Mountain Biodiversity: where are most species of vertebrates and why?

Christy M. McCain
Assistant Professor & Curator of Vertebrates
University of Colorado at Boulder

Talk Outline

- Overview of Mountain Biodiversity
- Where are the Most Species?
- What Drives Biodiversity Patterns?
- Tests in Colorado Rocky Mountains

First, a few definitions…

- Biodiversity
- Vertebrate
- Mountain

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- Biodiversity = the variety of all forms of life, from genes to species within a location, ecosystem, or on earth.

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- TODAY: Biodiversity = number of vertebrates species within a mountain ecosystem

Biodiversity Research

- Where on Earth are there lots of species?
- Where on Earth are there few species?

Biodiversity Research

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- Where on Earth are there few species?

- WHY?

Biodiversity Research

- Where on Earth are there lots of species?
- Where on Earth are there few species?

- WHY?

- What can these patterns tell us about conservation strategies for biodiversity?

First, a few definitions…

- Biodiversity
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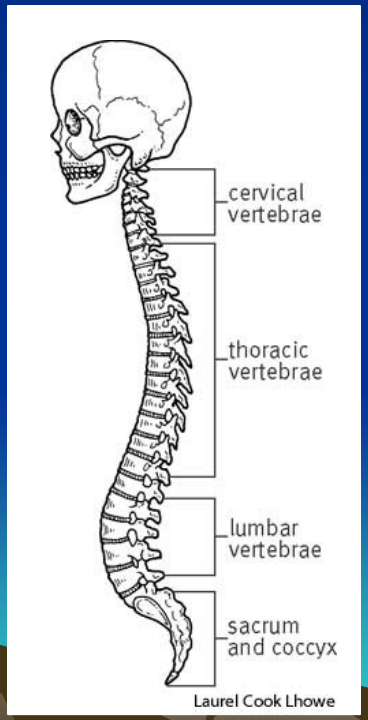
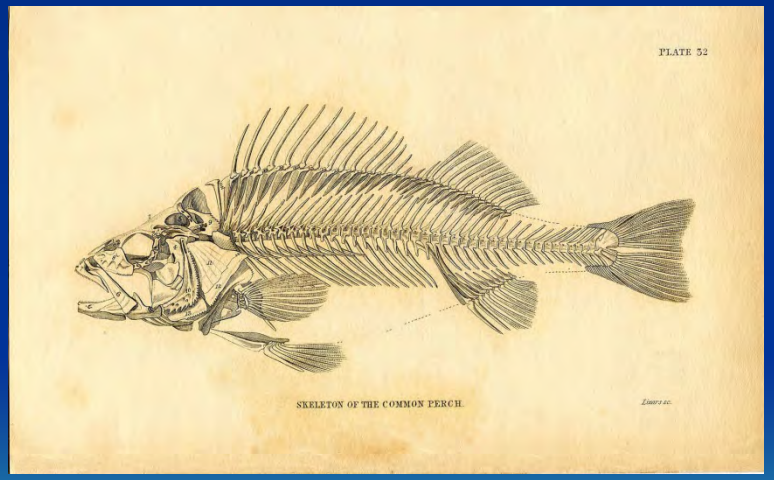
First, a few definitions…

- Vertebrate = an animal with a skull and backbones protecting its brain and spinal cord





First, a few definitions…

- Vertebrate = an animal with a skull and backbones protecting its brain and spinal cord, including:

Fish Amphibians Reptiles Birds Mammals





First, a few definitions…

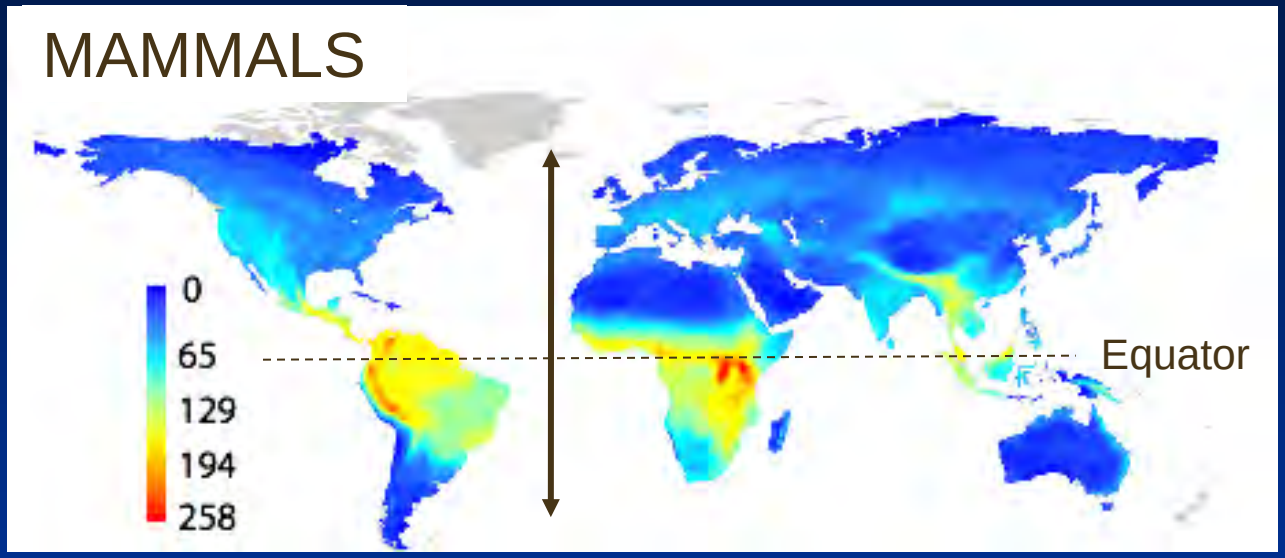
- Biodiversity
- Vertebrate
- Mountain = a region of the earth's surface with a large rise from the surrounding land across a broad span of elevations

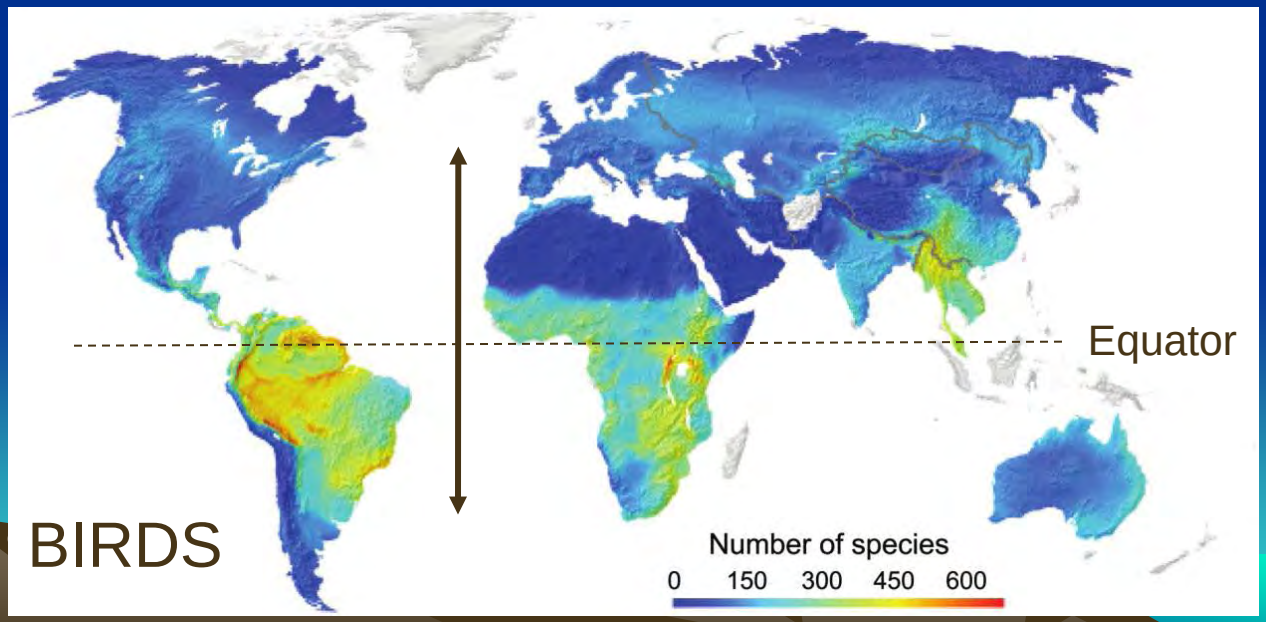
Elevational Gradient

Mtn Top

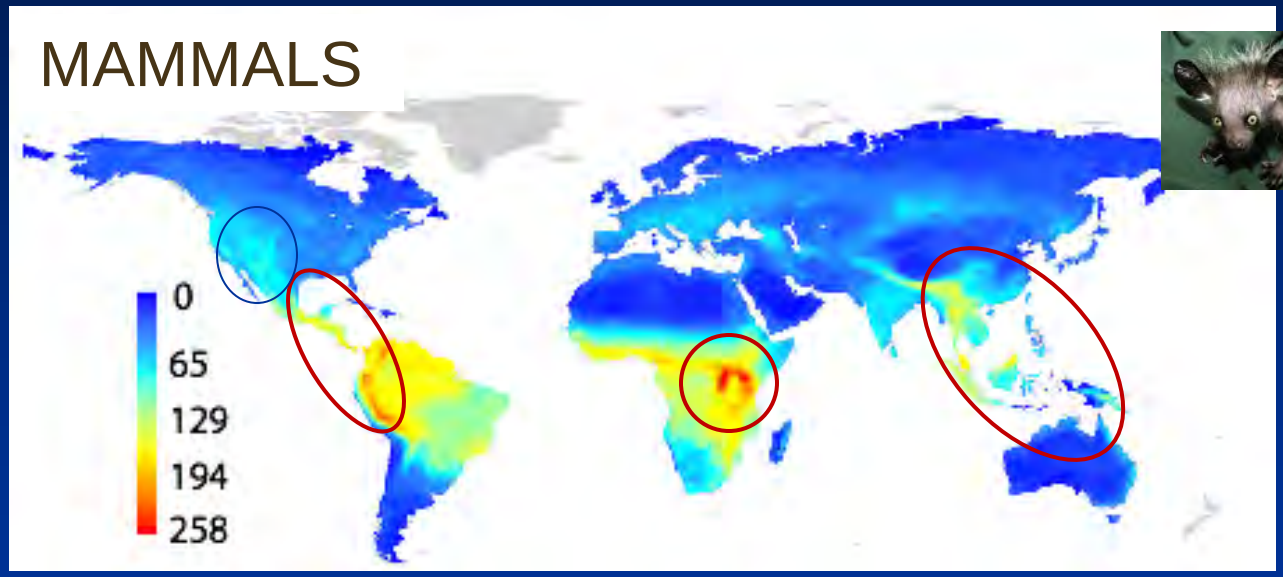
Mtn Base

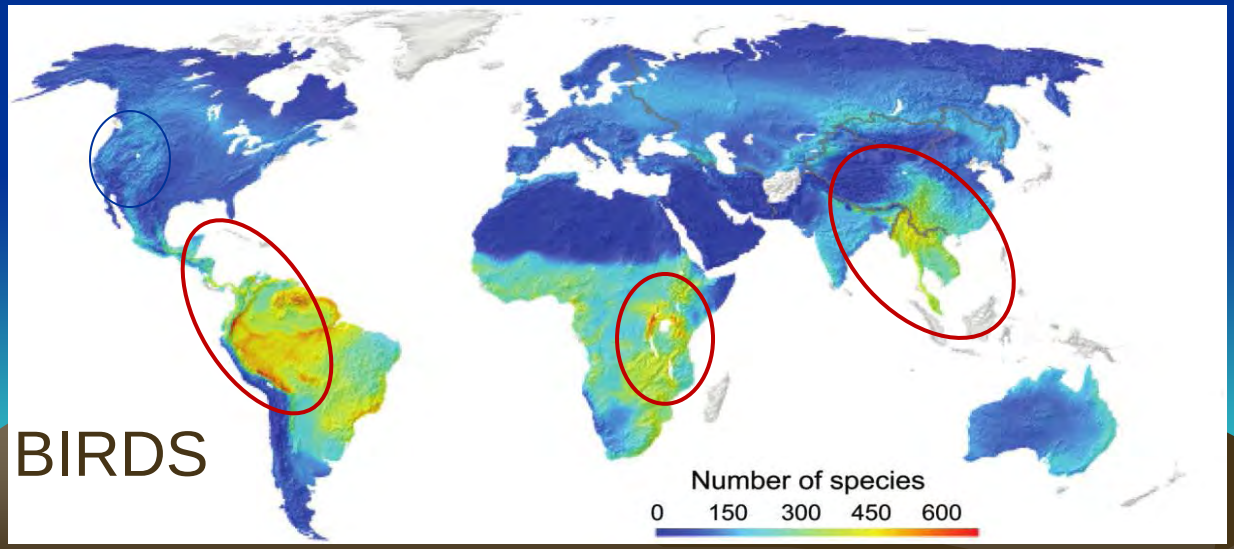
Global Biodiversity





Why Study Mountains?





