Community Processes: Species Interactions & Succession

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Durian Video: http://video.nationalgeographic.com/video/player/places/culture-places/food/malaysia_durian.html

Outline

1. The Ecological Niche
   roles, fundamental & realized niche, generalists vs. specialists
2. Some General Types of Species
   native, non–native, indicator, & keystone species
3. Types of Species Interactions
   predator-prey, competition, & symbiosis
4. Competition & Resource Partitioning
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5. Succession
   primary & secondary succession
6. Island Biogeography
7. Stability & Sustainability

1. The Ecological Niche

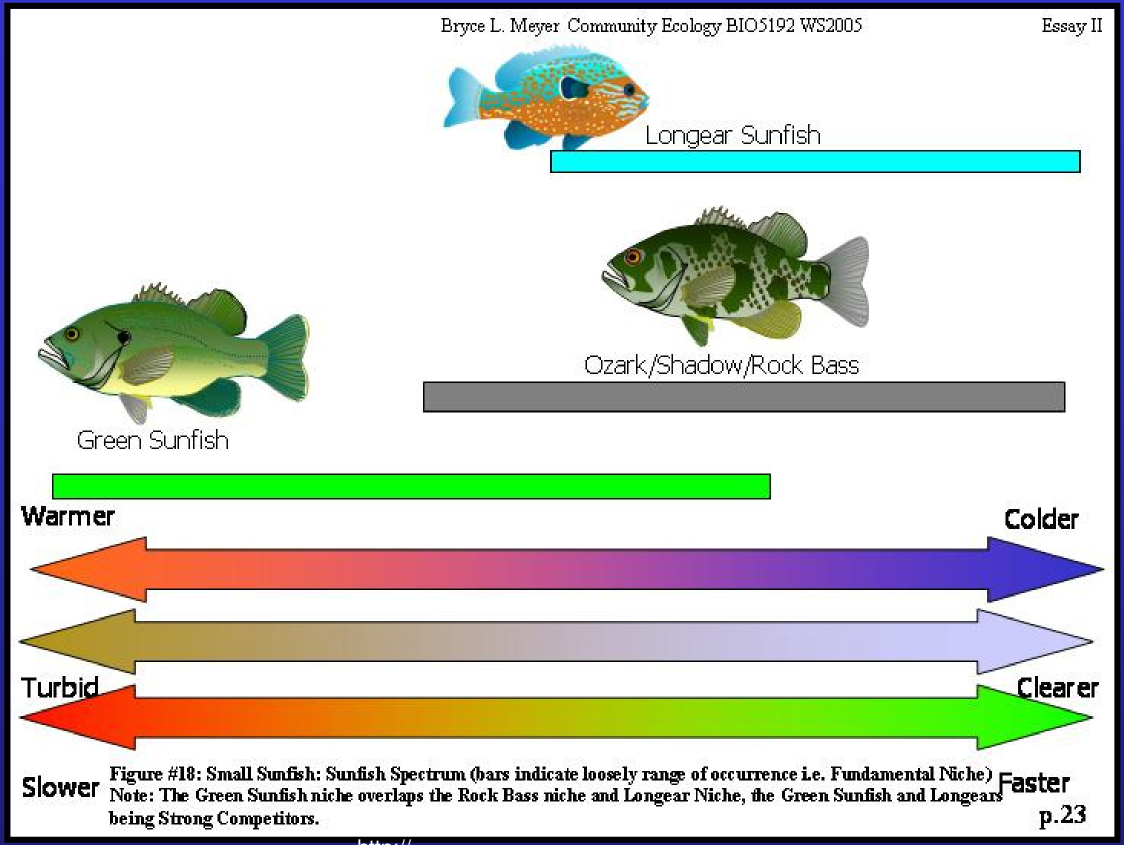
niche: the role that an organism plays in an ecosystem.

- defined by the range of **conditions** & **resources** within which an organism can live;
- **conditions**: the many physical attributes of the environment, though not consumed, that influence biological processes & population growth, e.g., temperature, salinity, acidity;
- **resources**: substances or parts of the environment used by an organism & consumed or otherwise made unavailable to other organisms , e.g., food, water, & nesting sites for animals; water, nutrients, & solar radiation for plants;
- contrast with **habitat**, the actual place an organism lives.

Fundamental vs. Realized Niche

fundamental niche: the full range of conditions & resources that an organism could theoretically use in the absence of competition with other species.

realized niche: the portion of the fundamental niche that an organism actually occupies; actual range of conditions & resources that an organism uses.



