

# Plant Ecology 3

## Biogeography, Biomes, Conservation

Jeff Phippen  
NC Botanical Garden

# 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

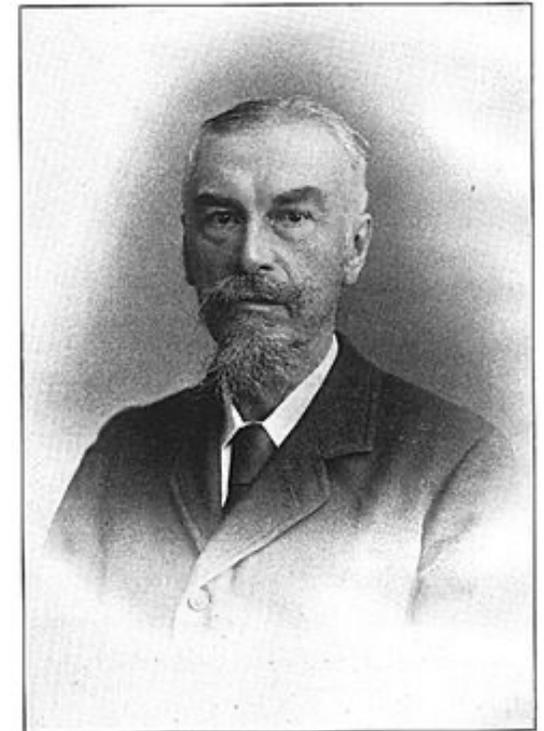


HMS Beagle by Ron Scobie,  
<http://www.ronscobie-marineartist.com/gallery8beagle.htm>

# 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



*P. Sclater.*



# Biogeography History

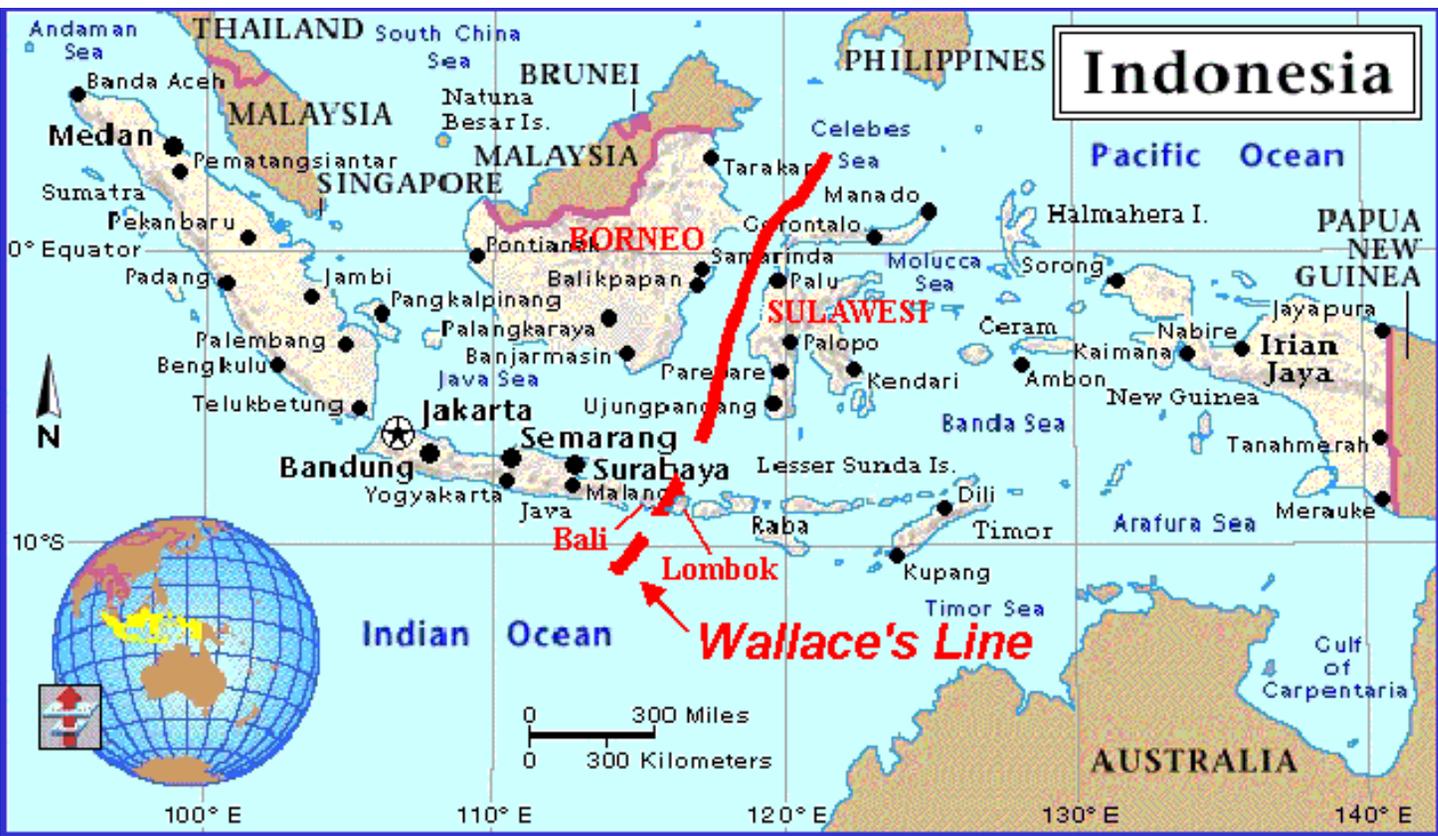
## Alfred Russel Wallace (1823-1913)

- 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



Wallace's  
Golden Birdwing  
Butterfly





# 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 -- Tangkoko National Park, North Sulawesi





# Essay on the Geography of Plants

ALEXANDER VON HUMBOLDT  
AND AIMÉ BONPLAND

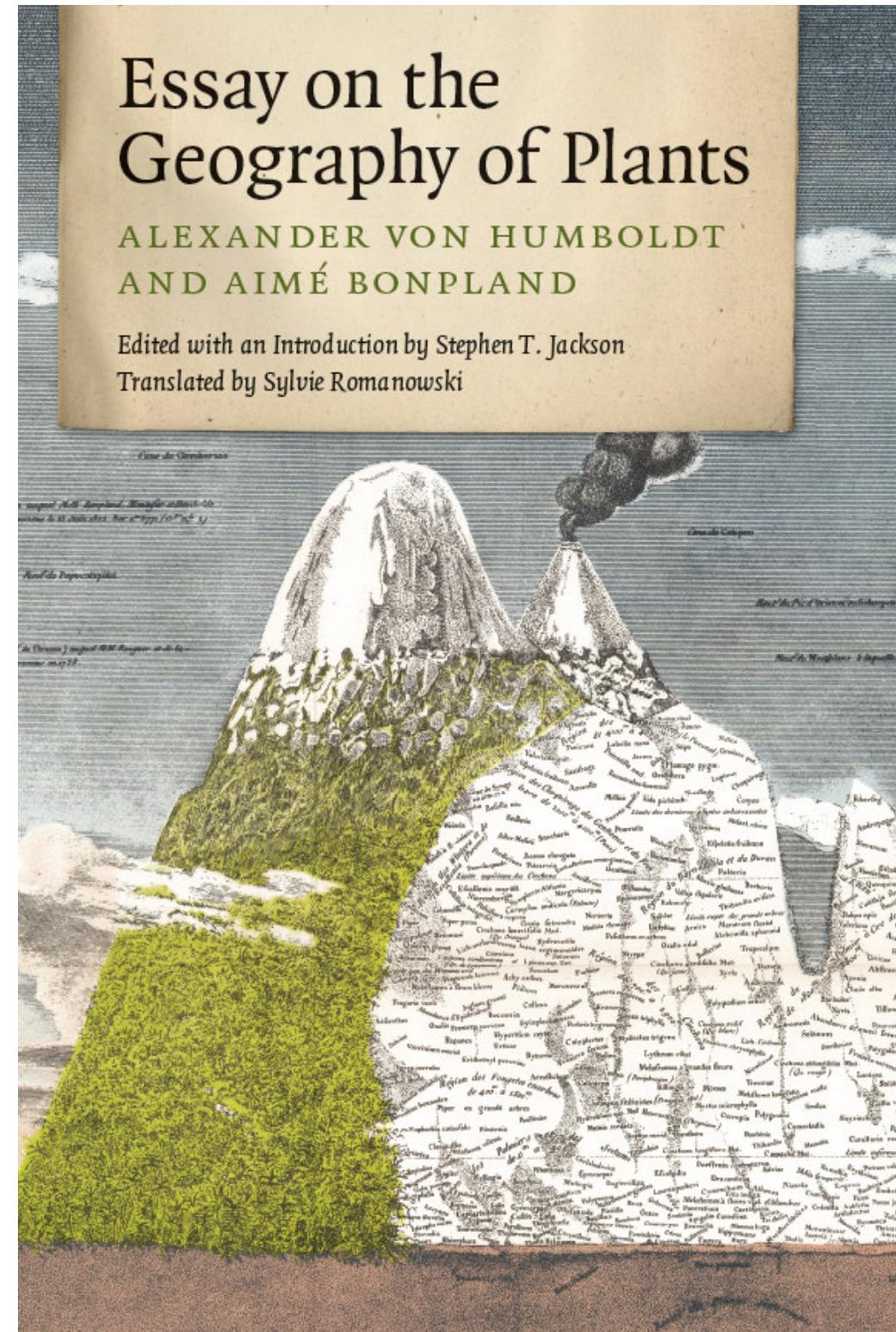
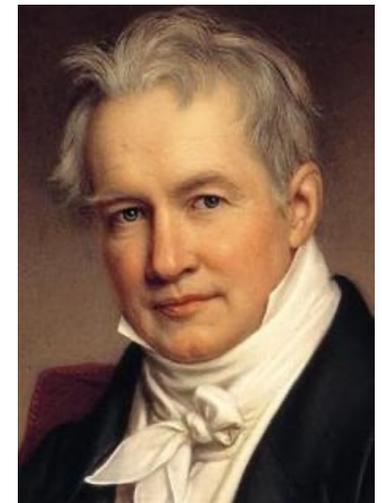
Edited with an Introduction by Stephen T. Jackson  
Translated by Sylvie Romanowski

