Chapter 6: Ecosystems & Living Organisms

Outline

- Evolution Produces Species Diversity
- Species Interactions Shape Biological Communities
- Community Properties Affect Species and Populations
- Communities are Dynamic and Change Over Time

Adaptation

- Why do some species live in one place but not another?
  - Adaptation - the acquisition of traits that allow a species to survive in its environment
- Adaptation is explained by Charles Darwin's theory of evolution by natural selection.

Evolution

- A trait must be inherited (genetic) for it to evolve.
- Individuals with traits that make them suited to a particular environment survive and reproduce at a greater rate in that environment than individuals with less suitable traits.

Natural Selection

- The process of better-selected individuals passing their traits to the next generation is called natural selection.
- Where do the differences in the genes within individuals come from?
  - Mutations - changes in DNA coding sequence that occur by chance (e.g., random mistakes in DNA replication, exposure to radiation, toxins...)

Limitations on Where an Organism Can Live

Environmental factors that determine where an organism can live include:

- Physiological stress due to inappropriate levels of moisture, temperature, pH, light, nutrients.
- Competition with other species
- Predation, parasitism, disease
- Luck - individuals move to a new and suitable location by chance (e.g., organism moved to a different beach after a storm)

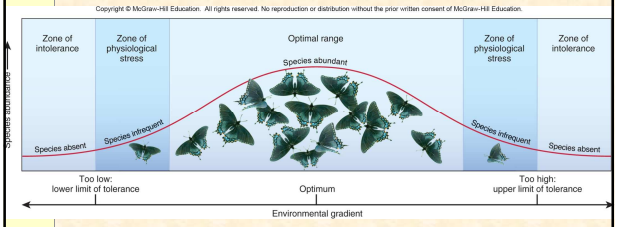
Critical Limits

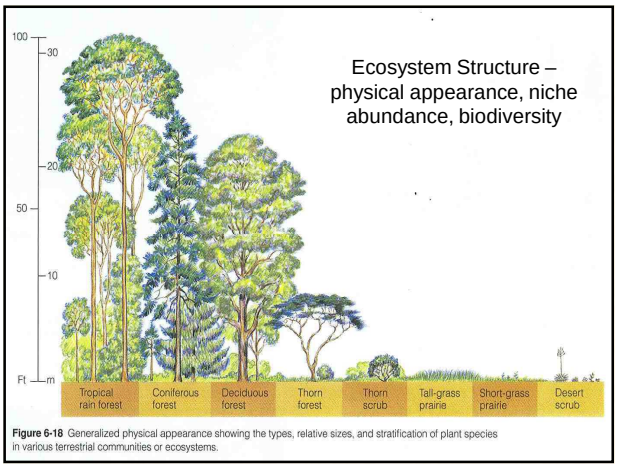
- Von Liebig proposed the single factor in shortest supply relative to demand is the critical factor in a species distribution.
- Shelford later expanded by stating that each environmental factor has both minimum and maximum levels, or tolerance limits, beyond which a particular species cannot survive or is unable to reproduce. The factor closest to the limits is the critical factor that determines where an organism can live.

Limiting Factors

- **Major factor in defining an organisms niche**
- **Tall trees cannot grow in desert because *Water* is limiting.**
- **What's is limiting in the rainforest?**

Tolerance Limits





Ecosystem Structure – physical appearance, niche abundance, biodiversity

Figure 6-18 Generalized physical appearance showing the types, relative sizes, and stratification of plant species in various terrestrial communities or ecosystems.

Intraspecific Competition

- **Between SAME species; intense competition over the same resources.**

Interspecific Competition

- **DIFFERENT species; less intense because of slightly different requirements**

Olympics are *INTER*national – different countries.

