BioSpace25 - Biodiversity insight from Space
10 - 14 February 2025 | ESA-ESRIN | Frascati - Italy

MAPPING MORE BIODIVERSITY

INTEGRATING SPATIAL AND PHYLOGENETIC INFORMATION TO IMPROVE DATA-DEFICIENT SPECIES

SHUBHI SHARMA, JEREMY COHEN & WALTER JETZ

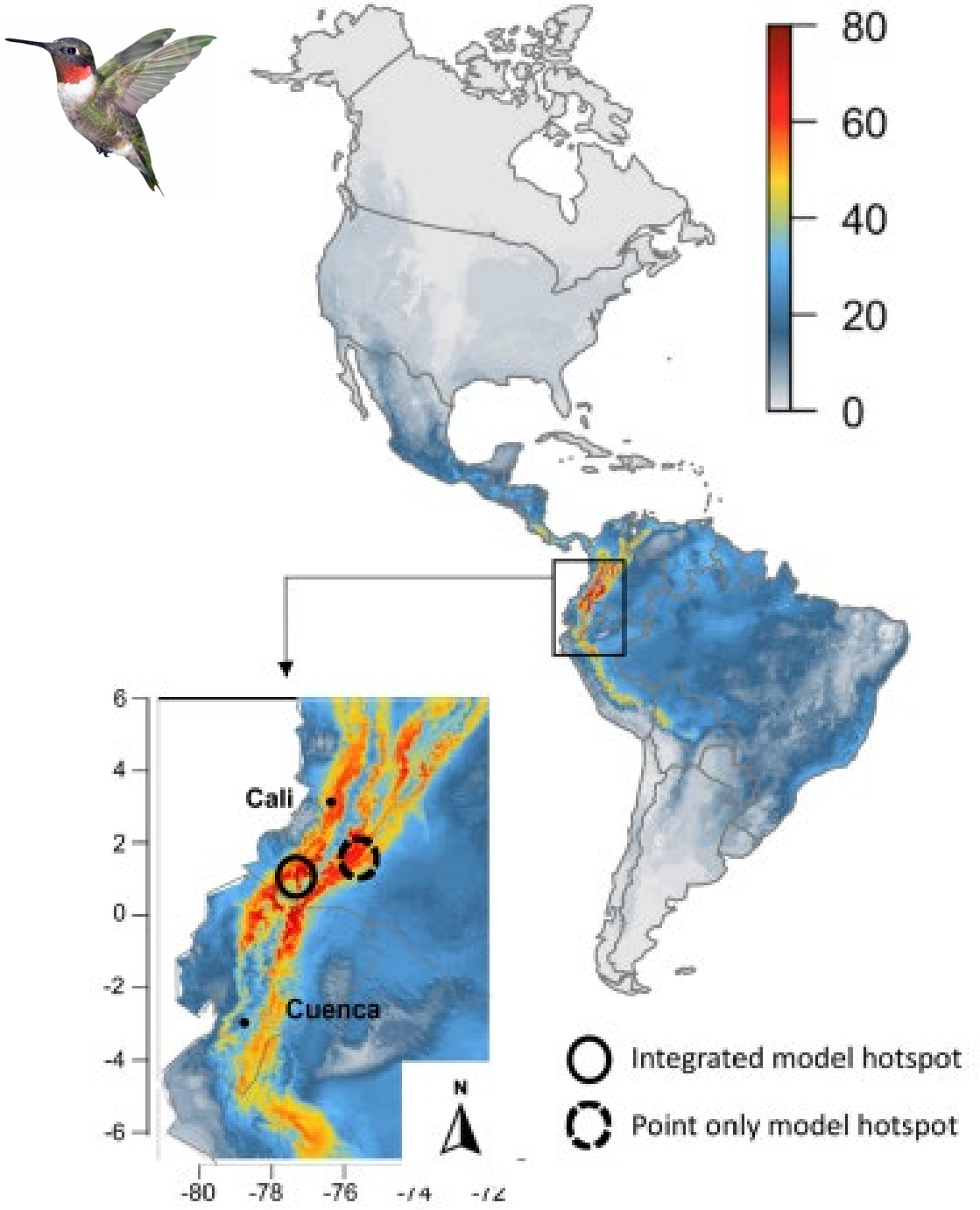
SDMs can improve our understanding of biodiversity distribution

Species distribution models (SDMs) outputs are often used to

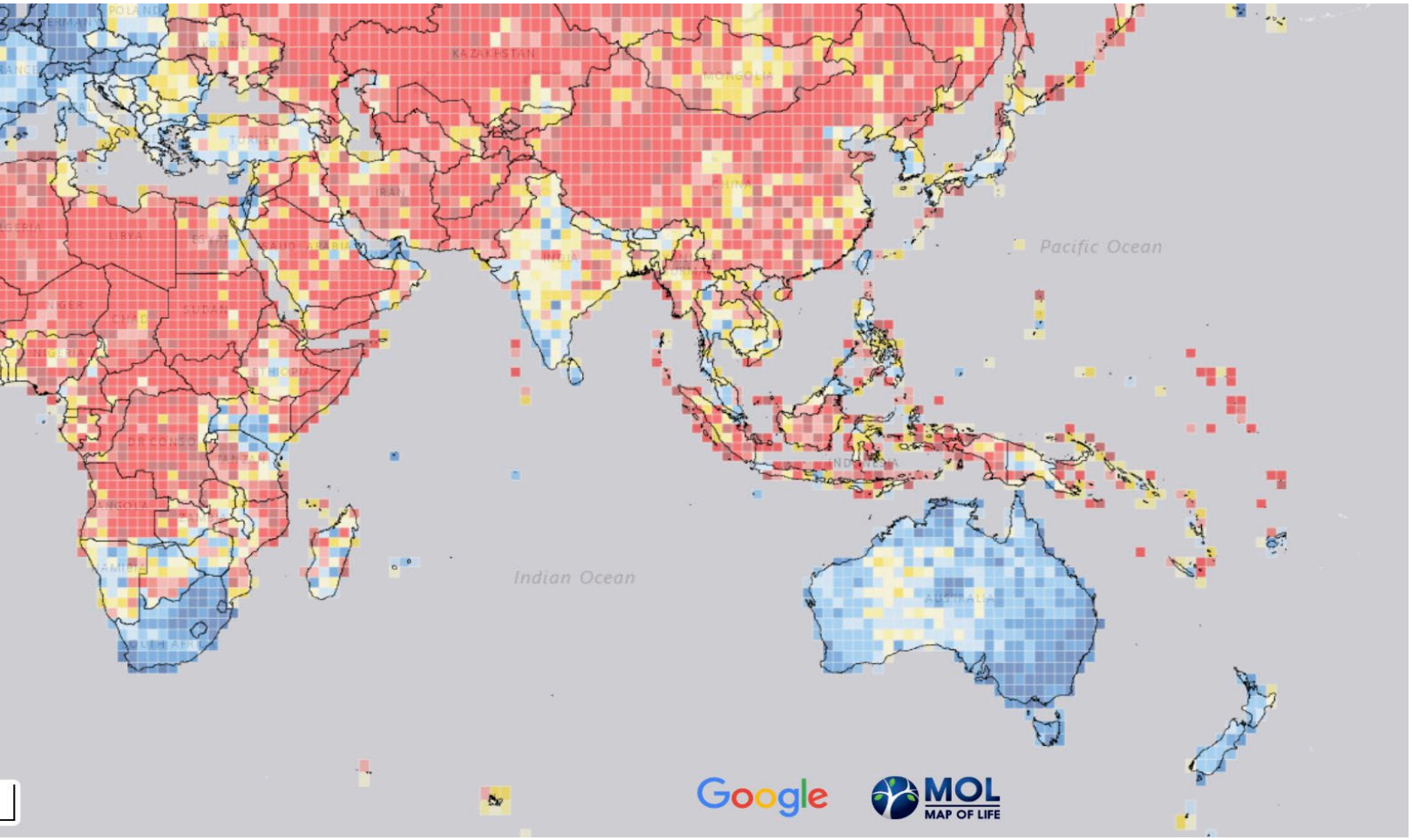
- **pinpoint biodiversity hotspots**

- develop effective conservation plans

Ellis-Soto *et al*., (2021)



Data-deficiency impedes our understanding of biodiversity distribution

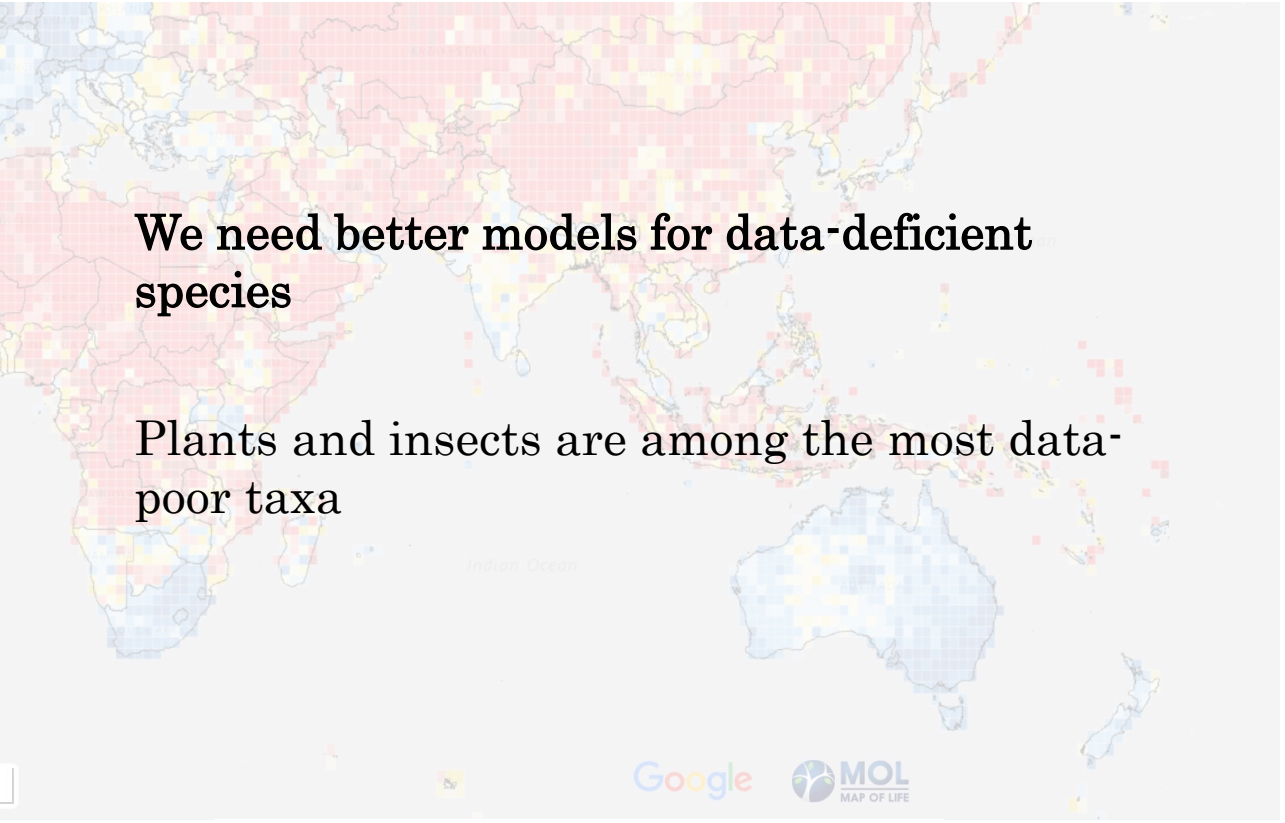


We need better models for data-deficient species

Most tropical places in the world have incomplete richness datasets

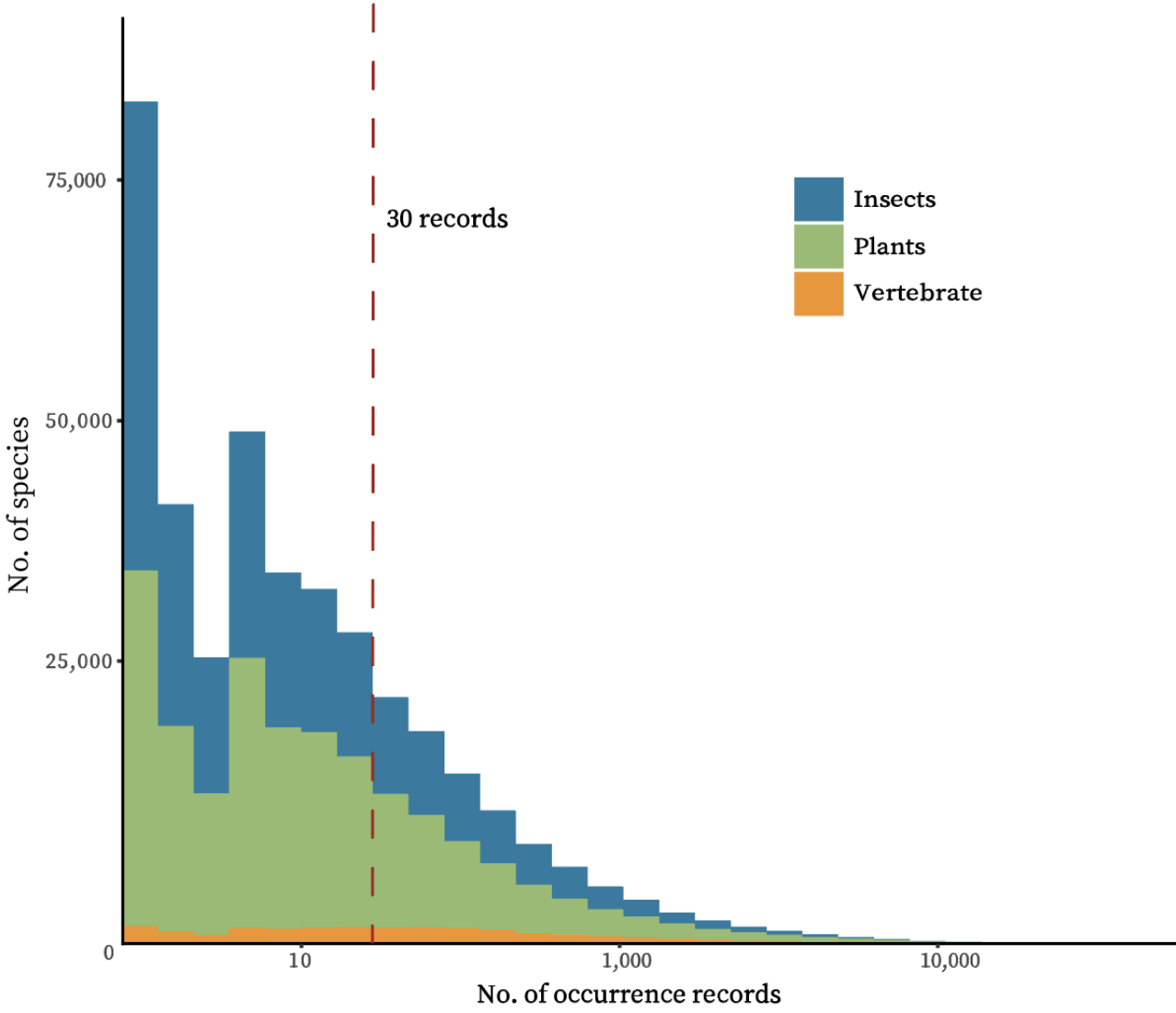
Data-deficiency impedes our understanding of biodiversity distribution