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

**Alexander von Humboldt (1769-1859)**

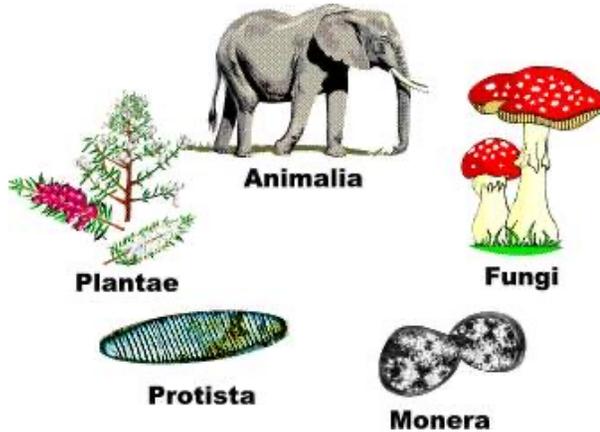
- *Geography of Plants*, 1807. Laid the foundation for field of Biogeography
- Relationships of dominant plant types to climate (temperature, precip) and soils
- One of the first to suggest Africa and S. America were once joined

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

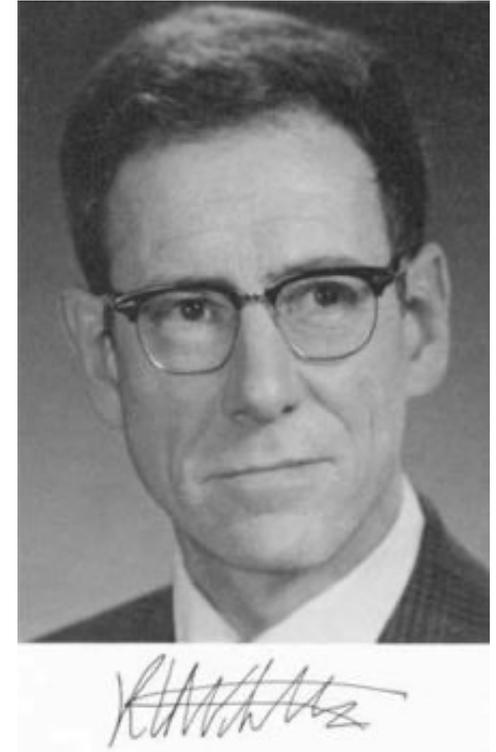


# Robert Whittaker (1920-1980)

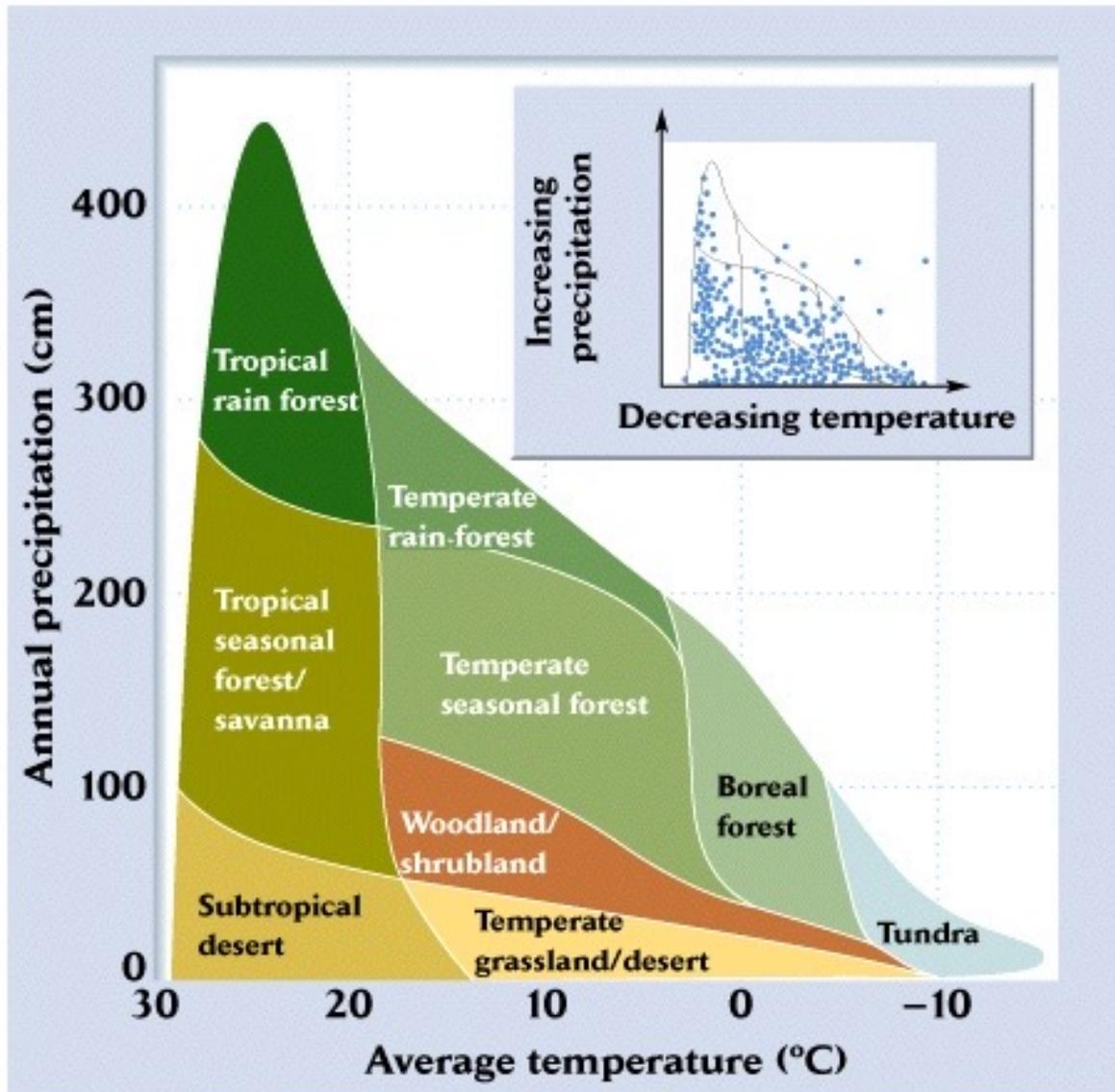
- American Plant Ecologist, Biogeographer
- First to propose 5 Kingdom classification system (Plant, Animal, Fungi, Protist, Bacteria)



