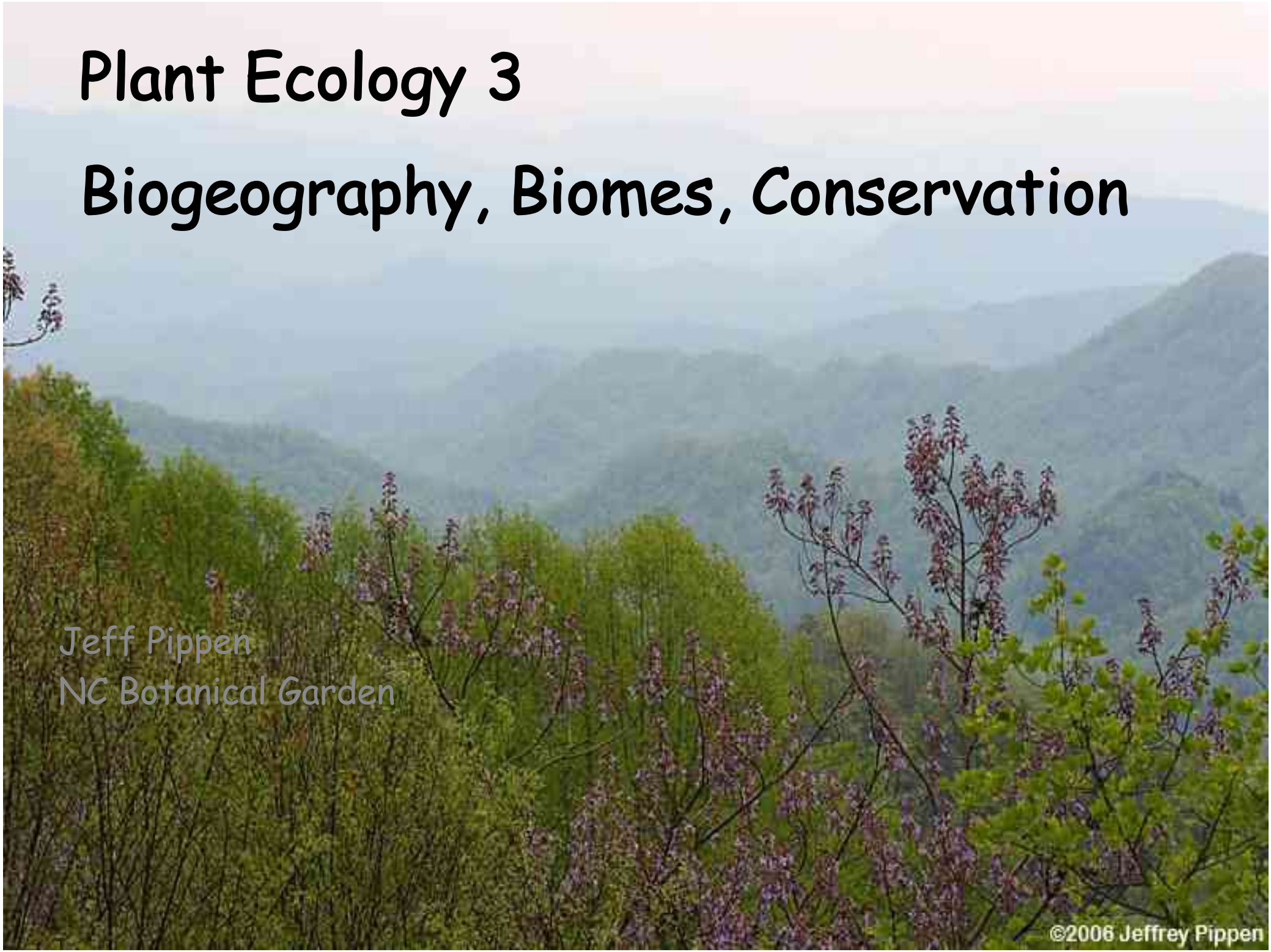
Plant Ecology 3

Biogeography, Biomes, Conservation



Today's agenda

- Species adaptation presentations
- Biogeography, Ecosystems, and Biomes
- Plant Conservation in North Carolina
- Carolinas Butterfly Monitoring Project
- Field trip to NCBG Natural Area trails
  - Plant ID
  - Plant conservation

What is Biogeography?

Biogeography

- The study of the geographical distribution of organisms, their habitats (ecological biogeography), and the historical factors which produced them.

- In other words, the study of the distribution of species and ecosystems through geographic space and through geologic time.

Central questions of biogeography

- Which organisms are found where, and why?
  - How are these organisms adapted to the local environment?
  - Why aren't other species also here with them?
- How and why have their distributions changed over time?

Corollary questions of biogeography

- What enables a species to live where it does, and what prevents it from colonizing other areas?

- What are a species closest relatives and where can they be found? Where did its ancestors live?

- How have historical events shaped a species' distribution?
  - Continental drift, glaciation, mountain formation, exotic species introductions…

Goals of Biogeographers

1. To develop natural laws and concepts that explain biogeographic processes and account for the development of biotic distributions.

2. To provide baseline information on the spatial and temporal distribution of organisms that can be used for further research and to conserve and manage Earth's biotic resources and heritage.

Biogeography History

Historically, subject is relatively old, with scientists interested in biogeography since the "Age of Exploration" starting nearly a thousand years ago or so

- Medieval travel sanctioned by kings and other rulers
- Explorers, cartographers, trade routes

Portuguese & Spanish, then British, Dutch, & French explorations of 1400s-1500s opened many doors, "discovered" new world…

Biogeography History

Opened the door for scientific exploration…

Key Players (among many others!):
- Alexander von Humboldt
- Philip Lutley Sclater
- Charles Darwin
- Alfred Russel Wallace

Explored the world in efforts to describe, catalog, and understand biodiversity

Sclater, Darwin, & Wallace used info to develop theories of evolution

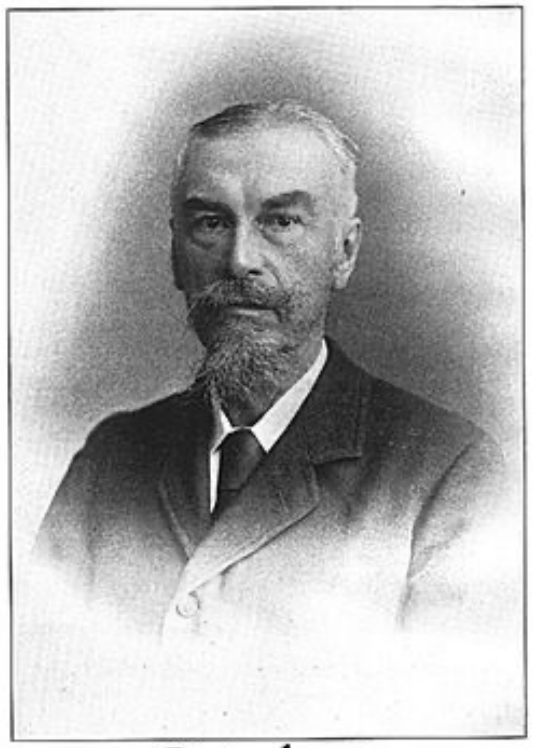
HMS Beagle by Ron Scobie, http://www.ronscobie-marineartist.com/gallery8beagle.htm

Biogeography History

Philip Sclater (1829-1913)

- expert ornithologist from England
- described a system of 6 biogeographic regions, still used today (!) based on distribution of birds
- phylogenetic basis--not based on adaptations, *per se*
- also holds for fish, herpetofauna, mammals

http://digilander.iol.it/avifauna/w_palearctic/zoogeographic.htm



P. L. Sclater.

Biogeography History

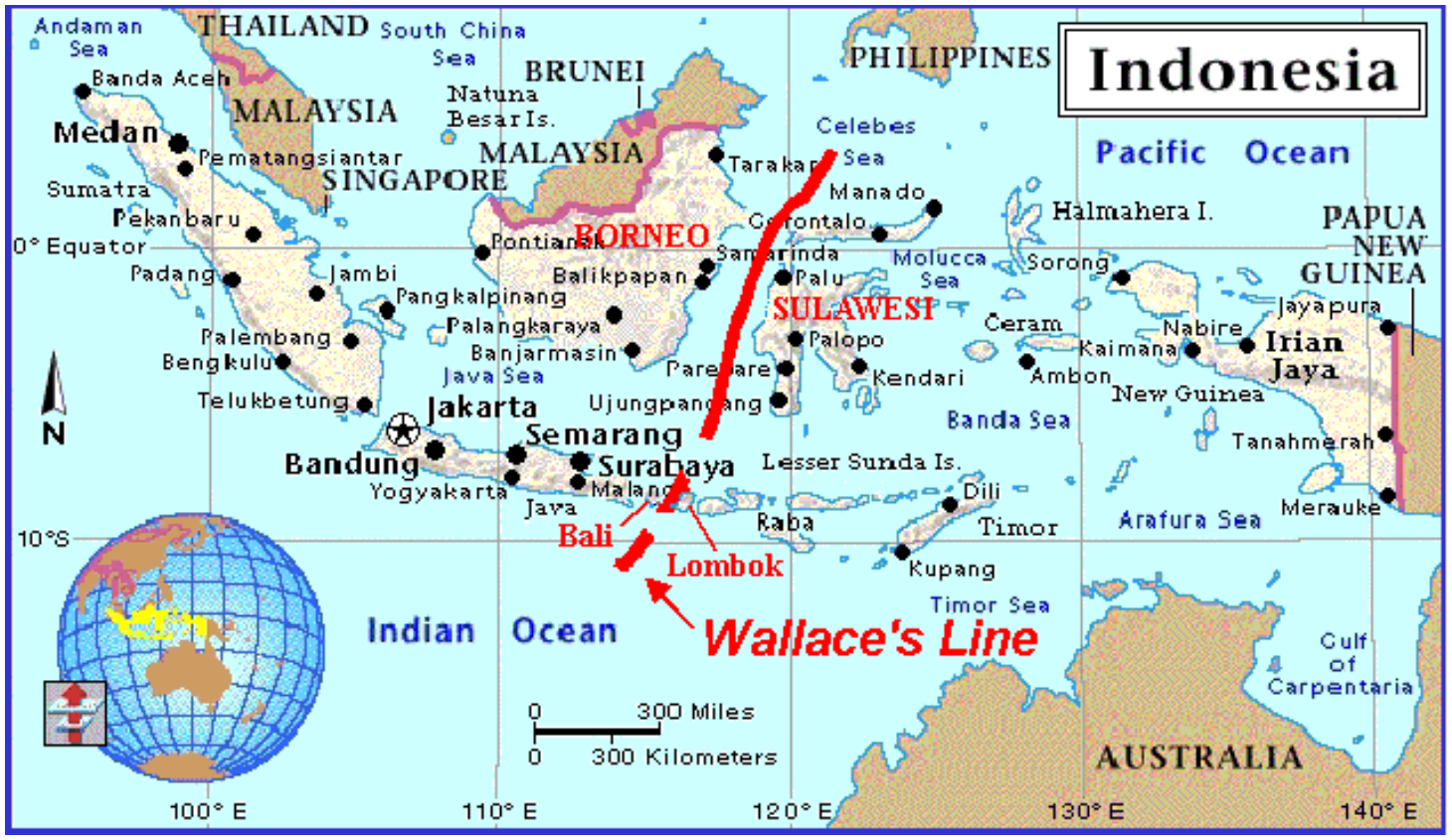
Wallace's Golden Birdwing Butterfly

Alfred Russel Wallace (1823-1913)

