



Galapagos Islands



**Galapagos Islands
2,700 endemic species!**

WHY?



Denali, Alaska

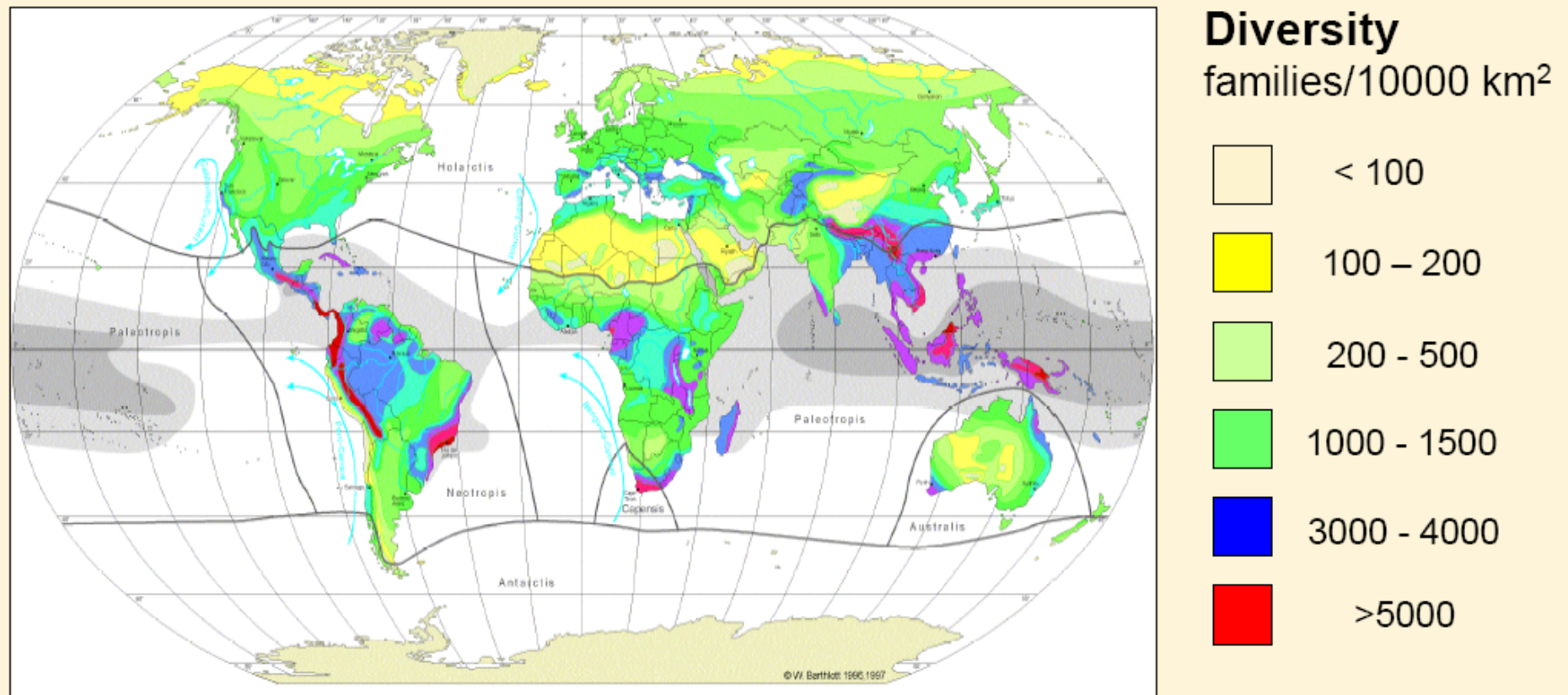
Low species diversity. Why?



Patterns of Species Diversity

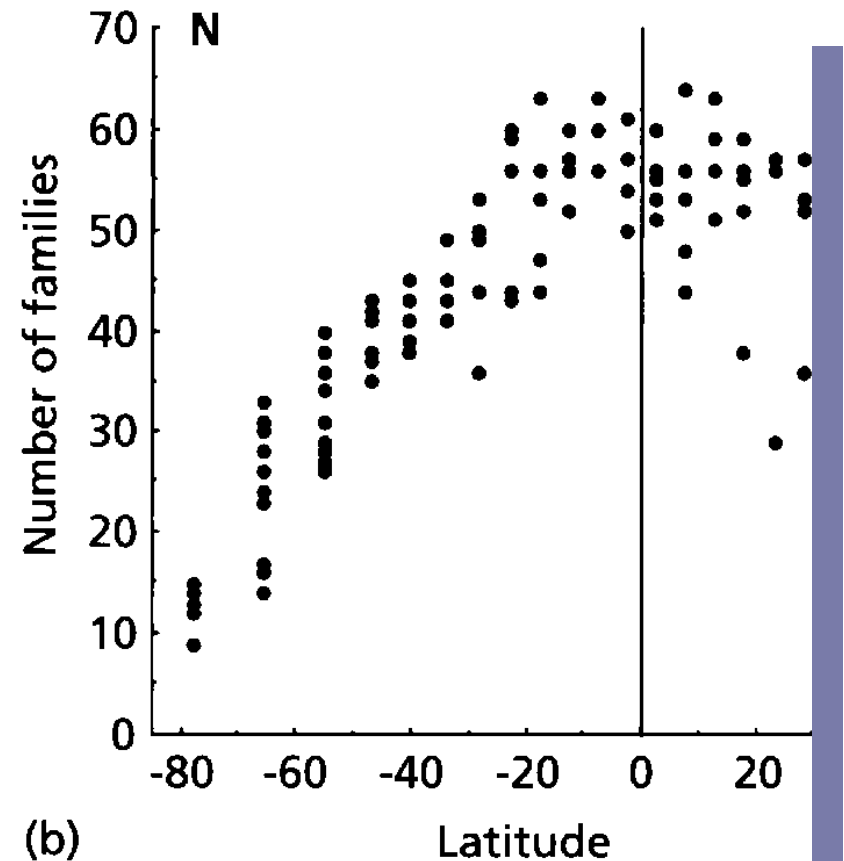
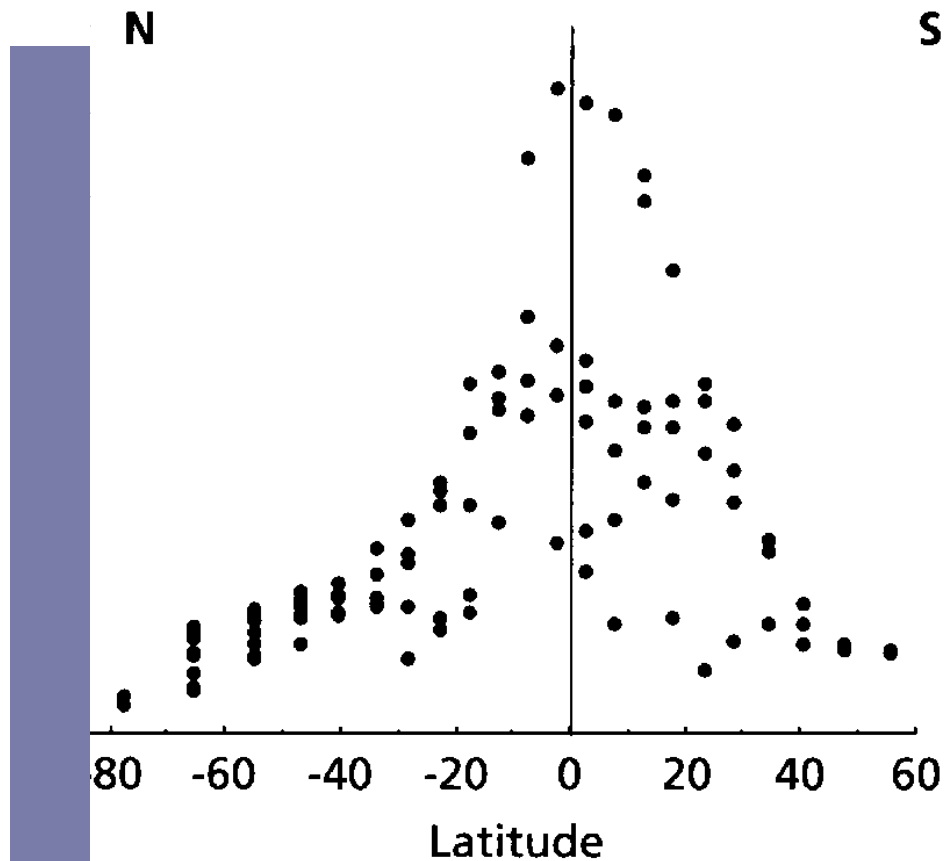
- **Latitudinal**
 - Global pattern—drivers?
 - **Islands (but also mtn. tops, lakes, etc.)**
 - Patterns with island size
 - Species-Area curves
 - Patterns with island size & distance
 - Theory of Island Biogeography
 - Predicting species diversity as a function of colonization and extinction rates
 - **Metapopulations***
 - Modern extension of island biogeography
- *not related to diversity

Global patterns of species diversity (land plants)



