Plant Ecology

Factors affecting diversity

Today's agenda

Factors affecting plant diversity

- Evolution and Plant Adaptations
- Field trip to Longleaf Community
- Competition/Predation/Herbivory
- Coevolution
- Field trip to natural areas

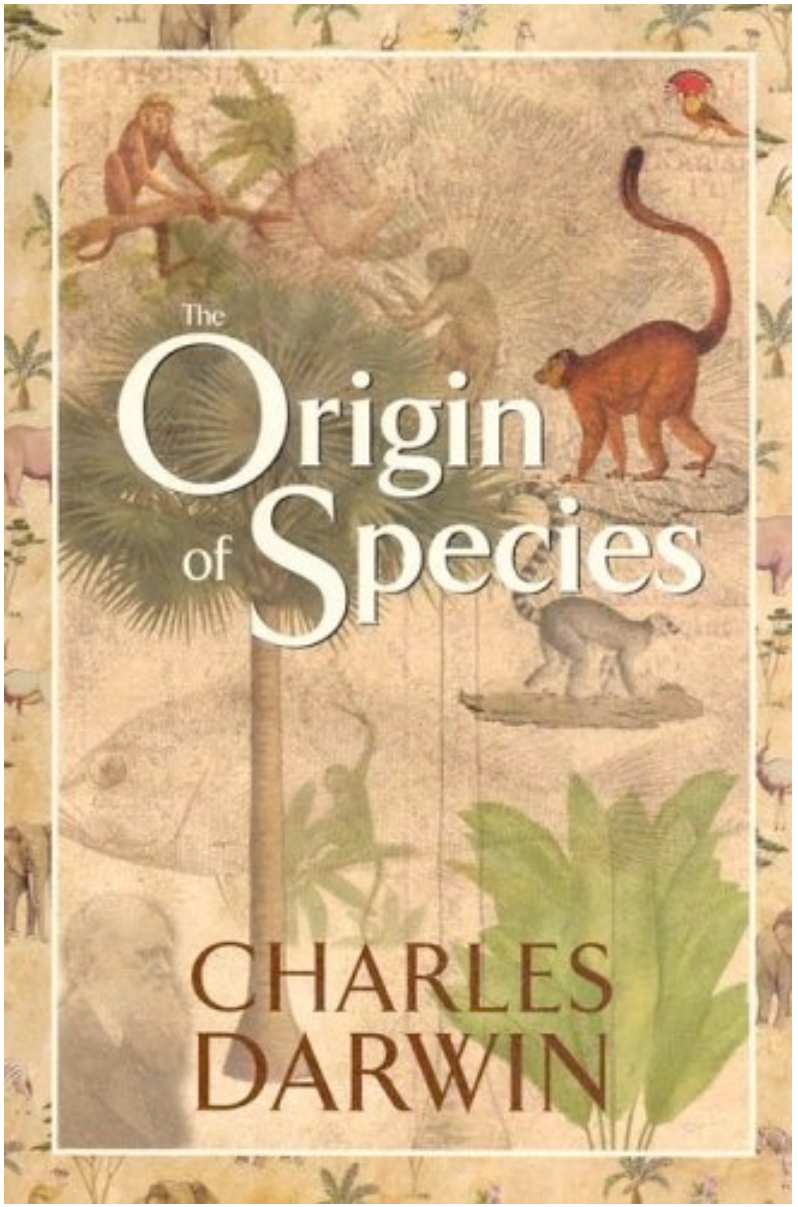
Evolution through Natural Selection

Charles Darwin. 1859.

Observ. 1: In natural populations organisms produce many more offspring than just enough to replace themselves
-- oak tree producing hundreds of acorns
-- frog laying hundreds of eggs

Observ. 2: Yet most natural populations remain relatively stable in numbers over time

Concl. 1: Resources are limited; individuals must compete for resources, and many individuals of a population die before they are able to reproduce



Evolution through Natural Selection

Observ. 3: Individual members of a population vary slightly from each other. Some of this variation is reflected in the ability of the individual to obtain resources like food, nesting space, shelter, mates, predator avoidance. In other words, some are better adapted or more fit than others

Concl. 2: The most fit (or well adapted) individuals will therefore obtain the best resources, survive the longest, reproduce the most, and leave the most offspring; "survival of the fittest"

This is called NATURAL SELECTION: the process by which the environment selects for those individuals whose traits best adapt them to that particular environment