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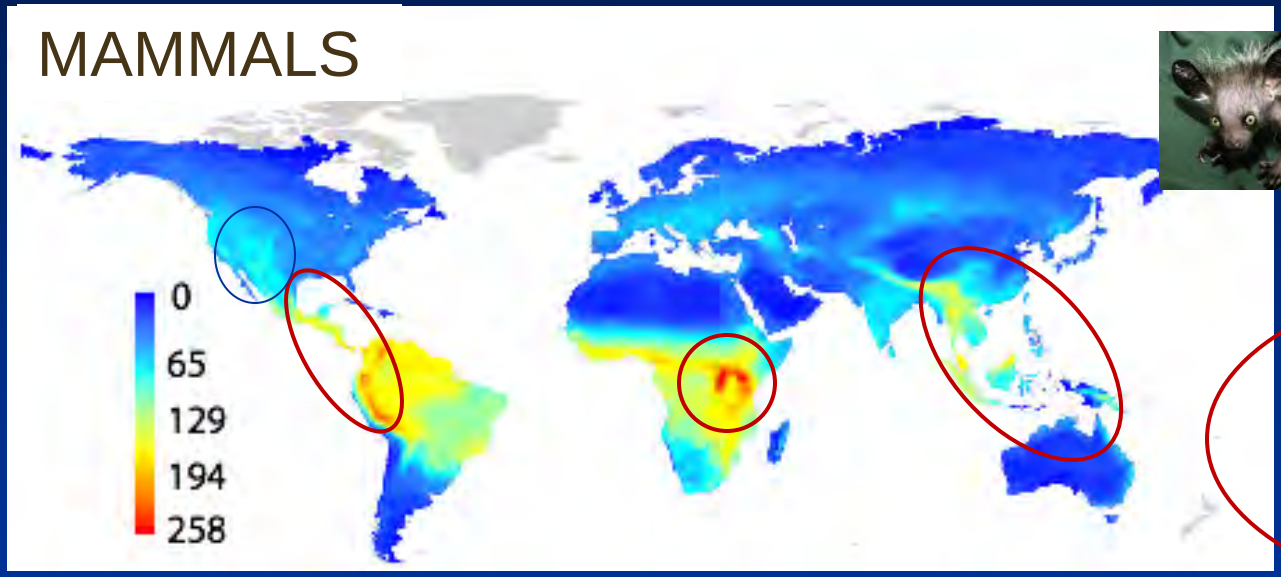
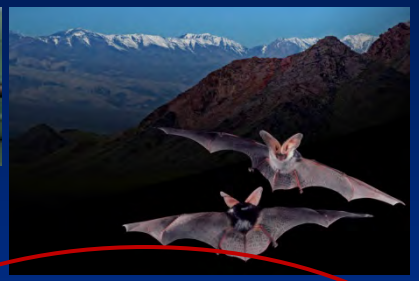
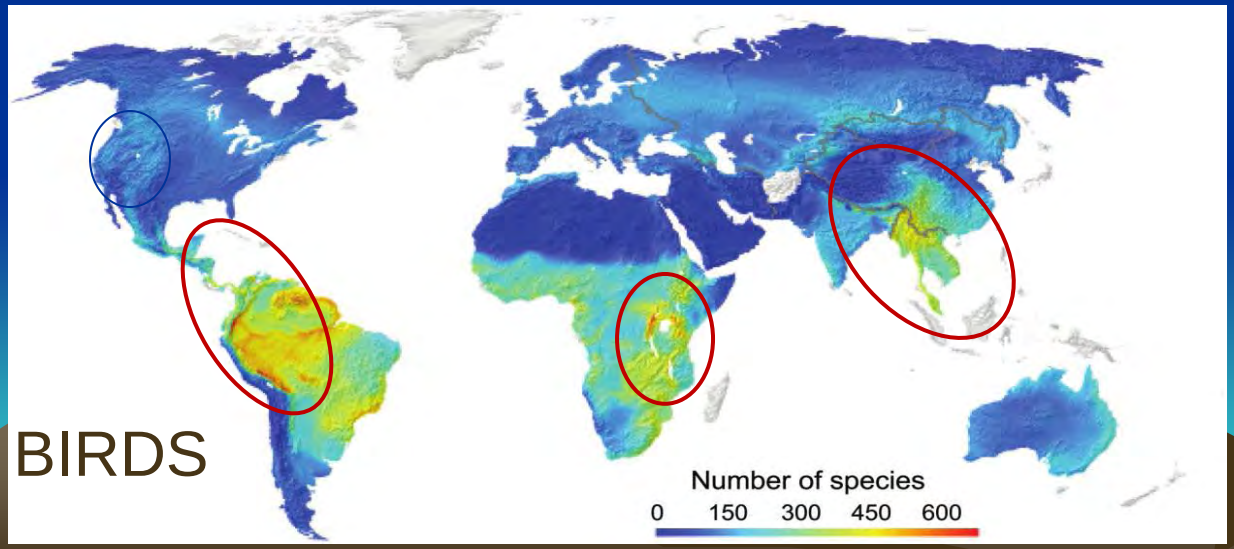
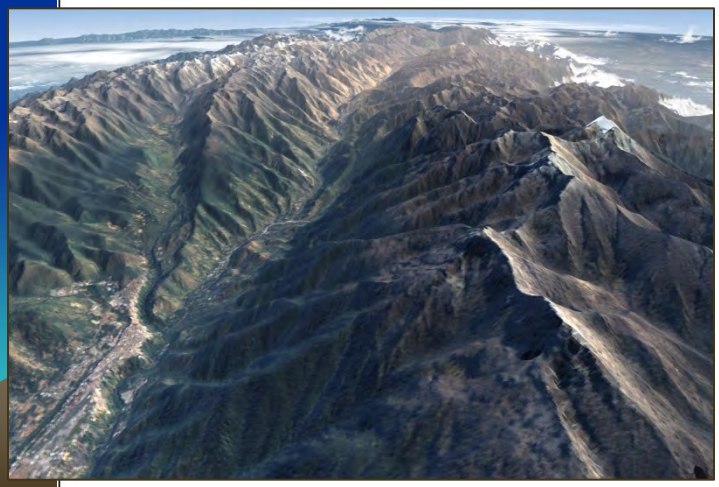




High Diversity:

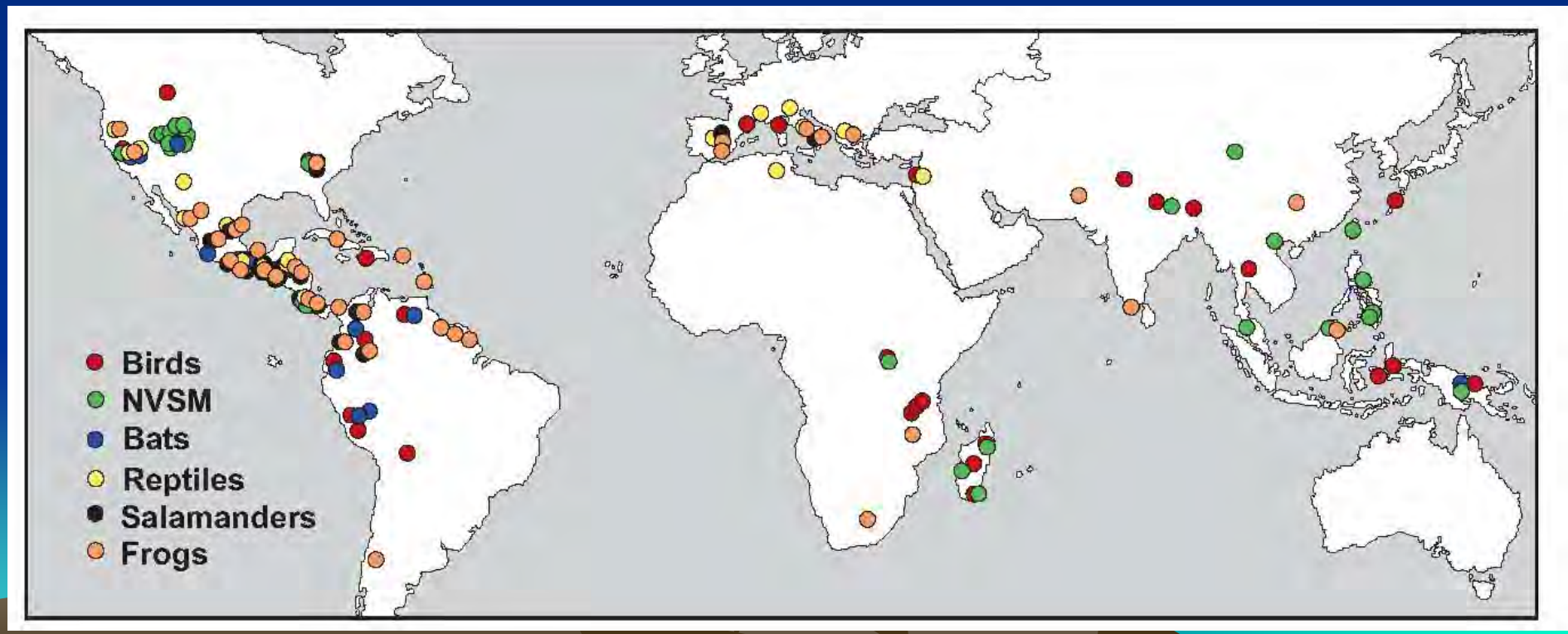
- All species
- Endemics
- Rare & endangered





Global Natural Experiment

Global Mountain Analyses



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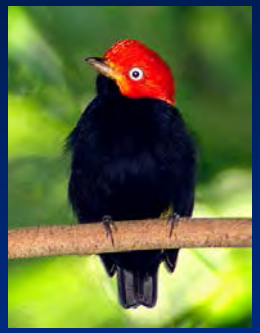
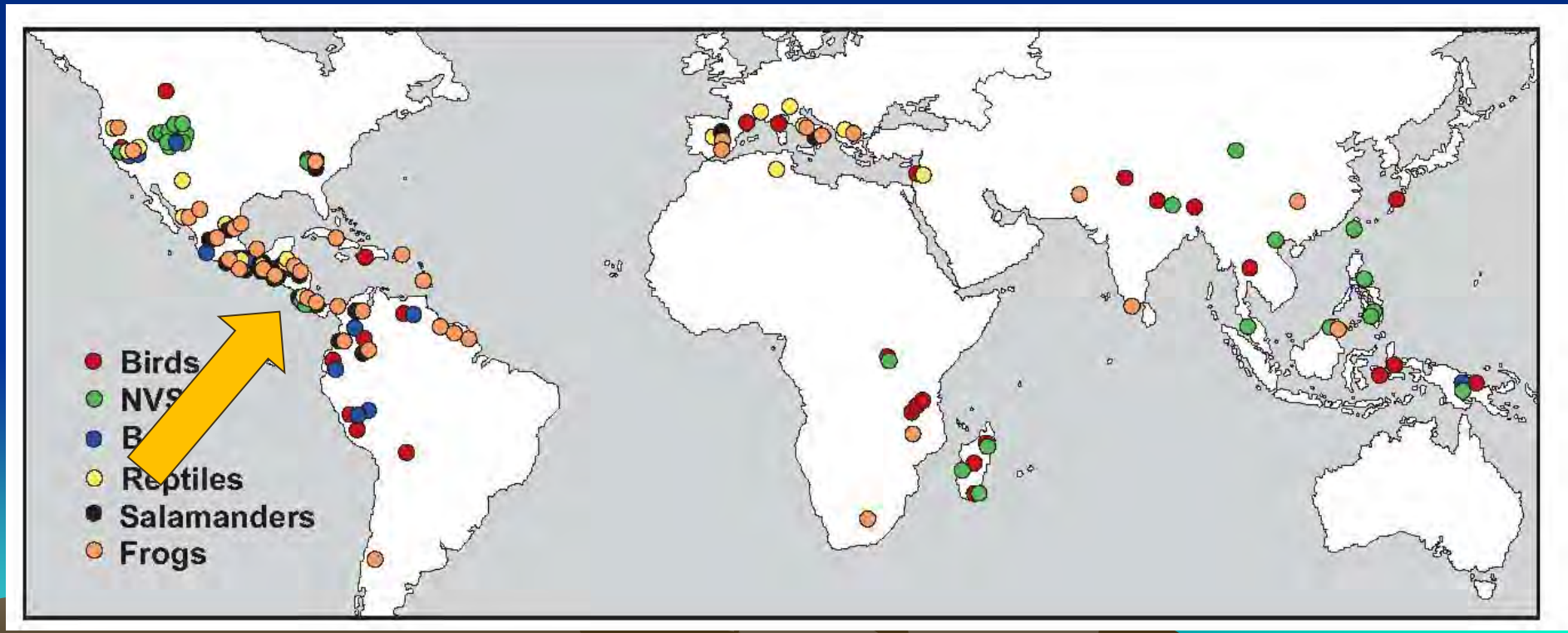
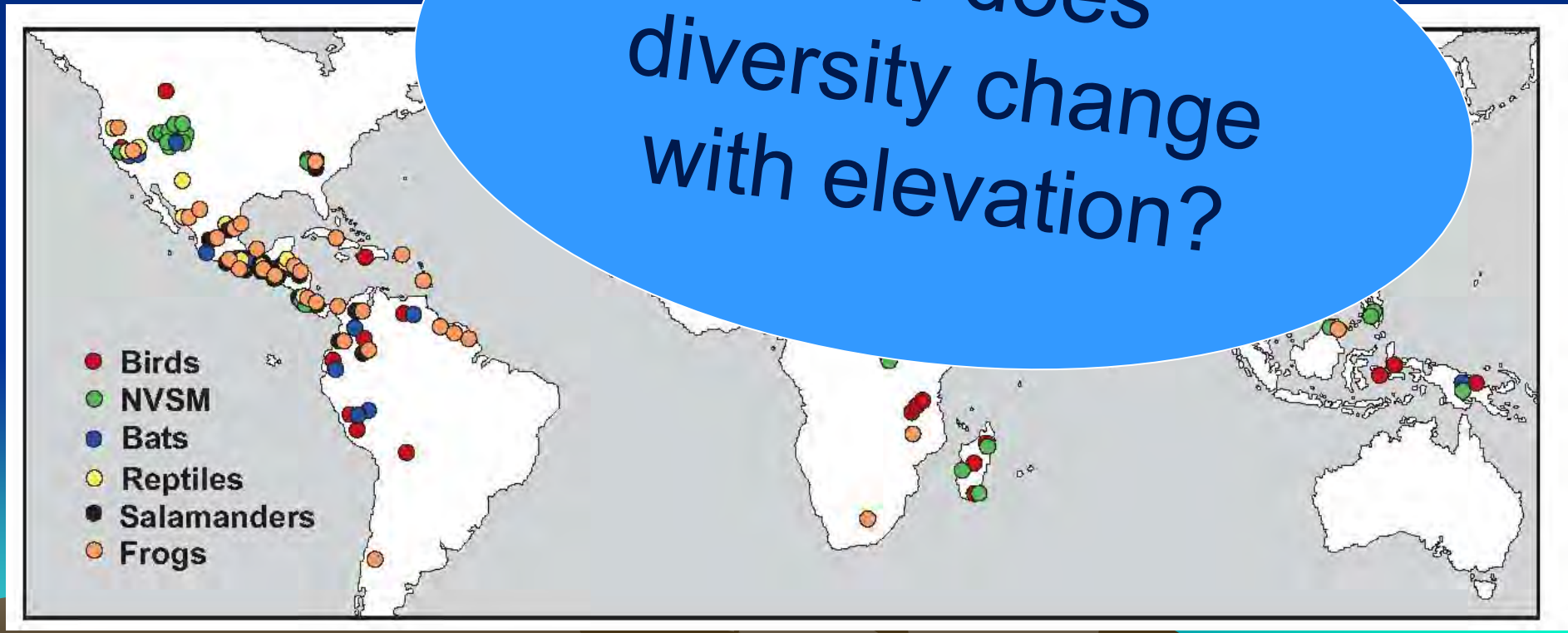