Data from W. Barthlott, 1996

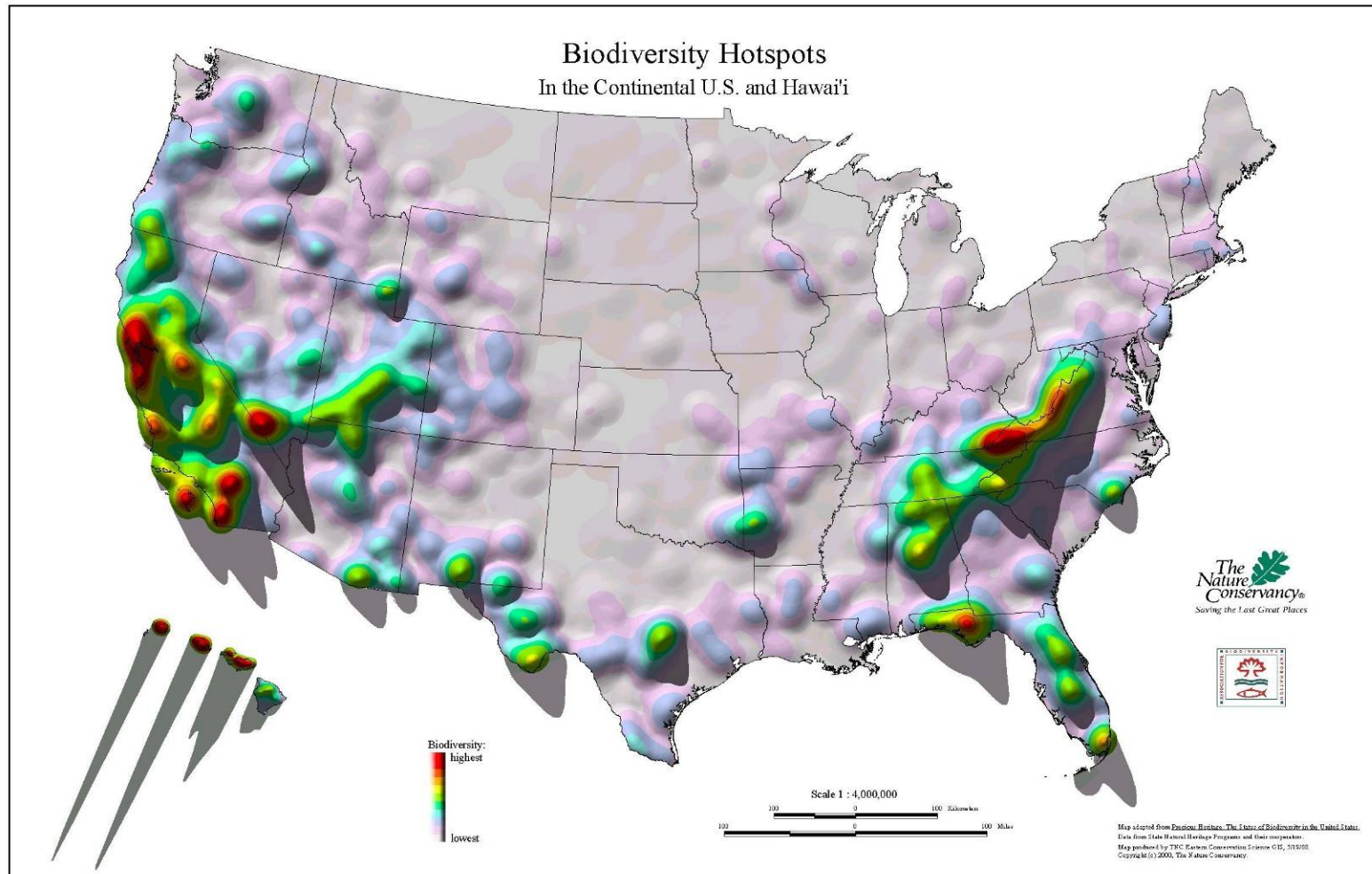
Latitudinal diversity gradient: Birds from the new world



Gaston & Blackburn (2000) Pattern and Processes in Macroecology.

BUT...other features also influence diversity

Evolutionary history, habitat heterogeneity, species interactions, etc.



Why are there latitudinal diversity gradients?

□ Time:

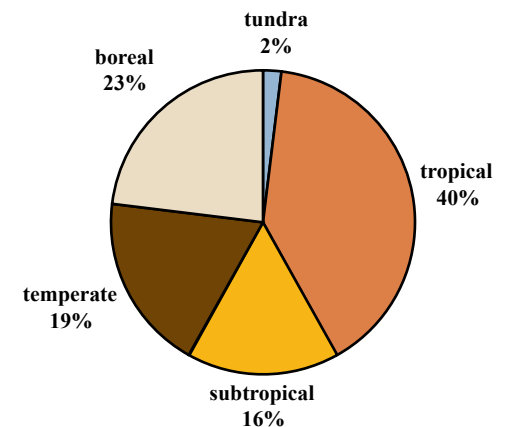
- ▣ time since glaciation/major disturbance, which “resets” diversity
- ▣ climate stability = more diversification

□ Area:

- ▣ global land area dominated by tropics, statistical artifact?

□ Energy:

- ▣ Solar input higher, more productivity could allow multiple species to coexist (more action at the base of the food web)



Some exceptions:

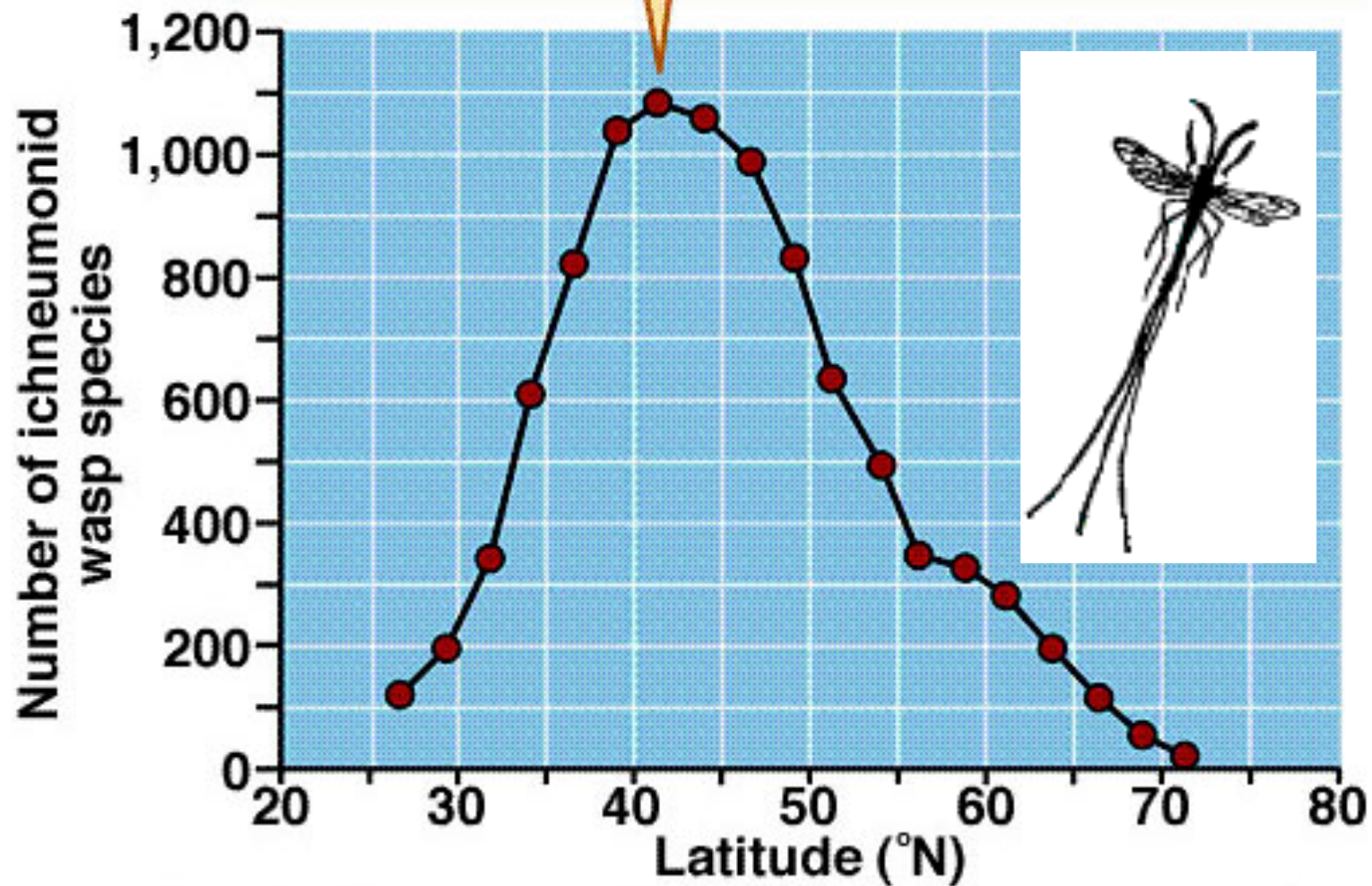
Some taxa are adapted to life at higher latitudes (e.g. penguins and auks)