Evolution through Natural Selection

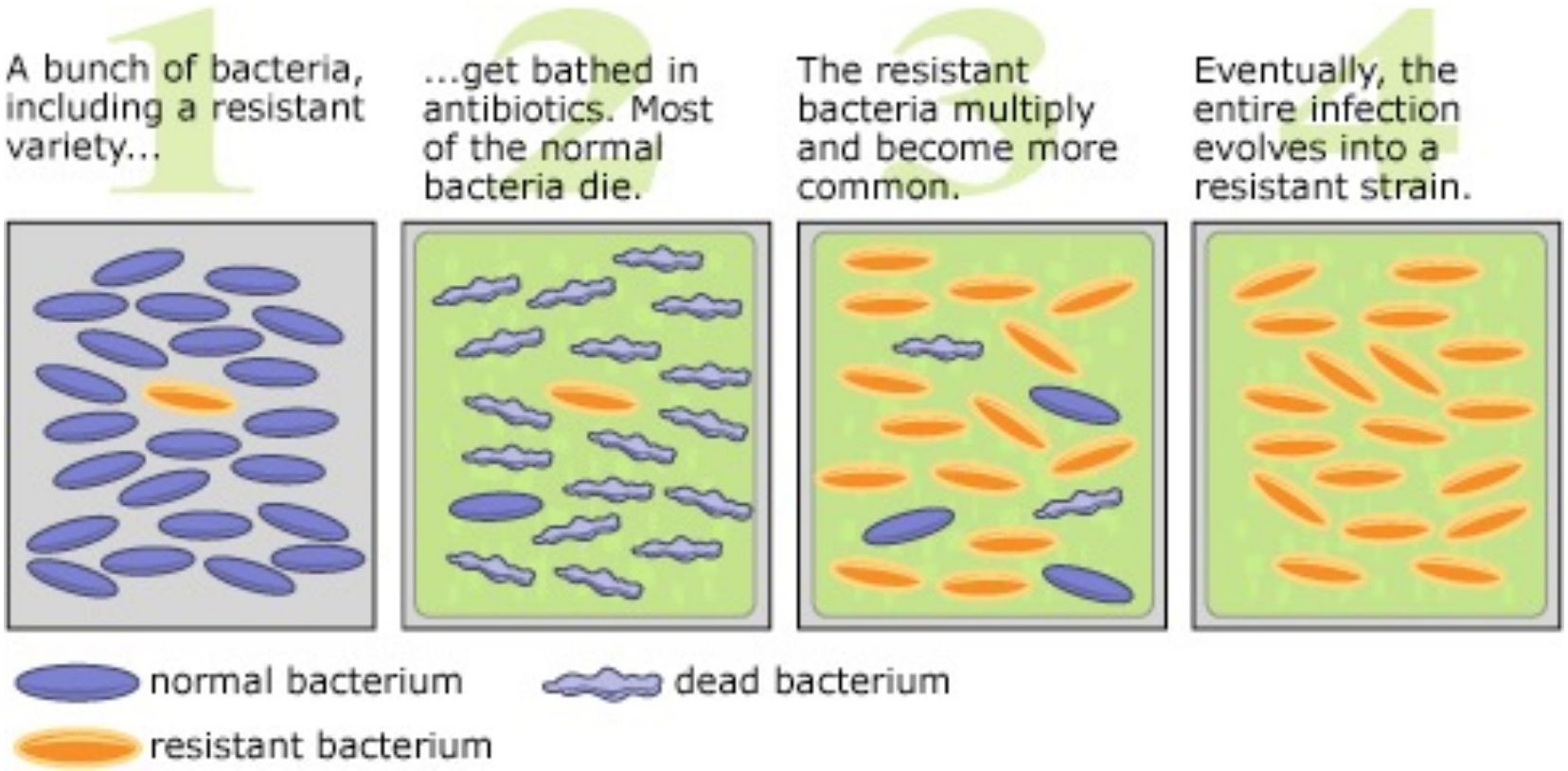
Observ. 4: At least some of the variation in adaptive traits among individuals is due to genetic differences that offspring inherit from their parents (heritable traits)

Concl. 3: Over many generations differential reproduction (i.e., some individuals will reproduce more than others) leads to a change in the overall genetic makeup of the population. The genetic composition of the most fit organisms will become prevalent in the entire population

Thus, over time the *population* will change and this is EVOLUTION through natural selection!

Note that this takes time! -- Usually many many generations.

Example: Antibiotic Resistance



Important to finish your antibiotic prescription even when you start to feel better!

University of California Museum of Paleontology's Understanding Evolution (http://evolution.berkeley.edu)

It was on a short-cut through the hospital kitchens that Albert was first approached by a member of the Antibiotic Resistance.