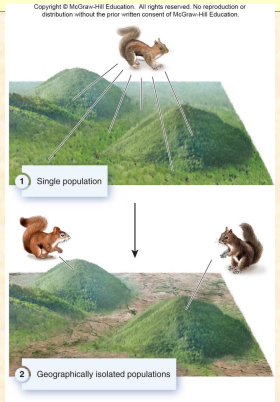
Critical Limits

- For some species, the interaction of several factors, rather than a single limiting factor, determines biogeographical distribution.
  - Tolerance limits may affect the distribution of young differently than adults.
- Species requirements and tolerances can be useful indicators of specific environmental characteristics. For example: Trout require cool, clean, well oxygenated water so their disappearance from a stream may indicate that it is being polluted.

Speciation

Speciation - the development of a new species. This can occur due to geographic isolation whereby a sub-population becomes separated from the main population and can no longer share genes with it. The new population evolves independently of the first, creating a new species. This is termed allopatric speciation.

Allopatric Speciation

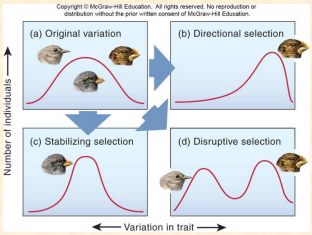


Speciation

- In sympatric speciation, organisms continue to live in the same place but become isolated by some other means.
- Example: Some fern species have doubled the number of chromosomes they have. This prevents them from breeding with the population from which they originally came and effectively creates a new species.

Types of Selection

- Directional selection - the shift toward one extreme of a trait
- Stabilizing selection - range of a trait is narrowed
- Disruptive selection - traits diverge toward the two extremes

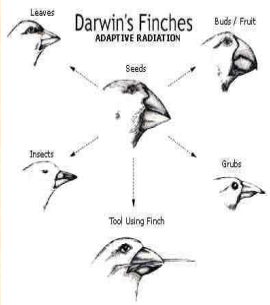


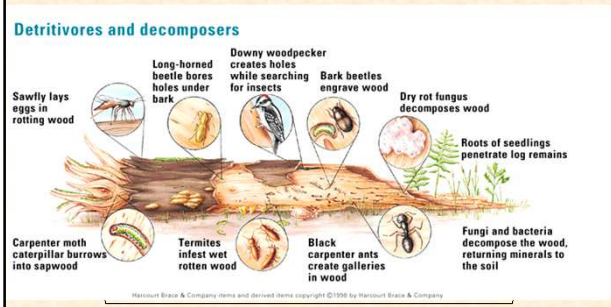
Habitat and Ecological Niches

- Habitat - the place or set of environmental conditions in which a particular organism lives
- Ecological niche - describes either the role played by a species in a biological community or the total set of environmental factors that determine a species distribution
  - Generalist - has a broad niche (brown rat)
  - Specialist - has a narrow niche (giant panda)

The Ecological Niche

- **Niche - Each organism has a role or job in an ecosystem**
- **Fundamental niche= full potential that could be theoretically achieved.**
- **Realized niche = a species only occupies only part of the fundamental niche.**

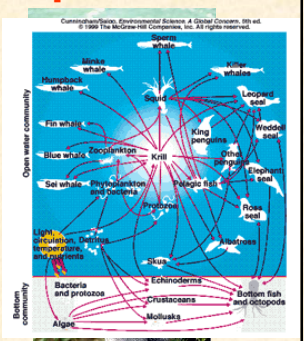




Generalists **Specialist**

Keystone Species

- **Key members of community**
- **NOT always most abundant**
- **ALWAYS most important**
- **The *KEY* to conservationist efforts**
- **Example: Grey wolf of Yellowstone Park**



Keystone Species

- A keystone species plays a critical role in a biological community that is out of proportion to its abundance.
- For example, in the tropics, figs bear fruit year around. In the dry season, this is the only food available for many species. If figs were removed from the forest, many fruit-eating animals would disappear; and this in turn would affect many other plants that depend upon these frugivores for pollination. So, the fig is key to the survival of the community.

What is Predation?

