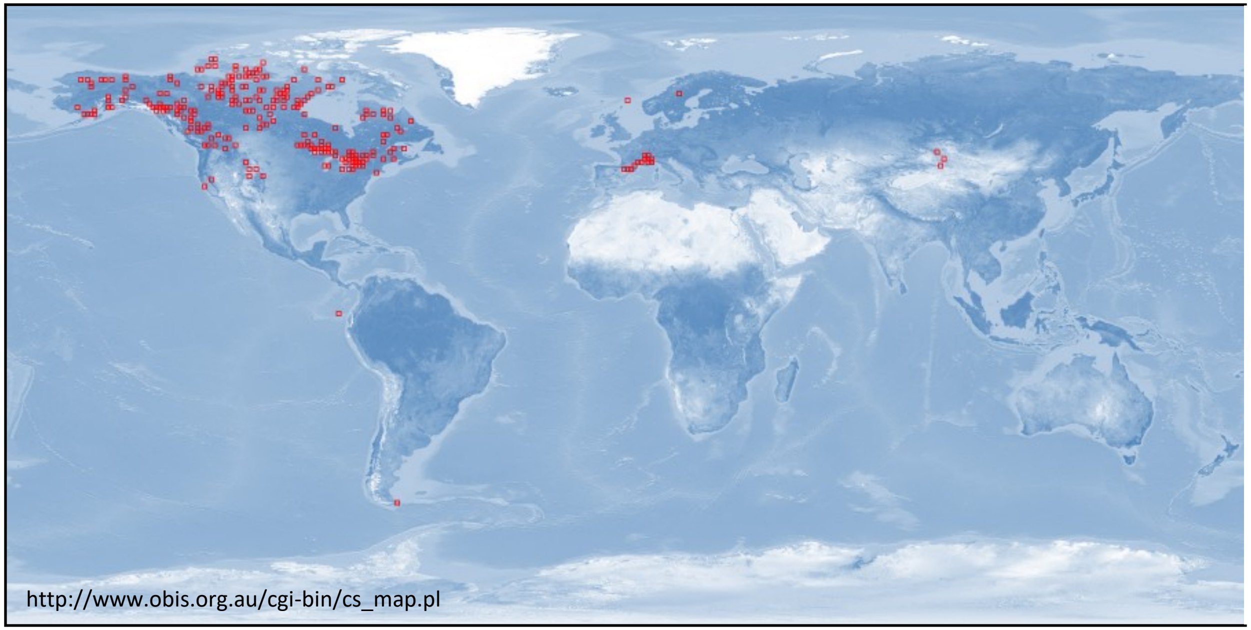
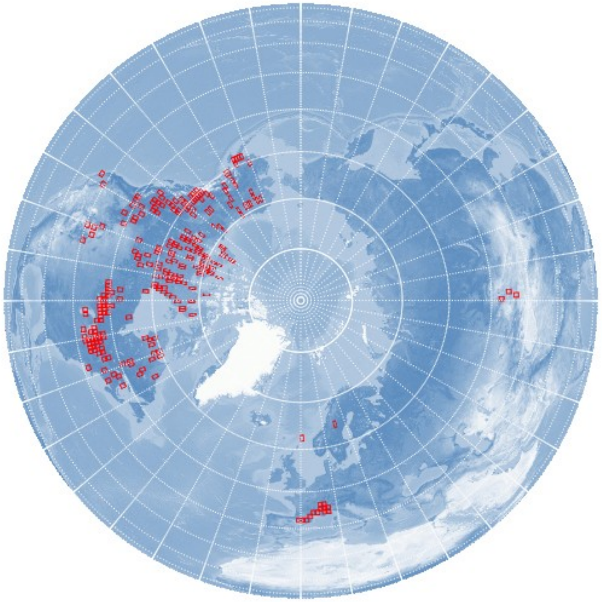
Species Distributions





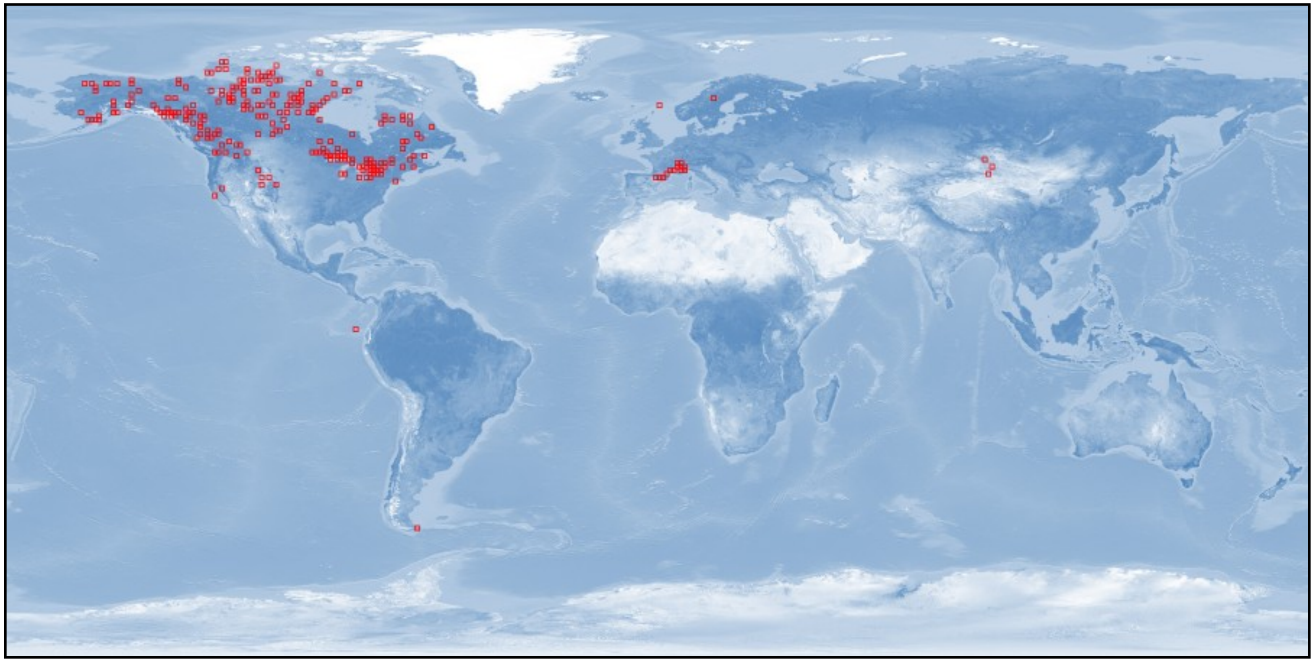
Goals and learning objectives

1) Consider how distributions can be examined on different spatial scales and with different levels of resolution, and the challenges for mapping species with different ‘natural histories’
2) Understand the kinds of data that are used to generate maps of species distributions, and appreciate the limitations and assumptions in creating distribution maps
3) Relate species distributions to the basic parameters that we use to describe populations and the abundance-center hypothesis
4) Understand how abiotic/biotic determinants of distributions are related to the fundamental/realized niche concepts
5) Consider how species’ ranges change, and how this is related to selection, movement of individuals within the range/gene flow

Species Distributions

Species distributions are the most basic biogeographic observation

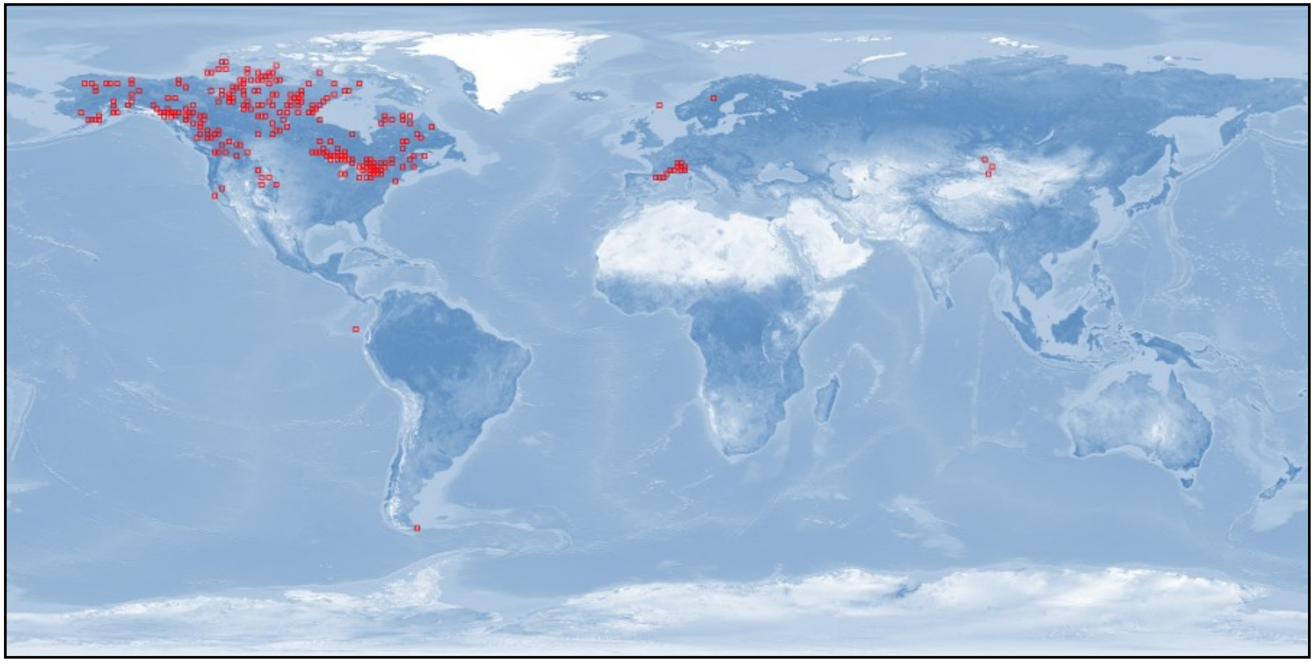
Geographic range: basic observational unit of biogeography, encompasses the maximum geographic extent of occurrences of a taxon during part or all of its life cycle



Species Distributions

Species distributions are the most basic biogeographic observation

Important: A species distribution is not necessarily the same as its geographic range. Species distributions can be quantified across different spatial scales (extent and grain)



Species Distributions

Spatial scale is important to consider in any description or study of species distributions.

