Dispersal

http://plantsandrocks.blogspot.ca/2012/02/leaving-home.html

Goals and learning objectives

1) Understand how dispersal and vicariance can influence speciation, and how these have different population histories.

2) Be able to relate the process of dispersal to dynamics and movements within species ranges and consider how this may affect ranges limits

3) Consider the different modes of dispersal by organisms (passive versus active) and how this impacts how isolated or connected populations may be in a landscape

4) Understand the impacts of dispersal barriers, corridors and filters, and how these can impact the dynamics of populations in ecological time, or evolution and speciation over long periods of time

5) Consider the costs and benefits of dispersal and philopatry and what sorts of environmental conditions would favor either of these

Dispersal

What is dispersal?

Dispersal: the movement of an individual from its place of birth to the place where it reproduces or would have reproduced had it survived and found a mate (after Howard 1960)

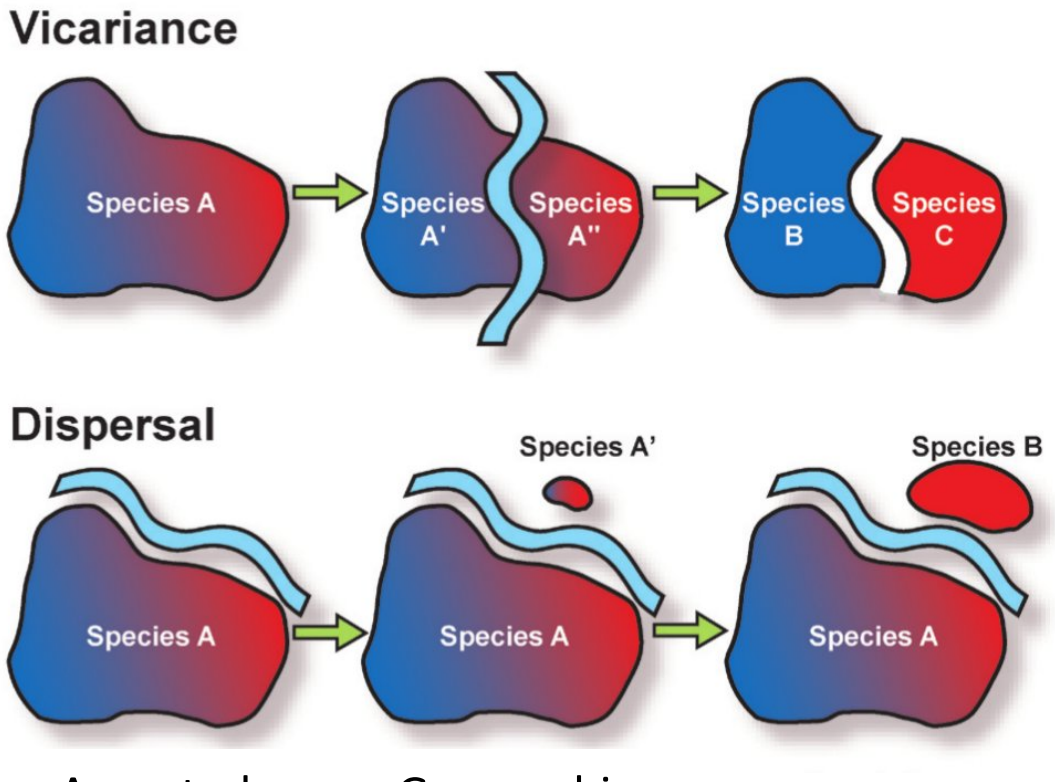
1. Dispersal does *not* necessarily result in gene flow
2. Dispersal is *not* the same as migration
3. Dispersal and migration may interact (e.g., long distance migration could influence dispersal)
4. Dispersal is *not* the same as dispersion, which refers to the spatial distribution of individuals in a population
5. Dispersal can be discussed in the context of *ecological process* (contemporary) or *historical biogeographic events*. Historical dispersal events are difficult to study (but we also know they are important)

Migration: the spatially and temporally predictable movement of individuals between breeding and foraging habitats (Hendry *et al.* 2004)

Dispersal

At the center of arguments to explain *disjunct distributions*: dispersal versus vicariance

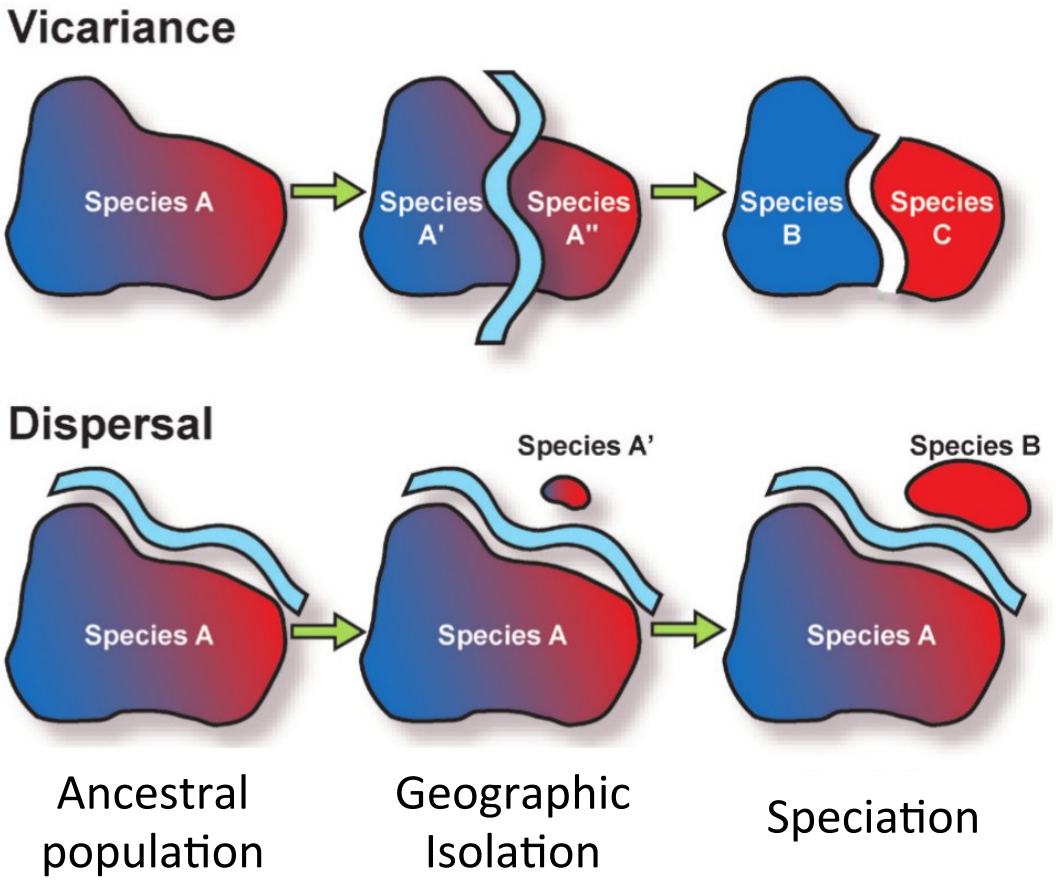
Vicariance: establishment of a barrier separating populations that were already present



Dispersal

At the center of arguments to explain *disjunct distributions*: dispersal versus vicariance

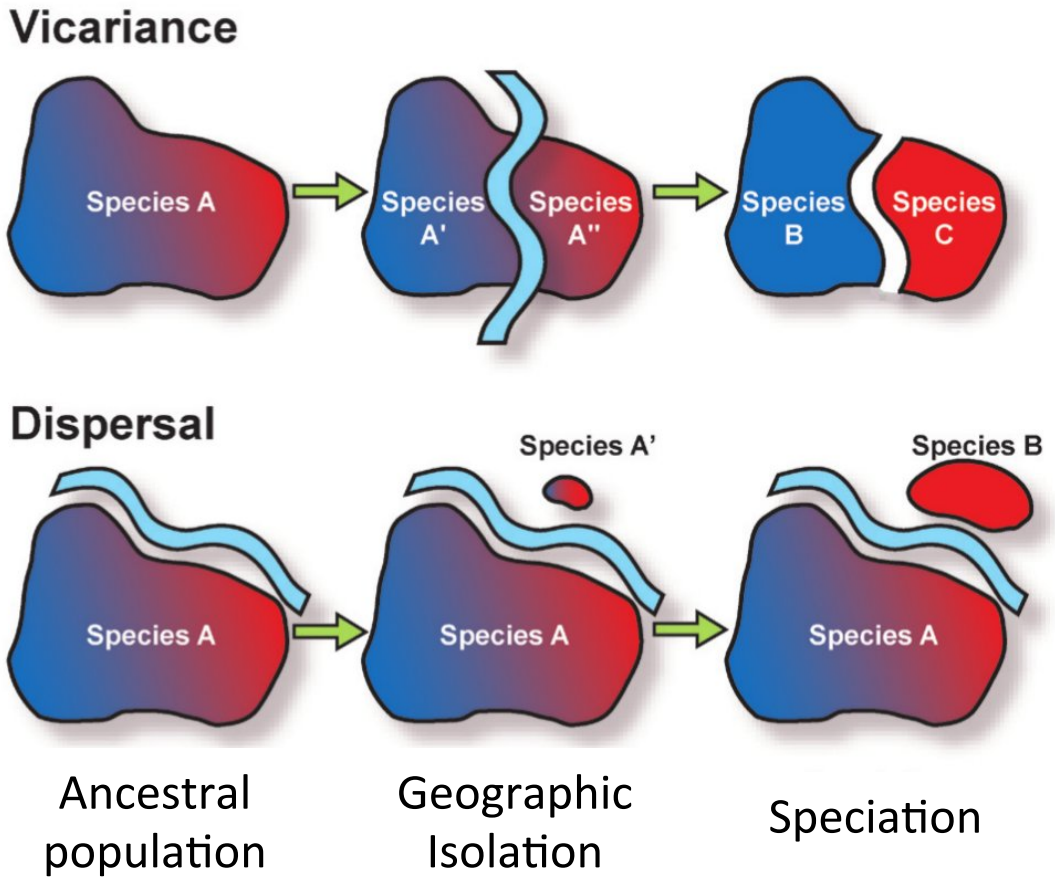
With vicariance, both "new" regions were previously occupied by the taxon before the existence of a barrier (speciation happens after the appearance of a barrier)



Dispersal

At the center of arguments to explain *disjunct distributions*: dispersal versus vicariance

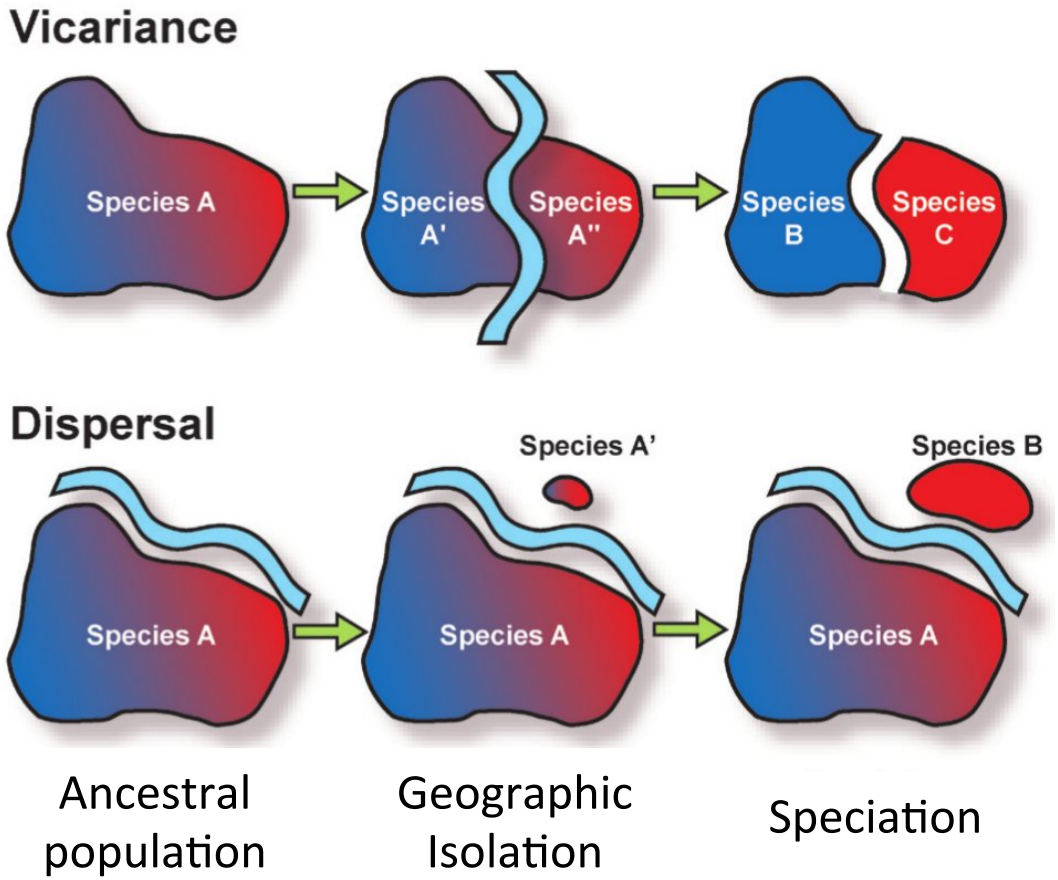
With dispersal, individuals actively colonize an area beyond a pre-existing geographic barrier to eventually form a new species



Dispersal

We'll revisit this later, but you should keep in mind for your paper assignment:

What evidence or information do we need to establish whether disjunct populations were caused by a dispersal event or by a vicariance event?