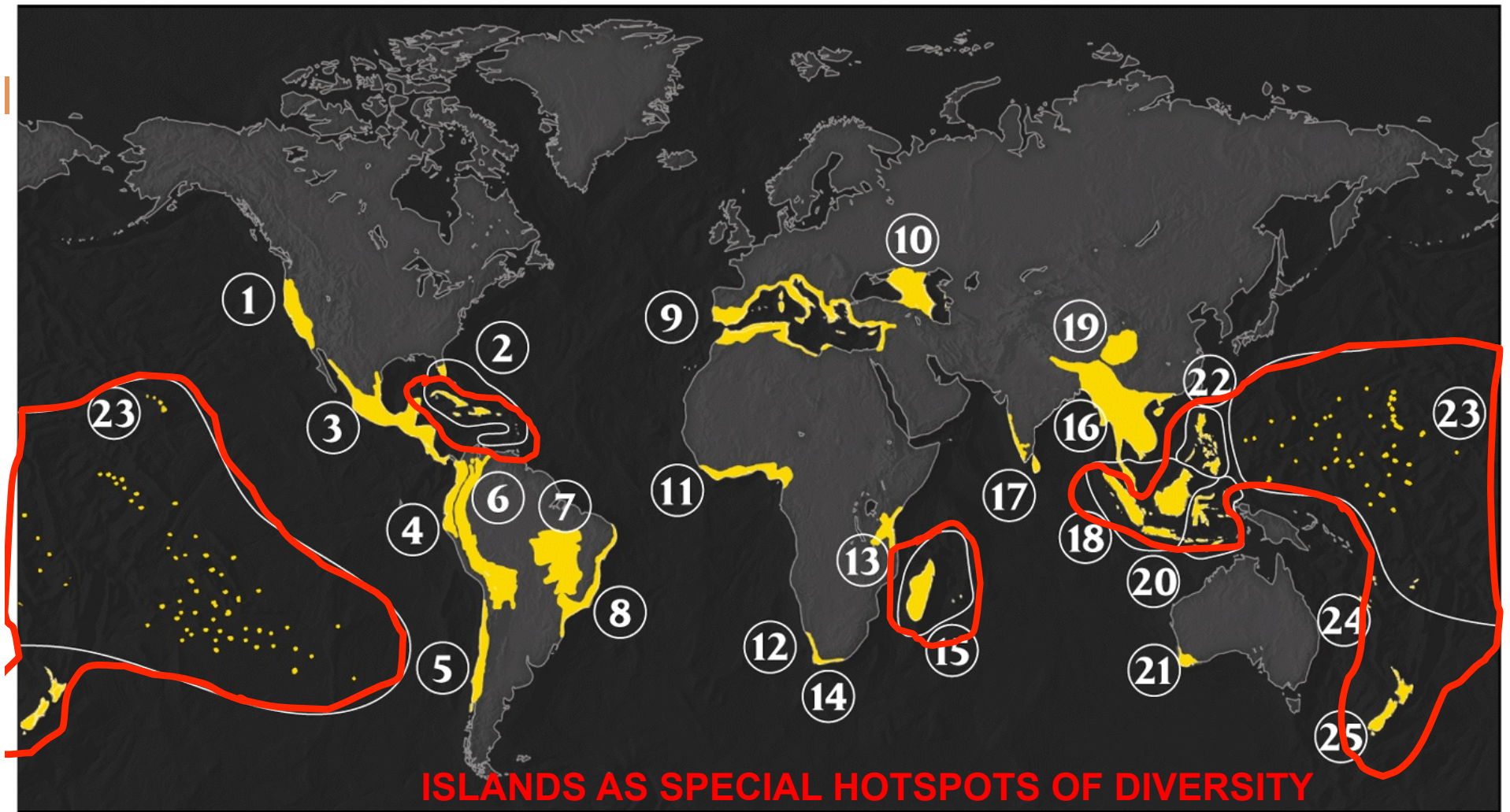
- Aphids, sawflies, ichneumonids and bees: show peaks at intermediate or high latitudes.



Ichneumonid wasp species richness peaks at middle latitudes.



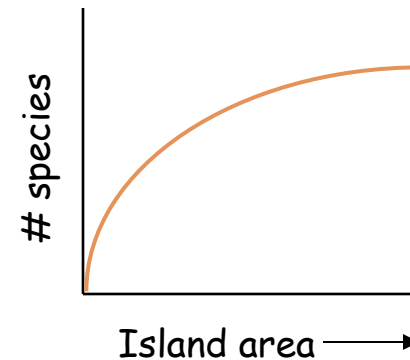
Hotspots



Endemic species are those found only in a single area

Island species richness

- Bigger islands have more species than small islands
- “Species-Area curves”
- Documented for diverse taxa
- Other types of habitat also follow this pattern.....island-like (mtn. tops, forest remnants, lakes, etc.)



Species richness increases with island **AREA**

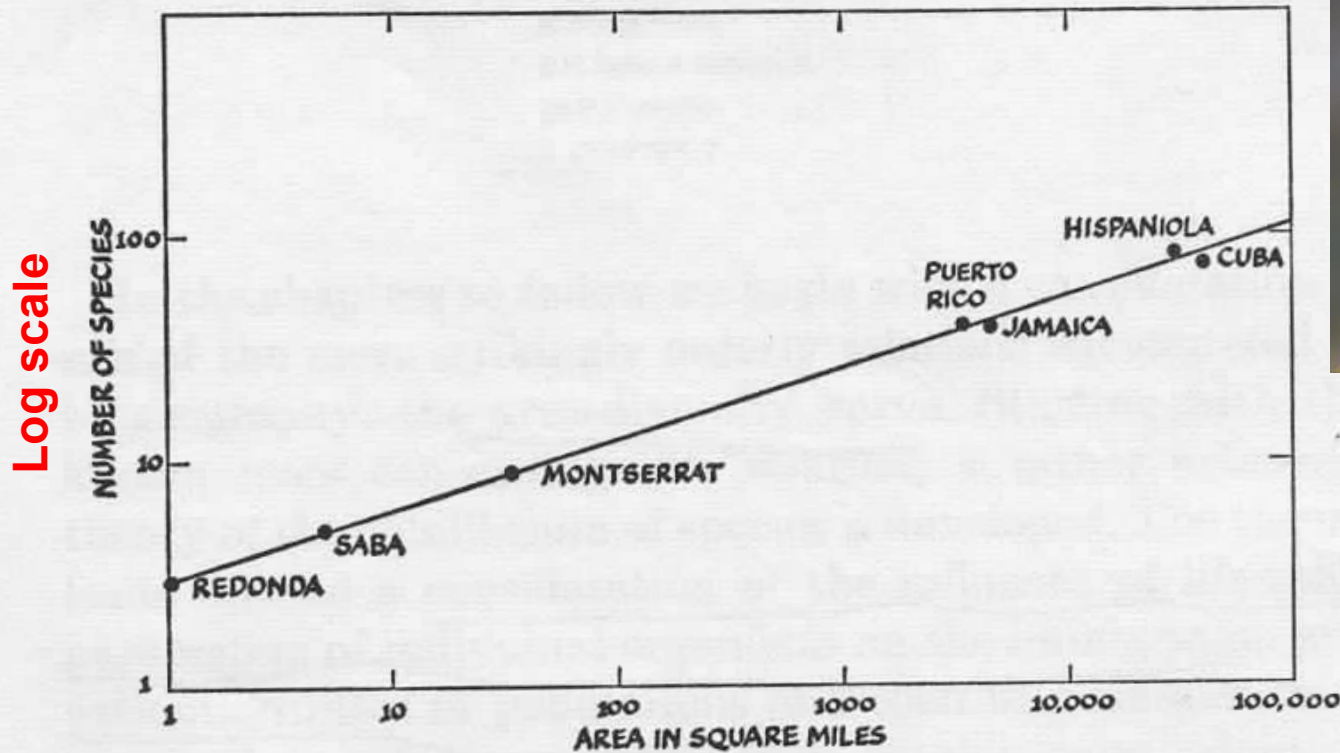


FIGURE 2. The area-species curve of the West Indian herpetofauna (amphibians plus reptiles).

8



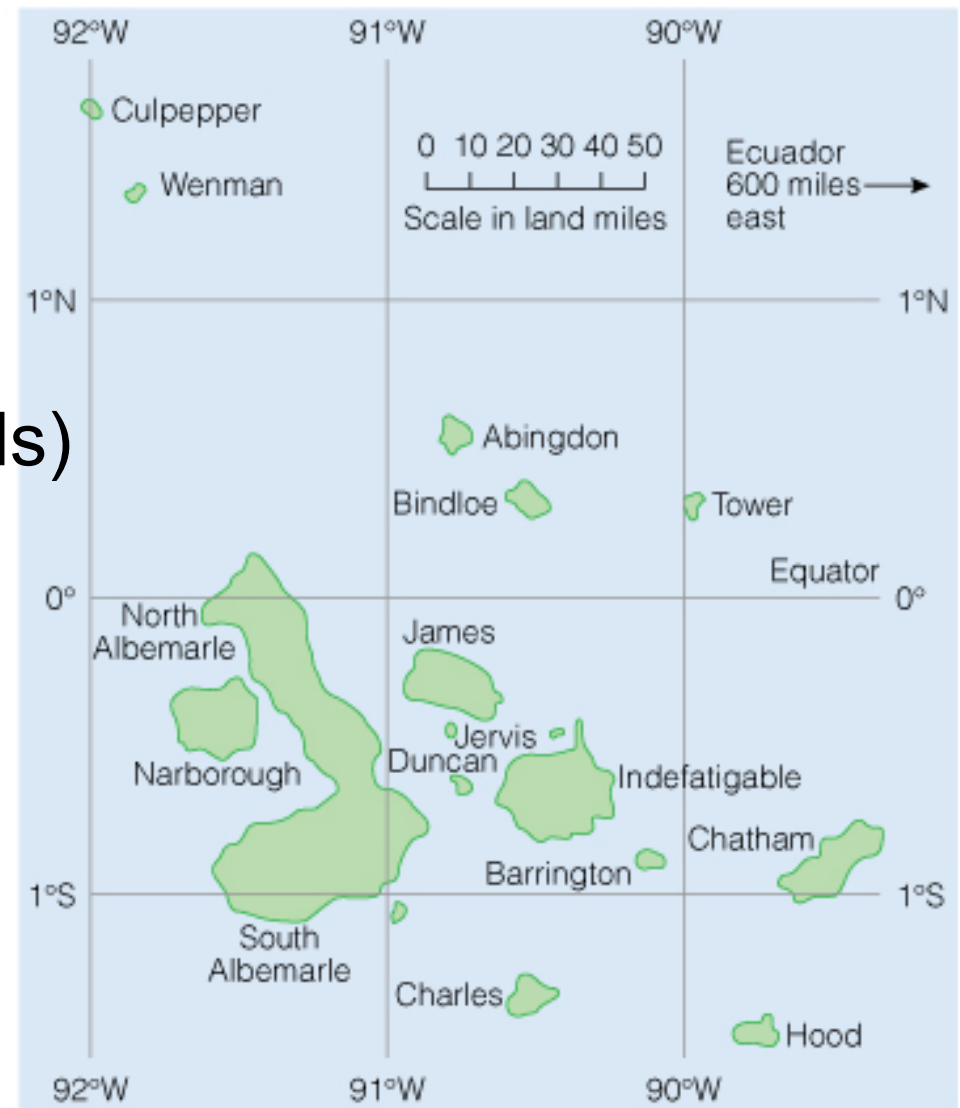
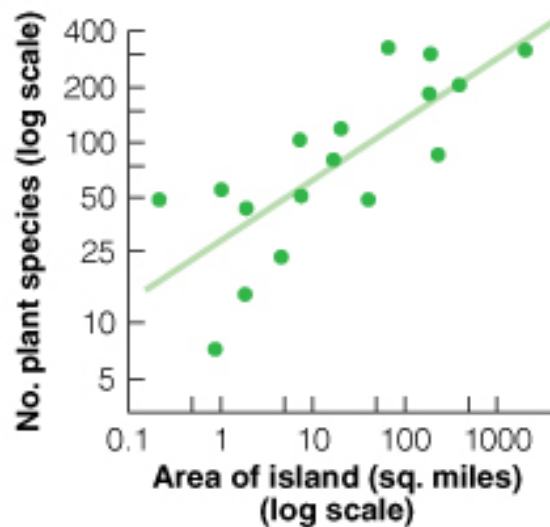
Galapagos land plants