•http://www.combat-fishing.com/SUnfishspectrumOzarkstream.JPG

•niche overlap between species leads to competition;

•competition causes organisms to not be able to occupy the full fundamental niche;

Generalists vs. Specialists

- **generalists** have broad niches, whereas **specialists** have narrow niches:
  - examples of generalists: cockroaches, coyotes, dandelions, humans;
  - examples of specialists: spotted owls, which require old–growth forests in the Pacific Northwest; giant pandas, which eat primarily bamboo in bamboo forests of China;
  - generalists may have advantage when environmental conditions change (e.g., weedy species such as dandelions in disturbed habitat); whereas specialists may have advantage when environmental conditions are more constant (e.g., many species of tropical rain forest).

•http://facweb.eths.k12.il.us/wartowskid/images/cockroaches.jpg

•http://i17.photobucket.com/albums/b99/sporazoa/Spotted-Owl.jpg

2. Some General Types of Species

native species: species that normally live & thrive in a particular ecosystem:

- by contrast **nonnative species** (also called **exotic species** or **alien species**) originate in other ecosystems; may enter an ecosystem by migration or by deliberate or accidental introduction by humans;
- example: "killer bees", wild bees from Africa were imported to Brazil to increase honey production, but instead displaced native bees, decreased honey production, spread, & posed threat because of aggressive behavior.

•http://www.virginmedia.com/images/african-killer-bees-431x300.jpg

Killer Bees Video: http://video.nationalgeographic.com/video/player/animals/bugs-animals/bees-and-wasps/killer_bee.html

Cane Toads Video: http://video.nationalgeographic.com/video/player/animals/amphibians-animals/frogs-and-toads/toad_cane.html

Fire Ant Video: http://video.nationalgeographic.com/video/player/animals/bugs-animals/ants-and-termites/ant_redfire.html

Some General Types of Species

indicator species: species that serve as early warnings that a community or ecosystem is being damaged:

- example: decline of migratory songbirds in North America indicates loss & fragmentation of habitat in mesoAmerica & South America;
- example: presence of trout in mountain streams is an indicator of good water quality;
- example: presence of spotted owls is indicator of healthy old–growth forest.

Some General Types of Species

keystone species: species that play a critical role in an ecosystem:

- <u>example</u>: sea otters are keystone species because they prevent sea urchins from depleting kelp beds;
- <u>example</u>: dung beetles are keystone species because they remove, bury, & recycle animal waste;
- <u>example</u>: beavers are keystone species because they build dams & create habitat for a diverse community of species (bluegill fish, muskrats, herons, ducks…).

"The loss of a keystone species is like a drill accidentally striking a power line. It causes lights to go out all over."
— *E.O. Wilson*

www.absc.usgs.gov/research/sea_otters/jb_31.jpg

i1.treknature.com/photos/12634/scarabeus.jpg

•http://animals.nationalgeographic.com/staticfiles/NGS/Shared/StaticFiles/animals/images/primary/beaver.jpg

3. Types of Species Interactions

major types of biotic interactions:

- **interspecific competition**: when two or more species use the same limited resource (food, space, etc.) and adversely affect each other

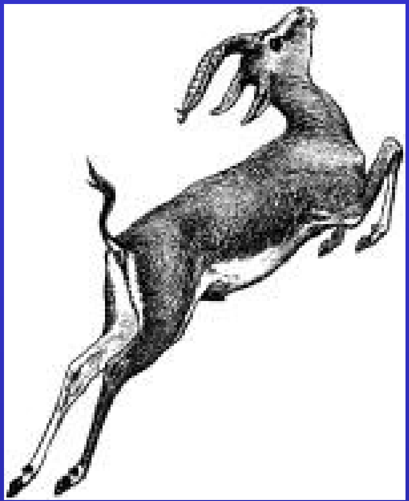
  example: fire ants and native species of ants in North America; fire ants sharply are better competitors & sharply reduce populations of up to 90% of native species.

•http://www.hrbizmall.com/catalog/images/ifavsnative%20Q4.jpg

- **predation**: members of one species (predator) feed on another species (prey);

  example: lion feeding on gazelle.

