Fundamental Niches and Tropical Mountains

Reading: Daniel Janzen

Species Ranges

Lecture 9 Recap

Evgenii Wulff

Species Ranges

Evgenii Wulff

- Species ranges are dynamic, and are the result of historical and ecological processes

- *"And it happens, as we shall see below, that the structure of an area in many cases, particularly of a discontinuous area, may be explained only on the basis of its conformation in former times and not on the basis of natural causes now in force."*

Species Ranges

- *Center of Area*

- *"Each genus seems to have arisen in that center in which the greater number of its species is found; these centers have doubtless undergone many modifications as a result of geological changes, and many anomalies in the distribution of plants may be thus explained."*

Species Ranges

Evgenii Wulff

- *Determination of the Center of Area*

- Must know its past history – paleobotany
  - Few cases where fossil remains are found exclusively within the boundaries of the present range

- Center of frequency
  - Greatest number of the species

- Center of maximum variation (mass center)
  - Greatest diversity of forms, many times this will be useful at higher taxonomic levels

Species Ranges

Evgenii Wulff

- Useful to also take into account the character of the species in the center of maximum variation, but species are not uniform and not of equal value

- Divide species in 3 groups
    - 1) Endemic and subendemic
    - 2) Species who have close associations with env.
    - 3) Widely distributed species

Species Ranges

- *Centers of dispersal/preservation*

- Species may die out due to unfavorable conditions over a considerable portion of their range

- Species renews dispersal from these retreats where it preserved its habits

Species Ranges

- *Holloway & Jardine (1968)*

- *Two Approaches to zoogeography: a study based on the distributions of butterflies, birds and bats in the Indo-Australian area*

- Dispersal can easily blur differences in distributions that originated in the geological past, with the extent of shifts depending on the dispersal power of the taxon concerned

Species Ranges

- *Habitat vs. Niche*

- Niche is not just where the organism is, but what it eats, who it competes with, who its eats it

- Habitat is the address of the organism, the niche is the job of the organism

Species Ranges

Robert MacArthur

- *Resource Partitioning*

Cape May warbler
Blackburnian warbler
Black-throated green warbler
Bay-breasted warbler
Myrtle warbler
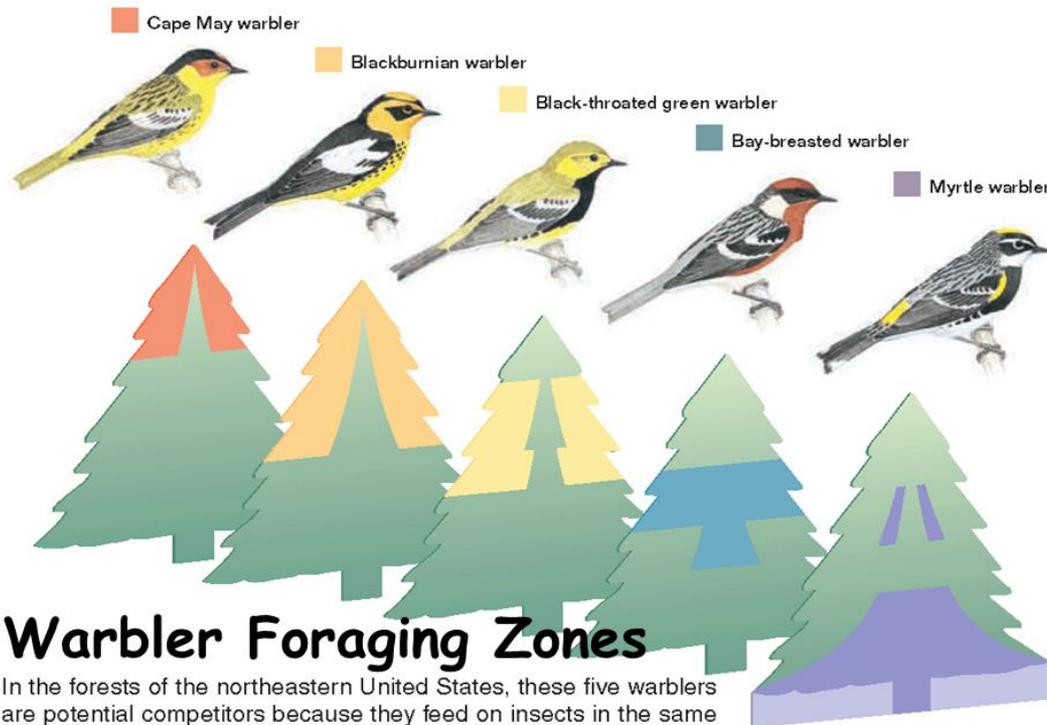
Warbler Foraging Zones
In the forests of the northeastern United States, these five warblers are potential competitors because they feed on insects in the same trees. However, each species hunts only in a portion of the tree. Ecologist Robert MacArthur proposed that this feeding strategy reduced competition among these species of warblers.