- **Predation = prey on other species, *but do not live in or on prey.***

Structural advantages

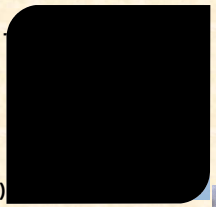
- **Natural Weapons - Fangs, claws**
- **Flexible bodies**
- **Larger Size**

Ambush-

- **Stalk a victim**
- **Gape & Suck (fish)**
- **Keen eyesight**
- **Venom**

SPEED & CUNNING

- **More intelligent**
- **Run faster than prey**
- ***Hunt in packs***



Prey Strategies

Defense Techniques

- Inflate, Flee, Fight Back, Stab, Poison

Structural advantages

- Hard Body Coverings, Thorns or Spines, Break away body parts, Natural Weapons

Chemical Warfare

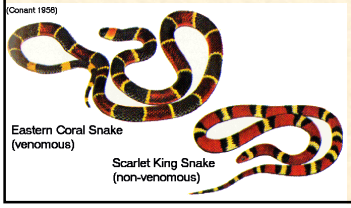
- Blinding ink, Poison, Offensive Smells and Tastes

Camouflage

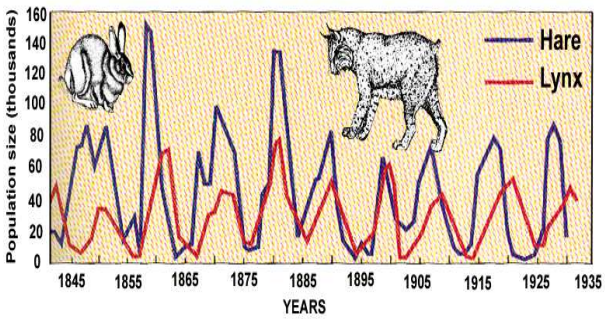
- Color Change, Counter-shading, Disruptive Patterns, Mimicry

Mimicry

- Mostly a prey technique
  - Optical and sonic illusions
  - LOOKS like a predator:
  - School of fish; false eyes; frilled neck and inflation



Predator Prey Activity



Species Interactions

Competition

- Intraspecific competition - competition among members of the same species which can be reduced if:
  - young disperse
  - exhibiting strong territoriality
  - resource partitioning between generations
- Interspecific competition - competition between members of different species

Predation

- A predator is any organism that feeds directly on another organism, whether or not this kills the prey. Example: a parasite feeds on an organism but does not kill it.
- Predator-mediated competition - one species may be the best competitor in a given location, but predators may reduce its abundance and allow the weaker competitor to increase its numbers

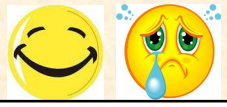
Adaptations to Avoid Predation

- As predators become more efficient, the prey evolve defenses (thorns, toxic chemicals, etc.).
- Over time predator and prey evolve in response to one another (coevolution).
- Species with chemical defenses often evolve warning coloration.
  - Harmless species mimic the warning coloration of harmful species to gain protection (Batesian mimicry).
  - Two harmful species evolve to look alike (Müllerian mimicry).

Batesian Mimicry

Interactions Among Organisms

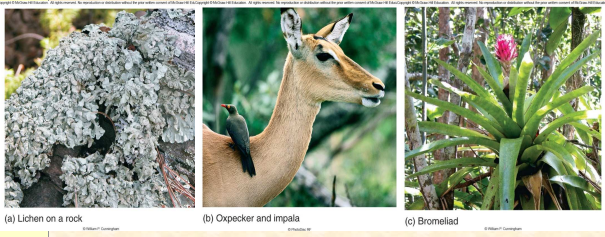
Symbiosis

- **Mutualism =** 
- **Commensalism =** 
- **Parasitism** 

Symbiosis

- In symbiosis two or more species live intimately together with their fates linked.
- Mutualism - both organisms benefit from their association (e.g., a fungus and an alga combine to make a lichen)
- Commensalism - one species benefits while the other neither benefits nor is harmed (e.g., a bromeliad growing on the trunk of a tree absorbs water and nutrients dripping down the tree trunk without harming the tree)
- Parasitism - a form of predation, is also sometimes considered a symbiosis because of the dependency of the parasite on its host.