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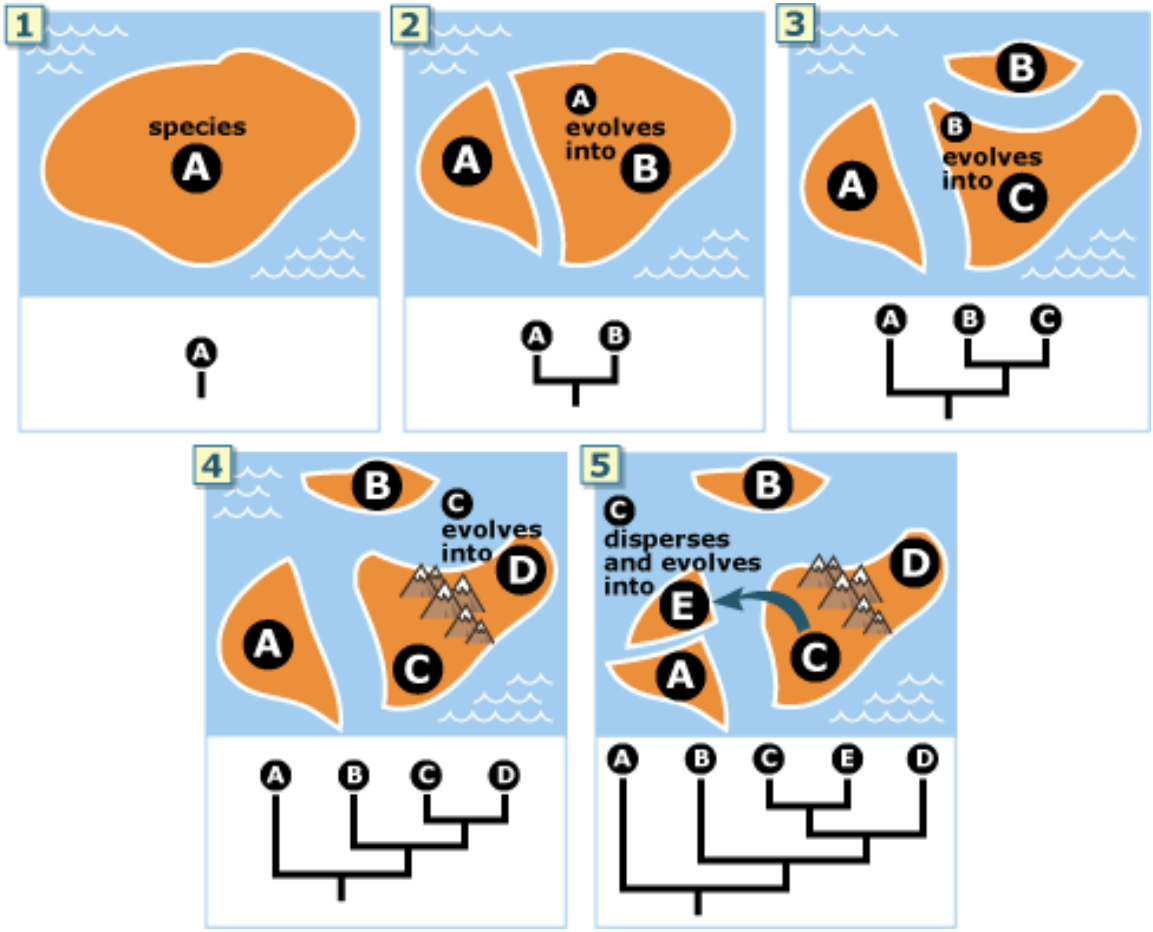

Dispersal

Features of dispersal as an ecological process:

- Can take place before or after first breeding
- May depend on environmental events or it may be "innate"
- May be density-dependent (or related to carrying capacity)
- Can be "condition dependent"
- Many taxa have sex-biased dispersal (e.g., birds and mammals)
- Successful reproduction by dispersers results in gene flow

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Dispersal

Outline of dispersal topics:

1) Mechanisms of Dispersal

2) Barriers and Corridors

3) Range Expansion

4) Evolution of Dispersal and Philopatry

Mechanisms of Dispersal

What is a propagule?

Propagule: any part of an organism, life stage of an organism, or individual in a group of organisms that can reproduce and establish a new population

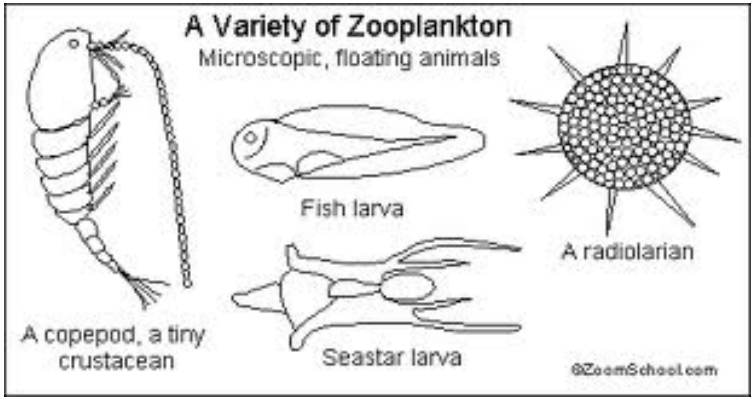
Challenges to establishing populations:

1. Sexual reproduction requires two individuals to found a population
2. Establishment of one species can be dependent on other species (i.e., trophic structure, mutualists, predator/prey, host/parasite interactions)

Mechanisms of Dispersal

Passive dispersal

Pagility: the ability of an organism to disperse passively, where dispersal is dependent on some force external to the organism



Mechanisms of Dispersal

Passive dispersal

Modifications allow seeds to travel varying distances from host plants using air, water or animals.

Wind dispersed

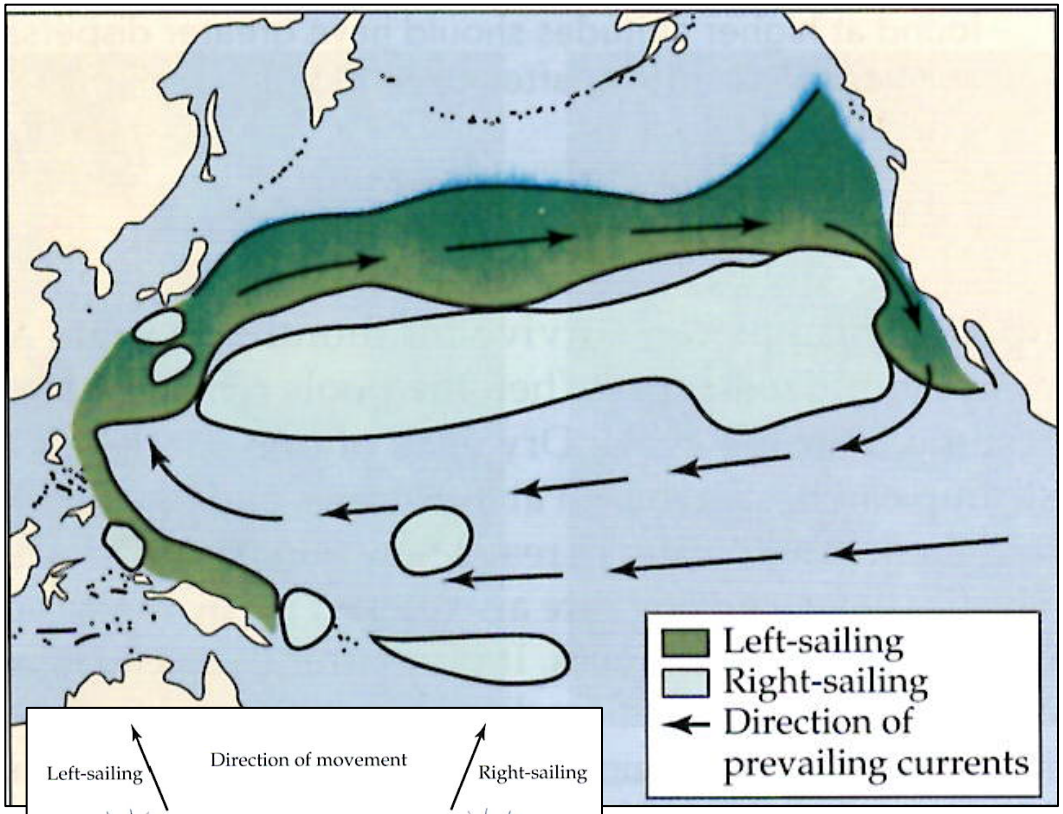

Adherent


Fleshy

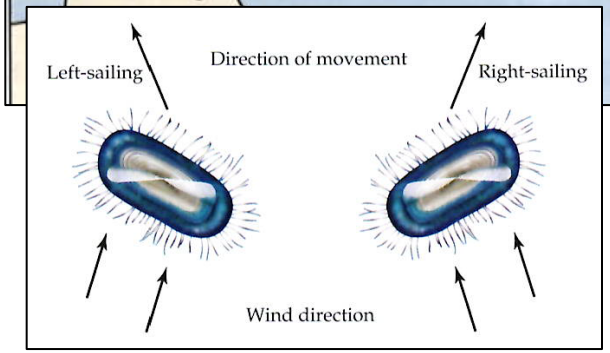

Explosive


Mechanisms of Dispersal

Passive dispersal



Most marine organisms have free-living juvenile stages that drift near the surface and move passively with ocean currents.



Cnidarian jellyfish have different “sails” that carry individuals in more predictable directions.