We need better models for data-deficient species

Plants and insects are among the most data-poor taxa



Sharma *et al., In Revision, TREE*

Data-deficiency impedes our understanding of biodiversity distribution



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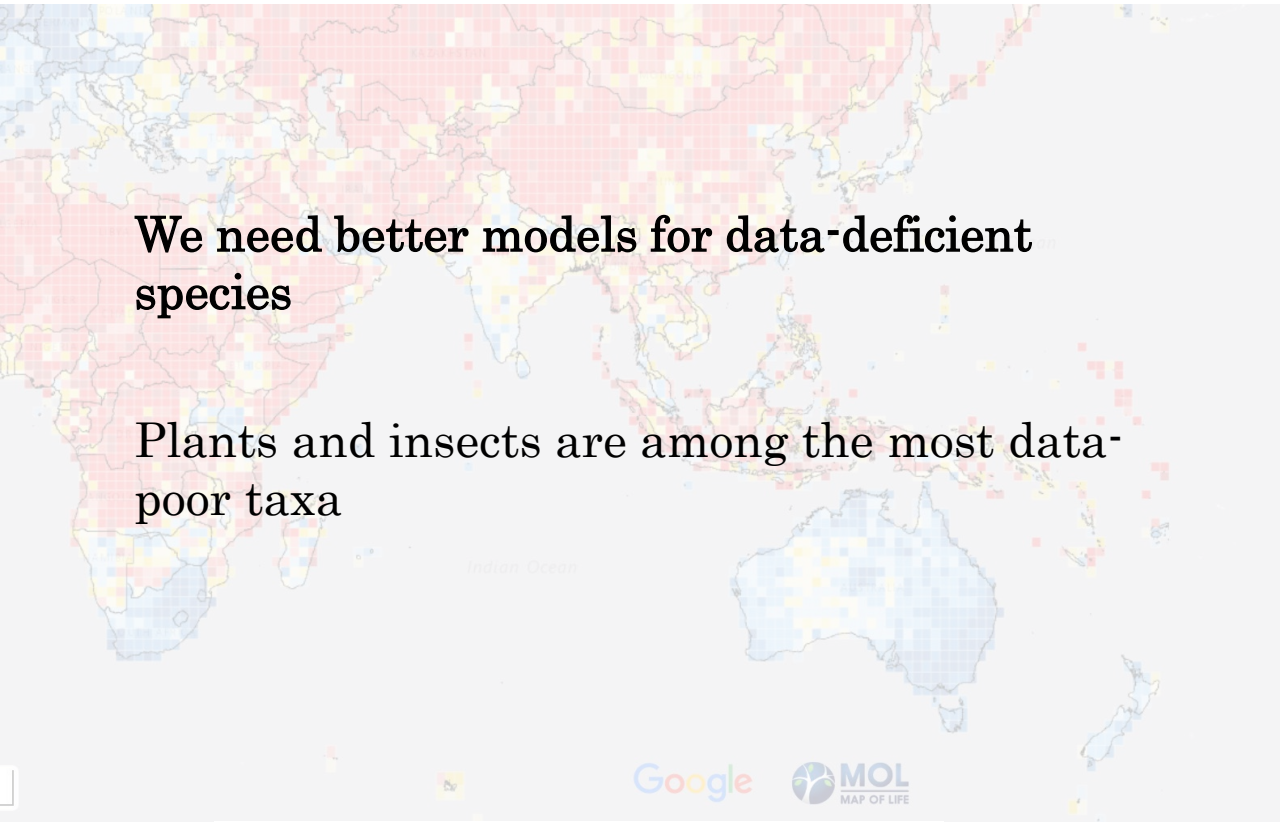
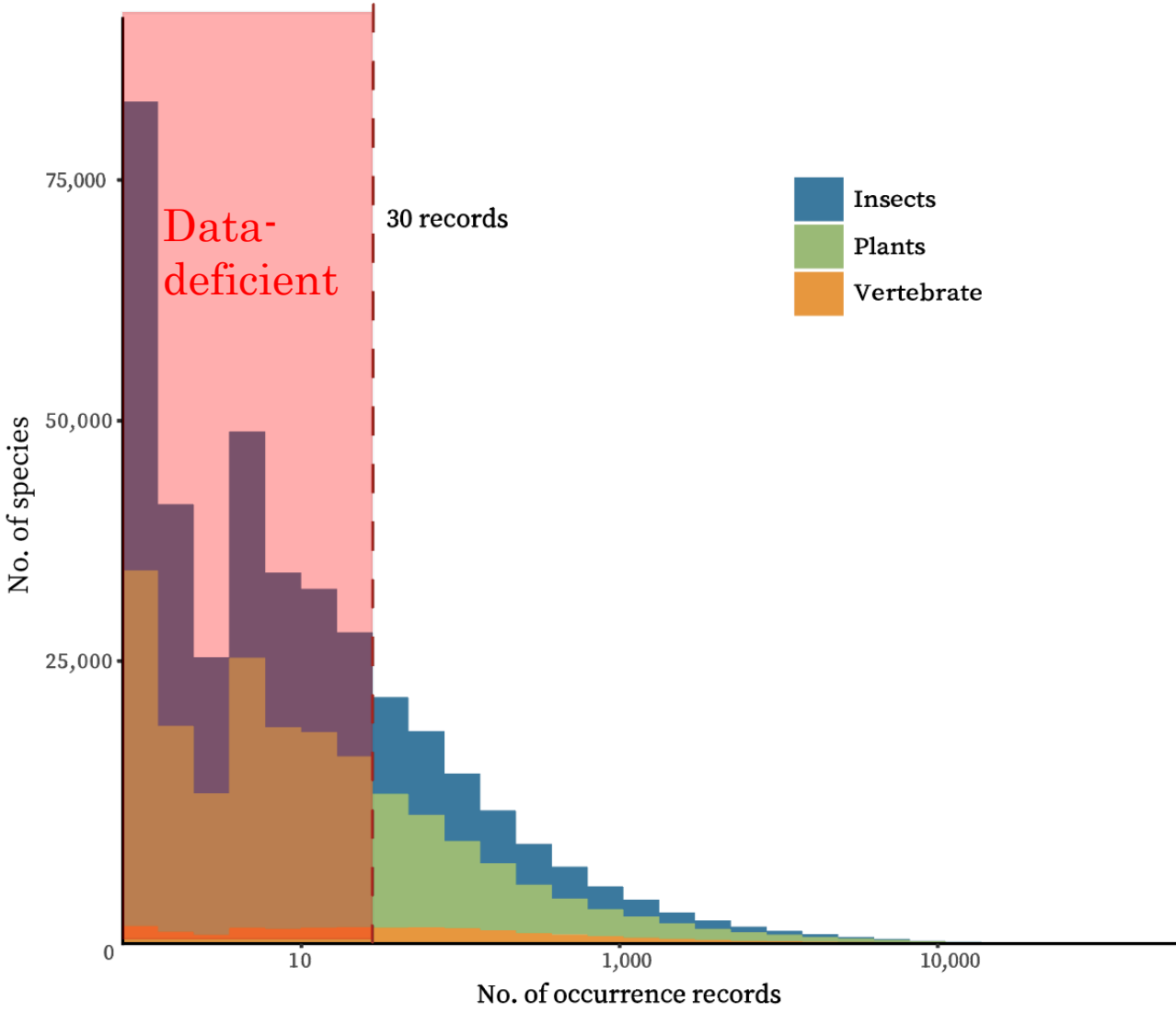


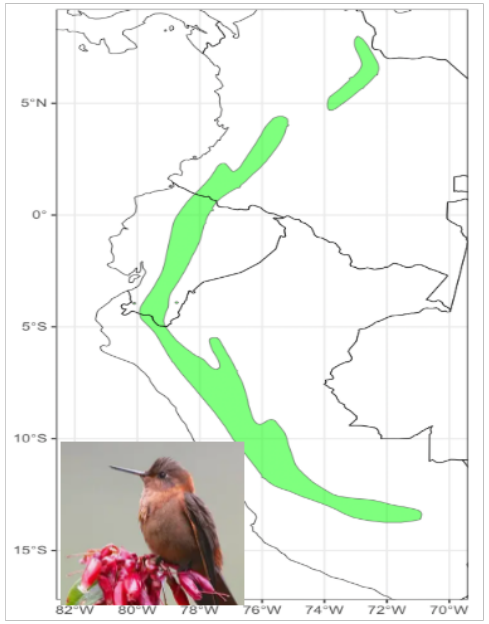


Sharma *et al., In Revision, TREE*

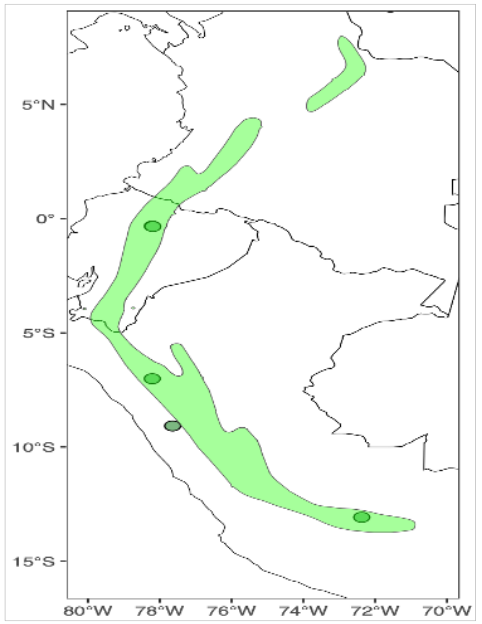
What about **data poor** species?

Our current models cannot handle species
that have little to no geographic/occurrence data

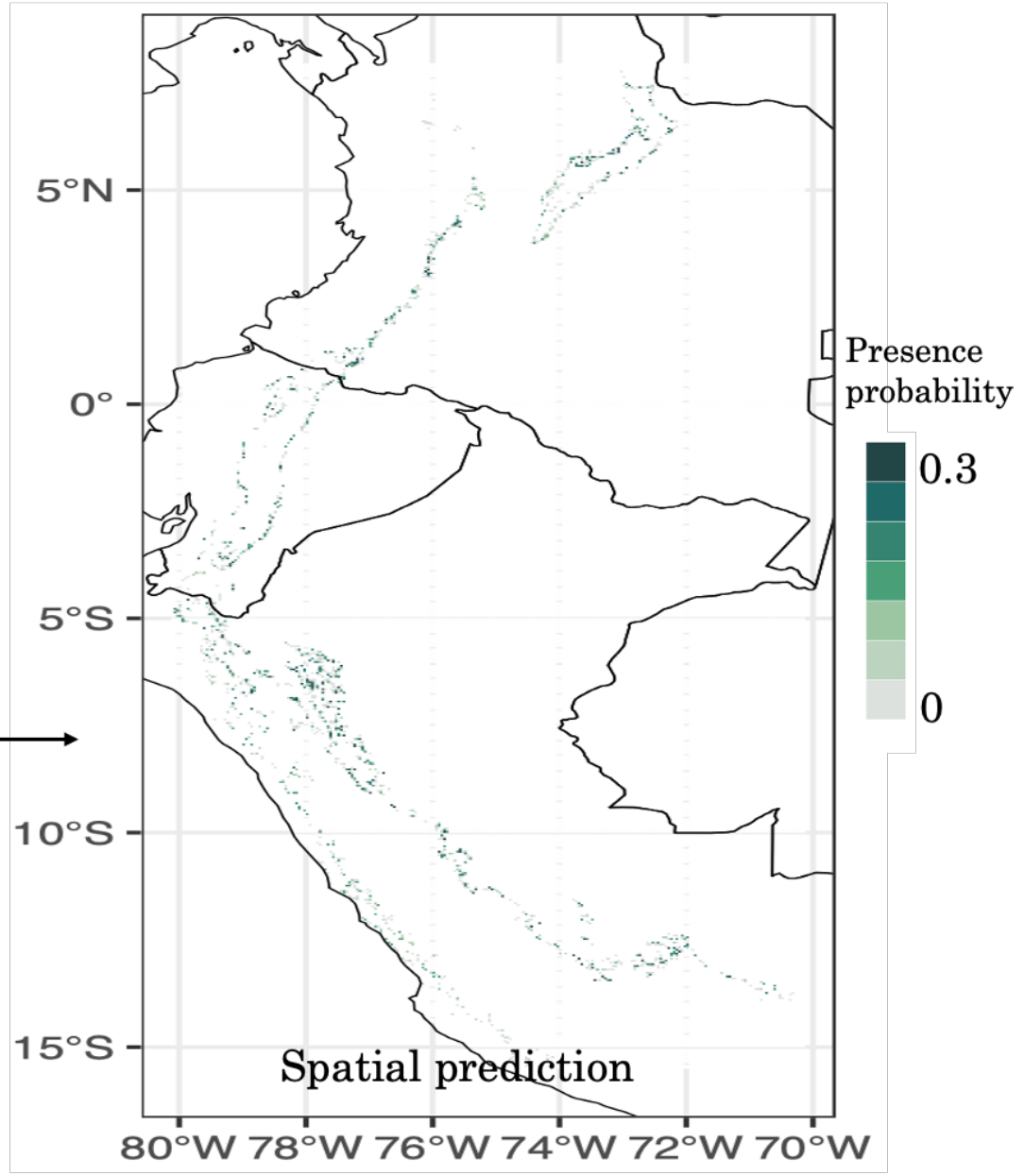
Shining sunbeam (Agalaectis cupripennis)



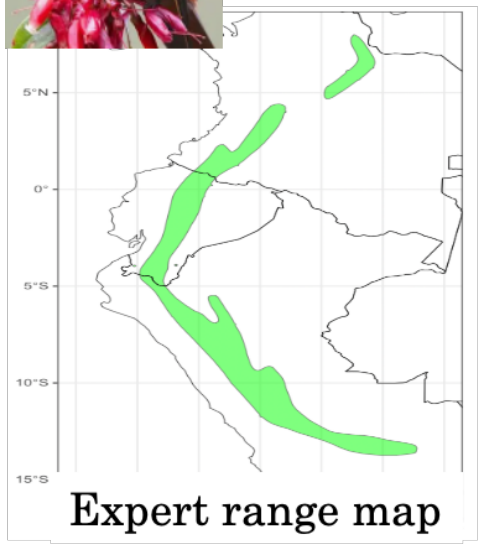
Expert range map



Presence points



Shining sunbeam (Agalaectis cupripennis)



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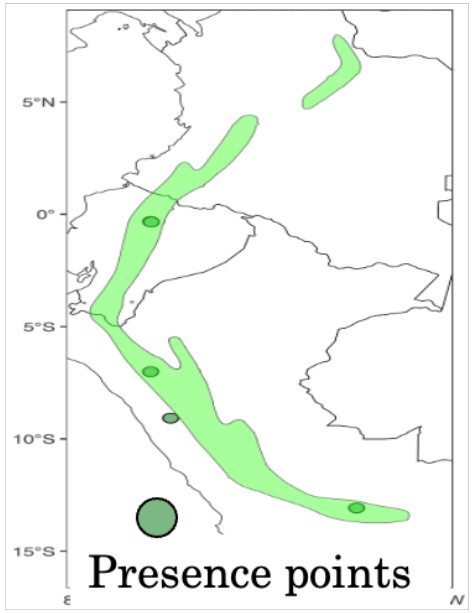
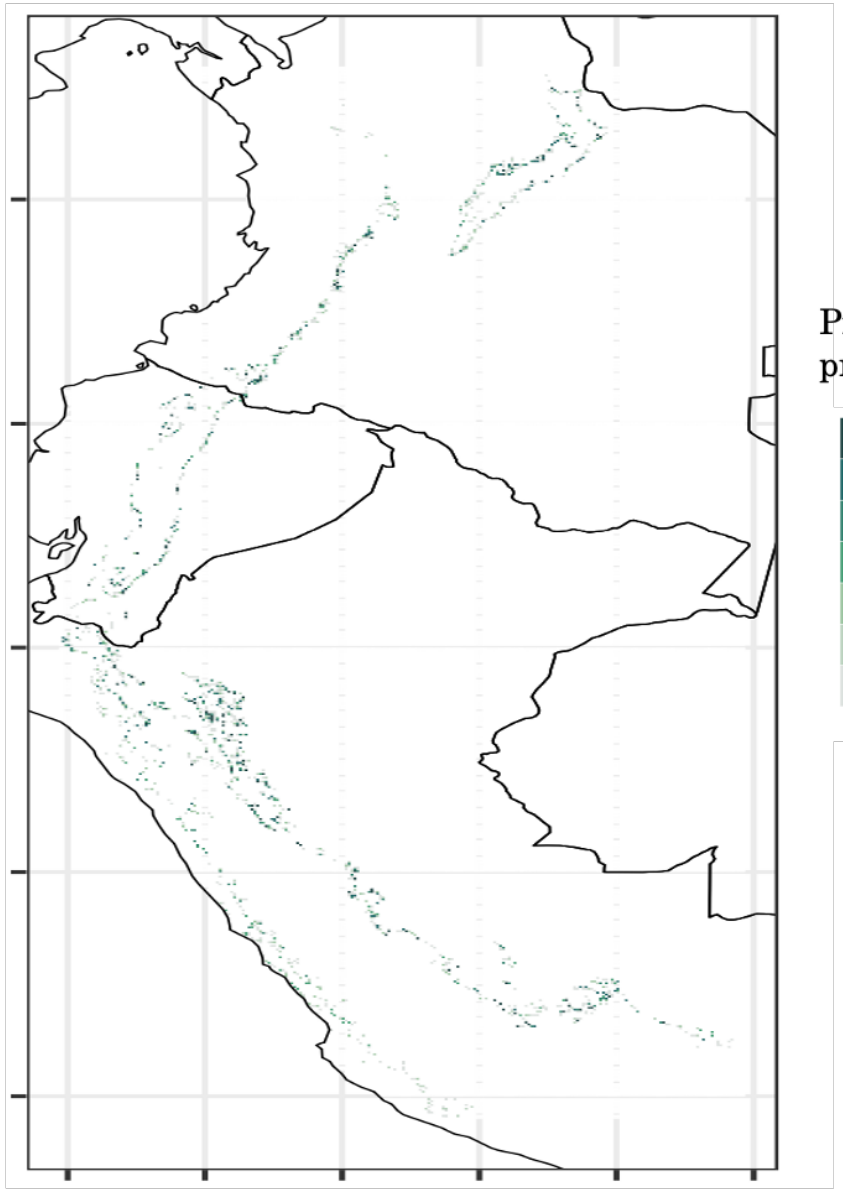