Global Mountain Analyses

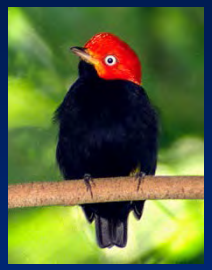



How does diversity change with elevation?



Global Mountain Analyses





What are the patterns of diversity on mountains?

Historically….

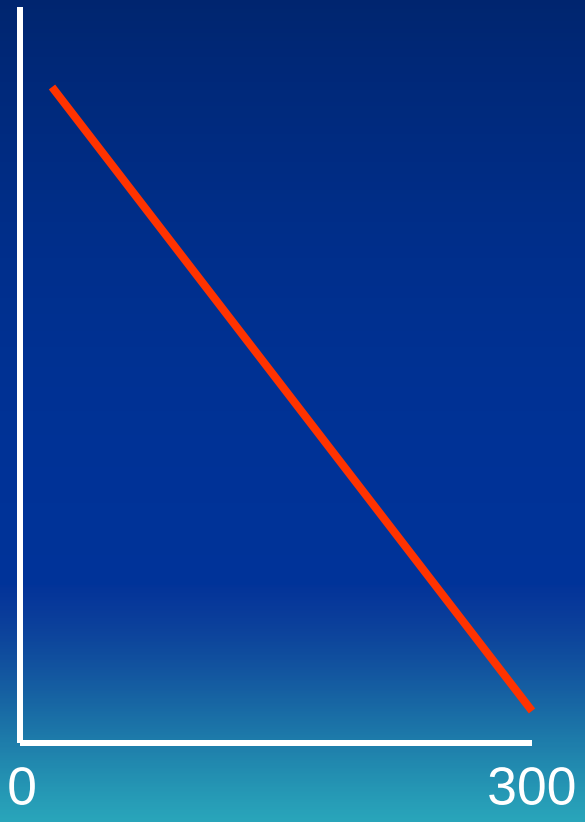
Elevation (m) →

Historically: Decreasing Diversity

Few Species

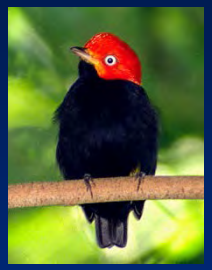
Lots of Species

Historically: Decreasing Diversity



Global Mountain Analyses





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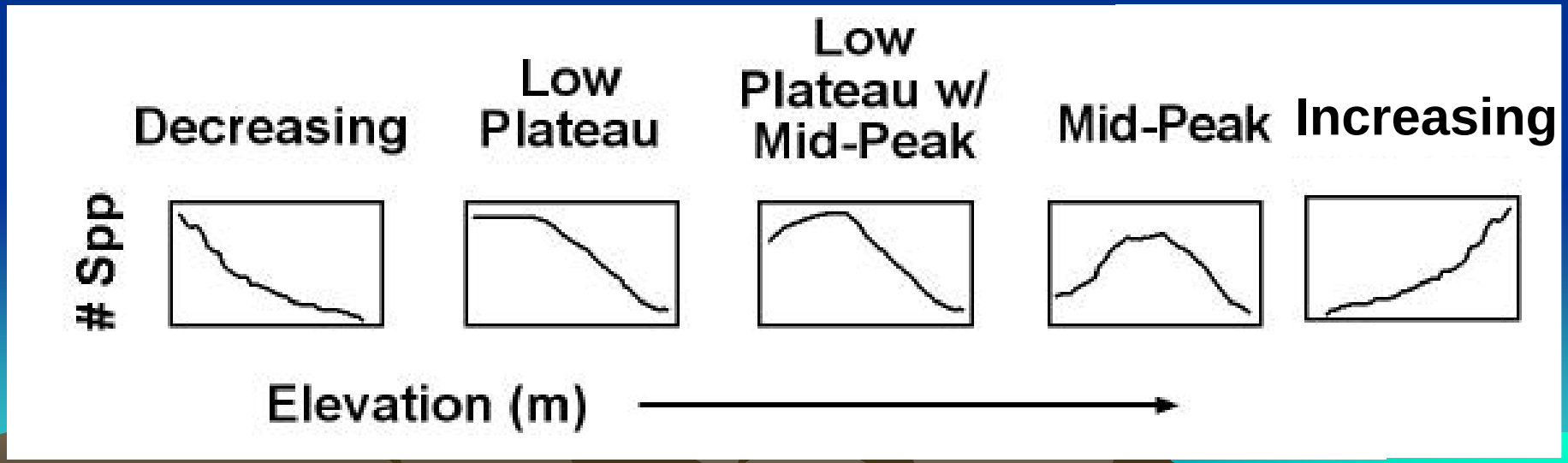
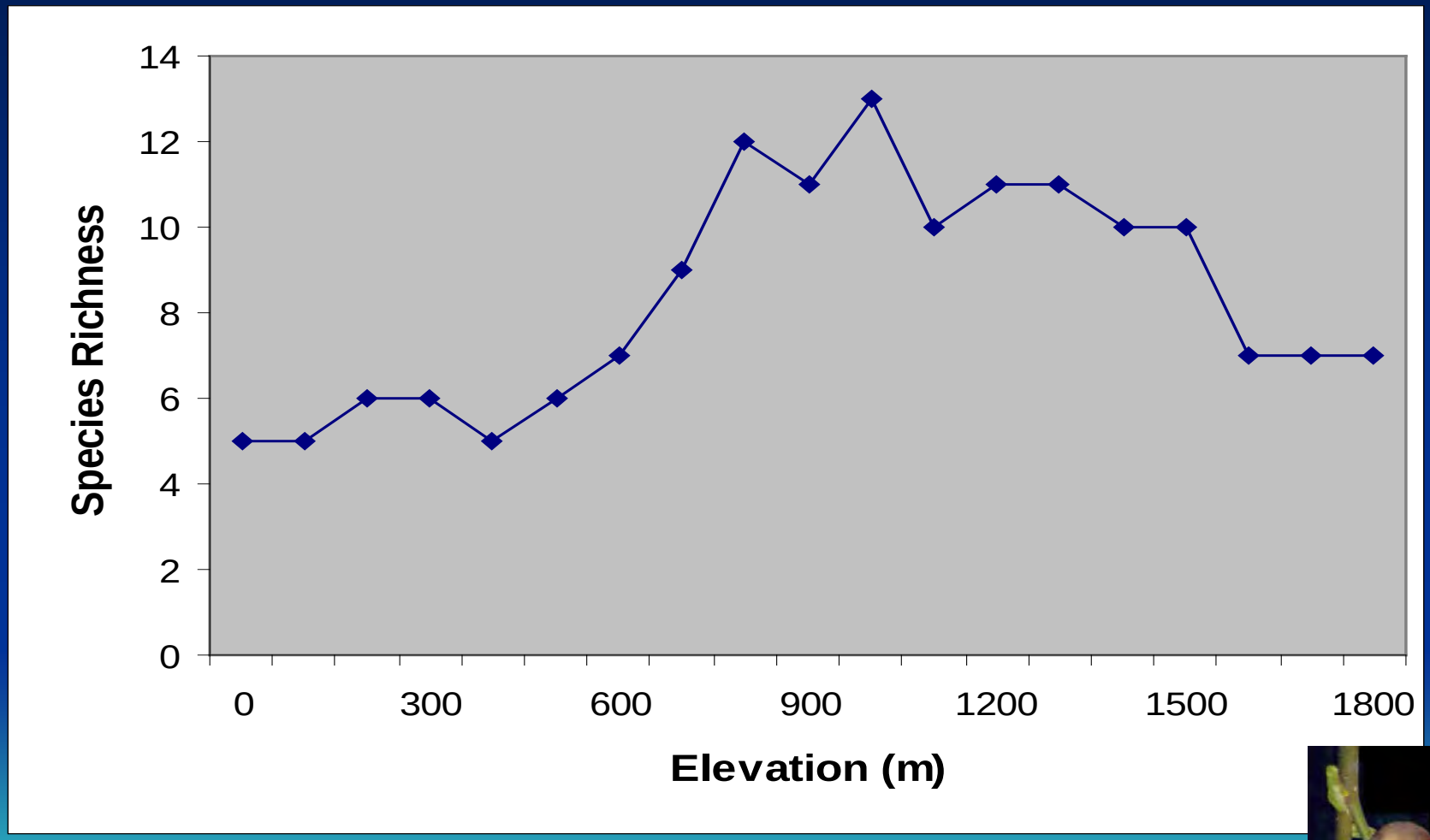
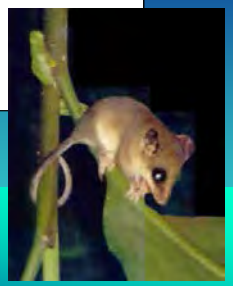


Field Studies:
Elevational Gradient in Costa Rica

Elevational Diversity Pattern

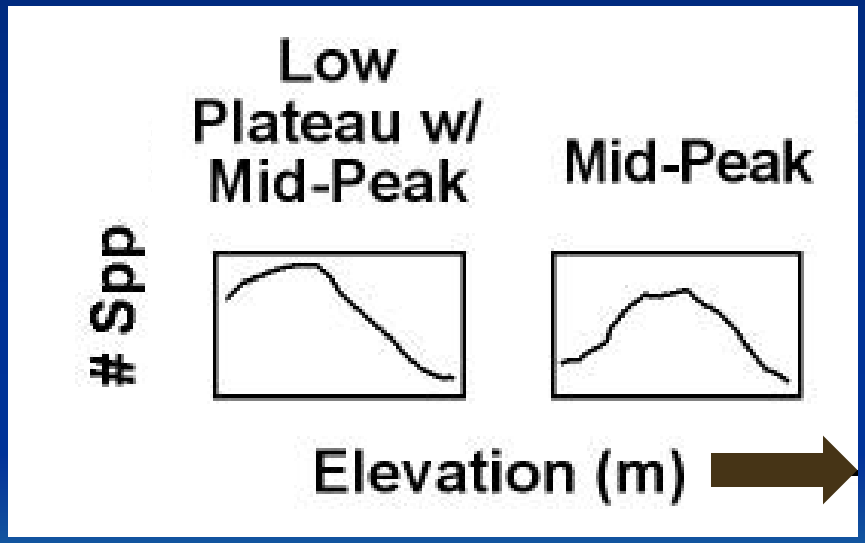




Global Mountain Analyses

Non-volant Small Mammals:

3% 97%



McCain 2005 Ecology

Global Mountain Analyses

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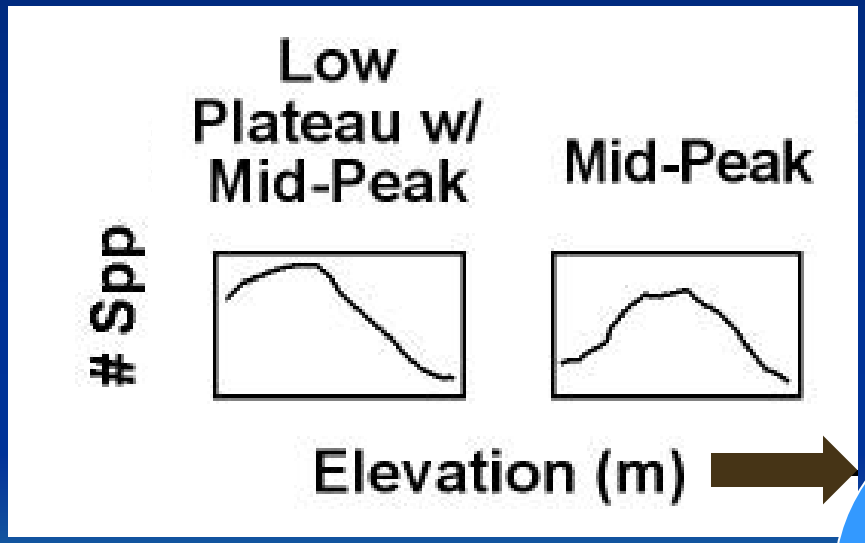


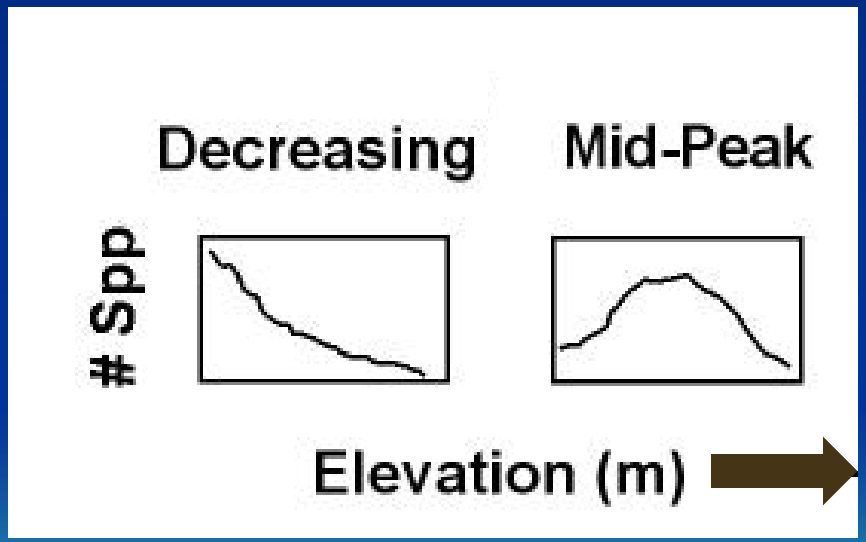
Small Mammal pattern in the Front Range

McCain 2005 Ecology

Global Mountain Analyses

Bats:

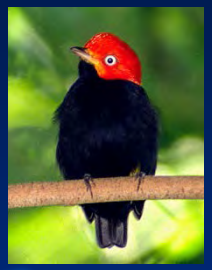
50% 50%



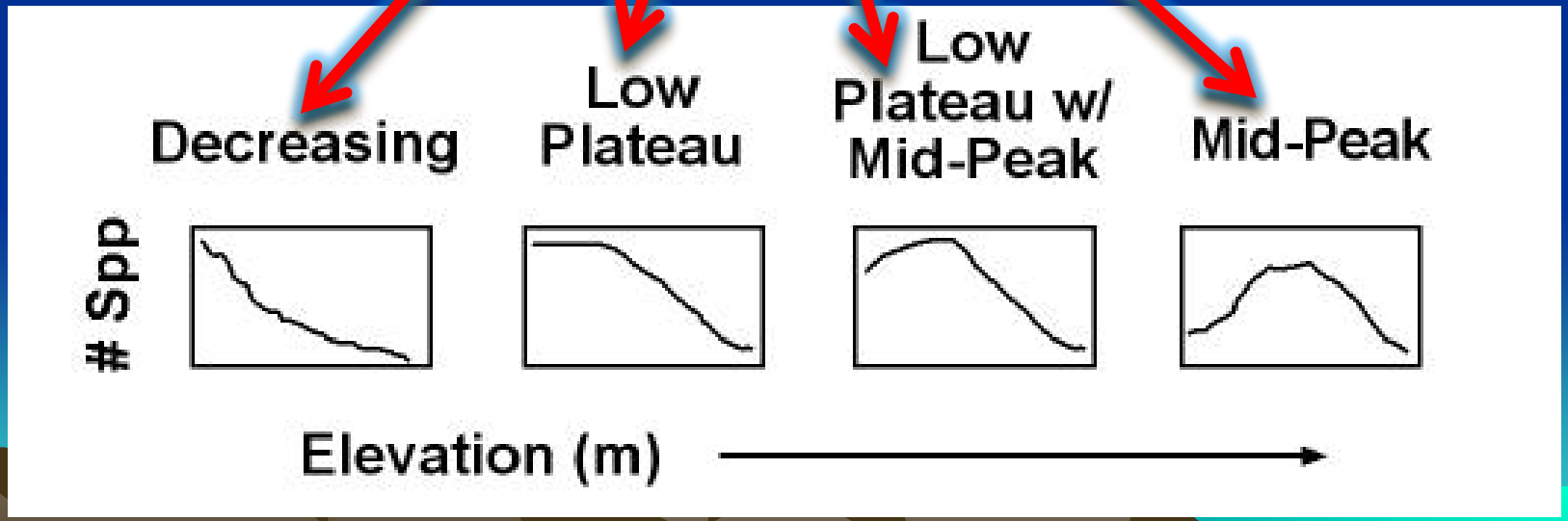
McCain 2007 Global Ecology & Biogeography

Global Mountain Analyses





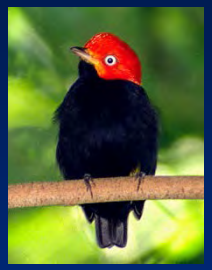
What are the patterns of diversity on mountains?



McCain 2009 Global Ecology & Biogeography

Global Mountain Analyses





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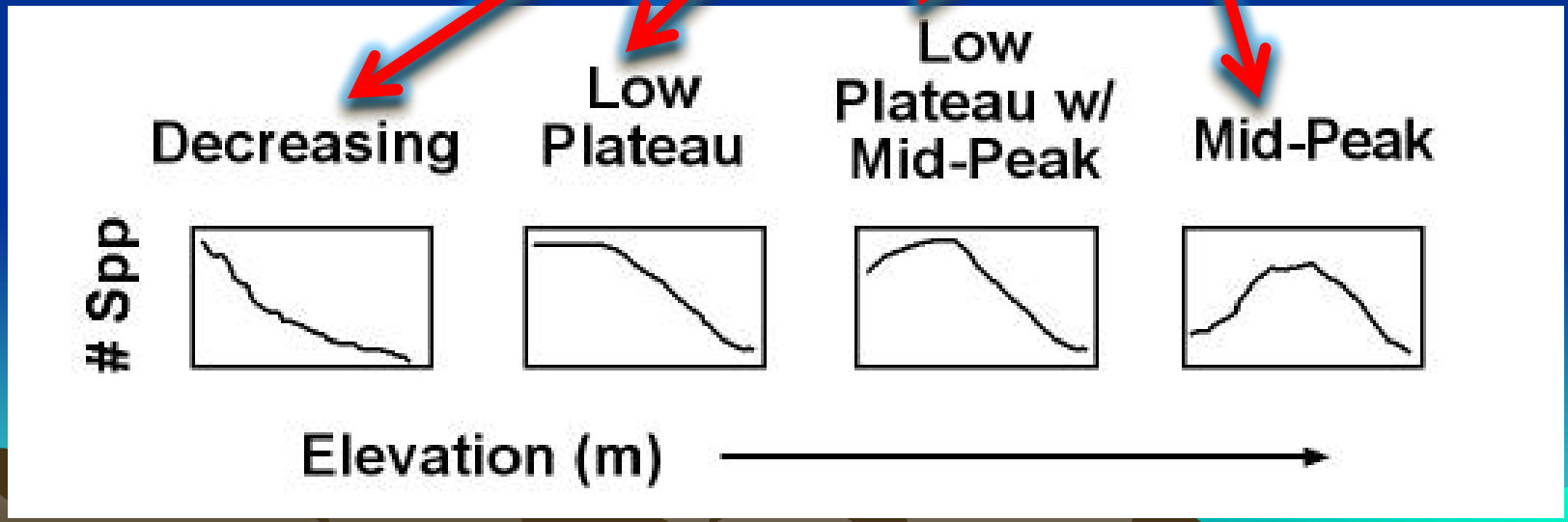

McCain 2010 Global Ecology & Biogeography

What drives these patterns?

- Climate
- Space
- Evolutionary History
- Biotic Interactions

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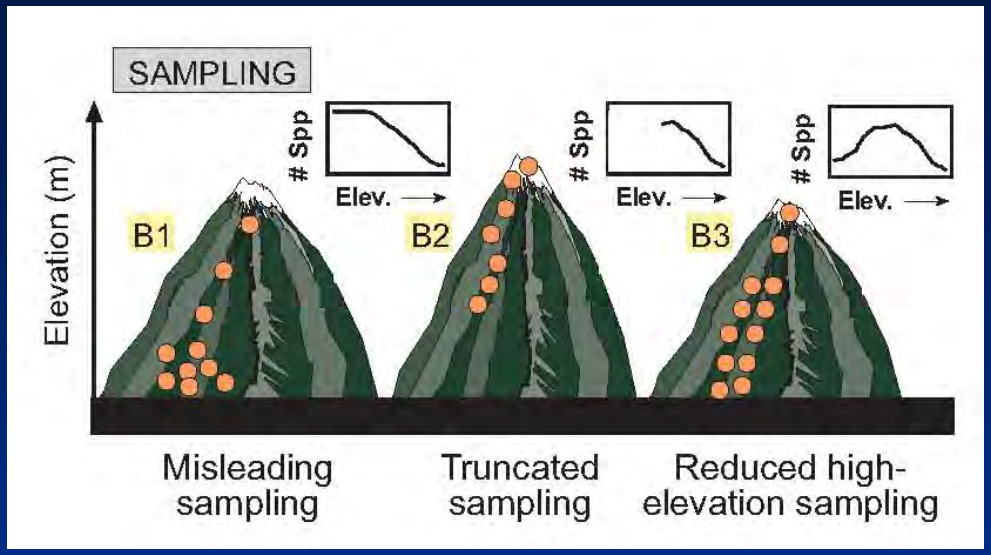
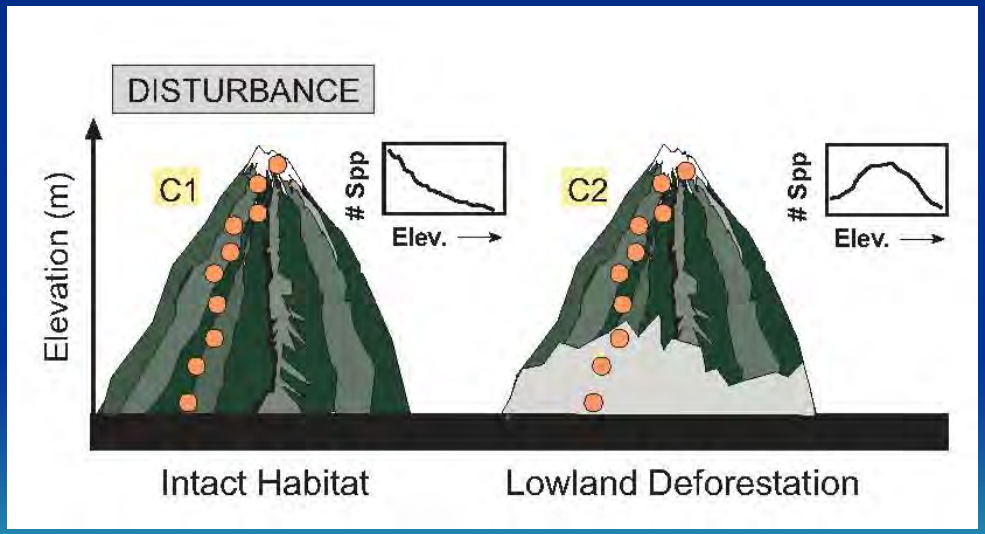
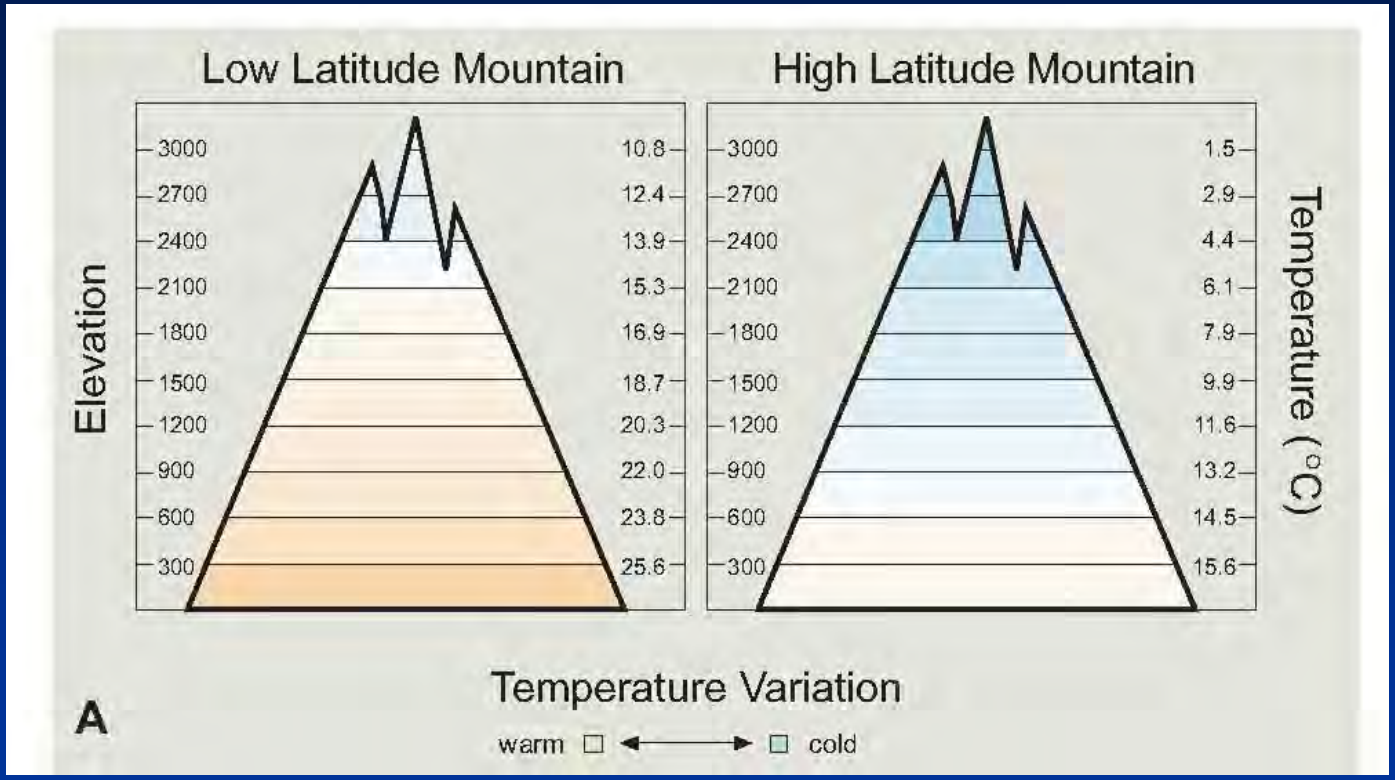
100s of proposed theories