Species Adaptation

Definition: evolutionary process resulting in an organism being better able to live in its environment

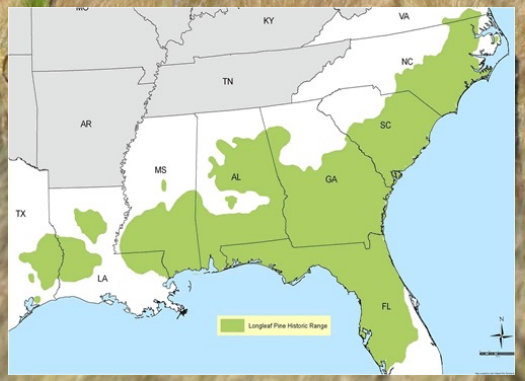
Adaptive Trait: heritable condition with a functional role that improves an organism's survival and fitness in its environment

Let's look at a couple examples of environmental factors influencing natural selection:

- Fire: Longleaf Pine
- Low nutrient soils: Plant carnivory

Longleaf Pine (*Pinus palustris*) Communities

- Coastal Plain from se Virginia to e Texas (formerly over 70 million acres, now <4 million; >90% loss)
- Fire common due to lightning strikes
- Community structure: trees widely spaced, diverse herbaceous layer, dominated by wiregrass



Longleaf Pine Adaptive Traits

- Large, dense needles protect seedling/sapling during light fires

Longleaf Pine Adaptive Traits

- Thick bark
  - Protects living tissue from fire
- Cones with large seeds fall after fires and seeds can germinate quickly
- Large seeds
  - Provide extra nutrients for rapid seed establhment

Longleaf Pine Adaptive Traits

- Large, deep taproot
  - Secures the tree in sandy and/or wet soils from hurricanes and fires

Longleaf Pine Community

- Very diverse, many threatened/rare species

- Red-cockaded Woodpeckers, Fox Squirrels, Pine Barrens Treefrog, many orchid species, pitcher plants…

Plant Adaptations: Carnivorous Plants

- Adapted to low nutrient soils (mountain bogs and rock outcrops, coastal plain sandy soils)
- NC is carnivorous plant biodiversity hotspot!! Butterworts, Venus Flytrap, Sundews, Pitcher Plants, Bladderworts

Plant Adaptations: Carnivorous Plants

- Arthropods get trapped and digested
- Pitchers have downward pointing hairs
- Digestive enzymes

Plant Adaptations: Carnivorous Plants

- Bladderworts trap aquatic insects
- Believed that carnivory in plants evolved 12 separate times!
- Several hundred species worldwide

Convergent Evolution

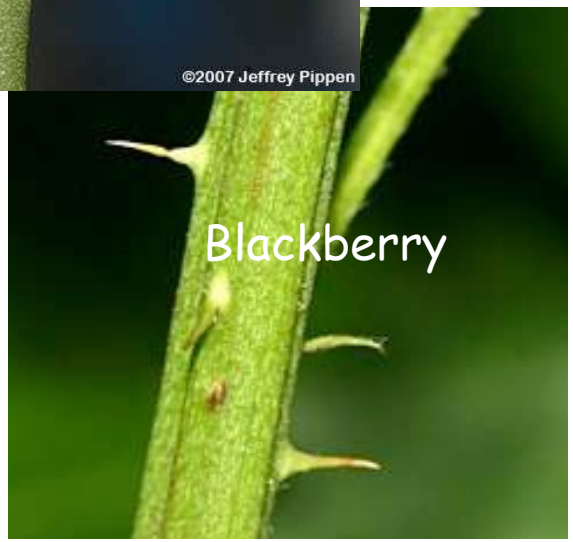
Independent evolution of similar features in unrelated organisms (lineages)

Driven by living in similar environmental conditions

Thousands of examples!