$$S = c \cdot A^z$$

c is constant of spp./ area

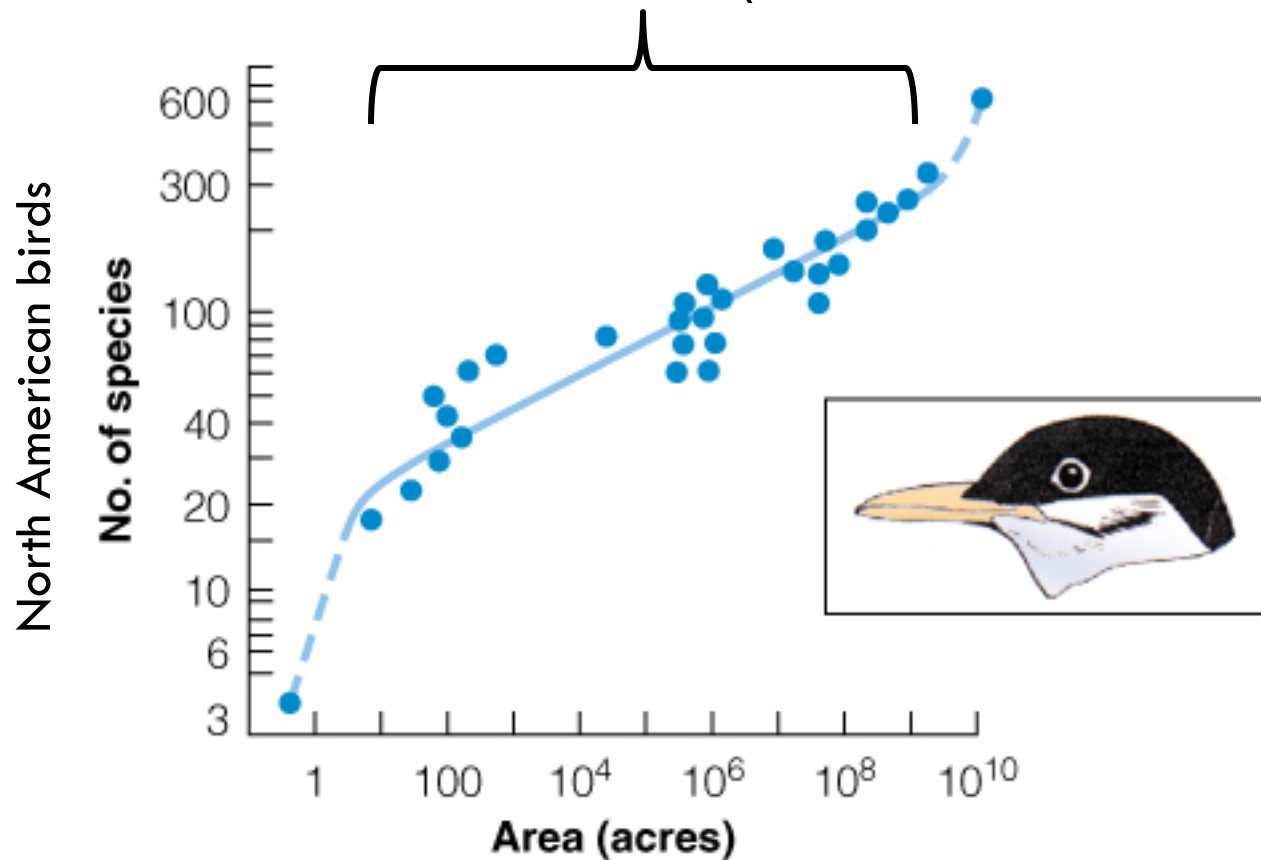
z is the slope

z = 0.32 (~0.3 most islands)

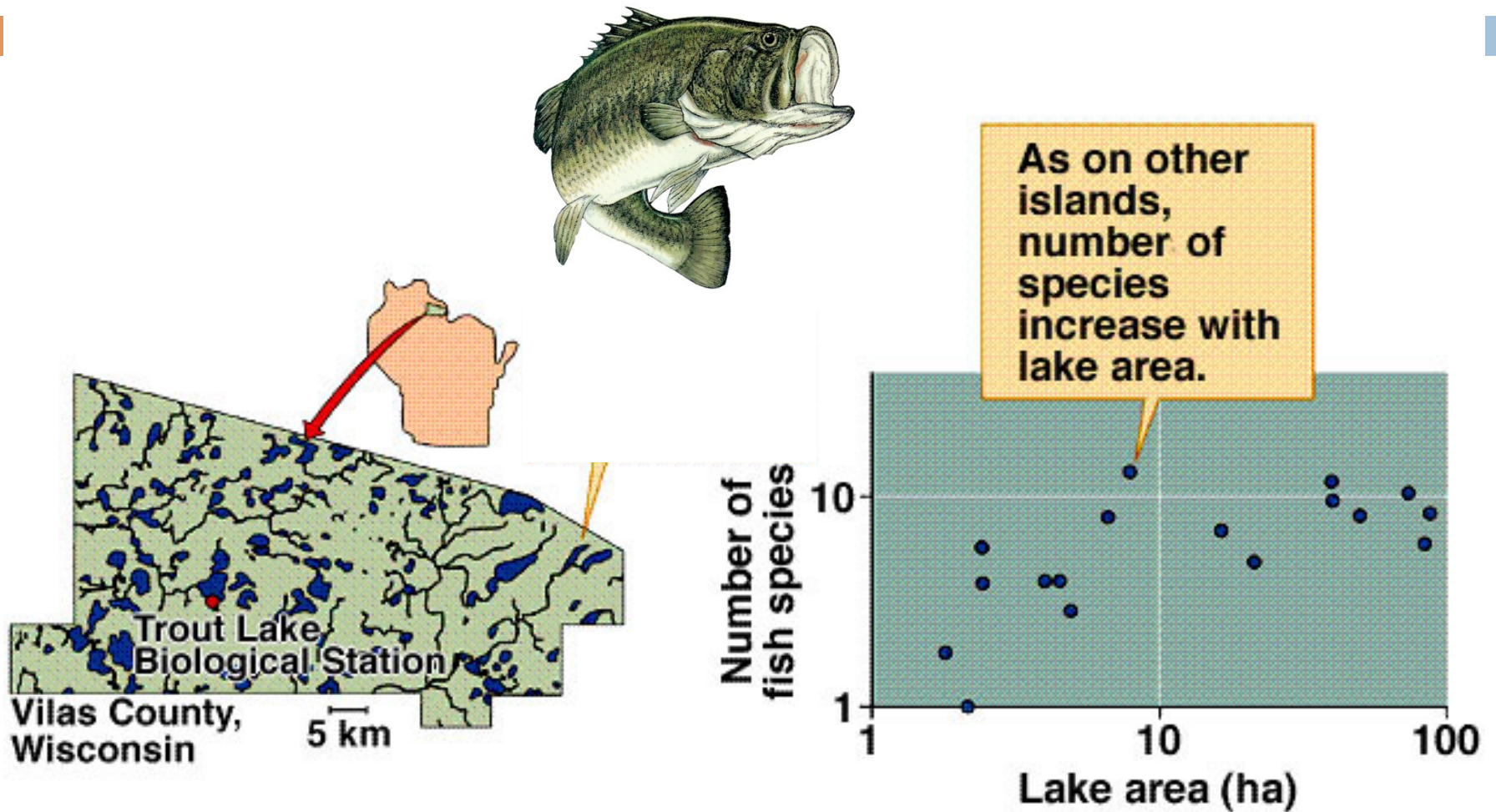


What's z for species-area curves on continental areas?

$z = 0.17$ (~ 0.15 - 0.24 for land areas)



Species-Area relationship for N. Wisconsin Lakes



Island species richness

- If $z \sim 0.3$ on islands, and $\sim 0.15-0.24$ on land
- What does that tell us about islands??