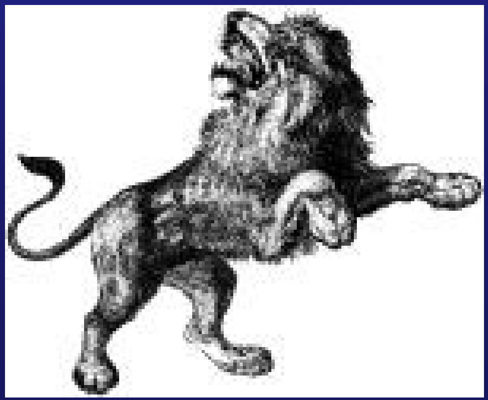
•http://www.maglite.com/images/lion_gazelle.jpg



"Every morning in Africa, a gazelle wakes up. It knows that it must outrun the fastest lion or it will be killed.

Every morning in Africa, a lion wakes up. It knows that it must out run the slowest gazelle or it will starve.

It does not matter whether you are a lion or gazelle. When the sun comes up you had better be running."



https://www.tatanka.com/reading/humanity/parable/liongaz.html

Types of Species Interactions

Symbiosis: a long–lasting relationship in which species live together in intimate association:

1. parasitism: one organism (parasite) lives on part of another organism (host), e.g., flea living on a dog,

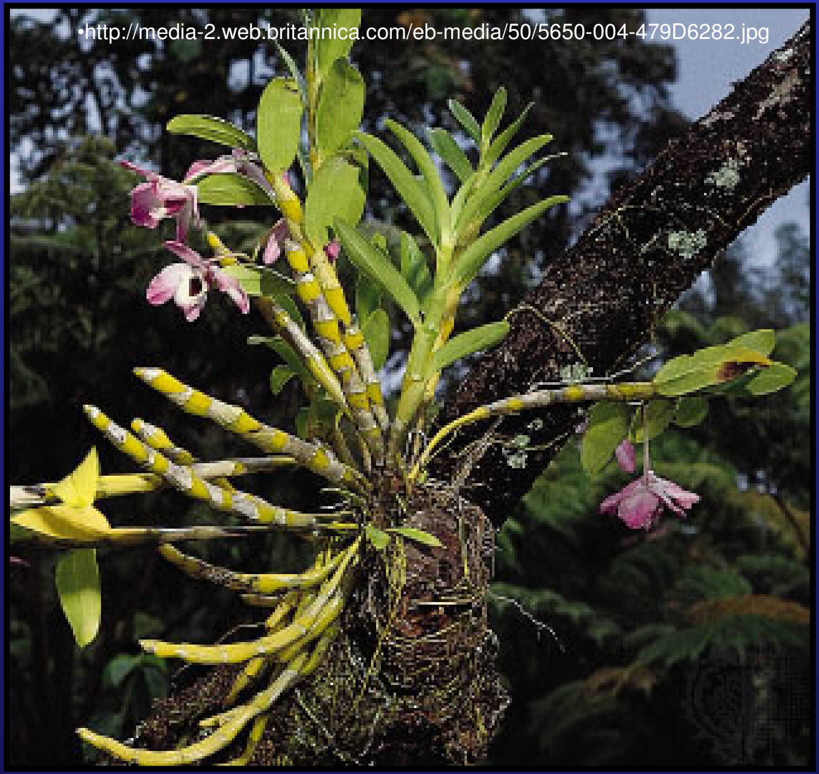
Video: http://video.nationalgeographic.com/video/player/animals/invertebrates-animals/other-invertebrates/snail_zombies.html

•http://cache.eb.com/eb/image?id=82638&rendTypeId=4

2. mutualism: two species interacting in a way that benefits both, e.g., flowering plants and insects;

Video: http://video.nationalgeographic.com/video/player/animals/bugs-animals/ants-and-termites/ant_acaciatree.html

3. commensalism: one organism benefits from another, but neither helps nor harm that other organism, e.g., epiphyte growing on a tree (epiphyte benefits & tree not effected, unless there are many epiphytes).



Secretive Symbiosis: The Study of Lichens & Mycorrhizae

Lichens

Mycorrhizae

•http://botit.botany.wisc.edu/images/332/Lichens/Foliose_lichens_130_d.gif

•http://www.greenmanconservation.co.uk/Images/Photos/Web%20Ready/Mycorrhiza/Roots.jpg

4. Competition & Resource Partitioning

*Interspecific competition results because of **niche overlap** (overlap in requirements for limited resources.)*

Types of Competition:

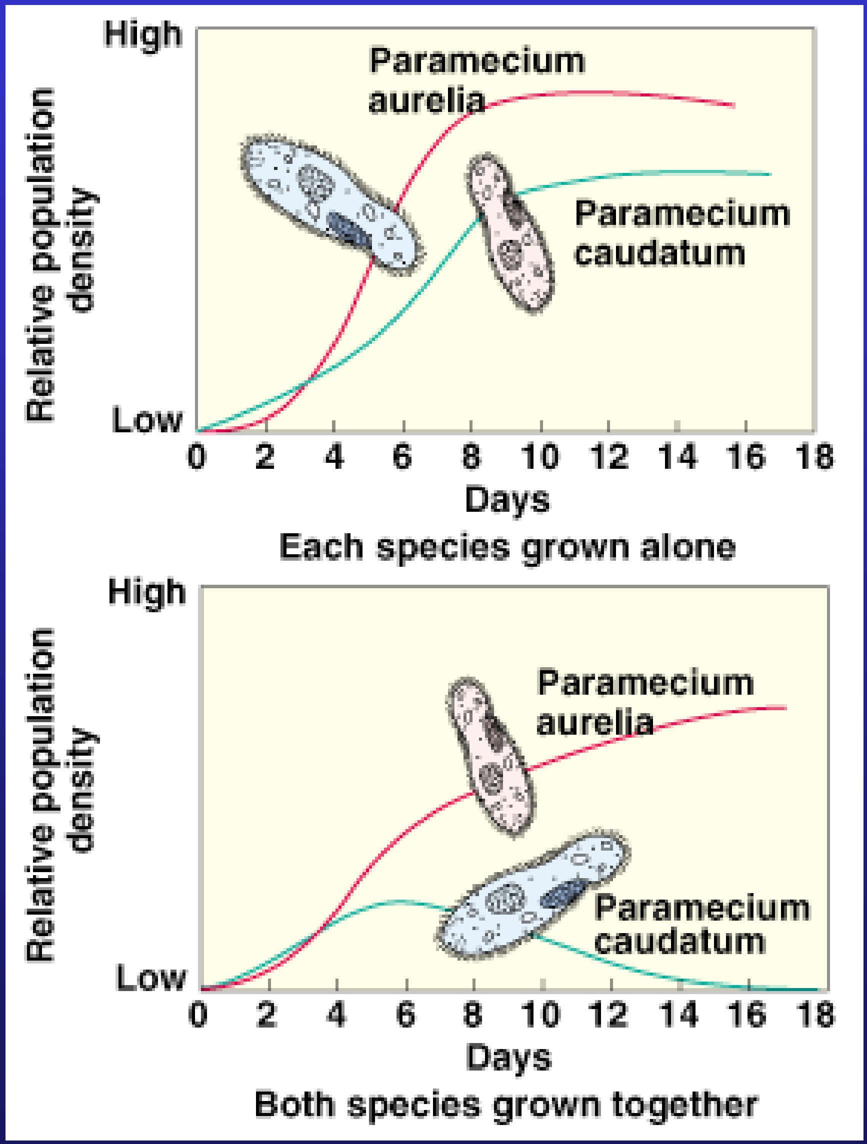
- **interference competition**: one species limits another species' access to a resource; e.g., hummingbirds defending feeding territories.
- **exploitation competition**: competing species both have access to a limited resource, but one exploits the resource more quickly or efficiently.

•http://lh6.ggpht.com/_dJiMh5CeHkU/SDOTwvB8mhI/AAAAAAAAAGA/udqCFhGOzEQ/fighting+hmg+birds+original.jpg