- Prickles/spines/thorns deter herbivory
- Succulents conserve water

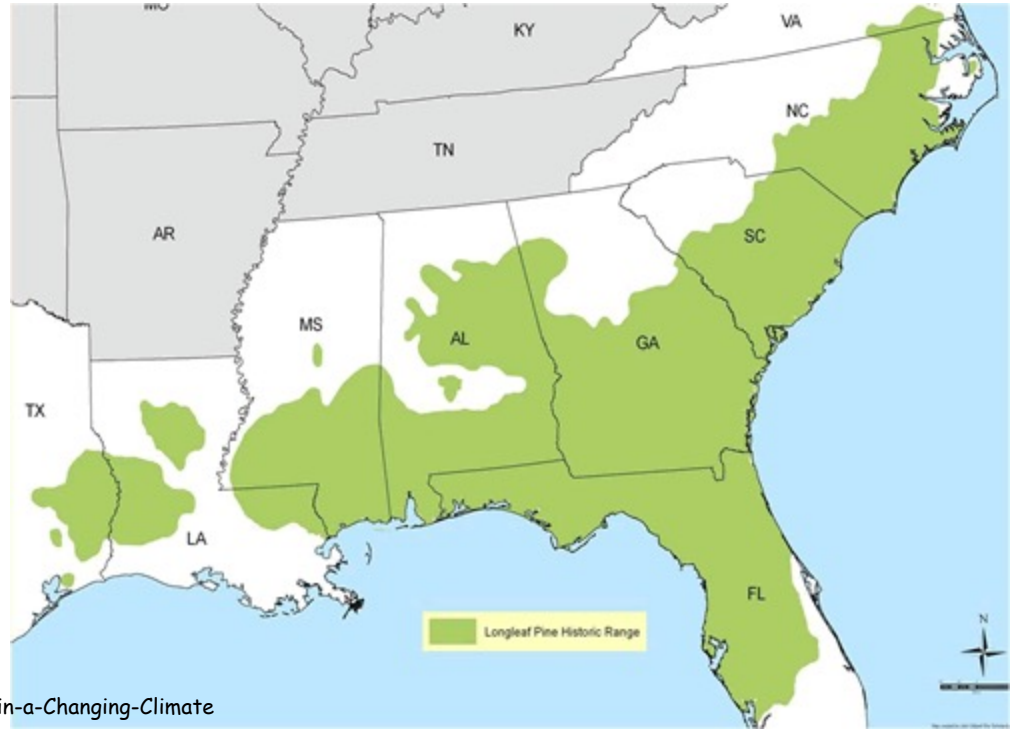
Cactus



Assignment

Choose a NC native plant species!

- Tell us about ONE adaptive trait that plant has.
- What is the habitat where it grows, and what is the environment driver that caused that trait?
- Informal (<2 min) oral report next week during class.



http://www.fws.gov/news/blog/index.cfm/2011/6/7/Georgia-Restoring-a-Wonder-Tree-in-a-Changing-Climate

Into the Garden

- Experience a Longleaf Pine community
- Then we will walk to a coastal swamp
- Consider the habitats and the plant adaptations to these different environments
- Return to class

Plant Ecology: Factors affecting diversity

Many complex interactions are important drivers of evolution and help determine which species thrive under different conditions

- Competition

(both intraspecific and interspecific)

- Predation/Herbivory
- Parasitism
- Mutualism
- Commensalism

Competition

Relates to acquisition of (often limited) resources

- Food (light), space, nutrients, water, etc.

Niche

- Relational position of a species or population in an ecosystem
- Incorporates interactions with other species (competition, etc.)
- Incorporates how it uses both biotic and abiotic resources