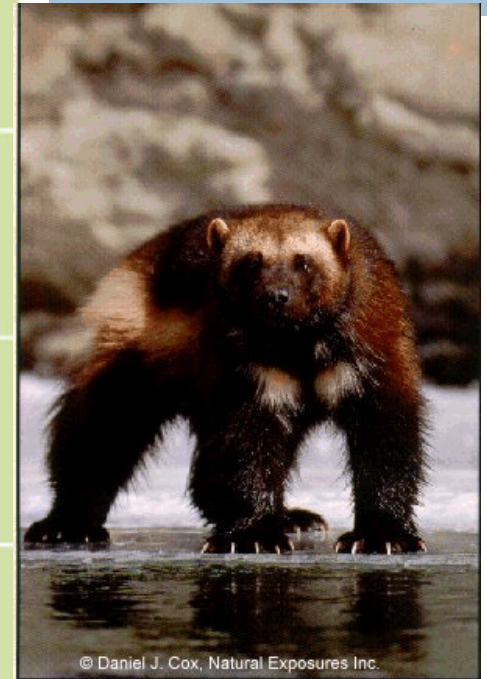
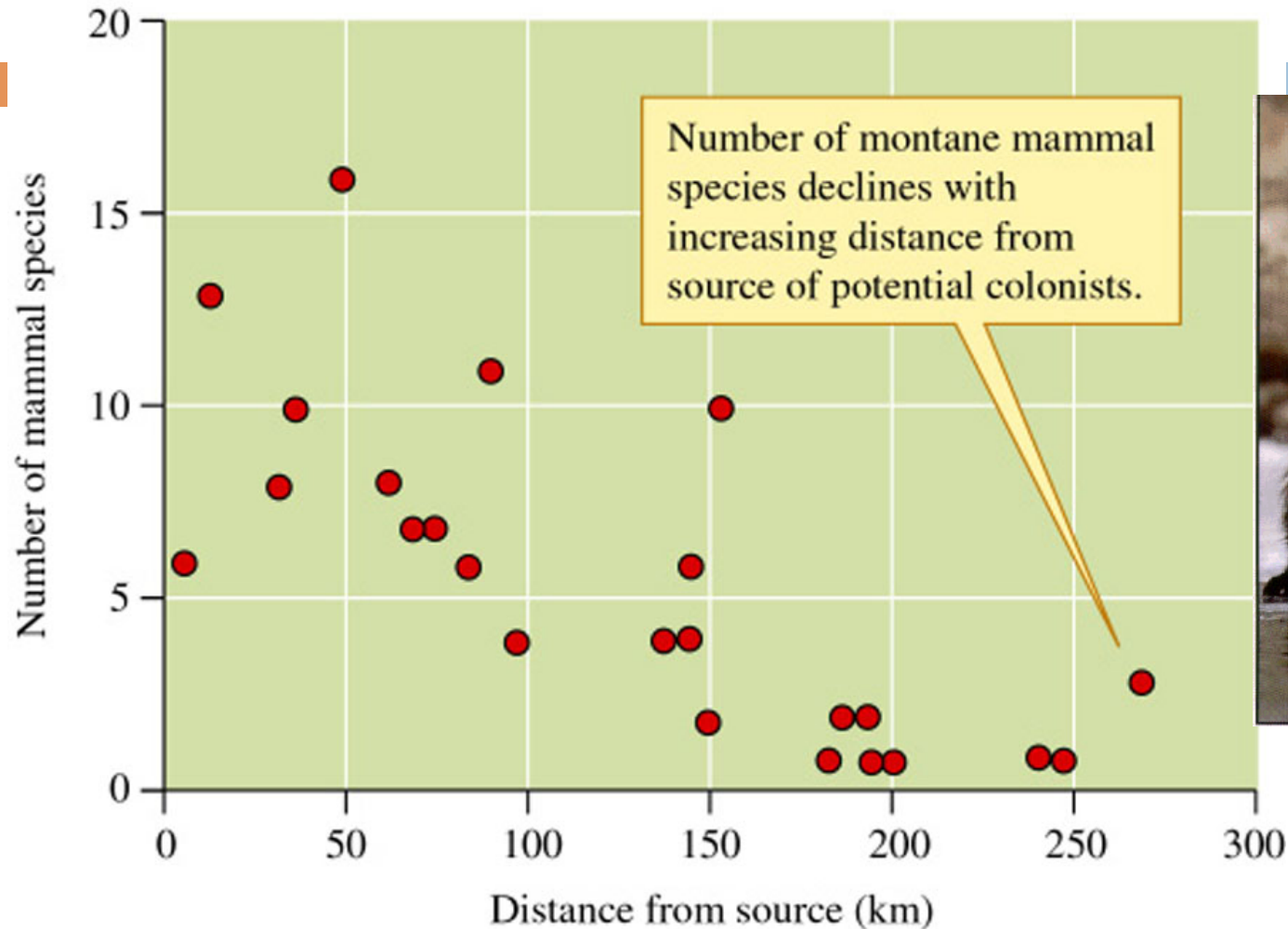
An extension of this idea:

Island biogeography



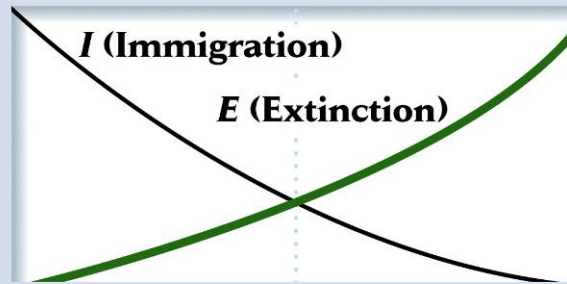
- Dynamic equilibrium theory that explains species richness of islands
- Island richness determined by **colonization** and **extinction** rates (number of species per unit time)
- Richness increases with **size** ---Why?
 - ▣ more habitats to support more species, less extinction....
- Richness decreases with **isolation** ---Why?
 - ▣ less likely to be colonized

Species richness decreases with **isolation**



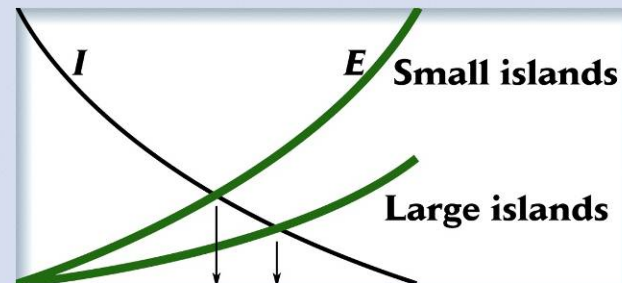
More isolated islands less likely to receive colonists (immigration low)

