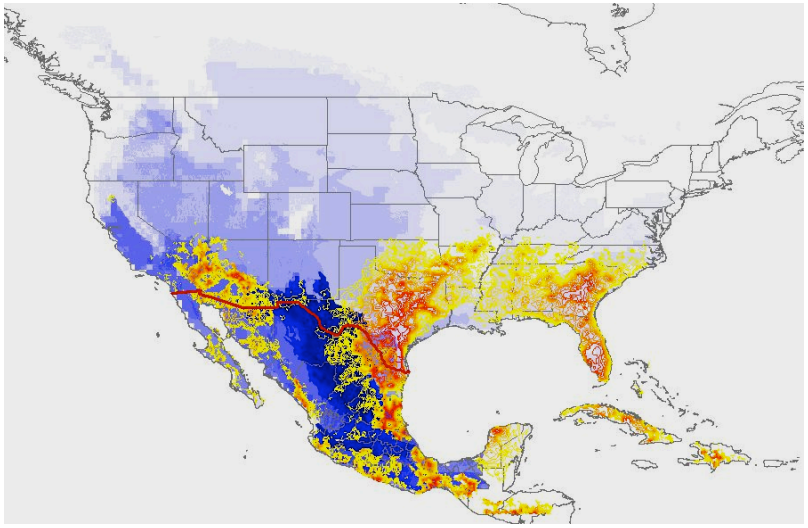
Niches, Interactions and Movements.

Calculating a Species Distribution Range

Jorge Soberon M.
A. Townsend Peterson

A Premise:

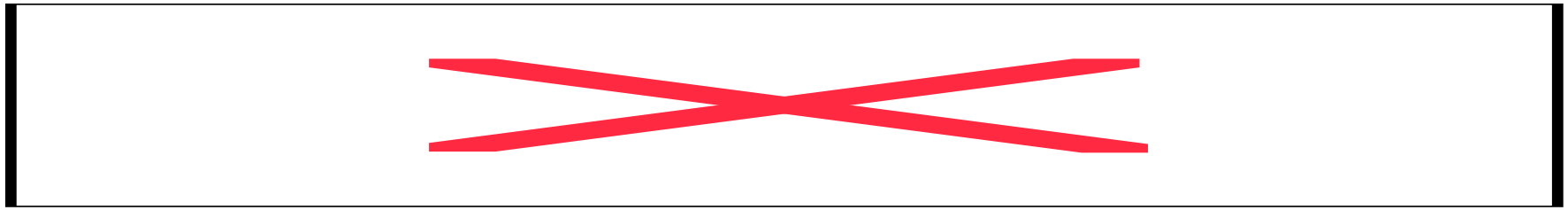
- I would like to estimate changes in species ranges of distribution for many species (thousands) and for most of the planet (not only for the well-known species in the well-studied countries)
- This means we need to assess the feasibility of doing it for large sets and incomplete data

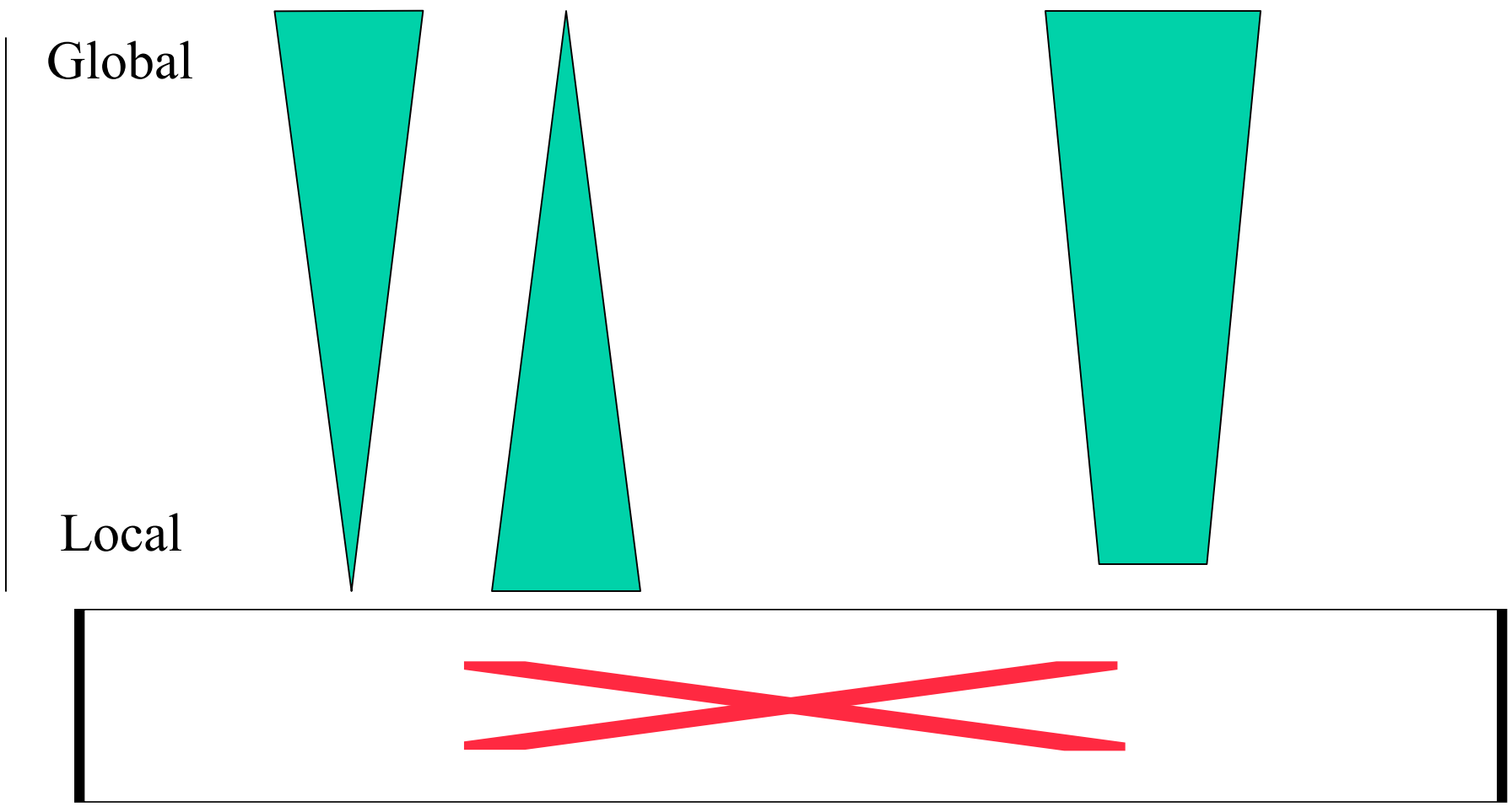


The Range of a Species is Something Very Dynamic:

Autoecology, interactions, migration patterns, historical factors, operating with different strenghts at different spatiotemporal scales.

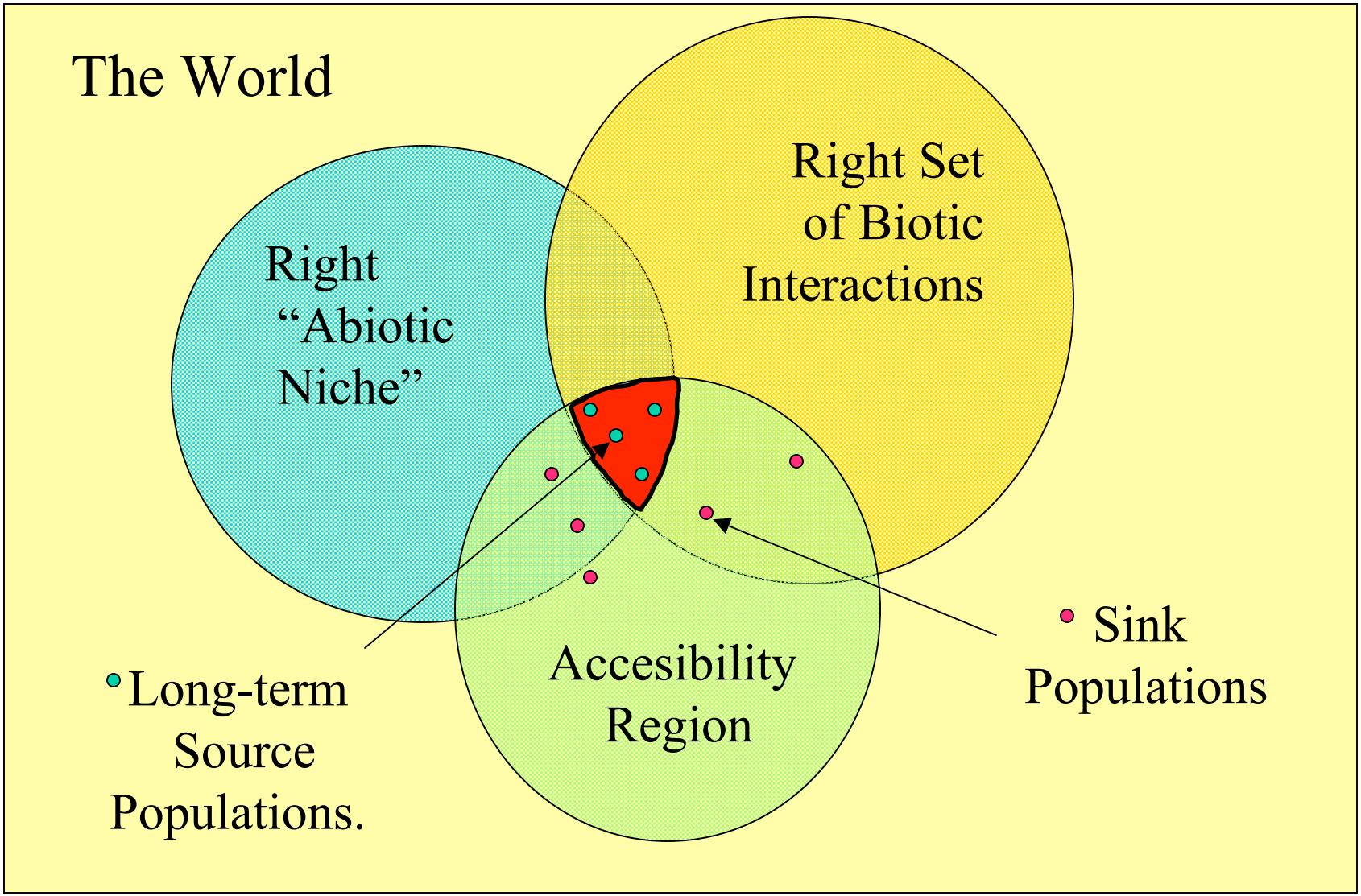
Models exist, but to estimate the parameters may be impossible.