- one of the 'fathers of biogeography'.
- took the step from merely describing species distributions to actually asking the question "Why"?
- extensive traveling/collecting in Indonesia

http://opencage.info/pics.e/large_13280.asp

http://commons.wikimedia.org/wiki/File:Bronze_statue_of_Alfred_Russel_Wallace.jpg



The Wallace Line

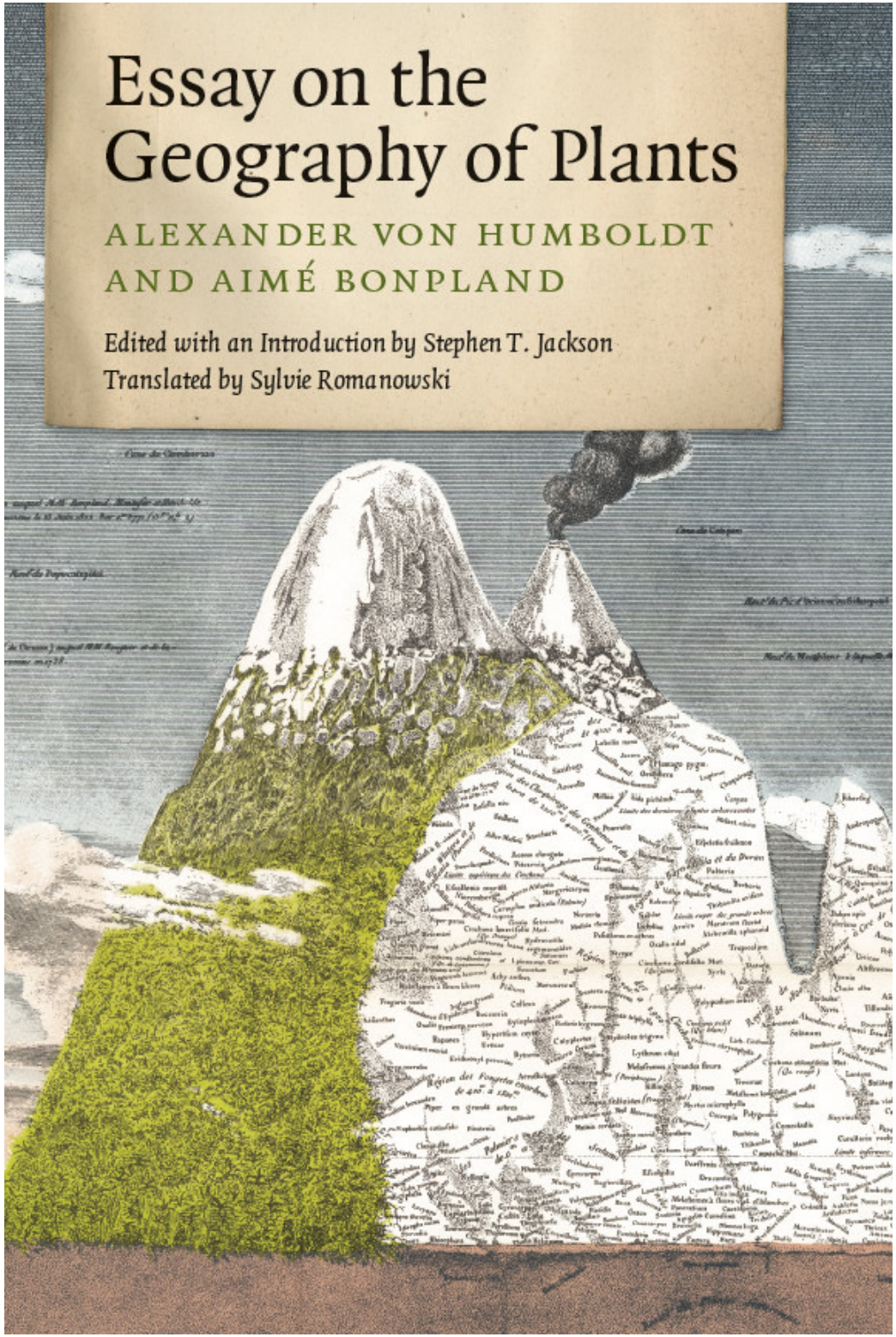
- divides Australian species from Asian species

- "Wallacea" – mixing zone on the islands near the line

Sumatran Orangutan - primate

Bear Cuscus – marsupial (Sulawesi)


© Jeffrey S. Pippen



Relationships between distributions of vegetation types and environmental factors have long been recognized

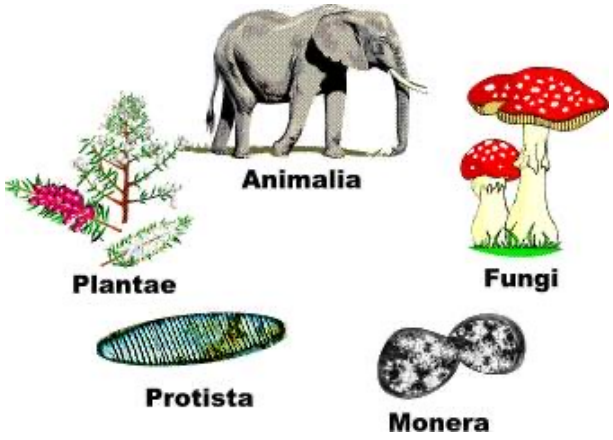
Alexander von Humboldt (1769-1859)

- *Geography of Plants,* 1807. Laid the foundation for field of Biogeography
- Relationships of dominant plant types to **climate (temperature, precip)** and **soils**
- One of the first to suggest Africa and S. America were once joined

Various schemes to describe global vegetation (**biomes**) in relation to climate & soils

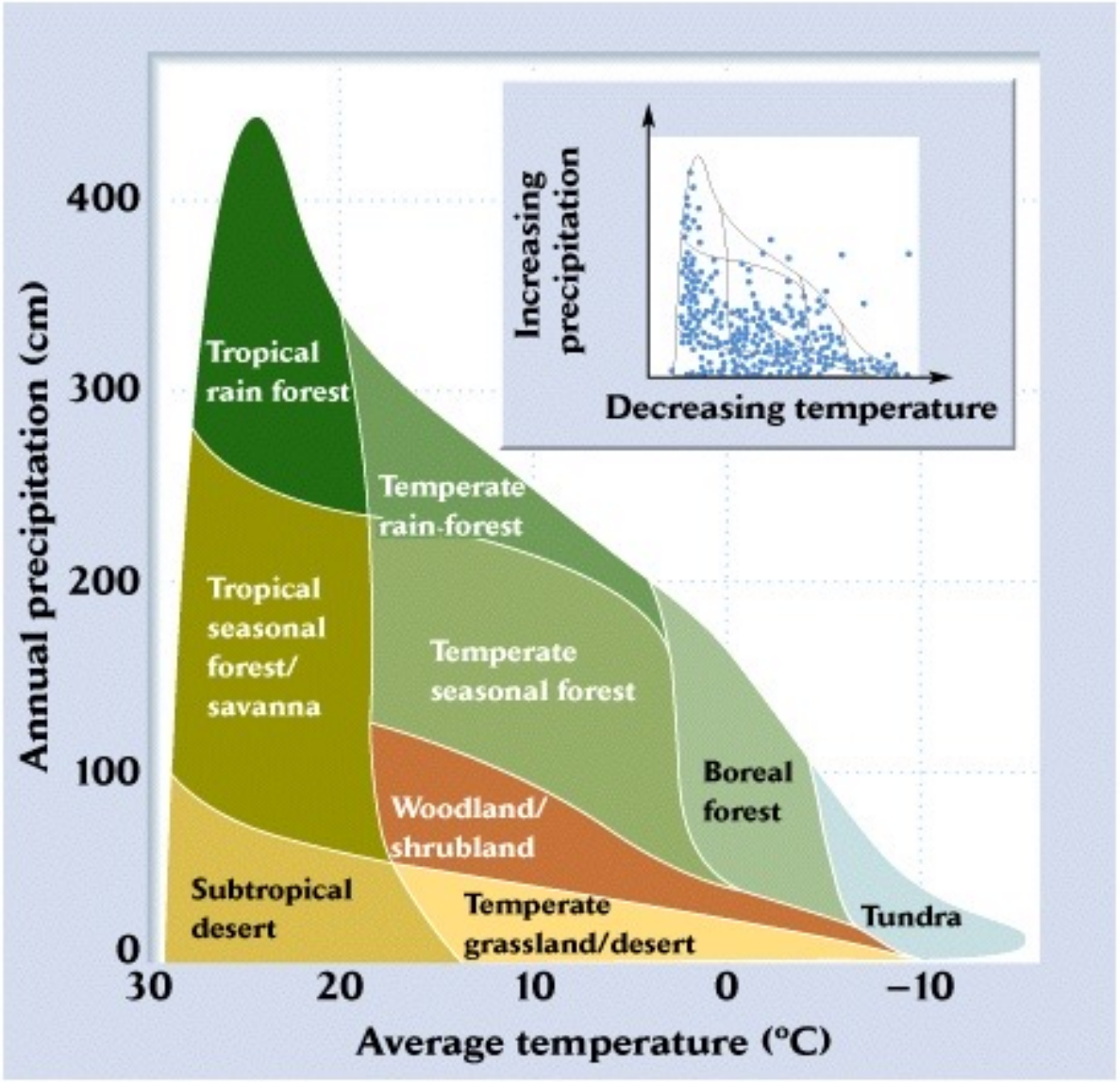
Robert Whittaker (1920-1980)

- American Plant Ecologist, Biogeographer
- First to propose 5 Kingdom classification system (Plant, Animal, Fungi, Protist, Bacteria)



- Published Whittaker Biome Classification based on two abiotic factors (temperature and moisture) to explain plant community types
- Developed gradient analysis to address questions in plant community ecology