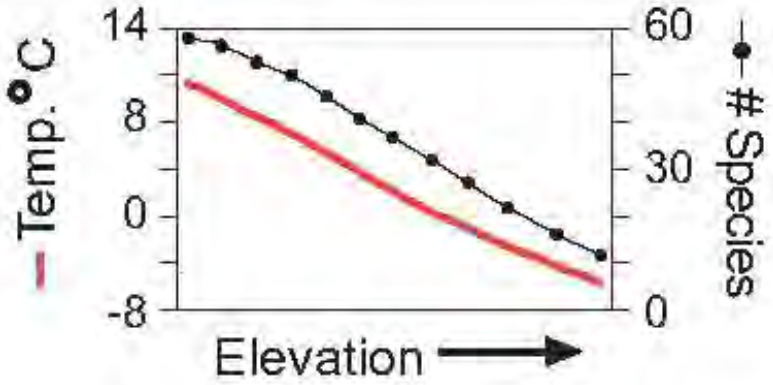
Caveats: Sampling, Disturbance

Biodiversity & Temperature

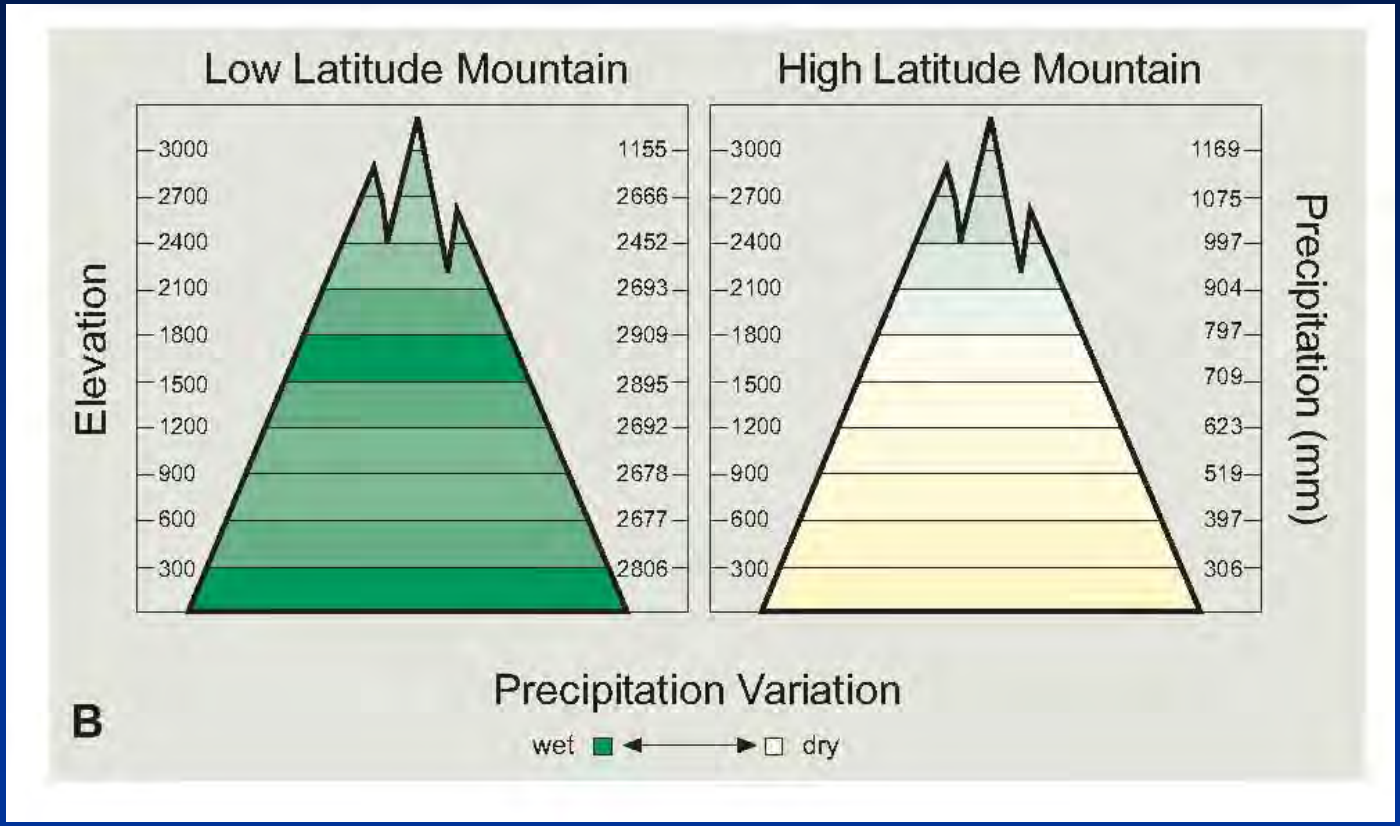


Temperature

Diversity positively related to temperature

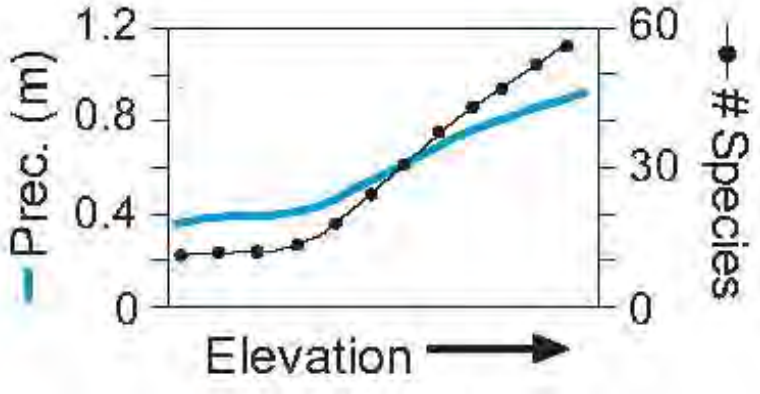


Biodiversity & Precipitation

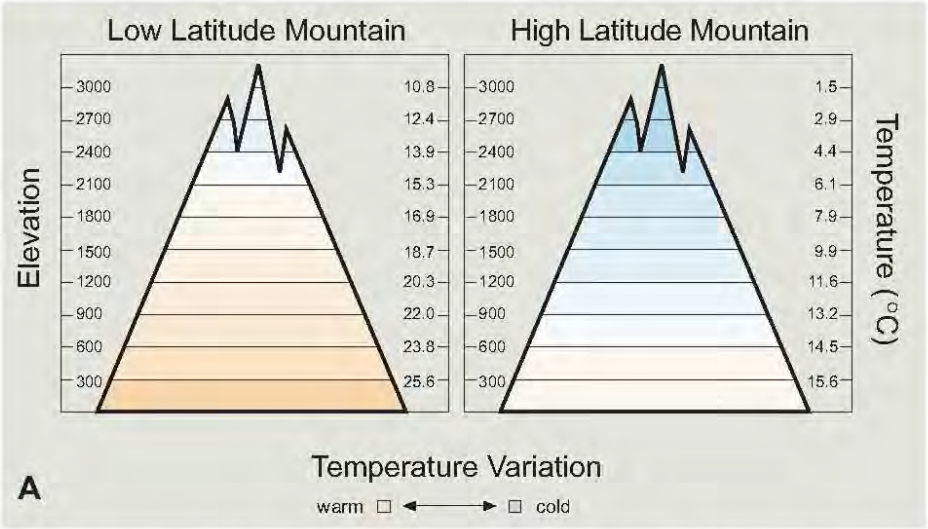


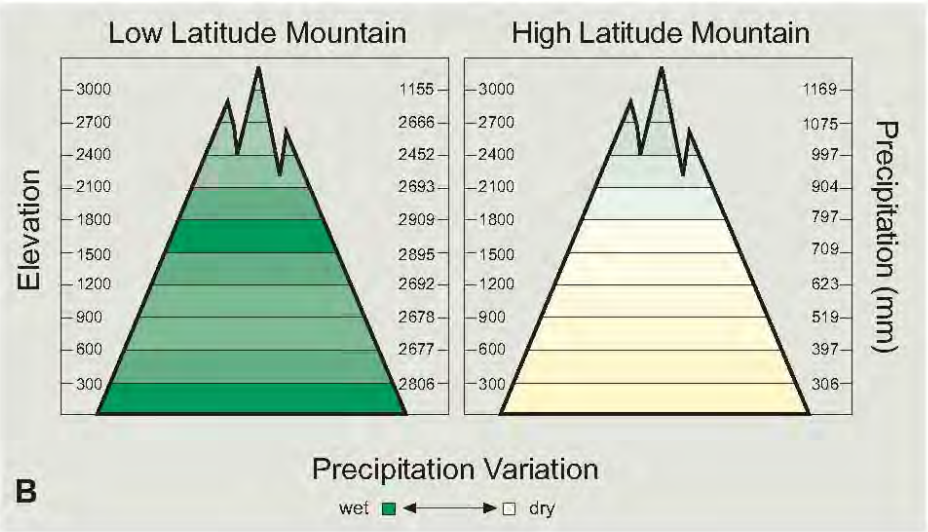
Precipitation

Diversity positively related to precipitation



Biodiversity & Productivity





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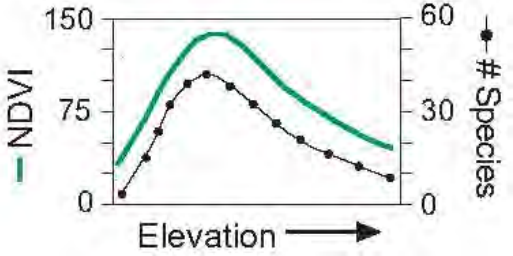
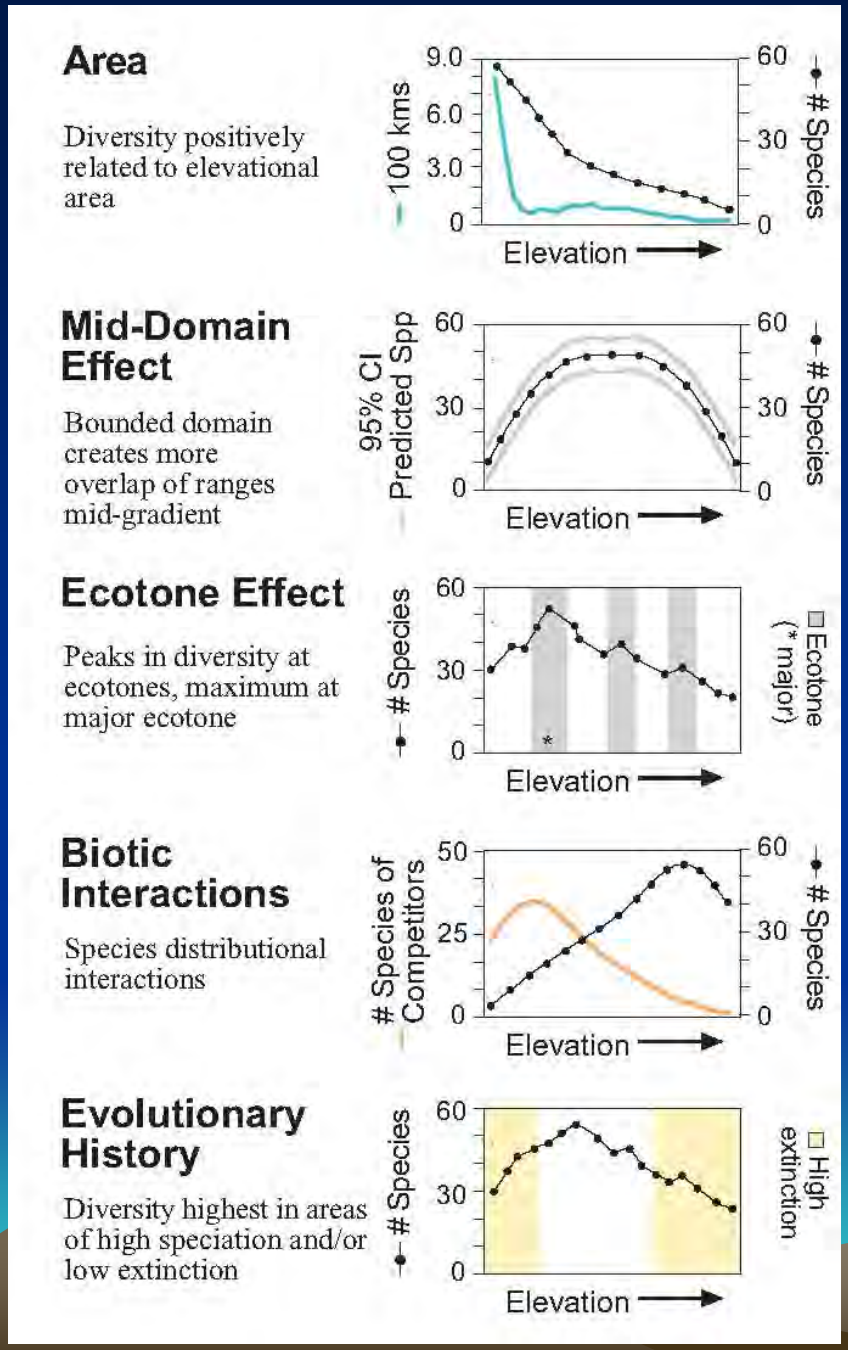


Other Biodiversity Predictions:



Diversity Causes:

- Climate
- ~~Space~~
- Evolutionary History
- ~~Biotic Interactions~~

Biodiversity & Mountains

- Current climate is critical to biodiversity

Biodiversity & Mountains

- Current climate is critical to biodiversity
  - Small Mammals: cool, wet, but not too wet

Small Mammals

- Intermediate conditions of temperature, rainfall & productivity
- Just below cloud cap

Small Mammals

- Intermediate conditions of temperature, rainfall & productivity