Symbiosis

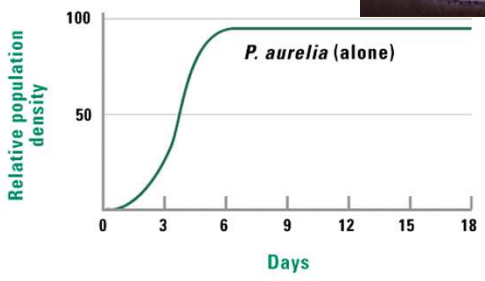


(a) Lichen on a rock (b) Oxpecker and impala (c) Bromeliad

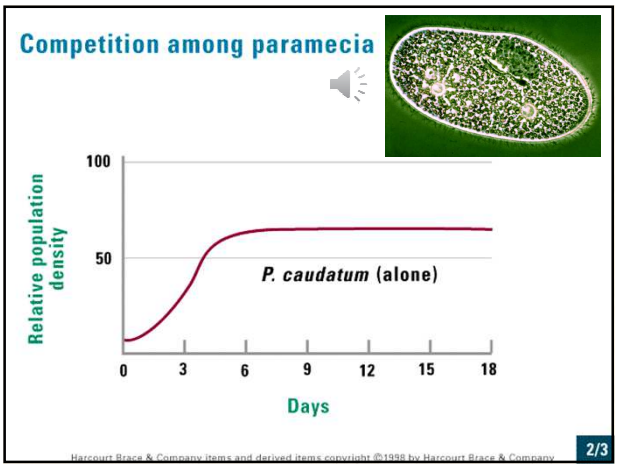
Competitive Exclusion

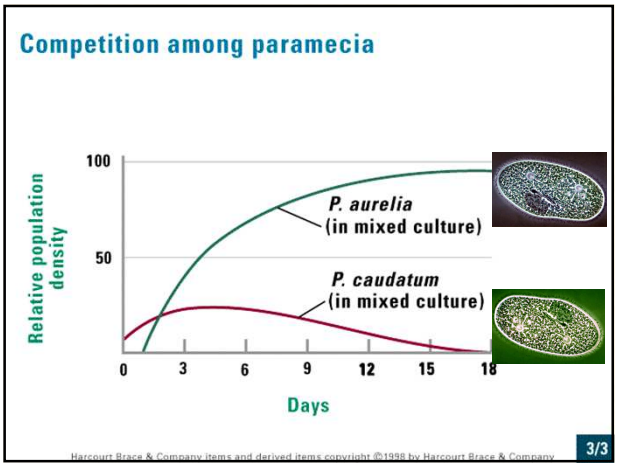
- Two species with similar requirments cannot occupy the same niche if resources are constant (Gause's Law)

Competition among paramecia



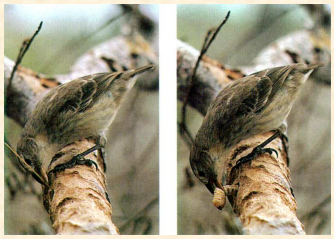
1/3





Solving the Competition Problem

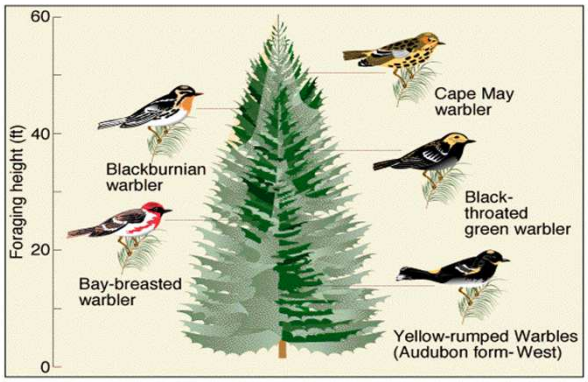
- **Leave**
  - Emigrate
- **Die**
  - Extinction
- **Adapt**
  - Resource Partitioning
  - Tool Use for new food resources