Whittaker Biome Classification

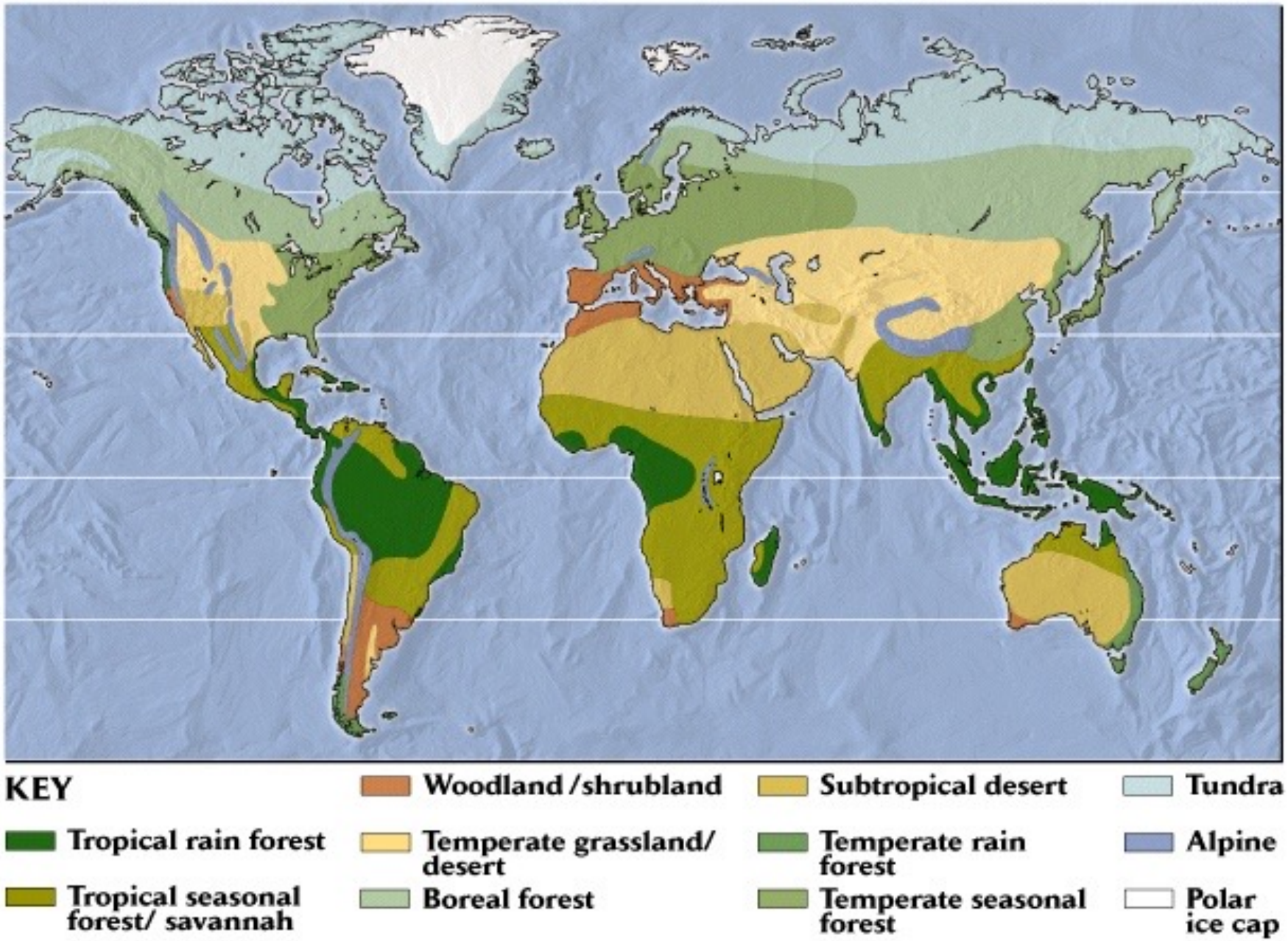


Note that biomes are not defined by phylogenetic similarities of organisms but rather by climate and plant structure/spacing/composition

- Heat
- Moisture
- **Cold**

Colder = fewer plants

Major World Biomes



So, **COLD** 🥶❄️ **temperatures** are one of the primary environmental factors limiting where plants can grow!

Different groups of plants differ in their adaptations to low temperatures, heat tolerance, and water availability – Plant Functional Types (PFTs)

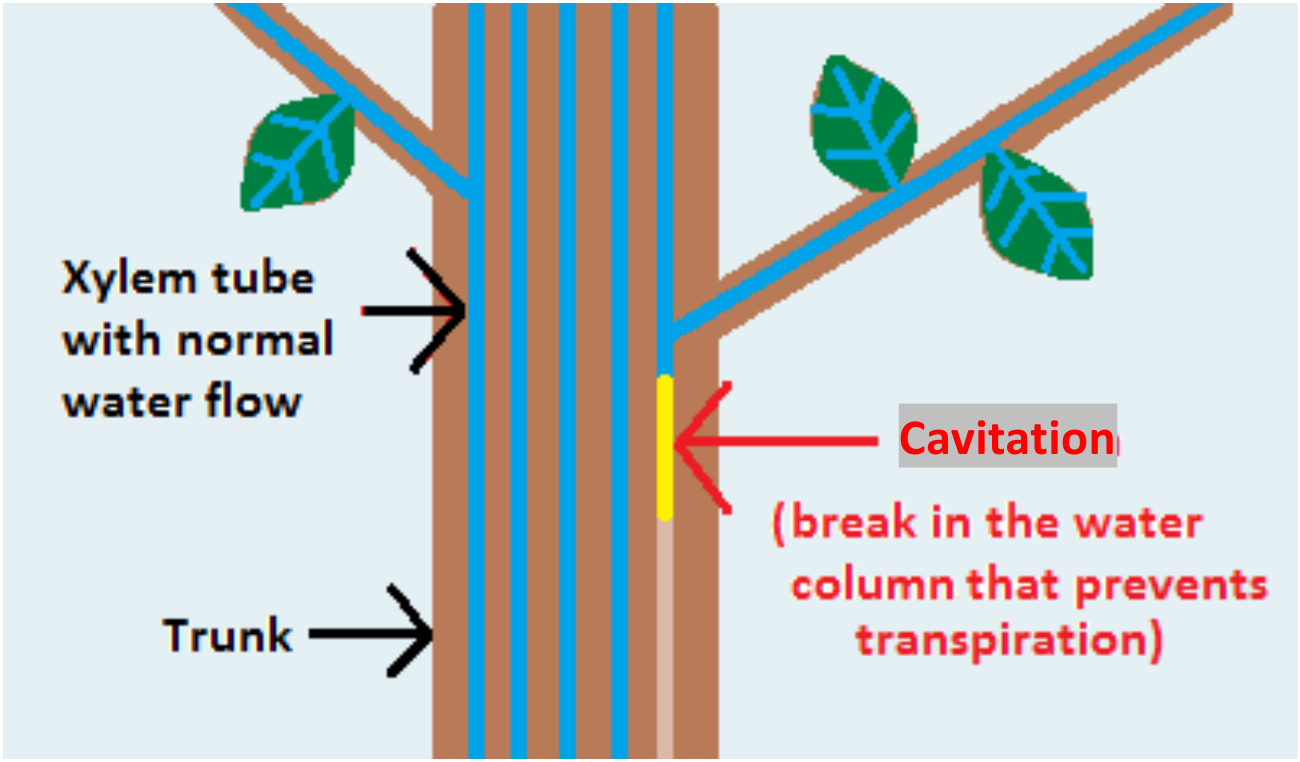
Needle-leaved trees (conifers) have sap transport tissues that can "recover" from freezing **cavitation** (air bubbles forming in vascular tissue due to high tension, thus disrupting flow)

Winter Deciduous (summer-green) trees avoid freezing damage by dropping leaves to limit the amount of active living tissue during the coldest part of the year

Some trees and shrubs from cold climates are capable of "**supercooling**" their cellular cytoplasm -- special cell architecture prevent ice nucleation to –40° C

Adaptive Traits to survive sub-freezing temperatures

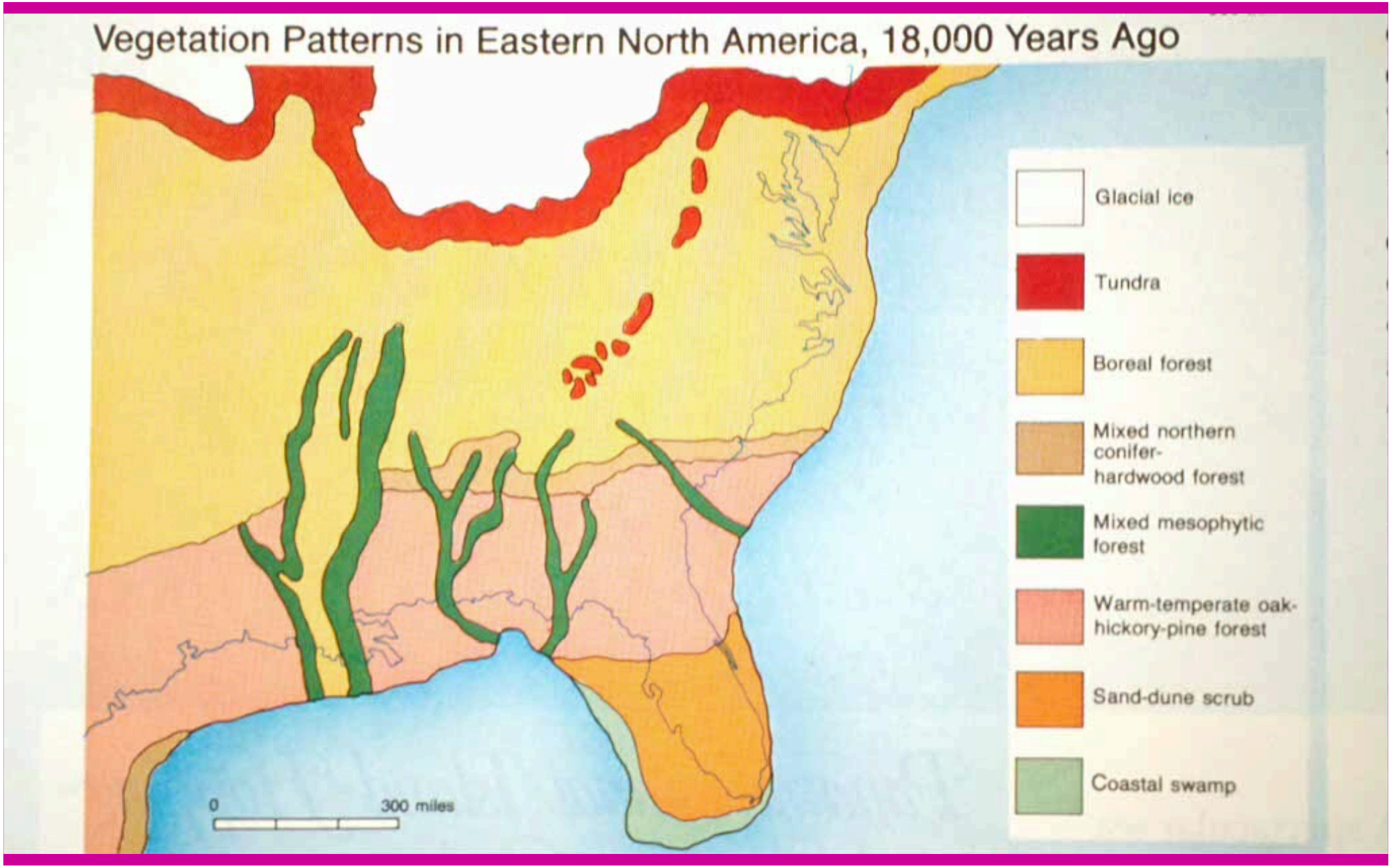
Diffuse-porous xylem: narrow water-conducting channels which tolerate high tension (e.g. maple, birch, willow, aspen) – more resistant to cavitation (air bubbles that break the water column) during drought/freezing