•http://www.the-gardeners-calendar.co.uk/images/newsimages/Bees_on_Artichoke.jpg

Principle of Competitive Exclusion

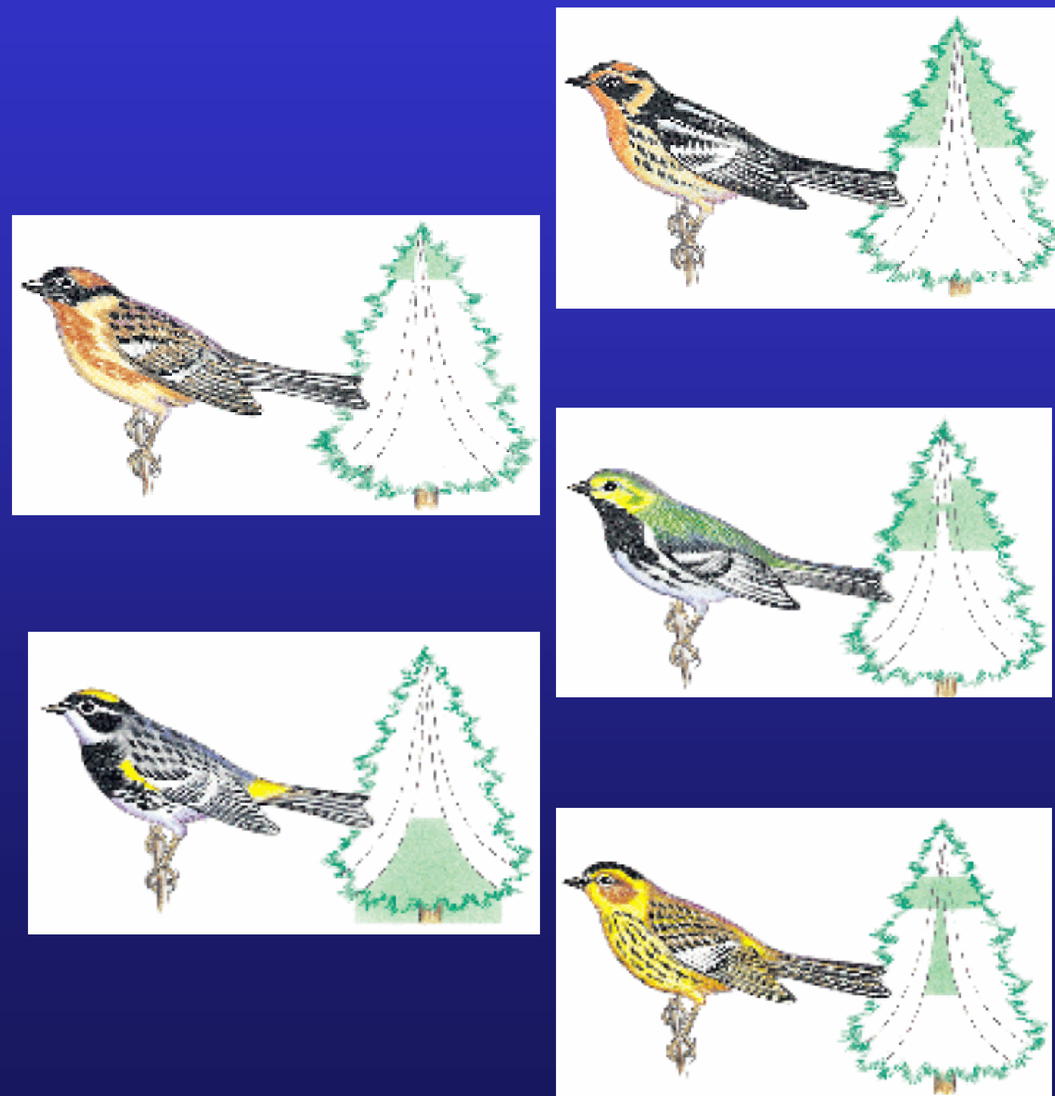
In a classic experiment (1934), Gause showed that two species with identical niches cannot coexist indefinitely. This is called the ***principle of competitive exclusion****. Note that when grown together, Paramecium aurelia outcompetes Paramecium caudatum.*