- 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



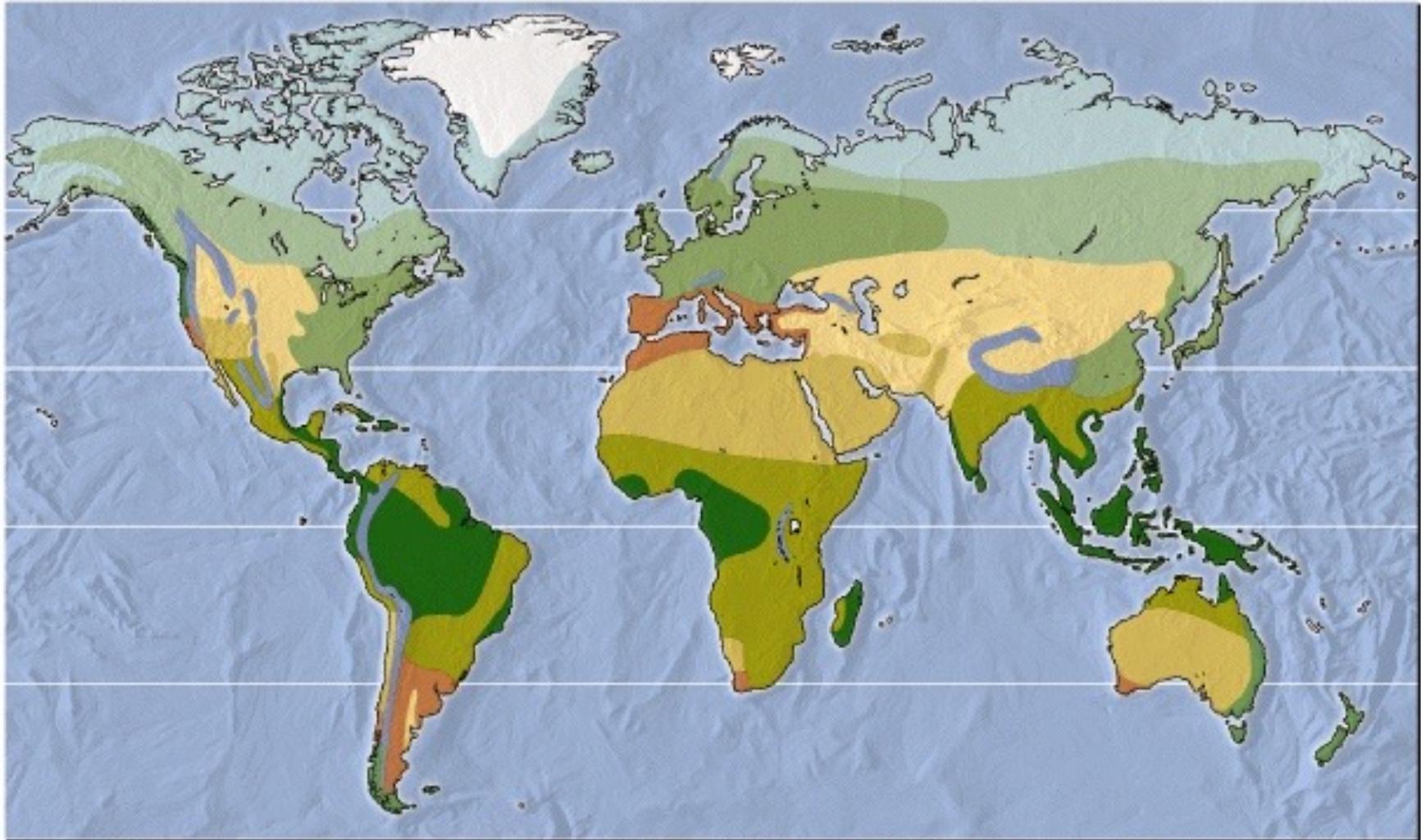
# Whittaker Biome Classification



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



## KEY

Tropical rain forest	Woodland /shrubland	Subtropical desert	Tundra
Tropical seasonal forest/ savannah	Temperate grassland/ desert	Temperate rain forest	Alpine forest
	Boreal forest	Temperate seasonal forest	Polar ice cap

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)

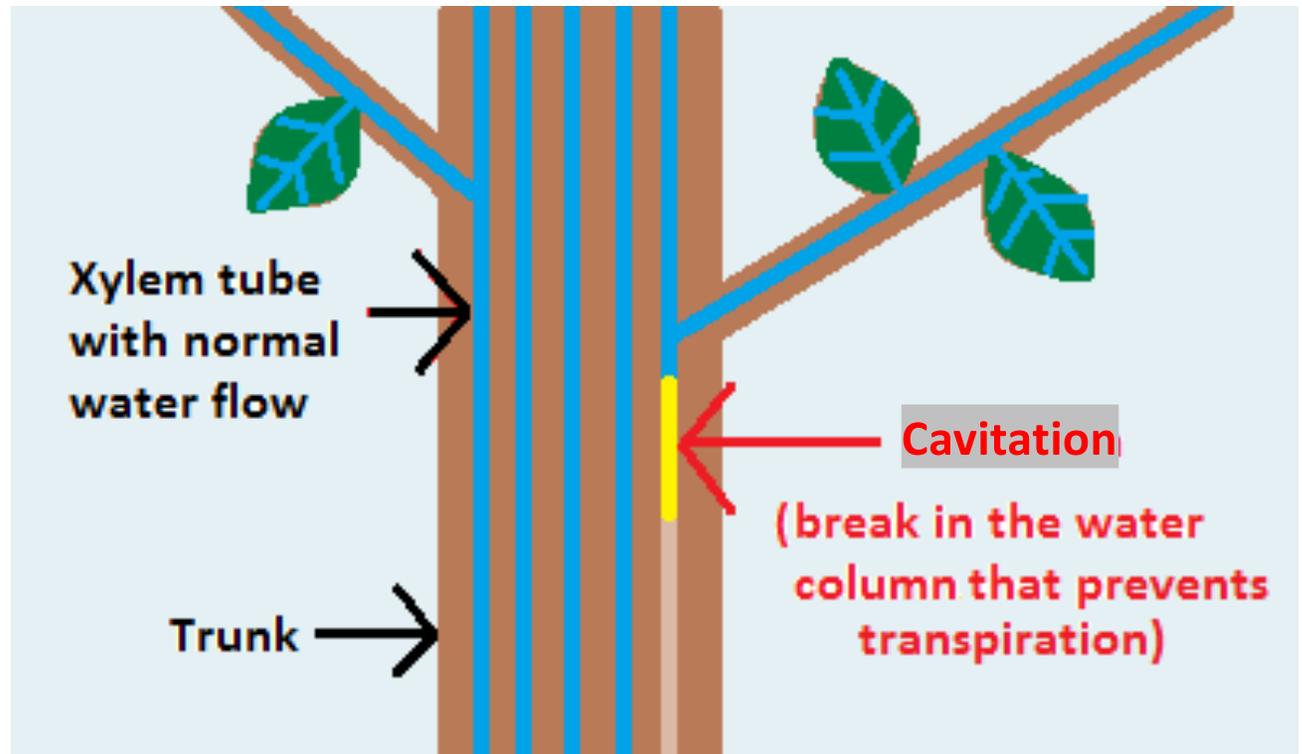
**Needle-leaved trees (conifers)** have sap transport tissues that can “recover” from freezing cavitation (air bubbles forming in vascular tissue due to high tension, thus disrupting flow)