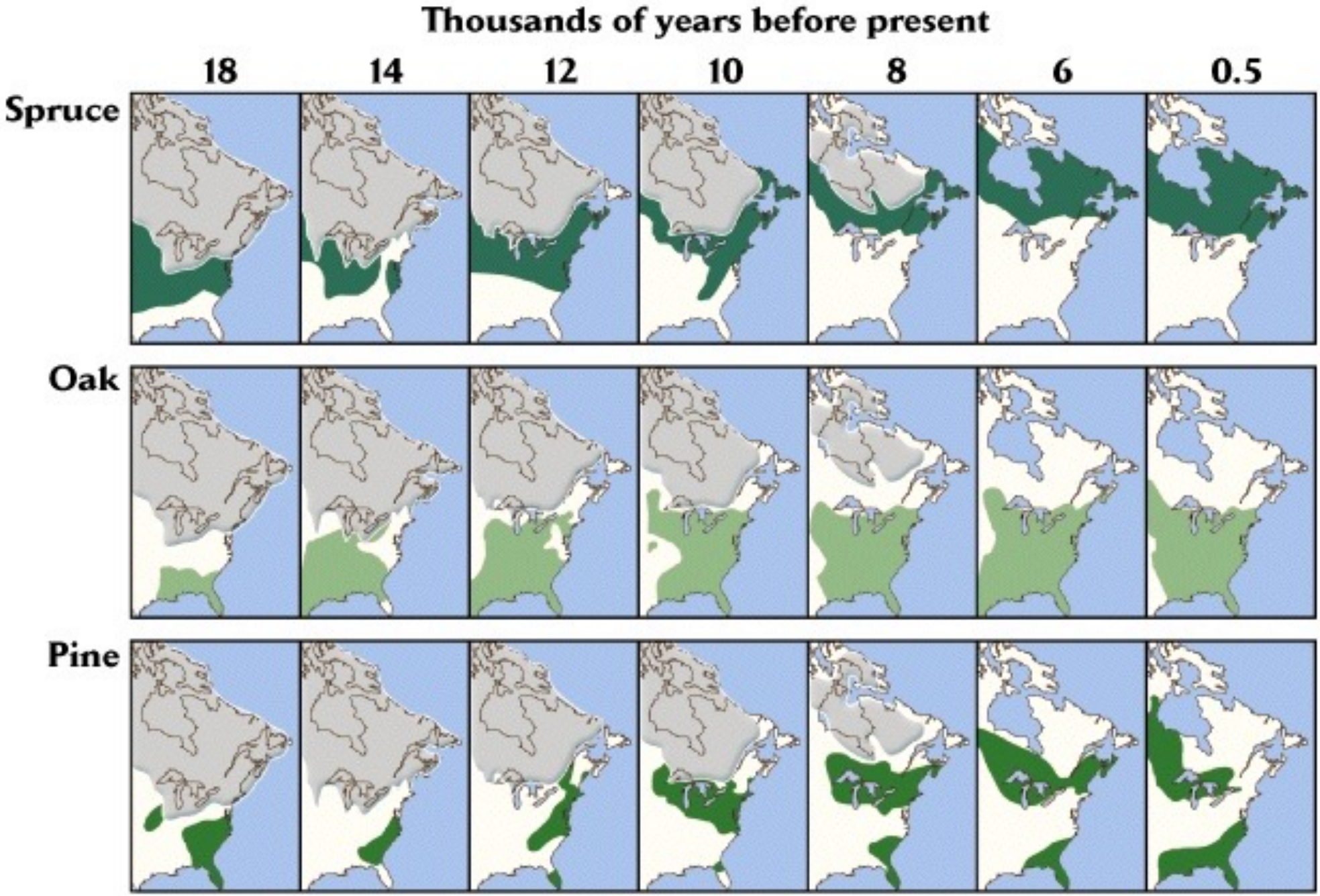


Broadleaved trees with diffuse-porous xylem: narrow channels which tolerate high tension (e.g. birch, willow, aspen, maple) – more difficult to count seasonal rings because vessels are consistently narrow

Broadleaved trees with ring-porous xylem: wide channels with high conductive capacity but low resistance to cavitation (e.g. oak, elm, ash) – spring wood with very large diameter vessels and summer wood with smaller diameter vessels – easier to count rings

Biogeography important and useful for studying climate change




Thousands of years before present
18
14
12
10
8
6
0.5
Spruce
Oak
Pine

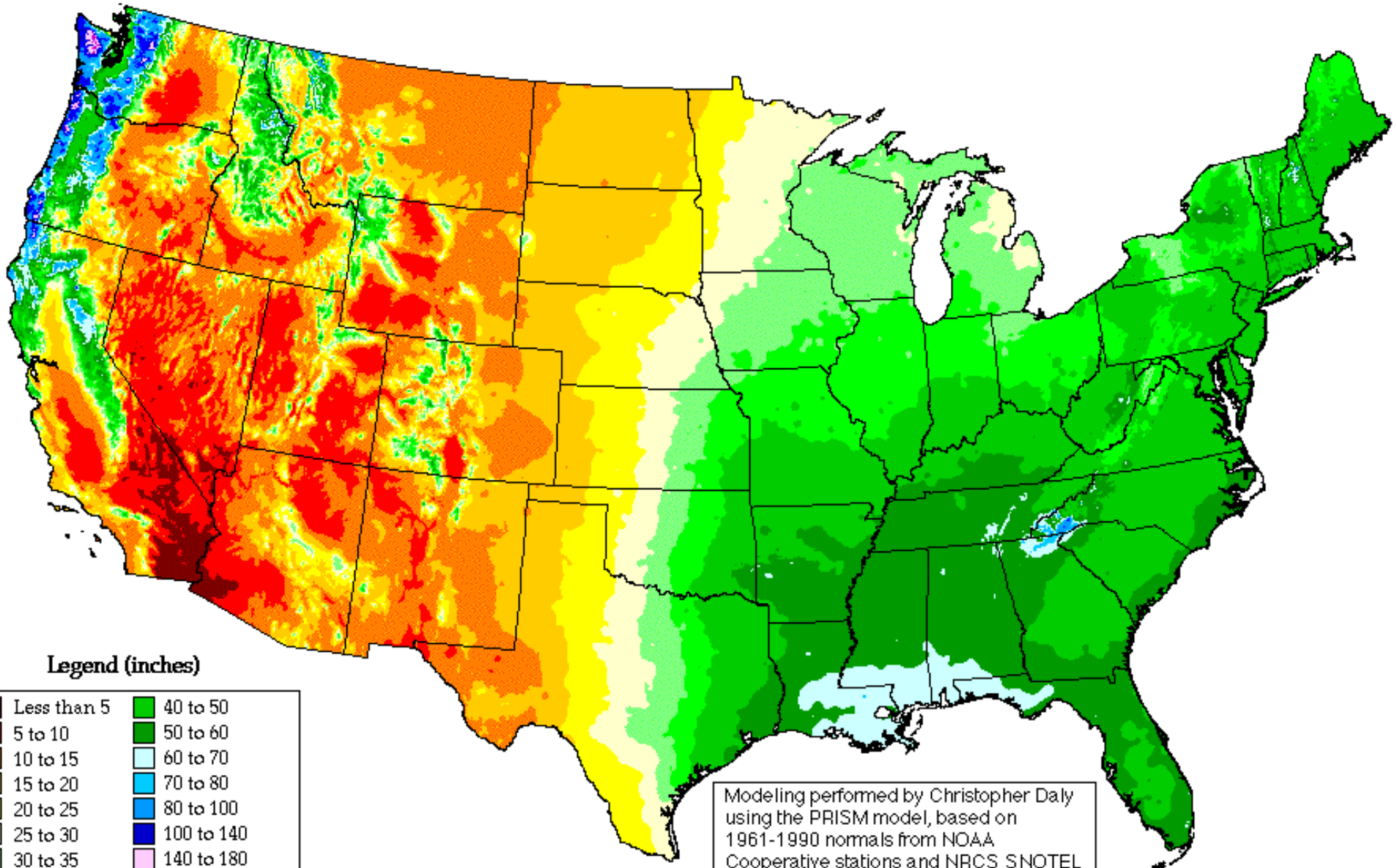
Some Key Points

- Temperature and water balance are the main controls on vegetation patterns at the global scale -- minimum temperatures, heat tolerance, water deficits and drought are key

- Due to competition, species and functional types often have a more limited distribution than expected based on their physiological limits

Annual Average Precipitation

United States of America



Legend (inches)