Rate of immigration
or extinction



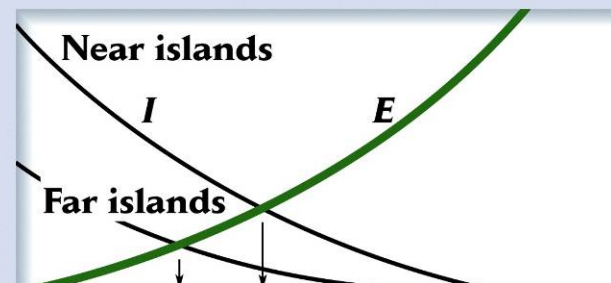
Number of species on island

Species per year



Number of species on island

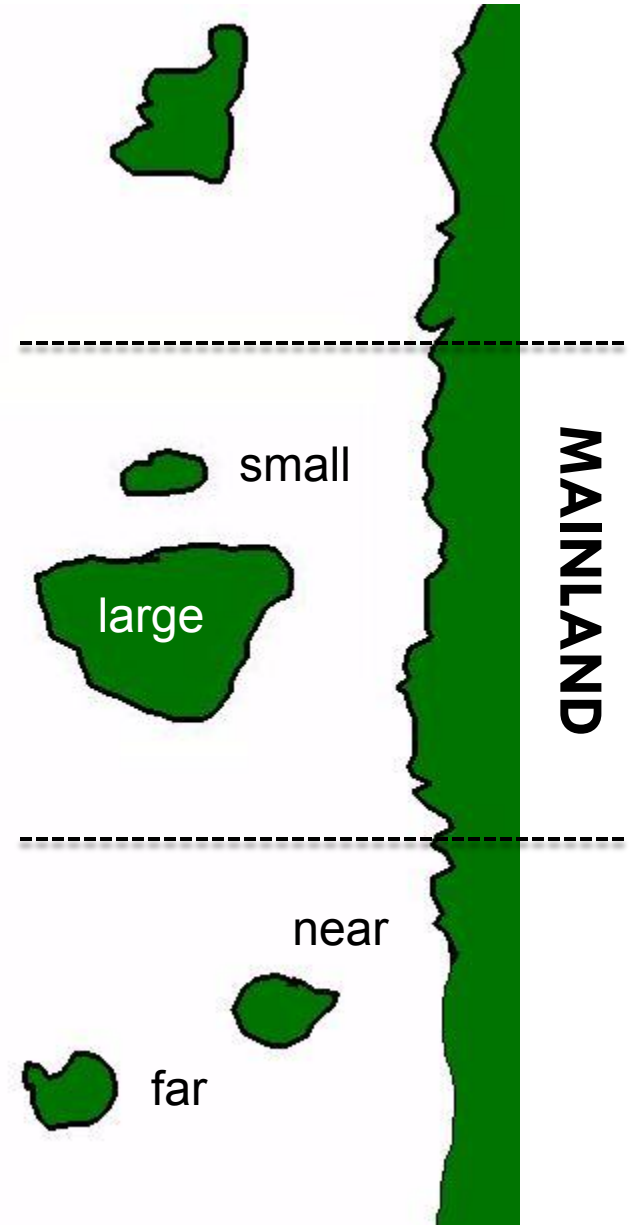
Species per year



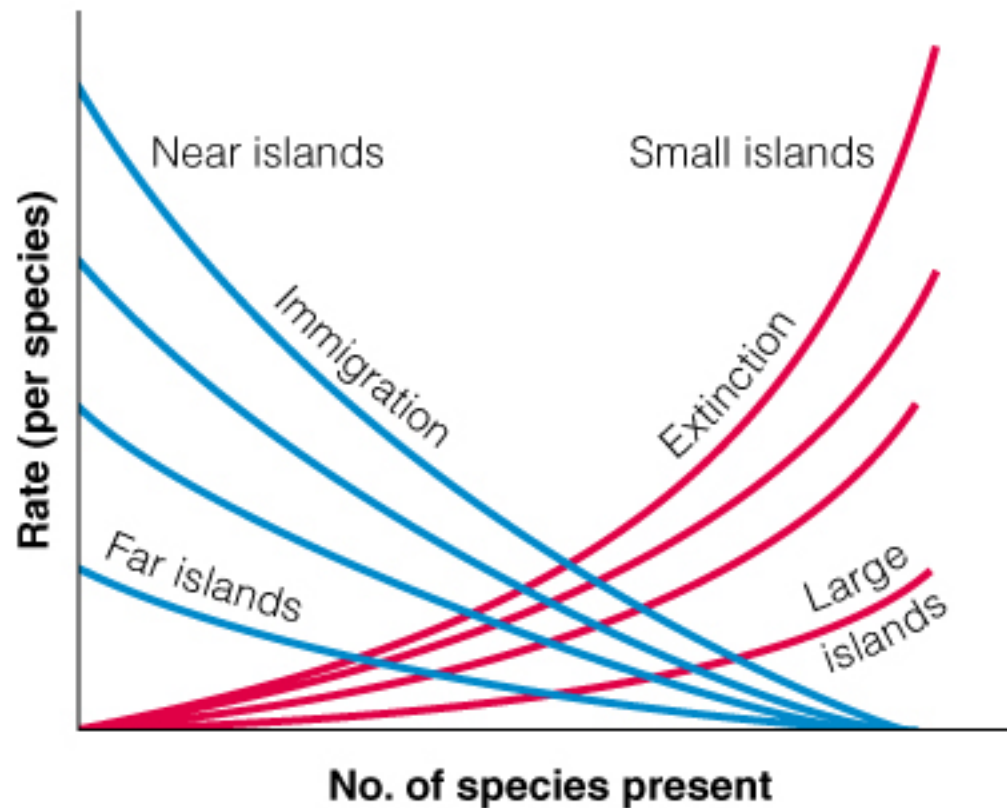
Number of species on island

Extinction more
likely for small
populations
(small islands)

Colonization
more likely for
closer islands



Island biogeography

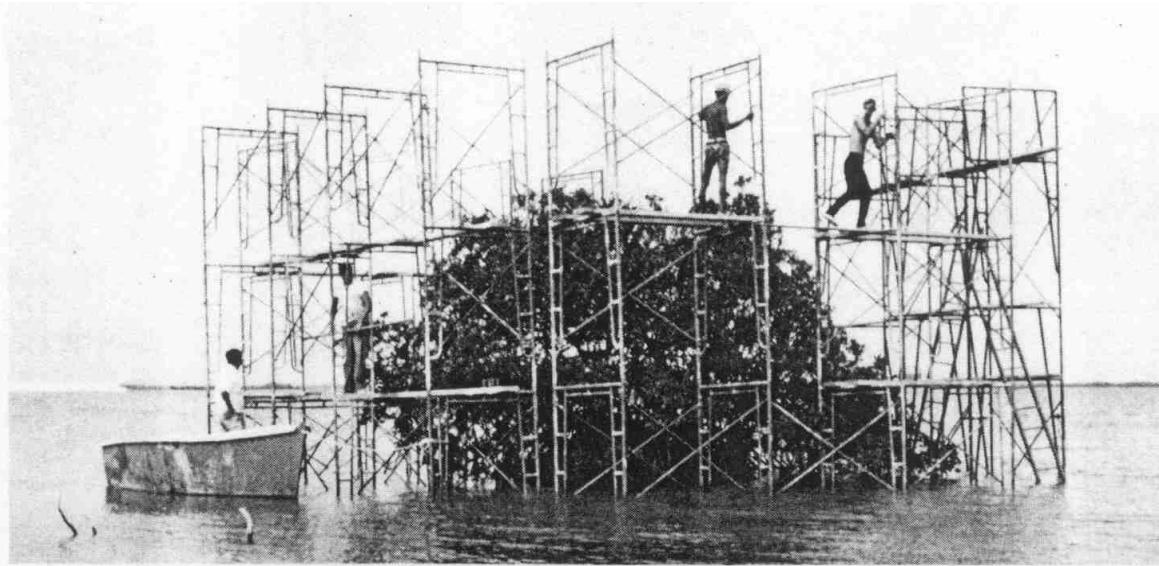


***Note:** Immigration & Colonization used interchangeably

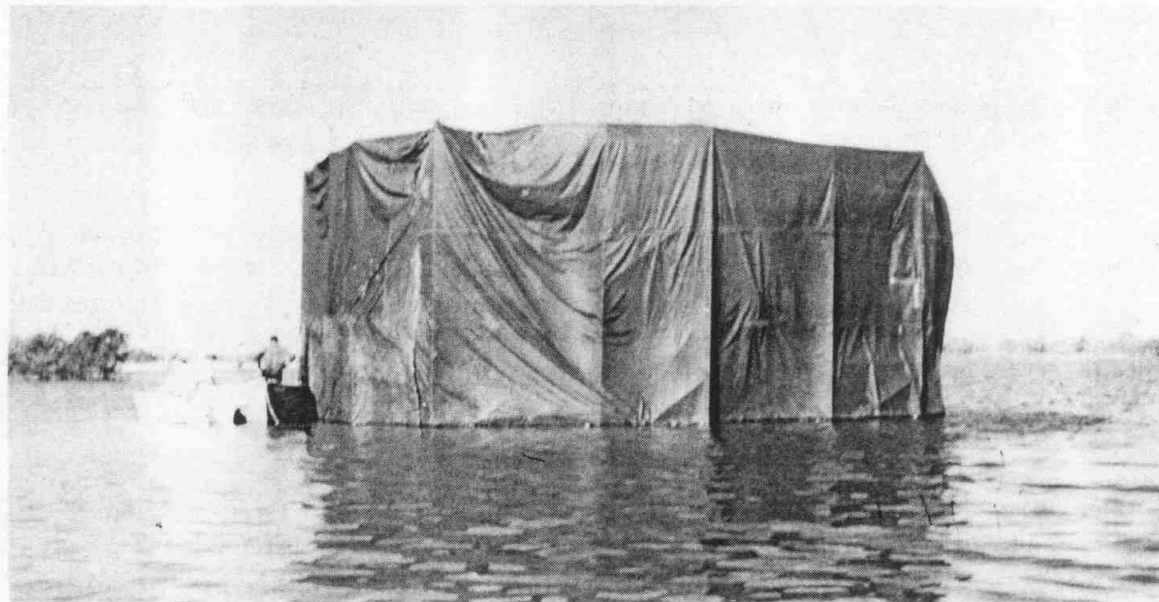
Experimental test of island biogeography



- Defaunation experiment by Simberloff and Wilson
- Methods:
 - ▣ Survey small mangrove islands for arthropods.
 - ▣ Cover islands with plastic and spray with insecticide (gets rid of all arthropods)
 - ▣ Observe colonization/ succession over one year.
 - ▣ How many and what species return?



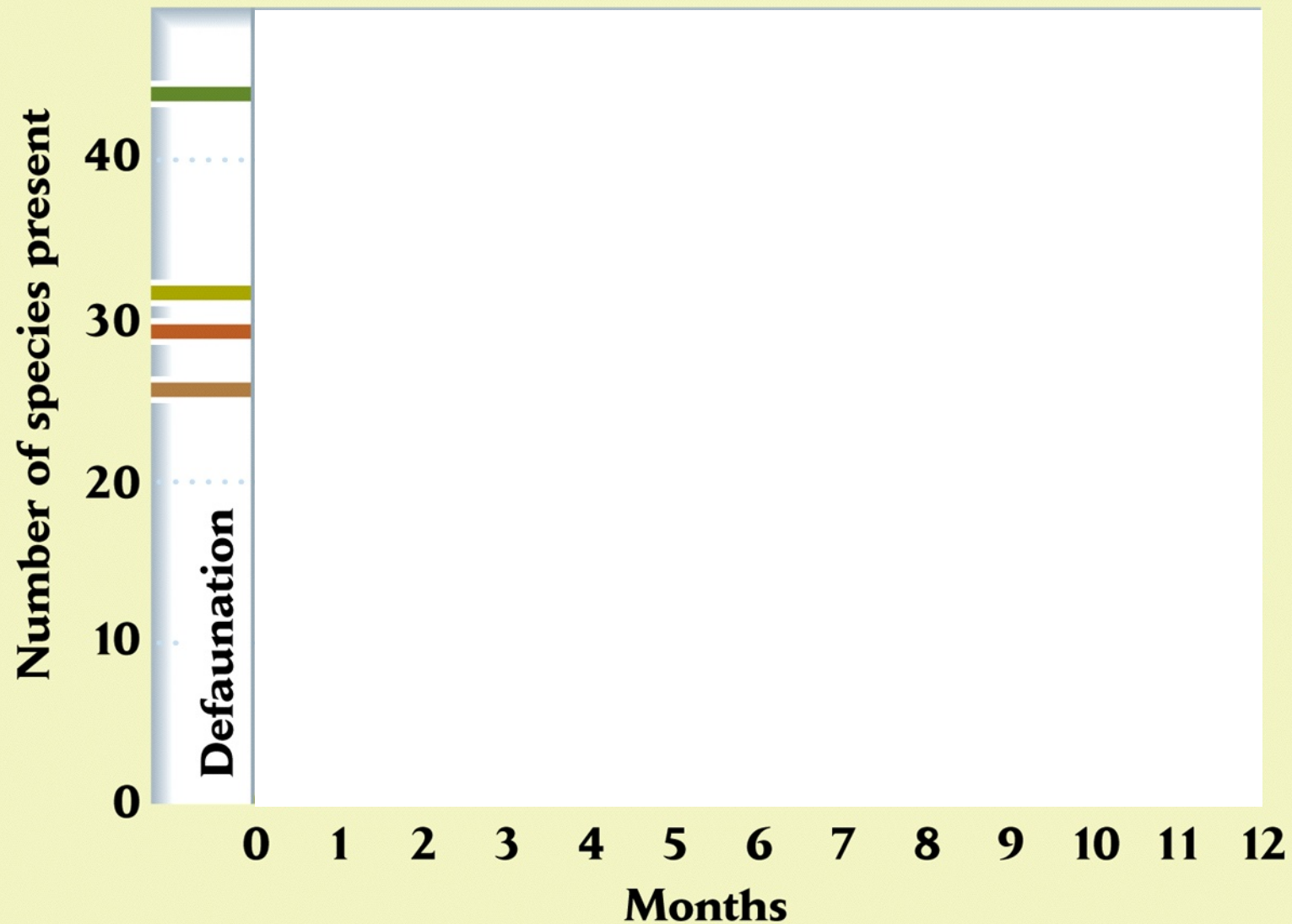
(A)