Global
Local

?

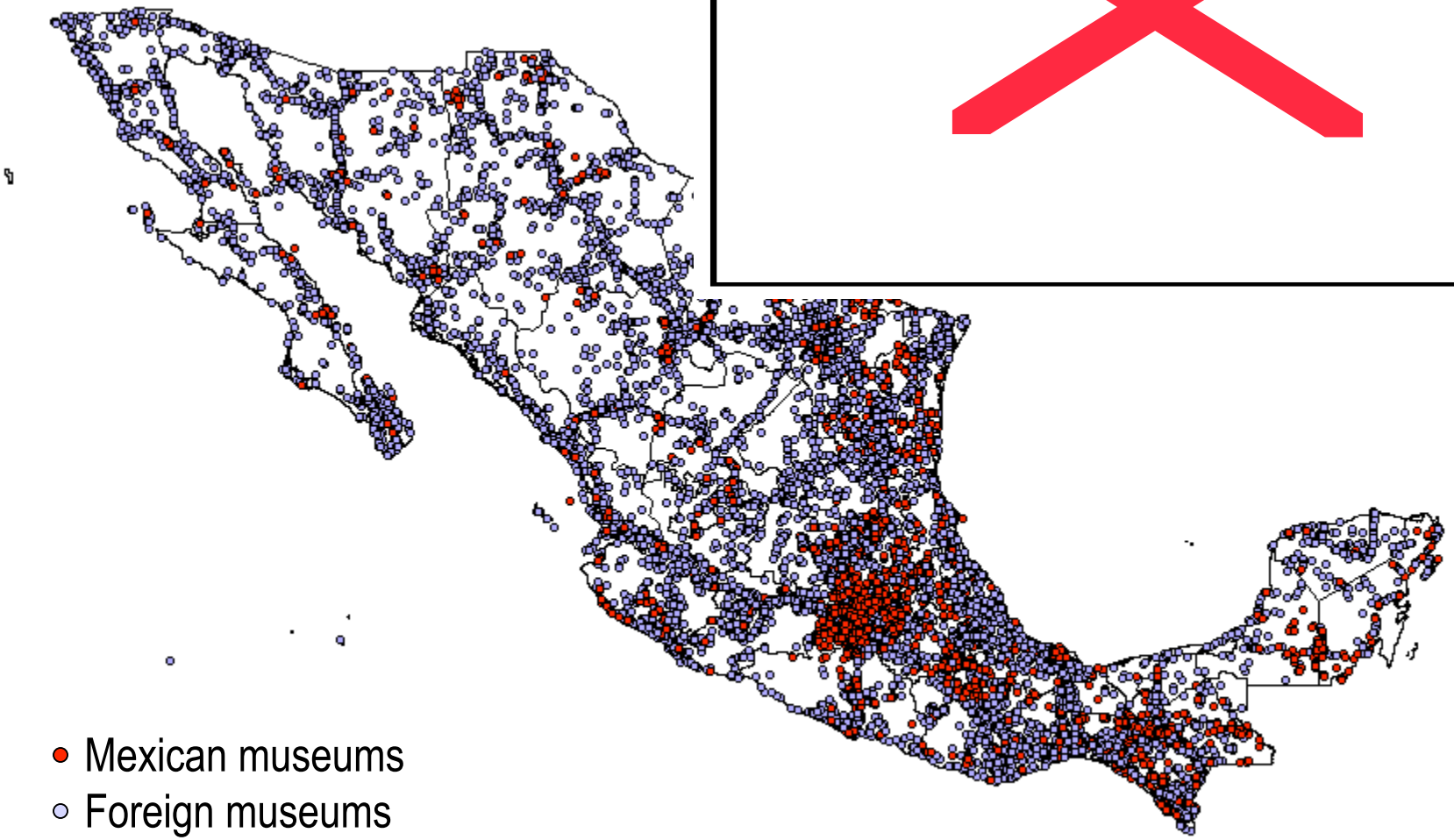
One way of infering a distribution is by using a static approximation to the dynamic problem



I. Uncertainties About the Abiotic Niche (estimated using museum data):

- Errors in the presence (presence-absence) data (Soberon et al., 2002):
  - Taxonomic
  - Georeference errors
  - Georeference biases
- Errors in the layers (Chapman et al., 2005)
- Choosing the right algorithm (Segurado and Araujo, 2004)