**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  $-40^{\circ} \text{C}$

# 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

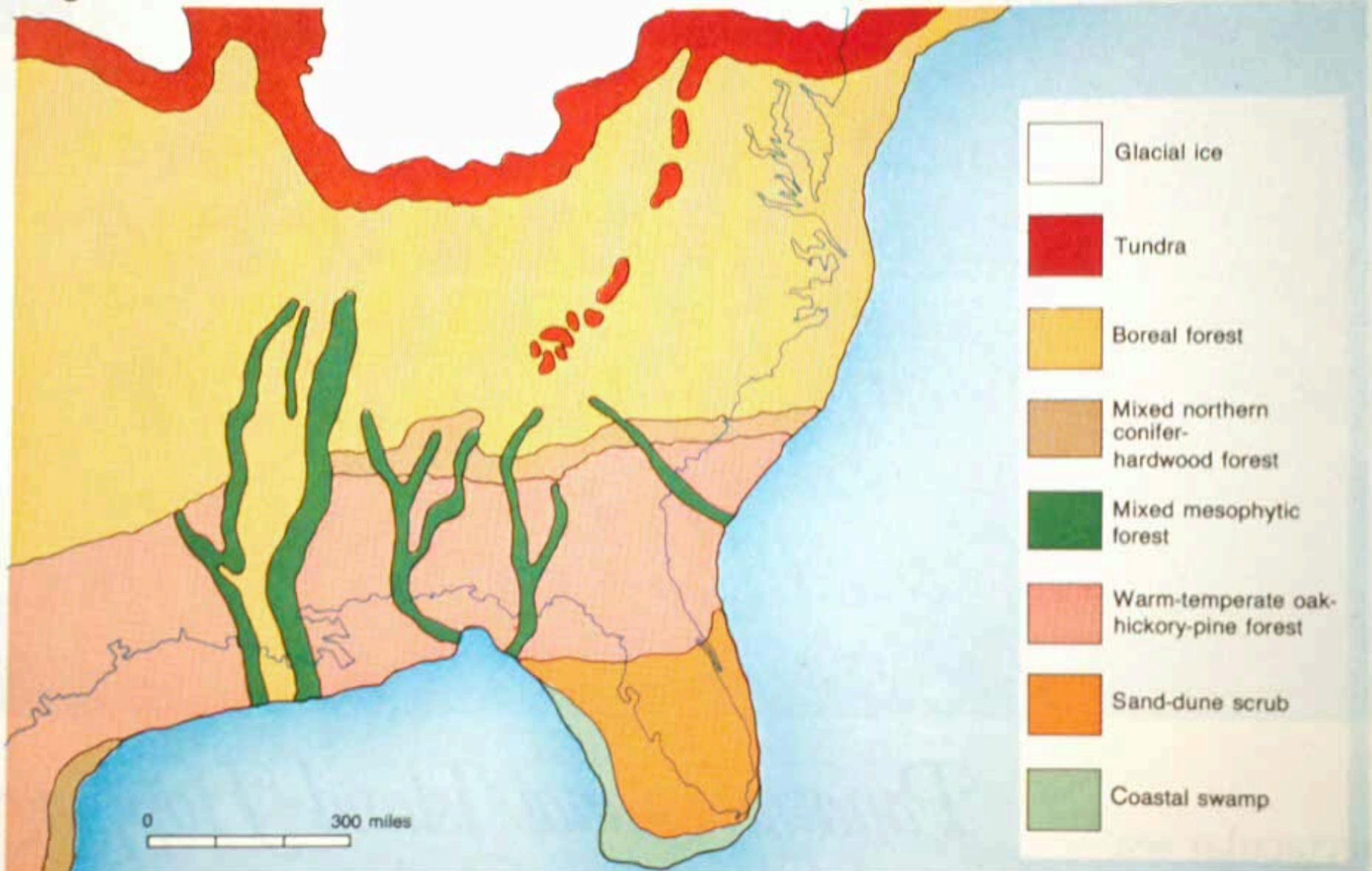


**Broadleaved trees with ring-porous xylem:** wide channels with high conductive capacity but low resistance to cavitation (e.g. oak, elm, ash) - spring wood with very large diameter vessels and summer wood with smaller diameter vessels - easier to count rings



# Biogeography important and useful for studying climate change

Vegetation Patterns in Eastern North America, 18,000 Years Ago



Thousands of years before present

18

14

12

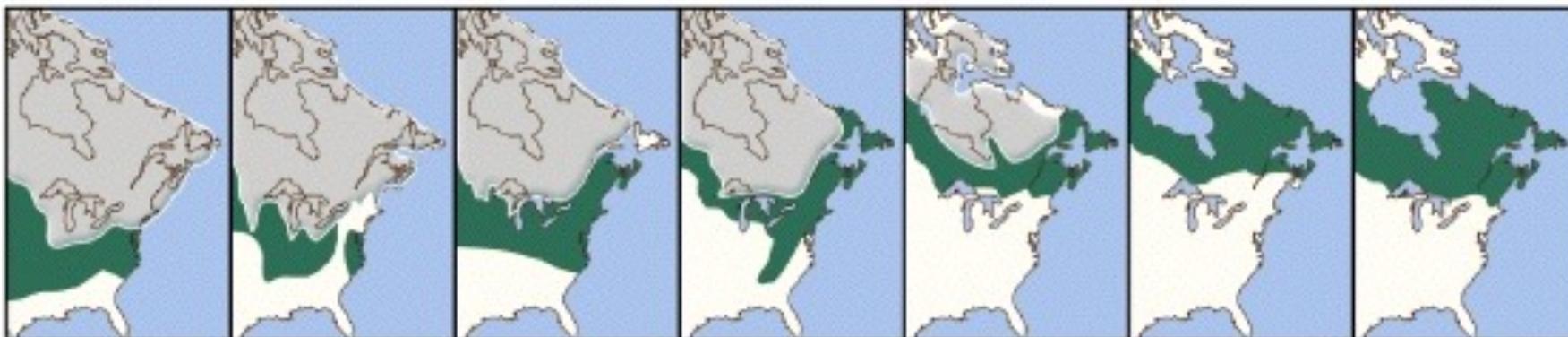
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8