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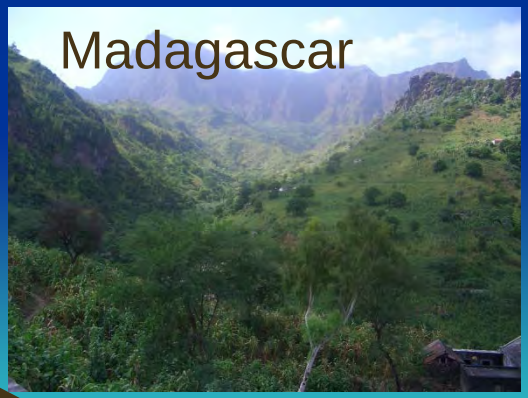
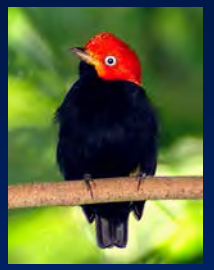
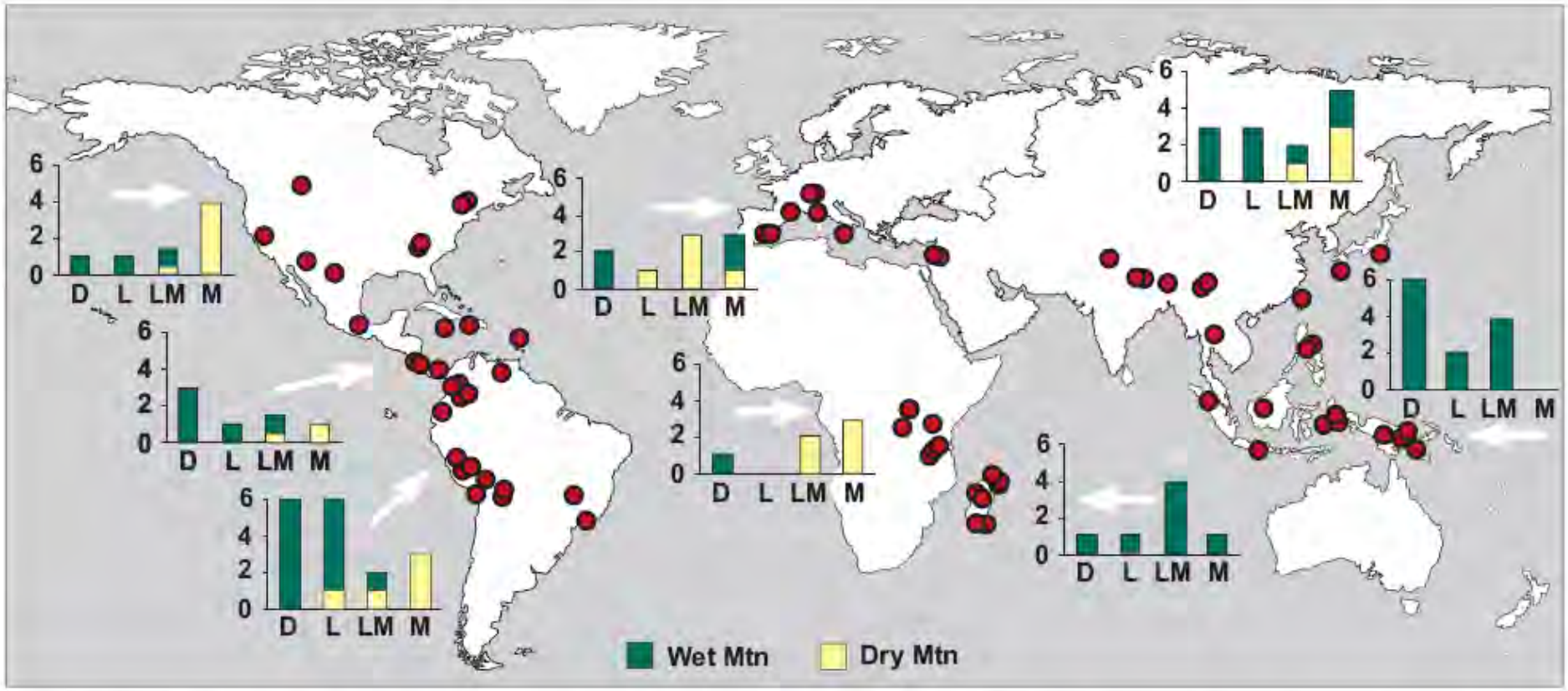


Biodiversity & Mountains

- Current climate is critical to biodiversity
  - Small Mammals: cool, wet, but not too wet
  - Bats & Birds: warm and wet

Birds: Mountain Climate





Biodiversity & Mountains

- Current climate is critical to biodiversity
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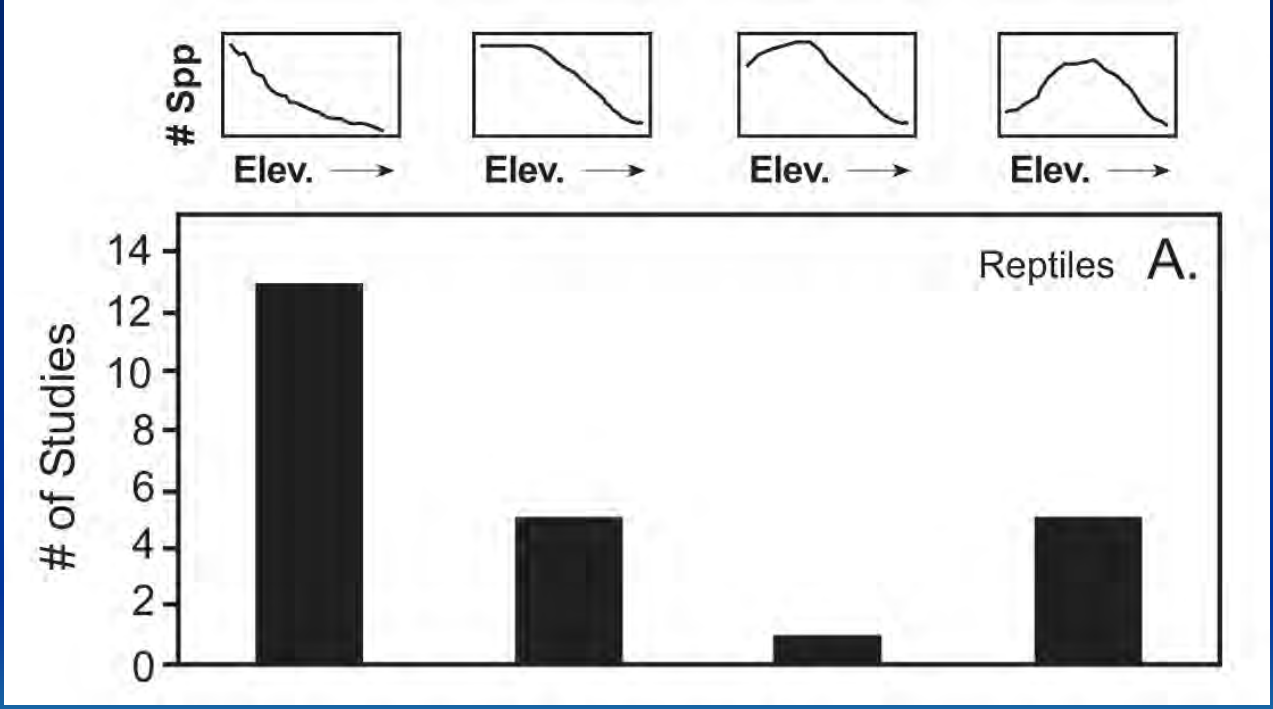
  - Reptiles: hot and sunny

Reptiles: Hot & Sunny



DEC. LP LPMP MP

McCain 2010 Global Ecology & Biogeography

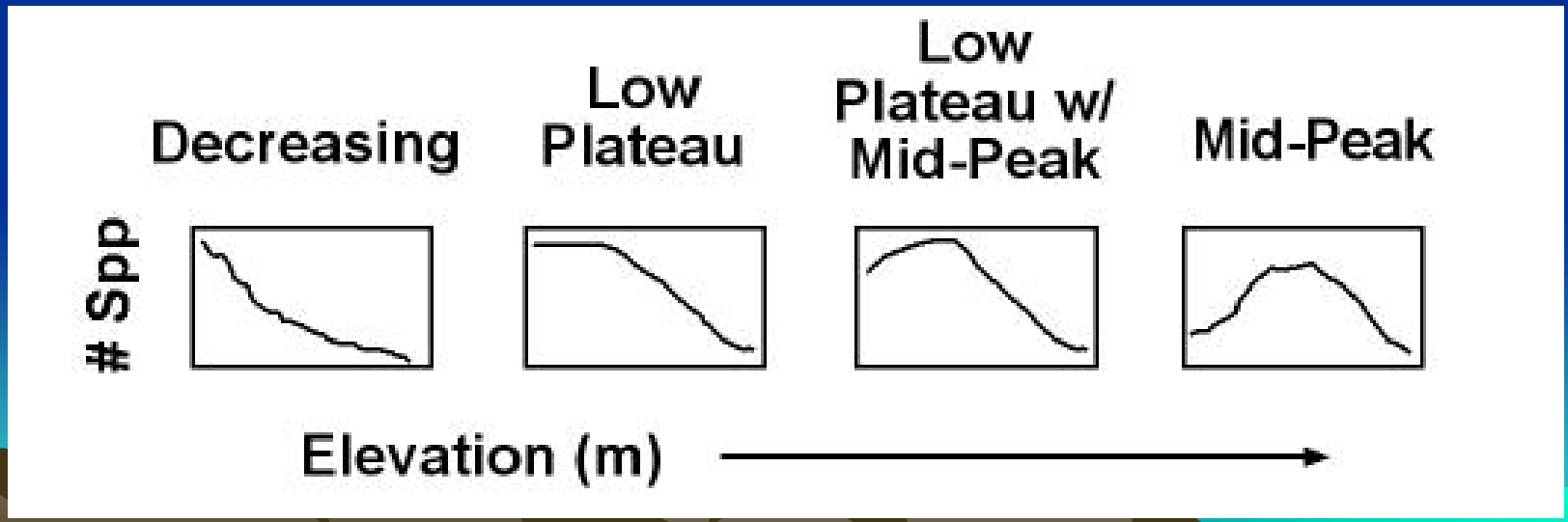
Biodiversity & Mountains

- Current climate is critical to biodiversity
  - Small Mammals: cool, wet, but not too wet
  - Bats & Birds: warm and wet
  - Reptiles: hot and sunny
  - Salamanders: cool and wet
  - Frogs: warm, wet, but modified by evolutionary history

Biodiversity & Mountains

- Current climate is critical to biodiversity

- How is this important to biodiversity conservation?