(B)

FIGURE 19-11 A mangrove island covered by a tent for the experimental application of insecticide. (A) Construction of scaffold around a mangrove island, Florida. (B) Completed tent around the mangrove island. (Photos by Daniel Simberloff, Florida State University.)

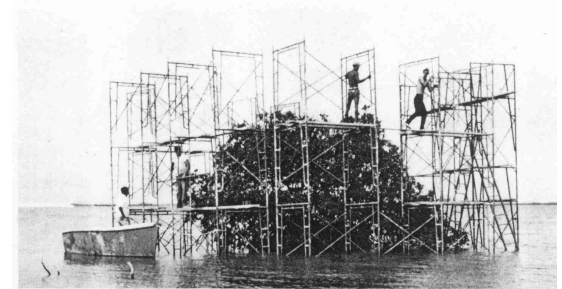
Simberloff and Wilson's experiment Florida Keys



Experimental Results

Simberloff & Wilson

- Species richness on islands returned to levels similar to before defaunation
- Closer, larger islands had more species
- The precise species identity was not consistent, only the total number of species
 - Order of colonization and species interactions important for “who” composes the community
- Support for **dynamic equilibrium**



(A)



(B)

FIGURE 19-11 A mangrove island covered by a tent for the experimental application of insecticide. (A) Construction of scaffold around a mangrove island, Florida. (B) Completed tent around the mangrove island. (Photos by Daniel Simberloff, Florida State University.)

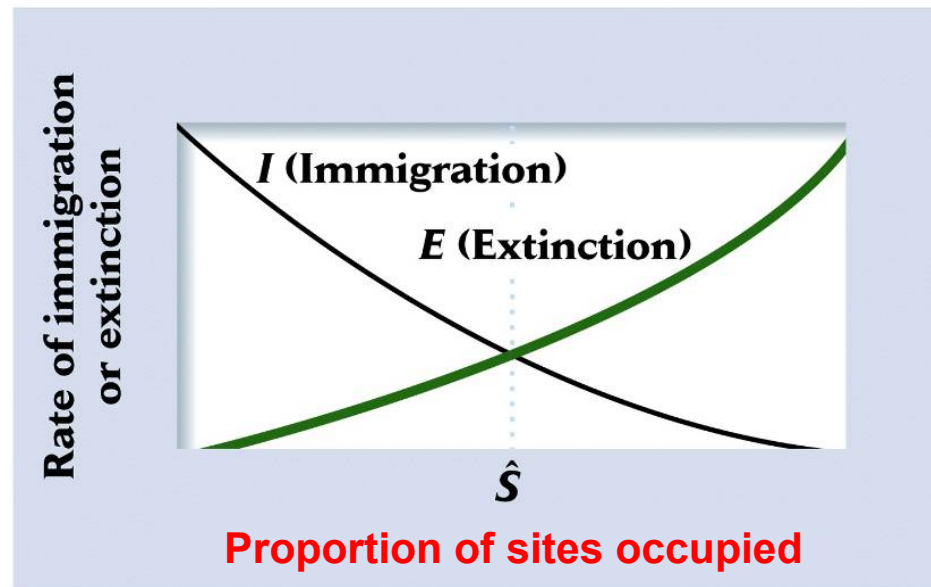
And now for a big mental leap...
from diversity to individual population
dynamics

Metapopulations

- Collection of subpopulations of 1 species
- **Proportion of sites occupied** determined by **colonization** and **extinction** rates at each site



Rana cascadae



And now for a big mental leap...
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Metapopulations



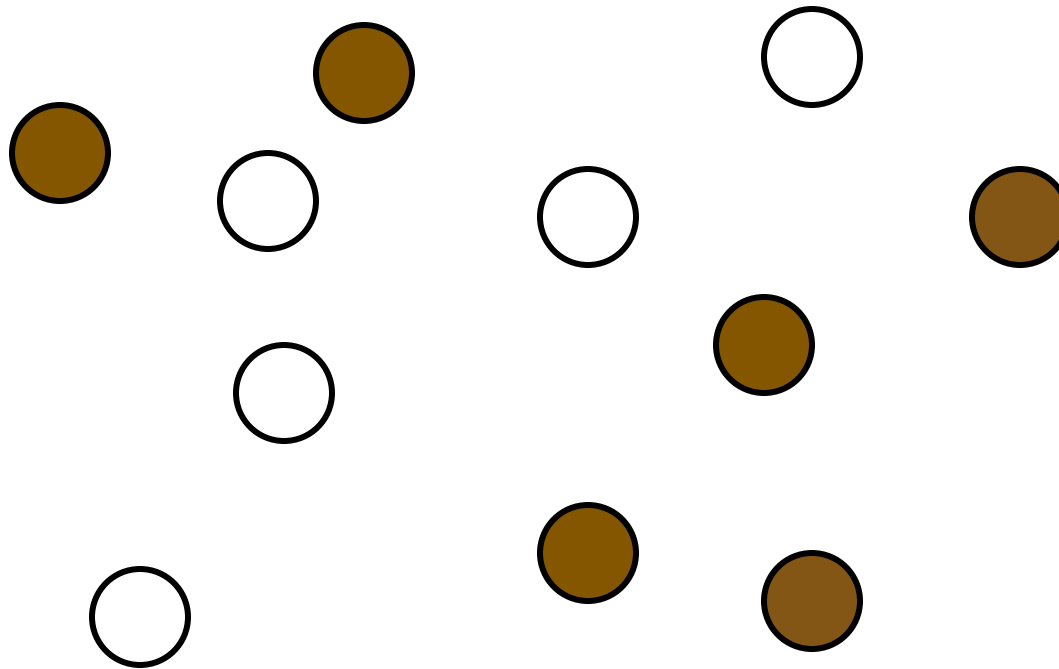
- Collection of subpopulations of 1 species
- **Proportion of sites occupied** determined by **colonization** and **extinction** rates at each site
 - ▣ Connected by individual movement (dispersal between sites provides colonists)
 - ▣ Individual sites may be colonized in one year, and extinct the next
 - ▣ Individual site dynamics are variable, but overall “metapopulation” is stable



Rana cascadae

Metapopulation dynamics

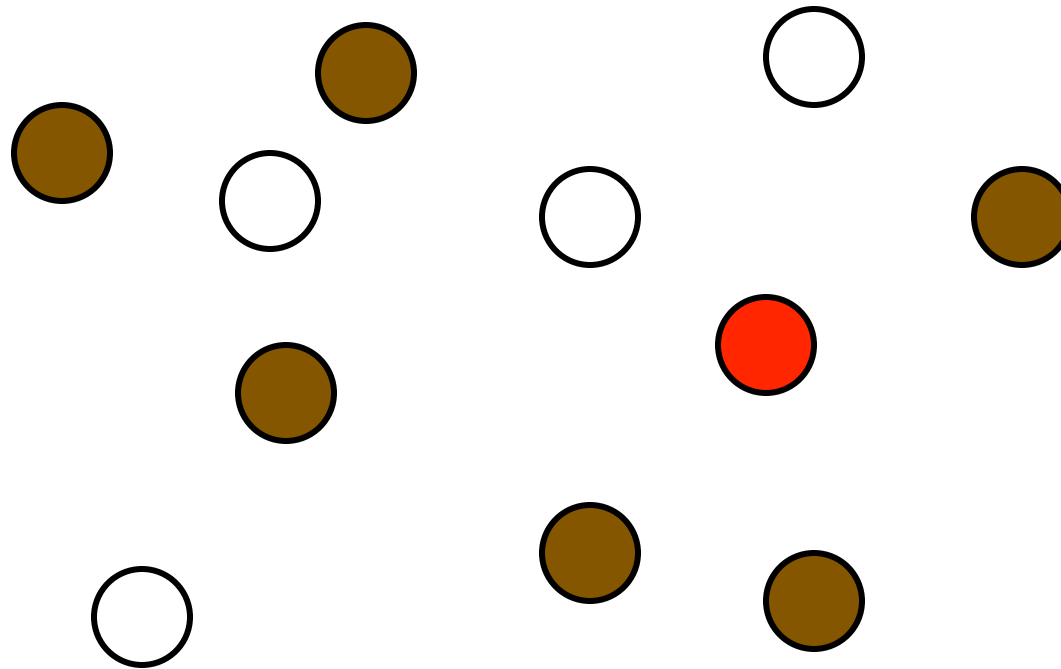
Given a fixed **colonization** rate and **extinction** rate...