Species Ranges

Robert
MacArthur

- Each of the warblers could probably live and feed in many parts of the tree

- However they each avoid competitive exclusion by avoiding competition and occupying a unique portion of the tree

- This can scale up to large areas or elevational belts

Species Ranges

Robert
MacArthur

- Highlights the difference between the

  fundamental   and   *realized* niche

Area it could occupy   Area it does occupy
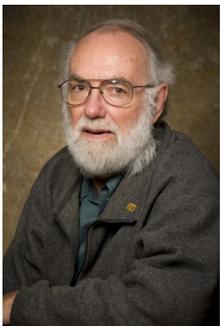
Species Ranges

Daniel Janzen

- *Why Mountain Passes are Higher in the Tropics*

- The ability to follow changing environmental conditions, and thereby cross barriers, depends not only on physiology, but also on the behavior and ecological tolerance (*niche breadth*) of the focal species
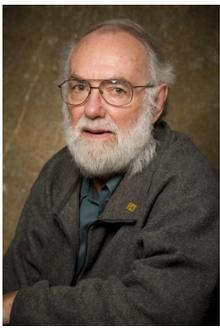
Species Ranges

Daniel Janzen

- *Why Mountain Passes are Higher in the Tropics*

- *"...relation between tropical climate uniformity at a given site and the effectiveness of topographic barriers adjacent to the site in preventing movements of plants and animals."*
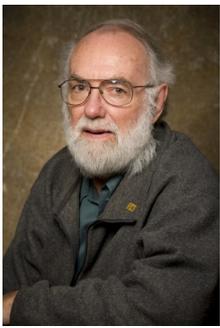
Species Ranges

Daniel Janzen

- **Three main concepts:**

- it is the temperature gradient across a mountain range which determines its effectiveness as a barrier, rather than the absolute height

- in the tropics, terrestrial temperature regimes are generally more uniform than temperate regions, and differ in their pattern of overlap across geographic barriers

- organisms are evolutionarily adapted to and/or have the ability to acclimate to the temperature normally encountered in their habitat
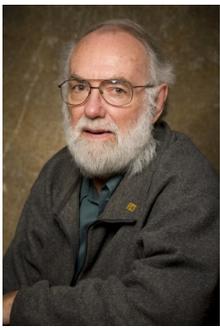
Species Ranges

Daniel Janzen

- *What is preventing an animal or plant from summiting a mountain pass?*
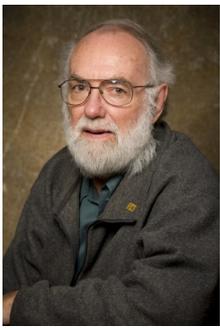
Species Ranges

Daniel Janzen

- *What is preventing an animal or plant from summiting a mountain pass?*

- *"The problem is the usual one of how much overlap there is between the temperature regime at the top of the pass and the valley below."*
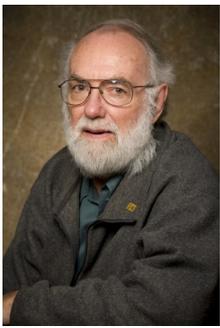
Species Ranges

Daniel Janzen

- Two major considerations on whether an organism can summit the mountain

- *The number of hours/days/months when the temperatures on the pass are similar to the valley*

- *The amount of time and degree to which the organism can withstand those temperatures*
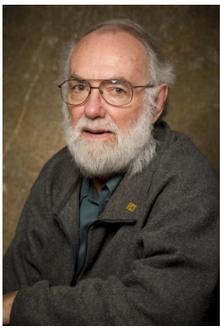
Species Ranges