Lomolino et al. 2017

Mechanisms of Dispersal

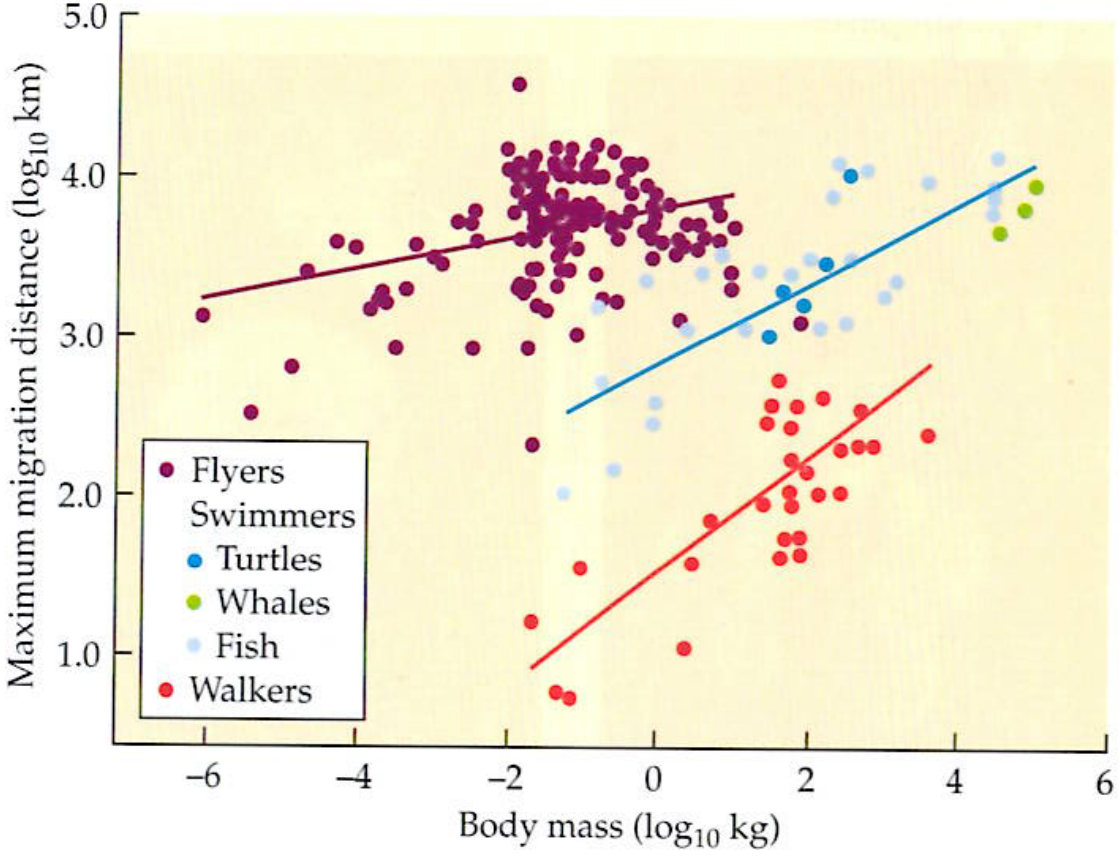
Active dispersal

Vagility: the ability to disperse actively

Mechanisms of Dispersal

Active dispersal

There is a strong and predictable relationship between dispersal capacity and two fundamental characteristics of active dispersers: **dispersal mode** and **body size**



The maximum recorded distance between breeding and foraging sites for active dispersal varies with the means of movement

For active dispersers, dispersal capacity increases with body size.

What relationship would you expect for passive dispersers?

Lomolino et al. 2017 - *Biogeography*

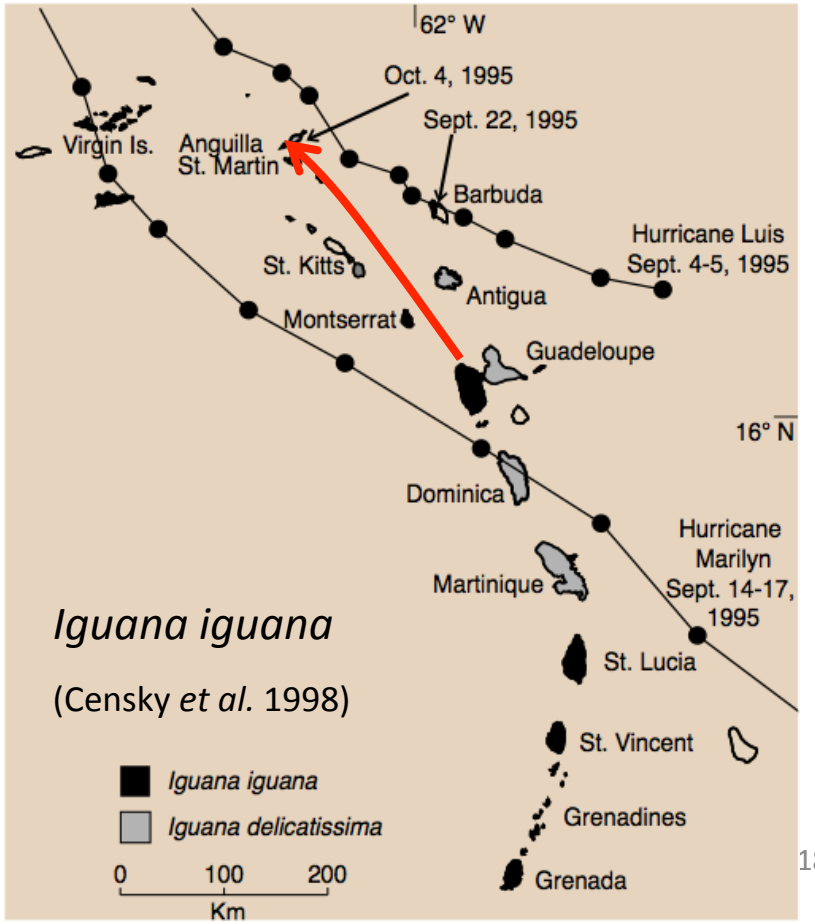
Mechanisms of Dispersal

Sweepstakes dispersal

Sweepstakes dispersal: the partly stochastic dispersal of some individuals, and the establishment of remote or disjunct biota.

Over-water dispersal due to hurricanes. On October 4, 1995, ~ 15 individuals of the green iguana appeared on eastern beaches of Anguilla in the Caribbean.

This species did not occur on the island previously, but arrived on a mat of logs and uprooted trees with large root masses.

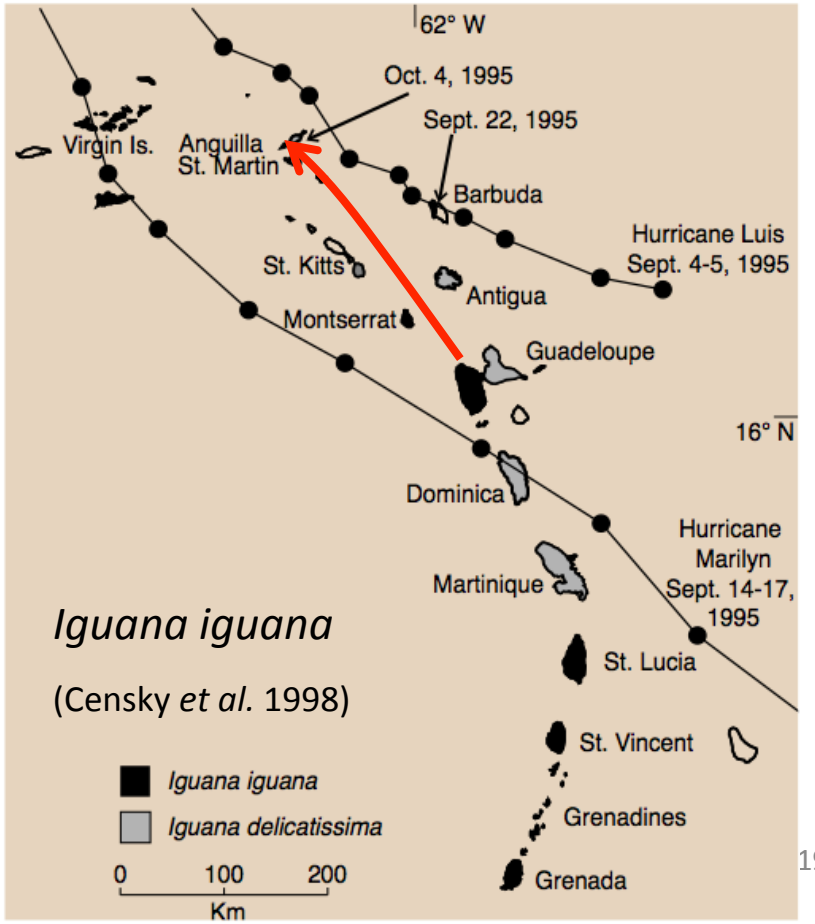


Mechanisms of Dispersal

Sweepstakes dispersal

Sweepstakes dispersal: the partly stochastic dispersal of some individuals, and the establishment of remote or disjunct biota.

Chances of successful "rafting" are small, but over long periods of time, there is a high probability of a few chance events being successful.



Mechanisms of Dispersal

Sweepstakes dispersal

Sweepstakes dispersal: the partly stochastic dispersal of some individuals, and the establishment of remote or disjunct biota.

The Hawaiian hoary bat is most likely derived from migrating North American hoary bats that went astray.

The Farallon Islands (near the coastline of California) are a stopover site for NA hoary bats and would be the closest landfall (~3665 km from Hawaii)

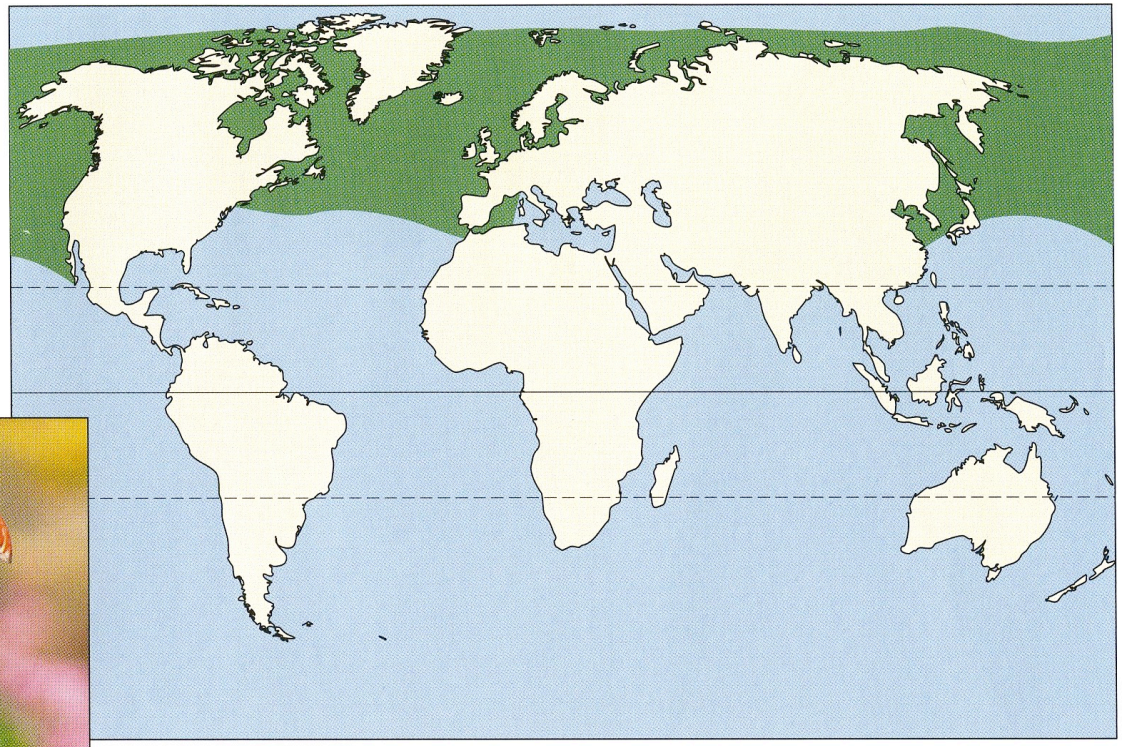
Hawaiian hoary bat (O-pay-ah-pay-ah) *Lasiurus cinereus semotus*