Competitive Exclusion

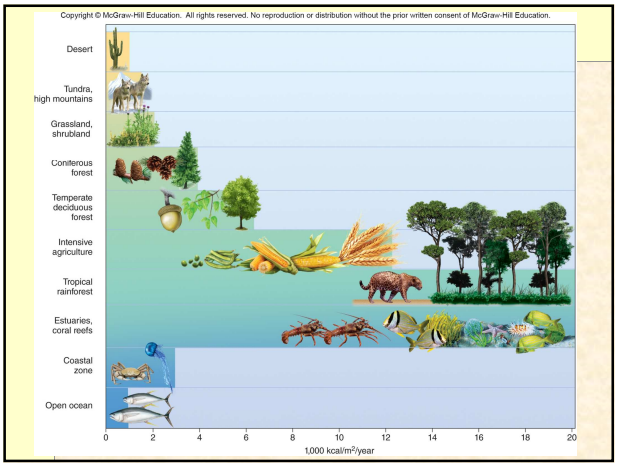
- Gause proposed the principle of competitive exclusion which states that no two species can occupy the same ecological niche at the same time. The one that is more efficient at using resources will exclude the other.
- Resource partitioning - species co-exist in a habitat by utilizing different parts of a single resource. Example: swallows eat insects during the day and bats eat insects at night.

Resource Partitioning



Community Properties

- Primary Productivity - rate of biomass production. Used as an indication of the rate of solar energy conversion to chemical energy
  - Net Primary Productivity - energy left after respiration
- Tropical forests, coral reefs, and estuaries have some of the highest levels of productivity.



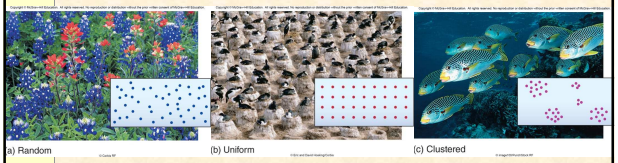
Abundance and Diversity

- Abundance - total number of organisms in a community
- Diversity - number of different species, ecological niches, or genetic variation
  - Abundance of a particular species is often inversely related to community diversity.
  - As a general rule, diversity decreases and abundance within species increases when moving from the equator to the poles.

Community Structure

- Ecological structure - patterns of spatial distribution of individuals and populations within a community
  - random distribution
  - clustered/clumped distribution - for protection, mutual assistance, reproduction, access to resources
  - uniform distribution - often the result of competition
- Distribution can be vertical as well as horizontal.

Community Structure



Complexity and Connectedness

Complexity - the number of trophic levels and number of species at each trophic level in a community

- Diverse community may not be complex if all species are clustered in a few trophic levels.
- Highly interconnected community may have many trophic levels, some of which can be compartmentalized.

Tropical Rainforests: Diverse and Complex

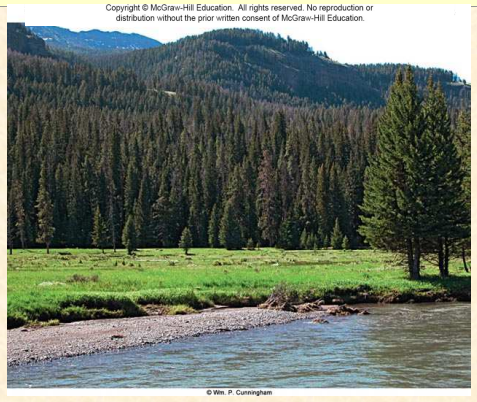
Resilience and Stability

- *Constancy* - lack of fluctuation in composition or function
- *Inertia* - resistance to perturbation
- *Renewal* - ability to repair damage after a disturbance
  - MacArthur proposed that complex, interconnected communities would be more stable and resilient in the face of disturbance.
    - Some studies have supported this idea while others have not.