Clematis fremontii (Fremont's leather flower) is endemic to Missouri in the Central US and grows on limestone soils. We can describe its patchy distribution across spatial scales.

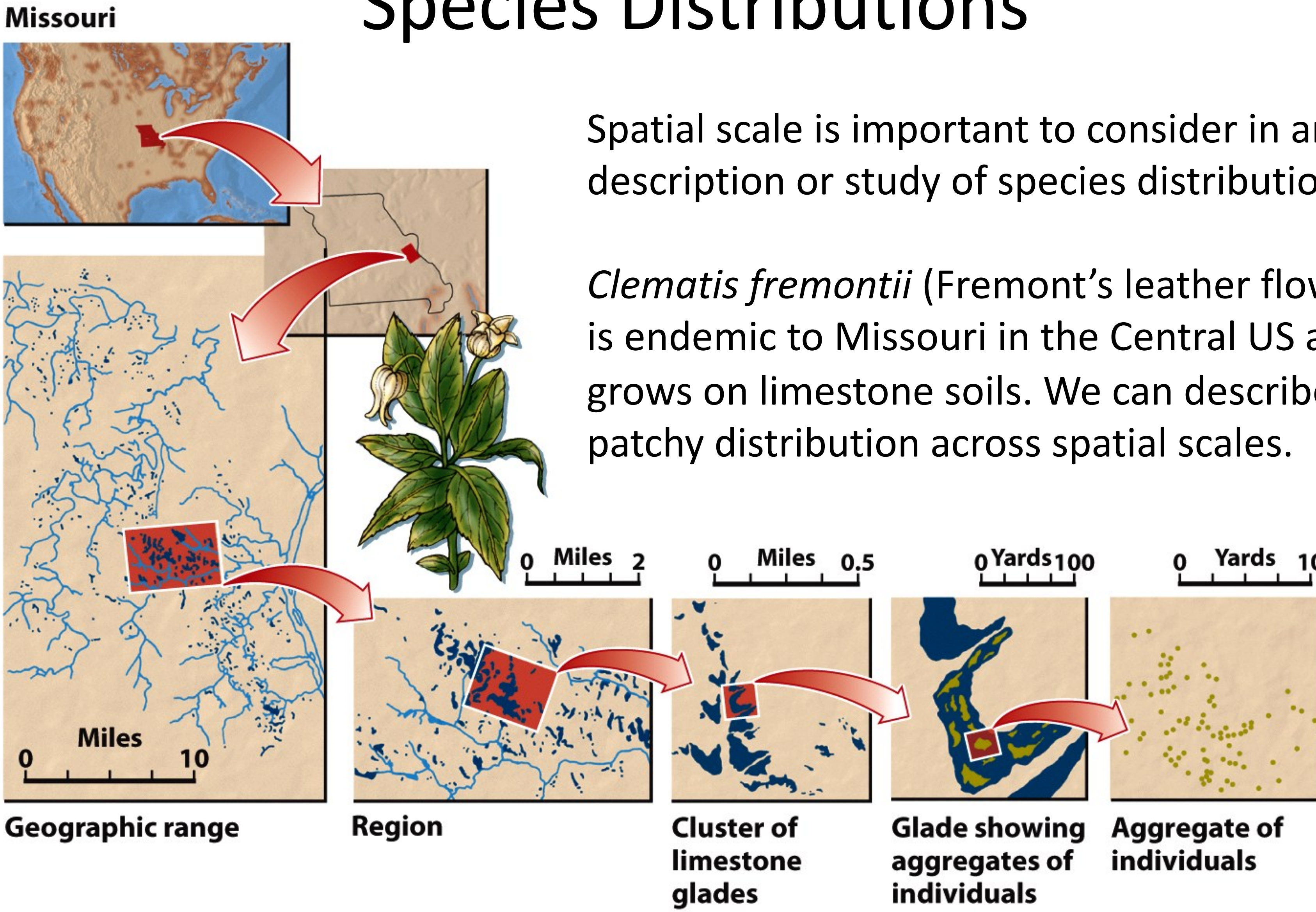


Figure 10.3
***The Economy of Nature,* Sixth Edition**

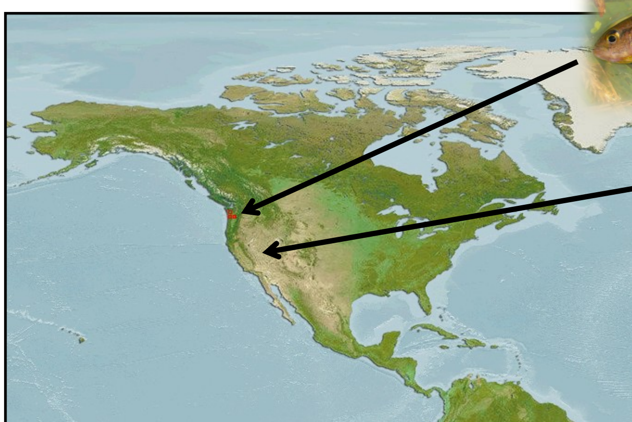
Species Distributions

A species geographic range is always limited and can be highly localized:

African Great Lakes cichlids (Pisces: Cichlidae) are endemic to single lakes

Olympic mudminnow (*Novumbra hubbsi*) found only on Olympic Peninsula, WA

Devil's Hole pupfish (*Cyprinodon diabolis*) found in a pool of >100 m^2 in SW Nevada, which lives at a warm 33° C with low dissolved O_2 and has persisted for thousands of years!



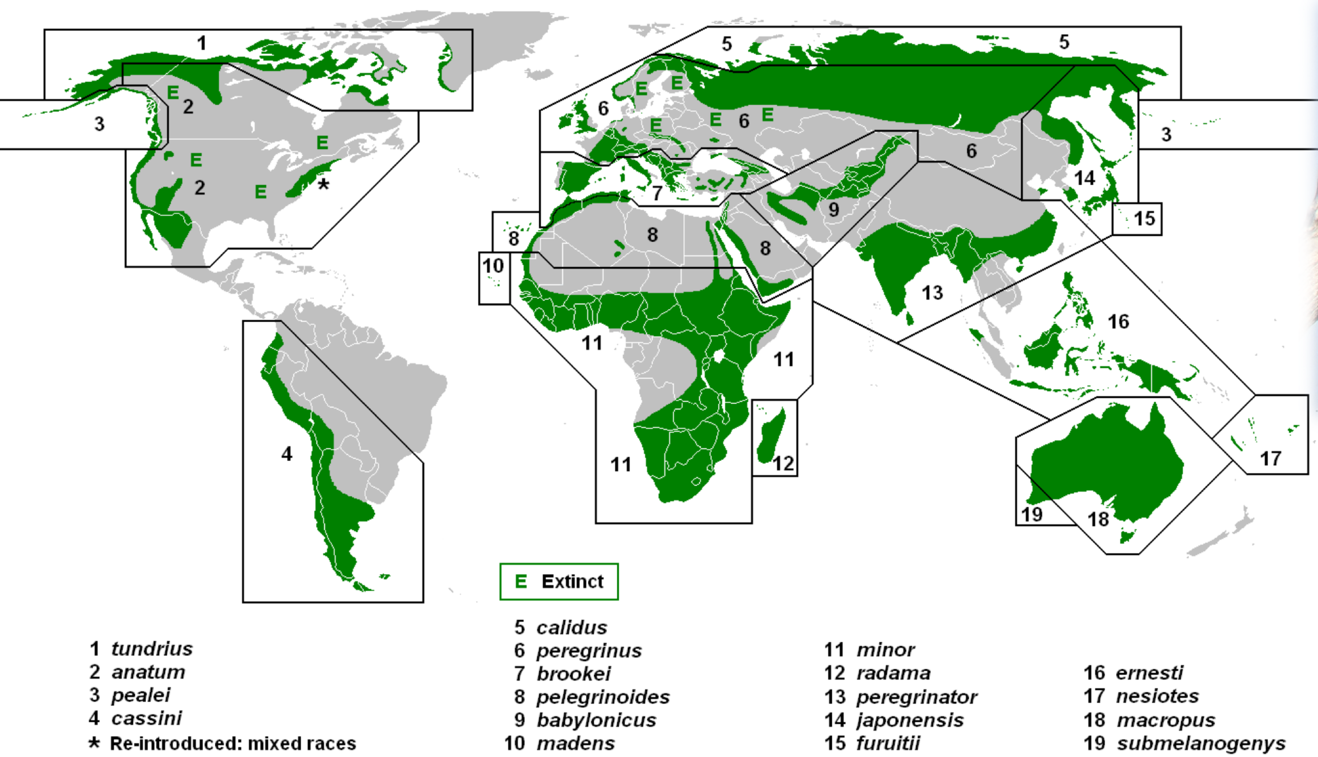
Devils Hole

https://www.fws.gov/nevada/protected_species/fish/species/dhp/dhp.html

Species Distributions

Taxa may also be *cosmopolitan* and found across the globe:

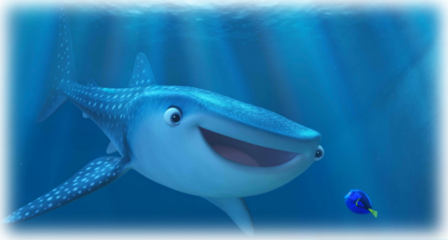
The Peregrine Falcon is found on all continents except Antarctica

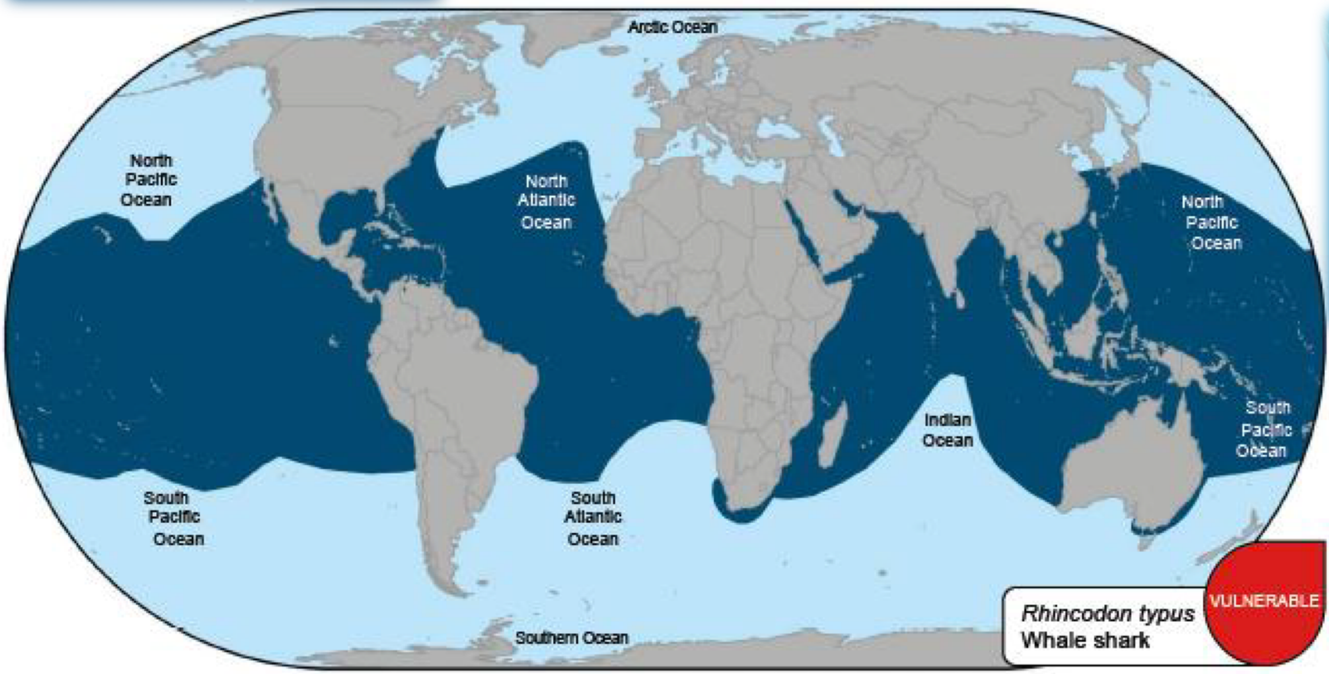


Species Distributions

Taxa may also be *cosmopolitan* and found across the globe:

Whale Sharks range across tropical and subtropical oceans worldwide





Describing Distributions

Maps show how species are distributed in space and are therefore intertwined with biogeography

Maps take many forms and give us different kinds of information, but all maps oversimplify species distributions in one way or another

Emerald Toucanet

Describing Distributions

Real distributions would show the location of all individuals of the species, but this is impossible for virtually all kinds of organisms…

Aerial photograph near the edge of the distribution of juniper tree (*Juniperus osteosperma*) in Eastern Nevada

Photo from US Forest Service, Figure 4.2 in Lomolino et al. *Biogeography*

Individual trees are dark spots on the landscape

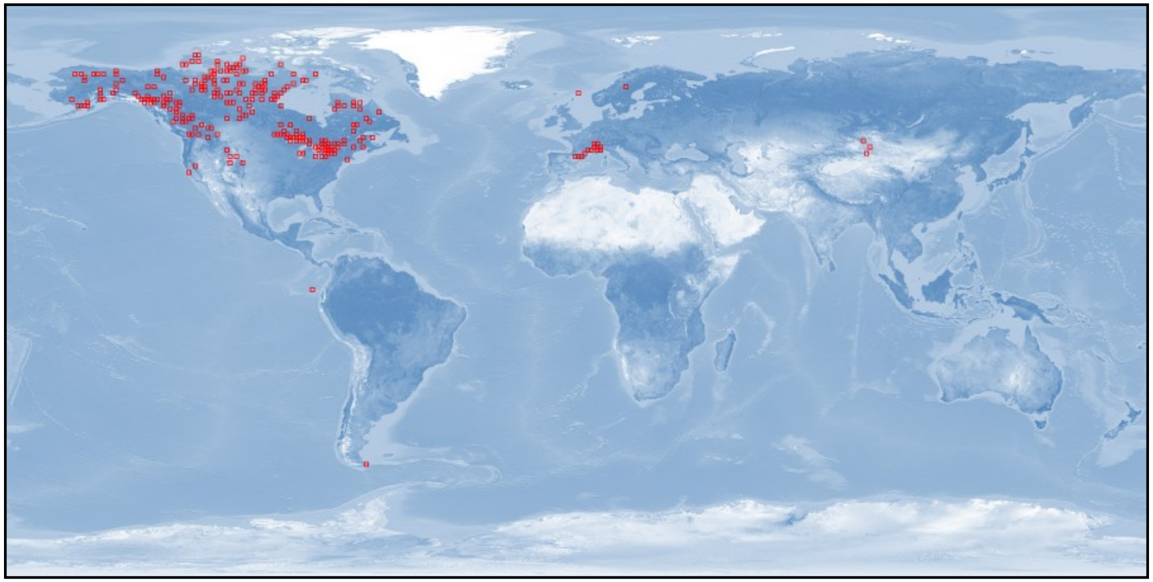
Abundance decreases from left to right

Distribution becomes patchy toward the range boundary - individuals are restricted to south-facing slopes