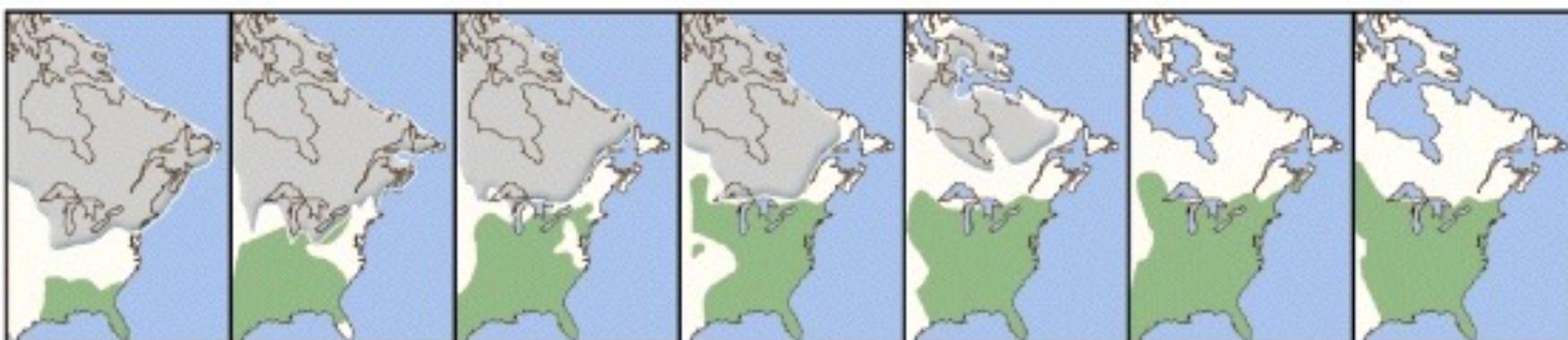
6

0.5

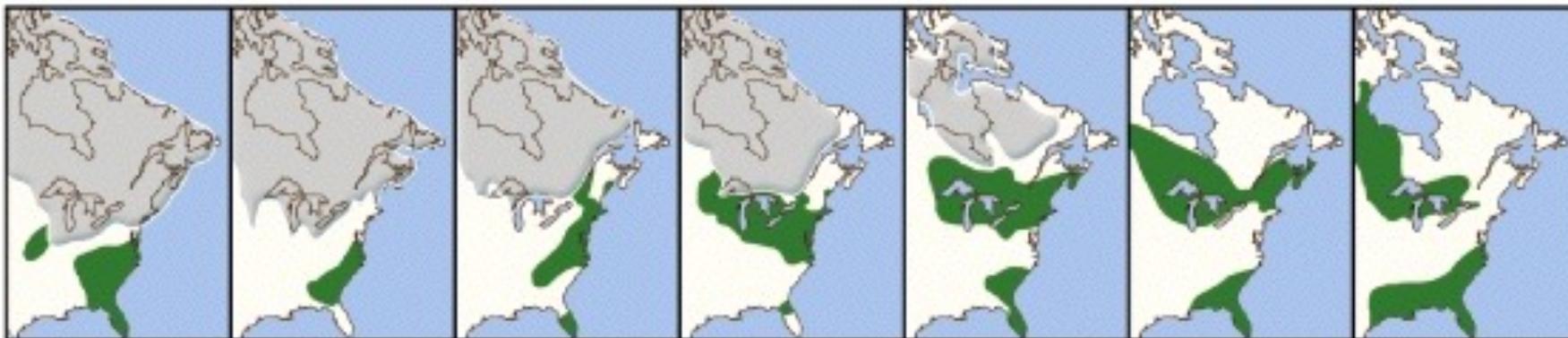
Spruce



Oak



Pine

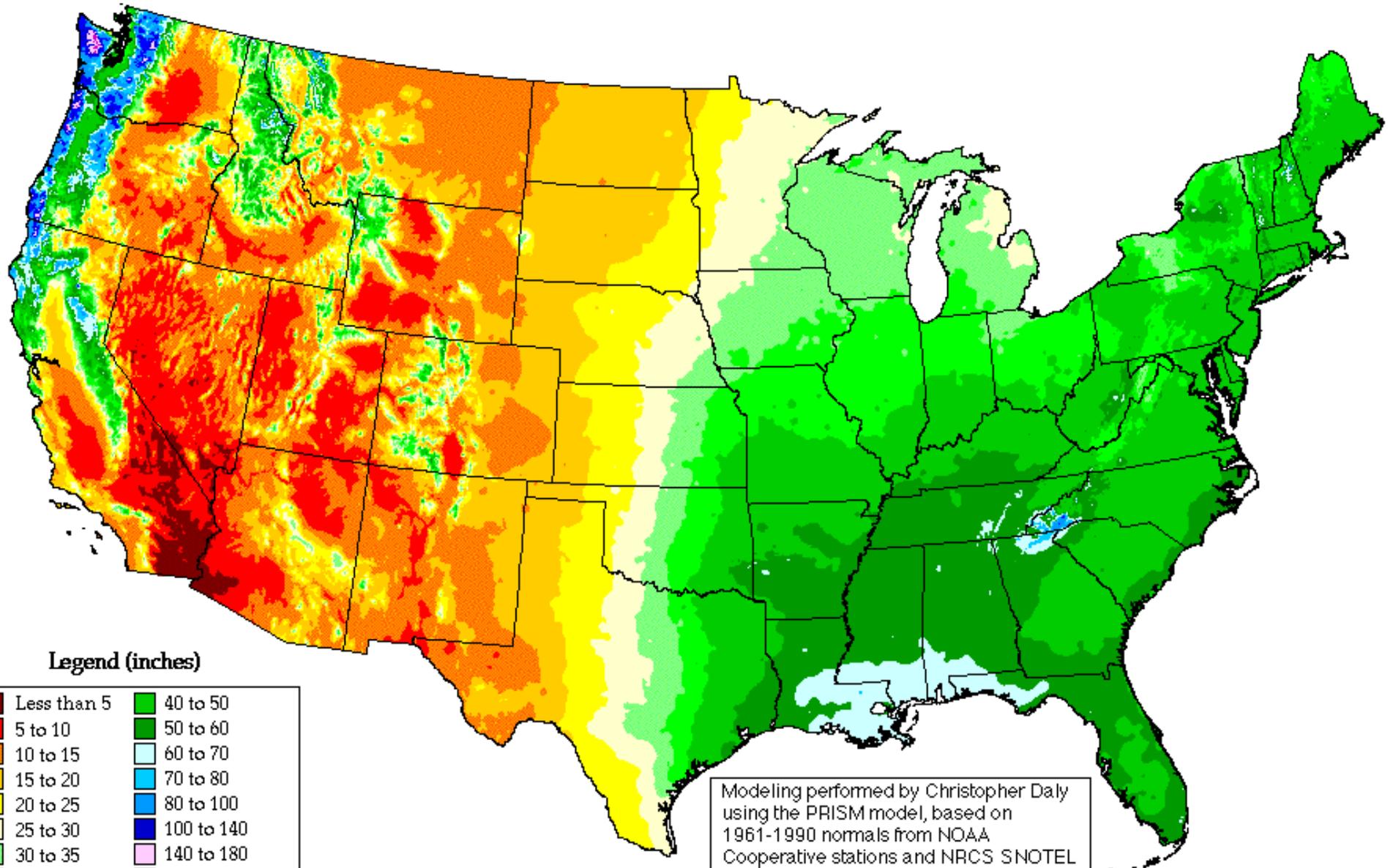


# Some Key Points

- 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

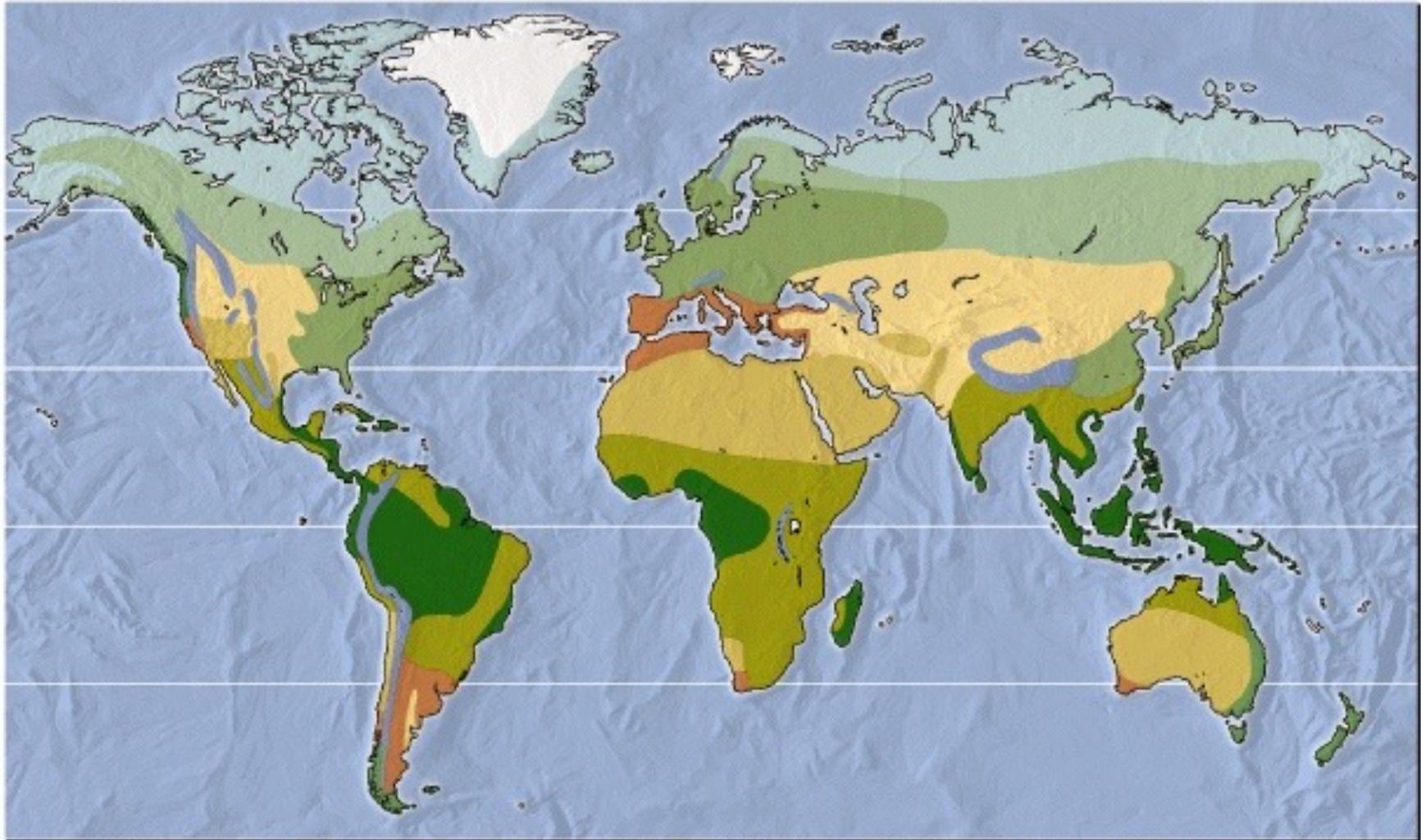
Period: 1961-1990

Copyright 2000 by Spatial Climate Analysis  
Service, Oregon State University

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



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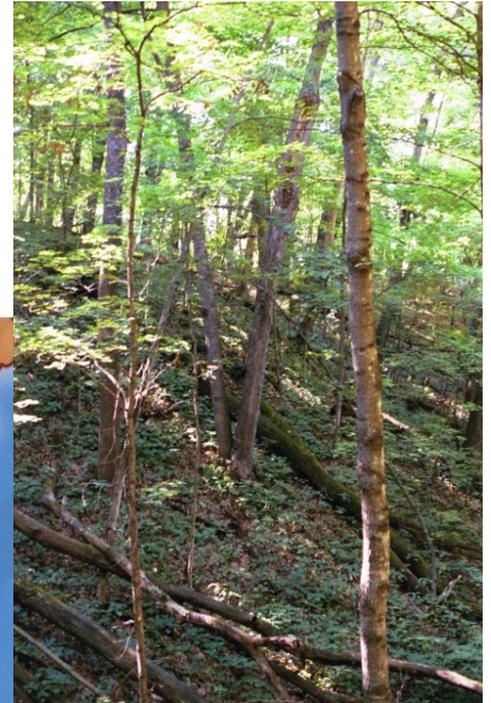
# Example:

## 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)



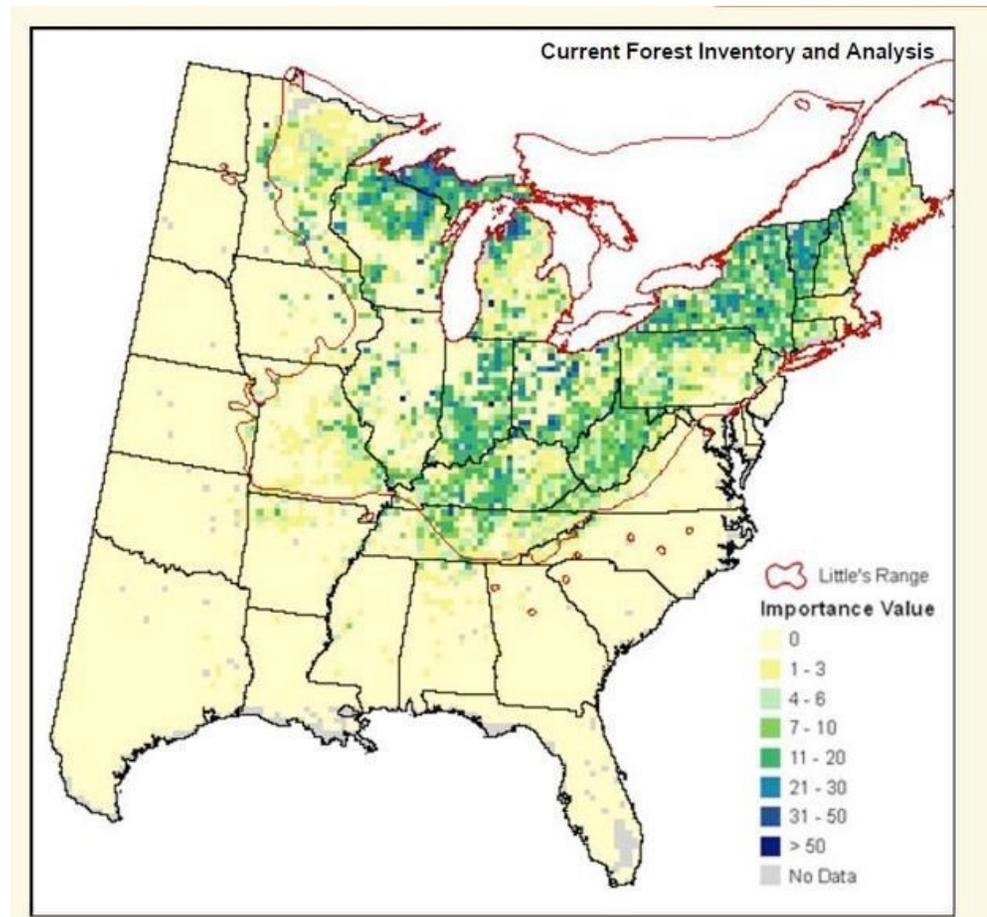
Sugar maple



# Northern Sugar Maple (*Acer saccharum*)

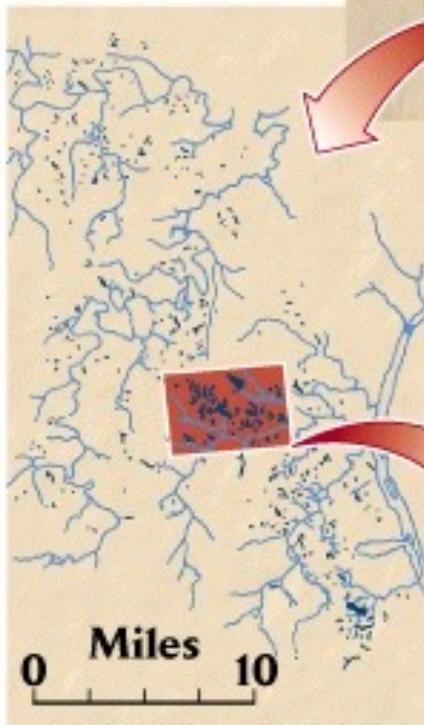
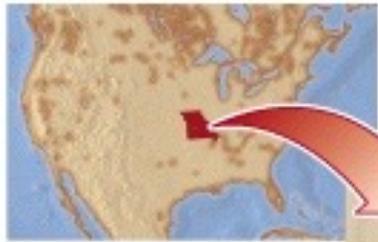
Within its general temperature/moisture range, other conditions limit where it's found:

- 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...

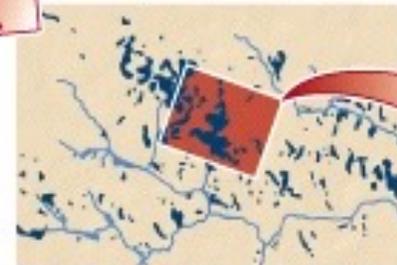
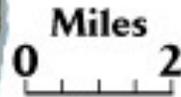
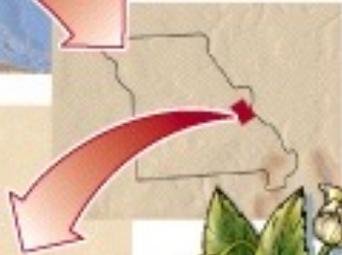


Occupancy within the geographic range is patchy, so within a geographic range, species only occupy suitable habitats

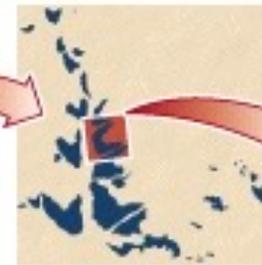
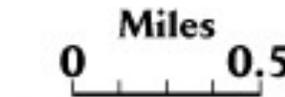
### Missouri



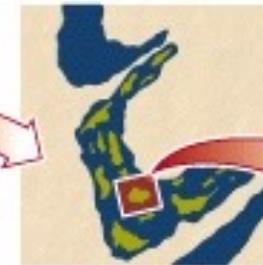
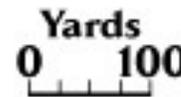
Geographic range



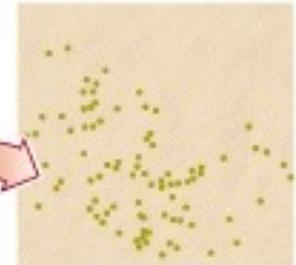
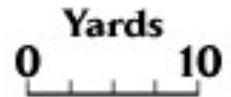
Region



Cluster of limestone glades



Glade showing aggregates of individuals

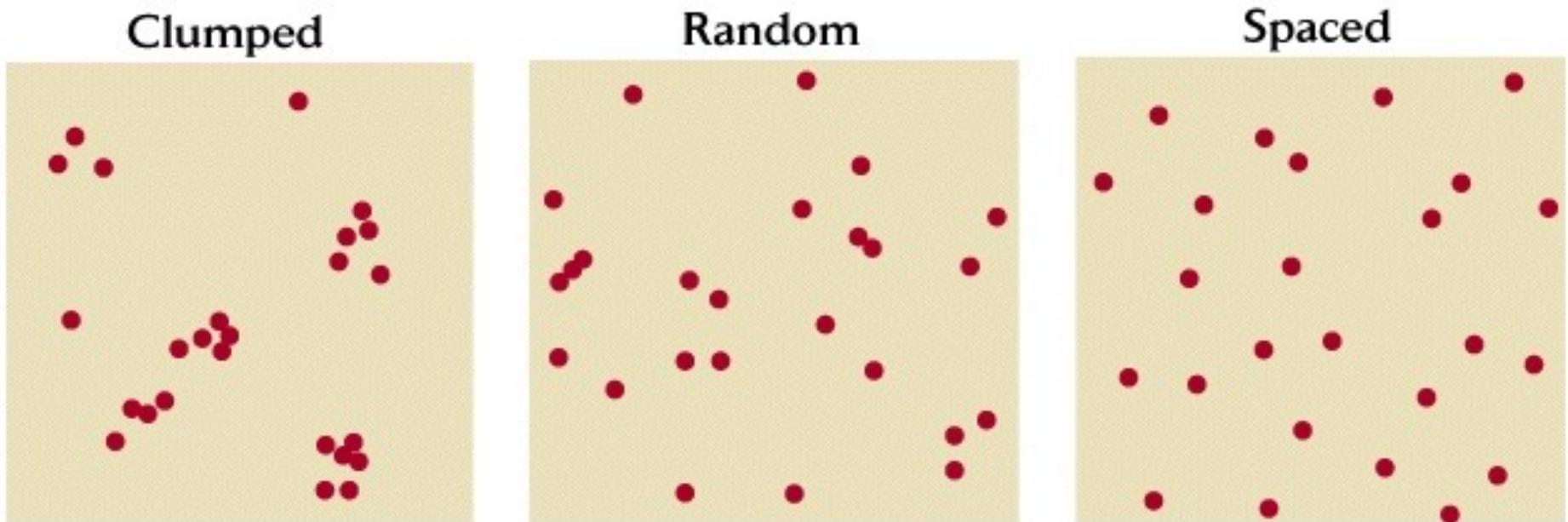


Aggregate of individuals

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 Phippen – Slash and burn agriculture practice, Northern Peru