Daniel Janzen

- Tropics have much more uniform temperatures than temperate zones

Denver, Colorado, Usa Average Temperatures

San Jose, Costa Rica Average Temperatures
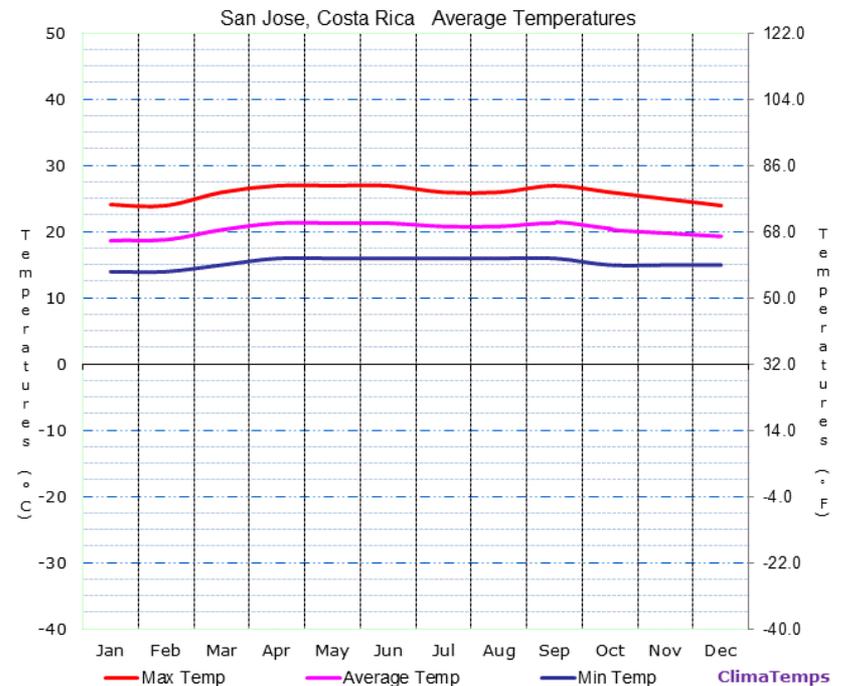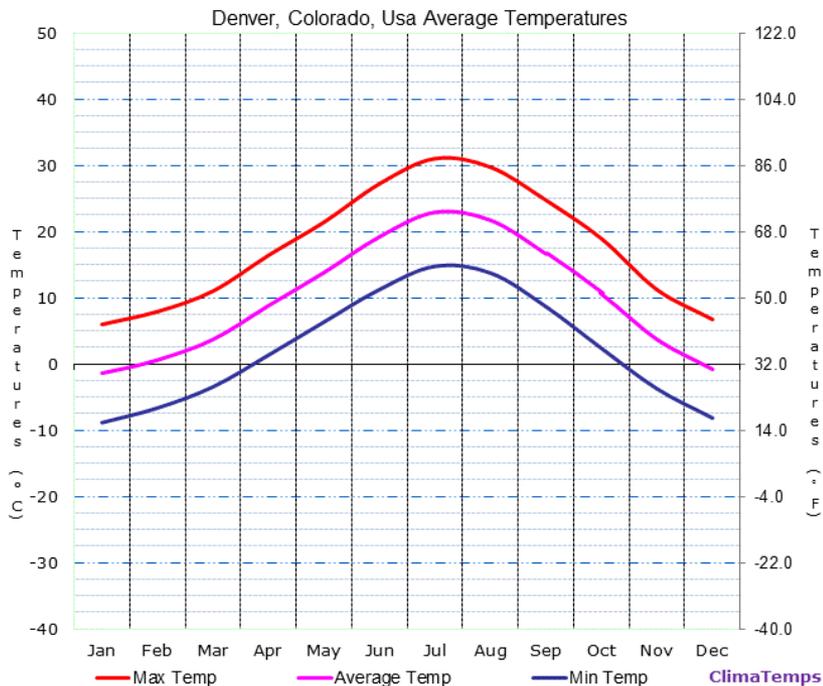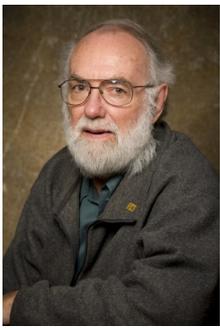
Species Ranges

Daniel Janzen

- Tropics have much more uniform temperatures than temperate zones
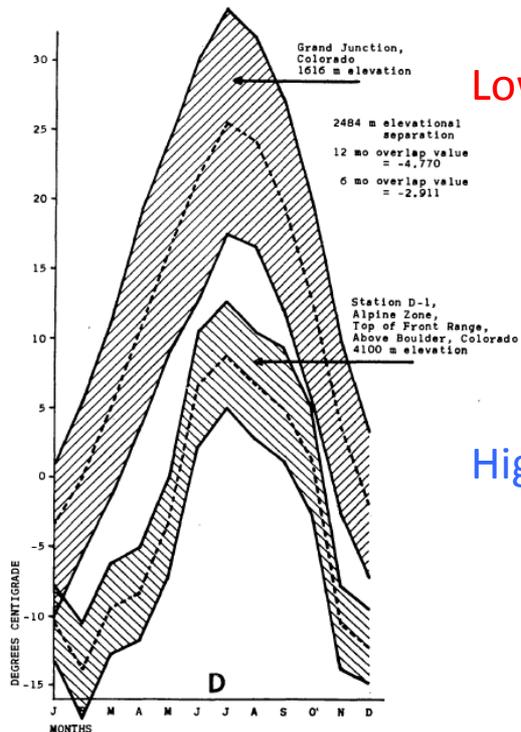
Low elevation