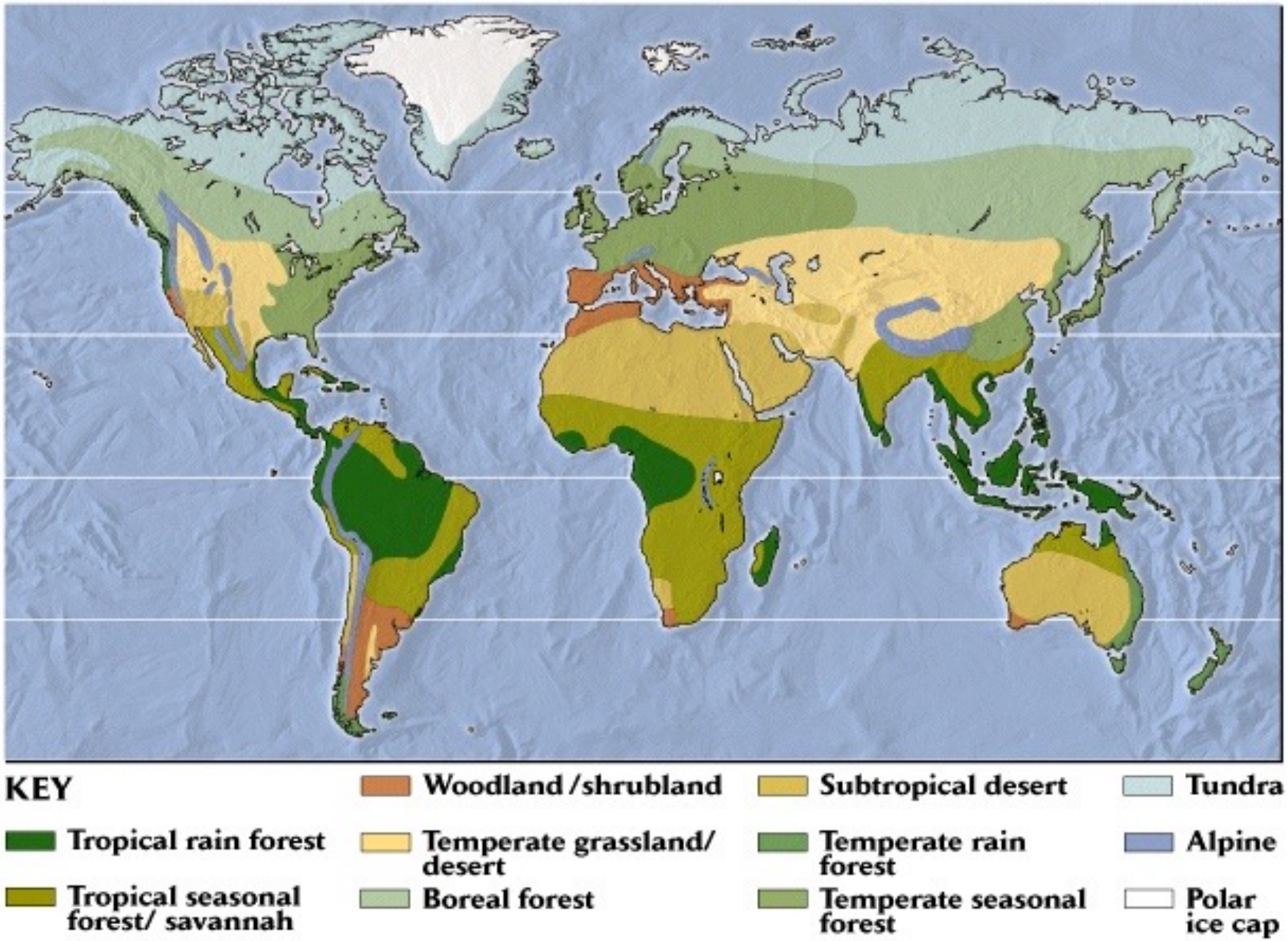
Less than 5	40 to 50
5 to 10	50 to 60
10 to 15	60 to 70
15 to 20	70 to 80
20 to 25	80 to 100
25 to 30	100 to 140
30 to 35	140 to 180
35 to 40	More than 180

Period: 1961-1990

Modeling performed by Christopher Daly using the PRISM model, based on 1961-1990 normals from NOAA Cooperative stations and NRCS SNOTEL sites. Sponsored by USDA-NRCS Water and Climate Center, Portland, Oregon.

Oregon Climate Service
George Taylor, State Climatologist
(541) 737-5705

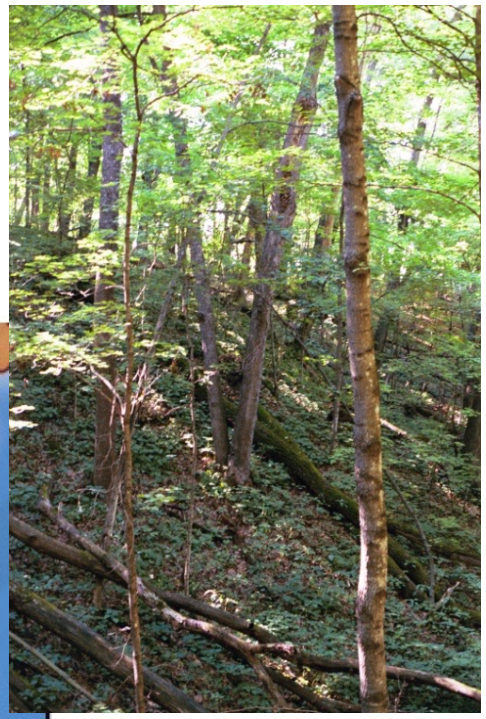
Major World Biomes



Example:

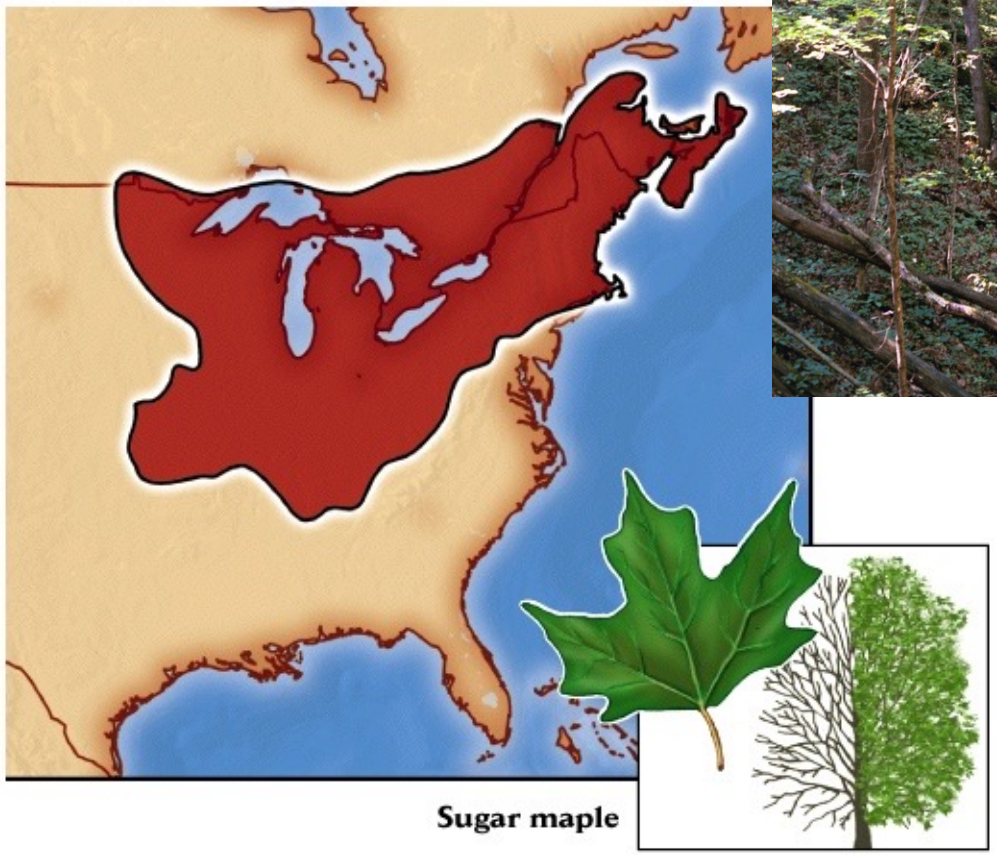
Northern Sugar Maple *(Acer saccharum)*

Why does it grow where it does? Species are limited in part by physical conditions.



Limited by:

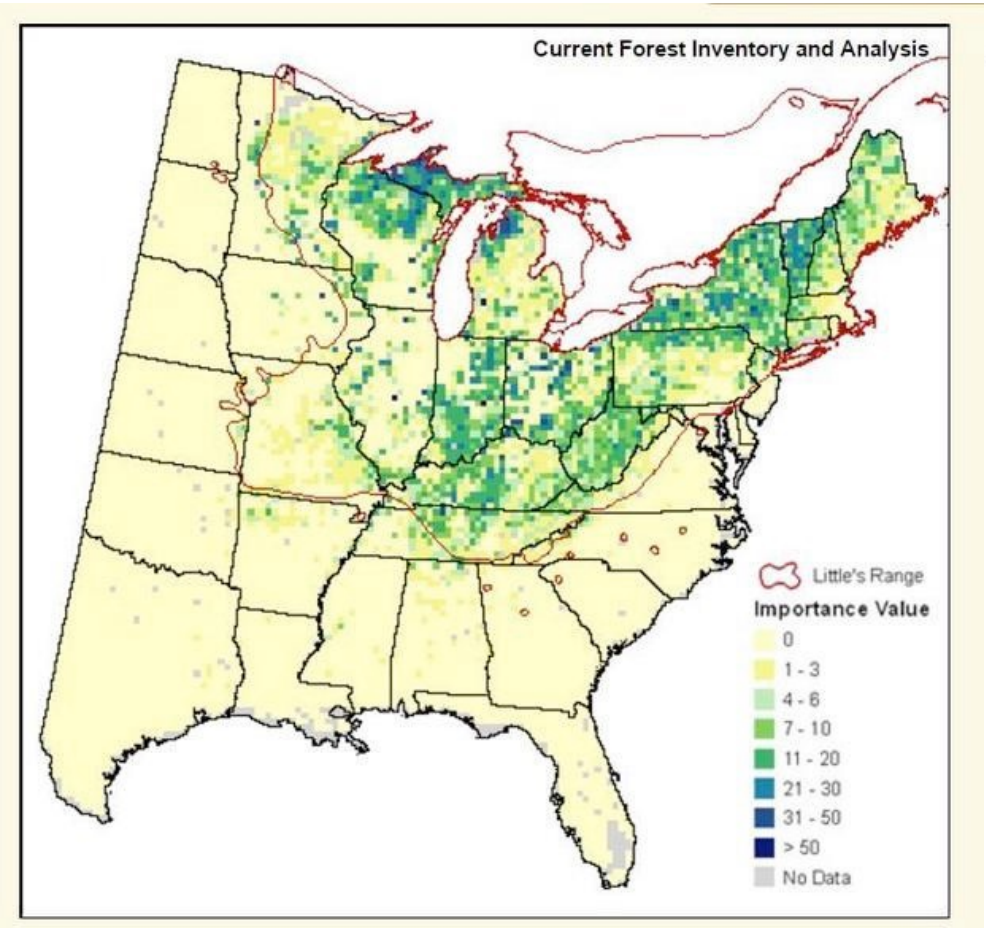
- North-cold winters
- South-hot summers
- East-ocean
- West-precipitation (dry)



