is then used in MCMC to calculate posterior distributions of the true state.

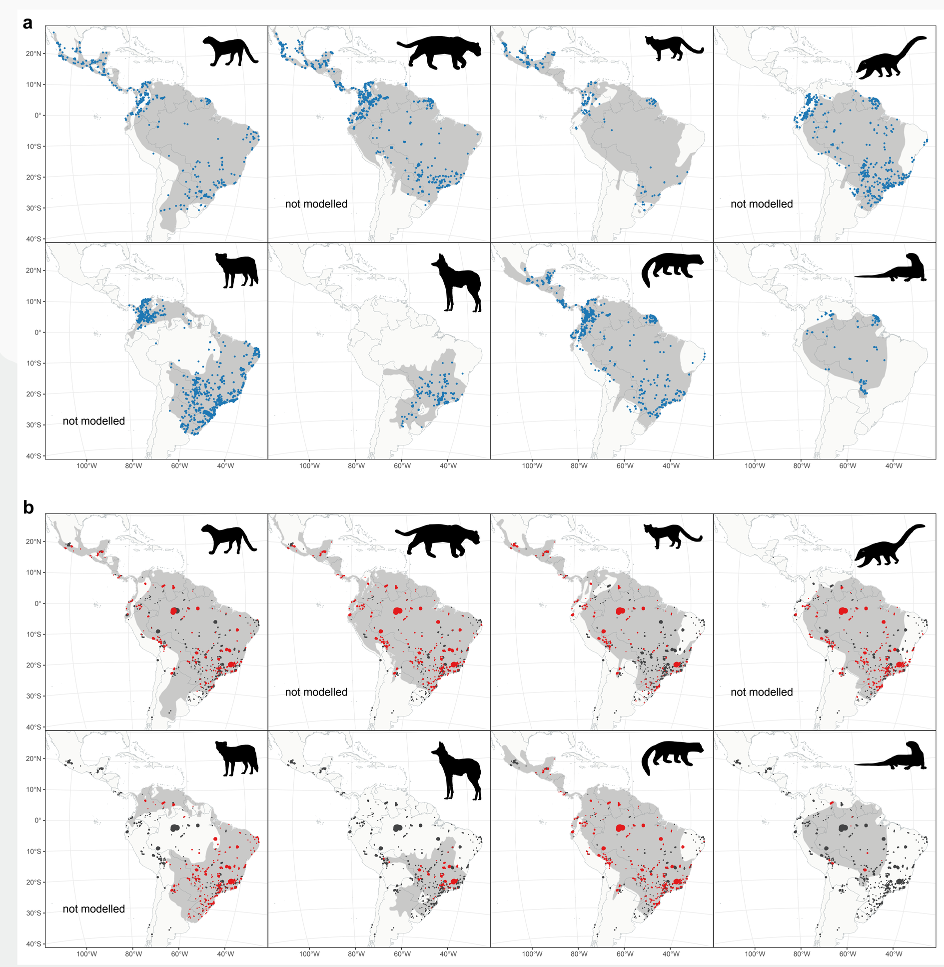

Figure 2. (a) Occurrence records from GBIF.org are shown in blue. (b) Camera-trap surveys from Nagy-Reis et al. (2020) and other sources. Presences are shown in red and absences in dark grey. The IUCN expert map is shown in light grey for each species.

RESULTS

From the eight species, six were well supported based on model performance. We were not able to assess the distribution range of *Leopardus pardalis*, *Cerdocyon thous* and *Nasua nasua*.

The changes in the area of distribution varied between species, ranging from -1,980,000 km^2 to 150,000 km^2, and were predominantly negative (**Figure 3**), meaning that **most species decreased their ranges relative to the initial range size**.

We evidenced a **decrease in species richness** in Uruguay, North Argentina, and Paraguay, and an increase in northeast Brazil, the tropical Andes and northern Mexico (**Figure 4**).

We saw an increase in temporal change of spatial dissimilarity with distance between periods (**Figure 5a**). Temporal dissimilarity of species composition between time$_1$ and time$_2$ (**Figure 5b**), concentrated in the northwest of Mexico (A1), northeast Brazil (A2), and the northeast of Argentina (A3).