Spatial bias in herpetofauna



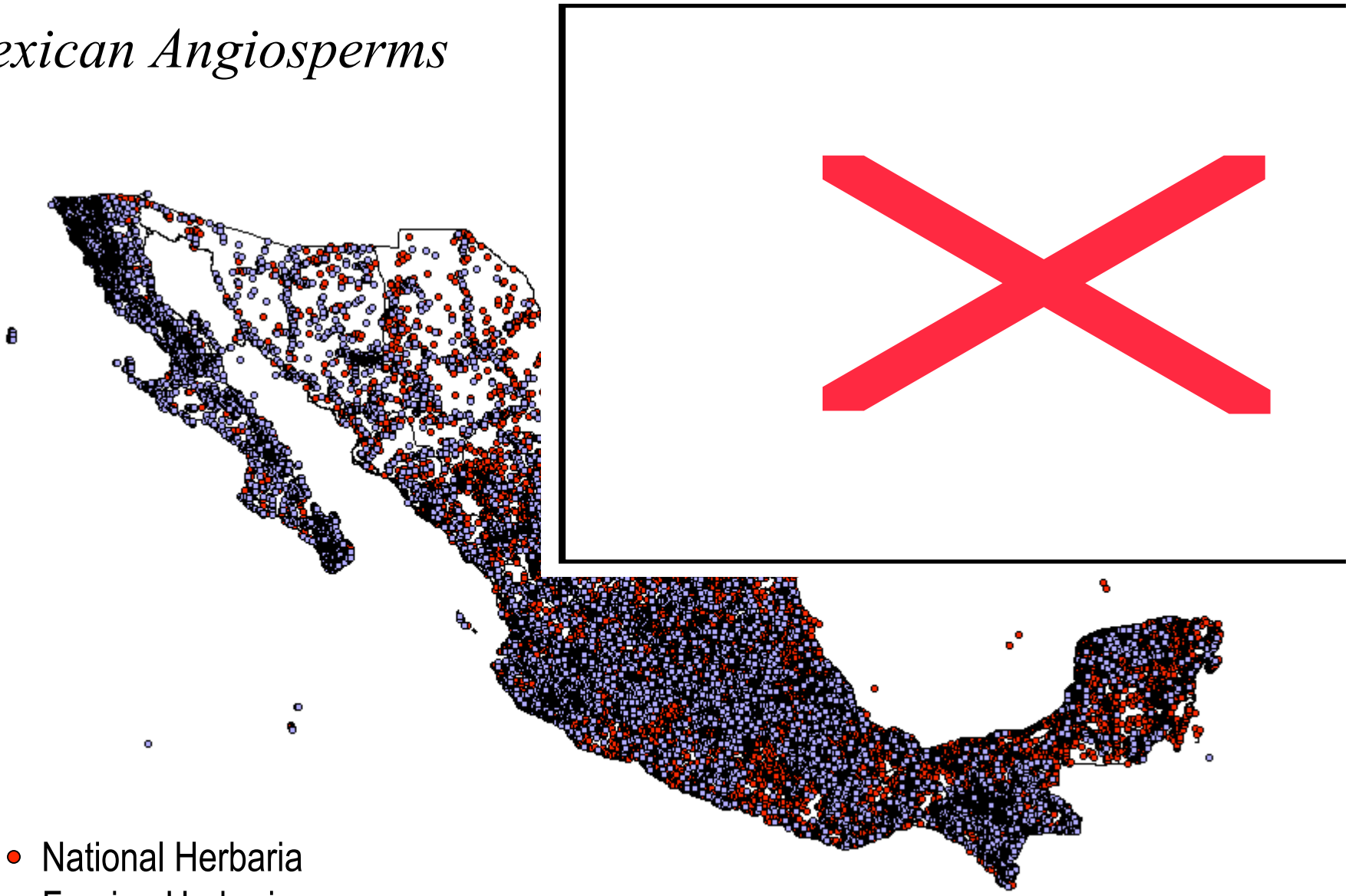
- Mexican museums
- Foreign museums

Total number of specimens = 85,345

Consistency = 89.3%

Sources: 17 databases in Conabio

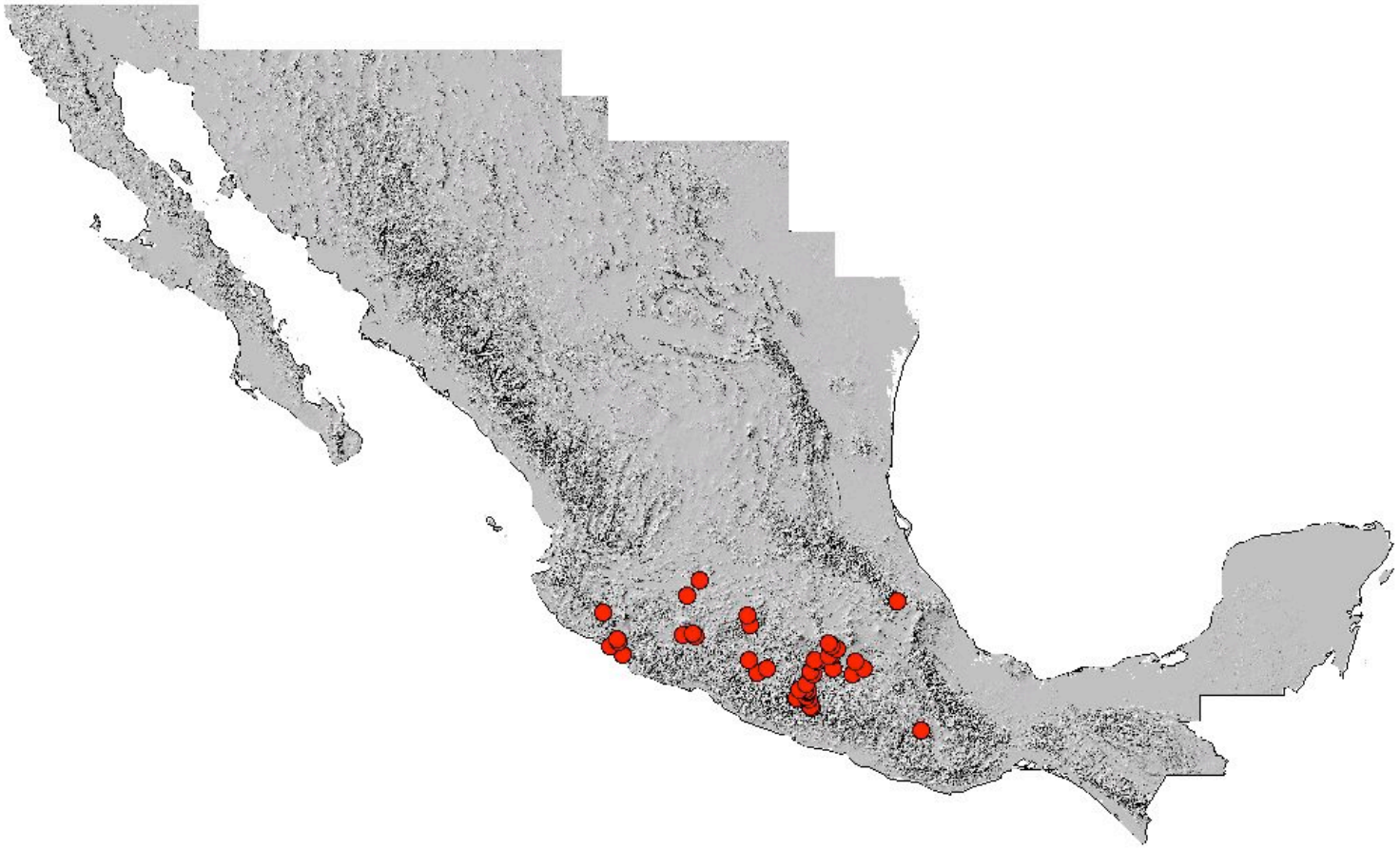
Mexican Angiosperms

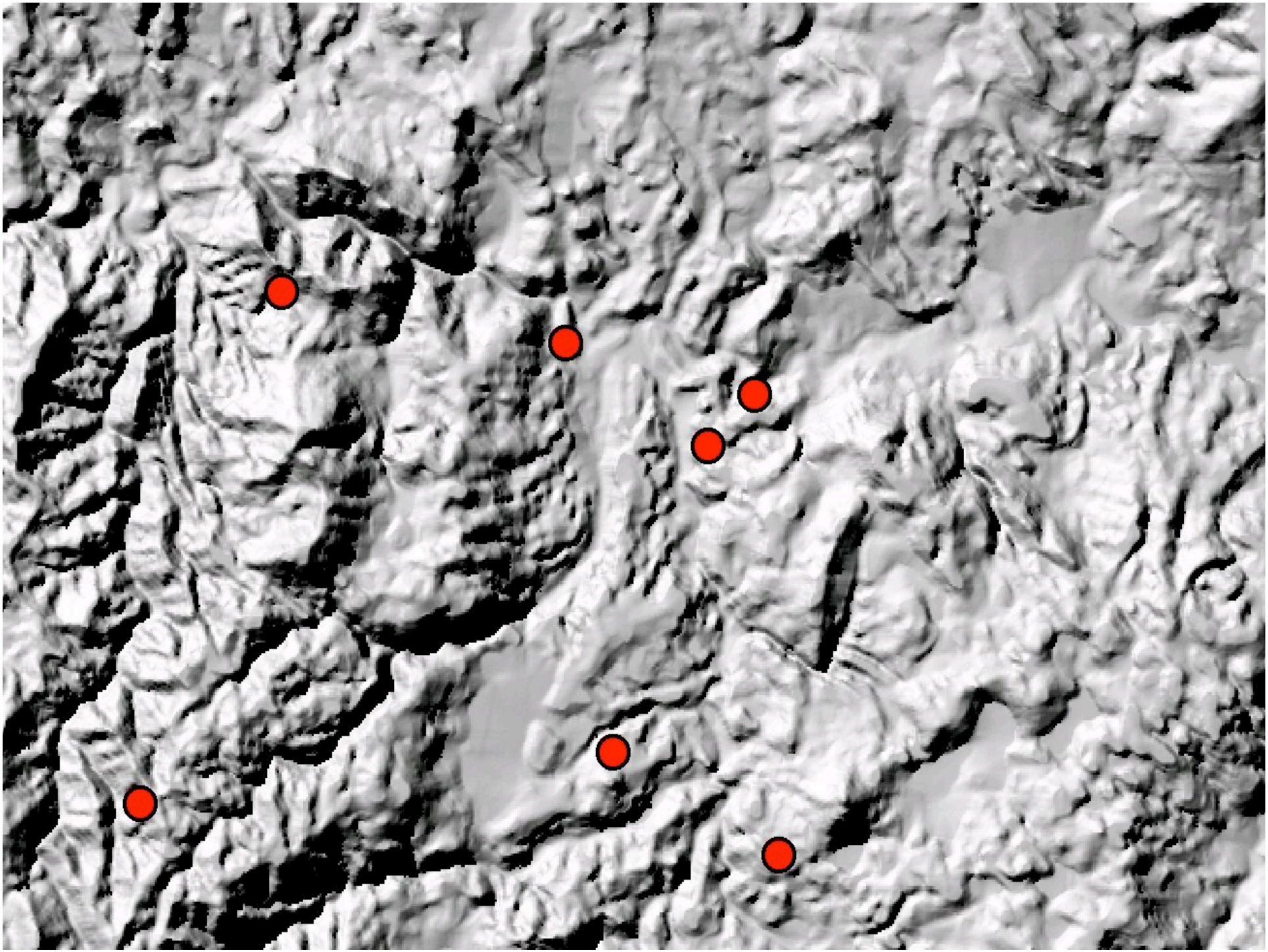


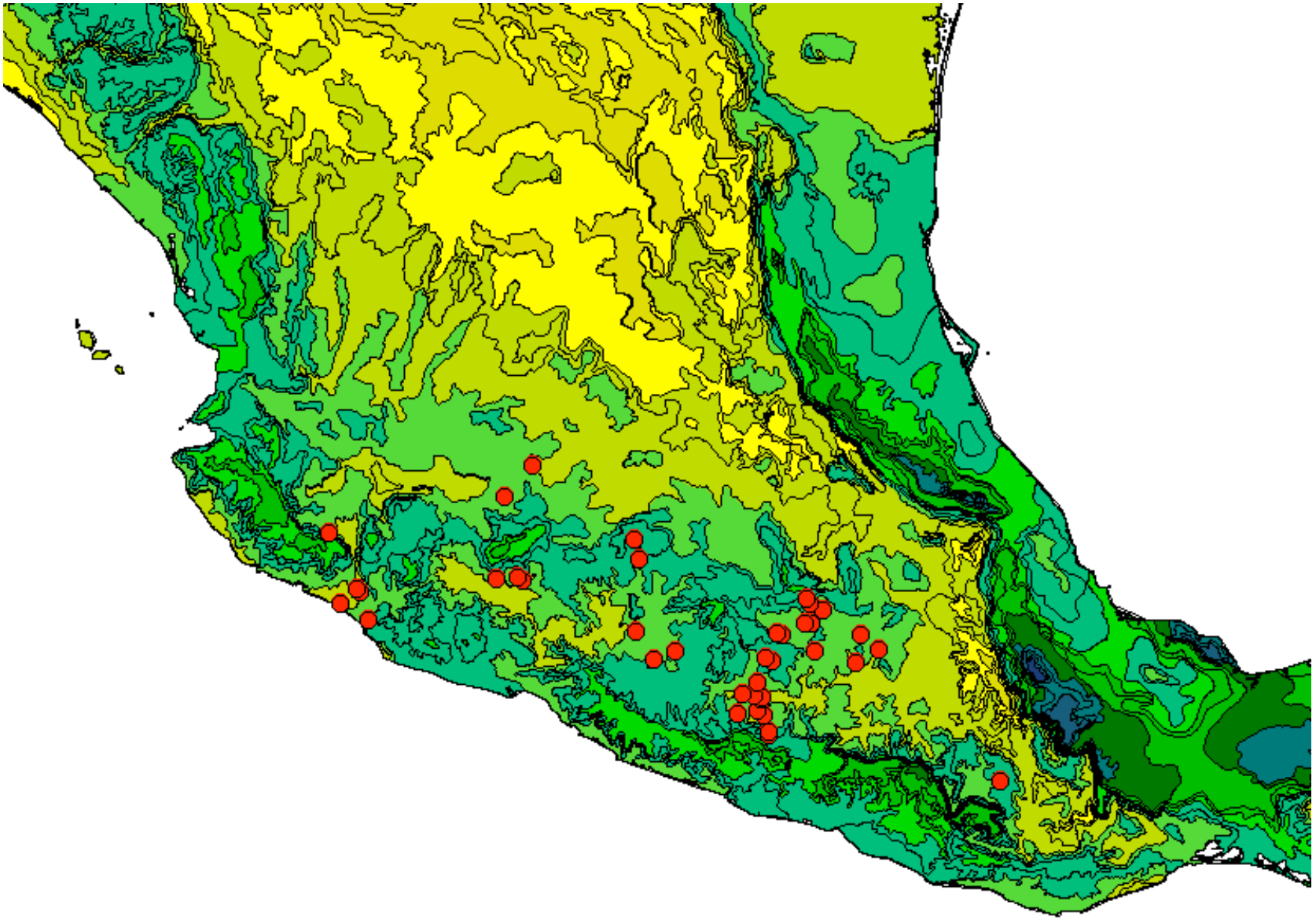