Hoary bat
Lasiurus cinereus

Barriers and Corridors

Physiological Barriers

Atlantic Puffin



Distribution of species in the family Alcidae

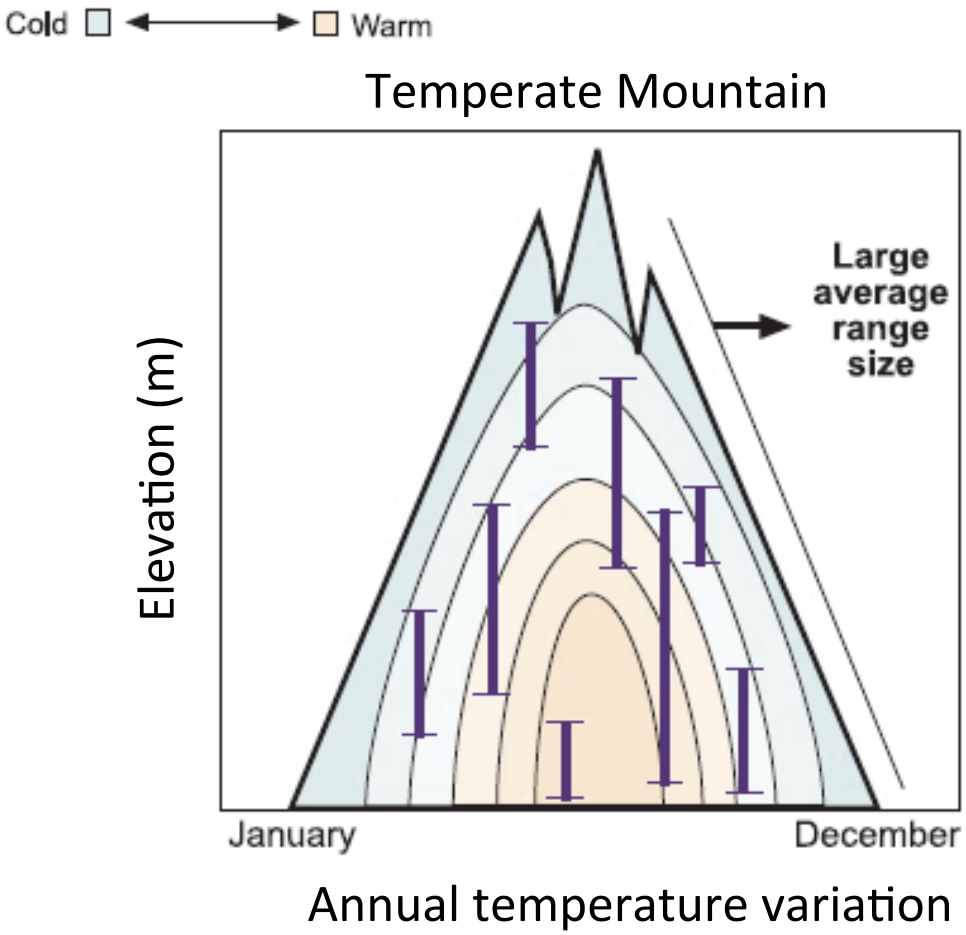
Many species appear to be restricted to particular regions due to temperature tolerance. The avian family Alcidae (auk, puffins, murres) is restricted to cooler regions of the northern hemisphere, whereas the family Spheniscidae (penguins) is restricted to the southern hemisphere

Lomolino et al. 2010

Barriers and Corridors

Physiological Barriers

Mountain passes are greater barriers to dispersal in the tropics than in temperate regions because there is less overlap in thermal regimes experienced at low and high altitudes in the tropics.



McCain 2009, *Ecol. Letters*; Janzen 1967, *American Naturalist*

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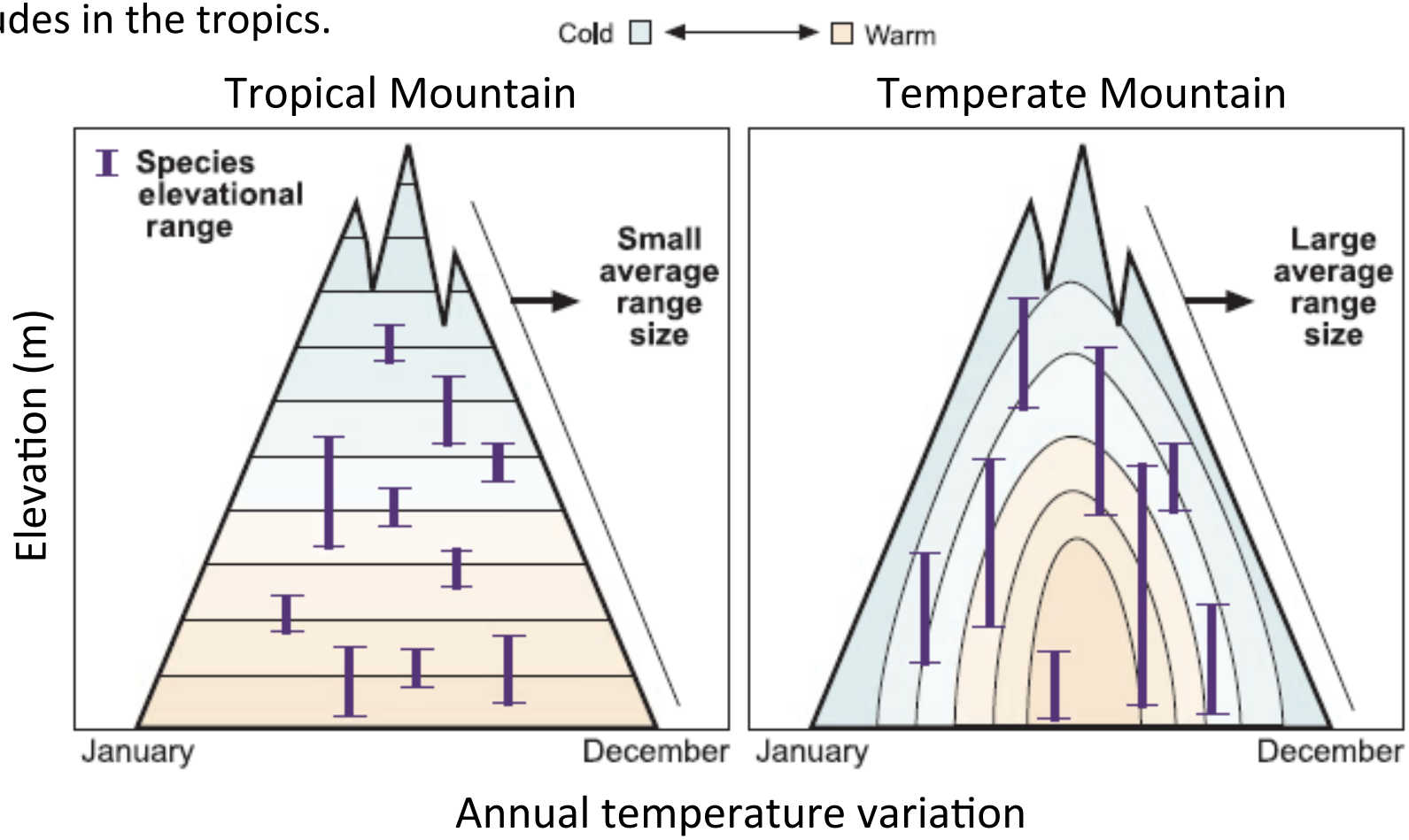

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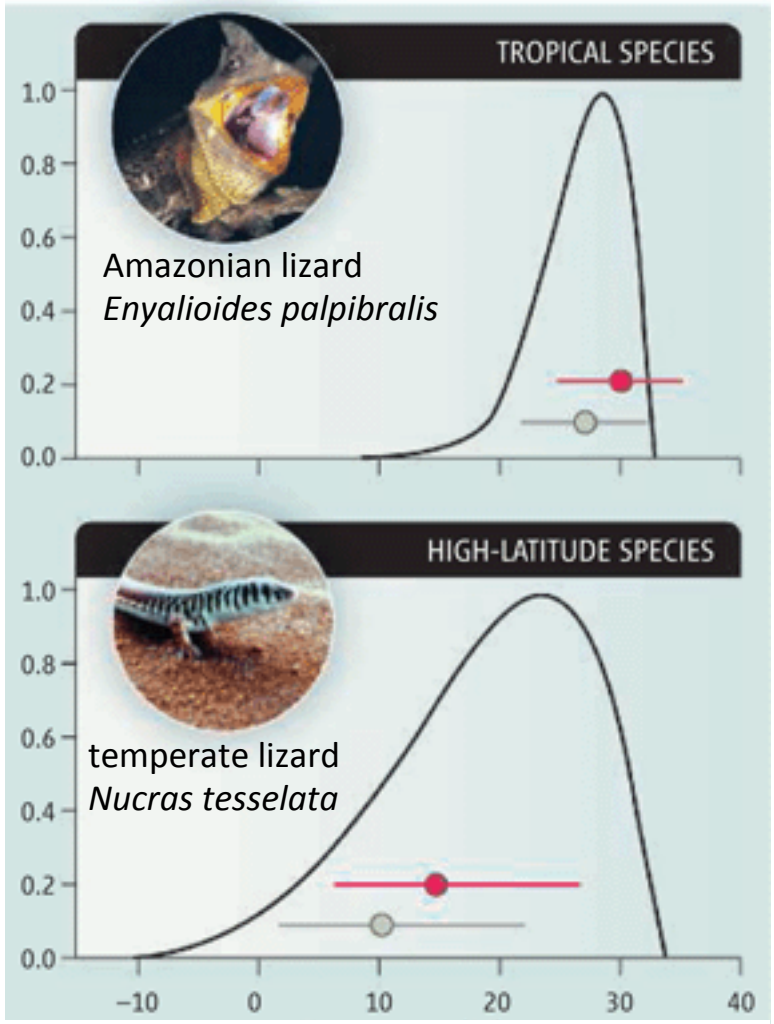
Barriers and Corridors



Data from diverse tropical ectotherms (e.g., fish, insects, reptiles, amphibians) suggest that tropical species living in stable aseasonal climates have:

1) narrower thermal tolerances than higher-latitude species

2) live in climates closer to their physiological optima

- Current mean temperature
- Current temperature range
- Predicted mean temperature in 2100
- Predicted temperature range in 2100

Tewksbury et al. 2008, *Science*

Barriers and Corridors

Corridors

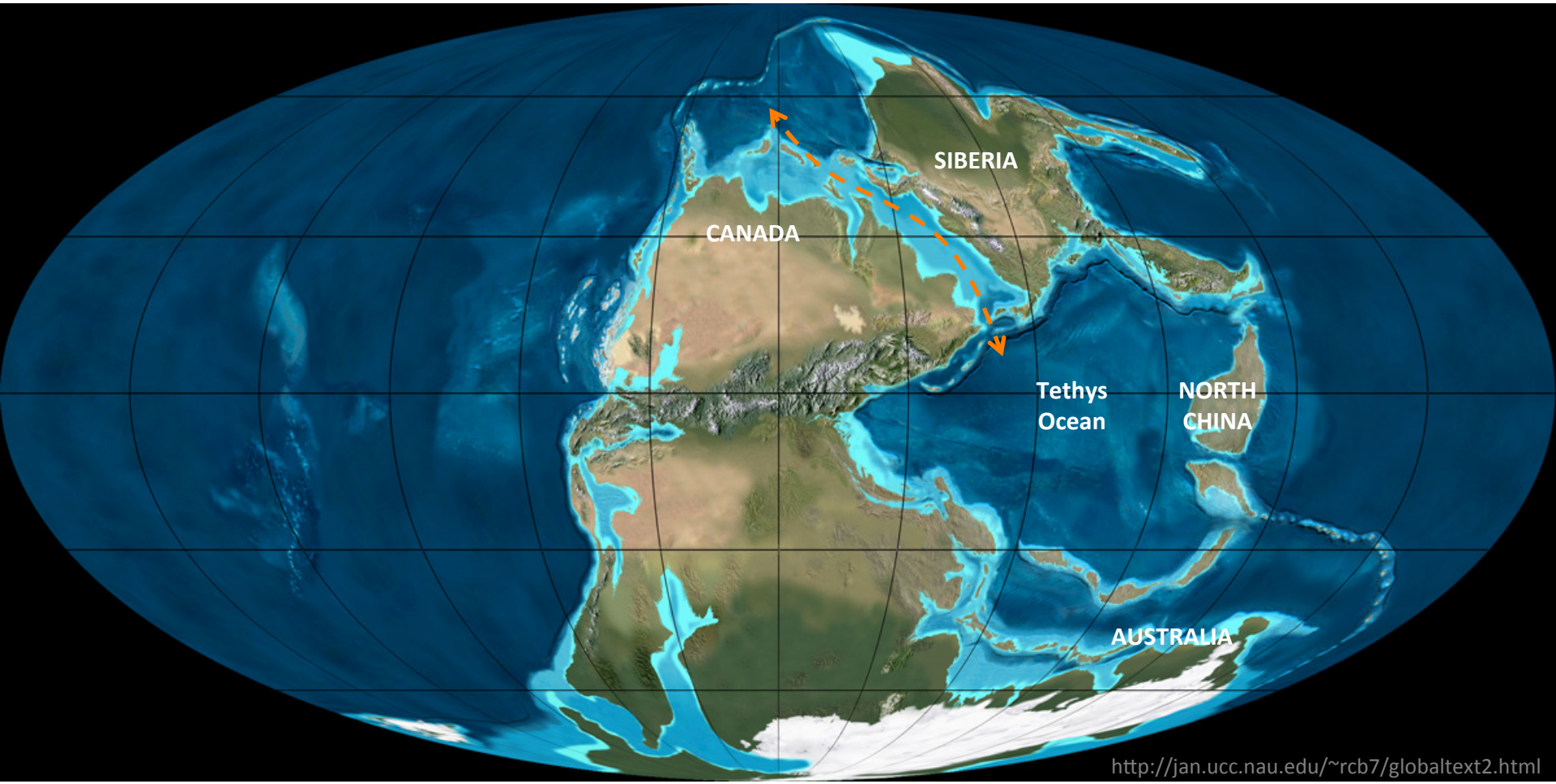
Corridor: a non-selective dispersal route that permits the movement of individuals from one region to another.