High elevation
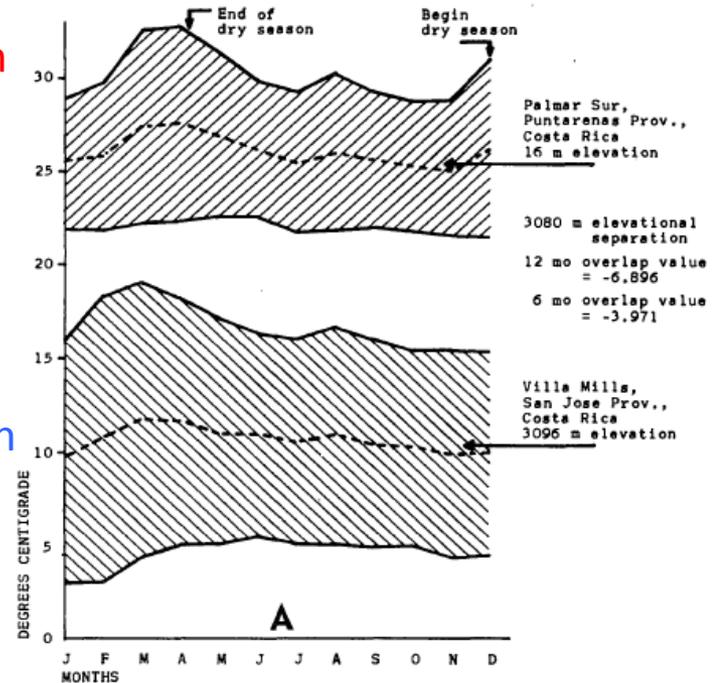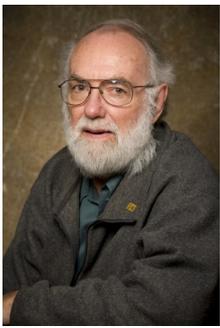
Species Ranges

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- No matter the elevation, the temperatures are more stable in the tropics

Species Ranges

Daniel Janzen

- Janzen calculated the degree of overlap for a 12 month and 6 month period for the mountain peaks and their associated valleys

$$\text{overlap value} = \sum_{i=1}^{12} \frac{d_i}{\sqrt{R_{1i}R_{2i}}}$$

- 6 month overlaps periods: for temperature zones this was the growing season, and for the tropics it was the rainy season
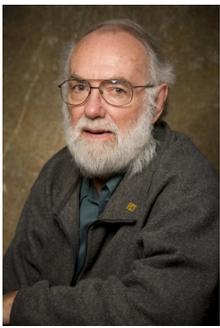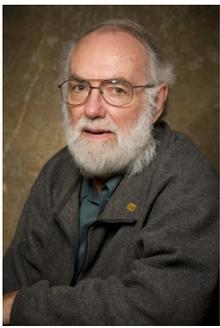
Species Ranges