Resource Partitioning

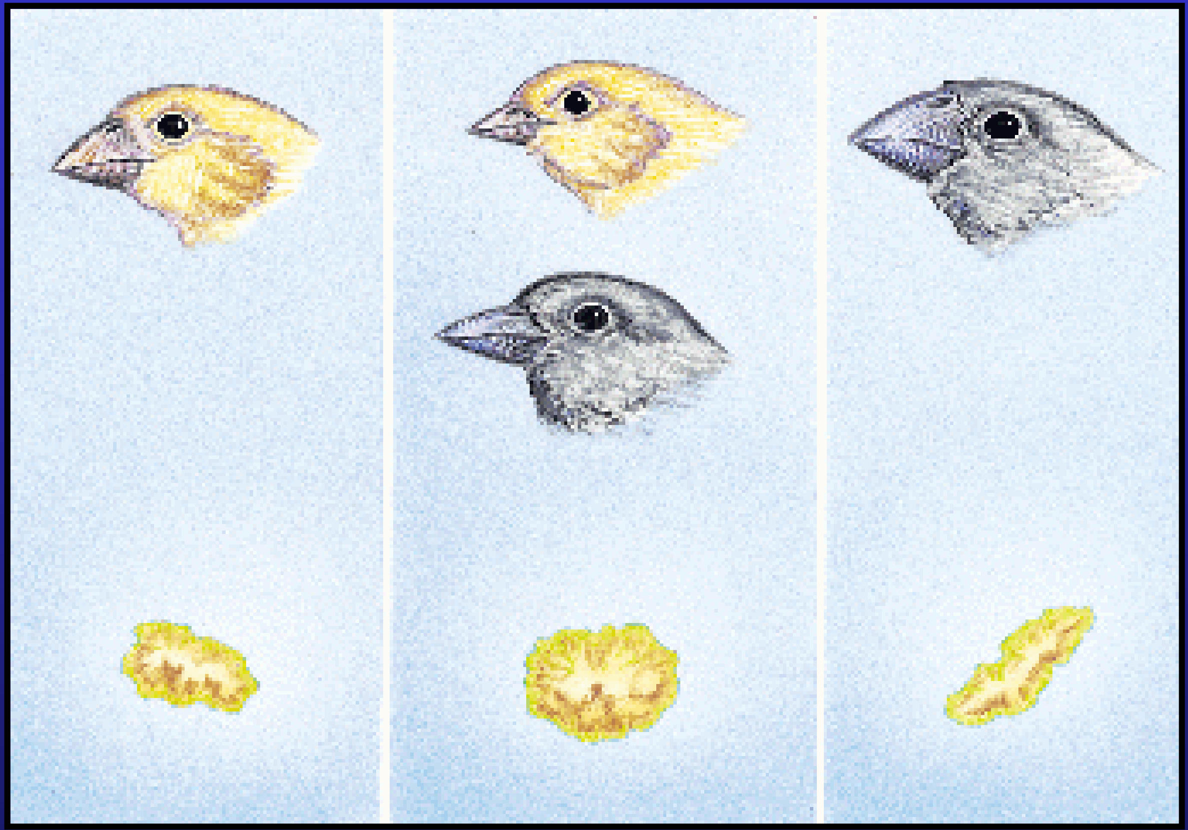
Species with similar resource requirements can coexist because they use limited resources at different times, in different ways, or in different places.

Five species of insect–eating warblers are able to coexist in spruce forest of Maine. Each species minimizes competition with others for food by spending at least half its feeding time in a distinct portion of spruce trees (shaded areas); each also consumes somewhat different insect species.