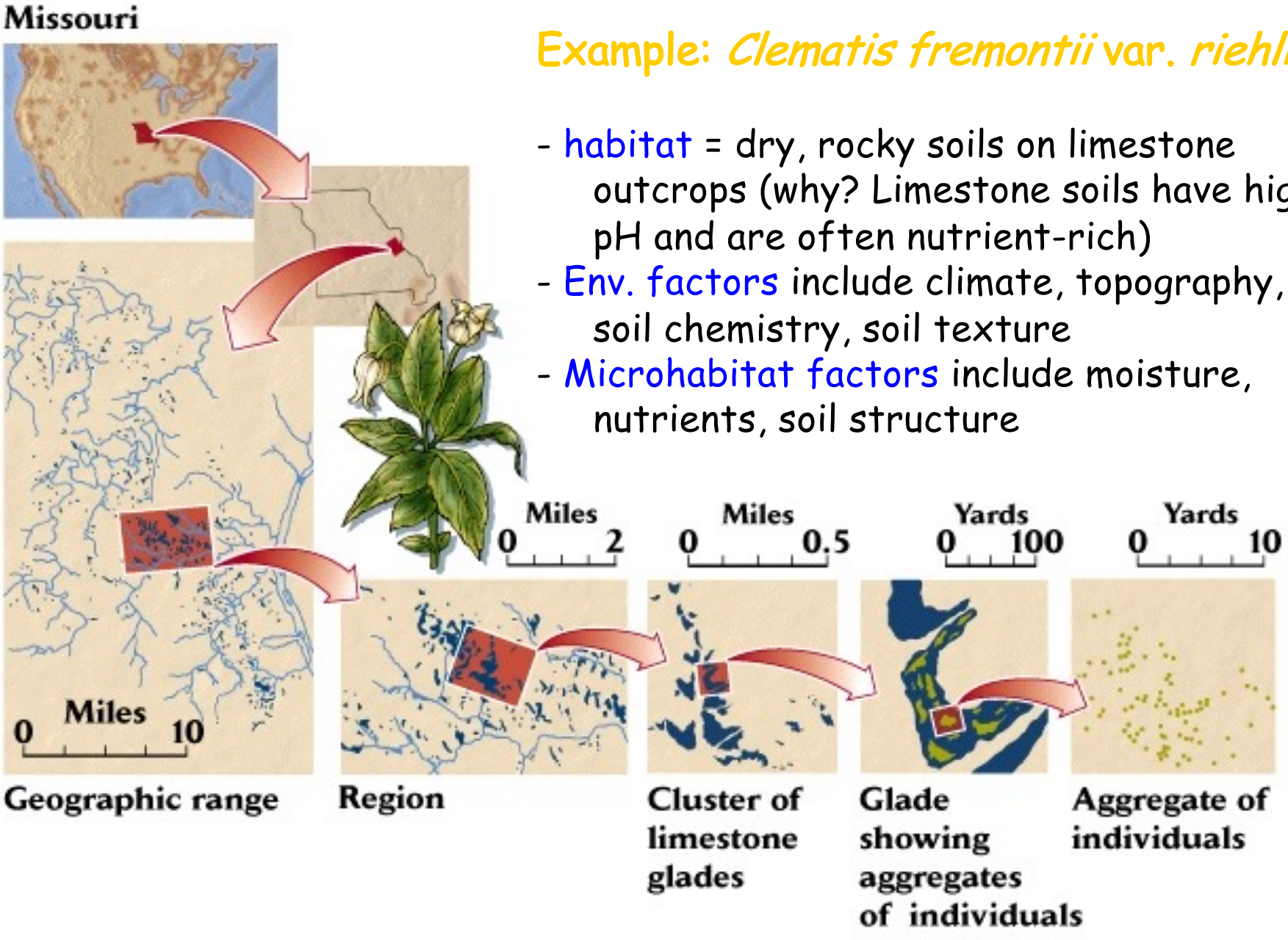
Northern Sugar Maple *(Acer saccharum)*

Within its **general** temperature/moisture range, other conditions limit where it's found:

- marshes/swamps – too wet
- sand dunes – too little soil organic material
- serpentine barrens – Ca:Mg ratio unfavorable
- recently burned areas
- dispersal – suitable habitat may be -found elsewhere but species has no -way to get there…



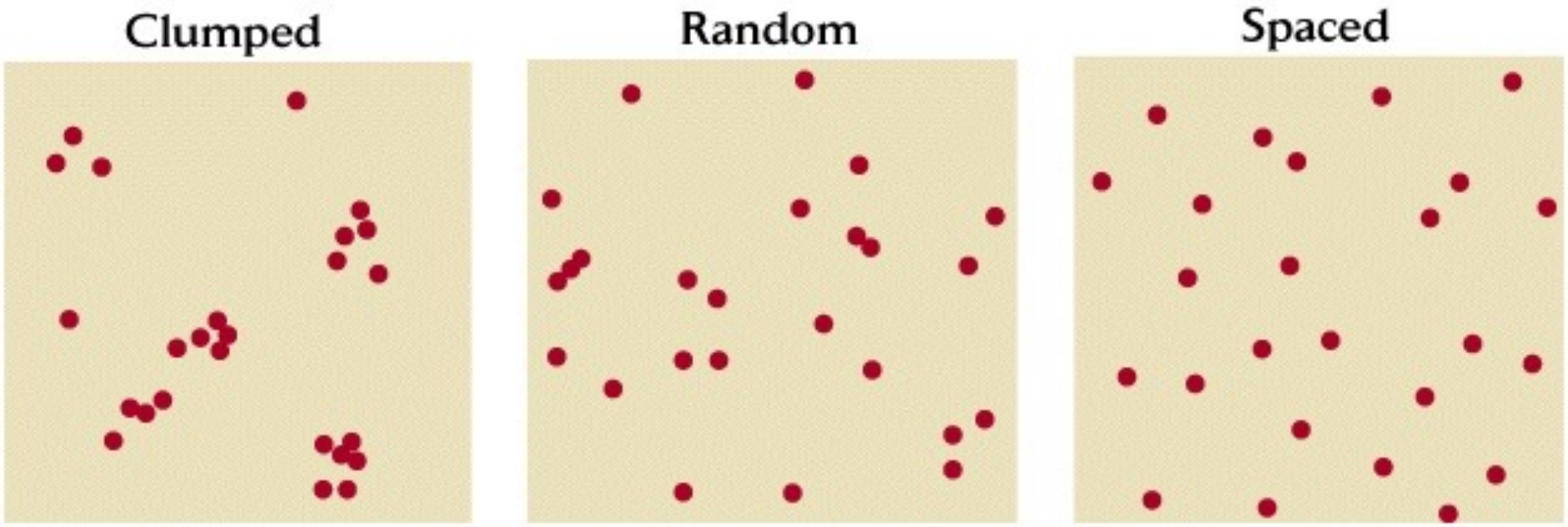
Occupancy within the geographic range is patchy, so within a geographic range, species only occupy suitable habitats



Example: *Clematis fremontii* var. *riehlii*

- habitat = dry, rocky soils on limestone outcrops (why? Limestone soils have high pH and are often nutrient-rich)
- Env. factors include climate, topography, soil chemistry, soil texture
- Microhabitat factors include moisture, nutrients, soil structure

Individual spacing within habitat patches



Dispersion = how organisms are distributed within patches of suitable habitat on a smaller scale

Clumped-individuals clumped near a resource (e.g., moisture, nutrients)

Random-individuals grow wherever they happen to land, without regard to other individuals

Spaced-competition within species might result in each individual with its own territory

Habitat Fragmentation

Natural caused on geologic scale, e.g. mountain ranges, large rivers

- may result in speciation and greater biodiversity

Human caused land conversion, e.g. agriculture, urban development, damming rivers

- rapid alteration of environment; too fast for species to respond by evolution
- may result in species extinctions and loss of biodiversity

© Jeffrey Pippen – Slash and burn agriculture practice, Northern Peru

Habitat Fragmentation

Results in

- Breaking up of one larger patch into multiple smaller patches
- Reduction of total area of habitat
- Isolation of habitat fragments from each other
- Decrease in average size of each patch
- Barriers to dispersal
- Increase "edge effect" (edge:interior ratio)

Edge Effects

- **Microclimatic** changes in light, temp & humidity, wind

- **Storm damage** likelihood increases

- **Fire** likelihood increases as humidity drops and temp and wind rise

- **Exotic** and/or pest species may establish/invade more easily due to greater access

Powerline right of way near Jordan Lake, NC

Edge Effects

- **Microclimatic** changes in light, temp & humidity, wind

- **Storm damage** likelihood increases

- **Fire** likelihood increases as humidity drops and temp and wind rise

- **Exotic** and/or pest species may establish/invade more easily due to greater access

Kudzu *(Pueraria montana)* prefers edges

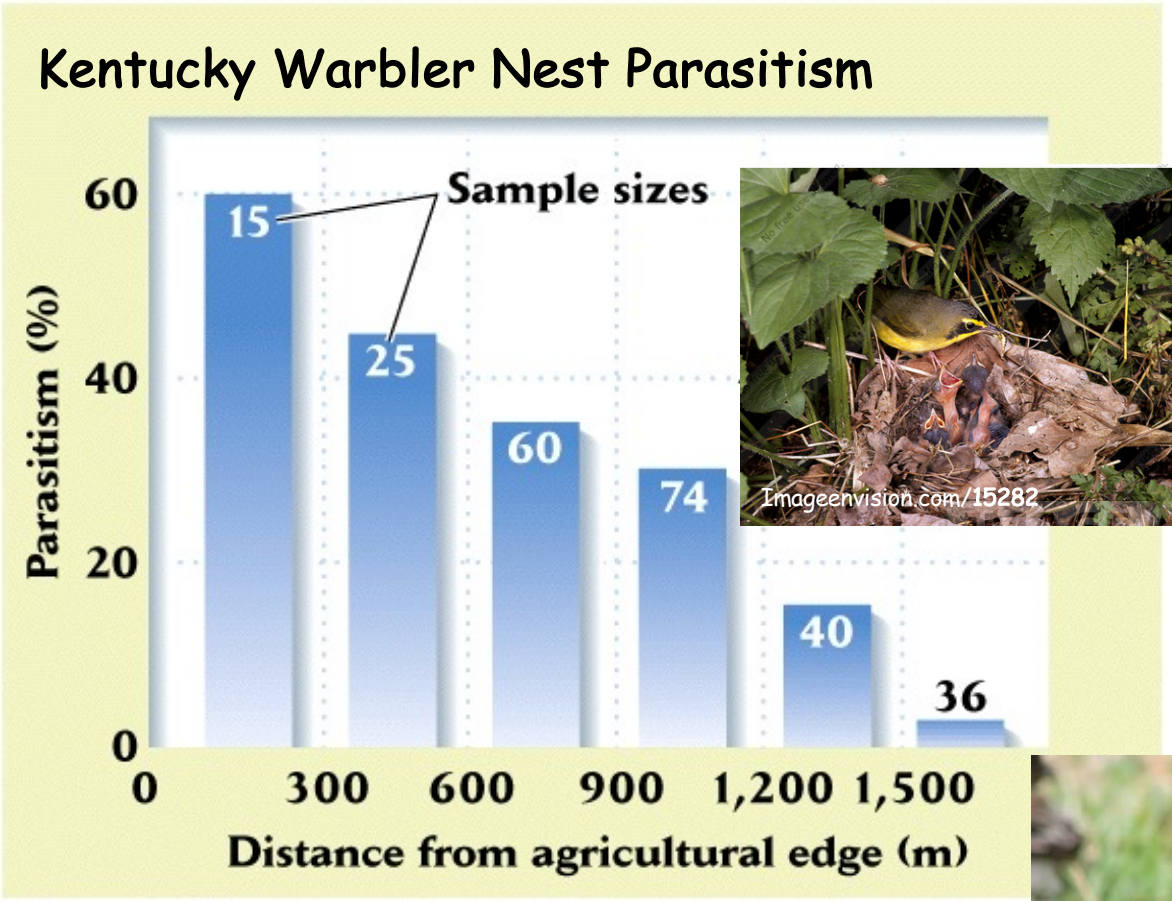
Habitat fragmentation and brood parasites