Competition

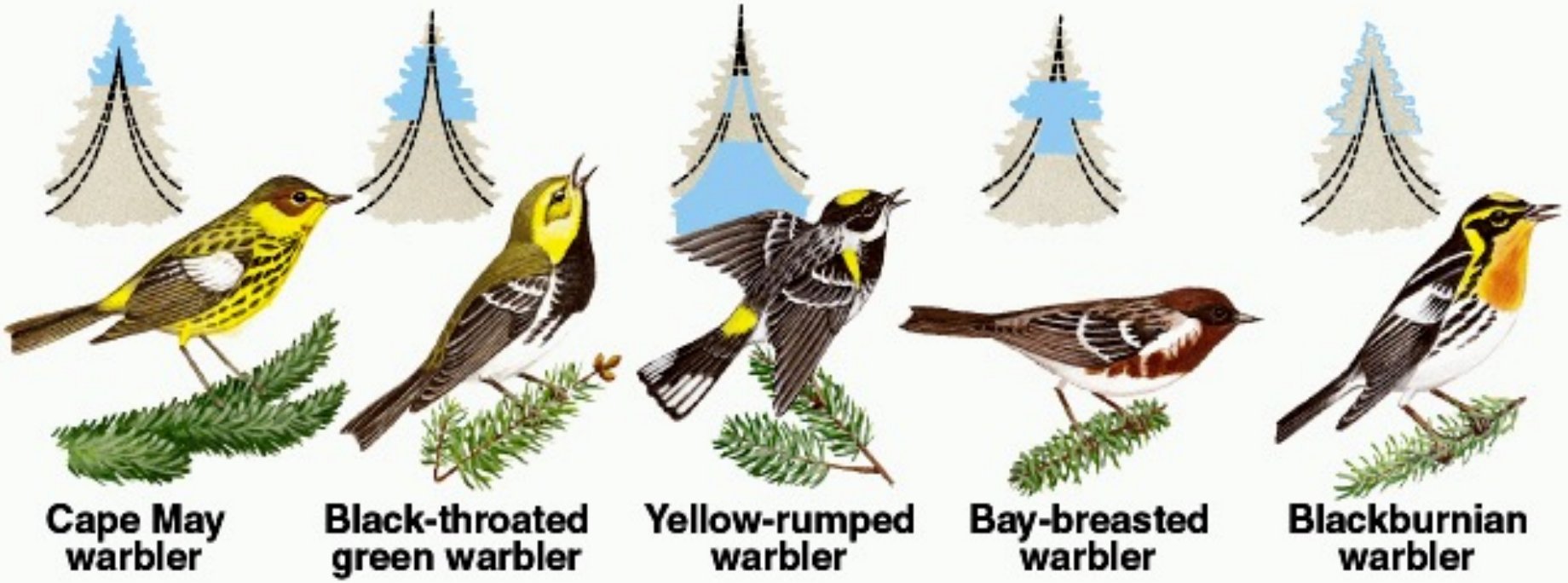
Gause's Law (G.F. Gause, 1934)

- In a constant environment, no two species that compete for exactly the same resources can coexist indefinitely
- "Competitive Exclusion"
- But environment rarely stays exactly the same!

Niche Partitioning

- Process of natural selection that drives individuals to use resources differentially
- Nature's solution to competitive exclusion!
- Requires sufficient space and genetic variation
- Example: boreal breeding warblers…

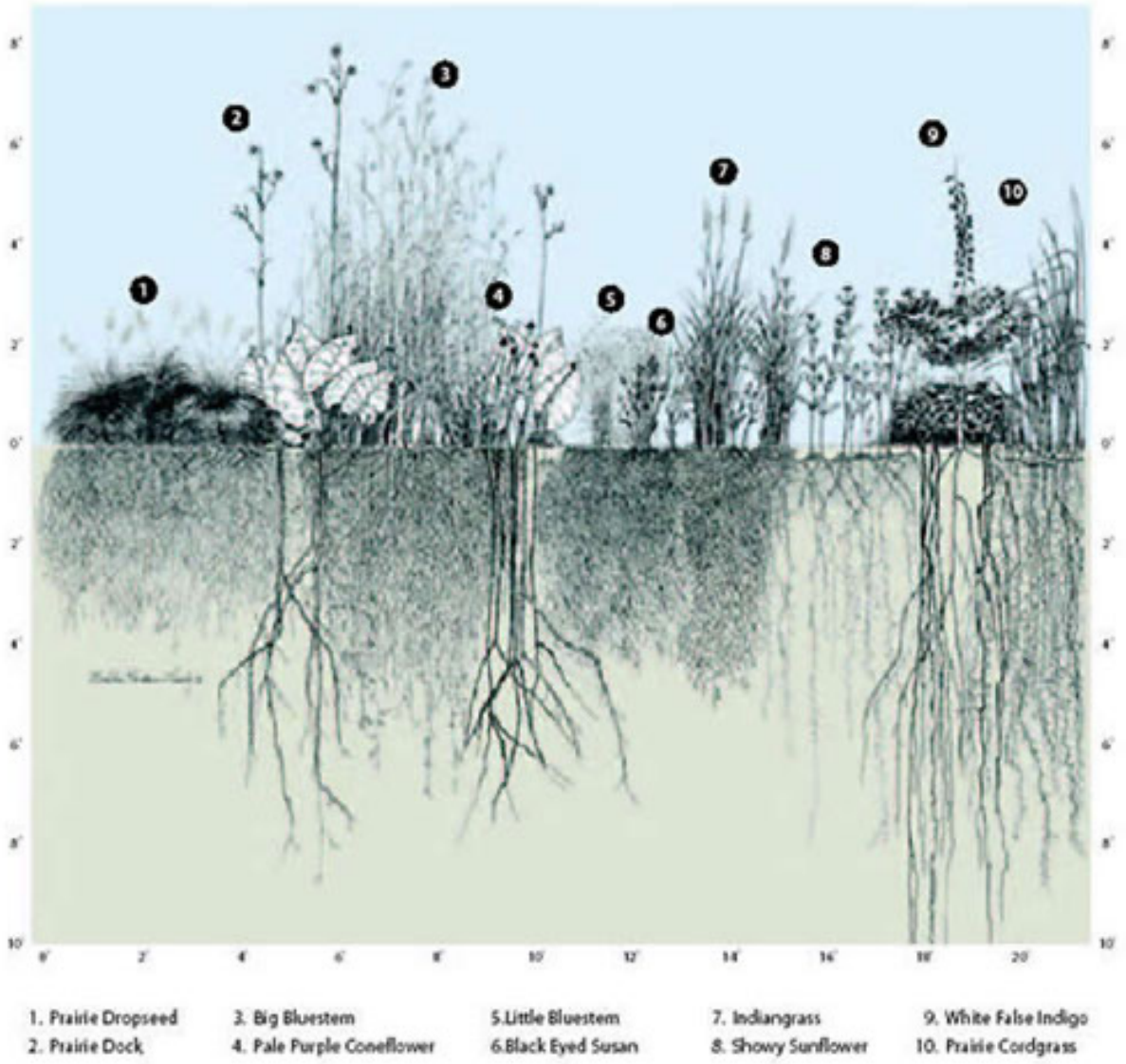
Niche partitioning among five species of coexisting warblers