Describing Distributions

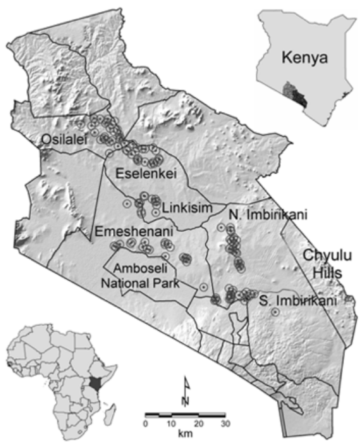
1) Outline Maps

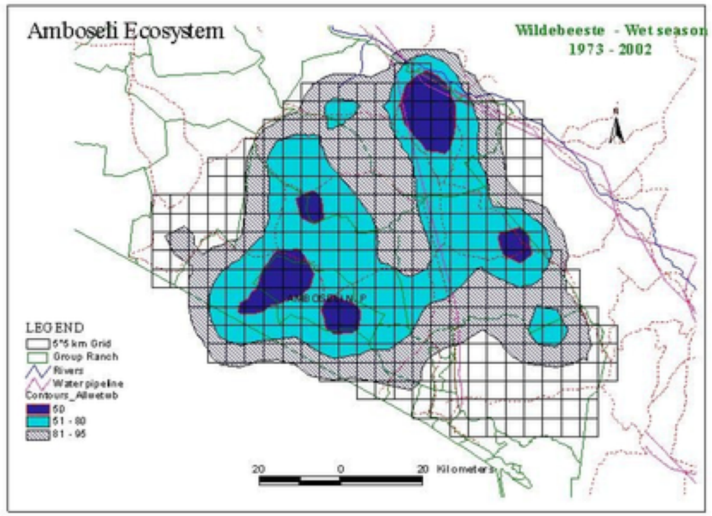
2) Dot Maps

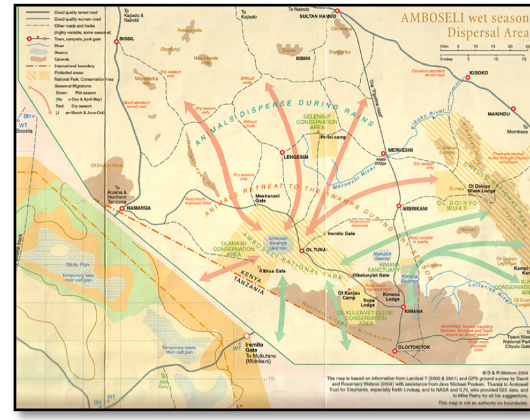


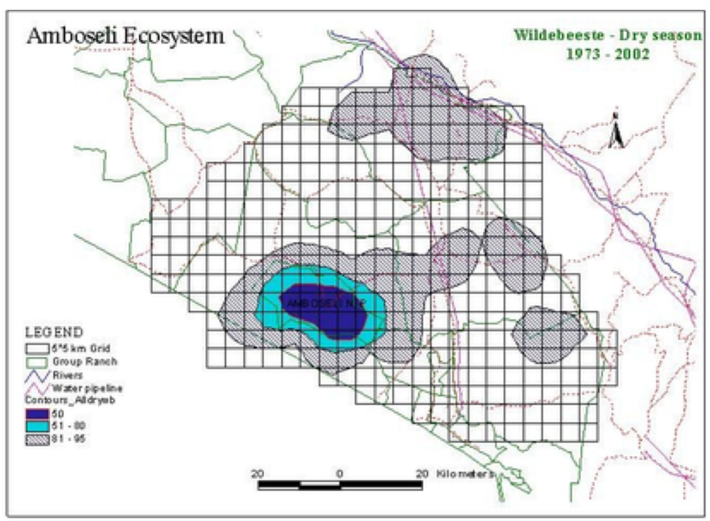
Describing Distributions

3) Contour Maps





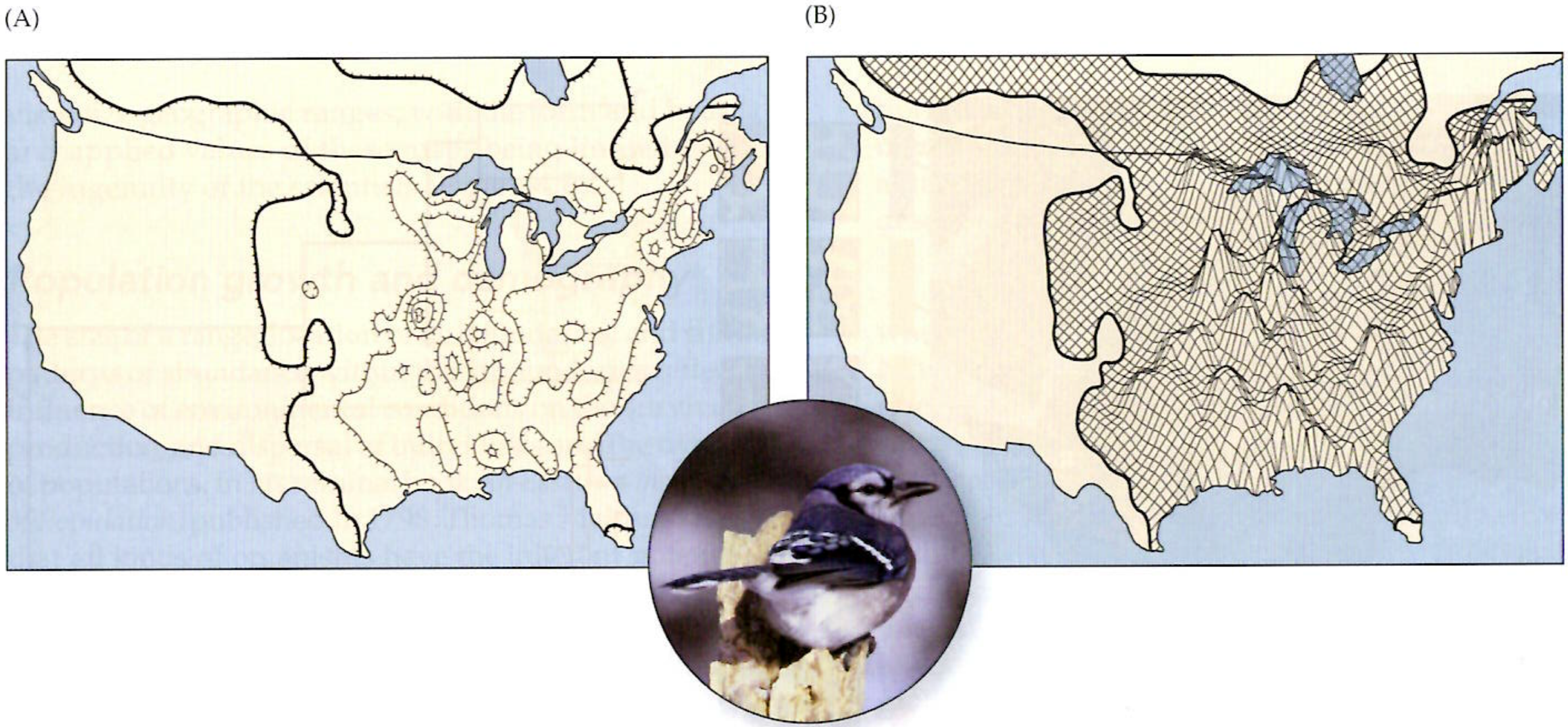




Seasonal distribution of Wildebeest in Amboseli NP, Kenya

Describing Distributions

3) Contour Maps

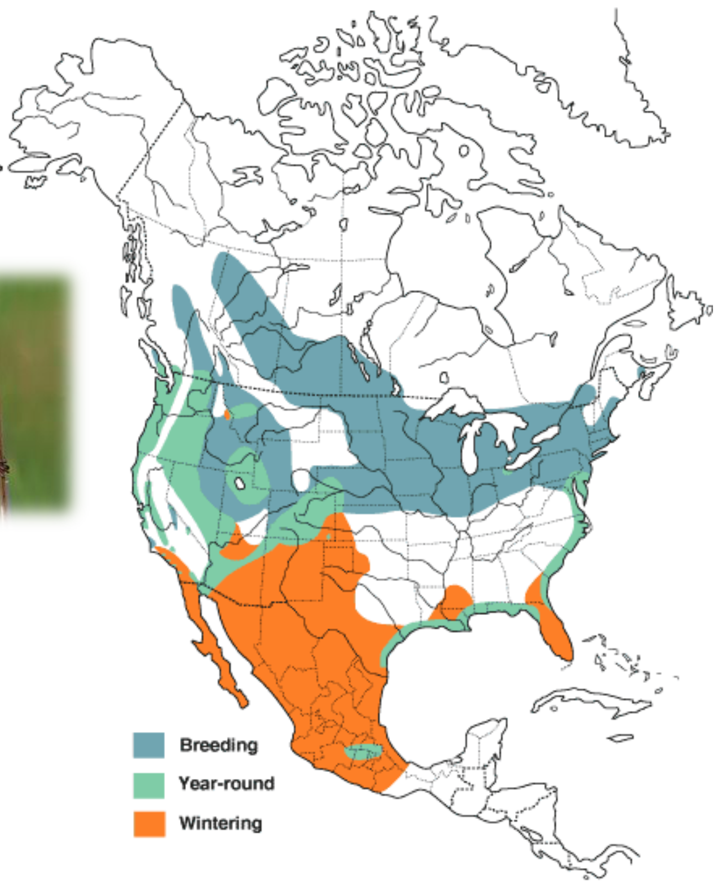


Range of the Blue Jay showing geographic variation in abundance with A) contour lines and B) a three dimensional landscape (Root 1988, Lomolino et al. 2017)

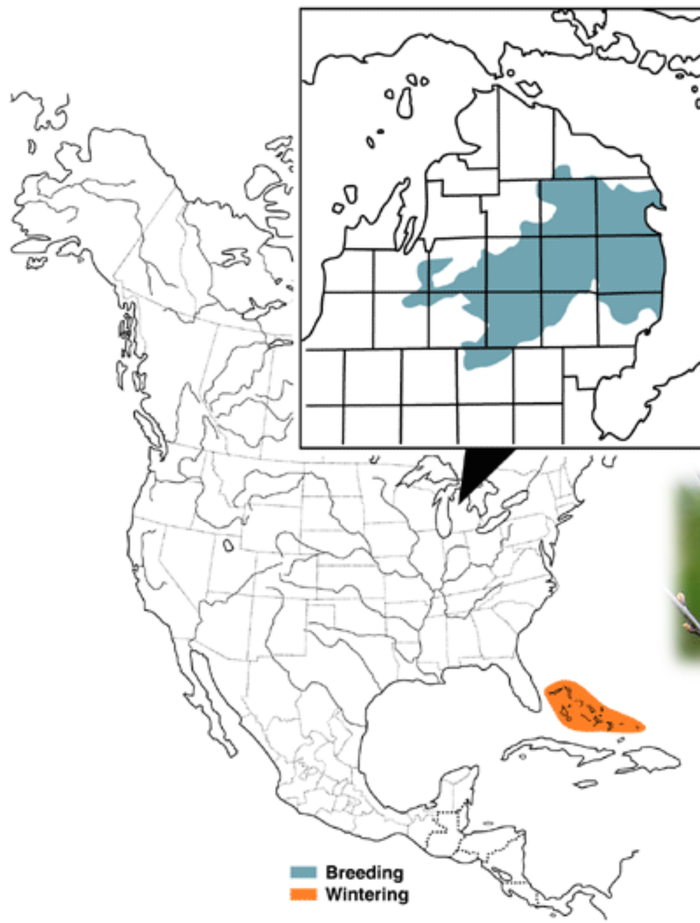
Describing Distributions

4) Seasonal Range Maps

Marsh wren



Kirtland's Warbler



http://en.wikipedia.org/wiki/Marsh_Wren

http://www.thayerbirding.com

http://en.wikipedia.org/wiki/Kirtland's_Warbler

Quantifying Distributions

Two methods to quantify distributions, often used by conservation organizations:

1) Extent of occurrence

2) Area of Occupancy

International Union for the Conservation of Nature

THE IUCN RED LIST OF THREATENED SPECIES™

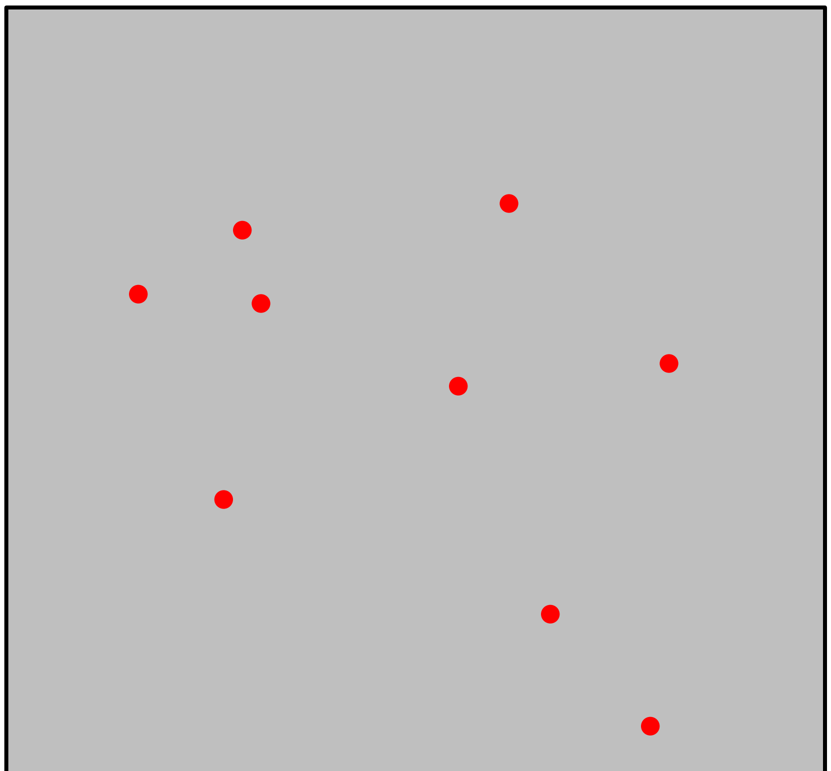
COSEWIC

Committee on the Status of Endangered Wildlife in Canada

Quantifying Distributions

1) Extent of occurrence

Uses the polygon method to encapsulate known occurrence records:

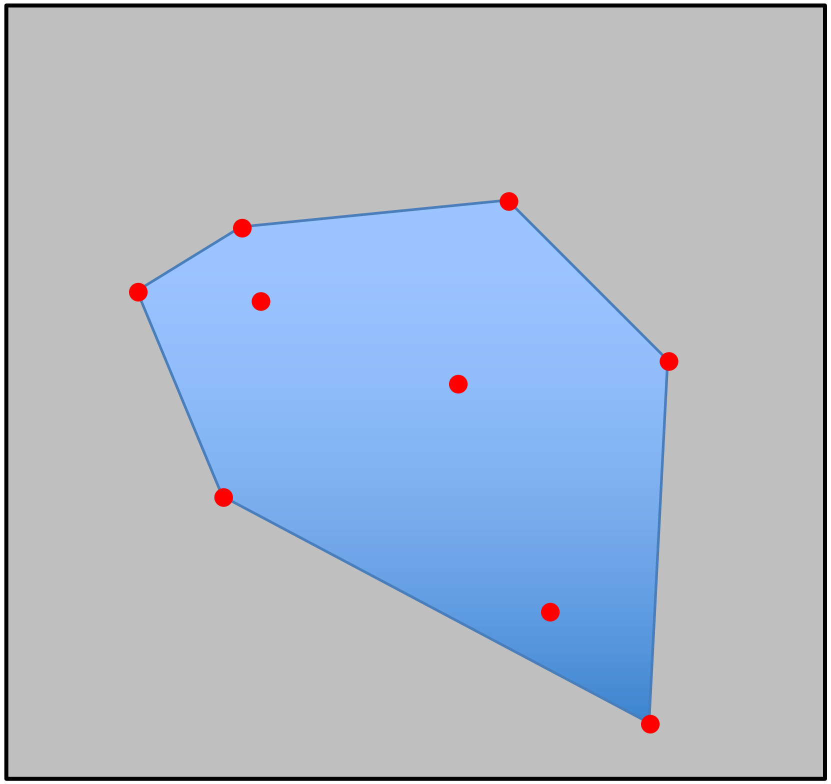


● Record of occurrence

Quantifying Distributions

1) Extent of occurrence

Uses the polygon method to encapsulate known occurrence records:



• Record of occurrence

Also known as the minimum convex polygon (MCP) method

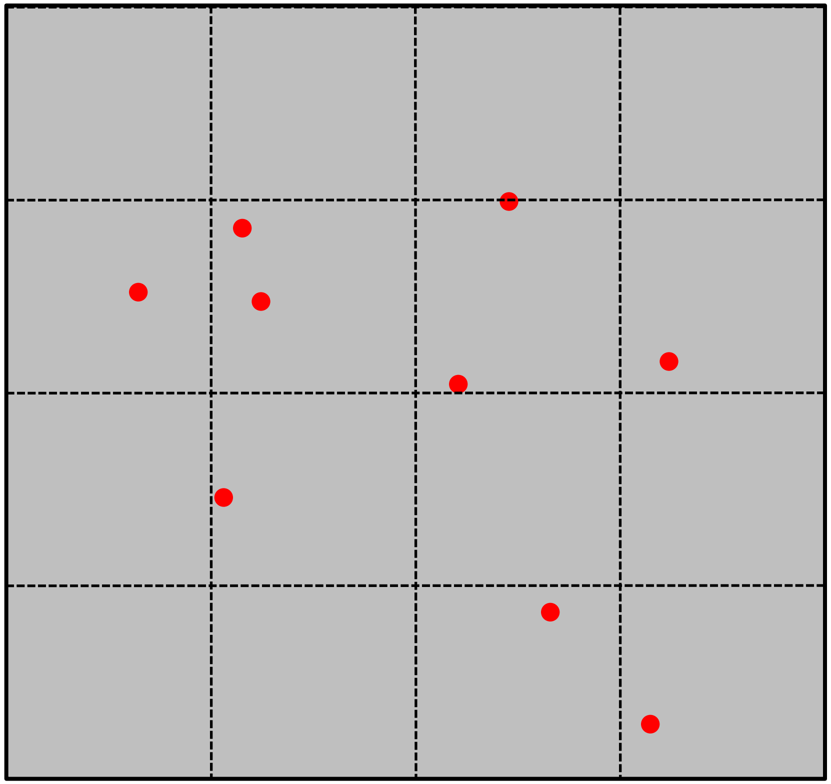
No internal angle is > 180°

May contain unsuitable or unoccupied habitats

Quantifying Distributions

2) Area of Occupancy

Using a grid:

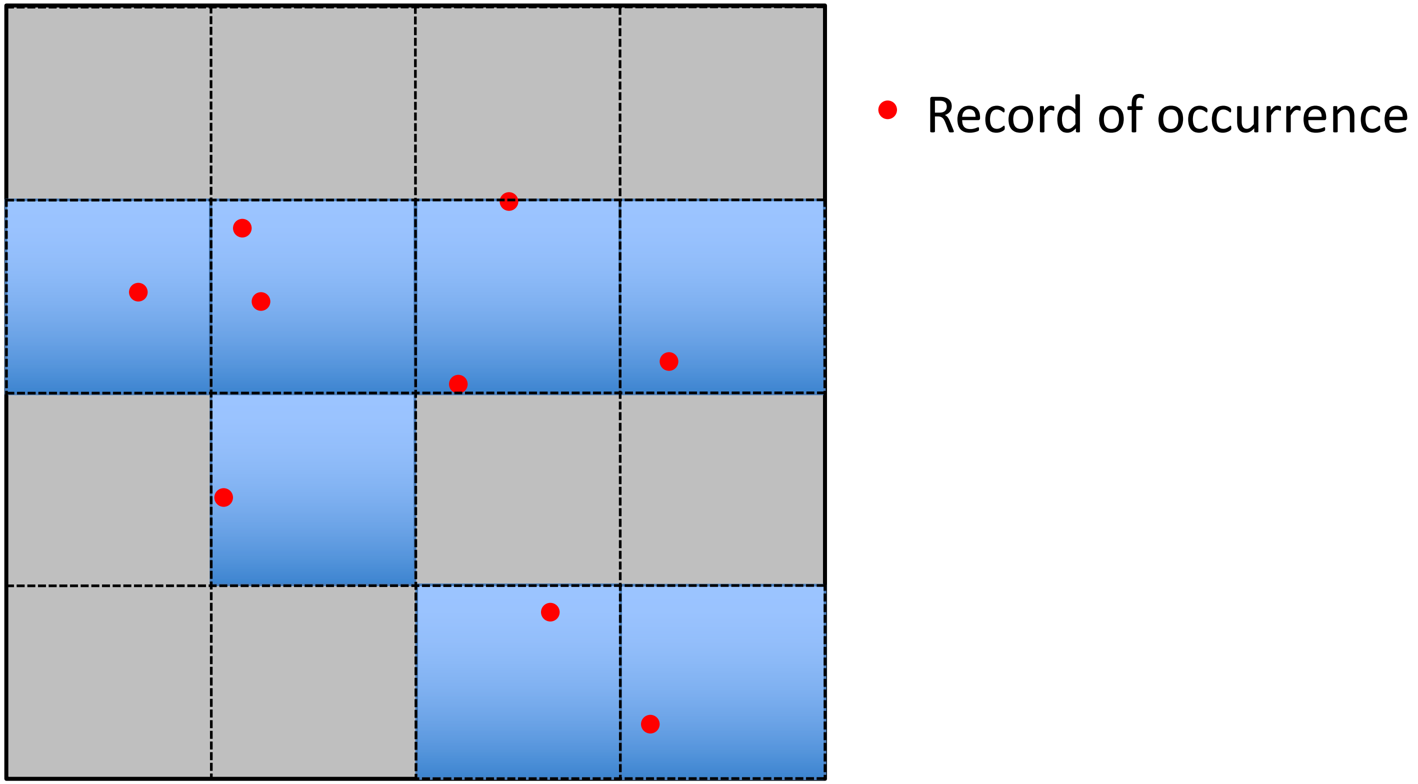


• Record of occurrence

Quantifying Distributions

2) Area of Occupancy

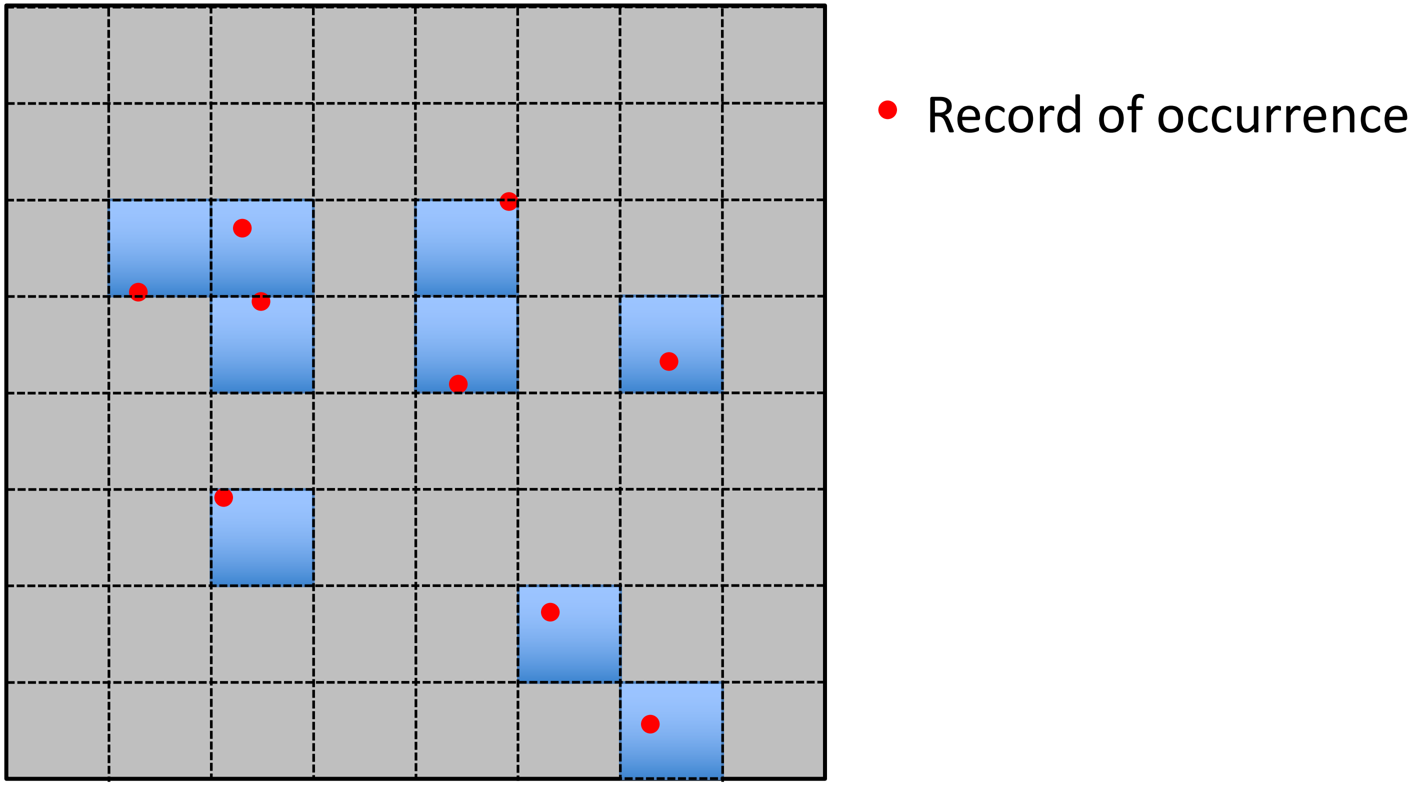
Using a grid:



Quantifying Distributions

2) Area of Occupancy

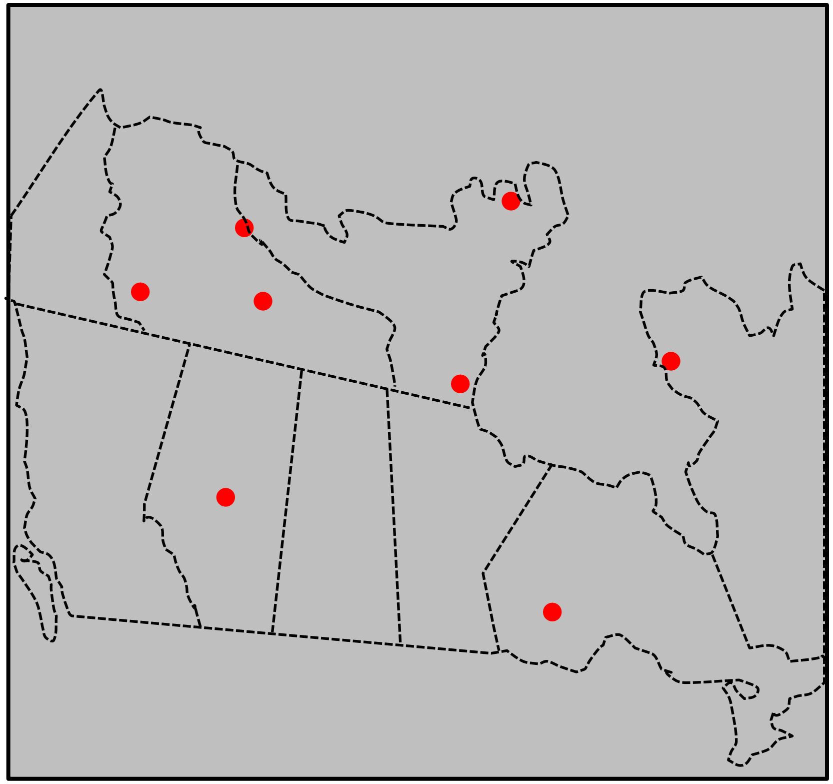
Using a grid:



Quantifying Distributions

2) Area of Occupancy

Using geopolitical boundaries:

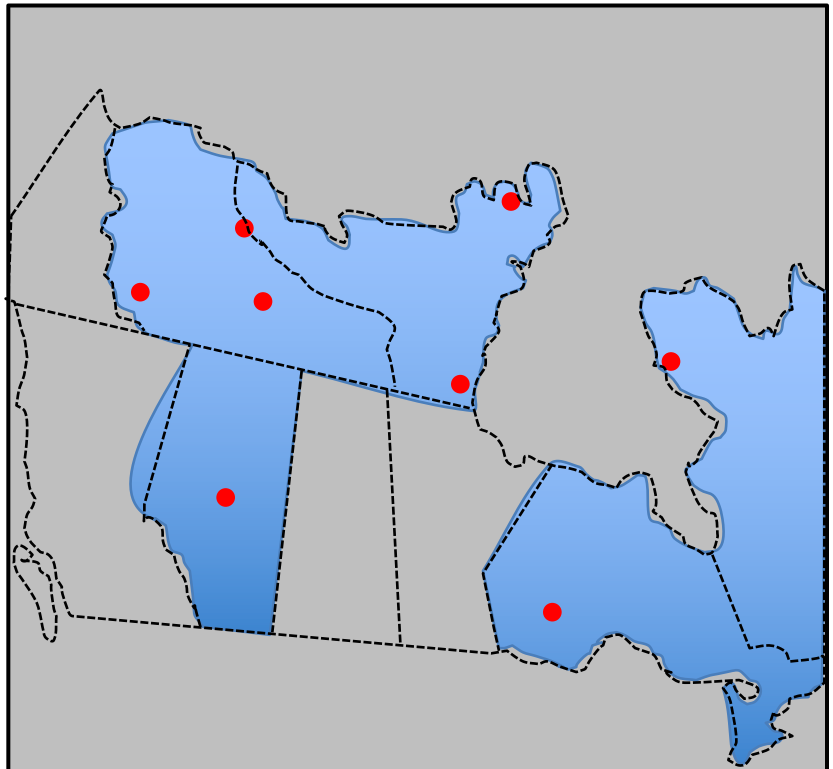


● Record of occurrence

Quantifying Distributions

2) Area of Occupancy

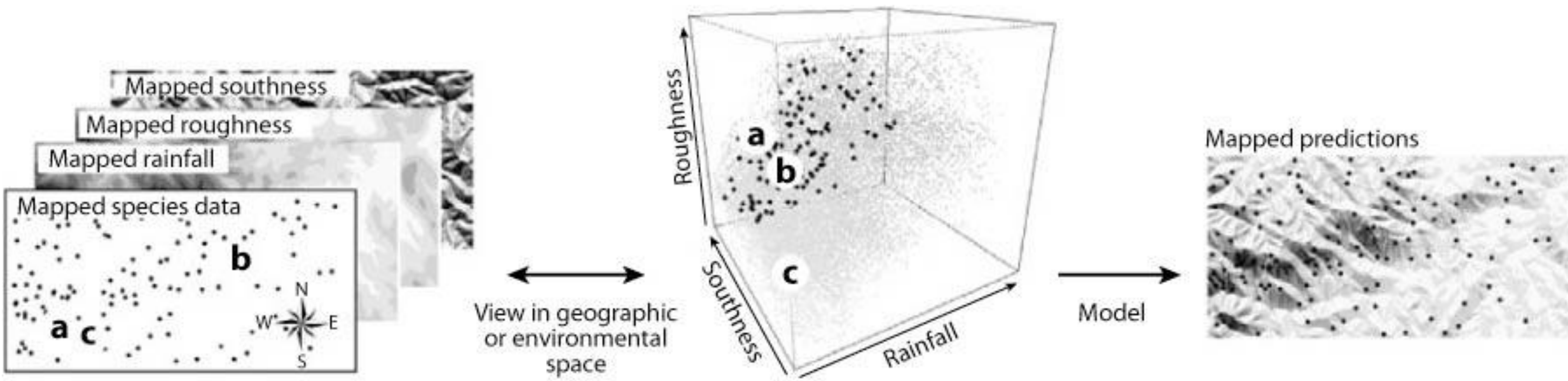
Using geopolitical boundaries:



● Record of occurrence

Predicting Species Distributions

Mapped species data are associated with environmental variables (sometimes referred to as a climate envelope).