- National Herbaria
- Foreign Herbaria

Total Number of Specimens = 783,513
Consistency = 85.4%

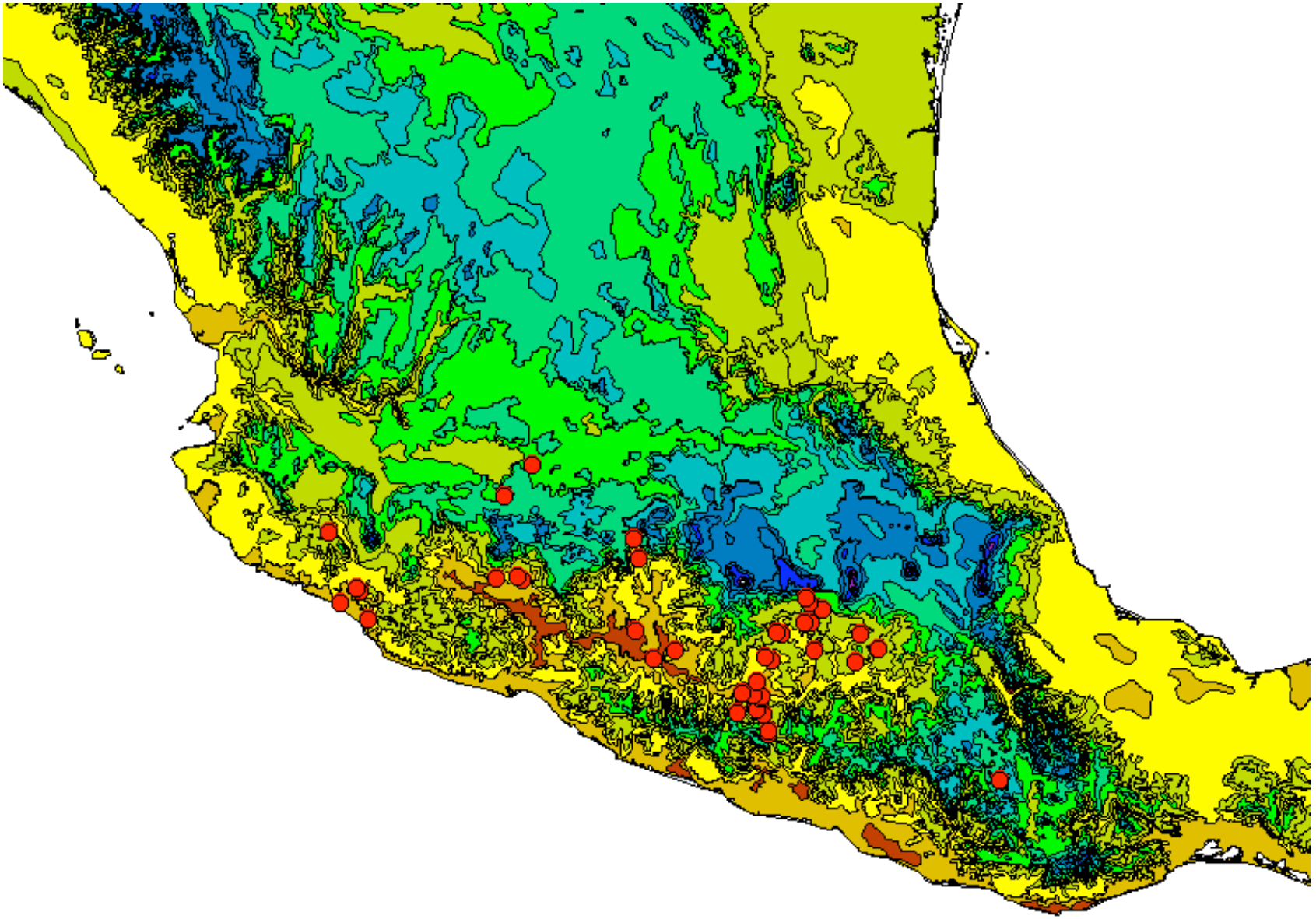
Fuente: 124 bases de datos pertenecientes al SNIB





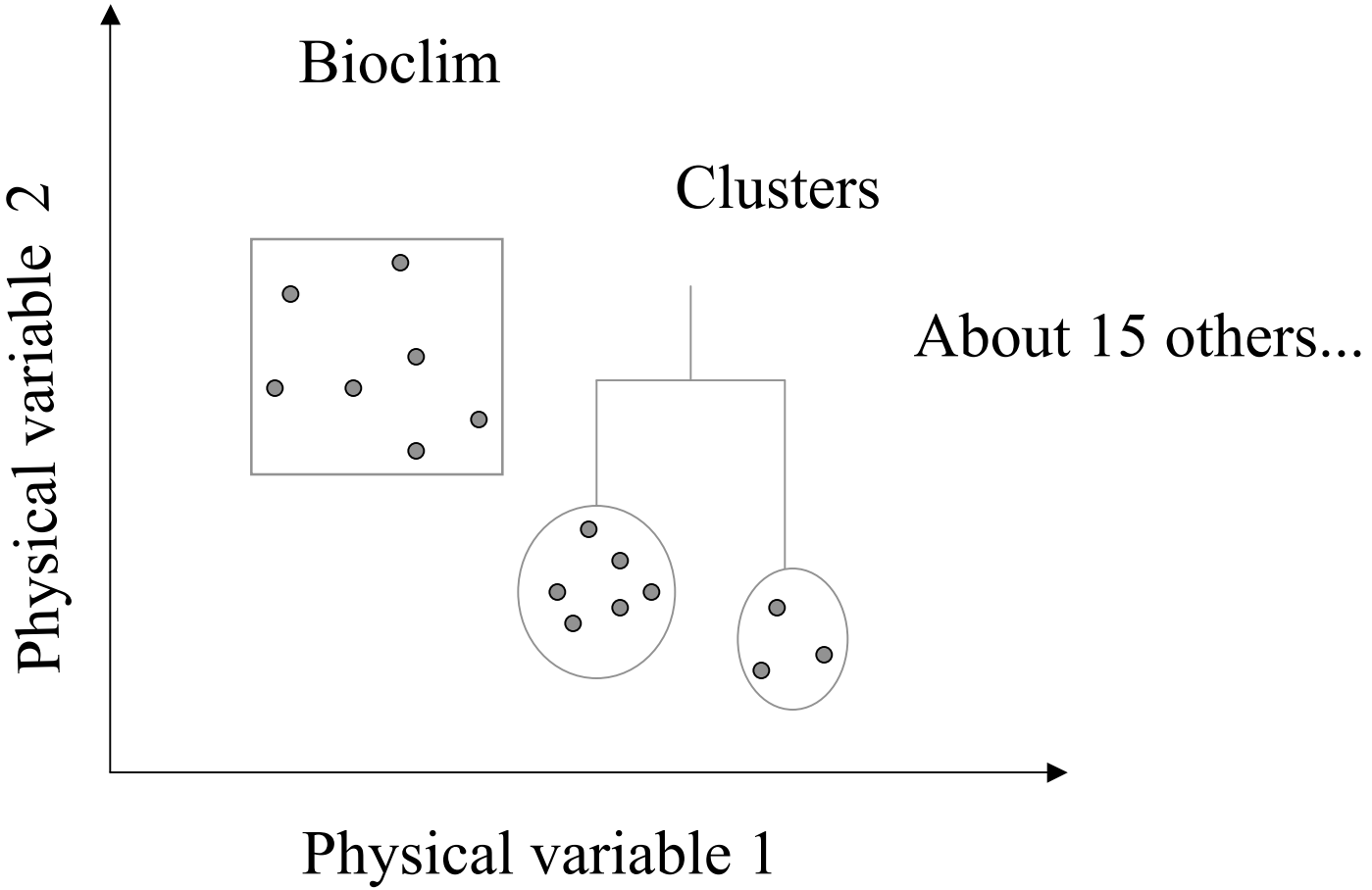


Variable 1, precipitation



Variable 2, yearly average temperature

How do we decide what algorithm to use?