Corridors should provide environments similar to that of the two source areas that it links

Corridors allow a taxonomically balanced assemblage of plants and animals to cross from one large source area to another

Barriers and Corridors

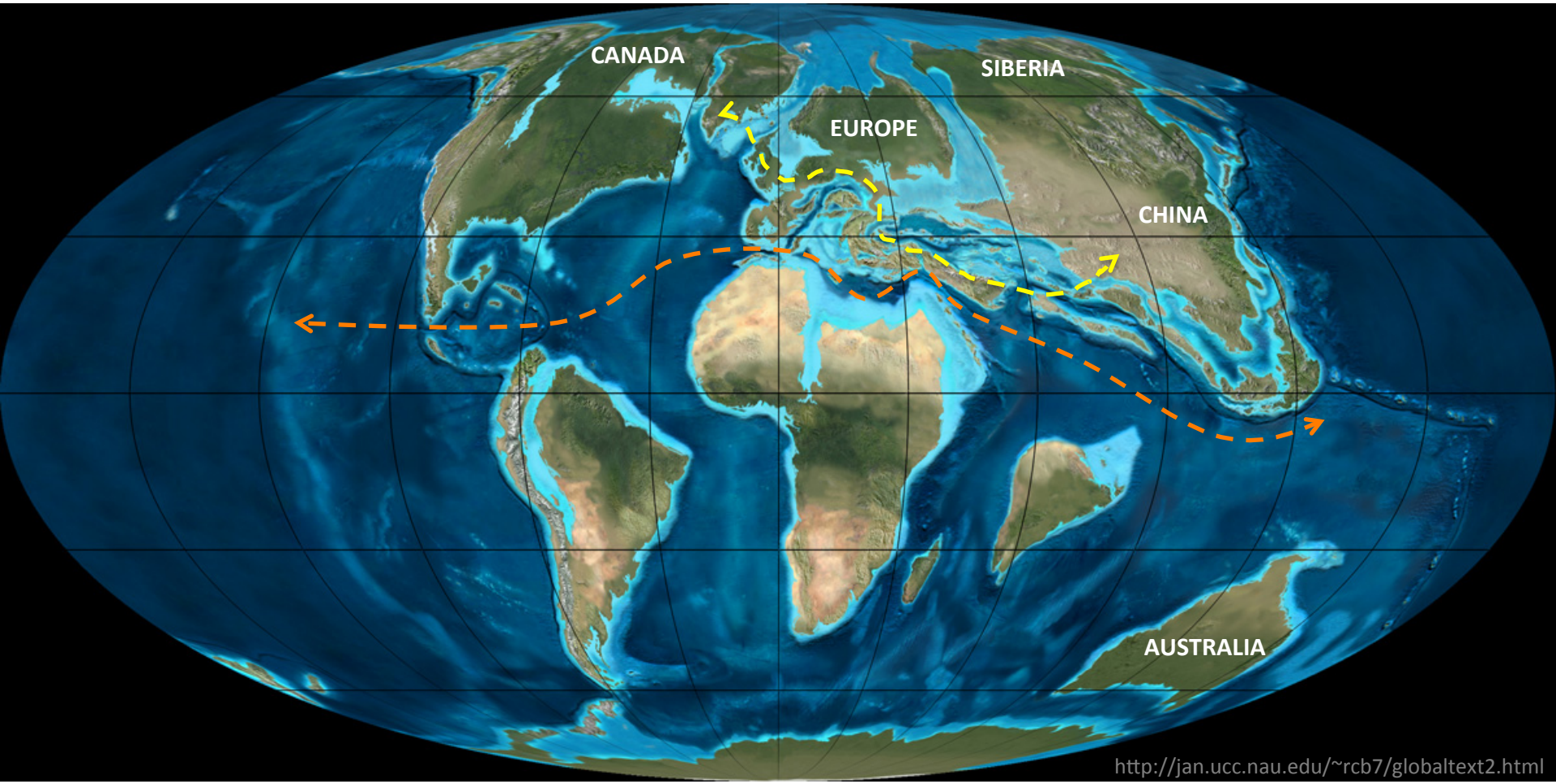
Historical Corridors



280 mya (Early Permian)

Barriers and Corridors

Historical Corridors

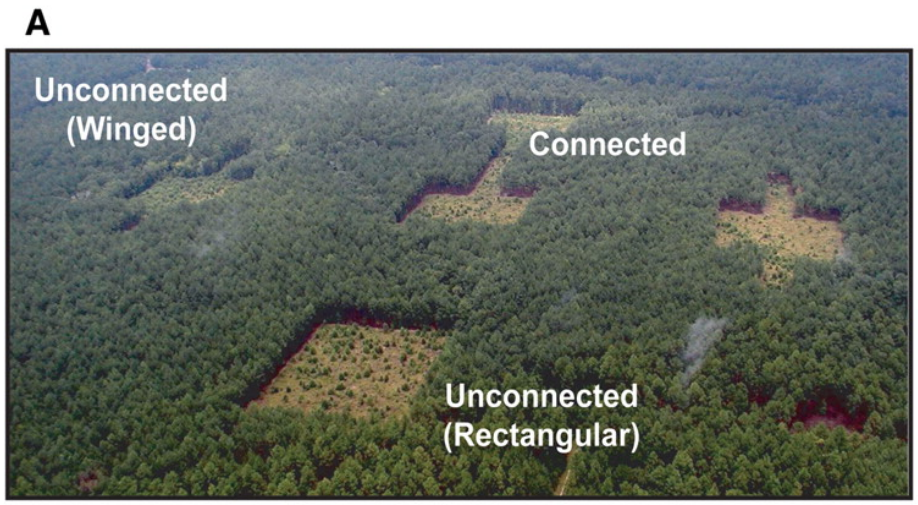


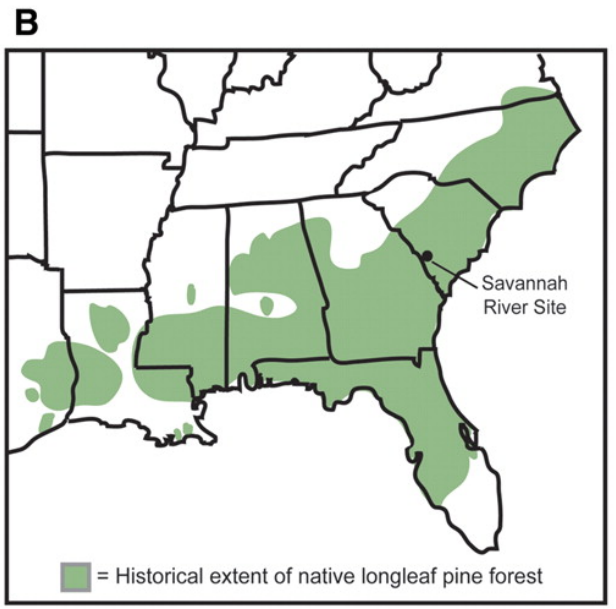
65 mya (Cretaceous-Paleogene)

Barriers and Corridors

Ecological corridors (i.e., habitat corridors)

Eight experimental deforestation landscapes at the Savannah River Site (SRS)





One of 8 landscapes of regenerating longleaf pine savanna

Examined connectivity while controlling for edge and area

Brudvig et al. 2009 PNAS, http://www4.ncsu.edu/~haddad/Corridors/SRScorridor.html

Barriers and Corridors

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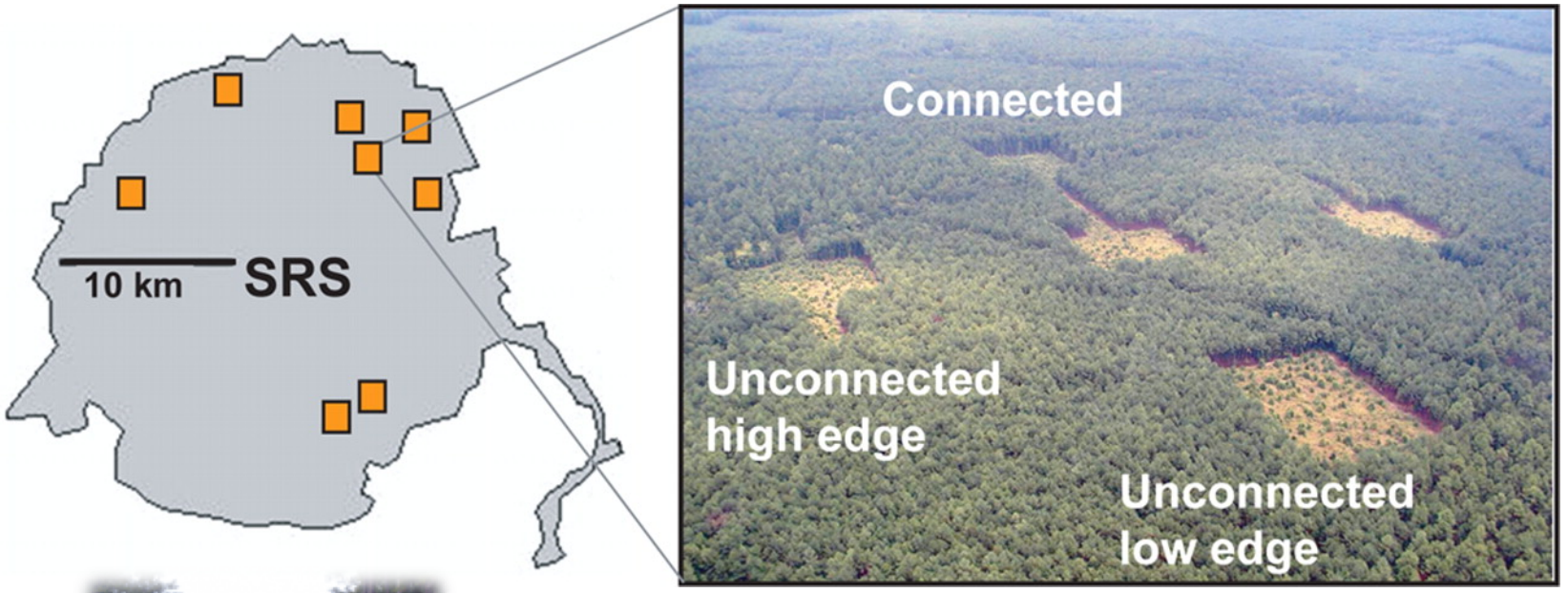