Biodiversity & Mountains

- Current climate is critical to biodiversity
- How is this important to biodiversity conservation?
- How is climate related to species distributions, range limits & thus biodiversity?

Biodiversity & Mountains

- If temperature & precipitation are important, then how?

Biodiversity & Mountains

- If temperature & precipitation are important, then how?
- Physiological limits?

Biodiversity & Mountains

- If temperature & precipitation are important, then how?

- Physiological limits?
- Influences indirectly through their available food resources?

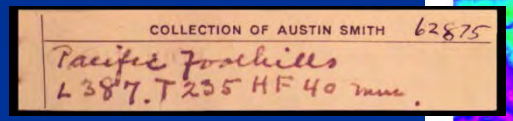
Biodiversity & Mountains

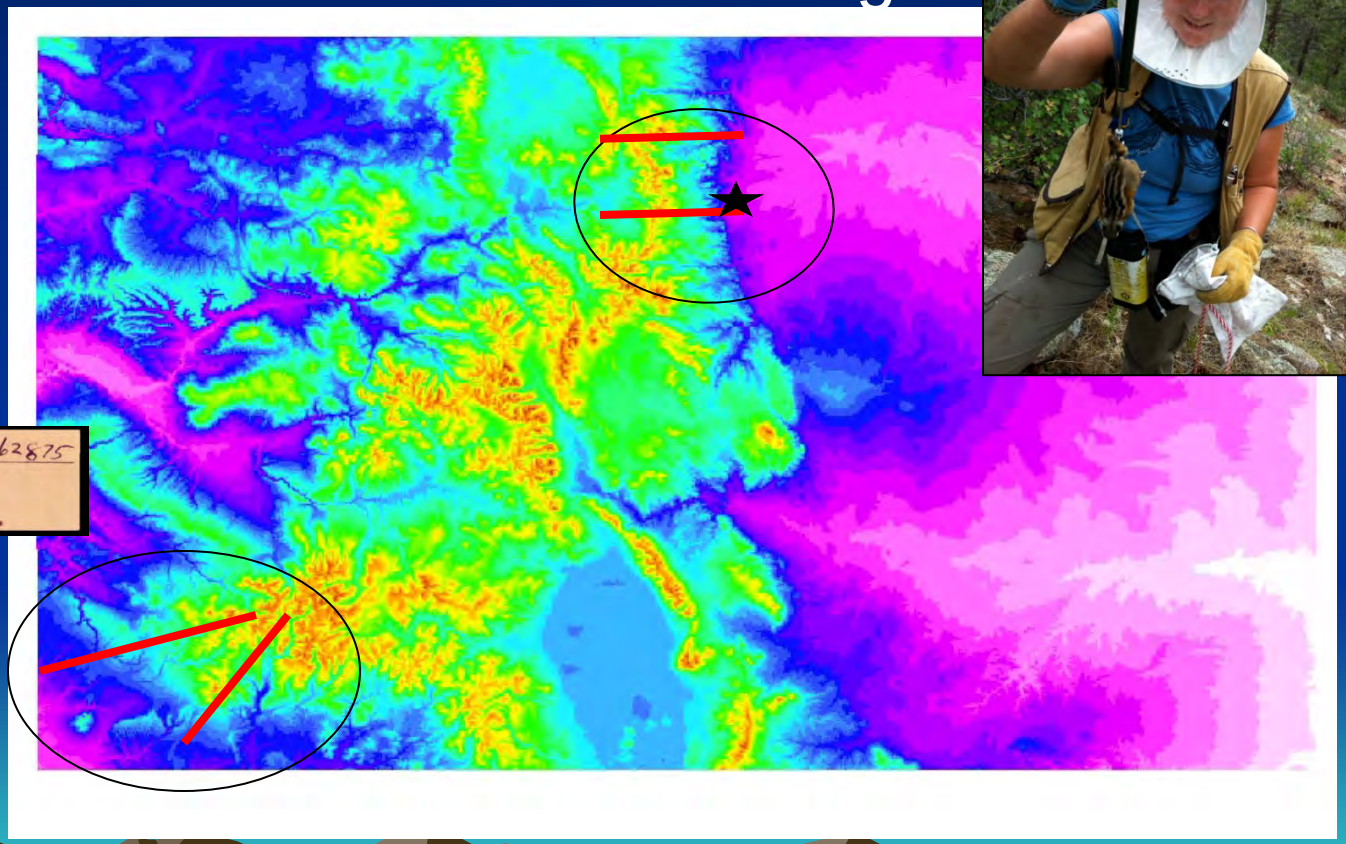
- If temperature & precipitation are important, then how?
- Physiological limits?
- Influences indir… food resources?

Answer critical to understanding effects of climate change

Field Studies: Colorado Rockies

Front Range





San Juans

McCain. 2010-2013. NSF-DEB grant

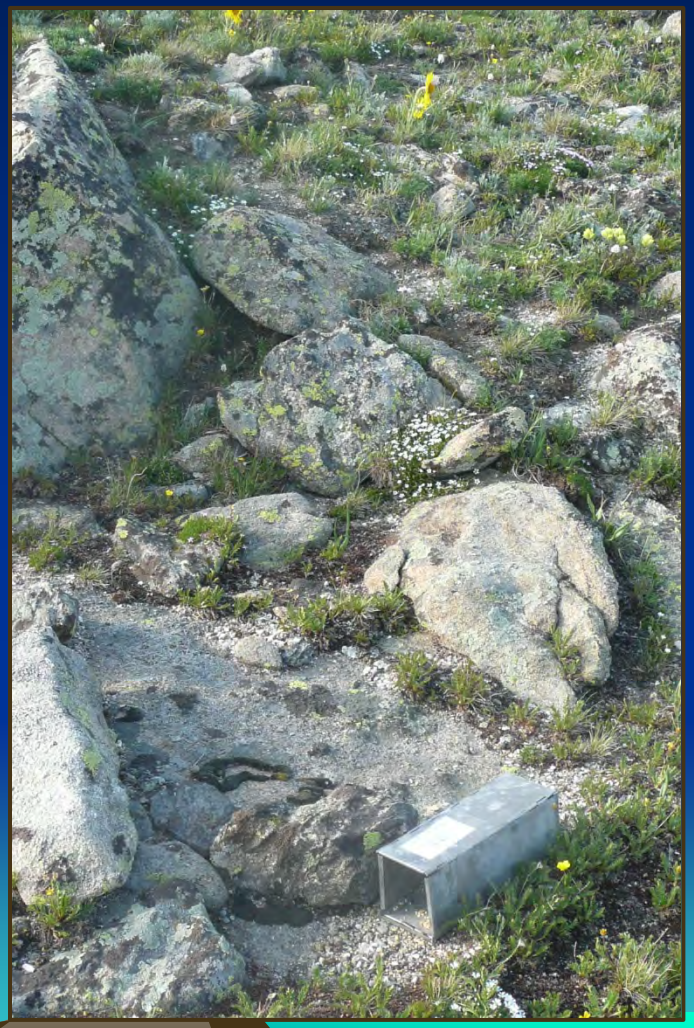
Colorado Rockies

- 1. Boulder to Niwot Ridge (2010)
- 2. Loveland to Sundance Mtn (2010-2012)
- 3. Utah-Colorado Border to Lizard Head Wilderness (2011-2012)
- 4. Cortez to Hermosa Peak (2012)

- 8 sites per transect

Small Mammal Trapping

- 5 consecutive nights
- 300 Sherman live-traps
- Main habitats at site
- Visual surveys



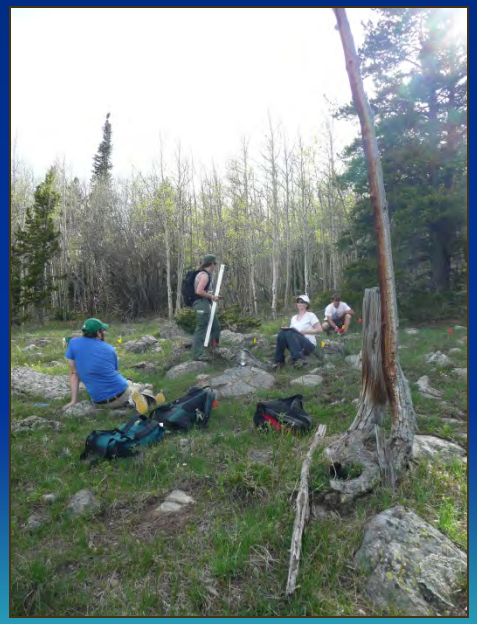
Climate Stations

- Soil temperature
- Air temperature
- Rainfall gauge

Vegetation Surveys

20 vegetation plots/ site: trees, shrubs, understory

(plant-based food resources)



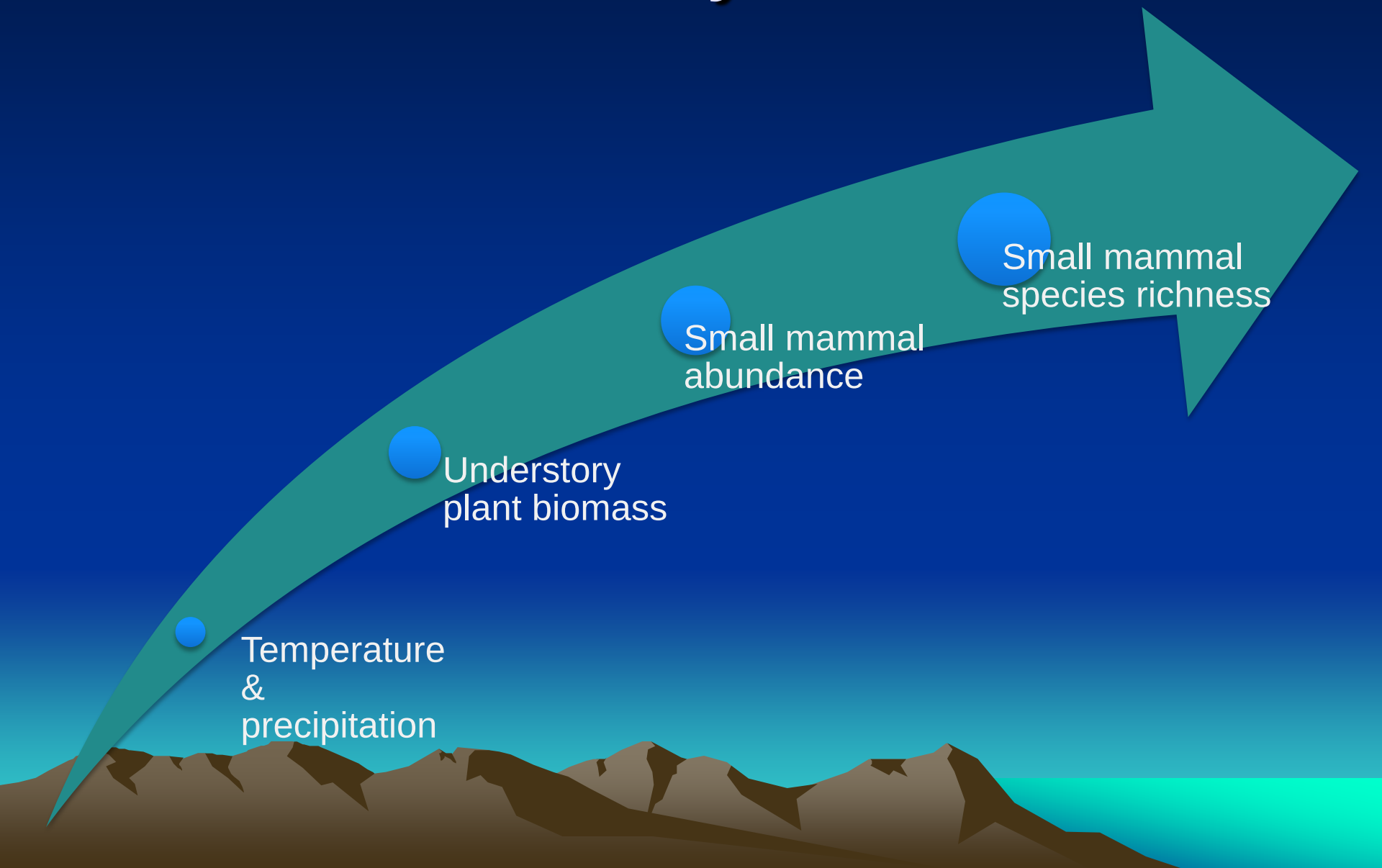
Insect Pitfall Traps

40 pitfalls per site

Assess arthropod biomass

(Also trap shrews)