II. Uncertainties About the Interactions

- We know that at certain scales, probably spatially "small" (Pearson and Dawson, 2003; Brandle and Brandl, 2001; Amaresekare, 2004; Whittaker et al., 2001), habitat selection and biotic interactions are more relevant. At "larger" spatial scales, it is the abiotic part of the niche what probably dominates.
  - How do we know what is small and what is large?
  - How do we map interactions?

III. Uncertainties about accesibility of space

- Historical and evolutionary unaccesibility
- Ecological unaccesibility
- At small spatial scales, probably everything is accesible. At larger scales the barriers and historical considerations play a role
- Basically, we know very little about the quantitative details of all the above

How do we do it anyway: *Baronia brevicornis* and its single food plant, *Acacia cochliacantha*

I. Estimating the abiotic niche

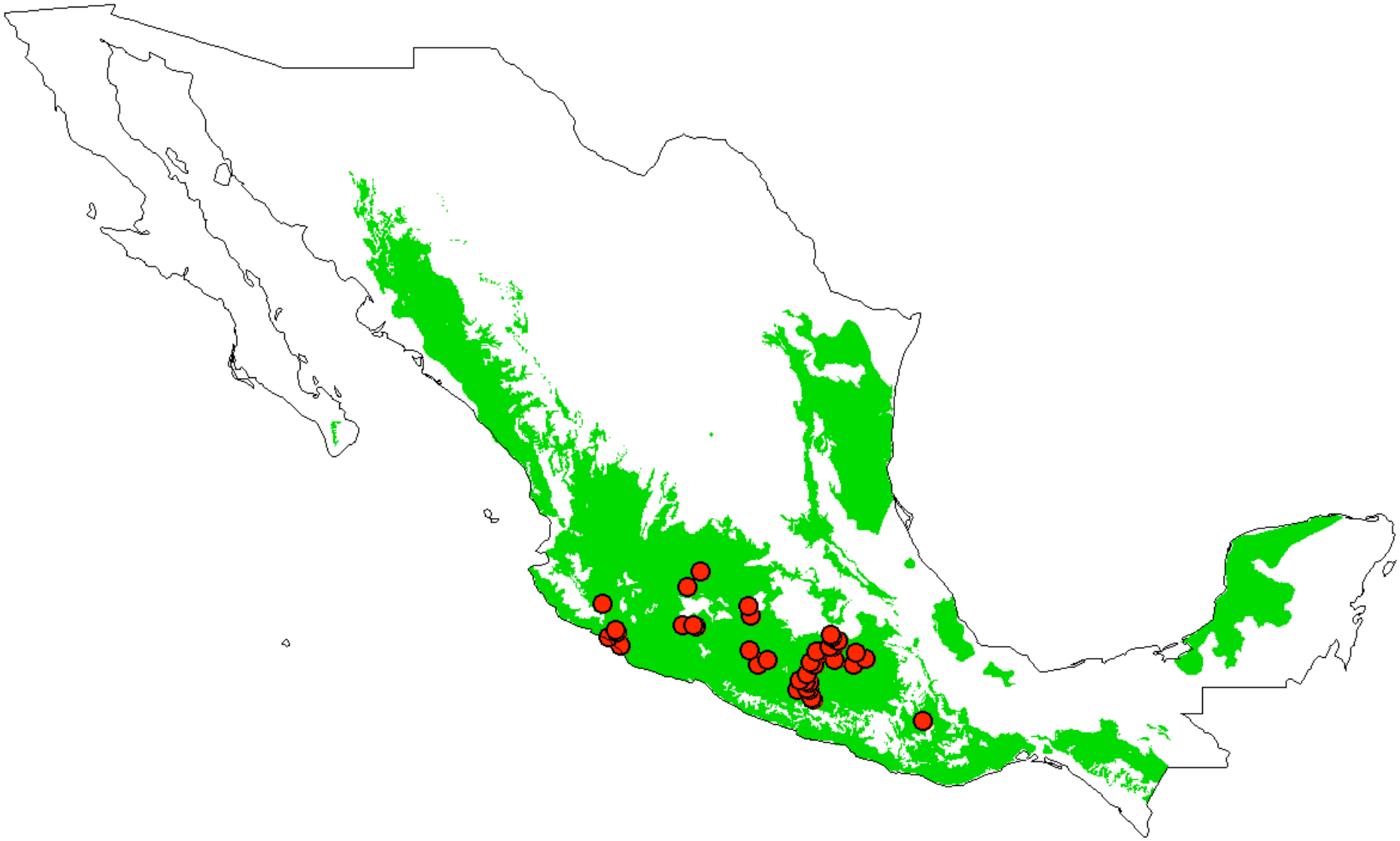
- One needs to find regions that are “similar” to those where the species has been observed.
- The basic data is:
  - Points of observation of the species
  - Electronic coverages of relevant physical variables

- A number of algorithms exist to do it:
- GARP
- FloraMap
- Bayes
- GAM, GLIM, CART
- One that has proved to be very predictive is GARP. Besides GARP can manage “presences only” data.

For this example the following layers were used, all at 1:1,000,000:

- Aspect
- Elevation
- Mean Temperature
- Average minimum daily temperature
- Average maximum daily temperature
- Yearly precipitation