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2484m difference
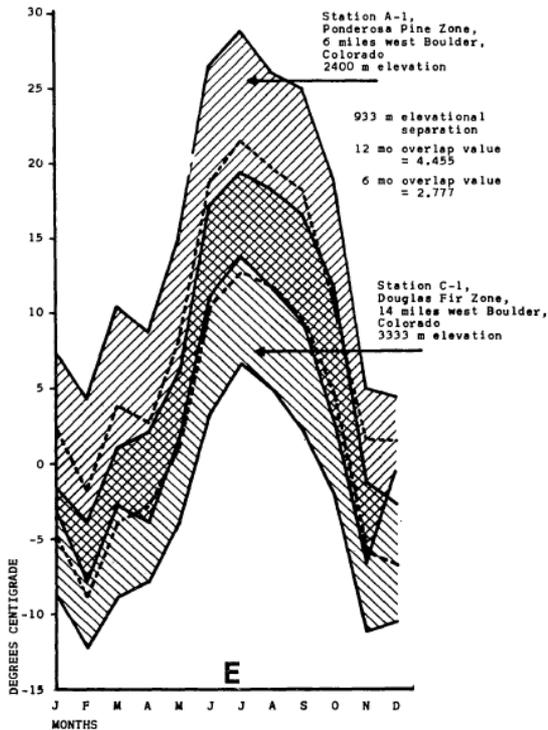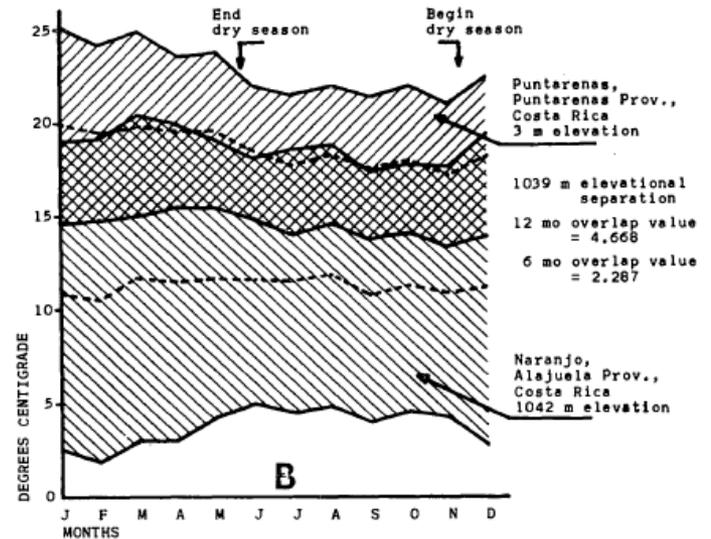6mo overlap = -2.9
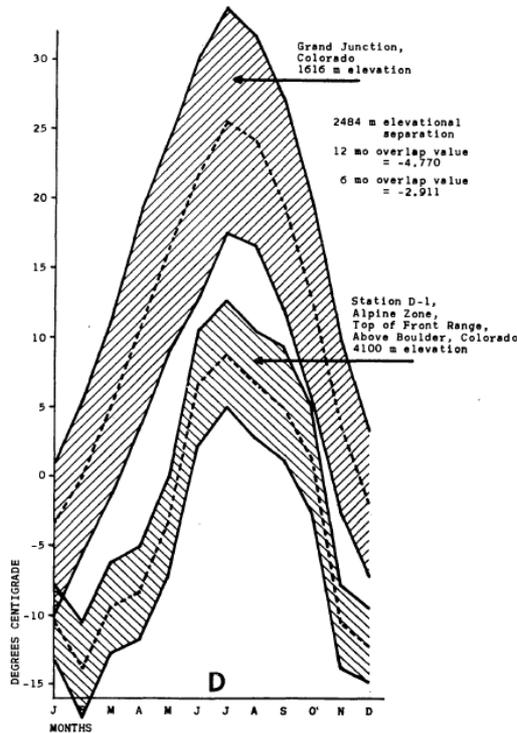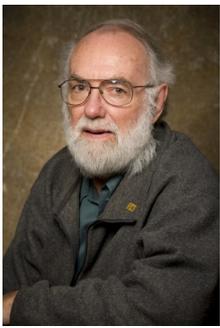
3080m difference
6mo overlap = -4.0
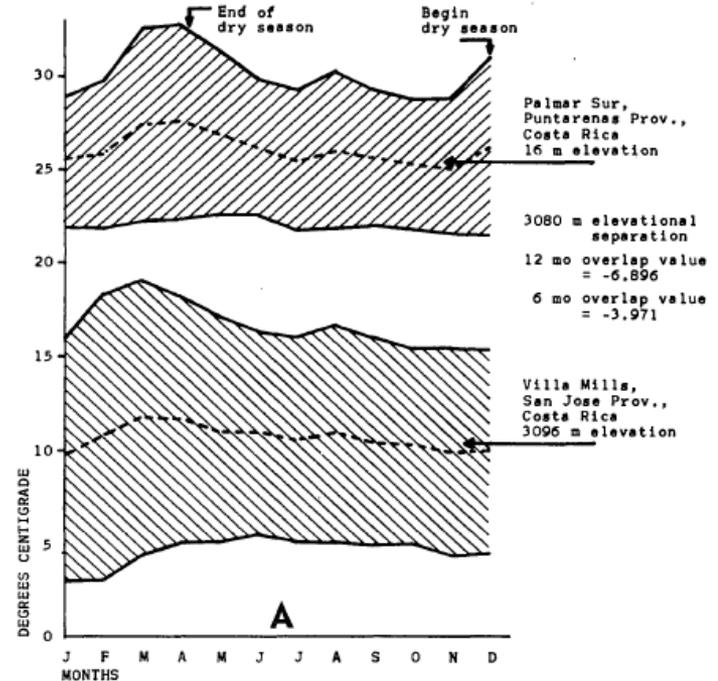
Species Ranges

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933m difference
6mo overlap = 2.8