Edges and Boundaries

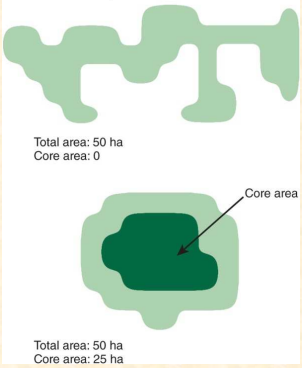
- Edge Effects - important aspect of community structure is the boundary between one habitat and adjacent ones
- Ecotones - boundaries between adjacent communities
  - Sharp boundaries - closed communities
  - Indistinct boundaries - open communities

Ecotones



© Wm. P. Cunningham

Edge Effects



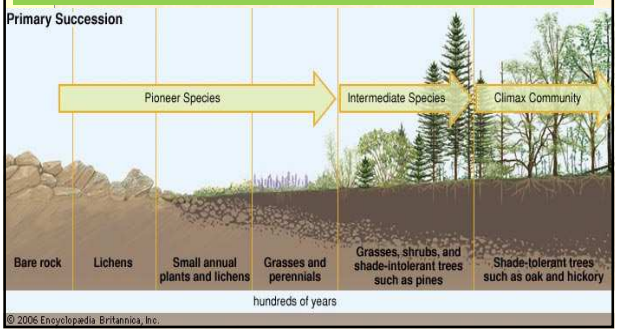
Communities in Transition

- Ecological Succession
  - Primary Succession - A community begins to develop on a site previously unoccupied by living organisms. Example: A lava flow creates a new land area that is colonized. The first colonists are termed pioneer species.
  - Secondary Succession - an existing community is disrupted and a new one subsequently develops at the site
  - Climax community - community that develops last and remains the longest

SUCCESSION

Ecological succession is the process of change in the species structure of a community over time.

Primary Succession – begins with bare rock.
Example: A new volcanic island in the ocean.
Annual – lives and dies once. Ex: dandelion
Perennial – lives year round. Ex: rose bush.



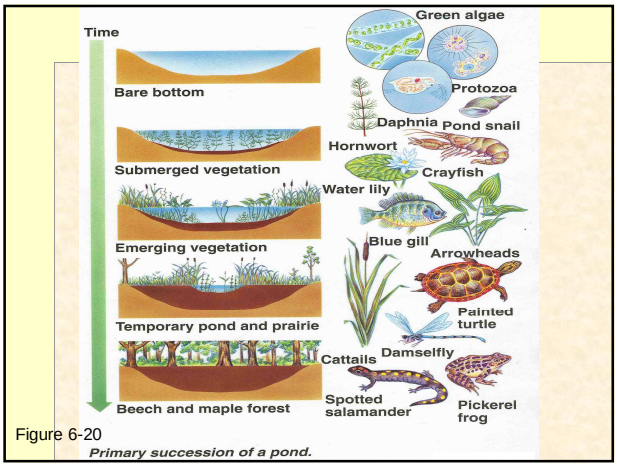
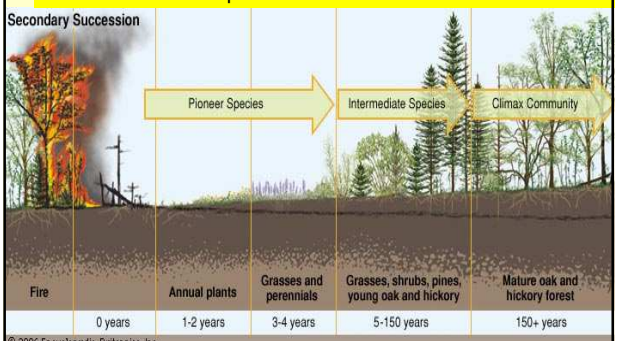


Figure 6-20
Primary succession of a pond.

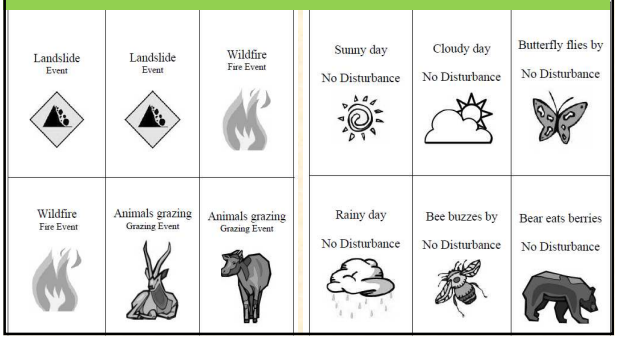
Secondary Succession – starts with soil.
Example. A forest fire disturbance.