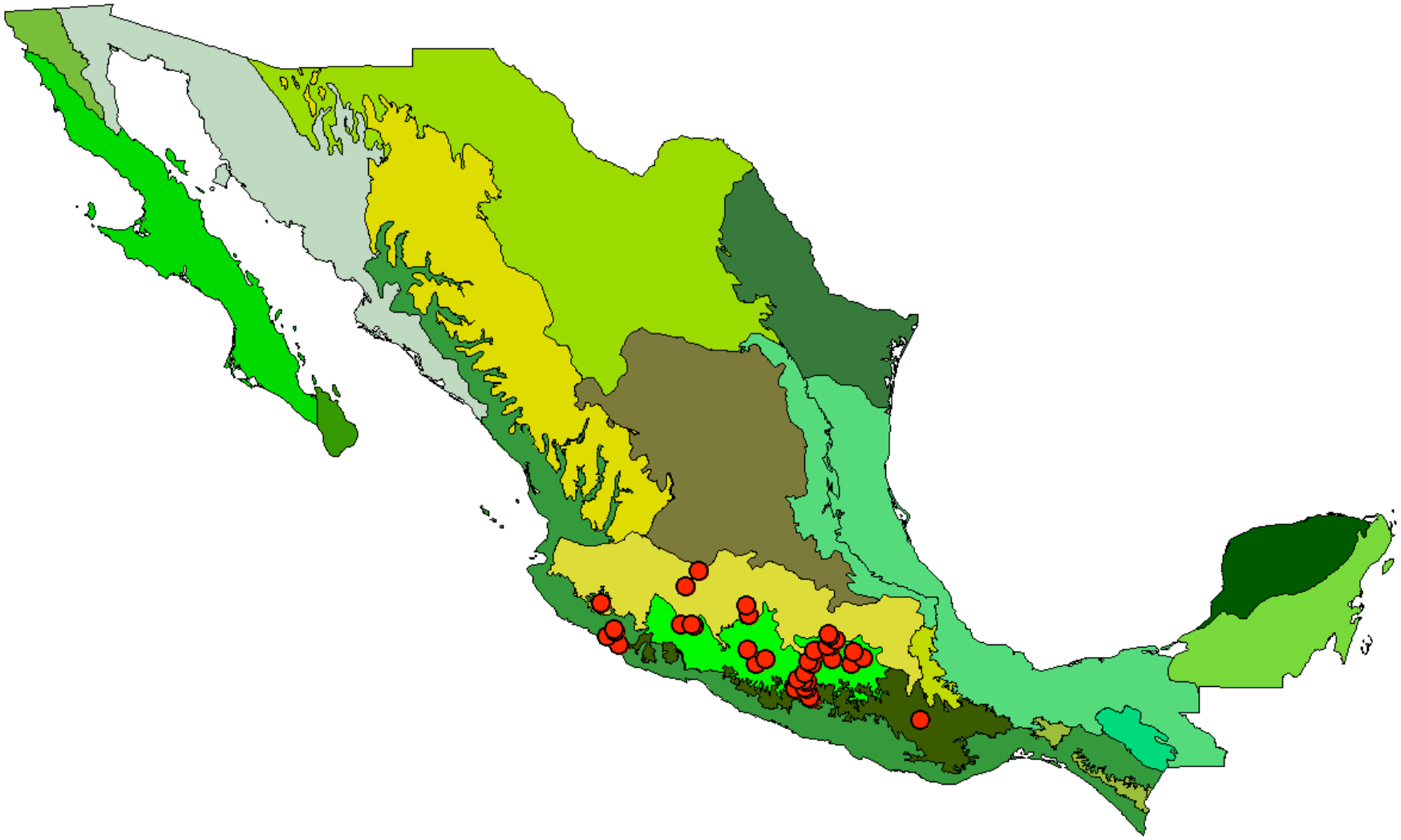
MME about 500 meters



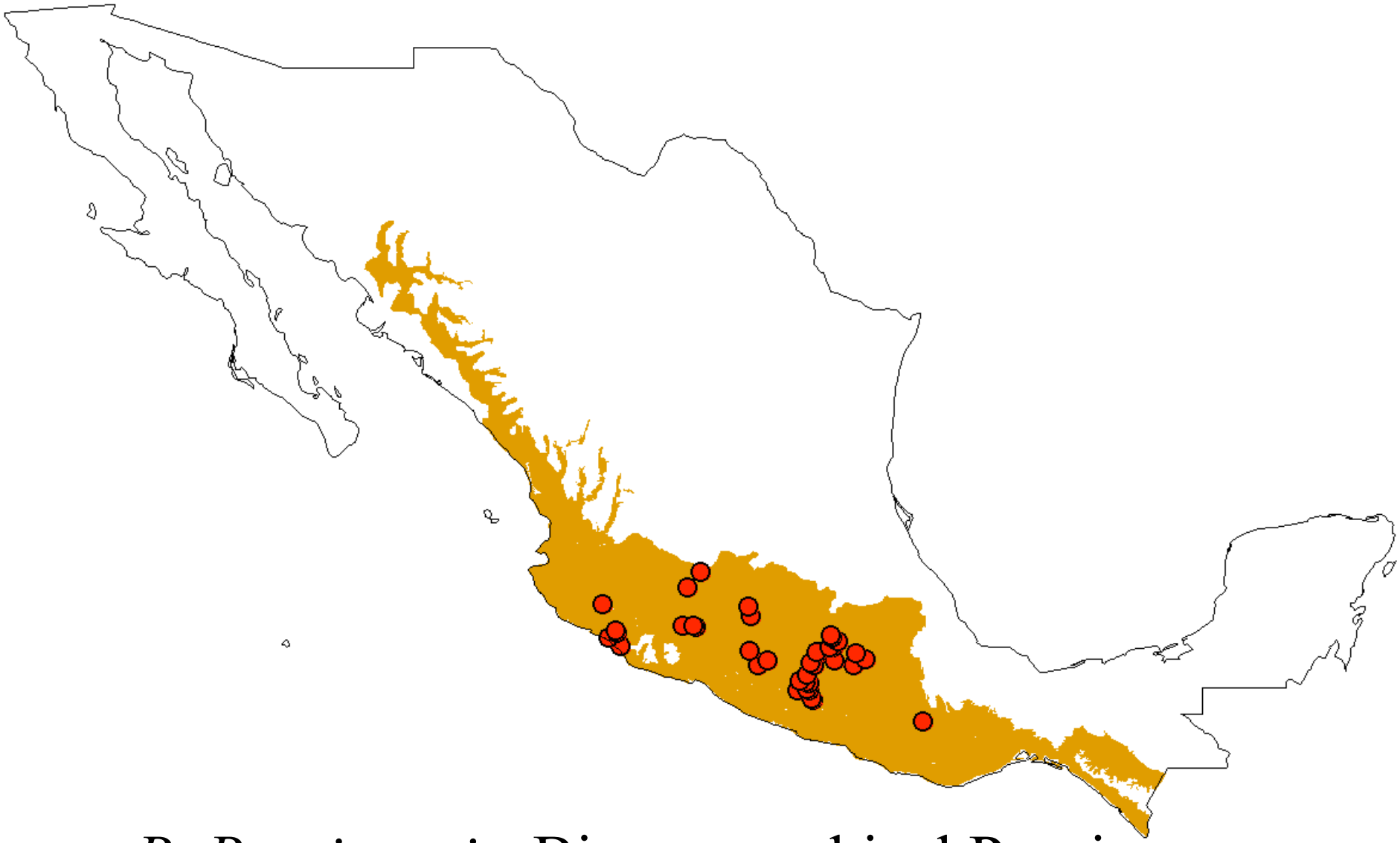
B. brevicornis Abiotic Niche using BS Garp

II: Estimating the "Area of Accesibility"

- From where? What is the initial condition?
- At what scale? In relation to what vagility parameters?
- At certain scales, one can assume that biogeography is a good surrogate for the accesibility areas, this is, we assume that if a species is present in a given biogeographical region, it can reach all of it.