1039m difference
6mo overlap = 2.3

Species Ranges

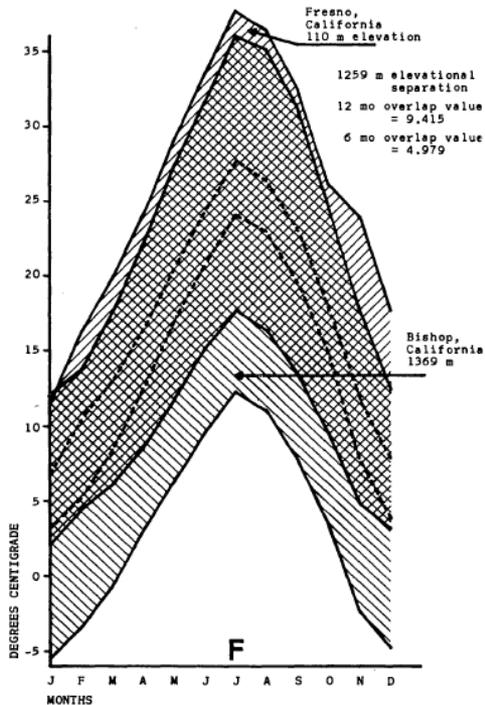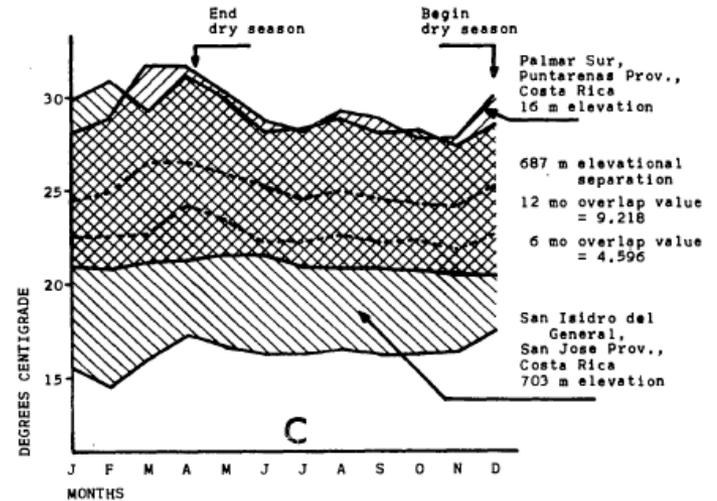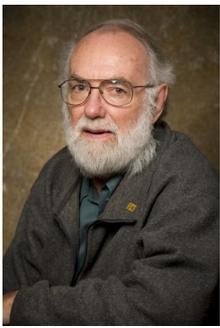Daniel Janzen

1259m difference
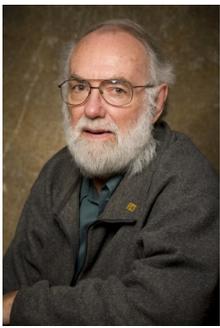6mo overlap = 5.0

687m difference
6mo overlap = 4.6
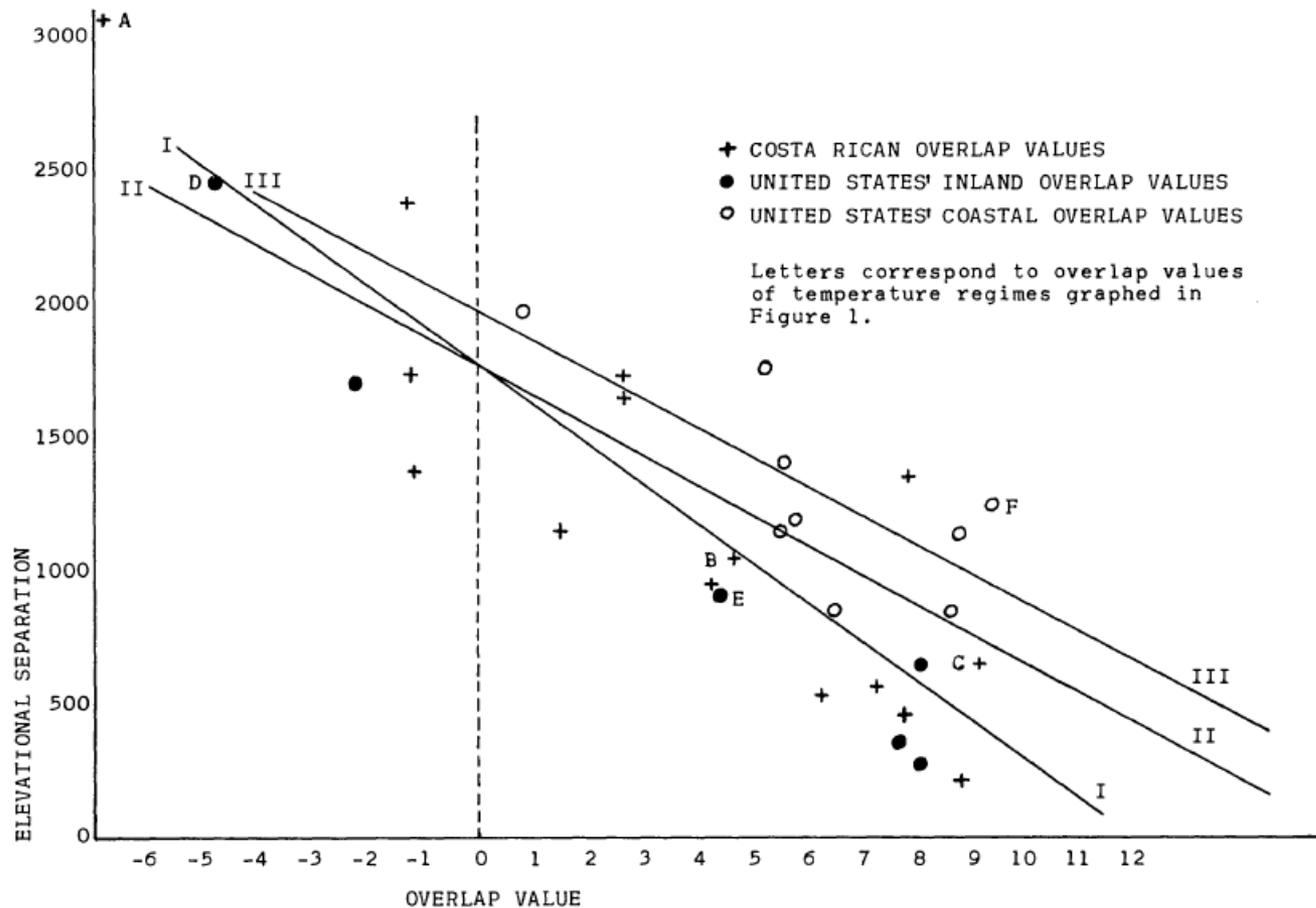
Daniel Janzen