Character Displacement

Over many years coexisting species with similar niches tend to evolve physical & behavioral adaptations to minimize competition. For example on islands where they co–occur, species of Darwin's finch have evolved different bill sizes & eat different size prey.



5. Succession

succession: gradual & fairly predictable change in species composition with time.

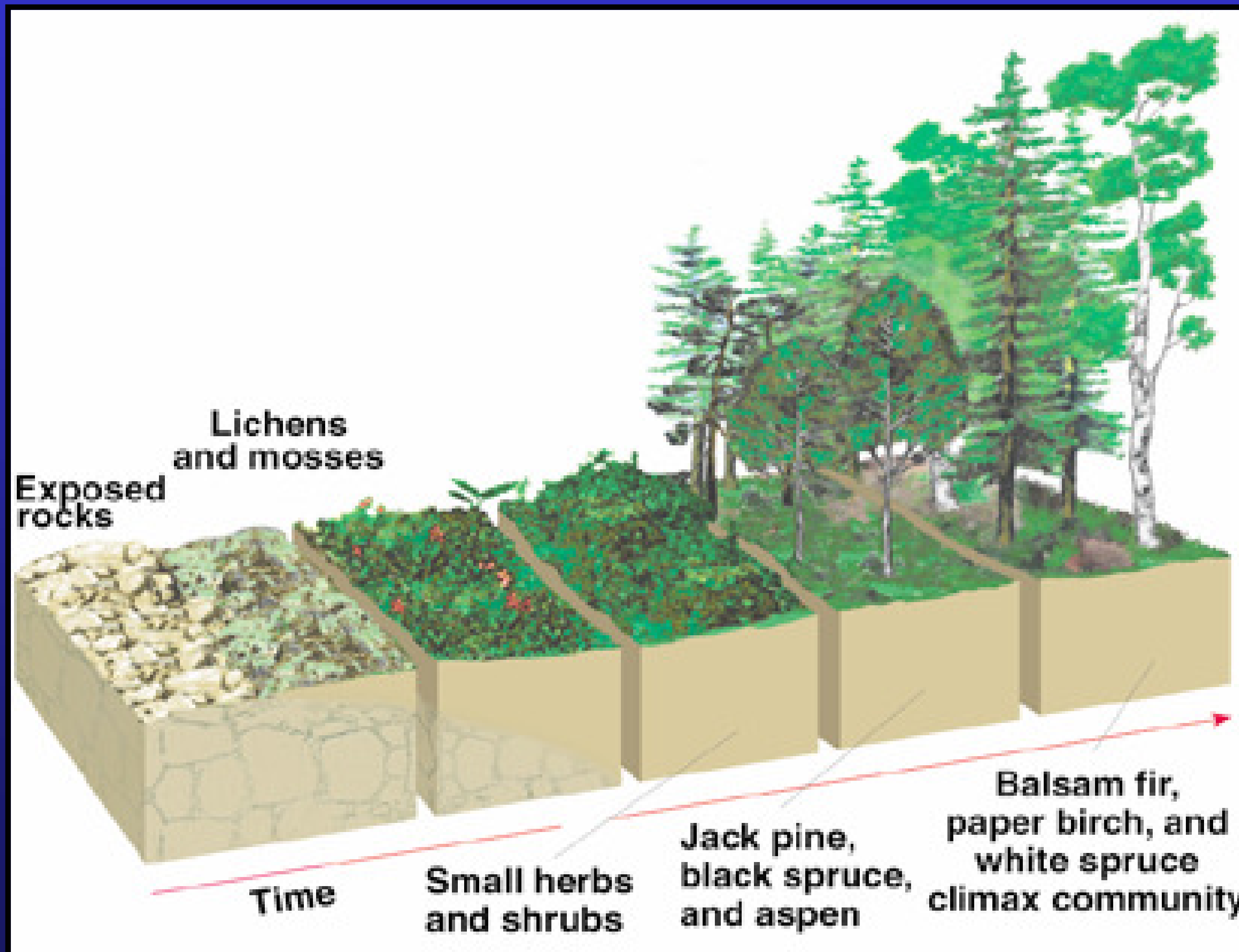
- some species colonize & become more abundant;
- other species decline or even disappear.