- This is a behavioral change

Niche Partitioning in Plants

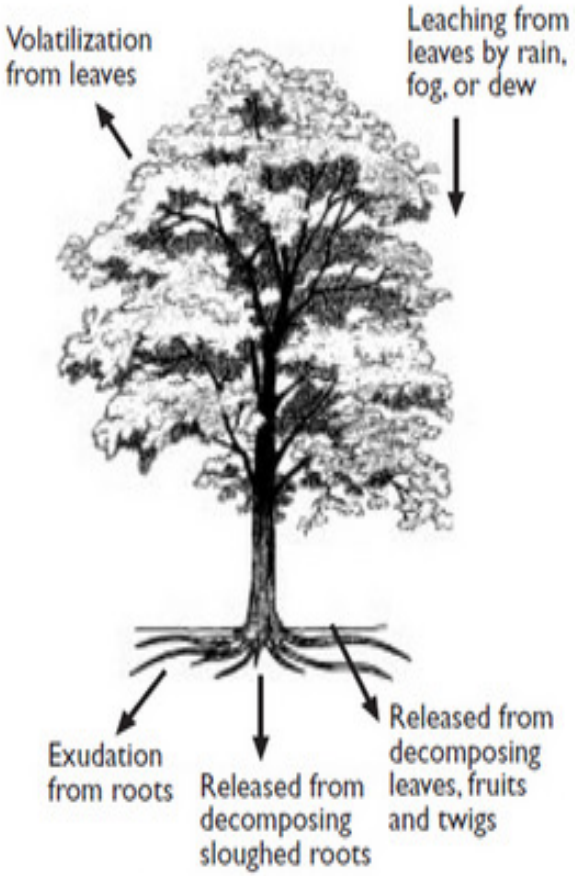
- Competing for below-ground resources
- Adaptation to vary root length and structure
- This is a morphological change



http://evol-eco.blogspot.com/2009/11/back-to-earth-taking-below-ground.html

Plant Competition: Allelopathy

Allelopathy: chemical inhibition of one species by another



Juglone production from walnut tree

- Chemicals may be present in any part of the plant
- May persist in the soil
- Affect targets in various ways
  - Inhibit shoot/root growth
  - Inhibit seed germination
  - Inhibit nutrient uptake
  - Attack a naturally occurring symbiont

http://csip.cornell.edu/Projects/CEIRP/AR/Allelopathy.htm; http://www.depauw.edu/about/campus/naturepark/research-project-list/allelopathic-effects-of-black-walnut/