Species Ranges

- Janzen performed this calculation for 30 pairs from US inland, US coastal, and Costa Rica

- He then plotted the overlap values for each region against elevational separation and compared the slopes
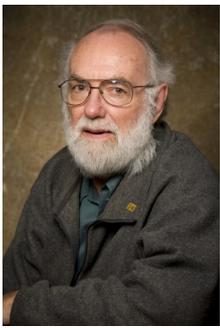
Species Ranges

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12 month overlap values

Species Ranges
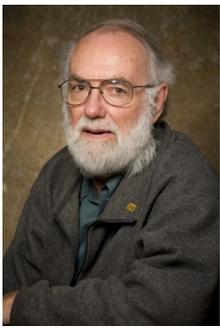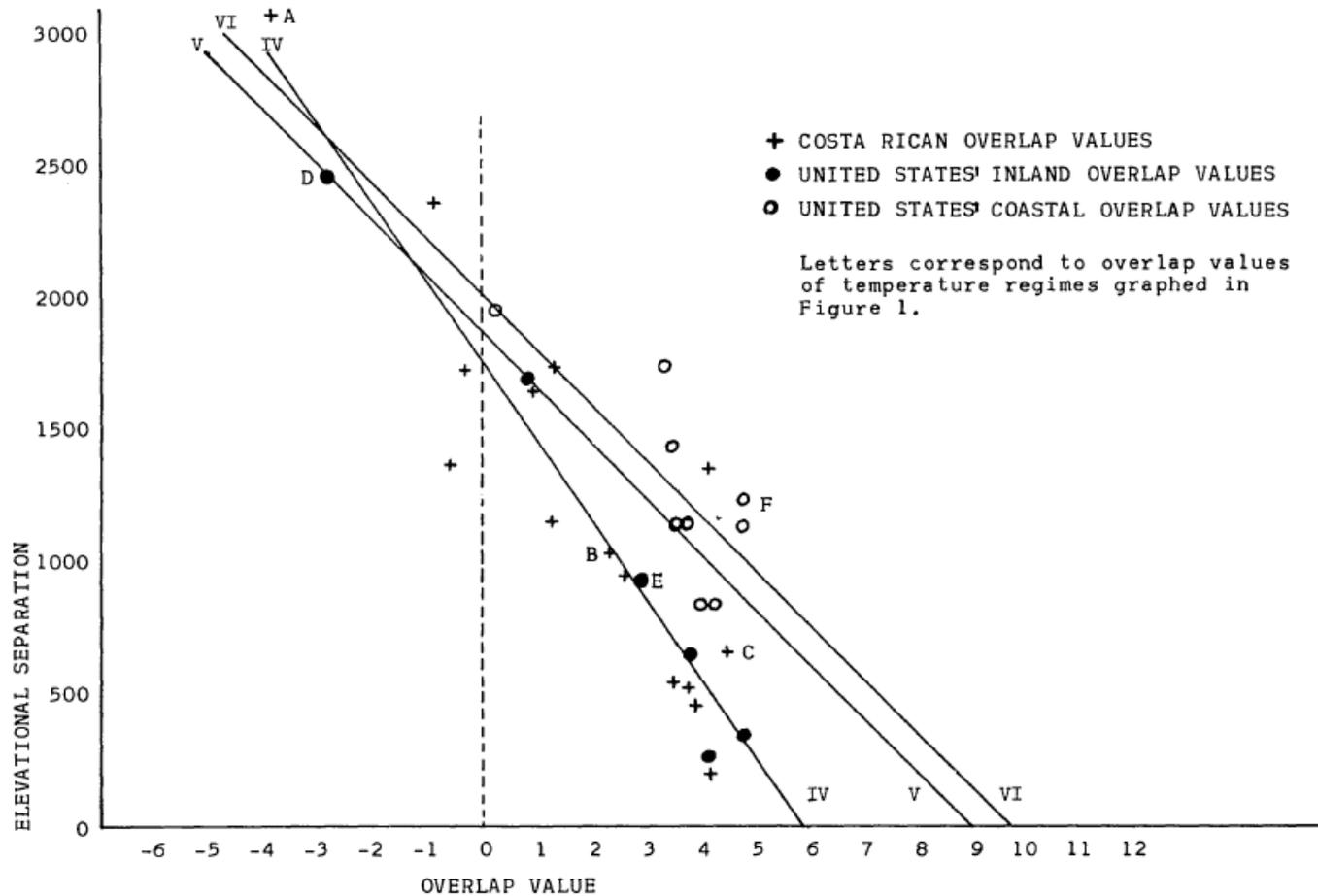
Daniel Janzen