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Barriers and Corridors

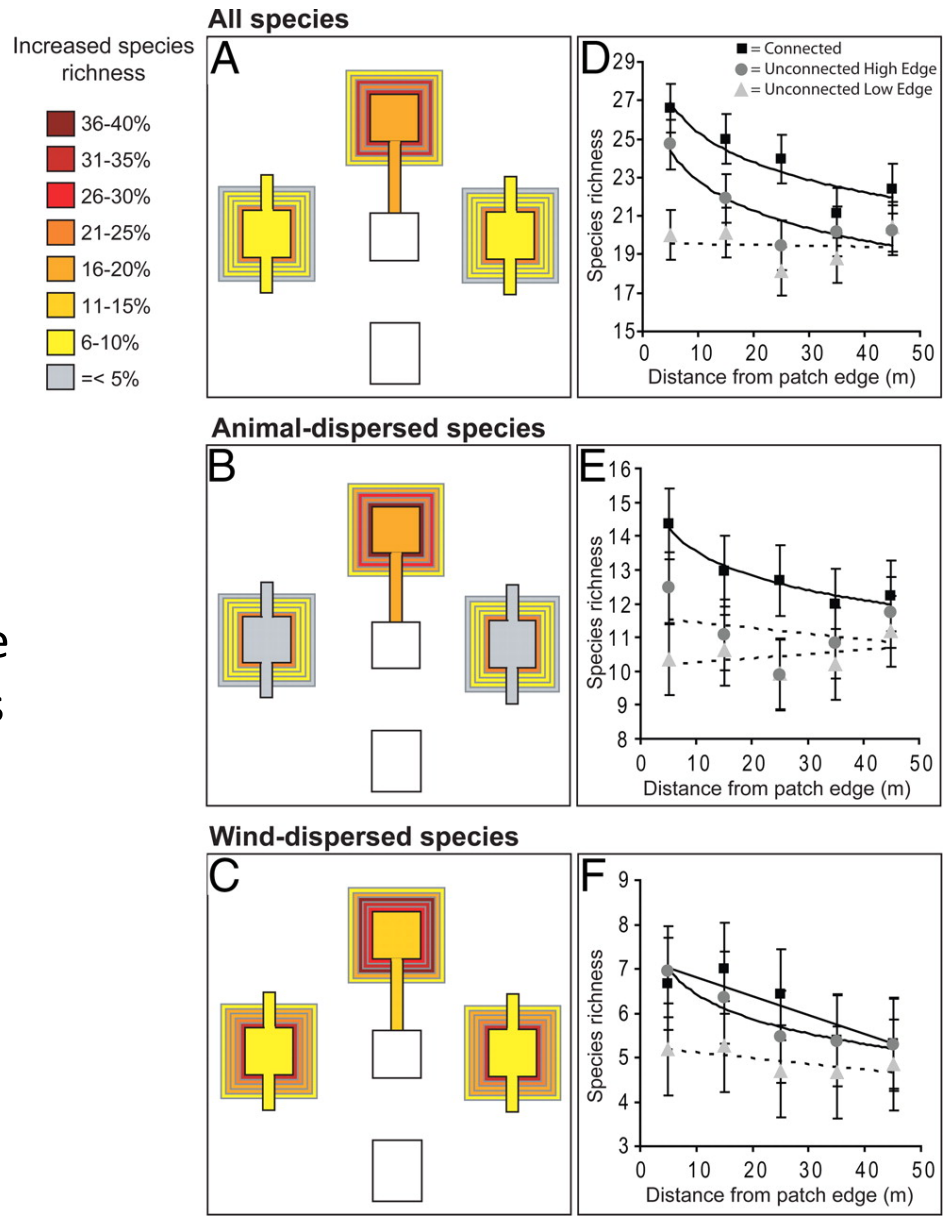
Ecological corridors

Species richness for plants (3 groups)

Within-patch colours show increases in species richness during annual surveys (2001-2007)

Coloured strips outside patches (non-target areas) show increases relative to unconnected areas in 10-m increments from target habitat

Both patch type and distance from target patch edge were significant predictors of species richness across groups



Brudvig et al. 2009 PNAS

Barriers and Corridors

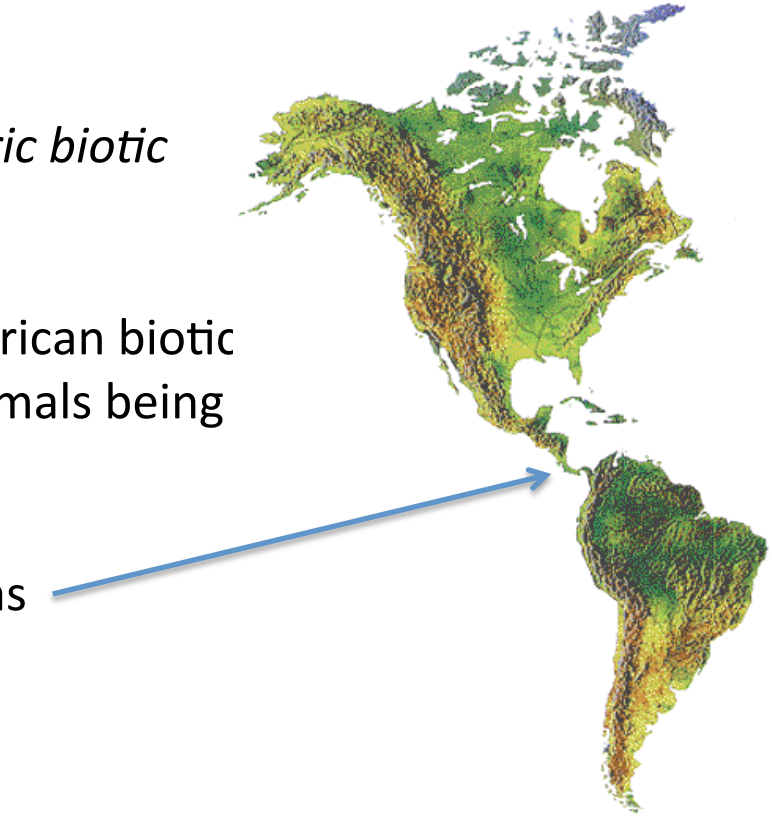
Filters

Filter: a selective or restrictive dispersal route that permits the movement of individuals with certain characteristics from one region to another.

A filtering dispersal route can lead to *asymmetric biotic exchange*

Example: the mammalian bias in the great American biotic exchange may have resulted from more NA animals being savanna-adapted (more savanna habitat in NA)

At the time of the exchange, the land bridge was continuous savanna



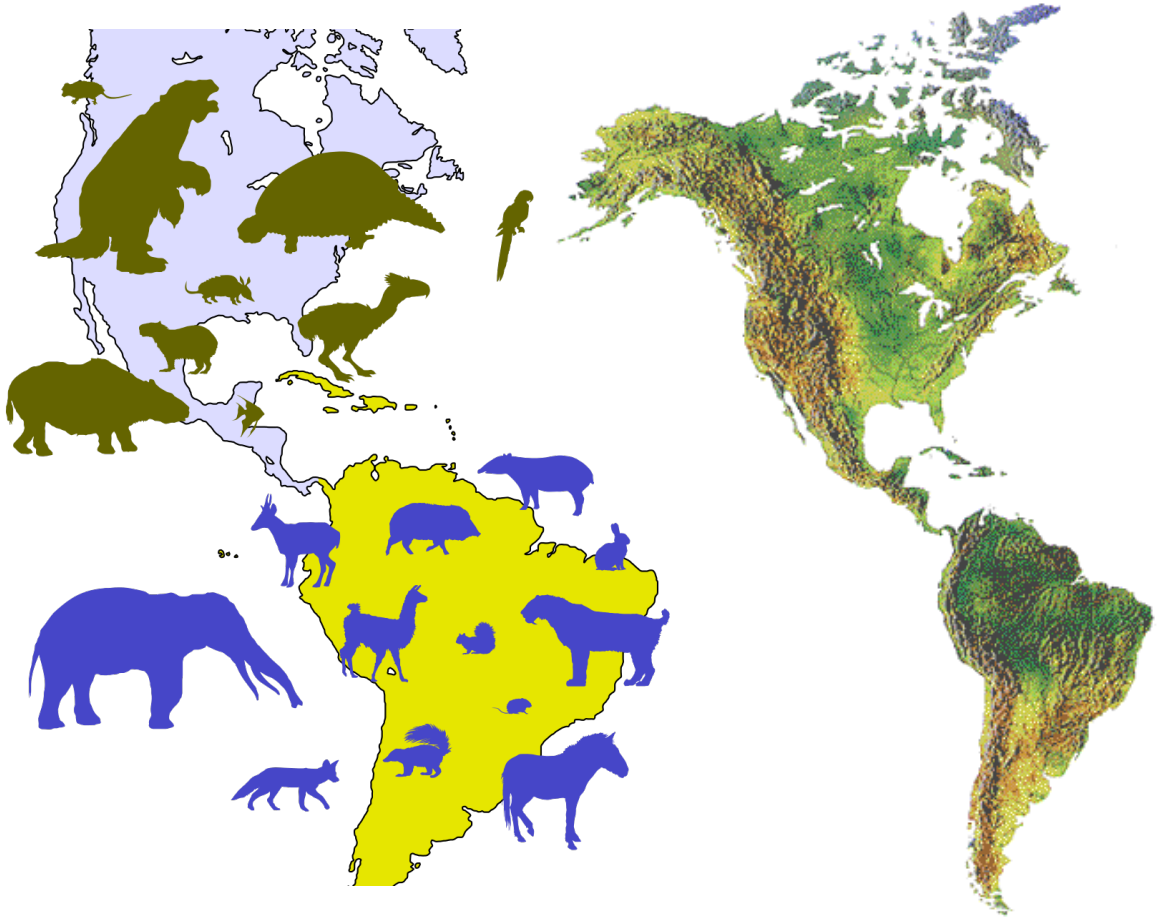
Barriers and Corridors

Filters

Filter: a selective or restrictive dispersal route that permits the movement of individuals with certain characteristics from one region to another.

Southern Origin
Porcupines
Glyptodonts
Armadillos
Giant ground sloths
Opossums

Northern Origin	
Rabbits	Mastodons
Field mice	Horses
Foxes	Tapirs
Bears	Peccaries
Raccoons	Camels
Weasels	Deer
Cats	



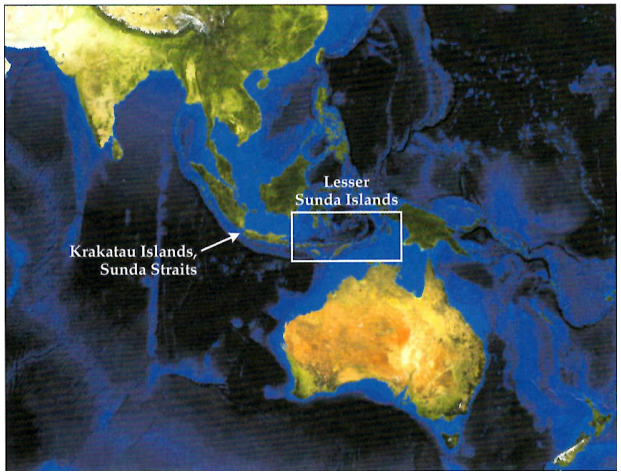
Barriers and Corridors

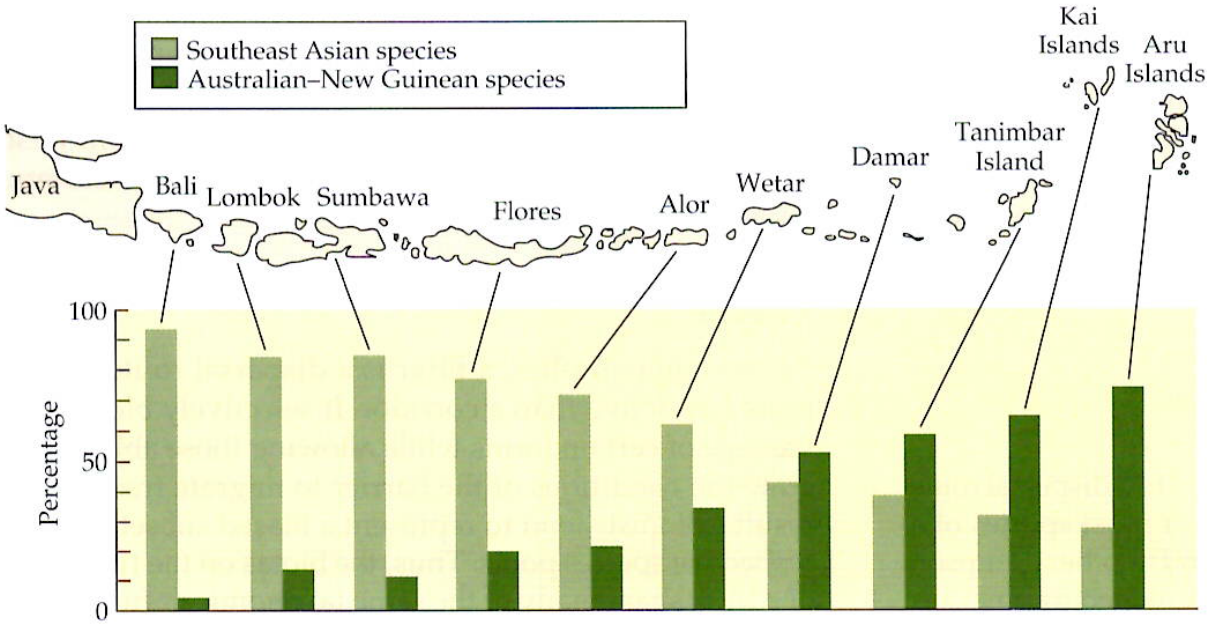
Filters

Filters can be identified easily because the number of species in certain taxa decreases in a regular manner with distance from the source area.