Plant Competition: Allelopathy

Allelopathy: chemical inhibition of one species by another

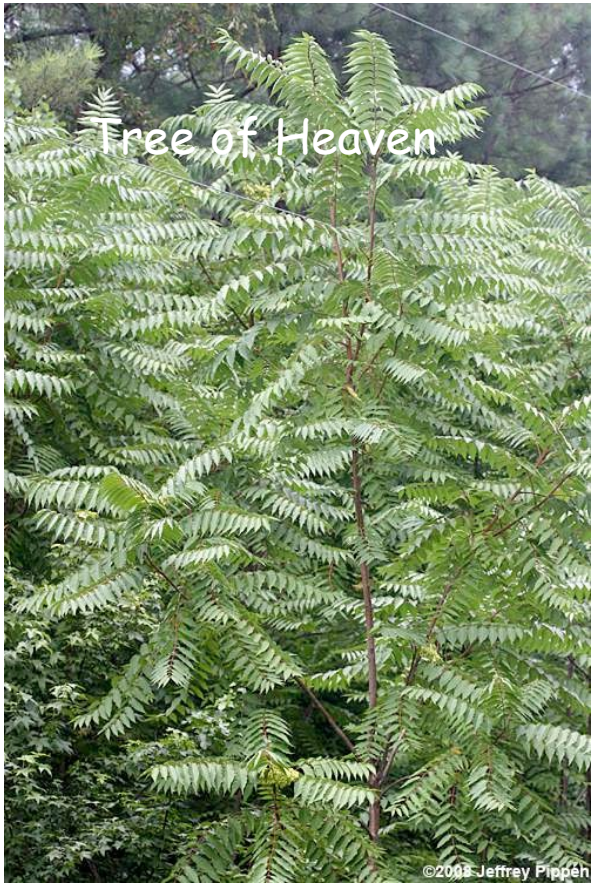
"Juglone"

- Produced by all parts of plant
- Concentrates in soil under drip line (not very water-soluble)
- Inhibits certain enzymes in metabolic functions
- Also helps prevent herbivory

http://phytoimages.siu.edu/imgs/paraman1/re/Juglandaceae_Juglans_nigra_4178.html

Allelopathy

- Does not affect all plants/organisms equally (some more resistant than others)
- Influences composition of vegetation growth and forest regeneration patterns
- Explains some success of exotic invasives



Predation/Herbivory

- Major drivers of evolution, plant population dynamics, forest composition, etc.

Plant Predation

Browsing/herbivory, seed predation, pollen predation…

- Obviously plants don't want their leaves, stems, and flowers eaten, but they do want pollen and seeds dispersed
- Arms race as plants evolve physical and chemical defenses and animals evolve ways around those defenses

Coevolution

Coevolution is likely to happen when different species have **close ecological interactions** with one another. These ecological relationships include:

- Predator/prey and parasite/host
- Competitive species
- Mutualistic species

Coevolution: Mutualism

Definition: Symbiotic relationship where both members benefit (e.g. trade resources or services)

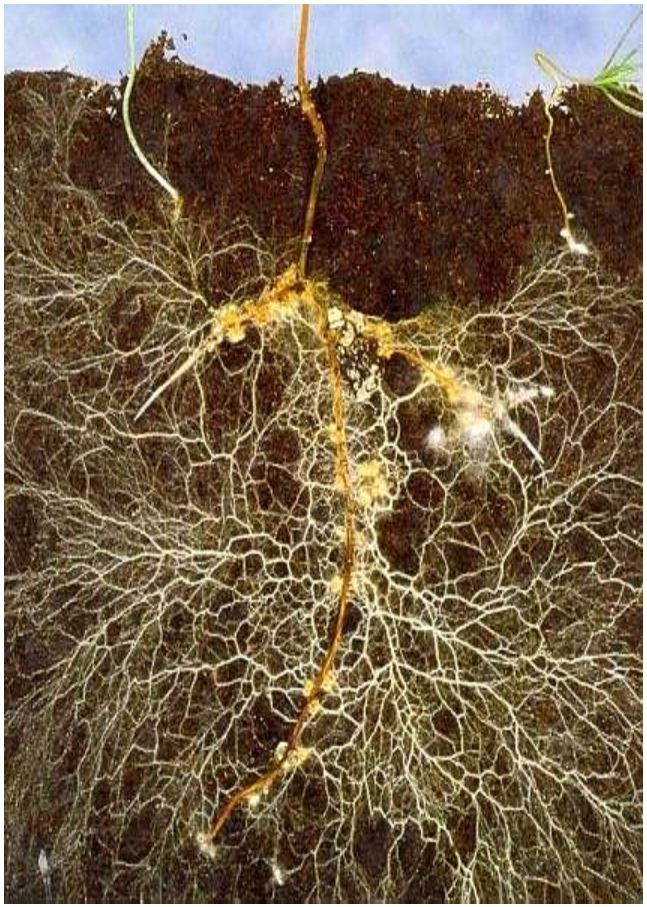
Critically important in driving ecological issues like diversity and biogeography.