Presence points



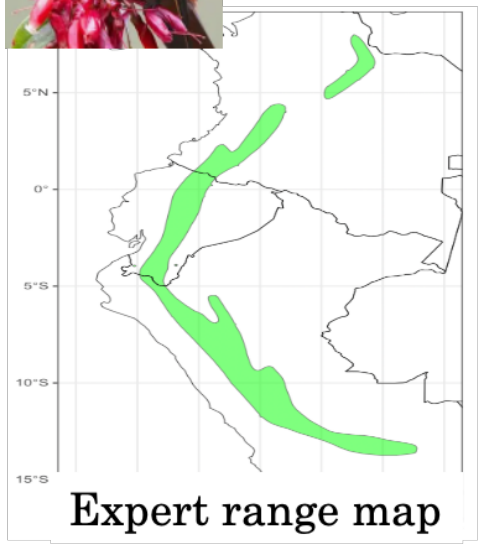
Presence probability

0.3

0

To improve this prediction, we need →

Shining sunbeam (Agalaectis cupripennis)



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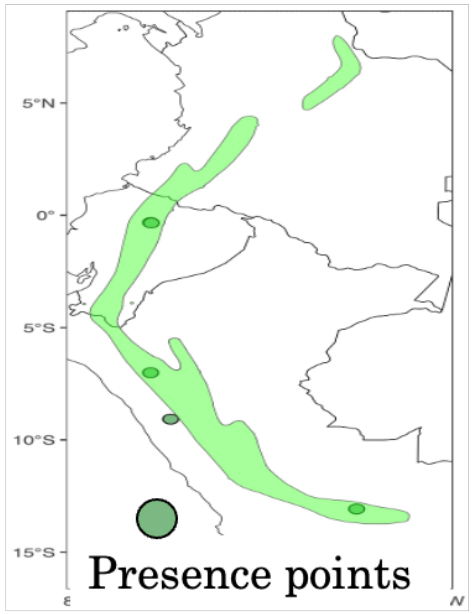
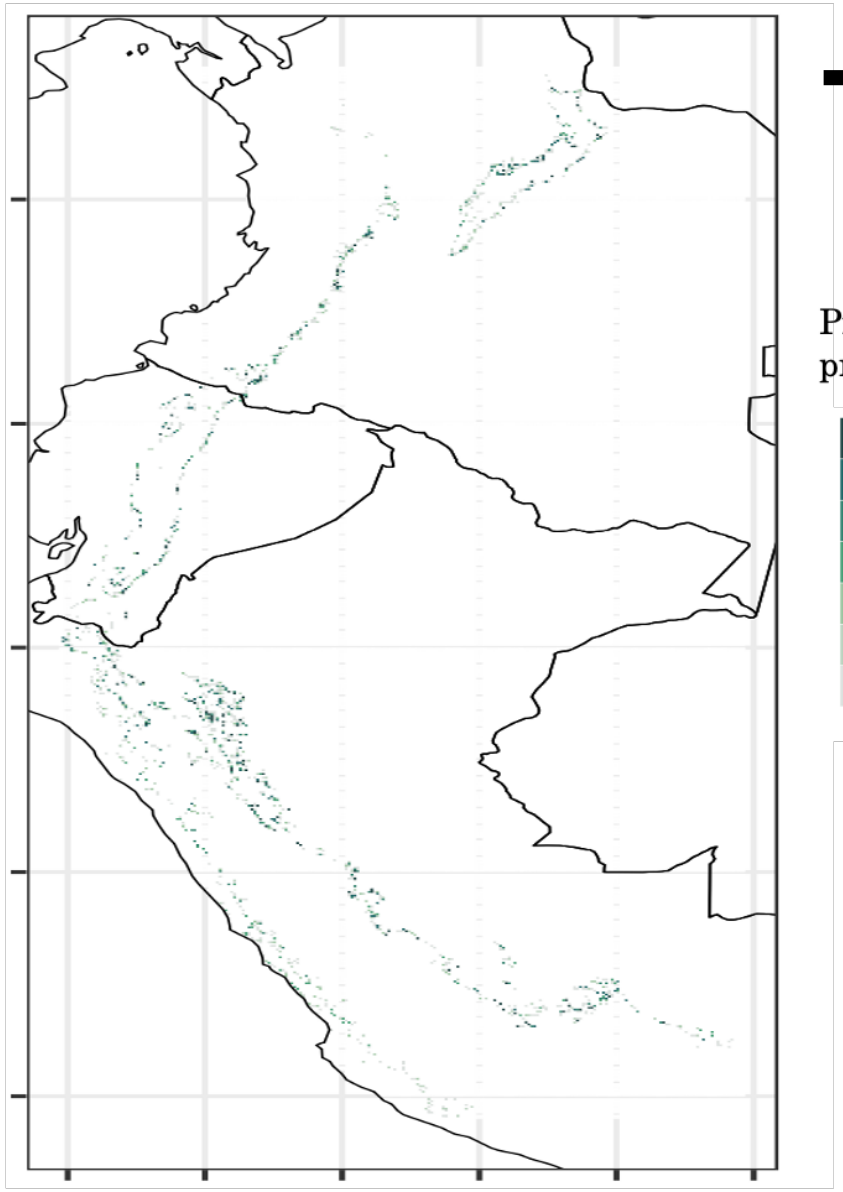


Presence points



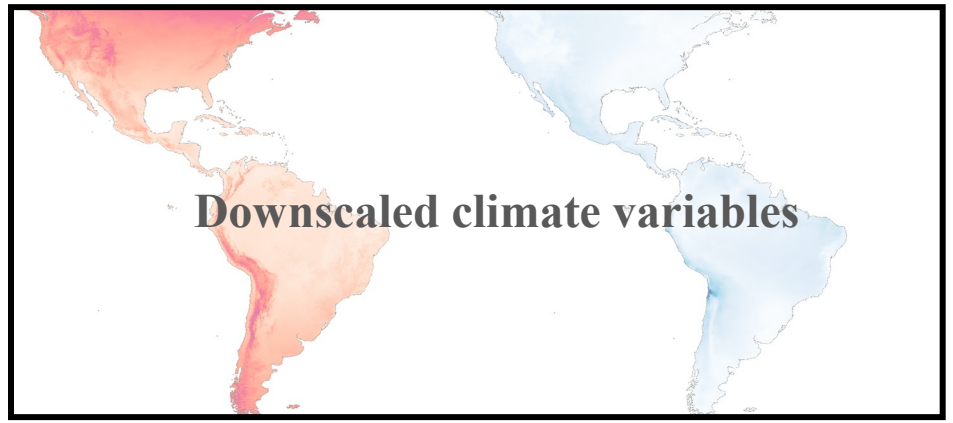
+

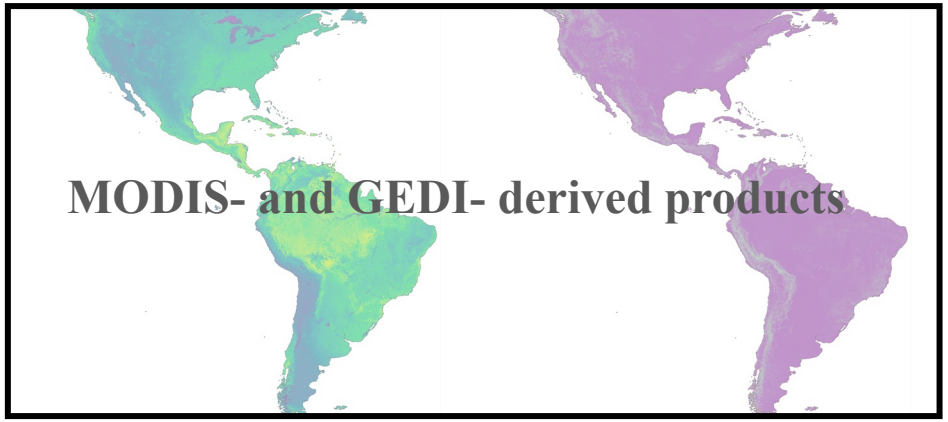
Presence probability

0.3

0

1. Habitat & environmental data





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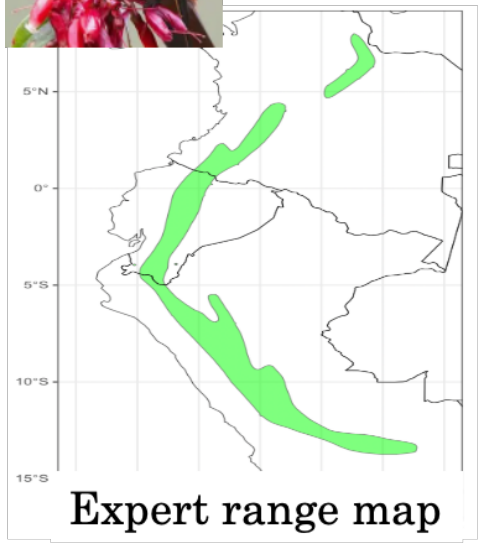
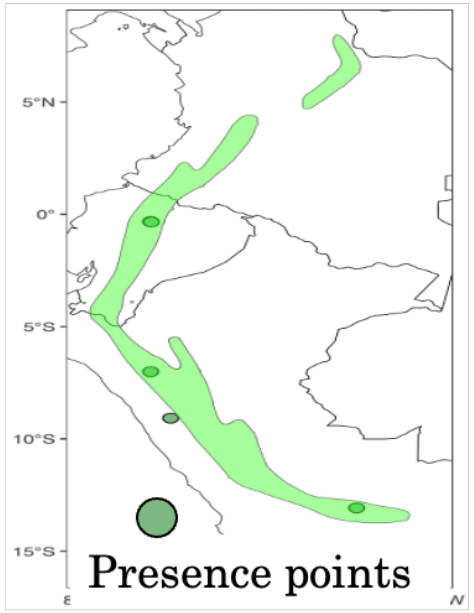
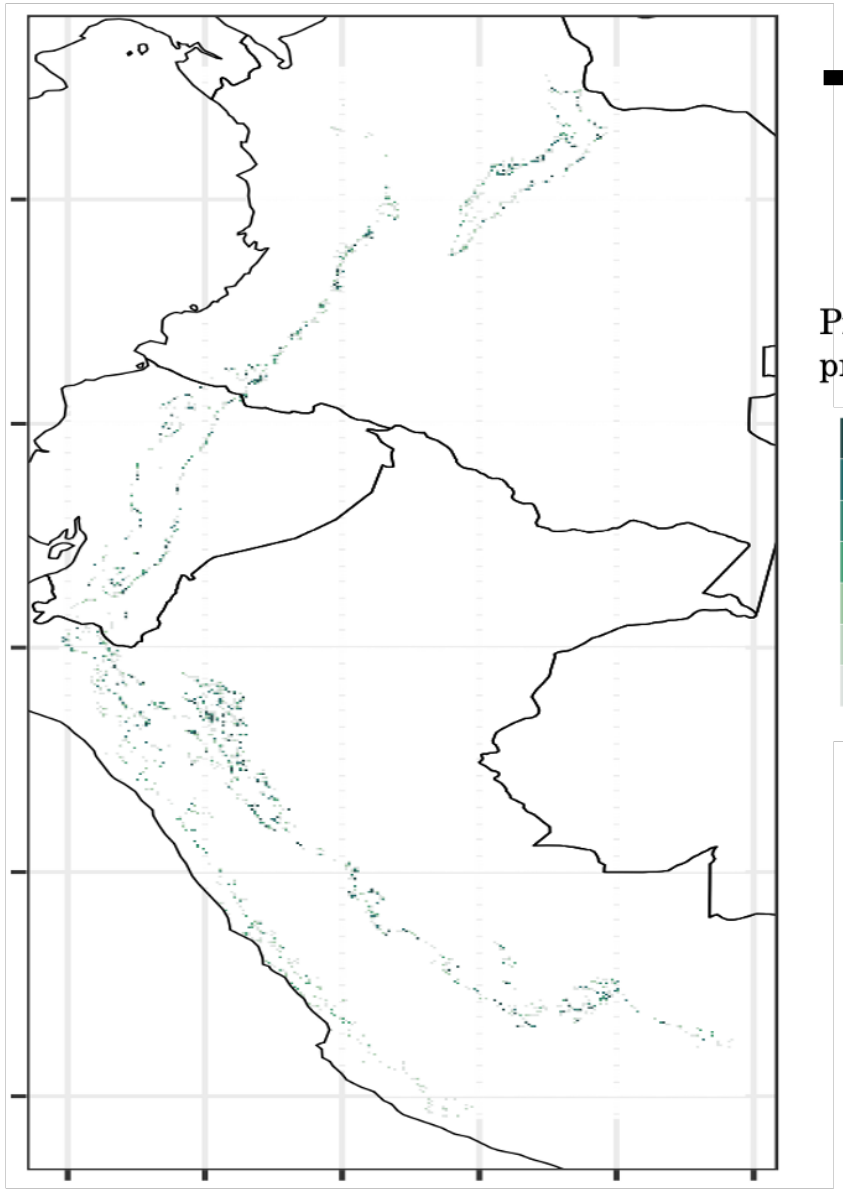