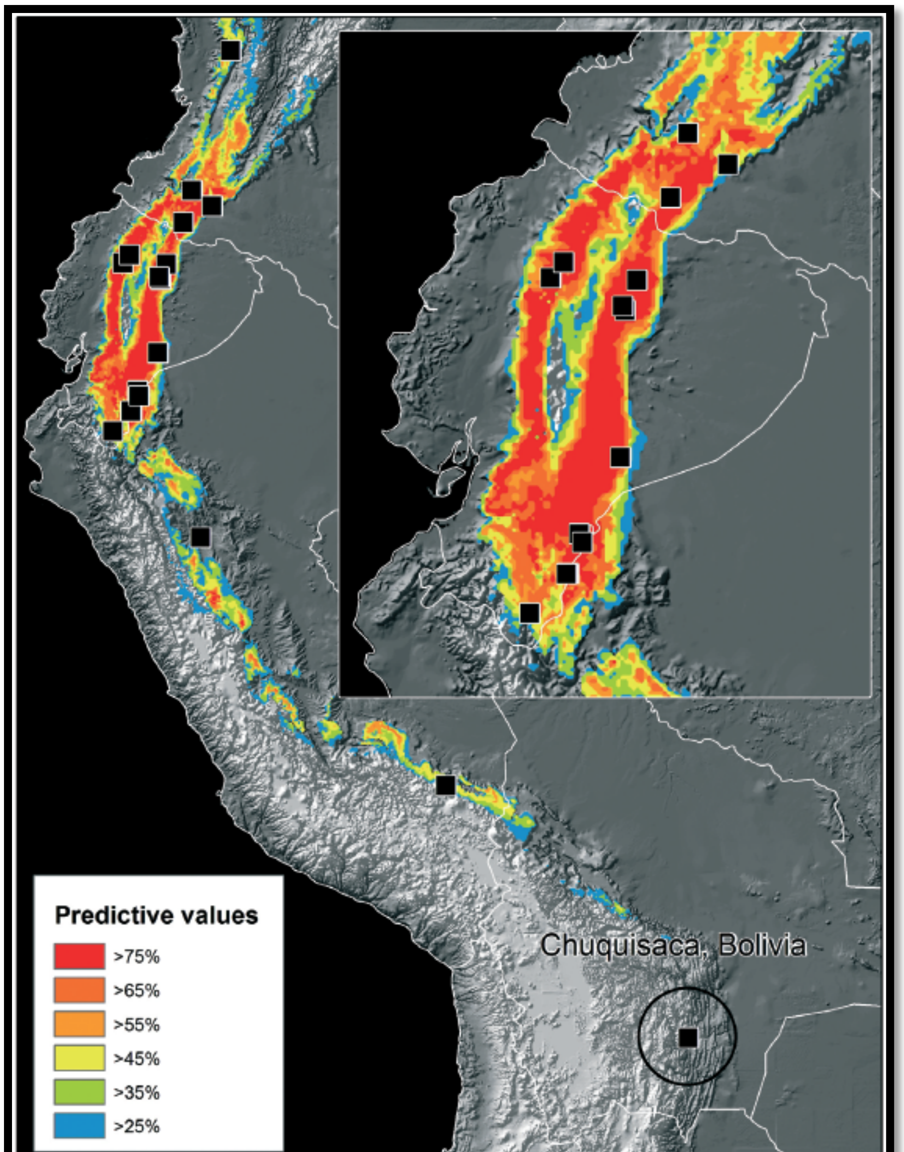


A species climate envelope is then projected onto geographic or environmental space to model the distribution.

(Can also be applied to predict distributional shifts, where changes in the environment are projected into the future, and species distributions are recast.)

Elith & Leathwick 2009

Predicting species distributions



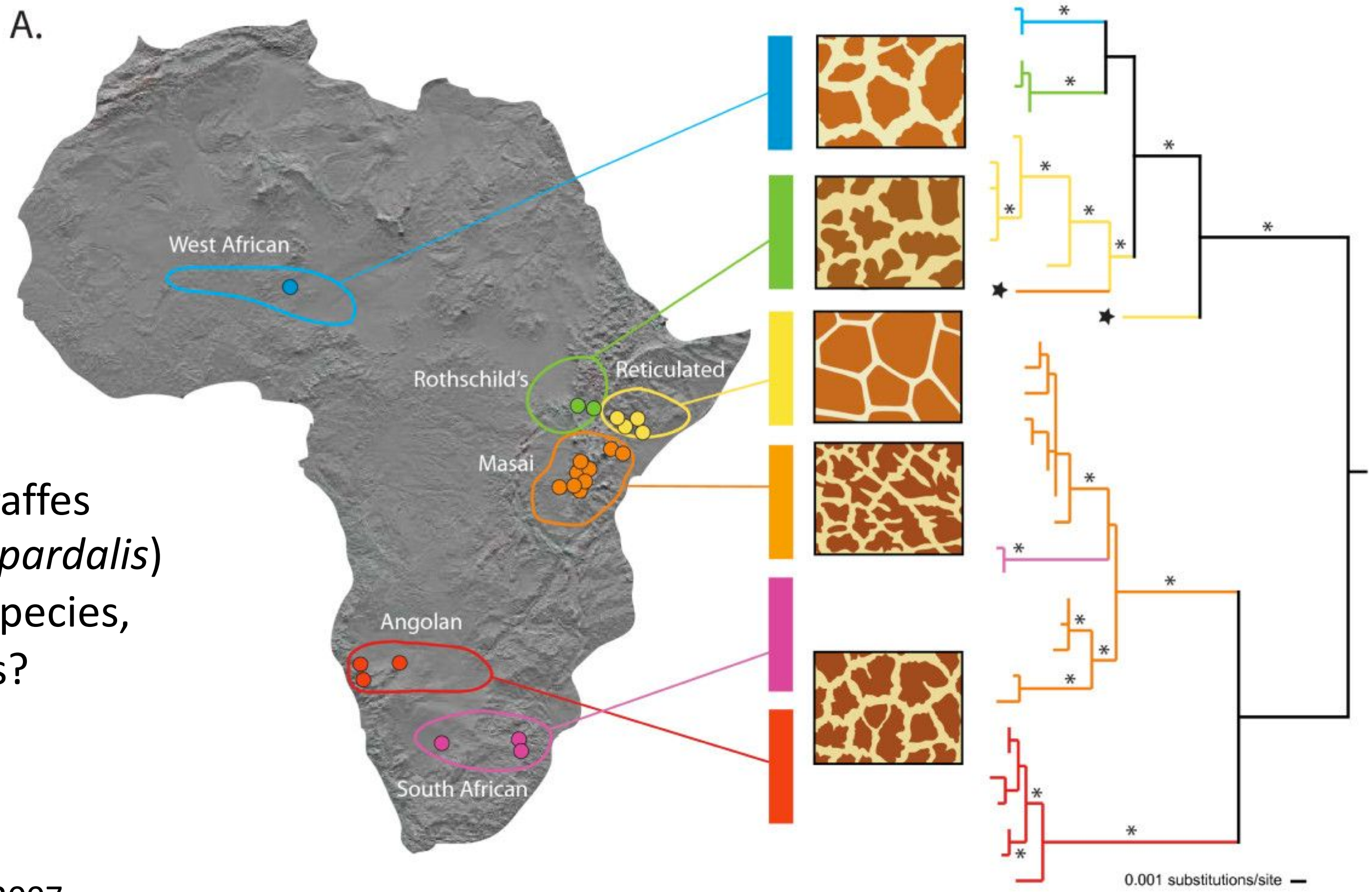
A MaxEnt niche model constructed for the nectarivorous bat (*Anoura fistulata*) in the Andes

Predicted occurrence is mapped using data from 19 localities of species presences

Figure from Mantilla-Meluk et al. 2014

Populations within distributions

When we link biogeographic data on distributions to traits and genetic signatures, we can better understand how populations differ within a range

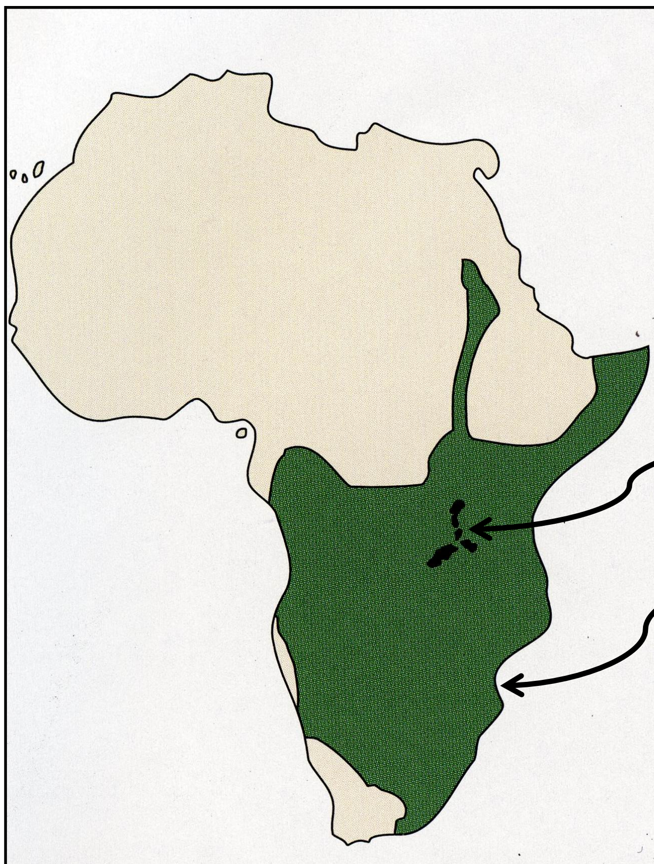


Do all extant giraffes (*Giraffa camelopardalis*) represent one species, or many species?