- Decreasing overlap with increasing elevational separation
  - Leads to the classical conclusion that it is the height of the mountain barriers that is most important

- Costa Rica has the steepest slope, but **is not** significantly different than the US lines' slopes for the 12 month overlap values
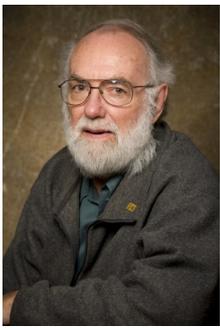
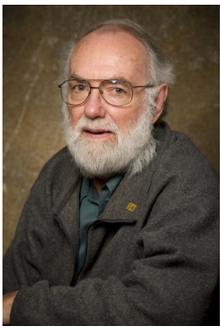# Species Ranges

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6 month overlap values

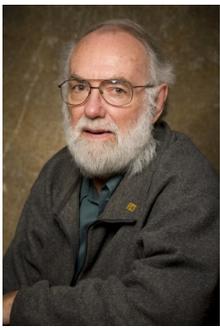# Species Ranges

Daniel Janzen

- Costa Rica has the steepest slope, but **is** significantly different than the US lines' slopes for the 6 month overlap values

- Decreasing levels of overlap, and more divergence, with less elevational separation
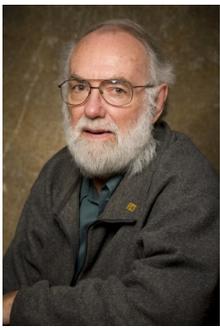
Species Ranges

Daniel Janzen

- Acclimation and Evolutionary Adaptation

- *"…the larger the usual variation around the mean environmental values, the higher the probability that an organism will survive a given deviation from that mean."*

Species Ranges

- Acclimation and Evolutionary Adaptation

- *"...a tropical organism from the valley bottom is less likely to get over the pass than is a temperate organism, because the tropical organism has a higher probability of encountering temperatures to which it is neither acclimated nor evolutionarily adapted than does the temperate organism."*

Species Ranges

Daniel Janzen

Main Points

- Species avoid competitive exclusion by avoiding competition and inhabiting unique areas versus competitors

- Fundamental niche – where species *could* exist
- Realized niche – where the species *does* exist

- In the tropics, terrestrial organisms are exposed to relatively stable conditions and, as a result, are presumed to have narrower niches, often limiting their travels to one watershed and elevational zone
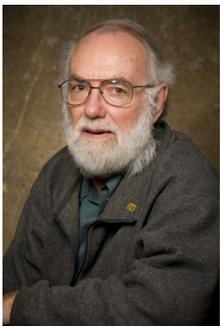
Questions on the reading?
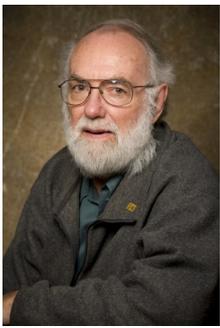
Discussion Point 1

Daniel Janzen

- Why did Janzen pick the temperate growing season and tropical rainy season for the 6 month overlap?

Discussion Point 2

Daniel Janzen

- Why does the timing of the overlap matter?

- How could this timing be related to the Wallace Effect?