Expert range map



Presence points



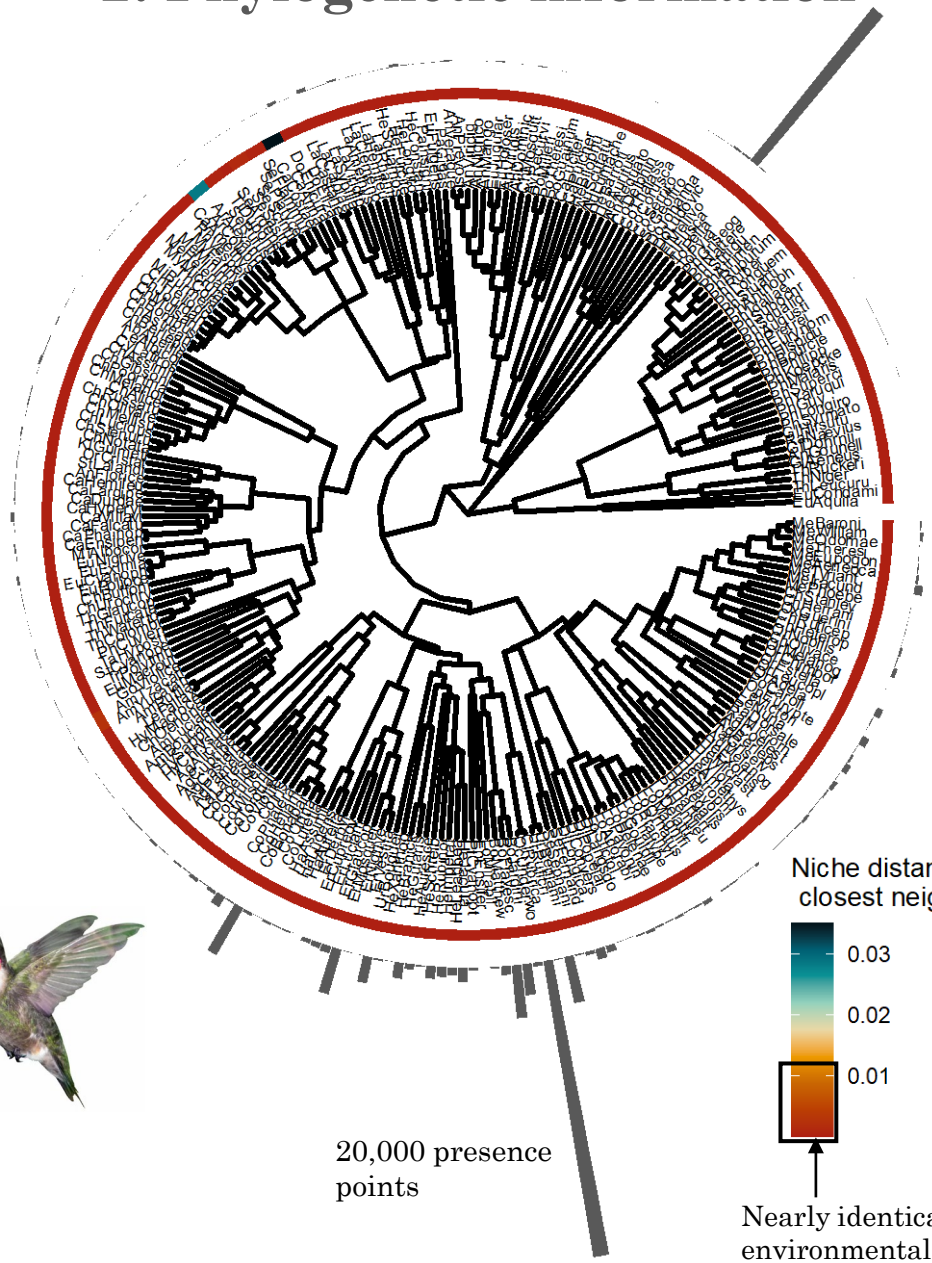
+

Presence probability

0.3

0

2. Phylogenetic information



20,000 presence points

Niche distance to closest neighbor

0.03

0.02

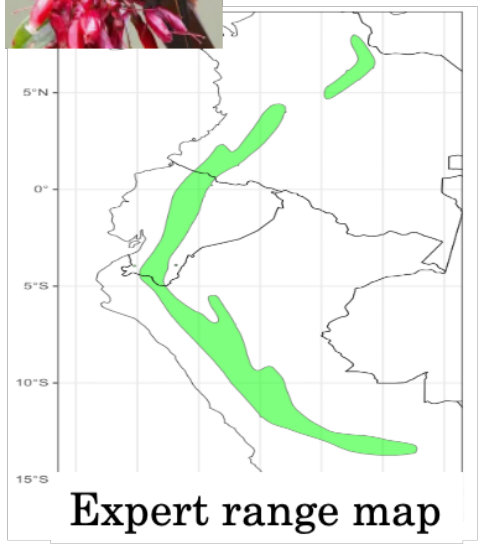
0.01

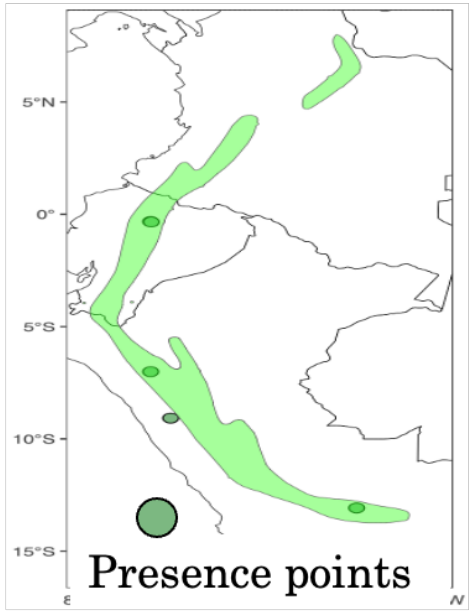
Nearly identical environmental niches

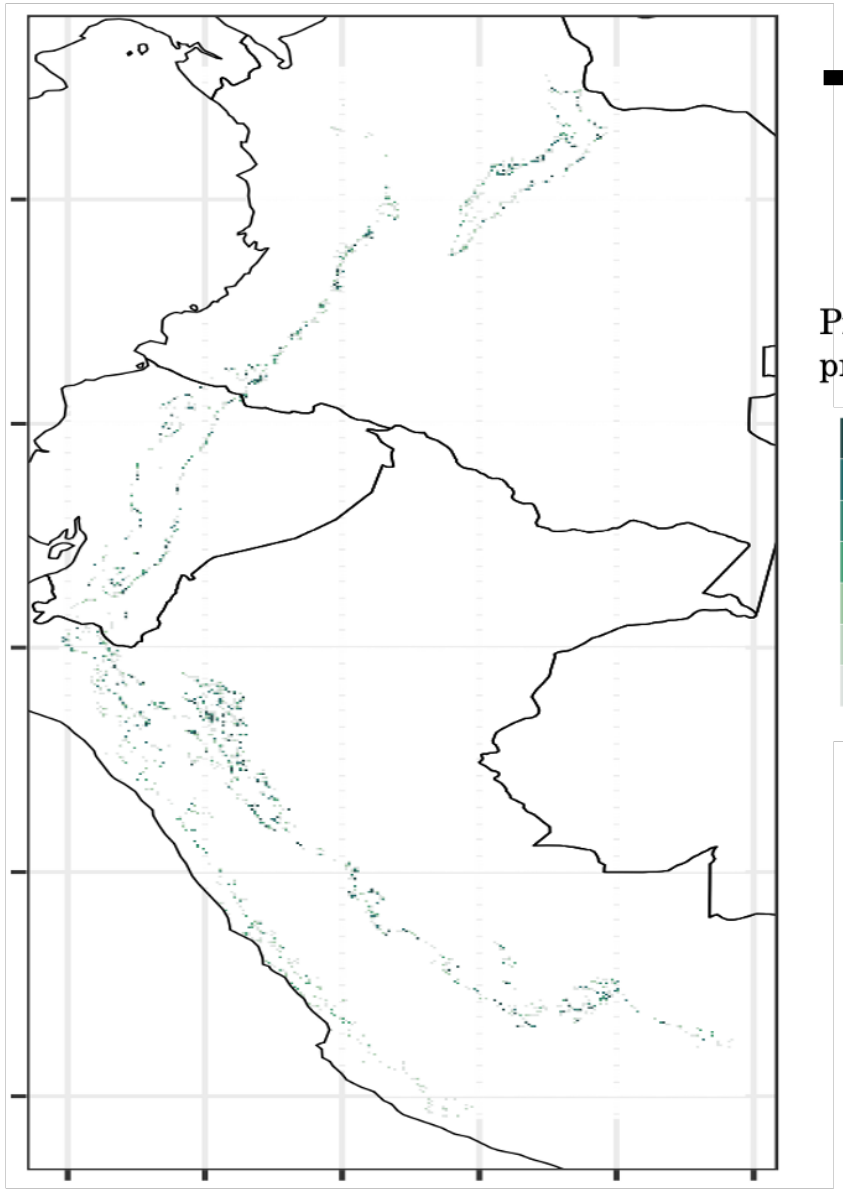
3. Model

Latent Gaussian Process

Shining sunbeam (Agalaectis cupripennis)







+

Presence probability

0.3

0

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Measuring the evolution of *n*-dimensional environmental niches

Shubhi Sharma, Kevin Winner, Jussi Mäkinen, Walter Jetz

First published: 19 November 2024 | https://doi.org/10.1111/ecog.07285

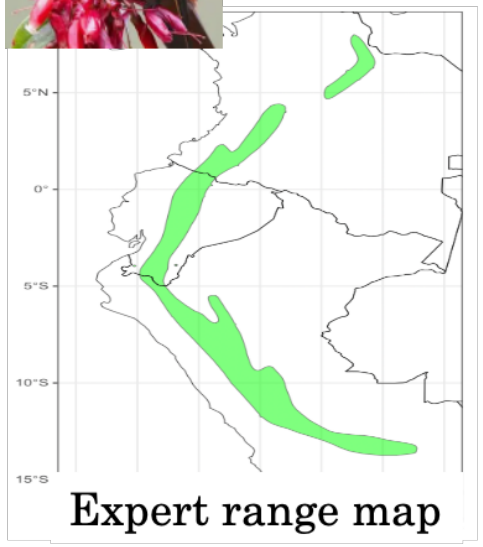
Yale Links

Abstract

The study of species' environmental niches underpins numerous questions in ecology and evolution and has increasing relevance in a rapidly changing world. Environmental niches, characterized by observations of organisms, inform about a species' specialization in multivariate environment space and help assess their exposure and sensitivity to changing conditions. Environmental niches are also the central concept

Sharma *et al.*, (2024), Ecography

Shining sunbeam (Agalaectis cupripennis)



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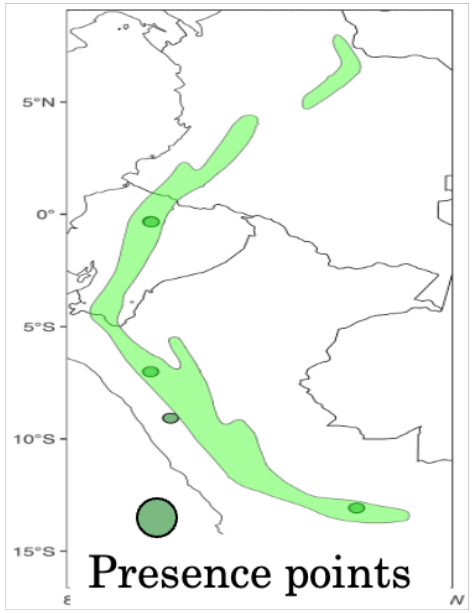
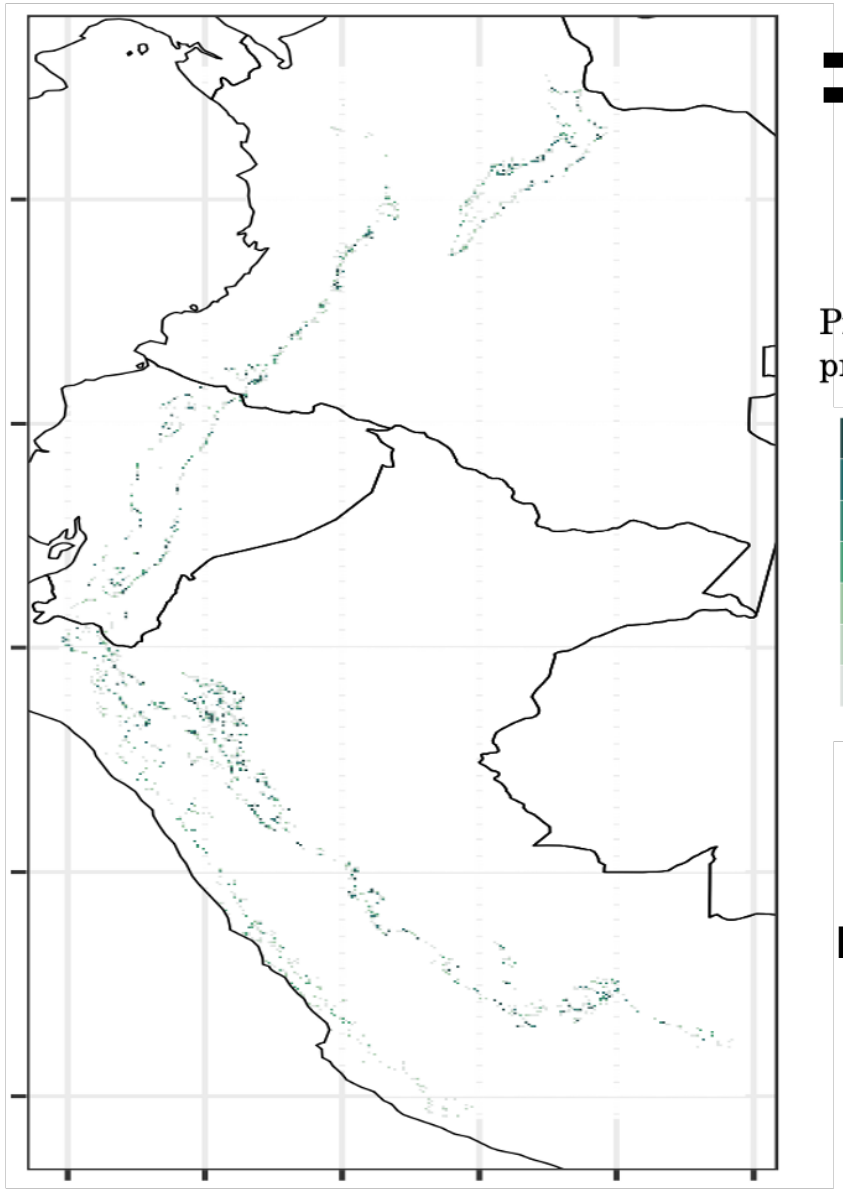


Presence points



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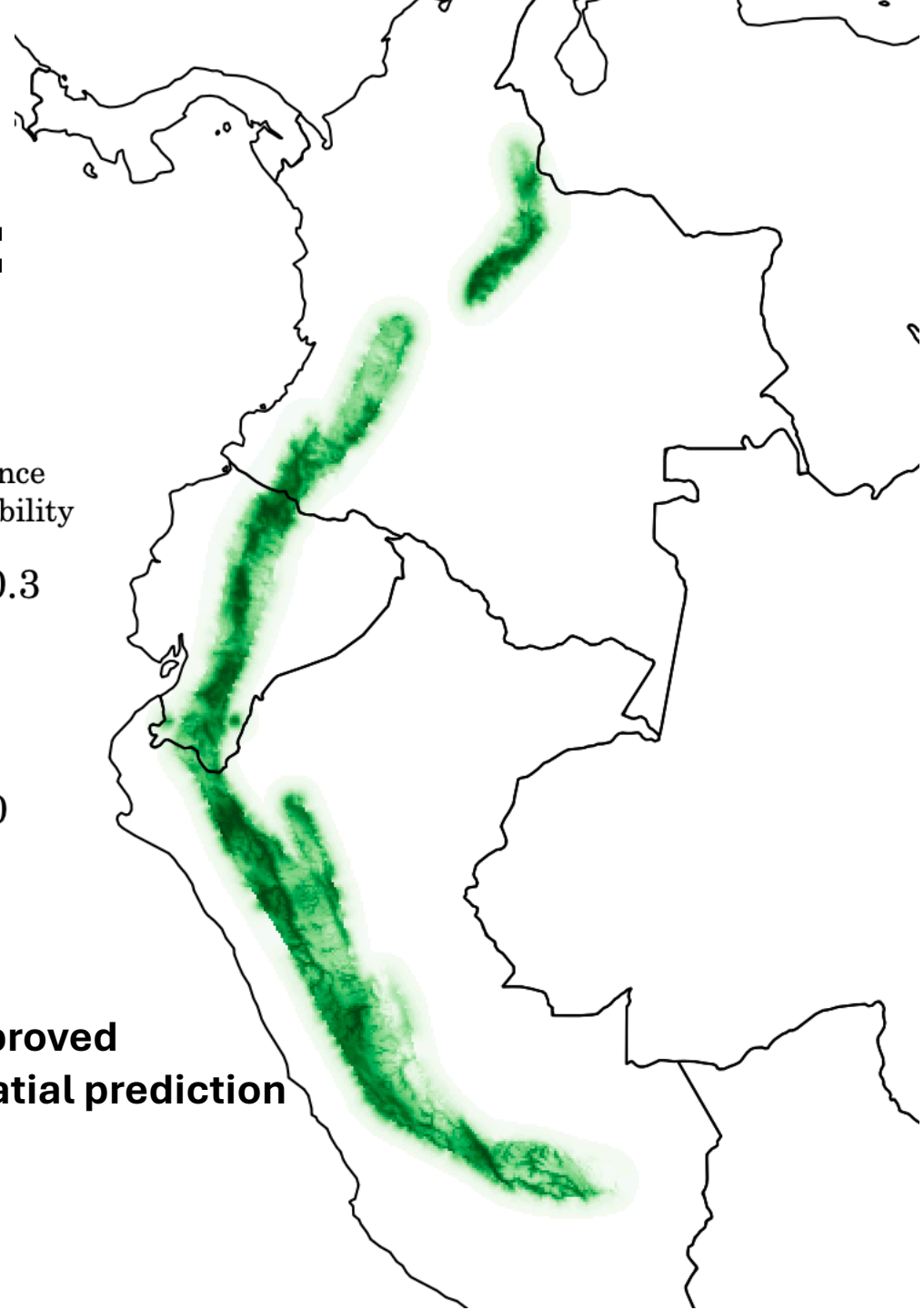