Filters can form transition zones between biogeographic regions:

Lesser Sunda Islands are a two-way filter for reptile species of Oriental and Australian origin





Lomolino et al. 2017 - *Biogeography*

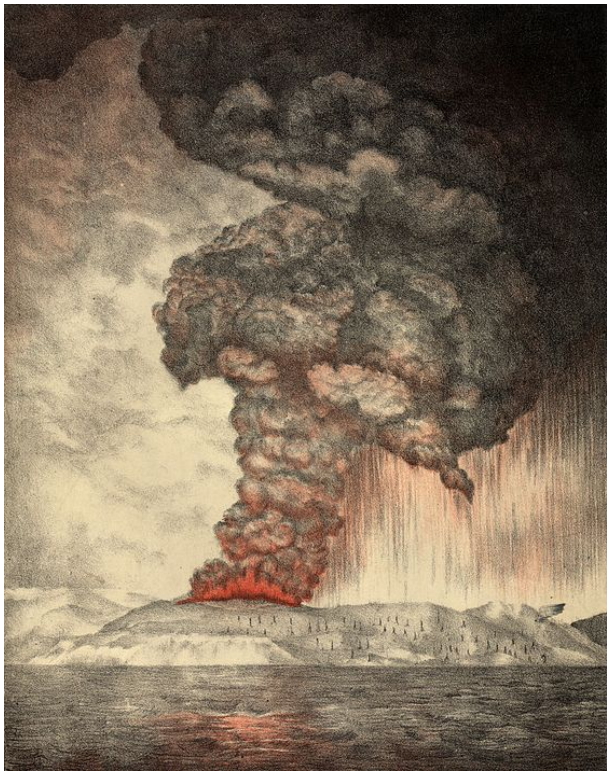
Range Expansion

Range expansion can follow one of two patterns:

1. Jump dispersal
2. Diffusive dispersal

Range Expansion

Jump Dispersal



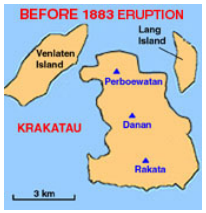
Eruption on Krakatau island in 1883

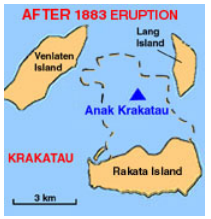
Was heard 3110 km away in W. Australia

Pressure waves recorded 5 days after explosion

Ash propelled 80 km high

Anyone within 16 km of explosion would likely have gone deaf…

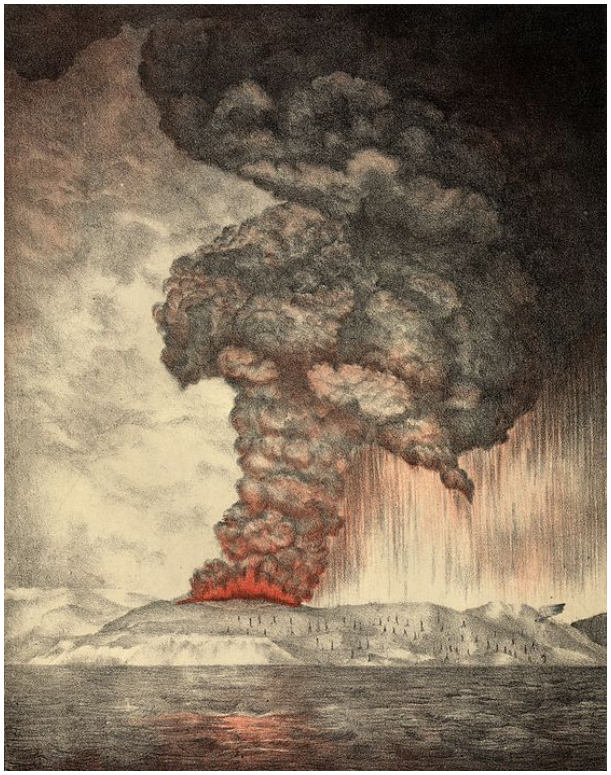




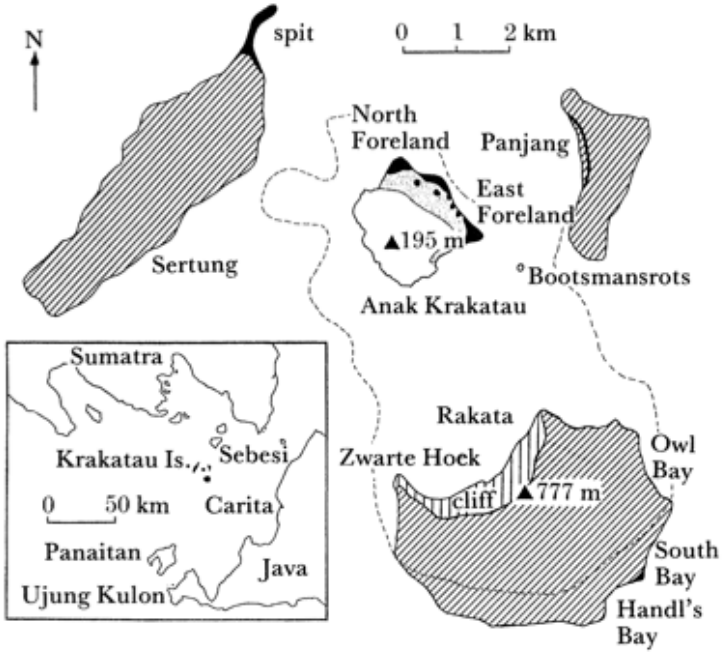
Bush and Whittaker 1991

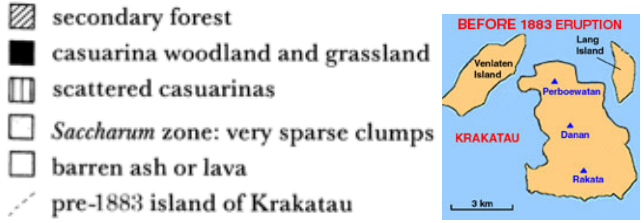
Range Expansion

Jump Dispersal



Species colonization for sea-, wind-, and animal-dispersed plants on Rakata Island, one of the islands near Krakatau

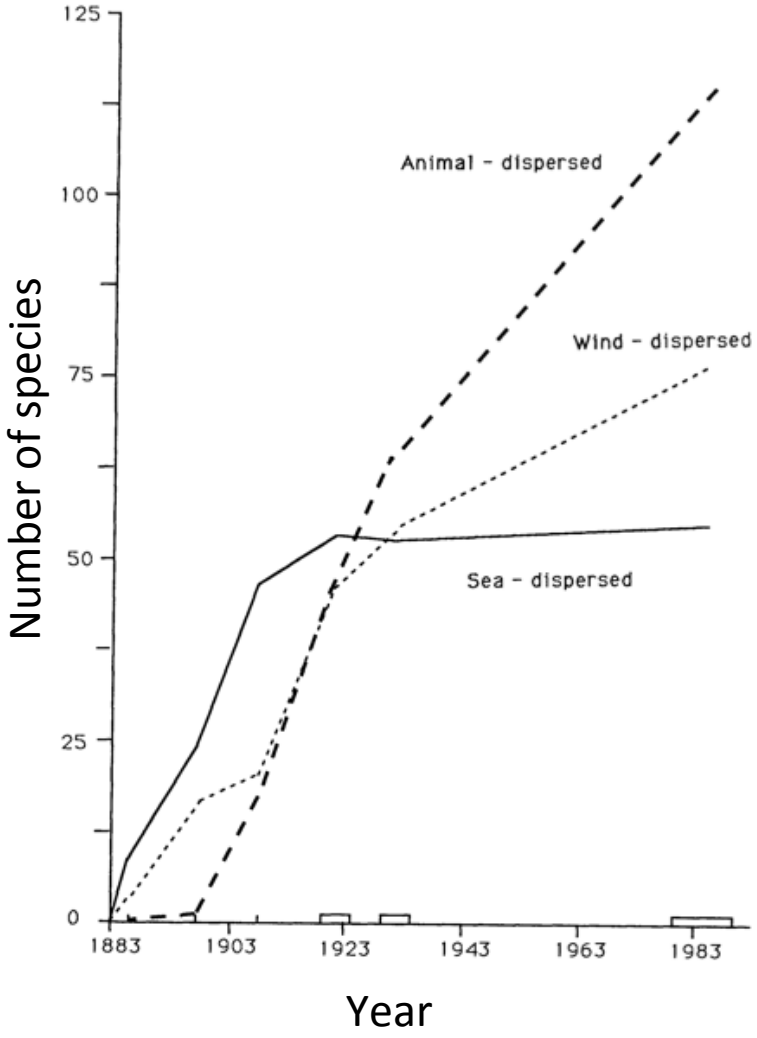




Bush and Whittaker 1991

Range Expansion

Jump Dispersal



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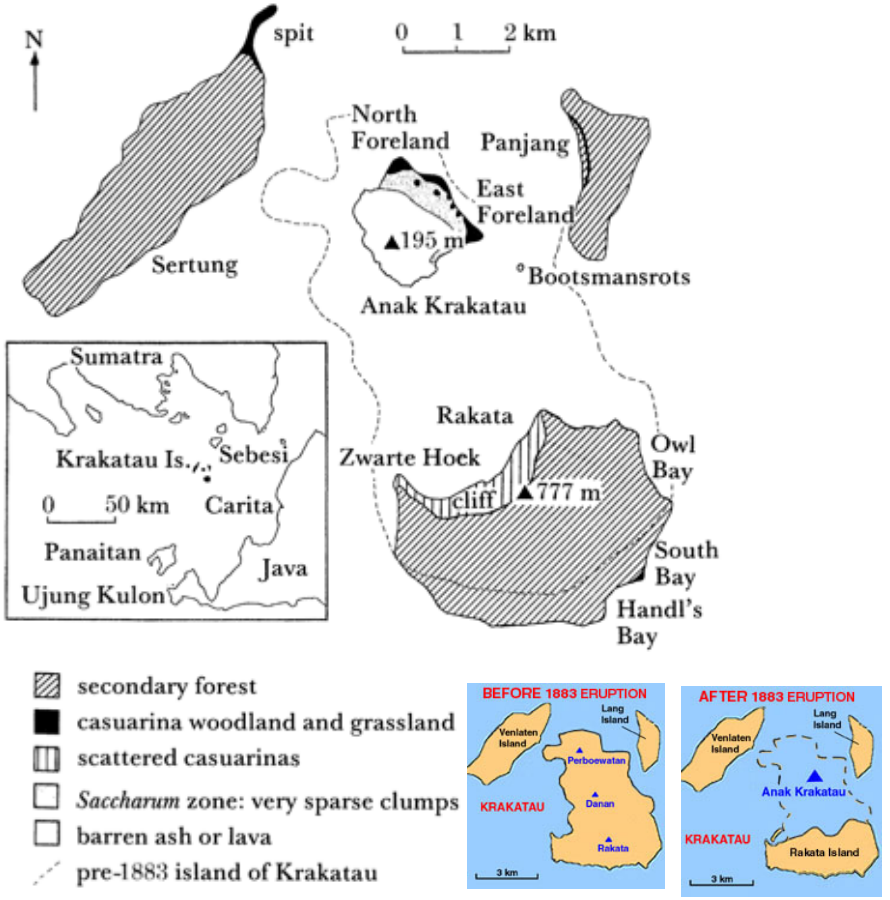
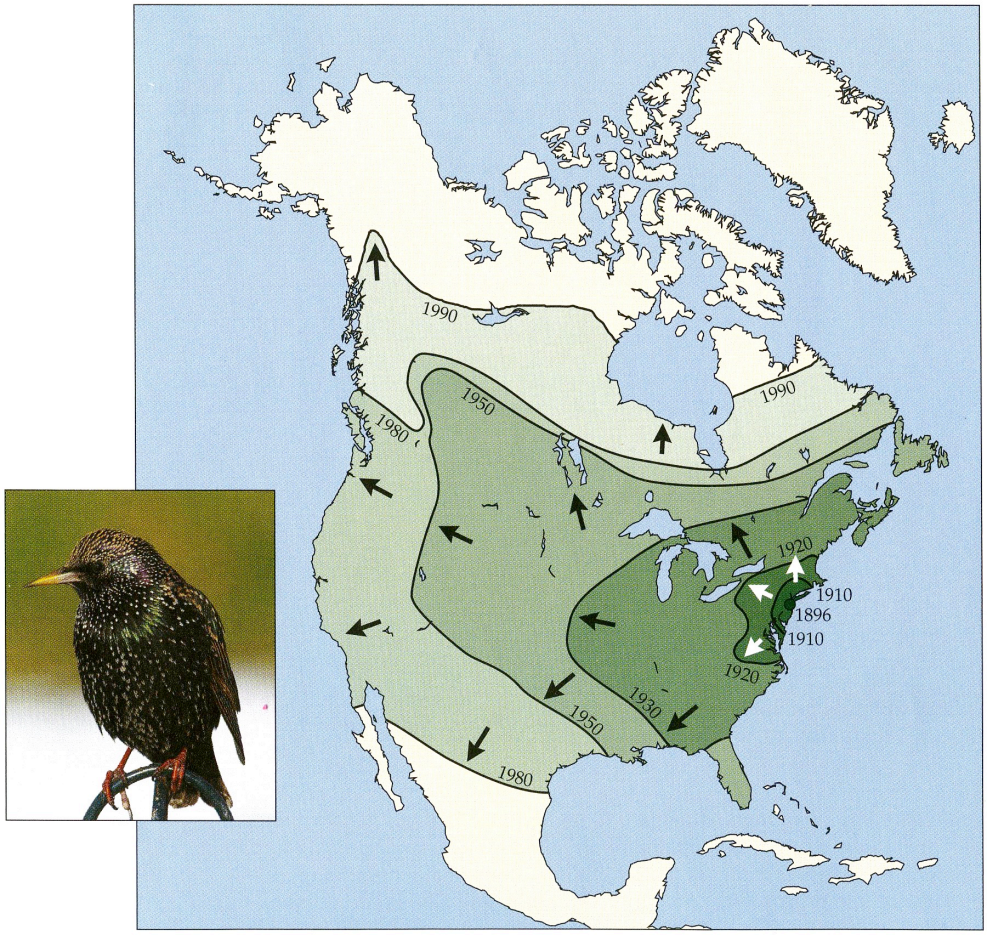