©2009 Jeffrey Phippen

# 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

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Kudzu (*Pueraria montana*)  
prefers edges



# Habitat fragmentation and brood parasites

## Kentucky Warbler Nest Parasitism

-KY Warblers require forest interior for breeding habitat



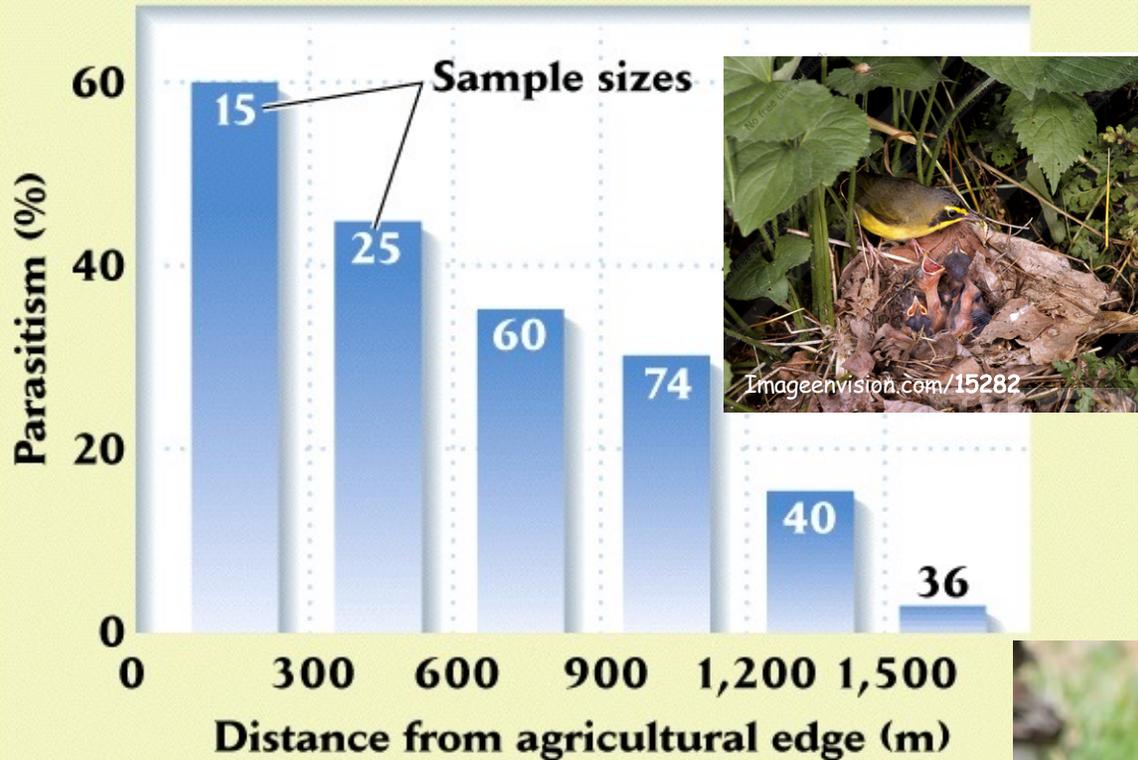
<http://palmbeachcountynaturally.wordpress.com/>



© Jeffrey S. Phippen

# Habitat fragmentation and brood parasites

## Kentucky Warbler Nest Parasitism



- 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...

Brown-headed Cowbird



# 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



PLANTS  
Database

DIMU4

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



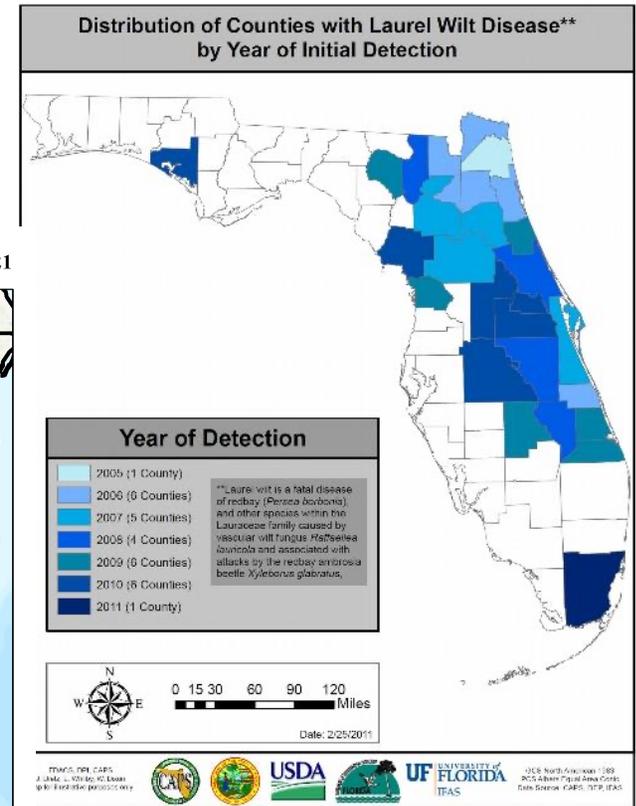
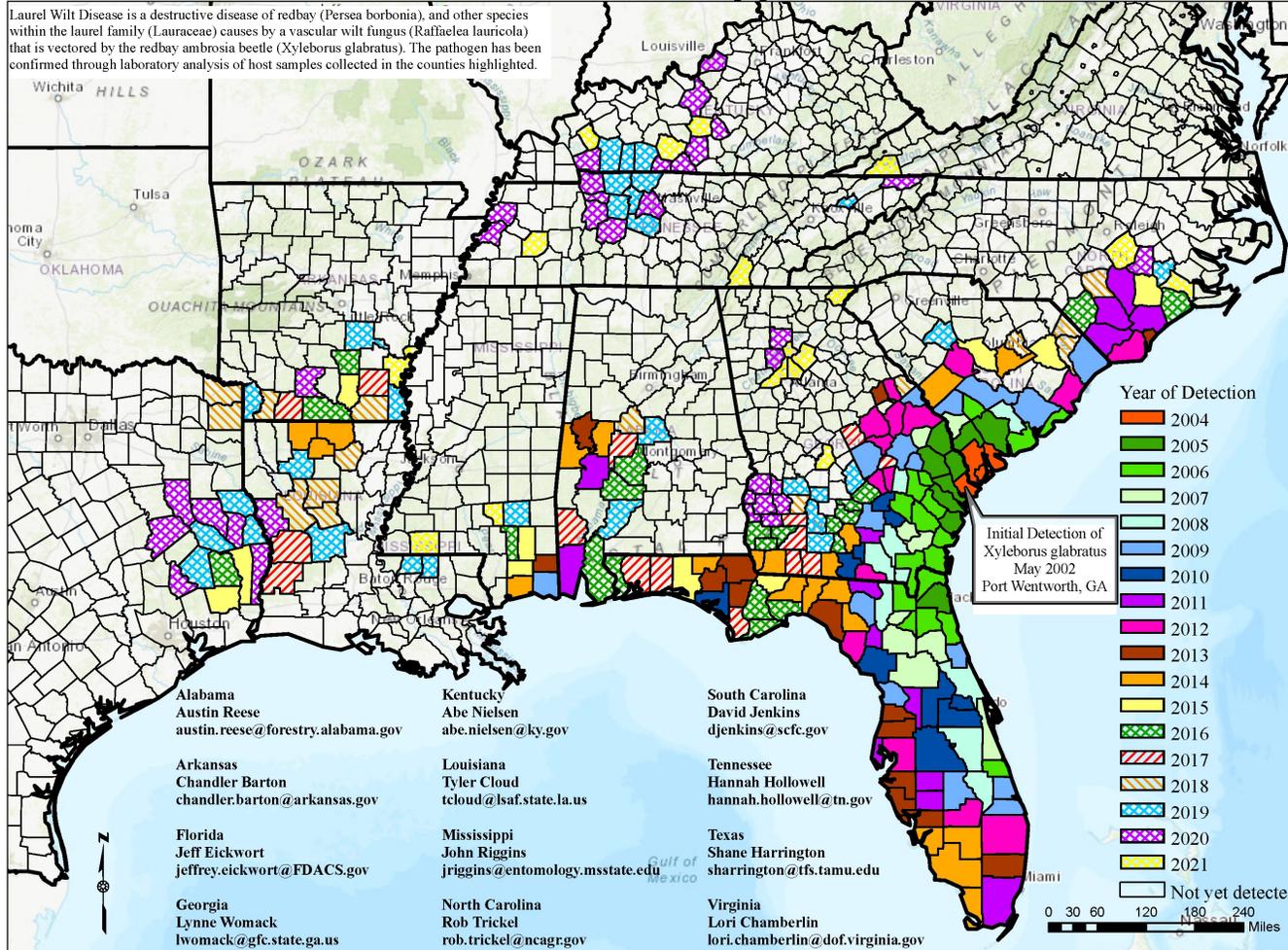
Laurel Wilt from  
Redbay Ambrosia  
Beetle carrying  
Laurel Wilt Fungus