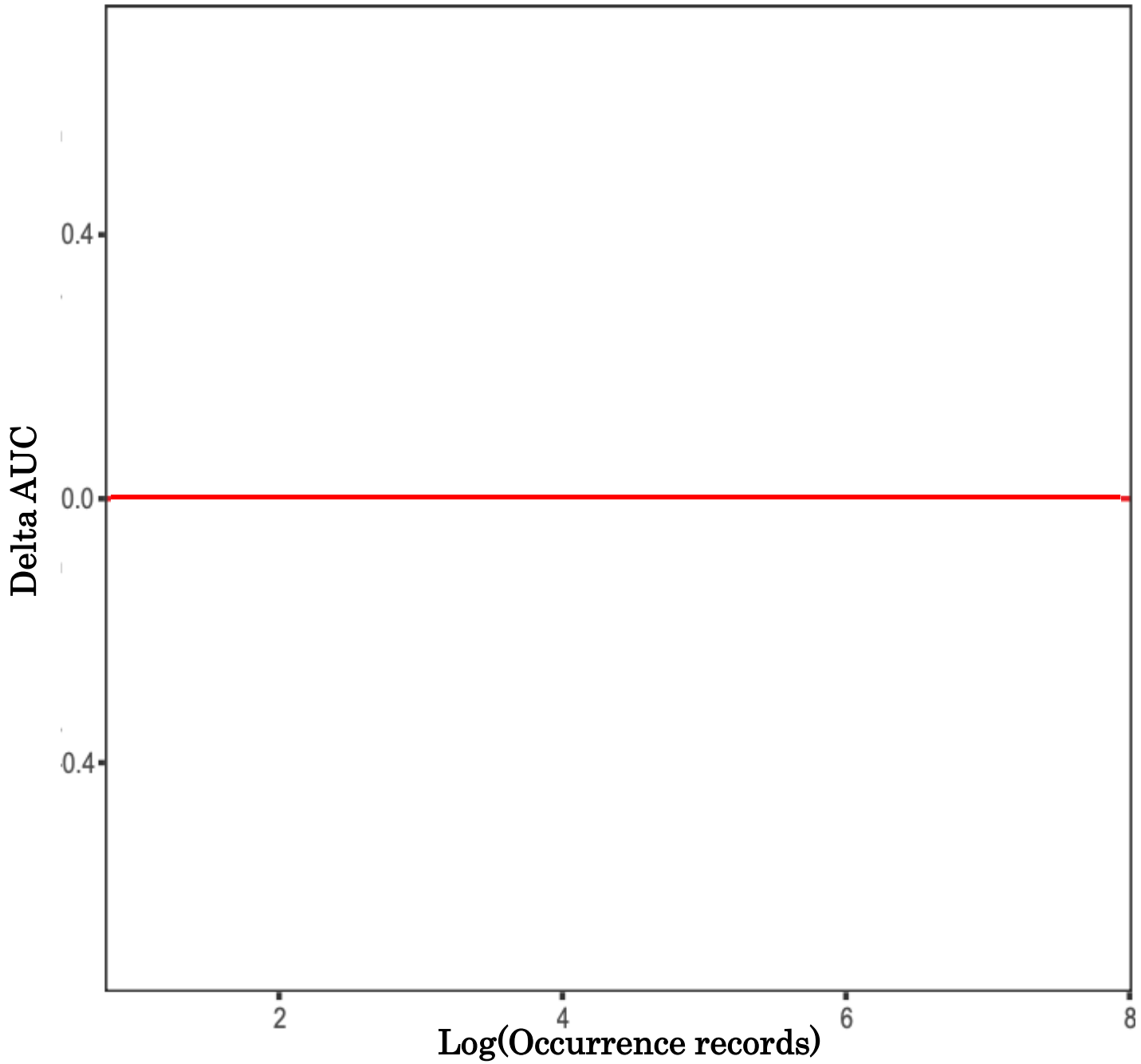
Improved spatial prediction

Across 280 hummingbird species →

PHYLO MODEL
compared to

NON PHYLO GAUSSIAN PROCESS

RANDOM FOREST



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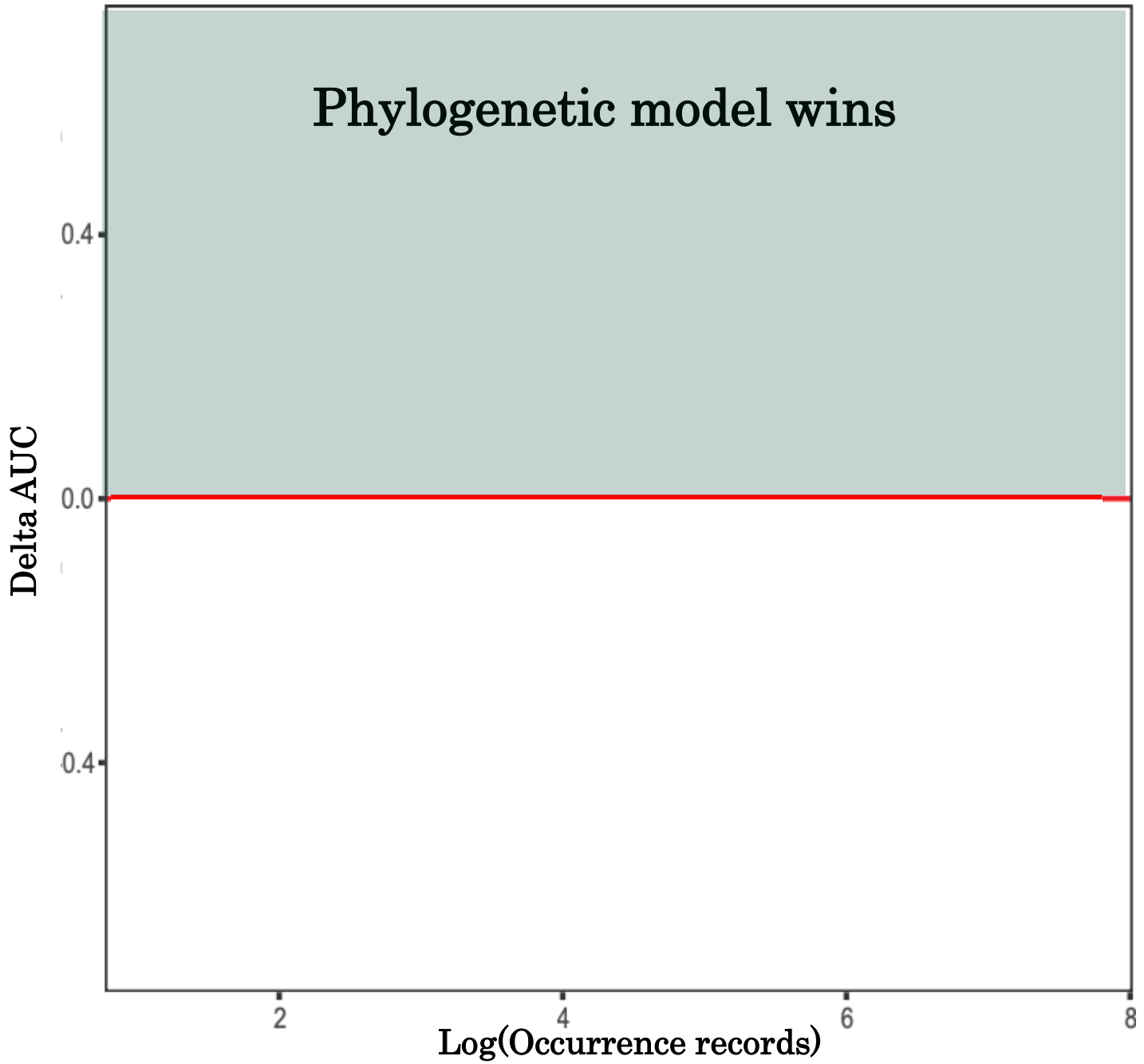

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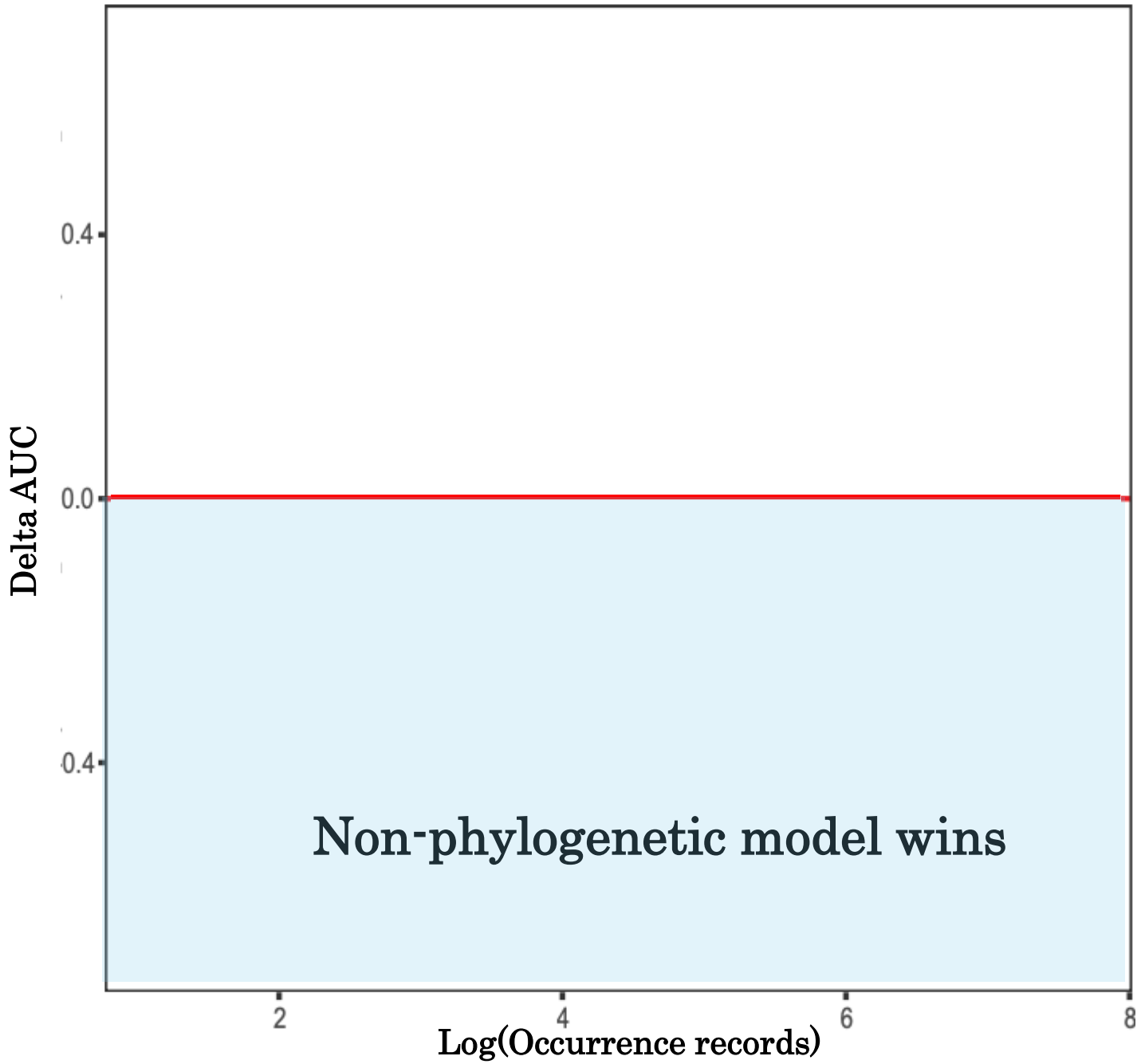

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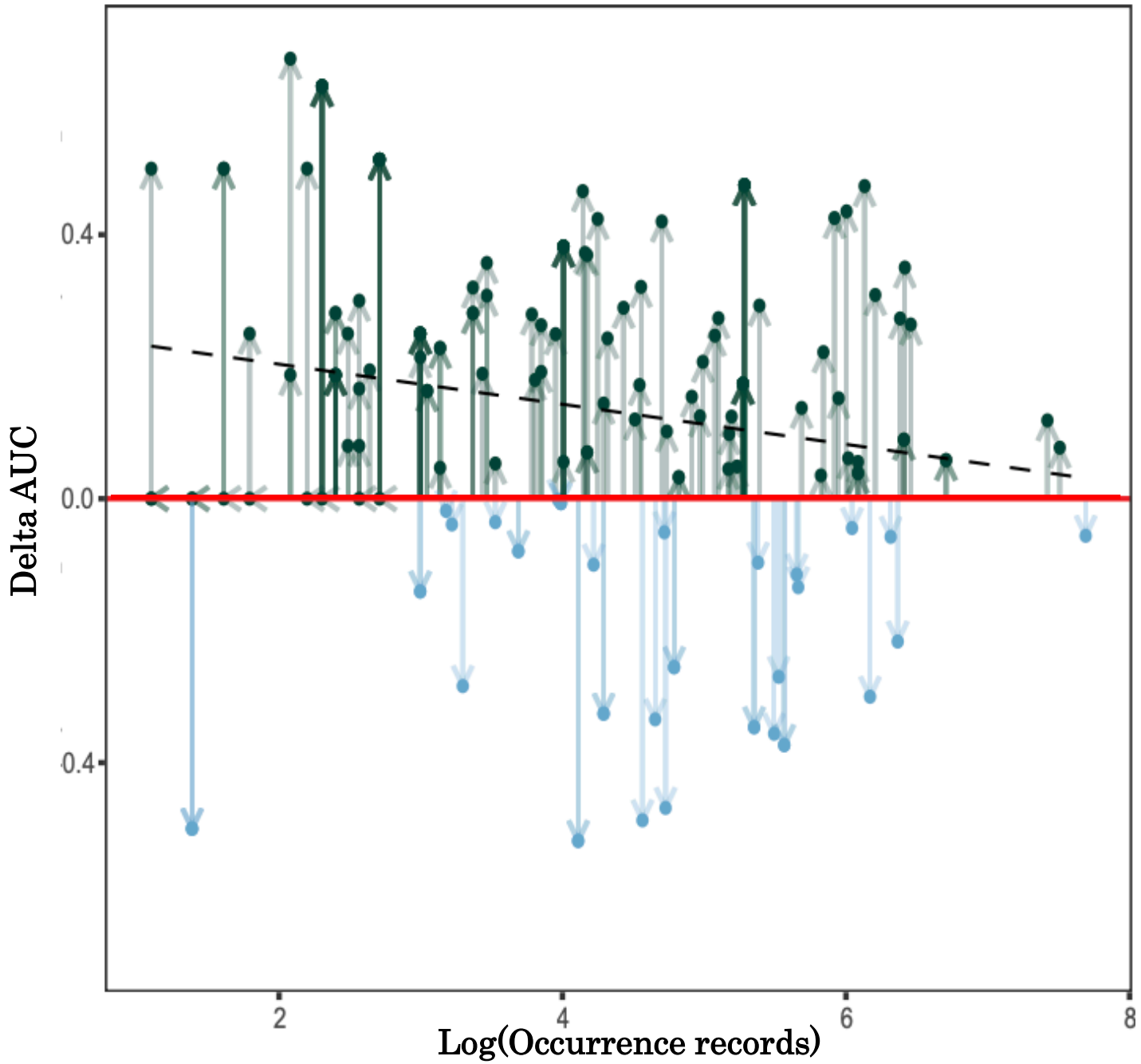