Annual – lives and dies once. Ex: dandelion
Perennial – lives year round. Ex: rose

What causes succession to

Some type of DISTURBANCE… but no disturbance is much more common.



DISTURBANCE

- Is Inevitable, species must adapt to changes.
- Isn't a bad thing for all species in fact…
- Fire is necessary for the giant sequoia to reproduce. The heat dries out the cones and causes them to open.

click here

Disturbances

- A *disturbance* is any force that disrupts established patterns of species diversity and abundance, community structure, or community properties, e.g., storms, fires, logging.
- Disturbance tends to disrupt the superior competitors the most and allows less competitive species to persist.
- Some landscapes never reach a climax community because they are characterized by periodic disturbances (such as wildfires) and are made up of disturbance-adapted species

Momerath herb	*Lorax tree*	*Grickle grass*
Character Type: **Early Successional**	Character Type: **Early Successional**	Character Type: **Early Successional**
Fire event: go forward 5 places	Fire event: stay in the same place	Fire event: go forward 2 places
Landslide event: go forward 2 places	Landslide event: go forward 5 places	Landslide event: stay in the same place
Grazing event: stay in the same place	Grazing event: go forward 2 places	Grazing event: go forward 5 places
No disturbance: go back 1 place	No disturbance: go back 1 place	No disturbance: go back 1 place
Truffula Tree	*Mimsy bush*	*Borogrove grass*
Character Type: **Late Successional**	Character Type: **Late Successional**	Character Type: **Late Successional**
Fire event: go back 4 places	Fire event: go back 1 places	Fire event: go back 1 places
Landslide event: go back 1 place	Landslide event: go back 4 place	Landslide event: go back 1 place
Grazing event: stay in the same place	Grazing event: stay in the same place	Grazing event: go back 3 place
No disturbance: go forward 3 places	No disturbance: go forward 3 places	No disturbance: go forward 3 places

Different types of plants and animals that are present at the different successional

Pioneer species live on bare rock then die, their matter is cycled and begins to form soil.
Examples: Lichens and mosses.

Early successional species – annual plants that continue making soil and grow at ground level, shade intolerant.
Examples: Grasses, herbs, ferns

Mid successional – larger shade intolerant species. Examples: Small shrubs, trees

Late successional - a "stable or climax" community. Examples: Mostly trees and shade tolerant shrubs.

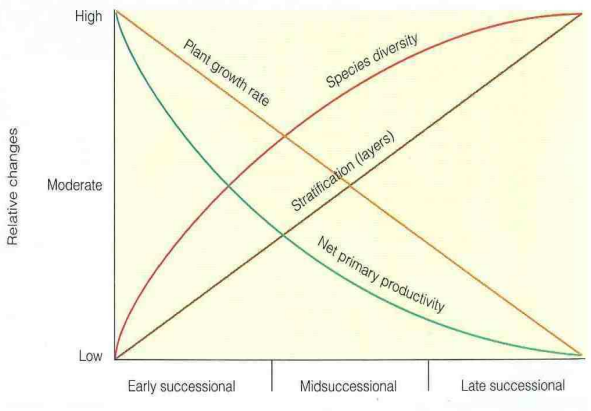


Figure 6-23

How do species interact?