brown=occupied
white=empty

Metapopulation dynamics

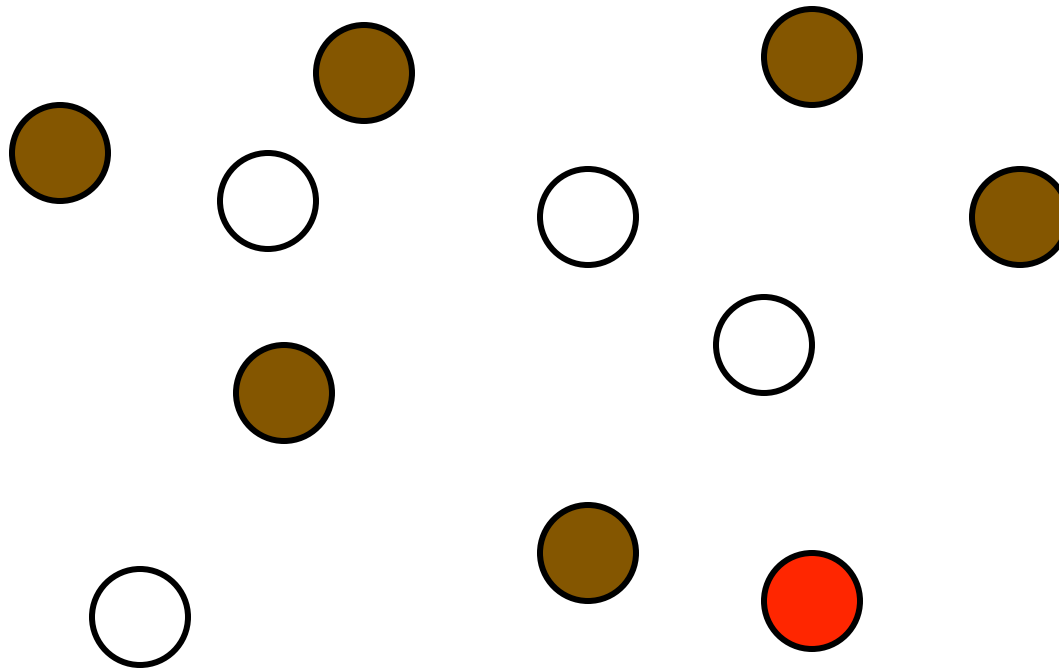
Given a fixed **colonization** rate and **extinction** rate...



red = went extinct
since last time
step

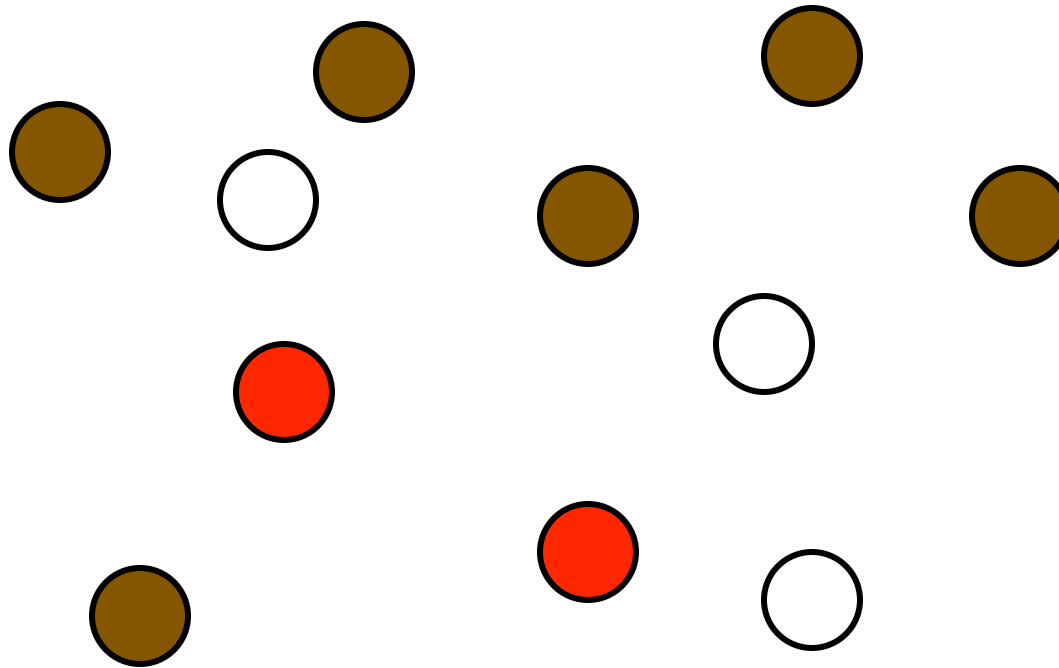
Metapopulation dynamics

Given a fixed **colonization** rate and **extinction** rate...



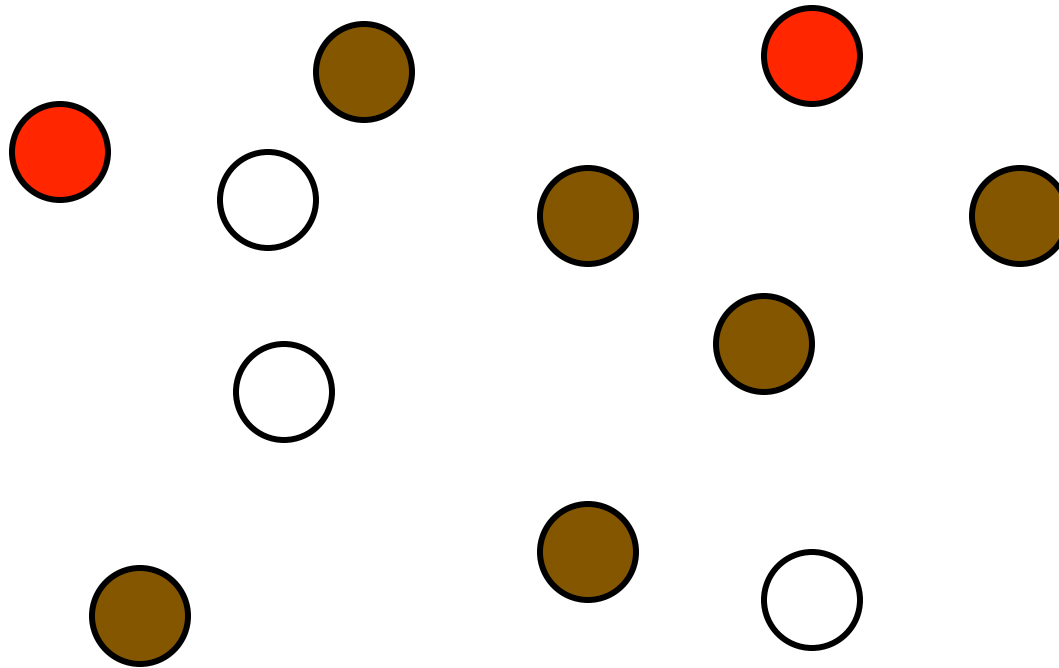
Metapopulation dynamics

Given a fixed **colonization** rate and **extinction** rate...



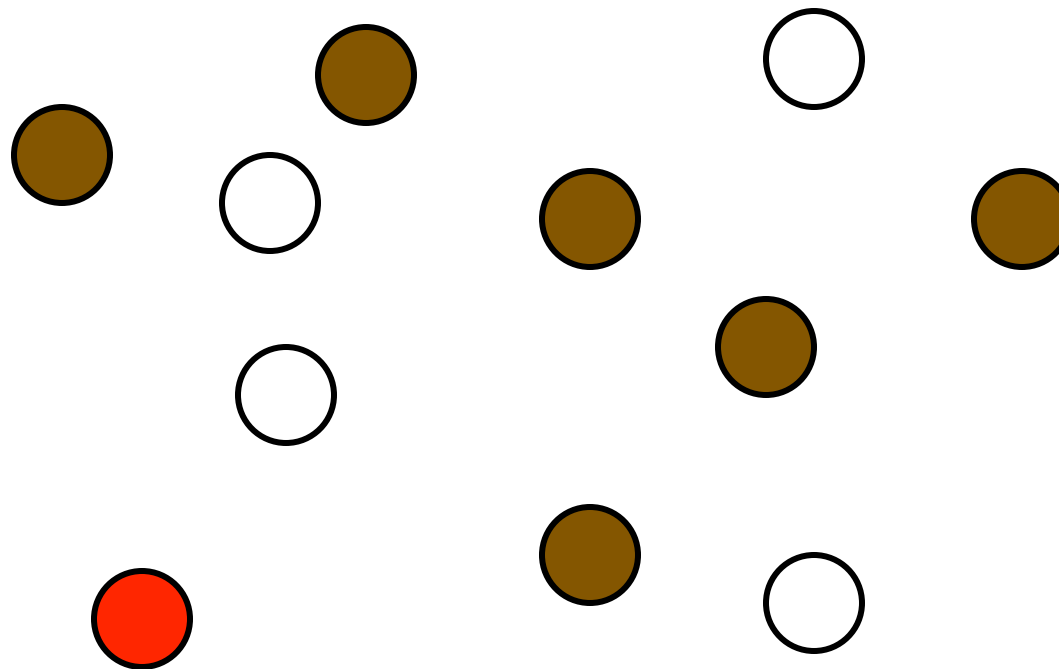
Metapopulation dynamics

Given a fixed **colonization** rate and **extinction** rate...



Metapopulation dynamics

Given a fixed **colonization** rate and **extinction** rate...



What is the DYNAMIC EQUILIBRIUM here?

Proportion of sites occupied by this single species ~ 6 of 11 sites

Classic metapopulation

- Governed by fixed colonization & extinction rates
- Subpopulations have independent dynamics and are connected by dispersal
- All patches of identical quality (not realistic)