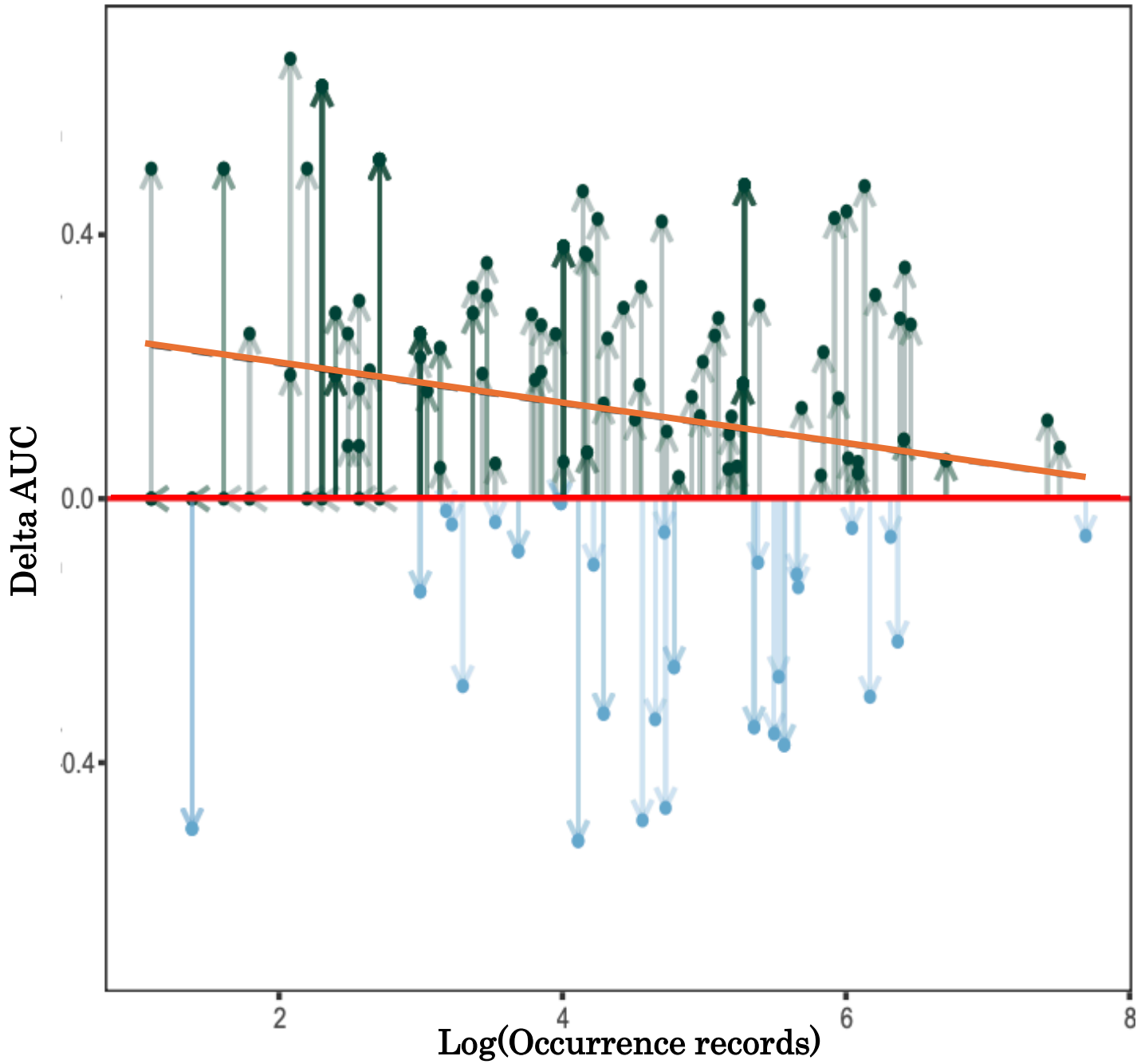
Across 280 hummingbird species →

PHYLO MODEL
compared to

NON PHYLO GAUSSIAN PROCESS

RANDOM FOREST

The phylogenetic model improves distribution estimates most for data-deficient species!



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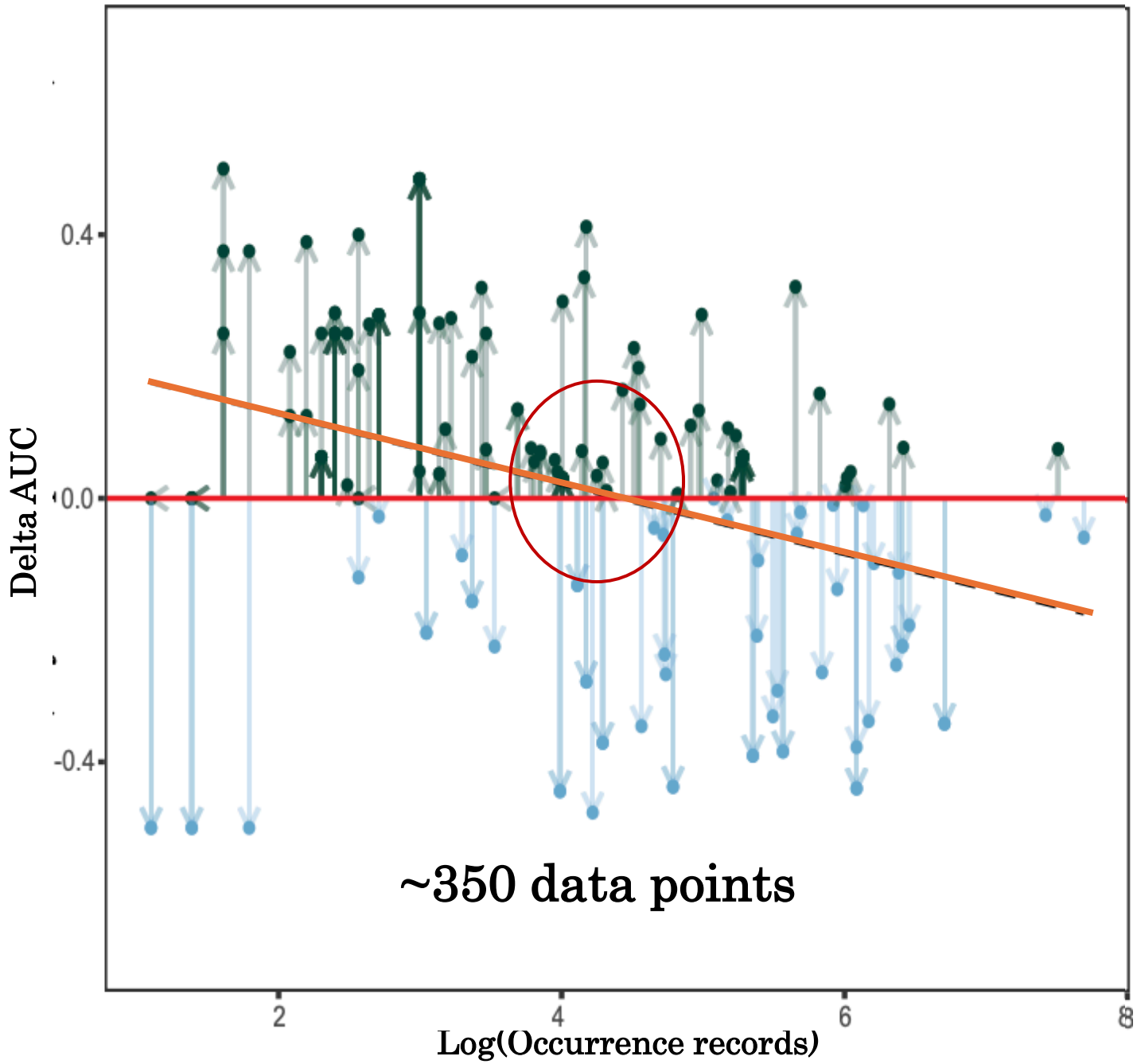
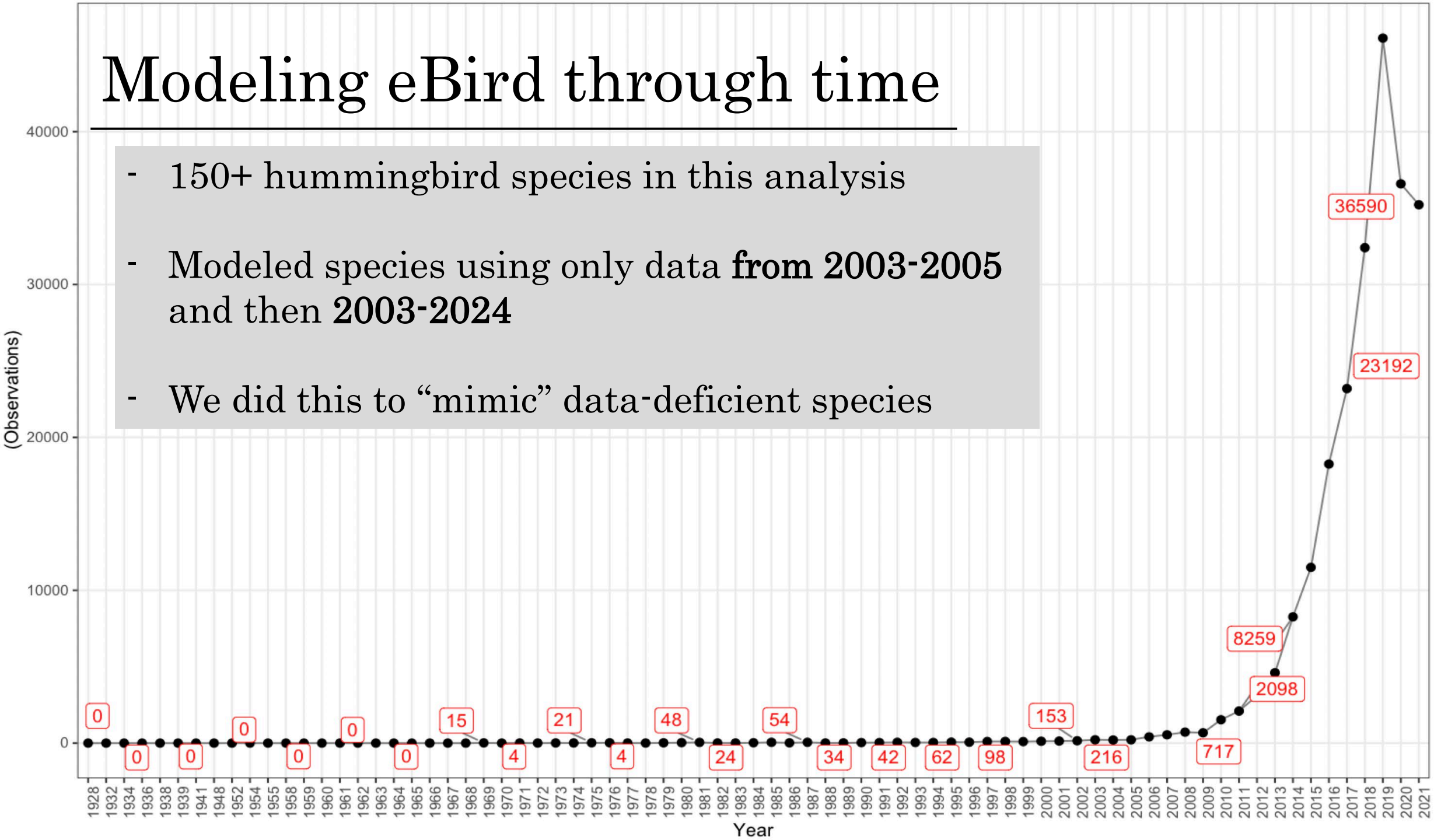
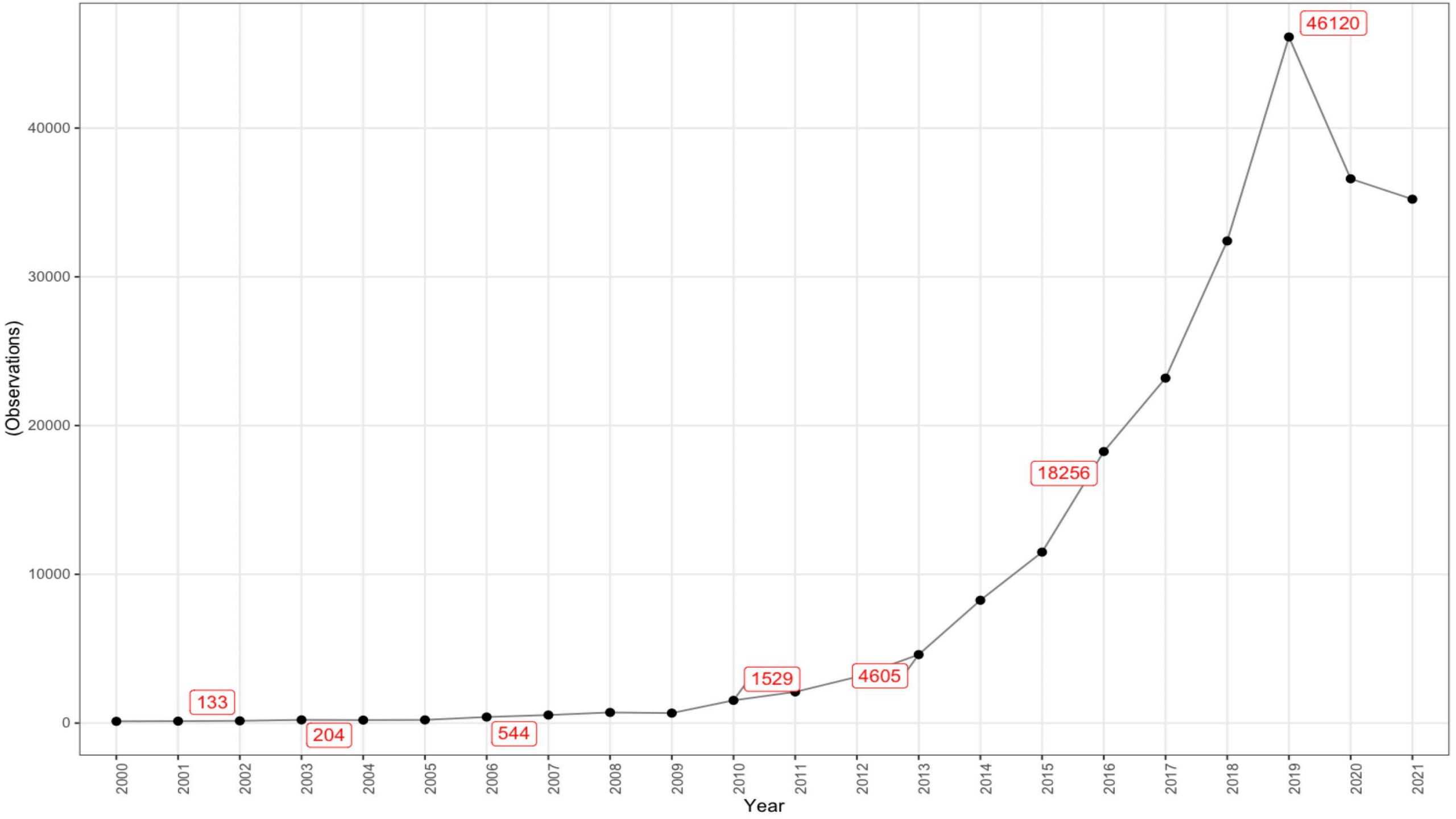
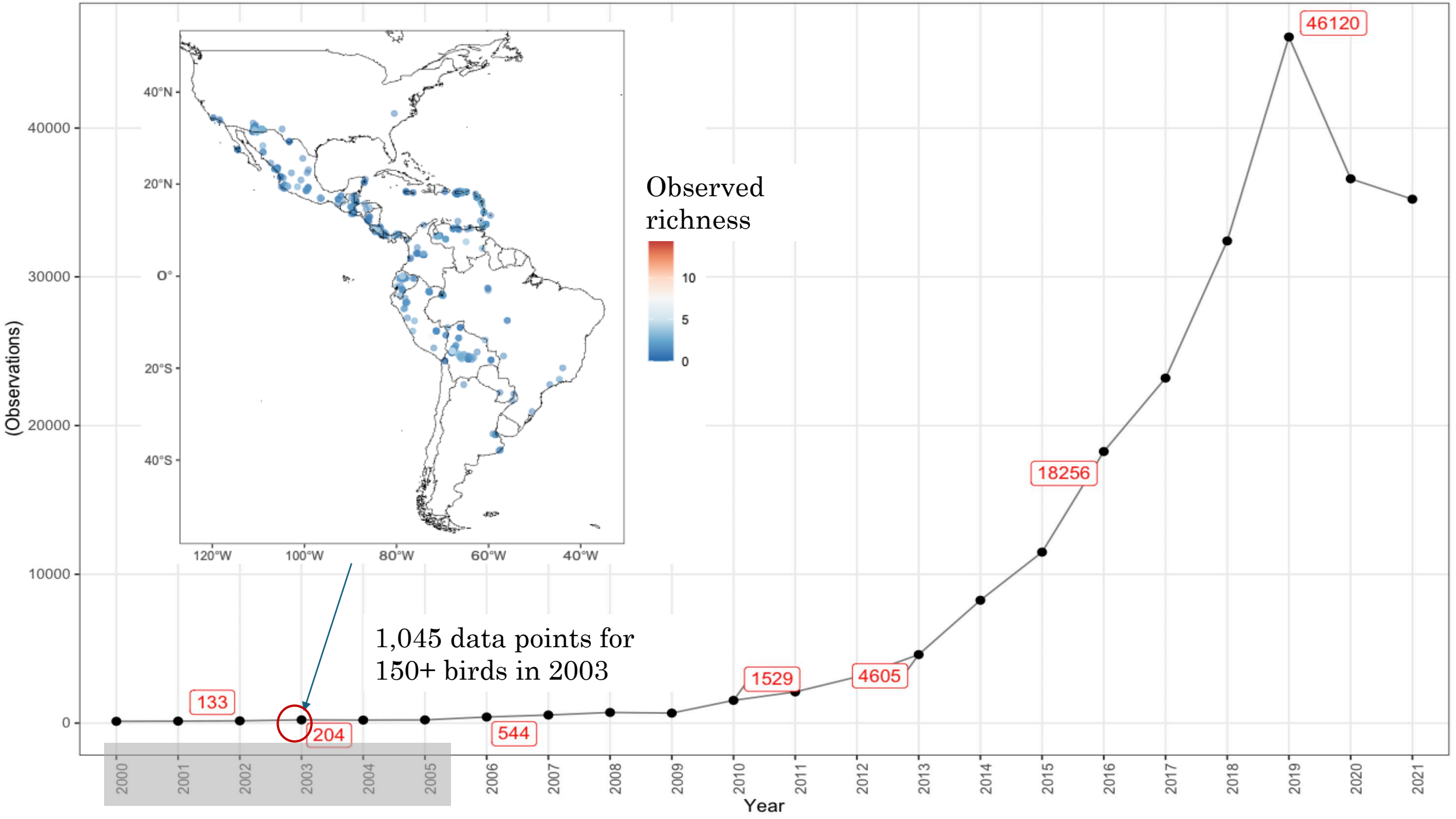