Kentucky Warbler Nest Parasitism

-KY Warblers require forest interior for breeding habitat

http://palmbeachcountynaturally.wordpress.com/

Habitat fragmentation and brood parasites



-KY Warblers require forest interior for breeding habitat

-Cowbirds require open, grassy areas to feed

-Parasitize nests of forest birds

-Forest fragmentation results in more warbler nests near edges with open areas, thus more parasitism

-Decreases warbler population

-May increase plant pests (caterpillars), and so on…

Extinction and conservation

- E.O. Wilson of Harvard made rough estimates of species extinction rates based on analyses of rainforests:
  - rates of rainforest destruction (ha/yr)
  - typical species richness/ha in rainforest
  - typical range (ha) of rainforest species
  - calculated 27,000 species lost/year
- Background rate = roughly 1 species per million species per year
- Conservative extinction rate currently estimated at least ~1000x natural "background" rate

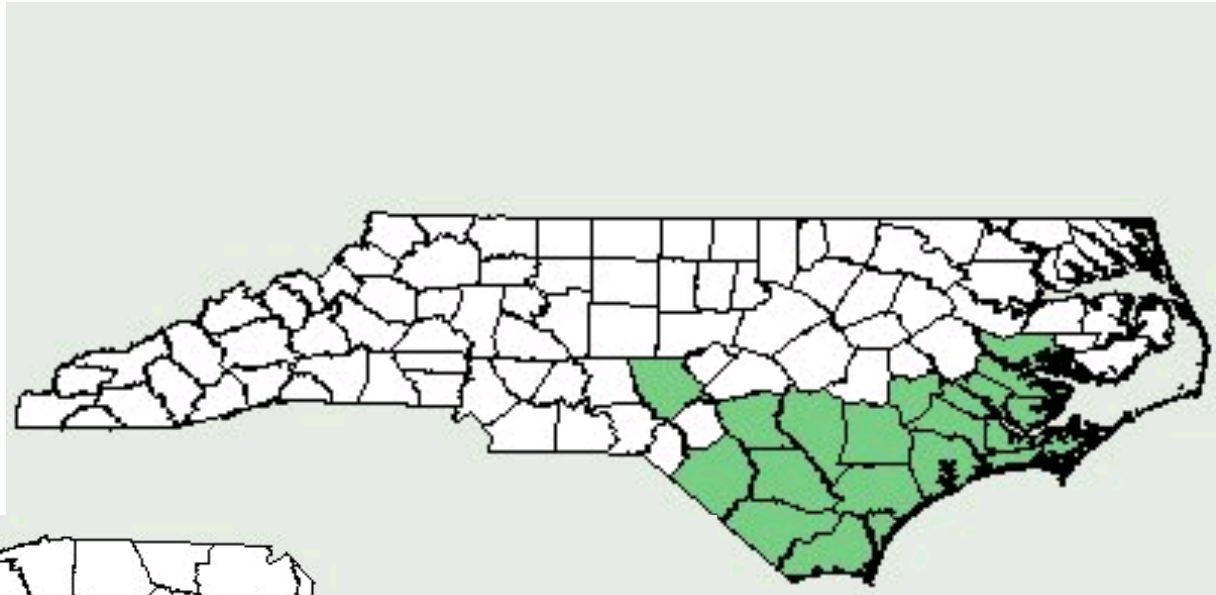
Anthropogenic Extinction

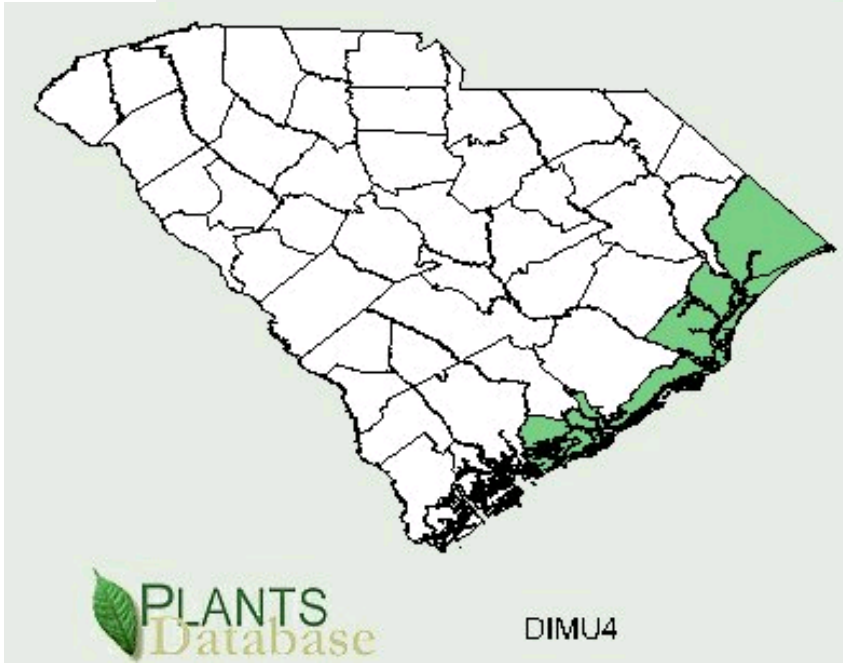
- Principal causes of population decline for endangered U.S. species:
  - habitat reduction and modification (67% of cases)
  - small population size
  - introduction of exotic species
  - Overexploitation/Poaching (e.g., ginseng, flytraps, etc.)

Venus Flytrap *(Dionaea muscipula)* worldwide

Small Population Size
(fragmentation exacerbates these problems!)

- Subject to stochastic local extinction (e.g. hurricane)
- May be unable to migrate with climate change (e.g. sea level rise)
- Biggest current threats = development, poaching





ABC News Headline 4 March 2024
BOILING SPRING LAKES, N.C. (AP) -- Authorities in North Carolina have arrested two people in a case of poaching **hundreds** of Venus flytraps, which grow naturally in the eastern part of the state.

Introductions of exotic species

NC Invasives – too many!!

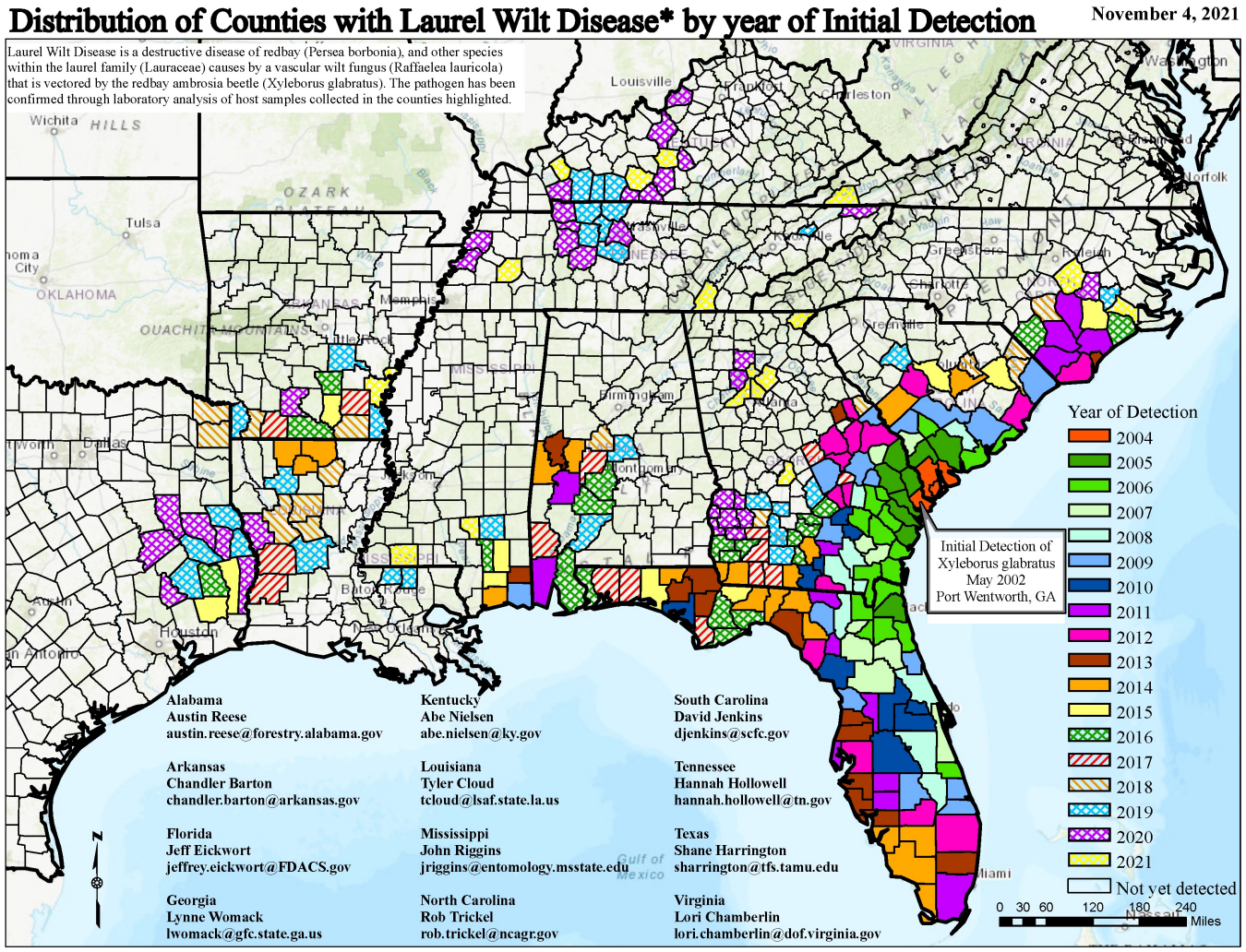
Japanese Honeysuckle, Kudzu, Japanese Stiltgrass (*Microstegium*), Autumn-Olive, Tree-of-heaven, Princess Tree, Chinese Privet, Garlic-Mustard, Silktree Mimosa, Fig Buttercup, English Ivy, Bradford Pear…