# Laurel Wilt from Redbay Ambrosia Beetle and Laurel Wilt Fungus

## Distribution of Counties with Laurel Wilt Disease\* by year of Initial Detection

November 4, 2021



• 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



Black Willow (*Salix nigra*) fruits

©2009 Jeffrey Phippen

# 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

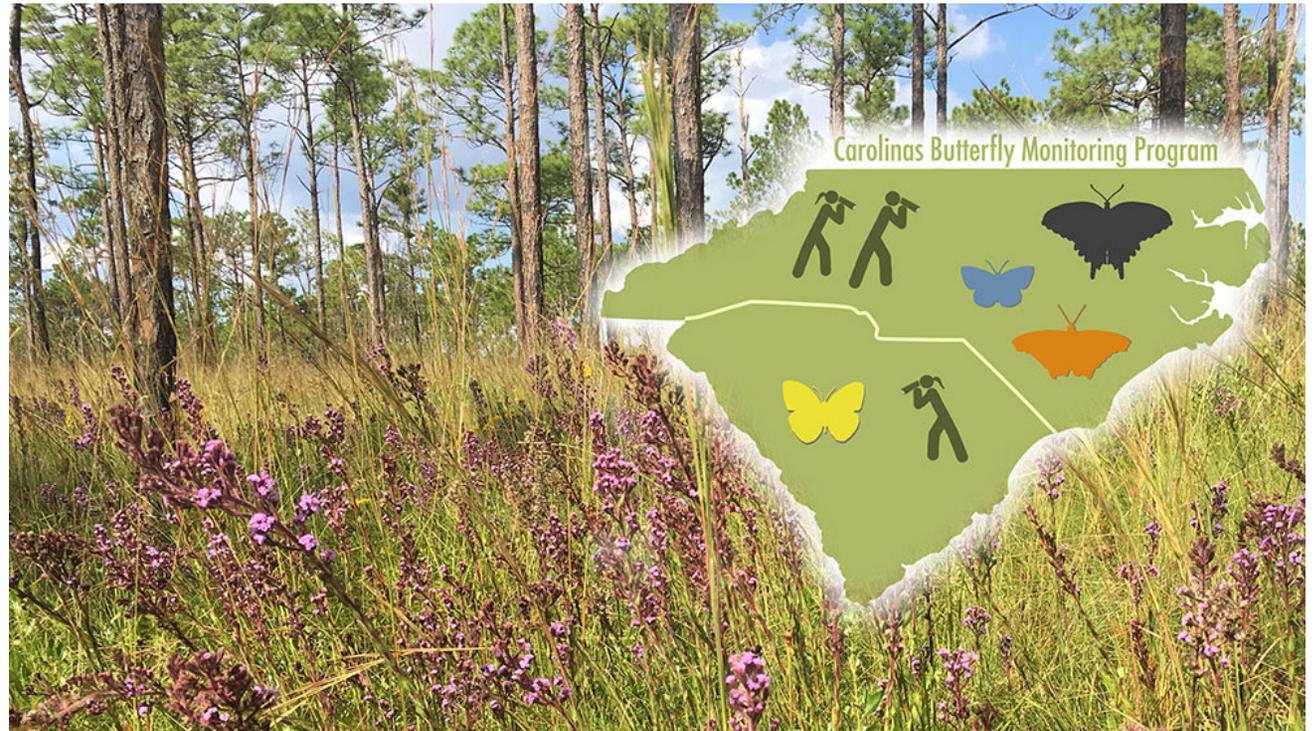
- NC Biodiversity Project
- Plant Conservation Program
  - a section of the NC Dept. of Agriculture
- Friends of Plant Conservation, works with NC PCP
- Natural Heritage Program, a section of NC DENR
- NC Botanical Garden
- NC Native Plant Society
- NC Audubon



**NORTH CAROLINA**  
**NATIVE PLANT**  
**SOCIETY**



# *Carolinas Butterfly Monitoring Program*

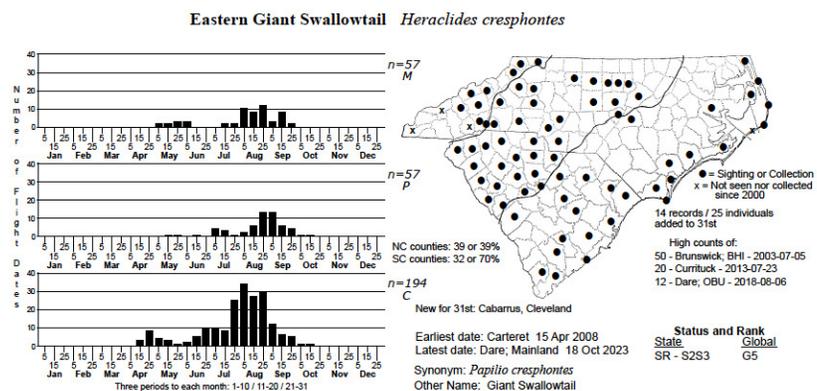


- State-wide community science initiative launched in 2023
- Provides data on butterfly populations, nectar plants, habitat quality
- Volunteers document butterflies across various habitat types
- Contributes to both state and national databases



# 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)



## Butterflies of North Carolina: their Distribution and Abundance

Home

33rd Approximation

NC/SC Checklists

Flight Charts

Status/Rank Definitions

Maps

Search

Recent Additions

New County Records

Early/Late Dates

Butterfly Foodplants

References

Websites

Other Site Links

Butterfly Book

NC Biodiversity Project

Photographers

Message to Authors

**Welcome to the on-line "butterfly atlas" for North Carolina!**



This website is more than just an atlas; it is a compilation of information about all of the 177 butterfly species that have been recorded in North Carolina, as of the end of 2025. This compilation has been updated for the past 32 years. Each species account, reached by clicking on a letter below or entering a name in either of the two boxes, provides a county map of its recorded occurrence, in addition to flight charts for each of the three physiographic provinces in the state. Each account also provides information on the distribution, abundance, habitat, flight dates, and other life history information; for nearly all species, one or more photographs taken in North Carolina are included. By clicking on "View PDF" on a species account page, one can see other information (not on the species account page), such as high counts, earliest and latest dates of occurrence, number of records for the previous year, and total number of counties reported. (The PDF also contains a county map for the species' occurrence in South Carolina.) The data on this website are based on the nearly 260,000+ records of all butterfly species entered into a database over these 33 years. Most of the data come from the general public, through e-mails posted to the carolinaleps listserve; some also come from the iNaturalist and other website databases. Starting in 2024, the colored county maps are automatically updated upon data entry by the authors, typically every two to four weeks. Starting in 2025, the flight charts on the account pages are also automatically updated at the same time.

Also check out the tabs on the left side of the homepage. The "33rd Approximation" tab contains a copy of the entire document (about 200 PDF pages), with the county dot maps and flight charts. That Approximation also contains a long list of people who have contributed many records to the database (through 2025), in addition to several appendices, such as species that might occur in NC and various statistics. The "Search" tab is very useful for conducting queries, such as seeing all of the records of a single species over the entire state or for a particular county. The "NC/SC Checklists" tab contains field checklists for North Carolina and for South Carolina.

Enjoy browsing the website!

Common Name:  Scientific Name:

Common Name begins with:  
[\[A\]](#) [\[B\]](#) [\[C\]](#) [\[D\]](#) [\[E\]](#) [\[F\]](#) [\[G\]](#) [\[H\]](#) [\[I\]](#) [\[J\]](#) [\[K\]](#) [\[L\]](#) [\[M\]](#) [\[N\]](#) [\[O\]](#) [\[P\]](#) [\[Q\]](#) [\[R\]](#) [\[S\]](#) [\[T\]](#) [\[U\]](#) [\[V\]](#) [\[W\]](#) [\[Y\]](#) [\[Z\]](#)

Scientific Name begins with:  
[\[A\]](#) [\[B\]](#) [\[C\]](#) [\[D\]](#) [\[E\]](#) [\[F\]](#) [\[G\]](#) [\[H\]](#) [\[J\]](#) [\[L\]](#) [\[M\]](#) [\[N\]](#) [\[O\]](#) [\[P\]](#) [\[S\]](#) [\[T\]](#) [\[U\]](#) [\[V\]](#) [\[Z\]](#)

**Number of records: 262,066**

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> 260,000 Records!!

# Field Trip!