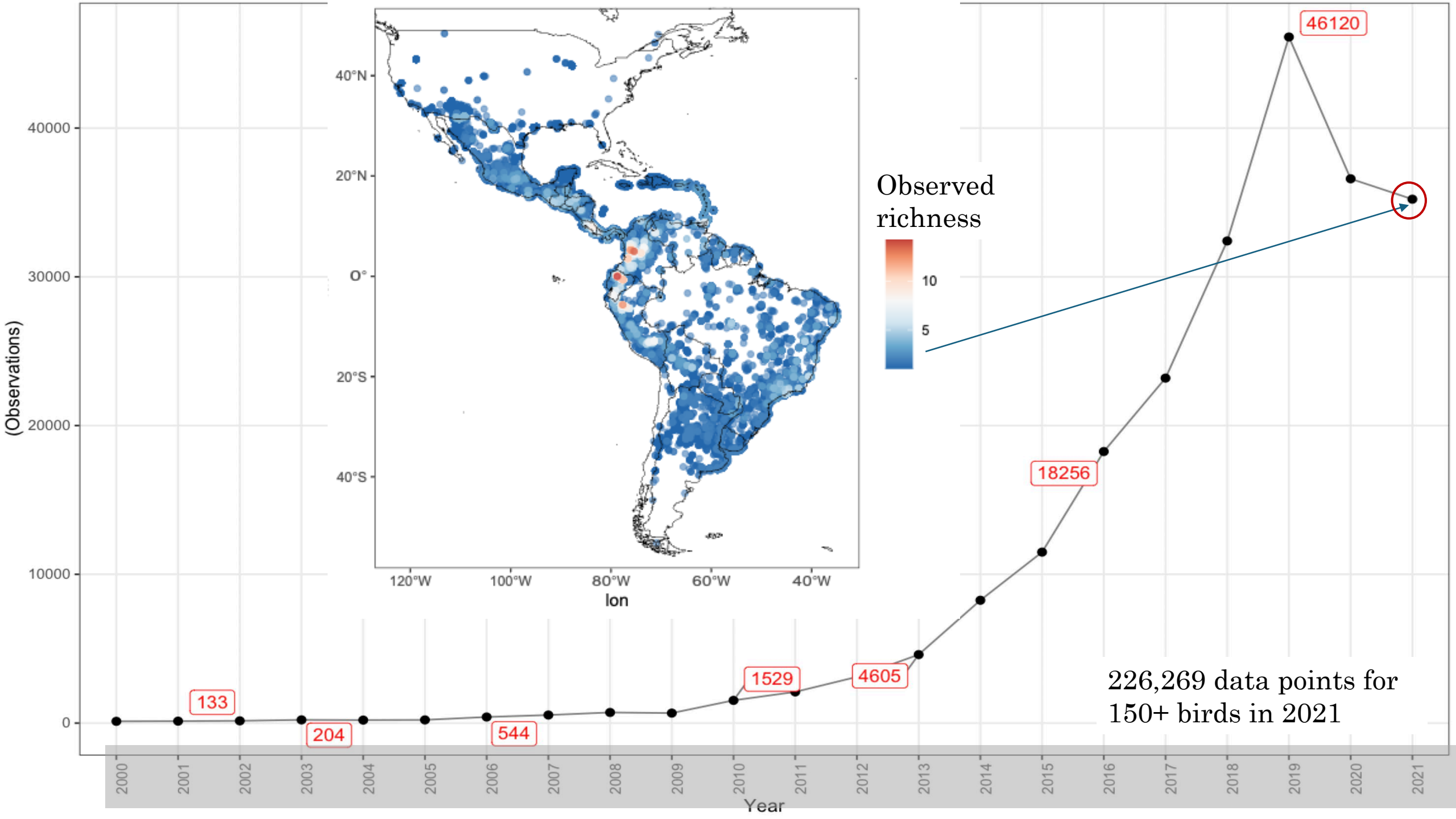
Modeling eBird through time

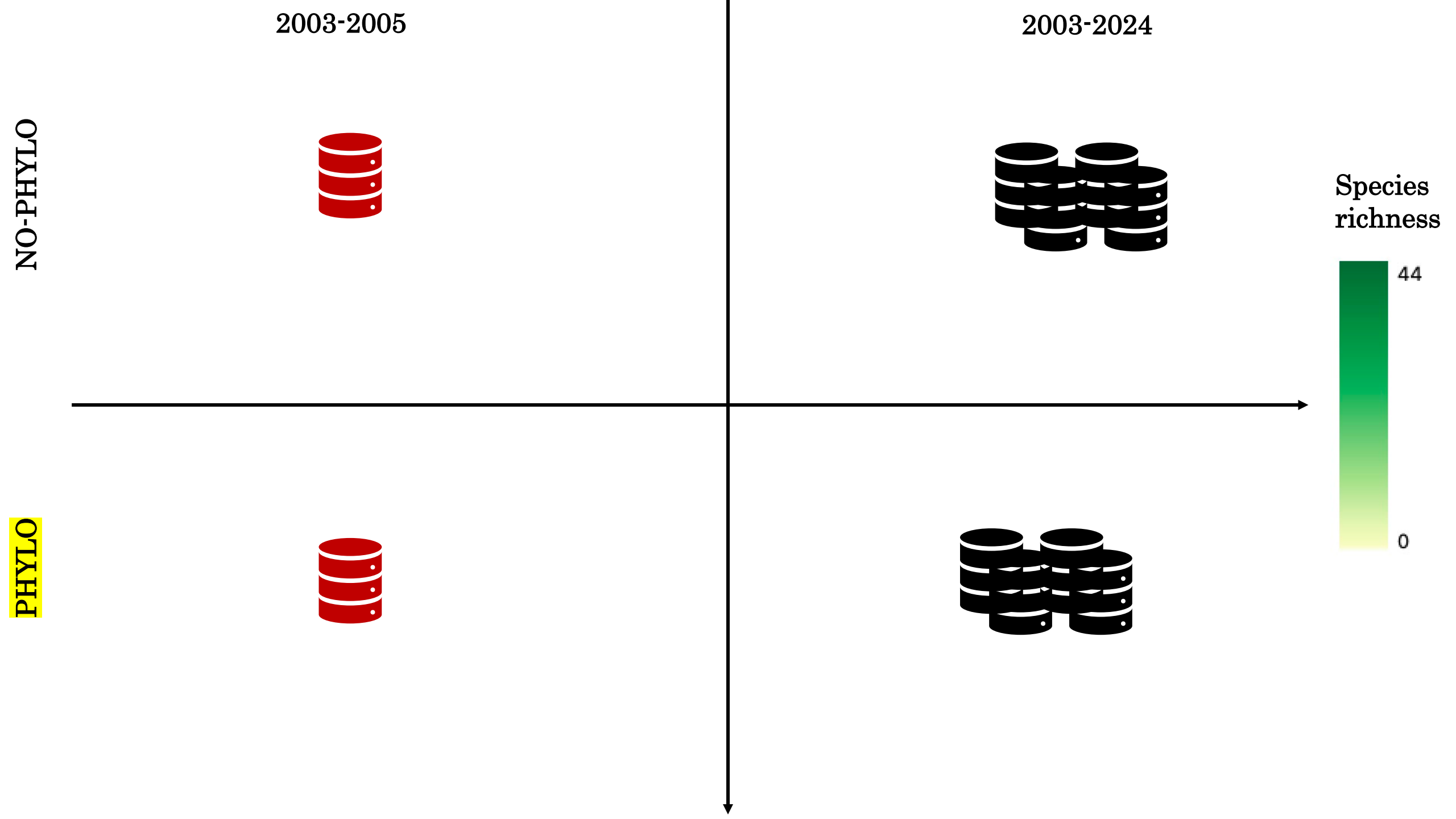
- 150+ hummingbird species in this analysis
- Modeled species using only data **from 2003-2005** and then **2003-2024**
- We did this to "mimic" data-deficient species




46120
18256
4605
1529
544
204
133
40000
30000
20000
10000
0
(Observations)
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
Year


40°N
20°N
0°
20°S
40°S
120°W
100°W
80°W
60°W
40°W
Observed richness
10
5
0
(Observations)
40000
30000
20000
10000
0
133
204
544
1529
4605
18256
46120
1,045 data points for 150+ birds in 2003
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
Year


40°N
20°N
0°
20°S
40°S
120°W
100°W
80°W
60°W
40°W
lon
Observed richness
10
5
46120
18256
1529
4605
544
204
133
226,269 data points for 150+ birds in 2021
40000
30000
20000
10000
0
(Observations)
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
Year