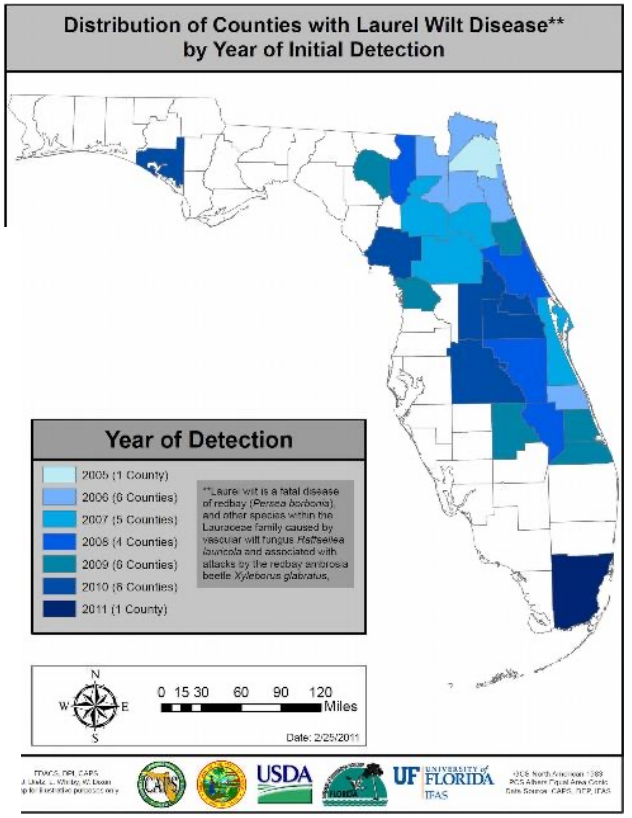
Case Study-Laurel Wilt from Redbay Ambrosia Beetle

- 2002: Non-native beetle first discovered in US near Port Wentworth, GA, apparently arrived by ship in untreated wooden crates/pallets
- Beetles selectively burrow into members of Lauraceae (Red Bay, Swamp Bay, Spicebush, Sassafras, Avacodo)
- Beetles carry Laurel Wilt Fungus which grows in vascular tissue of plant, ultimately clogging it up, and killing the tree

Laurel Wilt from Redbay Ambrosia Beetle carrying Laurel Wilt Fungus

Laurel Wilt from Redbay Ambrosia Beetle and Laurel Wilt Fungus





- Expanding range ~20 miles per year
- Could decimate US avocado industry if reaches California

Biogeography

Basic processes leading to species distribution:

- Evolution
  - Adaptation
- Competition
- Dispersal
- Extinction

Plant Conservation
Landscape Ecology: Preserve design

- **General recommendations exist for creation of preserves from large expanses of uniform habitat:**
  - Larger *usually* better than smaller (support more species, reduces stochastic extinction, buffers against disturbances)
  - Undivided is better than divided
  - Corridors help, if must be divided
  - Avoid too much edge
- **Other considerations:**
  - Habitat requirements of target species

Ecological applications: Conservation planning

- Successful planning for conservation must include adequate habitat for self-sustaining populations; what's the minimum required space to support a long-term viable population?

- Many other factors, often species specific!

Plant Conservation in North Carolina

Many groups focused on plant conservation

- Habitat preservation
- Biogeography (distribution, habitat & species records/monitoring, etc.)
- Plant rescues
- Exotic-invasive removal efforts
- Outreach/education

Plant Conservation in North Carolina

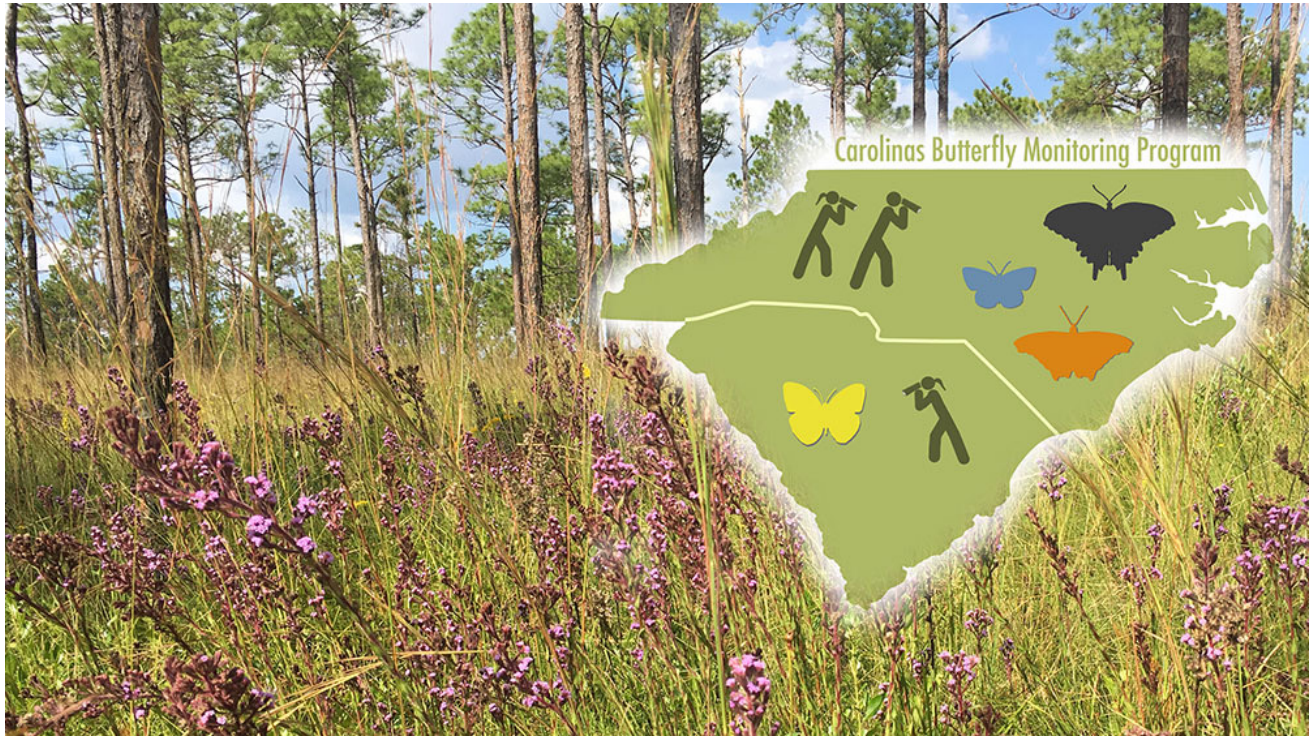
- NC Biodiversity Project
- Plant Conservation Program
  - a section of the NC Dept. of Agriculture
- Friends of Plant Conservation, works with NC PCP
- Natural Heritage Program, a section of NC DENR
- NC Botanical Garden
- NC Native Plant Society
- NC Audubon

We Are Blogging!
audubon
north carolina

NORTH CAROLINA
BOTANICAL
GARDEN

NORTH CAROLINA
NATIVE PLANT
SOCIETY

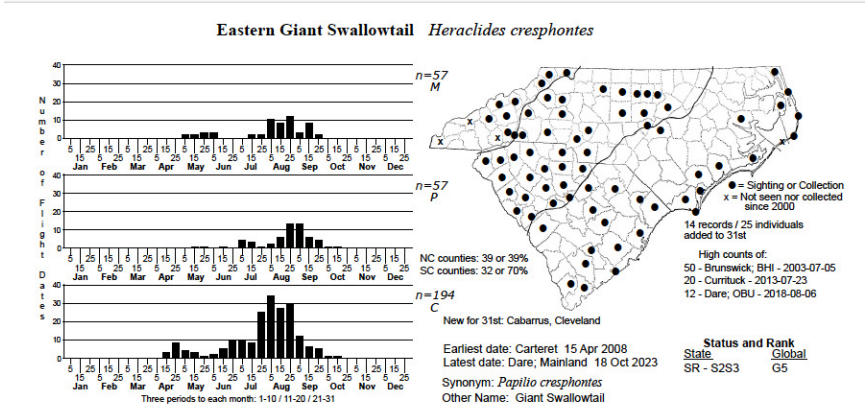
Carolinas Butterfly Monitoring Program

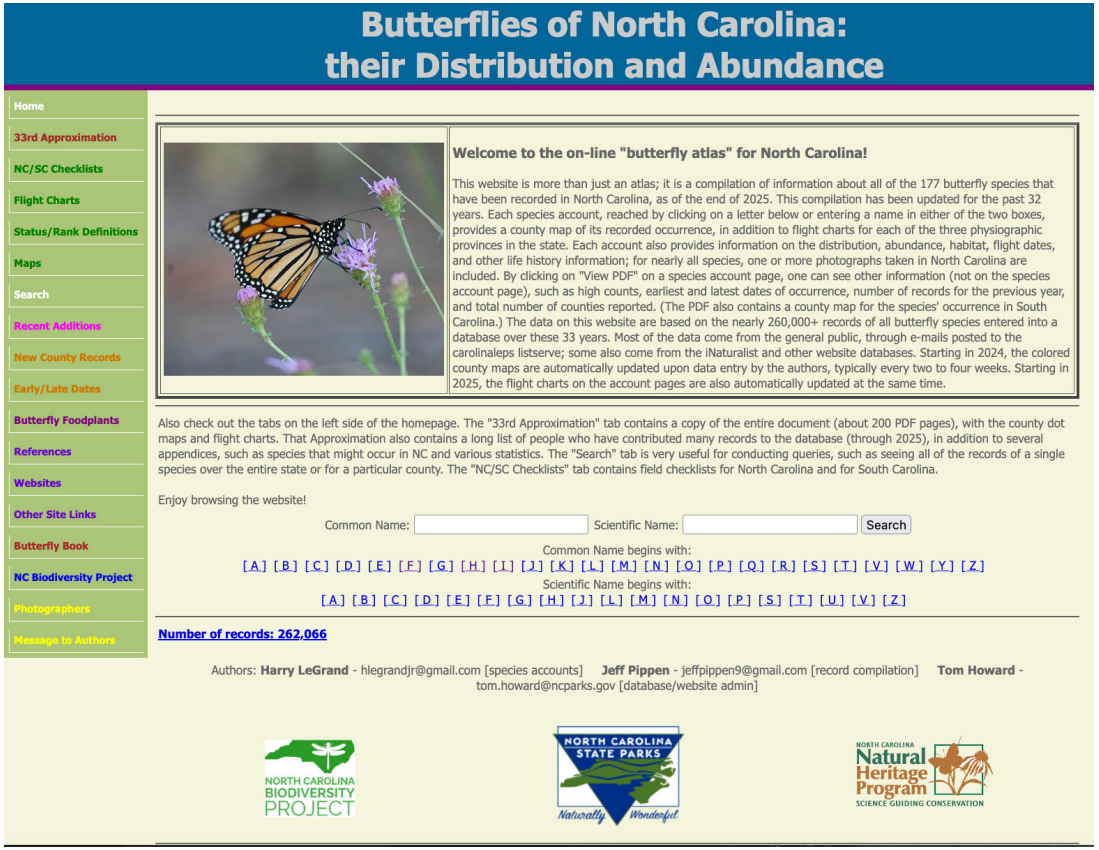


- State-wide community science initiative launched in 2023
- Provides data on butterfly populations, nectar plants, habitat quality
- Volunteers document butterflies across various habitat types
- Contributes to both state and national databases

NORTH CAROLINA BIODIVERSITY PROJECT

All data from the Carolinas Butterfly Monitoring Program are shared with the NC Biodiversity Project's state database to update and refine distributions and flight times (phenology)





> 260,000 Records!!

Field Trip!


© Jeffrey S. Pippen


© Jeffrey S. Pippen


Noronha Island Cactus, Brazil
© Jeffrey S. Pippen