Preliminary Results



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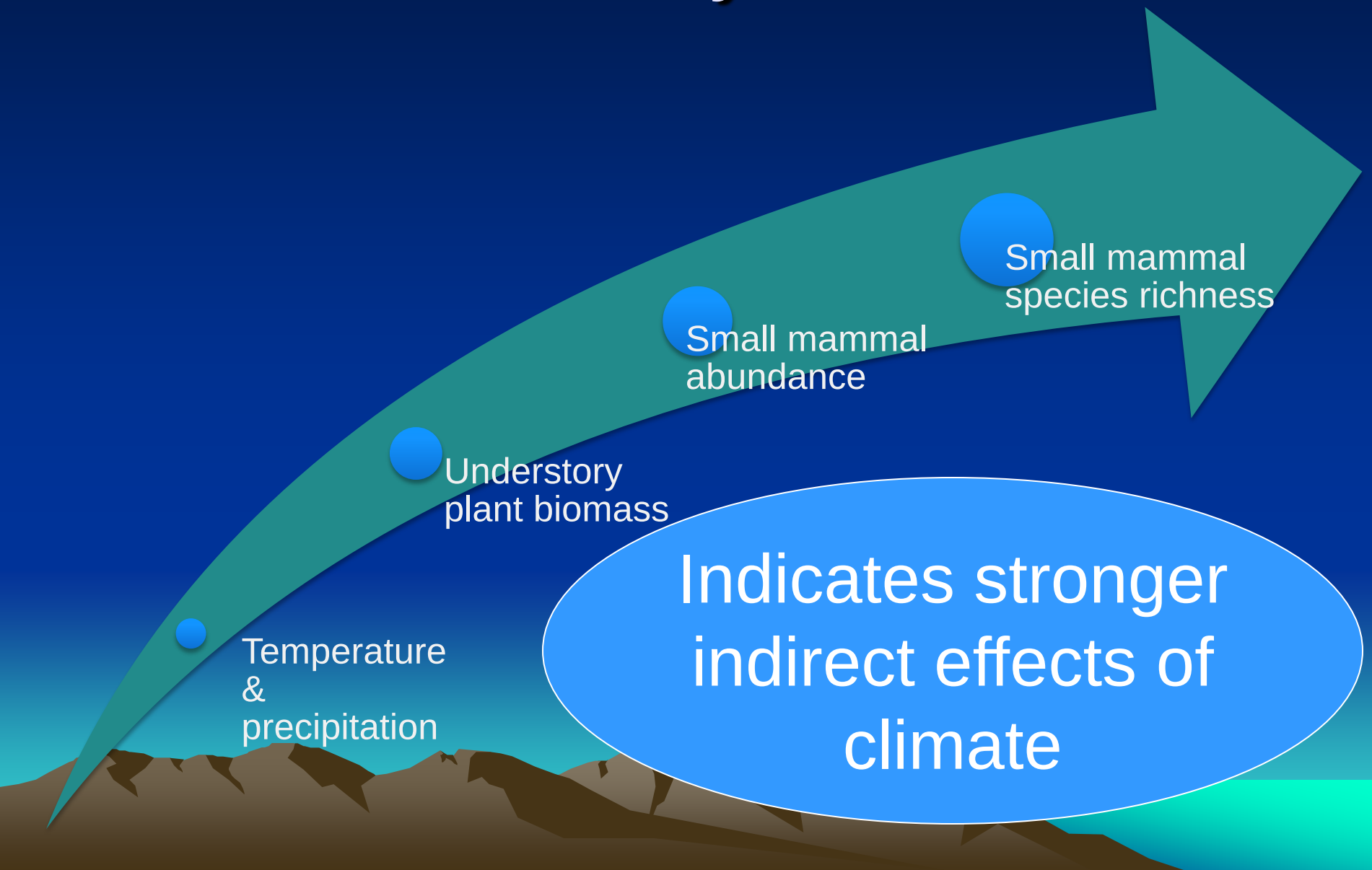
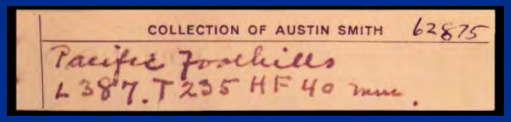


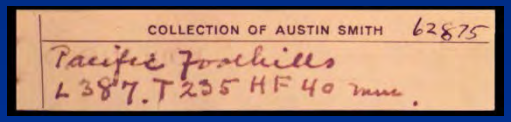
Climate Change & Mountains

- Historical distributions of these species before 1980's
- >60, 000 Specimen records



Climate Change & Mountains

- Historical distributions of these species before 1980's
- >60, 000 Specimen records
- Estimate elevational range before climate change to compare to current distributions



Climate Change: Shifting ranges

Range Contraction or Shift

Climate Change

- Shifts are likely not so simple
- Precipitation change equally or more important

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- Embedded in context of land use change
- Not all mammals respond similarly to climate change: body size & activity times

Acknowledgements

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- National Science Foundation
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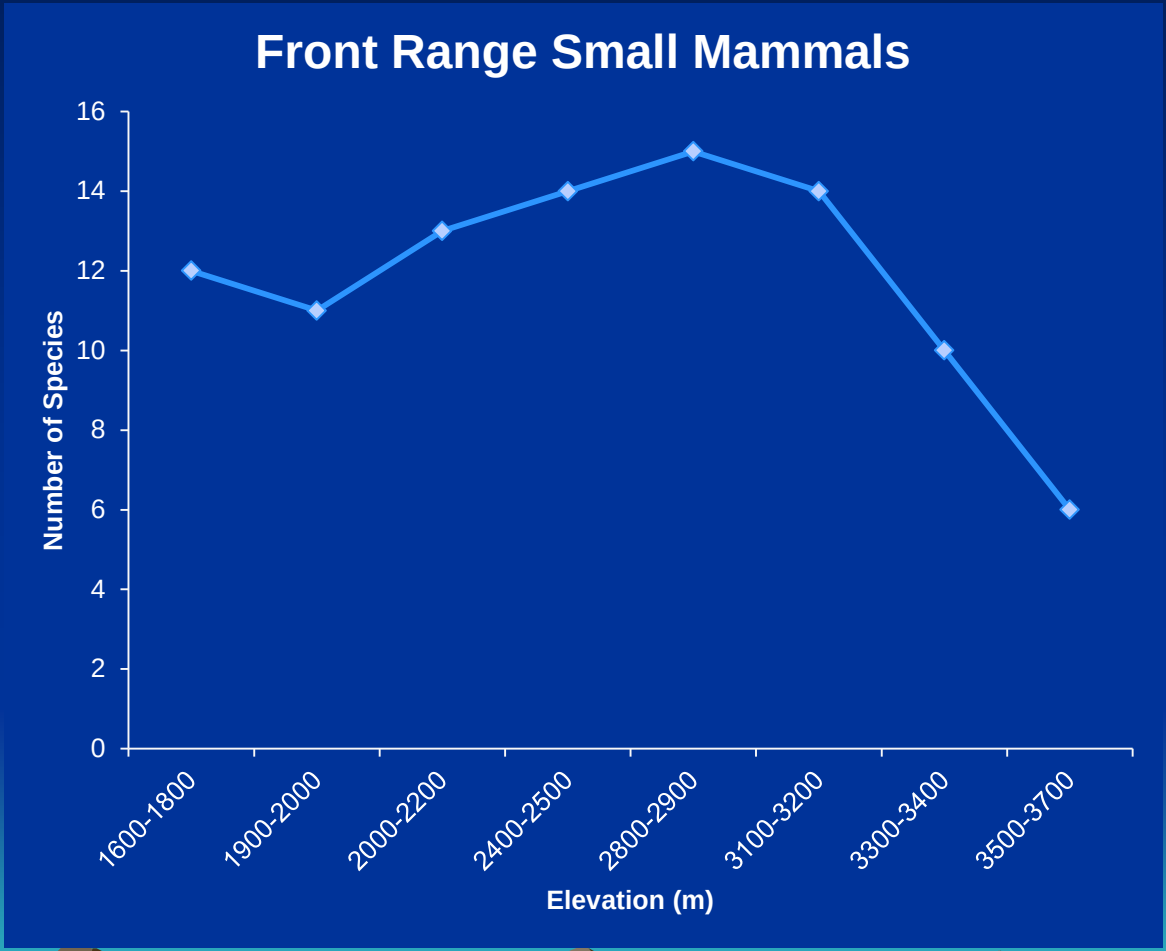
COLLABORATORS

Rocky Mountain National Park

Questions?

Mid-elevational Diversity Peak



What are these species?

- Shrews!
  - *Sorex nanus* (Dwarf)
  - *Sorex hoyi* (Pygmy)
  - *Sorex cinereus* (Masked)
  - *Sorex monticolus* (Montane)
  - *Sorex merriami* (Merriam's)
  - *Sorex palustris* (Water)

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New to ROMO

What are these species?

What are these species?

- Voles
  - *Microtus montanus*
  - *Microtus longicaudus*
  - *Microtus ochrogaster*
  - *Myodes gapperi*
  - *Phenacomys intermedius*

Southern Red-backed vole

Heather vole

What are these species?

- Mice & Rats
  - *Peromyscus maniculatus*
  - *Peromyscus nastutus*
  - *Reithrodontomys megalotis*
  - *Reithrodontomys montanus*
  - *Zapus hudsonicus (ESA)*
  - *Zapus princeps*
  - *Neotoma mexicana*
  - *Neotoma cinerea*

Preble's Jumping Mouse

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- Mice & Rats
  - *Peromyscus maniculatus*
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  - *Reithrodontomys montanus*
  - *Zapus hudsonicus (ESA)*
  - *Zapus princeps*
  - *Neotoma mexicana*
  - *Neotoma cinerea*

Deer Mouse

What are these species?

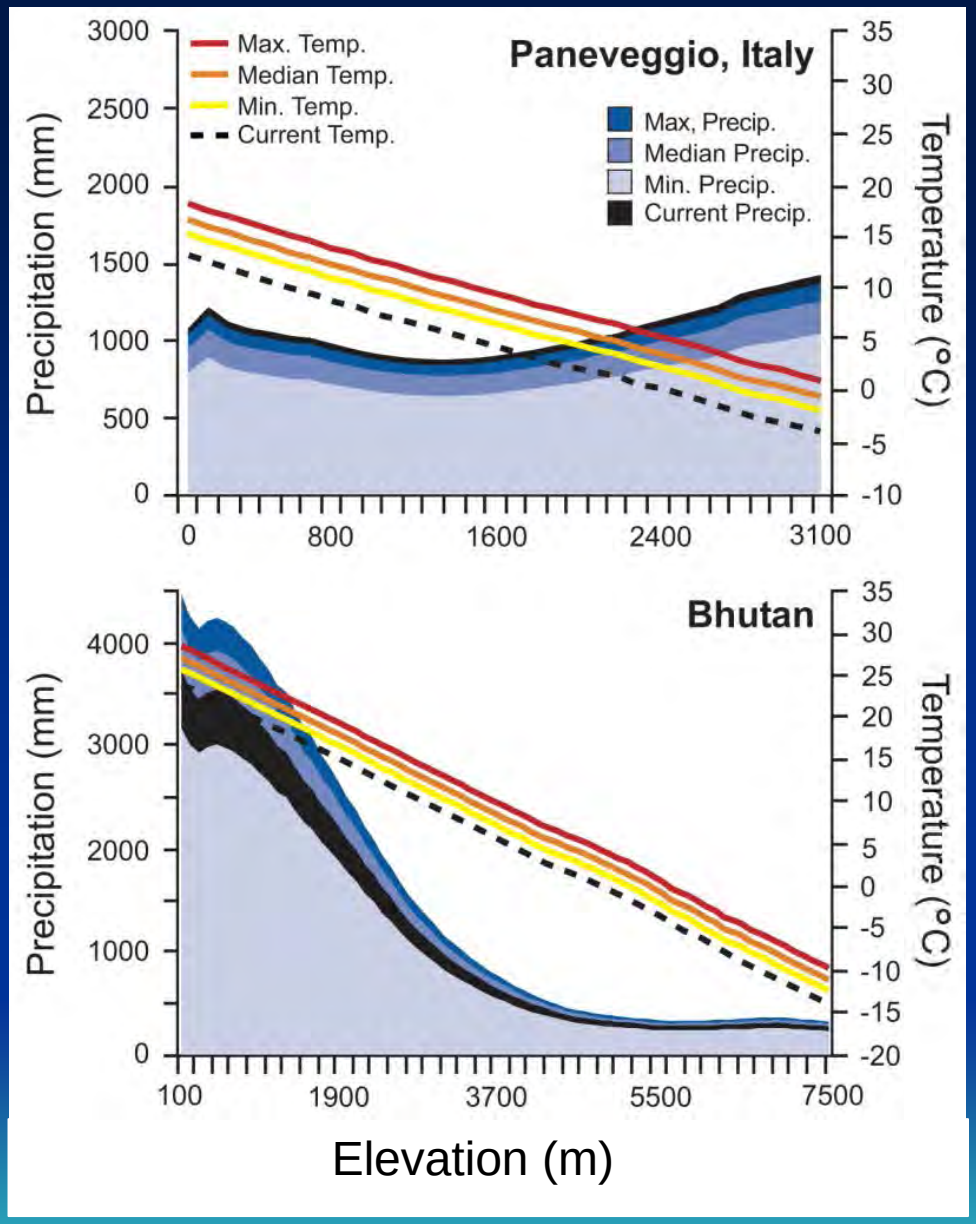
- Chipmunks & Squirrels
  - *Tamias minimus*
  - *Tamias umbrinus*
  - *Tamias quadrivittatus*
  - *Spermophilus lateralis*
  - *Spermophilus elegans*
  - *Sciurus aberti*
  - *Tamiasciurus hudsonicus*
  - *Marmota flaviventris*

Abert's squirrel

What are these species?

- Lagomorphs:
  - *Ochotona princeps*
  - *Lepus americanus*
  - *Sylvilagus nuttallii*

Snowshoe Hare



Climate Change Predictions: Importance of Temperature & Precipitation Interaction

Mountain Extinction Risk: Geographic Region