Bush and Whittaker 1991

Range Expansion

Diffusive Dispersal



European starlings (*Sturnus vulgaris*) were introduced intentionally to North America.

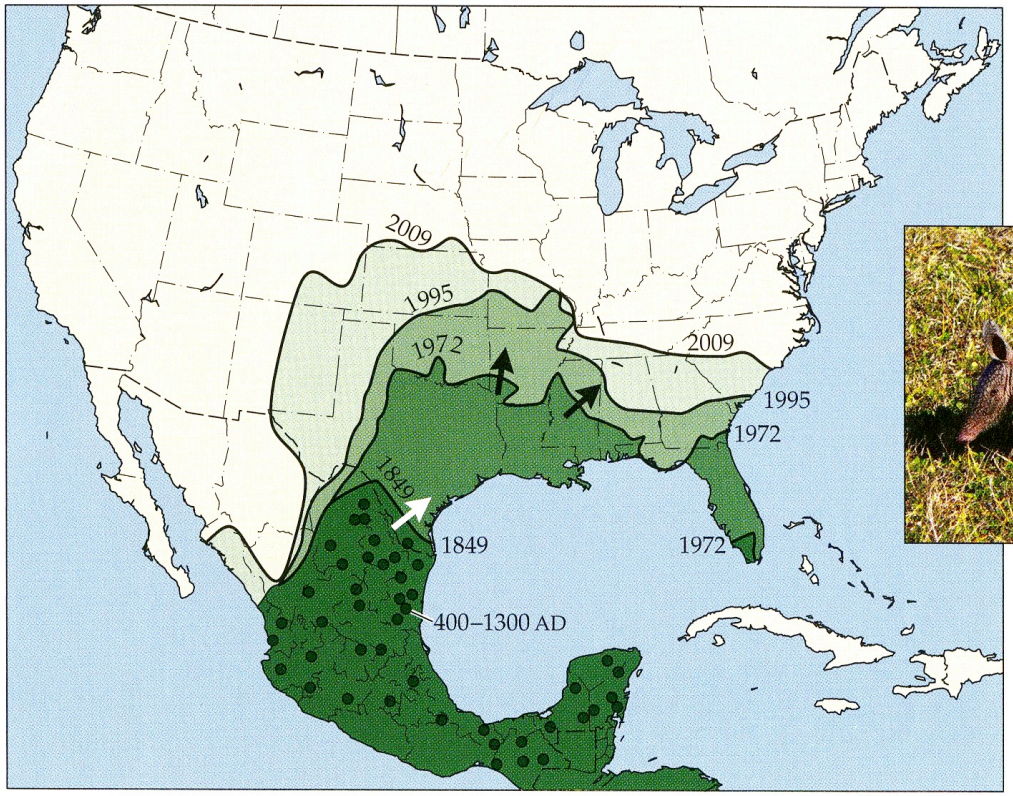
The American Acclimatization Society for European settlers, which hoped to introduce to the U.S. every bird mentioned in Shakespeare's scripts, released 80-100 starlings in New York City's Central Park in 1890 and 1891.

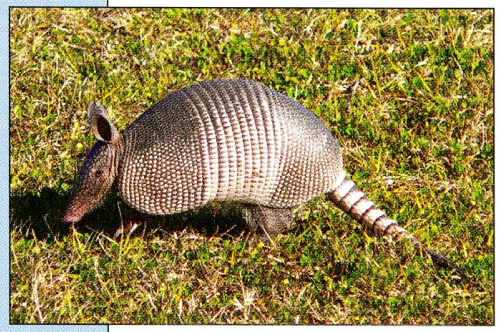
Now a population of > 200 million

Lomolino et al. 2010

Range Expansion

Diffusive Dispersal



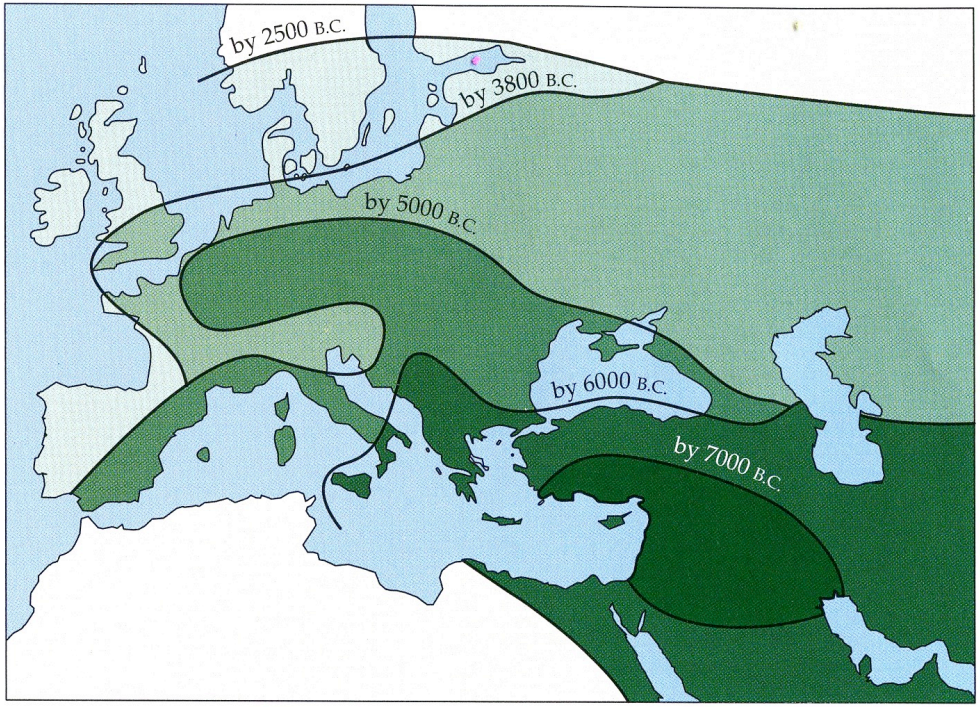


Northern range limit likely determined by cold tolerance and low heat conservation

The nine-banded armadillo (*Dasypus novemcintus*) is native to South America and continues to expand its range northward.

Range Expansion

Diffusive Dispersal

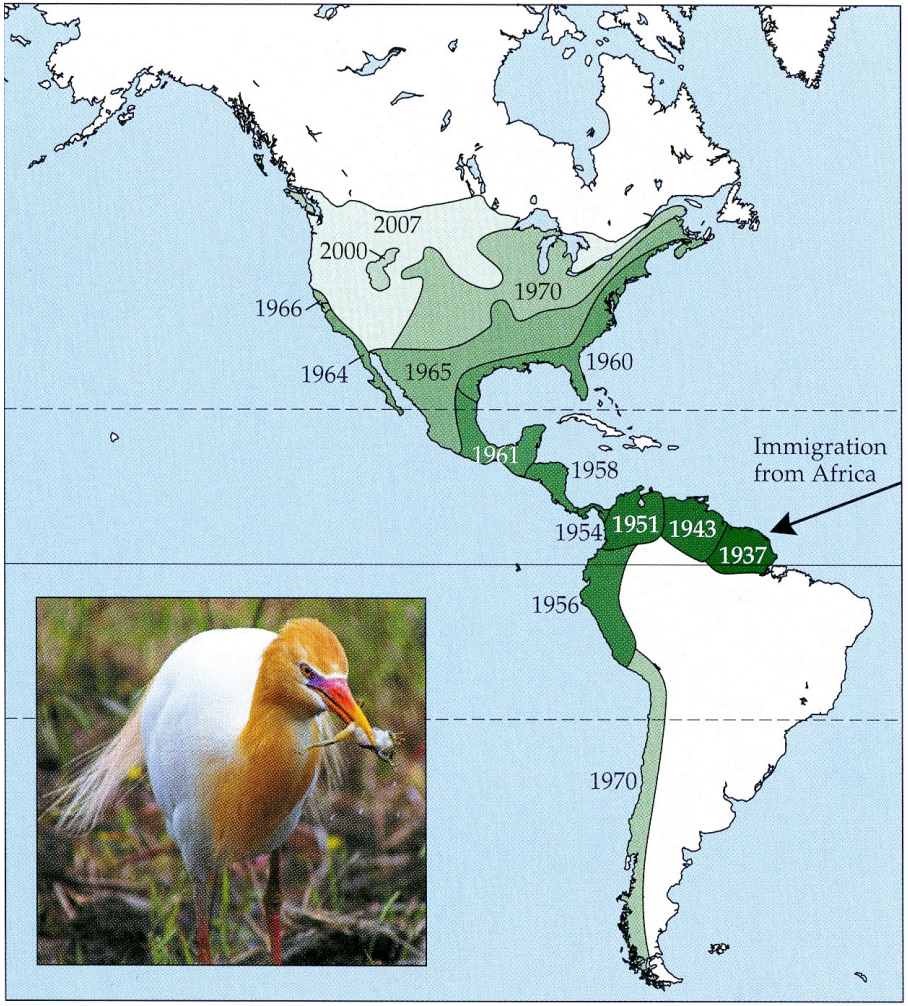


Fertile Crescent crops:

- Wheat
- Barley
- Flax
- Chick peas
- Lentils

Range Expansion

Jump and Diffusive Dispersal



The cattle egret (*Bubulcus ibis*) crossed the South Atlantic under its own power and colonized northeastern South America in the late 1800s

The species then expanded its range over long periods of time via diffusive dispersal and population expansion

…many invasive species colonize and spread through a combination of jump and diffusive dispersal

Lomolino et al. 2010

Moralez-Silva & Nassif Del Lama 2014