Figure from Brown et al. 2007

Distributions are dynamic in space and time

Red Locust spread to huge areas during outbreaks, but are known to sustain permanent populations in a few small source habitats.



Red Locust

permanent populations (black)

outbreak range (green)

Distributions are dynamic in space and time

Radio tracking data for hundreds of individuals of marine top predators

Daily mean position estimates reveal dynamic and interdependent distributions across the Pacific Ocean

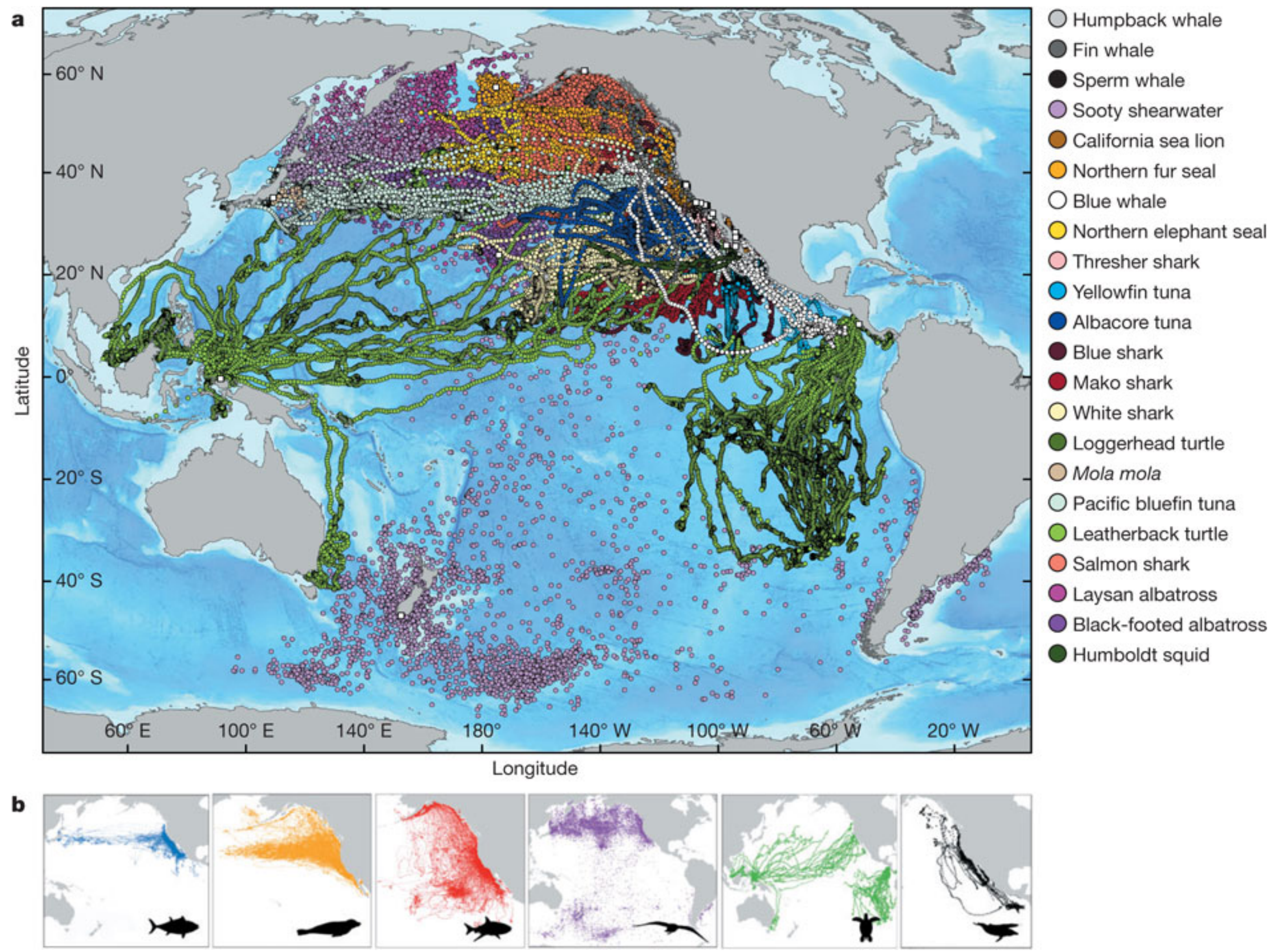


Figure from Block et al. 2011, *Nature*

Distributions are dynamic in space and time

Migratory birds use vastly separated regions for overwintering and breeding

Western Tanager

eBird allows birdwatchers to log sightings in an online database

Animated Occurrence Maps from eBird

http://ebird.org/results/STEM/animations/WETA_large.gif

Distributions are dynamic in space and time

Other animated maps of migration as well as the path of invasion by introduced species:

eBird occurrence maps for many migratory bird species:
https://ebird.org/explore

Improved dynamic range maps from eBird (Ruby-throated Hummingbird ex.)
https://ebird.org/science/status-and-trends/rthhum/abundance-map-weekly

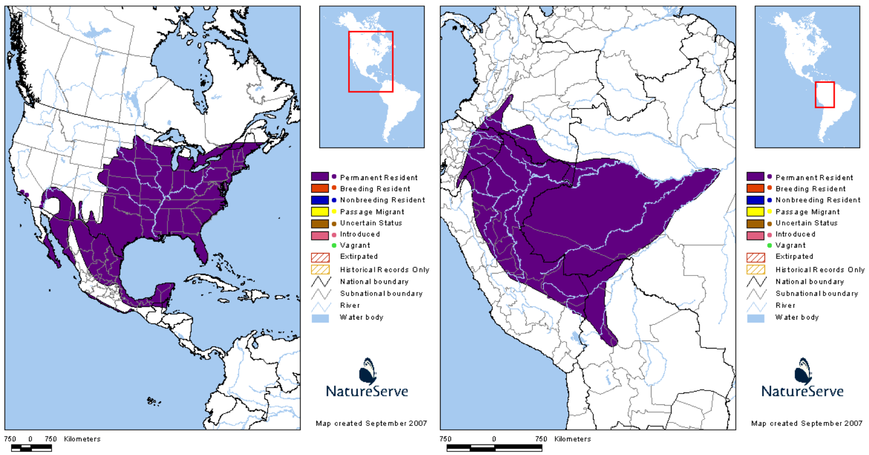
Ocean tracker (tracking movements of tagged individuals)
https://www.ocearch.org/tracker/?details=30

Lionfish (*Pterois volitans*) was introduced to Florida in the 1980's from the aquarium trade and has spread across the Caribbean and along US coastlines
http://nas.er.usgs.gov//queries/SpeciesAnimatedMap.aspx?speciesID=963

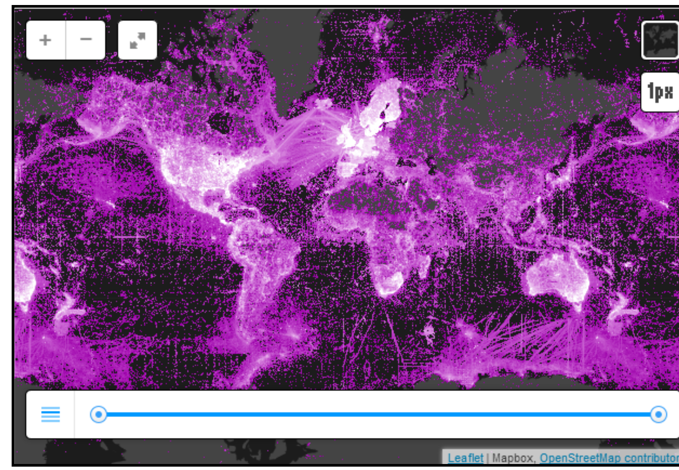
Species Distributions

Examples of Online Resources for Exploring Species Distributions:

NatureServe – www.natureserve.org

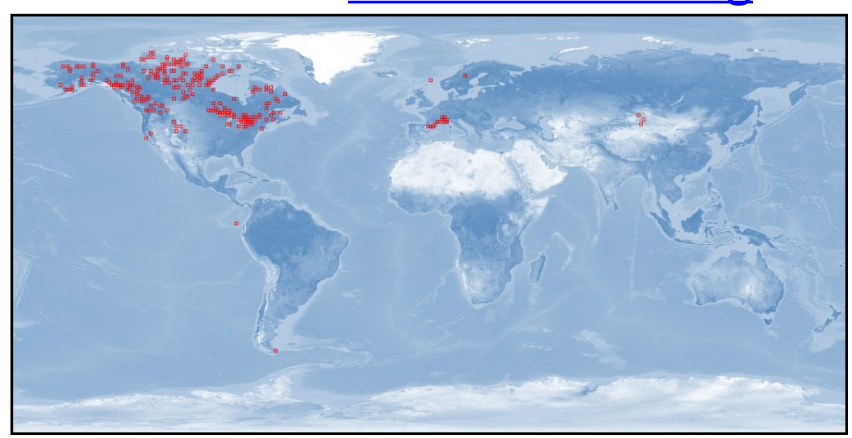


GBIF – www.gbif.org



Avibase – avibase.bsc-eoc.org

FishBase – www.fishbase.org



Distributions are dynamic in space and time

No matter how complex the life processes of species within their range:

Range size, boundaries and shifting density within the range reflect the influence of environmental conditions on survival, reproduction and dispersal of individuals.

$$r = b + i - d - e$$

r is the per capita rate of population growth
if *r* is positive = population increase
if *r* is negative = population decline

b and *d* are per capita birth and death rates, respectively

i and *e* are per capita rates of immigration to and emigration from populations, respectively