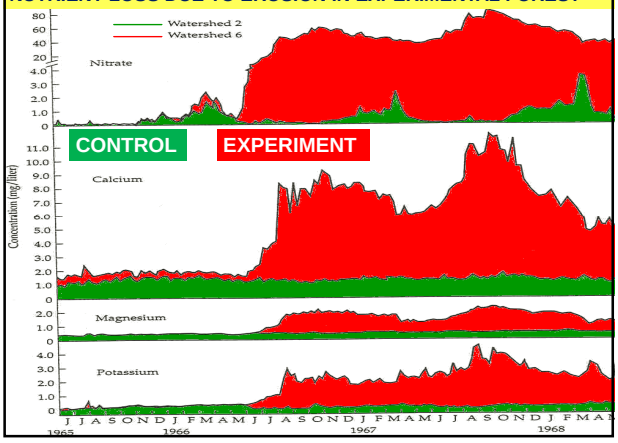
Competition	Competition	Facilitation
Late character type has more roots & uses up all the water	Late character type shades Early character type	Early character type adds nitrogen to the soil
Late move forward 2, Early move back 1	Late move forward 2, Early move back 1	Early stays in place, Late move forward 2
If: 2 Early characters or 2 Late characters meet, then flip a coin to decide the winner. Winner moves forward 2, loser moves back 1.	If: 2 Early characters or 2 Late characters meet, then flip a coin to decide the winner. Winner moves forward 2, loser moves back 1.	If: 2 Early characters or 2 Late characters meet, then flip a coin to decide the winner. Winner moves forward 2, loser stays in place.
Facilitation With Shade	**Tolerance**	**Tolerance**
Early character type protects Late character from heat and drying out.	Species tolerate each other	Species tolerate each other

Inhibition – one species prevents another from growing by creating shade, altering soil ph, etc.

Hubbard Brook Experimental Forest

Figure 5-32:

NUTRIENT LOSS DUE TO EROSION IN EXPERIMENTAL FOREST



frequent disturbance → more species diversity, opens niches for opportunistic species

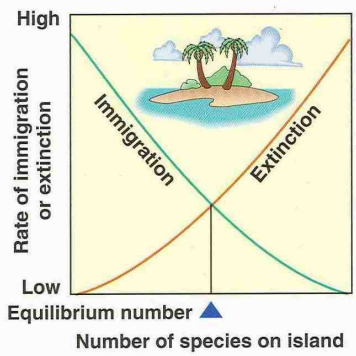
Stability - Systems move towards a stable climax community.
greater diversity → greater stability (better

Inertia (persistence) – the ability to resist change
ex: Deserts are hard to turn into tropical rain forests.
ex: Loblolly pine forests can turn into hardwood forests

There are not periodic small fires to kill the young hardwood trees.

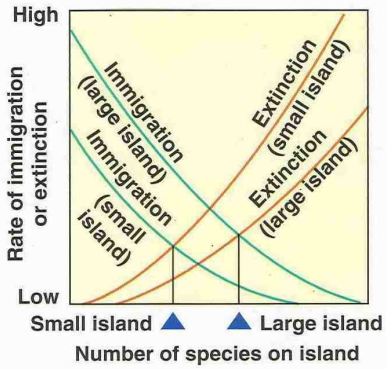
Resilience – the capacity of an ecosystem to recover from disturbance.
ex: hardwood forest takes a long time to grow back because Oak trees take a long time to grow.
ex: Grasslands are resilient because grass grows back quickl

Channel Islands National Park. What do you observe about these islands? These last 4 slides won't be covered on the



(a) Immigration and extinction rates

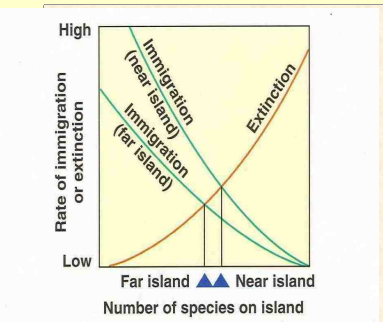
On an Island there is an equilibrium between species immigrating (entering) and going extinct (exiting)



(b) Effect of island size

Small Island = less immigration and extinction.

Large Island = more immigration and extinction.



(c) Effect of distance from mainland

Near Island – more immigration and more extinction

Far Island – less immigration and less extinction.

Introduced Species and Community Change

If introduced species prey upon or compete more successfully than native populations, the nature of the community may be altered.

- Introduction of rats, cats, goats and pigs on islands where European sailing ships landed
- Intentional introduction of exotic species (e.g., mongoose) to solve problems caused by previous introductions

Mongoose

© Gerals Lacz/Peter Arnold.