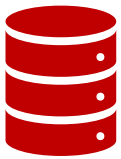

2003-2005
2003-2024
NO-PHYLO
PHYLO
Species richness
44
0

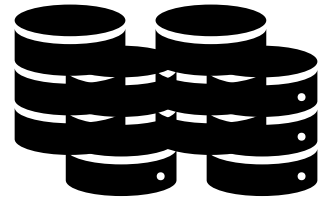
2003-2005

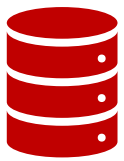
2003-2024

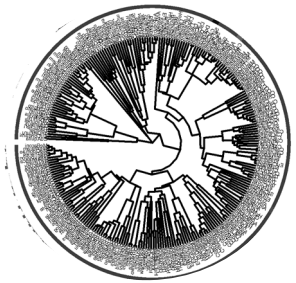
NO-PHYLO

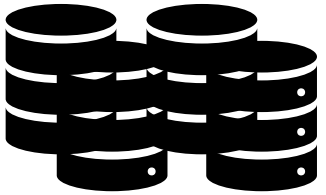
PHYLO

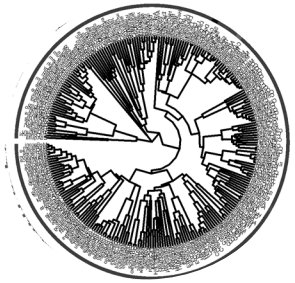




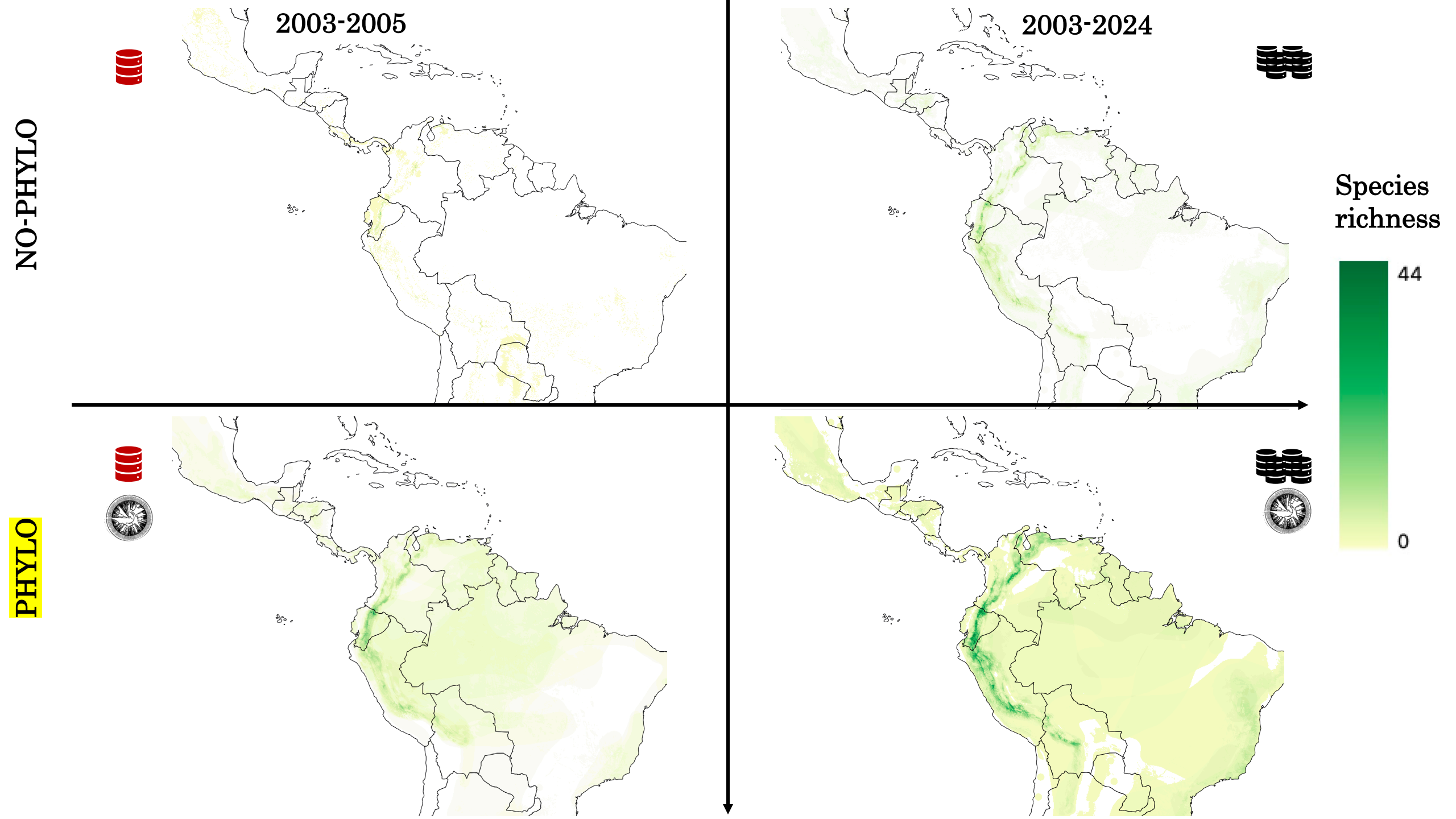


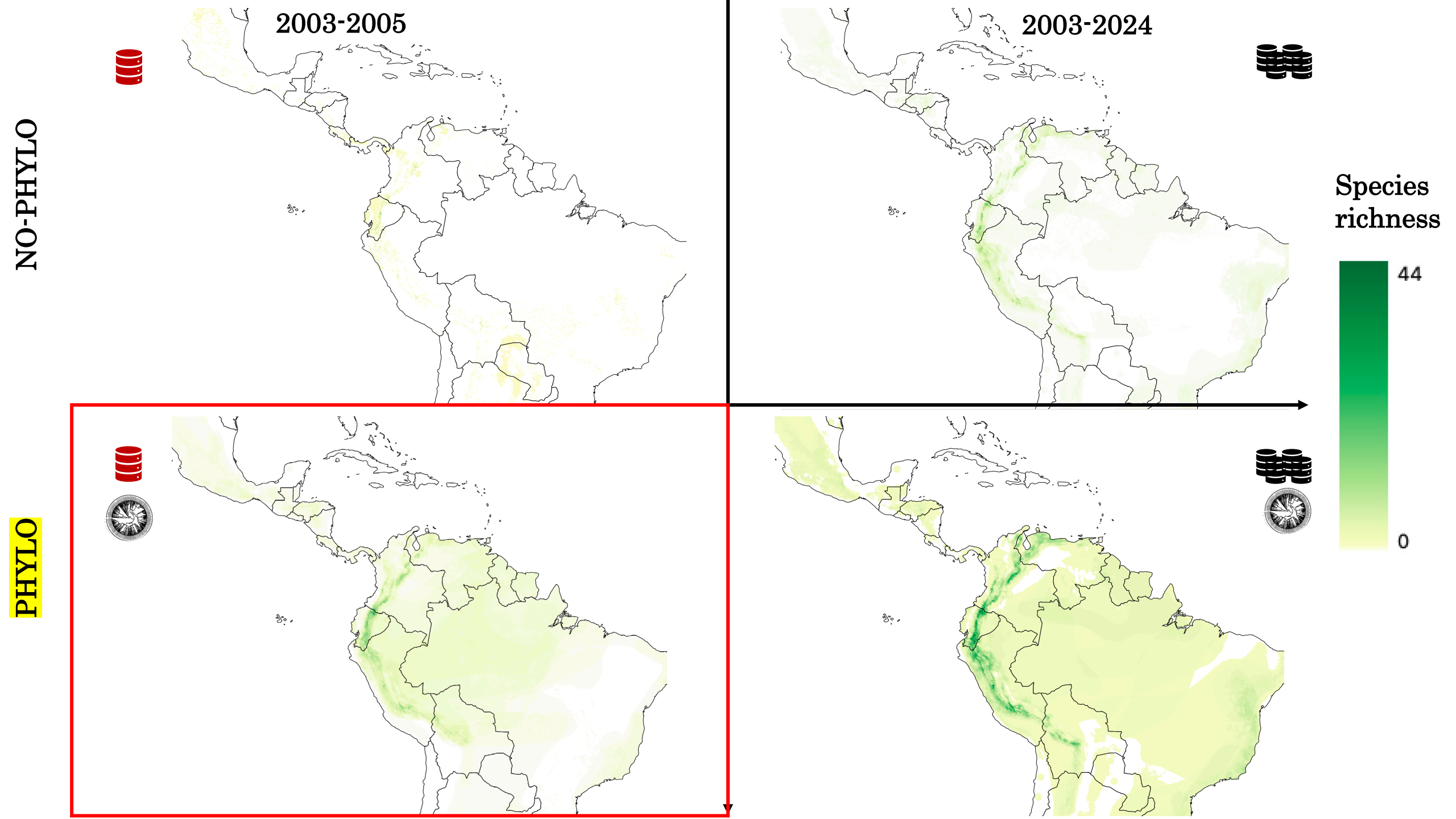






Species richness


2003-2005
2003-2024
NO-PHYLO
PHYLO
Species richness
44
0


2003-2005
2003-2024
NO-PHYLO
PHYLO
Species richness
44
0

NO-PHYLO

PHYLO

2003-2005

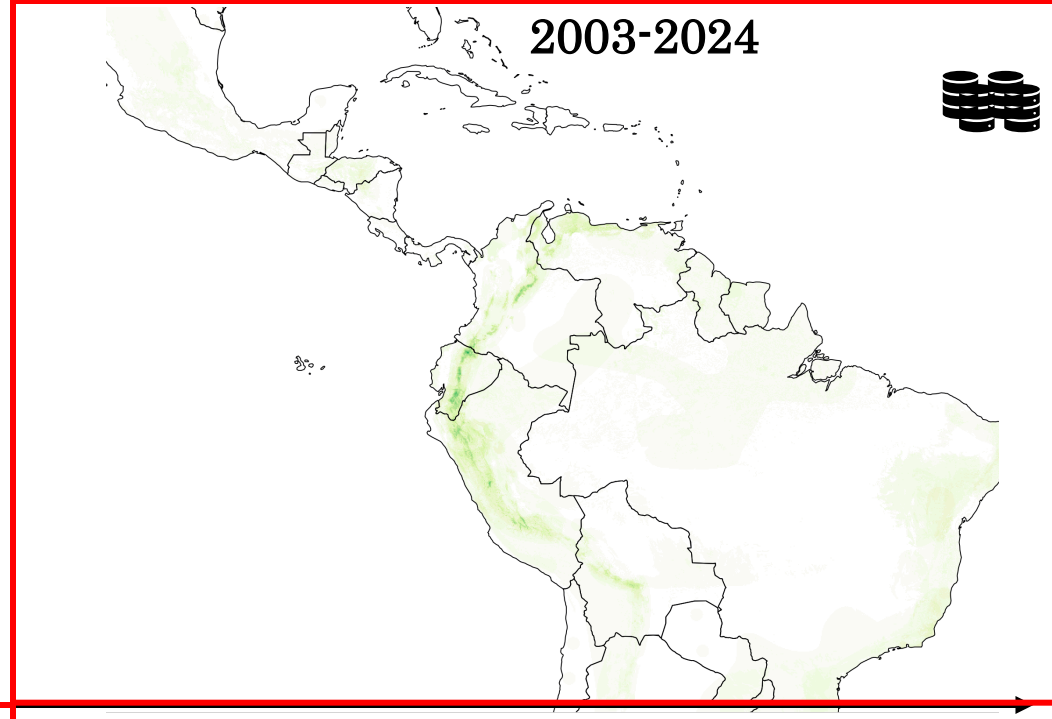
2003-2024

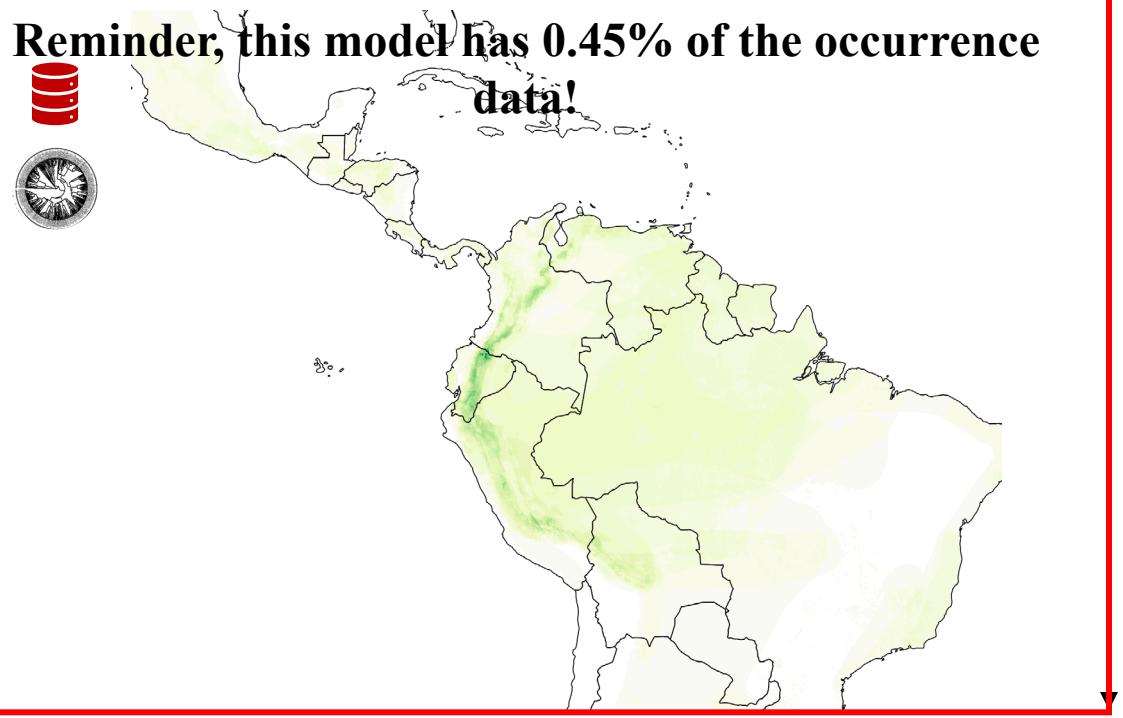
Species richness

44

0

Reminder, this model has 0.45% of the occurrence data!

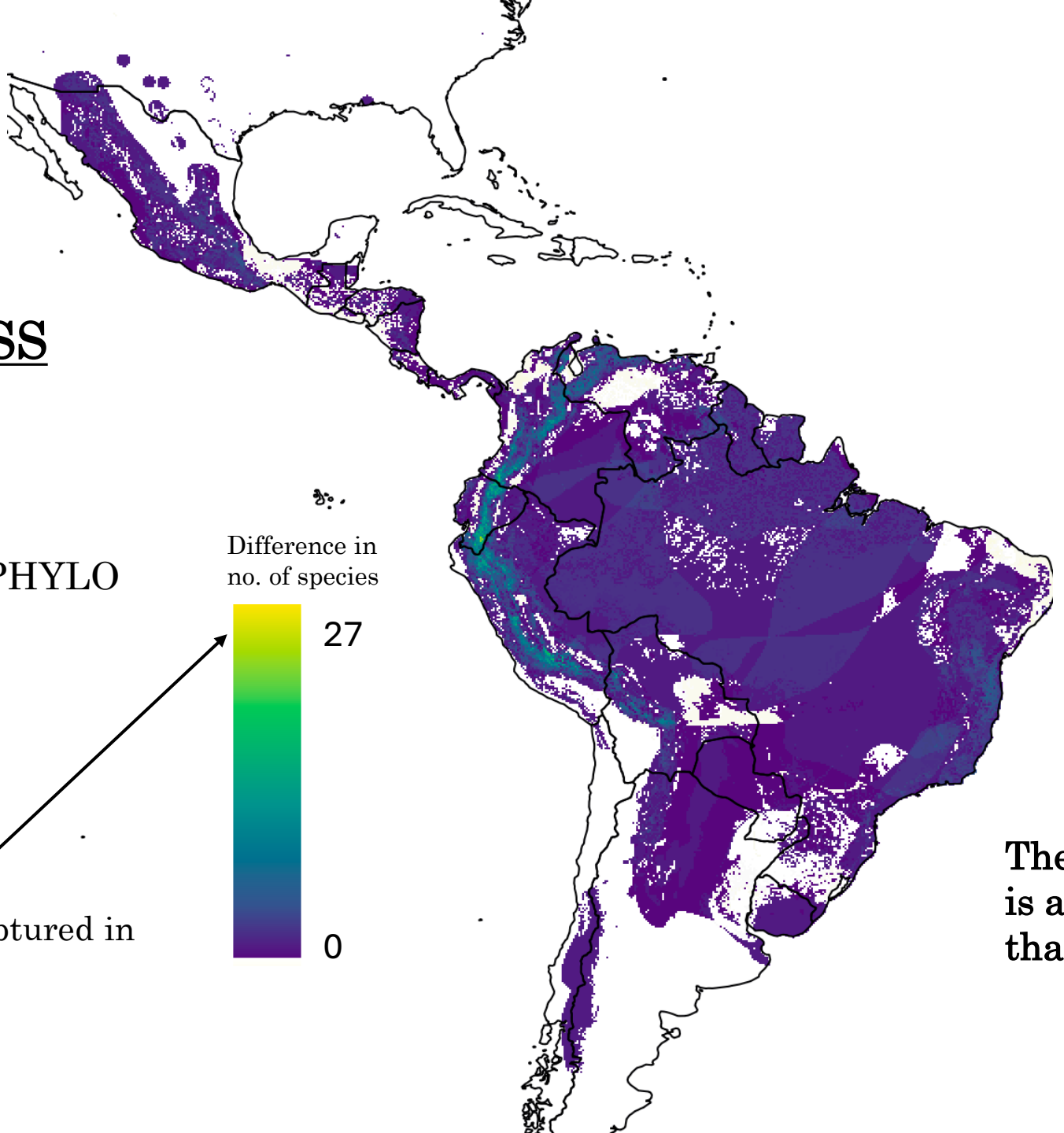




DELTA RICHNESS MAPS

2003-2024

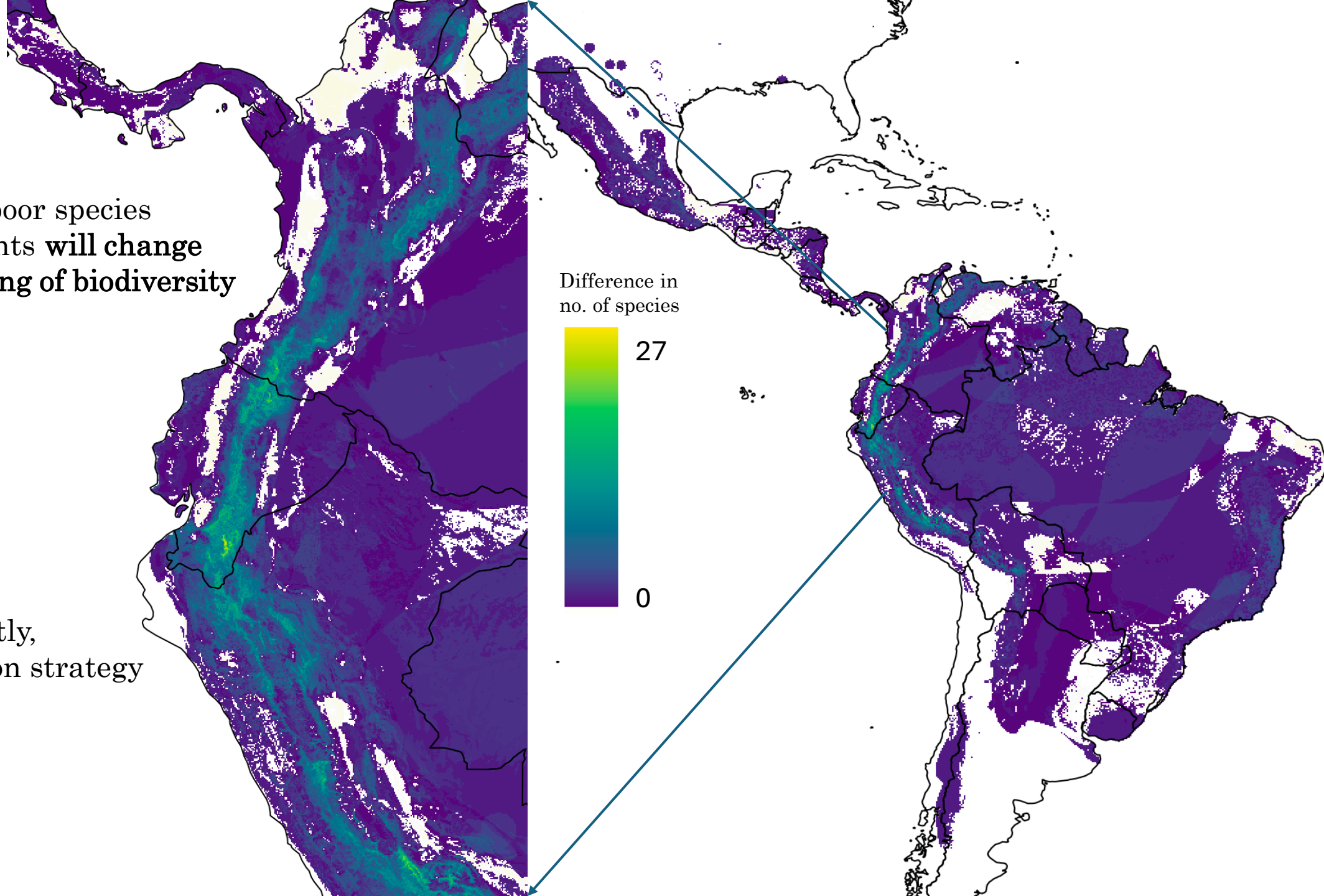
(PHYLO model) – (NO-PHYLO model)



The phylogenetic model is able to model more species than the non-phylo models

Including data-poor species in our assessments **will change our understanding of biodiversity distribution**

and consequently, our conservation strategy



Recommendations →

1. Focus on **improving spatial models for data-deficient** species as conservation prioritization analyses depend on accurate maps of biodiversity distribution

2. **Uncertainties** associated with species' distribution, particularly data-deficient species distributions must be taken into account

3. Remote-sensing derived habitat variables for all taxonomic groups **improve niche characterization**, which SDMs rely on

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THANK YOU!