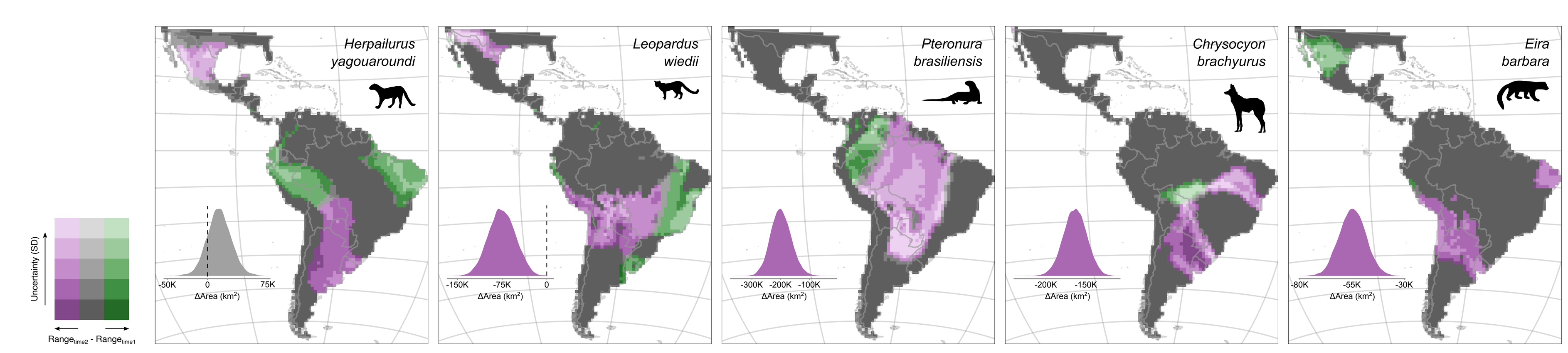

Figure 3. Changes in the area of occupancy of species. The change between the two time periods (2000 to 2013 and 2014 to 2021) is split by the uncertainty of the prediction; darker pink and darker green colours show highly certain losses and gains, respectively. The distribution of the area of change is shown in the lower left corner for each species.