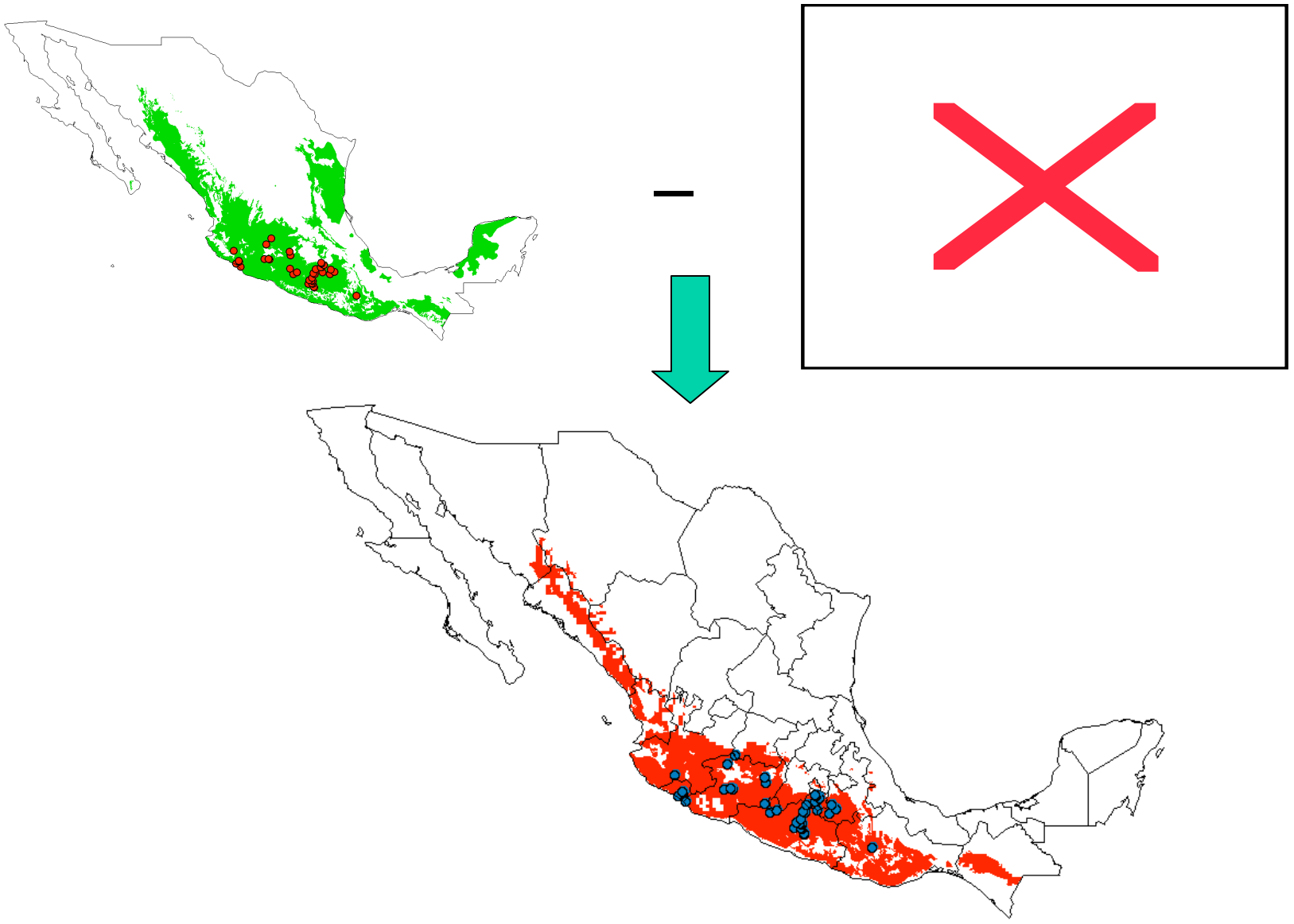


B. brevicornis Biogeographical Provinces



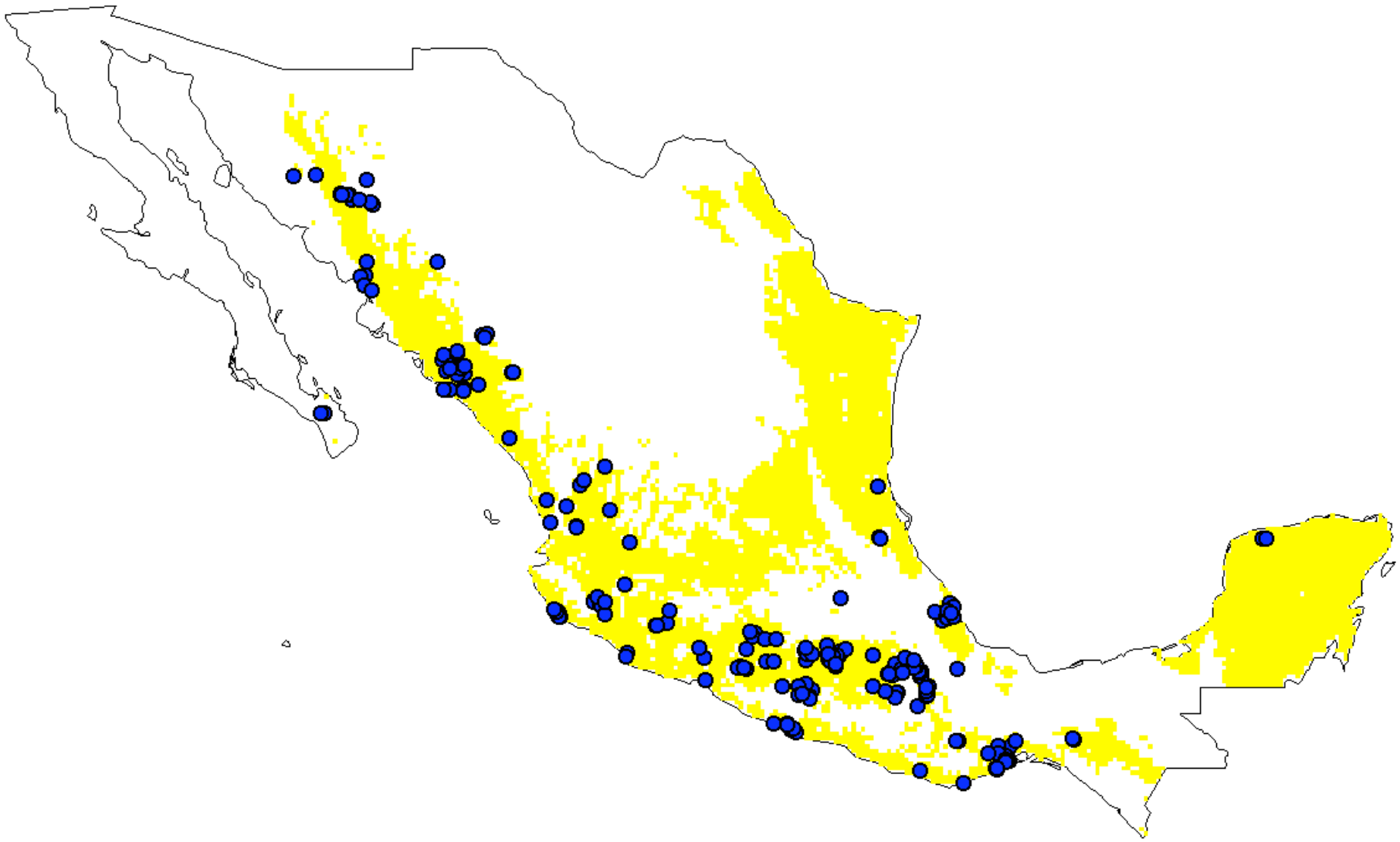
B. Brevicornis. Biogeographical Provinces as Surrogates for Accesibility Areas

B. Brevicornis Niche _ Accesibility

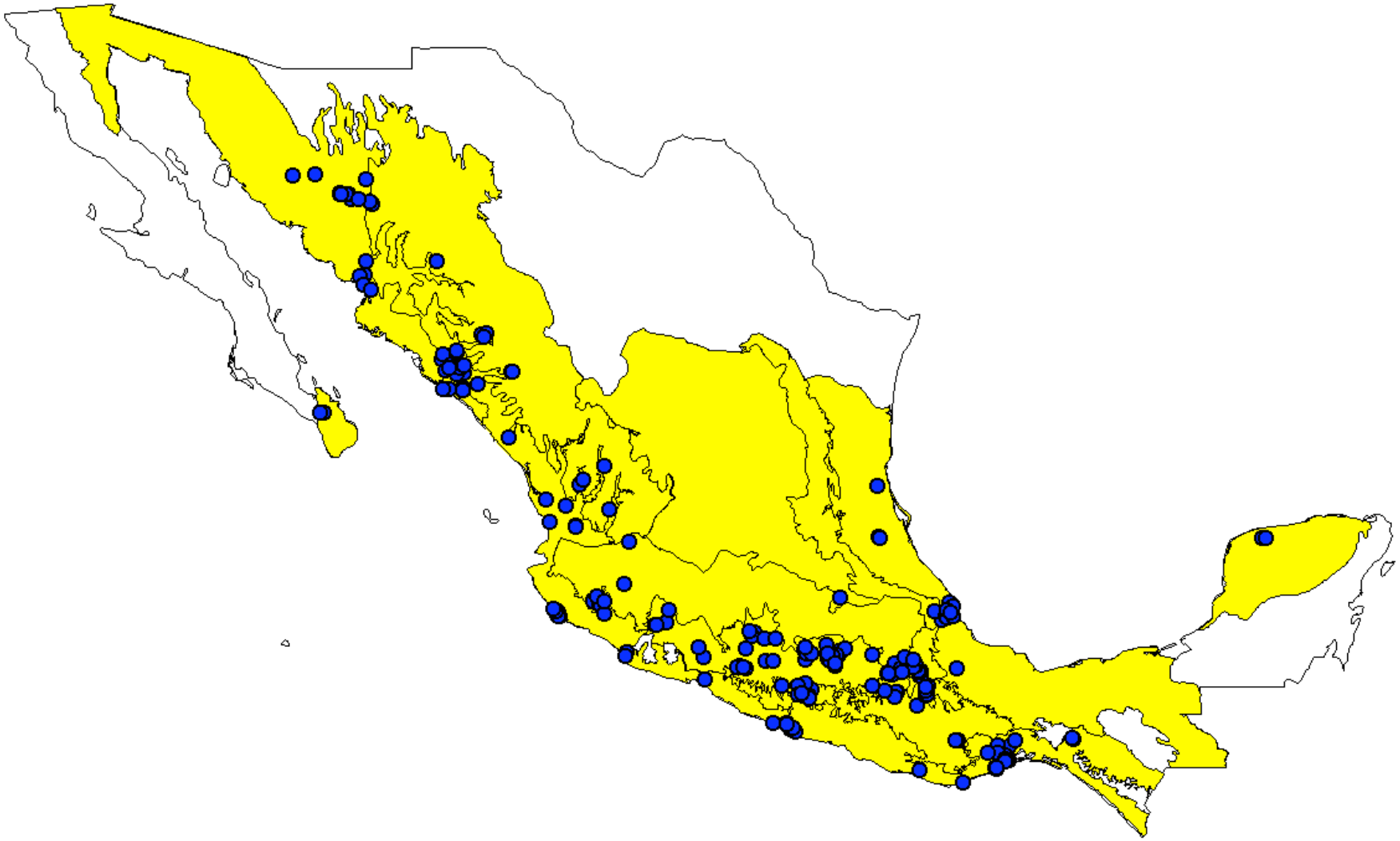


III. Estimating an Obligate Interaction

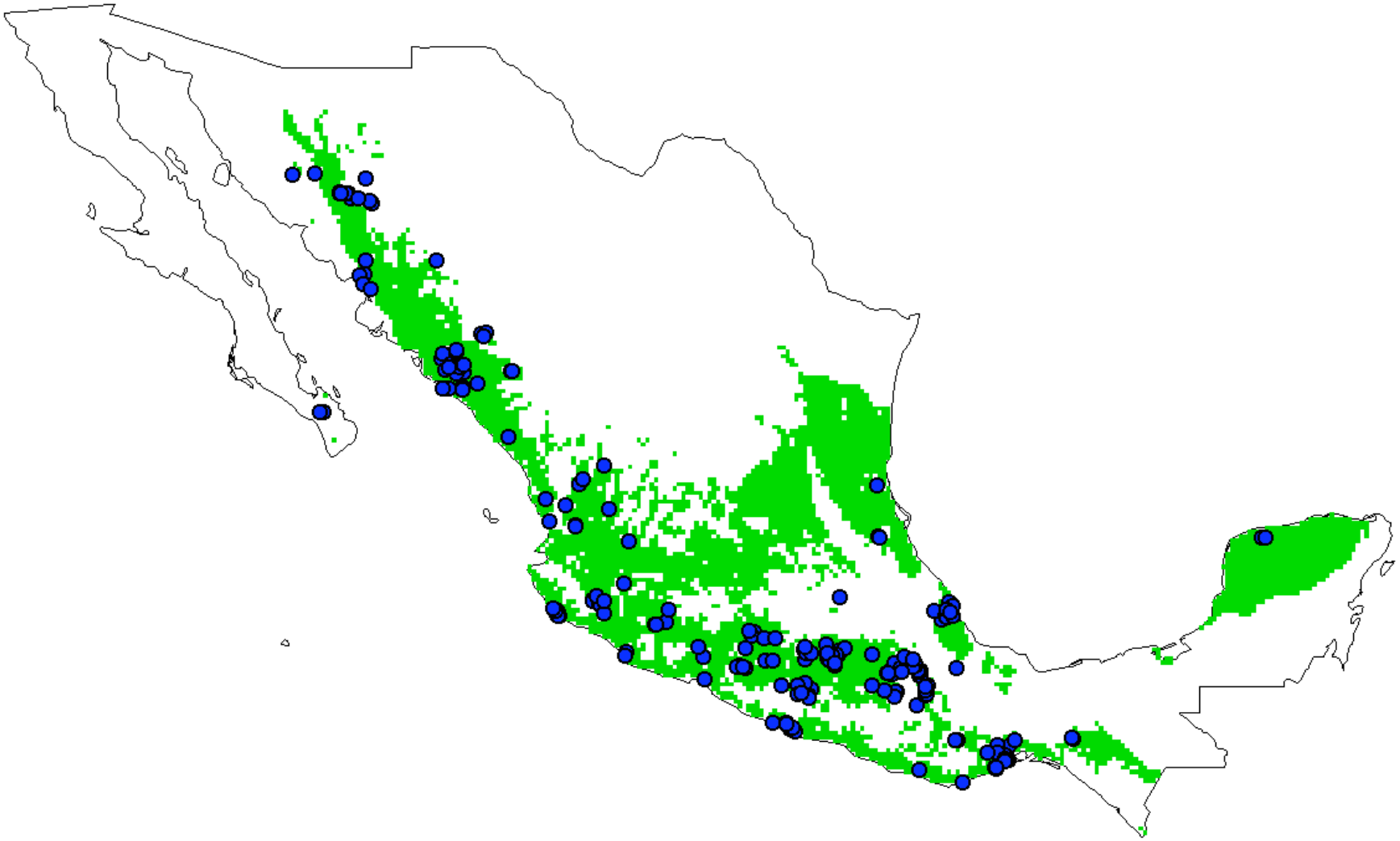
- *B. brevicornis* only food plant is the legume *Acacia cochliacantha*
- A similar analysis is the repeated for *A. cochliacantha*