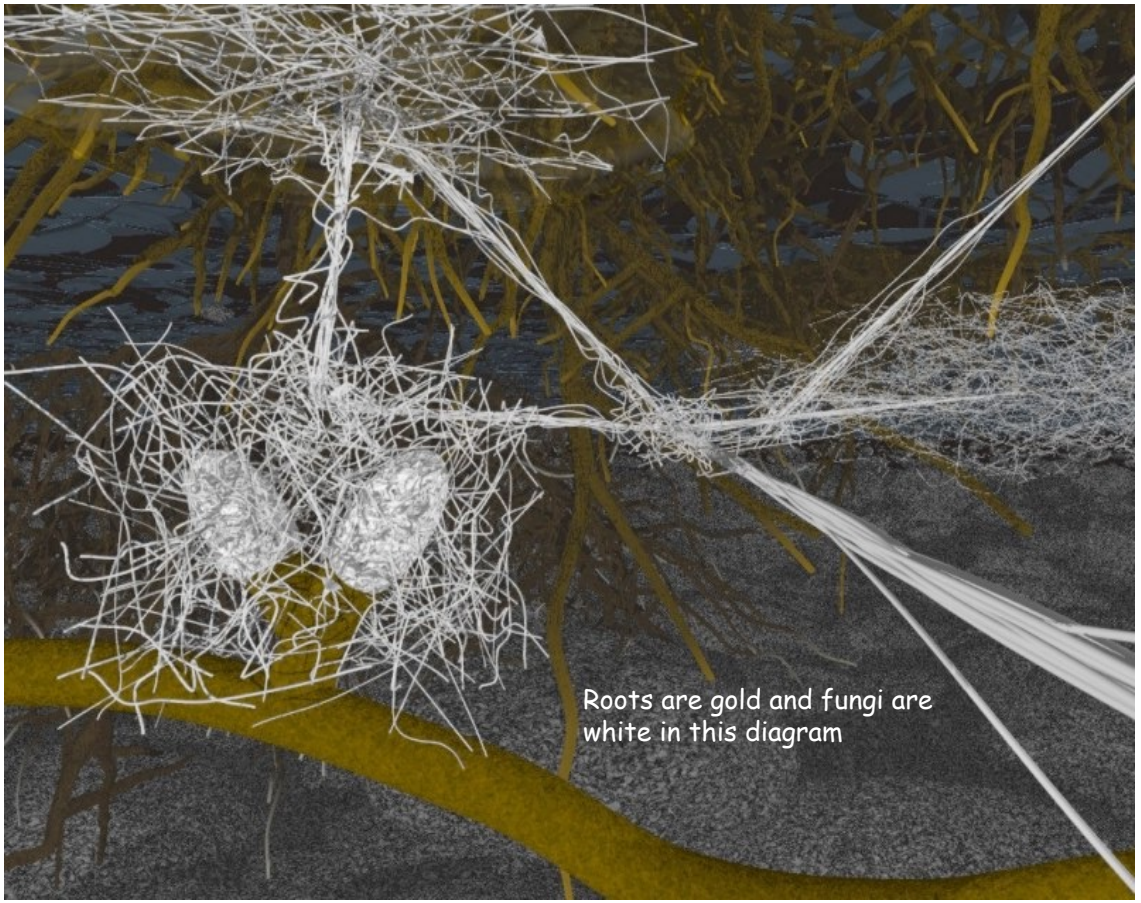
Thousands of examples!

- Beneficial bacteria in our intestine
- Nectar drinking insects that pollinate plants
- Lichens (fungus + alga)

Mutualism: Mycorrhizal Associations & Plant Roots

- More than half of all terrestrial plants depend upon mycorrhizal fungi to provide them with inorganic compounds and trace elements from the soil
- In turn, the fungi receive food (sugars) from the plant





http://sciweb.nybg.org/science2/hcol/mycorrhizae.asp.html

http://www.scivit.de/blog/?p=97

Commensalism

Definition: Symbiotic relationship where one member benefits and the other is neither positively nor negatively affected

- Epiphytes ("airplants"), esp. bromeliads, orchids
- Phoresy ("biological hitch-hiking"), beggar-tick, burdock

Coevolution: Parasitism

Definition: when one species of plant derives some or all of its nutrition from and at the expense of another plant

- ~ 4500 species across 20 flowering plant families currently known
- Root Parasites
- Stem Parasites
- "Haustoria" penetrate host & absorb nutrition

Pinesap *(Hypopitys monotropa)*

American Mistletoe *(Phoradendron leucarpum)*

Great Purple Hairstreak
(Atlides halesus)

Mistletoe
(Phoradendron leucarpum)

Field Trip!