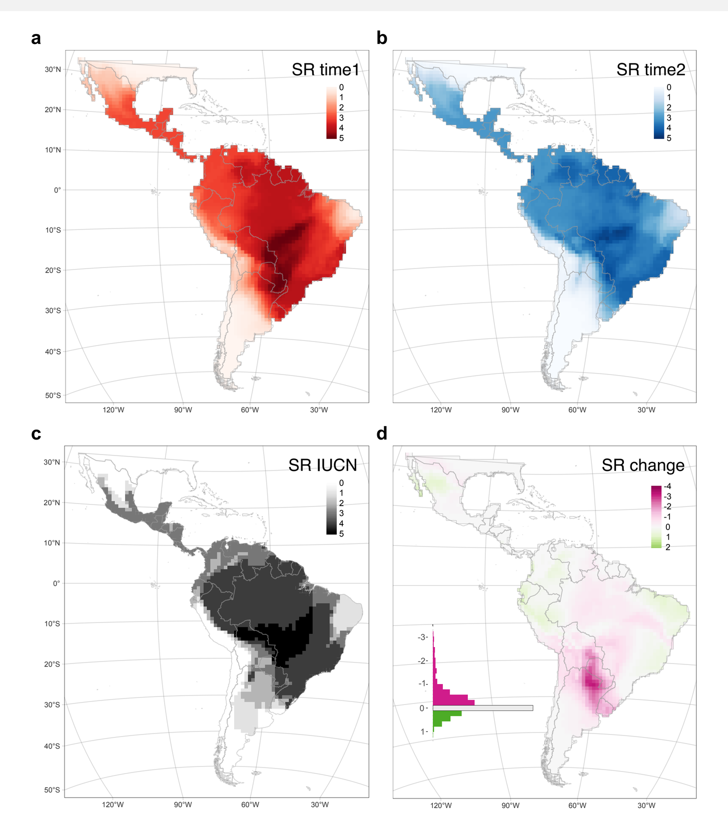

Figure 4. Patterns of species richness (SR) and SR change. Including maned wolf (*Chrysocyon brachyurus*), giant otter (*Pteronura brasiliensis*), jaguarundi (*Herpailurus yagouaroundi*), tayra (*Eira barbara*), and margay (*Leopardus wiedii*). (a) Species richness in time$_1$ (2000 to 2013), (b) species richness in time$_2$ (2014 to 2021), (c) species richness according to the IUCN expert range maps, and (d) change in species richness between both time periods (pink regions indicate species losses and green regions indicate species gains).

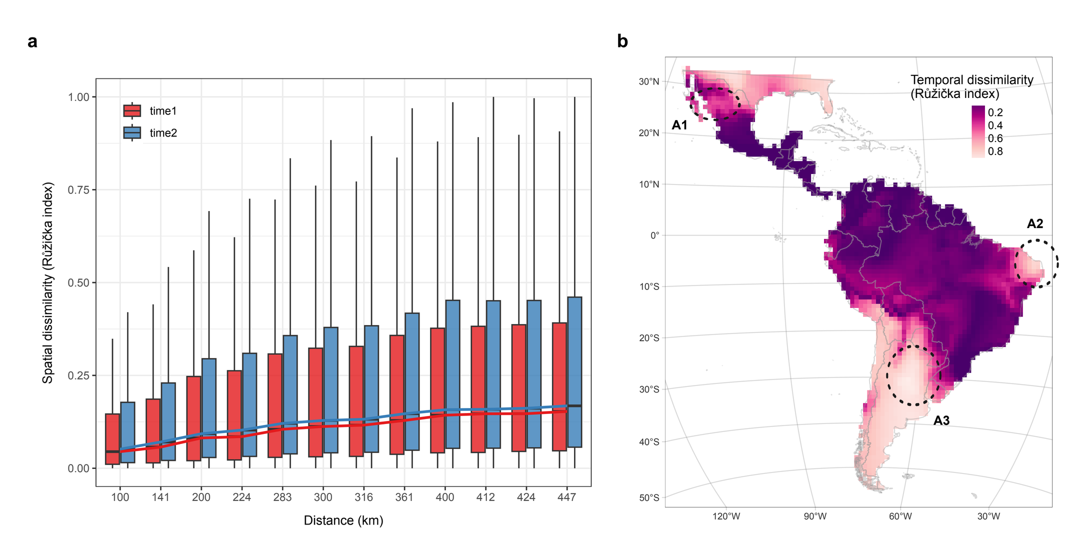

Figure 5. Change in temporal and spatial dissimilarity measured with Růžička index. (a) Temporal change of spatial dissimilarity, i.e., between each time period at the same grid cell. Dissimilarity is higher in time$_2$ and increases with distance for both periods. (b) Spatial variation in temporal dissimilarity, i.e., between pairs of grid cells within the same time period. High dissimilarity between time$_1$ and time$_2$ is represented in light pink and low in dark purple. A1, A2 and A3 highlight areas of interest due to high dissimilarity and richness.

CONCLUSIONS

- This is the first multi-species range dynamic integrated SDM study at a continental scale that looks at **different facets of biodiversity at the same time**.
- Most carnivore species, several endangered, have shown **overall declines in their area of occupancy** in the last two decades.
- We revealed that the ongoing land use changes in the Neotropical region have been coupled with a **transformation in the status of biodiversity** there.

GOING FORWARD

With our approach, we aim to transition from using static range polygons to adopting a **dynamic macroecological** perspective, incorporating both contemporary and historical distributions. This shift can enhance the communication of the profound and ongoing global biodiversity changes, especially with a focus on improving understanding among the general public.

References:
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Nagy-Reis et al. 2020. 'NEOTROPICAL CARNIVORES: A Data Set on Carnivore Distribution in the Neotropics'. *Ecology* 101(11): e03128.

Acknowledgements: Thanks to Bob O'Hara and Diana Bowler for their valuable advice.

Funding: European Union (ERC, BEAST, 101044740). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Council Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

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