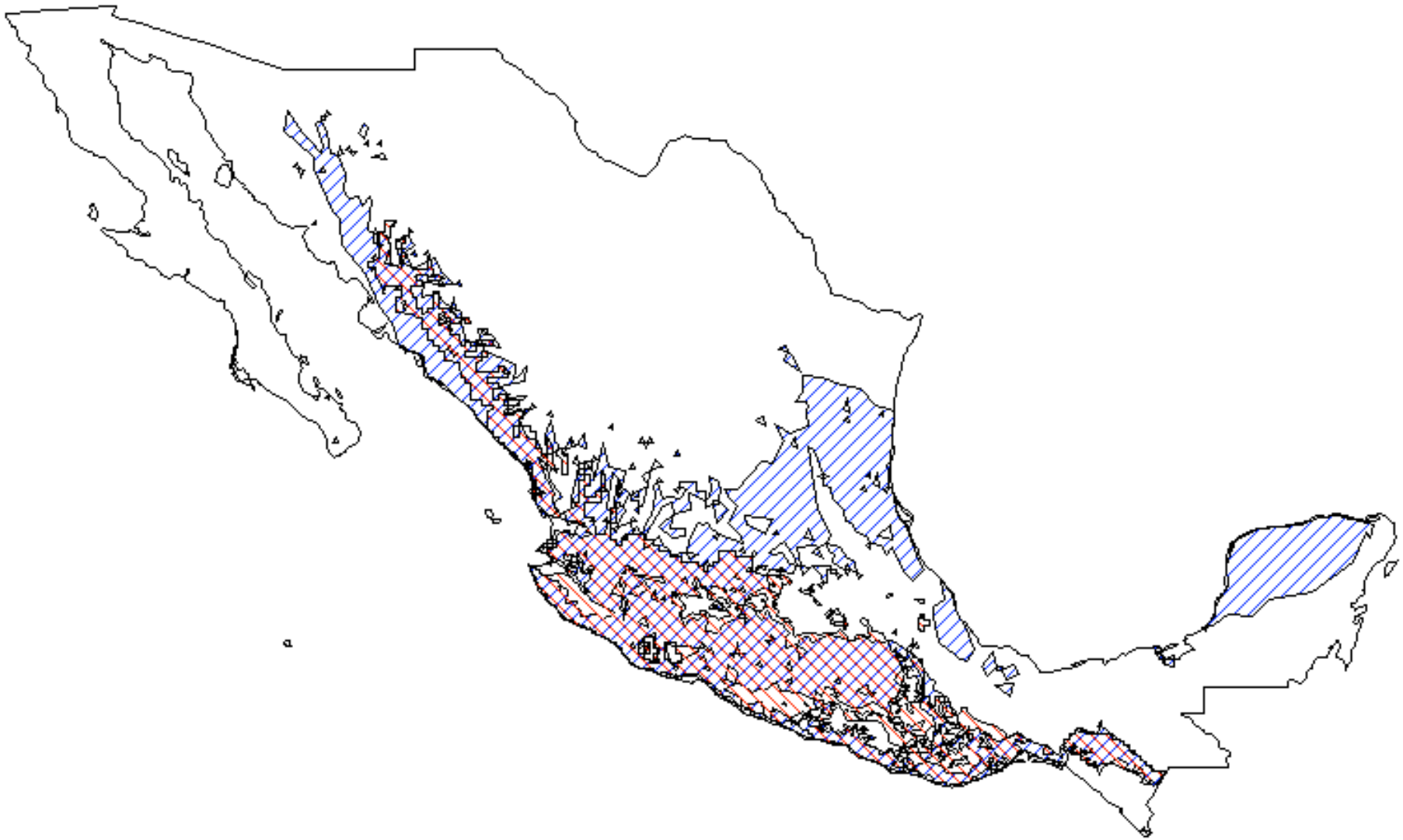
A. cochliacantha Abiotic Niche



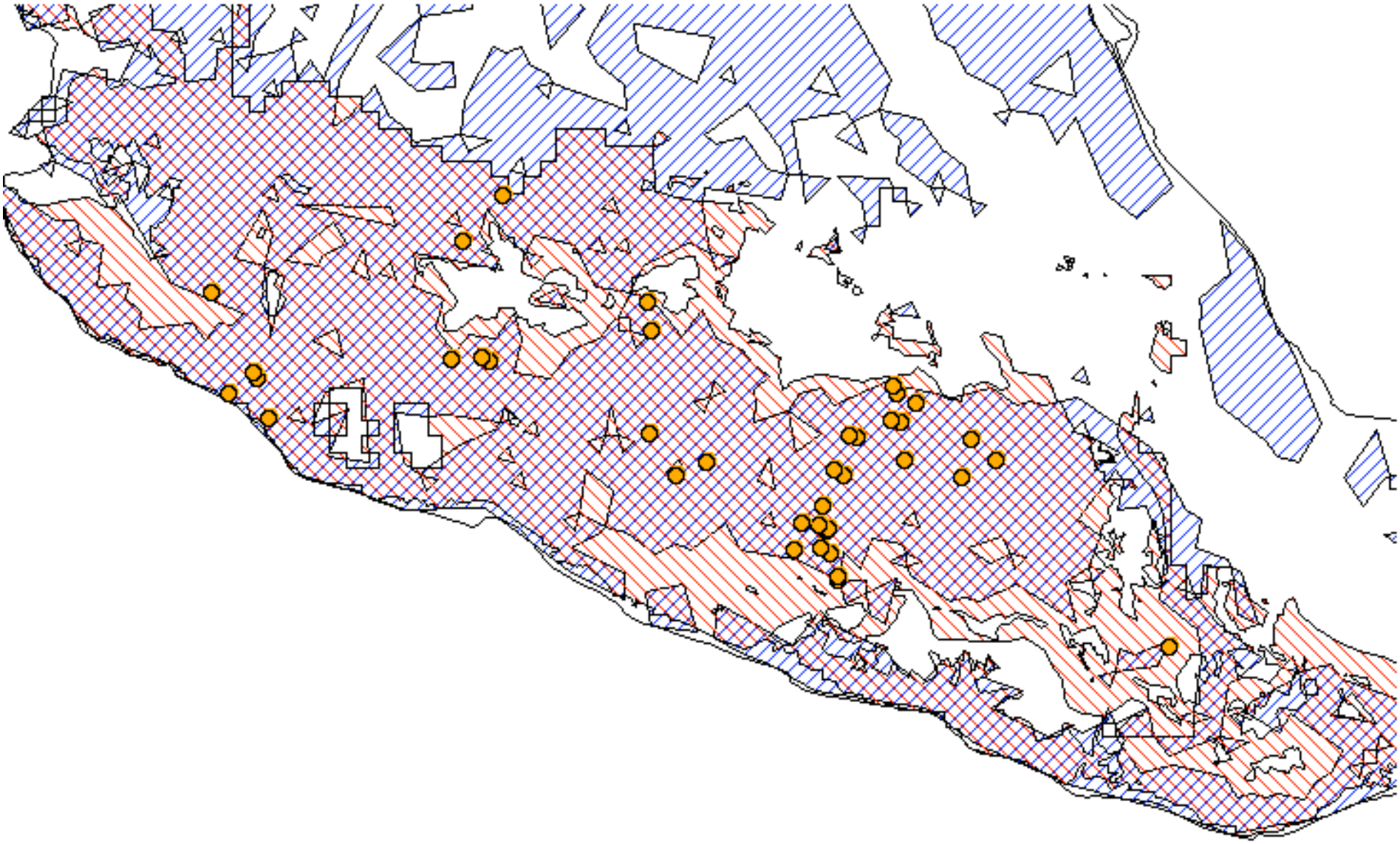
A. cochliacantha accesibility region (biogeography)



A cochliacantha niche _ accesibility



B. brevicornis (red) _ *A. cochliacantha* (blue)



How predictive is the procedure?

- Field-tested at scales of 10^4 to 10^7 km^2
- For birds, mammals and some butterfly families, in Mexico and the USA.
- The “niche” part extensively tested in Australia, at smaller scales

But...will it work for climate change?

- How good and detailed are the climate models?

Probably not very. For Mexico they do not reproduce current climate.

- How well can we predict movement?

Perhaps a little bit more. Birds, maybe butterflies...

- And what about the %$&?* interactions?

So, shall we despair...?

- Probably not. Properly applied, bioclimatic models do predict niches and distributions.
- A growing body of literature suggests that interactions are less important at regional scales.
- Realistic movement scenarios can be postulated for some taxonomic groups.

Bioclimatic Models are part of a suite of tools:

- Biome modeling
- Individual-based modeling, experiments
- Individual-species bioclimatic envelopes
- Observational trends and patterns.