two kinds of succession:

- **primary succession** involves the gradual establishment of biotic communities in an area where no life existed before;
- **secondary succession** involves the gradual reestablishment of biotic communities in an area where a biotic community was previously present.

Primary Succession

Primary succession over several hundred years on bare rock exposed by a retreating glacier on Isle Royal in northern Lake Superior.



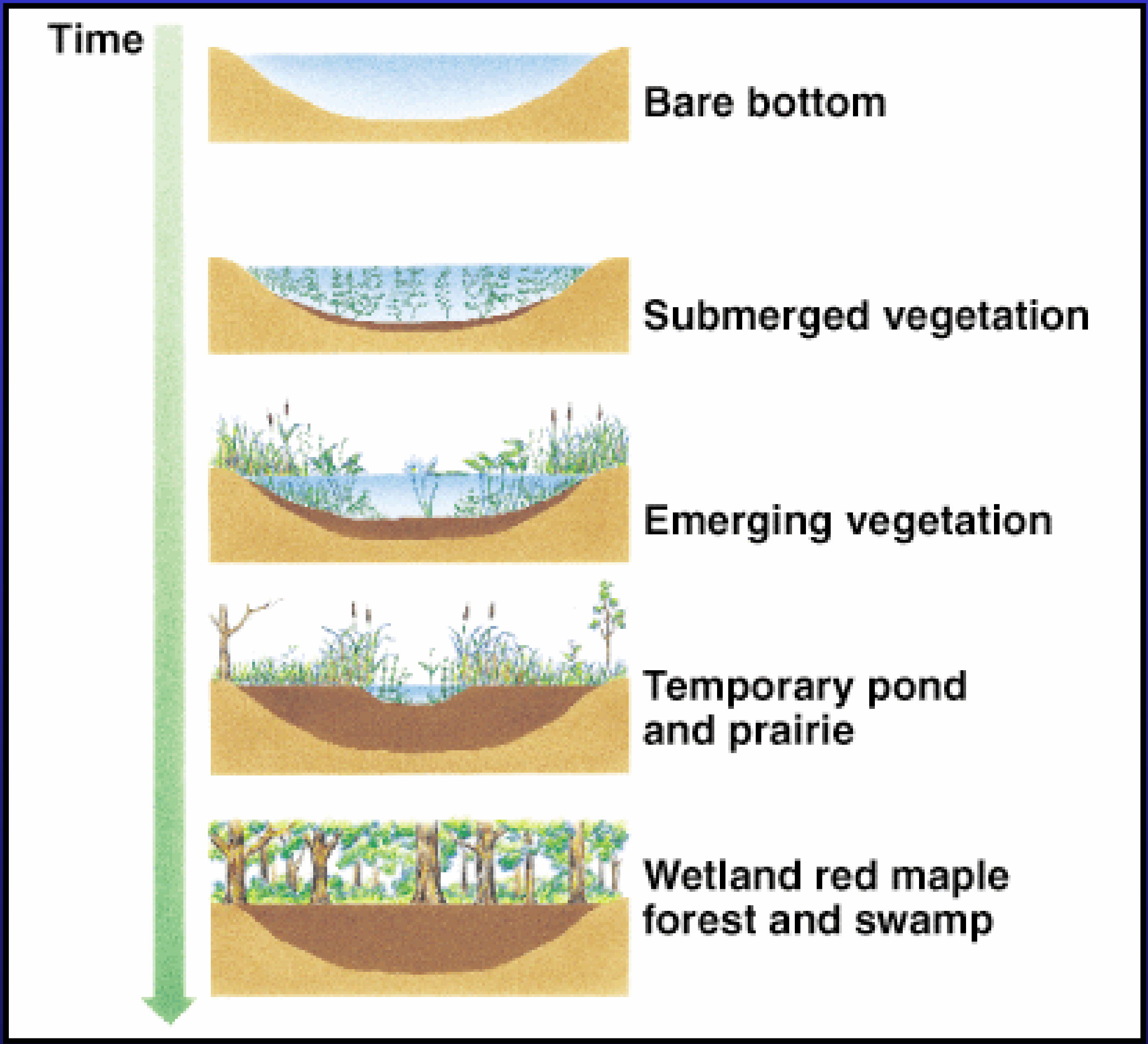
Primary Succession

Primary succession occurs with time in lifeless areas.

- examples include succession newly formed islands & succession after the retreat of a glacier;
- typically lichens & mosses first colonize bare rock;
- the first species to colonize are termed **pioneer species**;
- later small herbs & shrubs colonize;
- finally tree species colonize;
- the progression of species that colonize with time are commonly termed early, mid, & late successional species.

Primary Succession

Greatly simplified view of primary succession in a newly created pond in a temperate area. Nutrient rich bottom sediment is shown in dark brown.



Successional changes in the animal community accompany successional changes in the plant community.

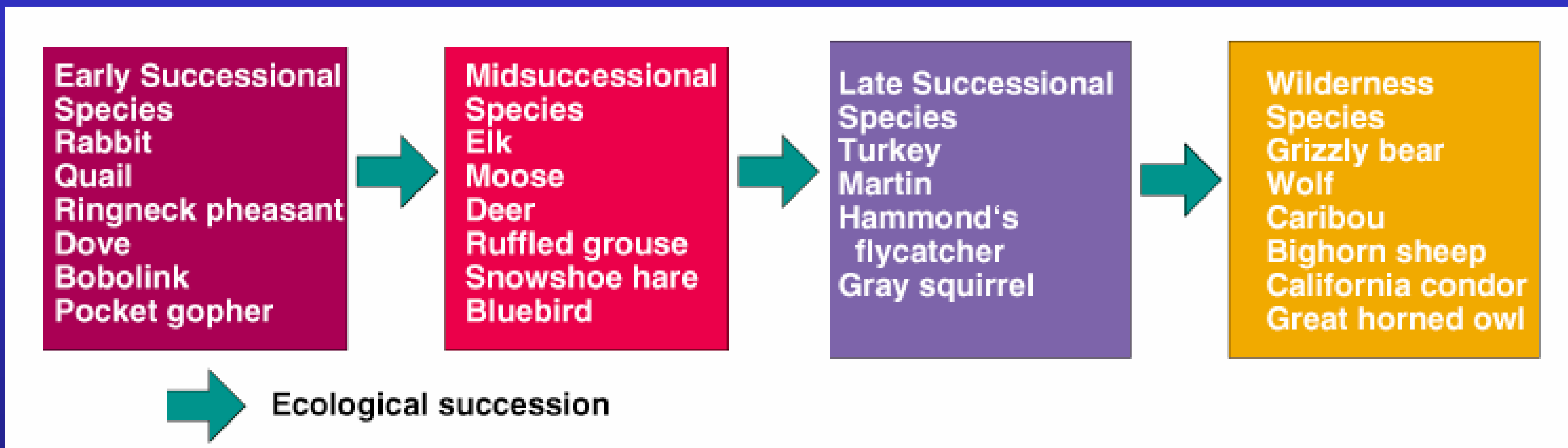


Fig. 9–22

Mechanisms of Succession

Both primary & secondary succession are driven by three mechanisms:

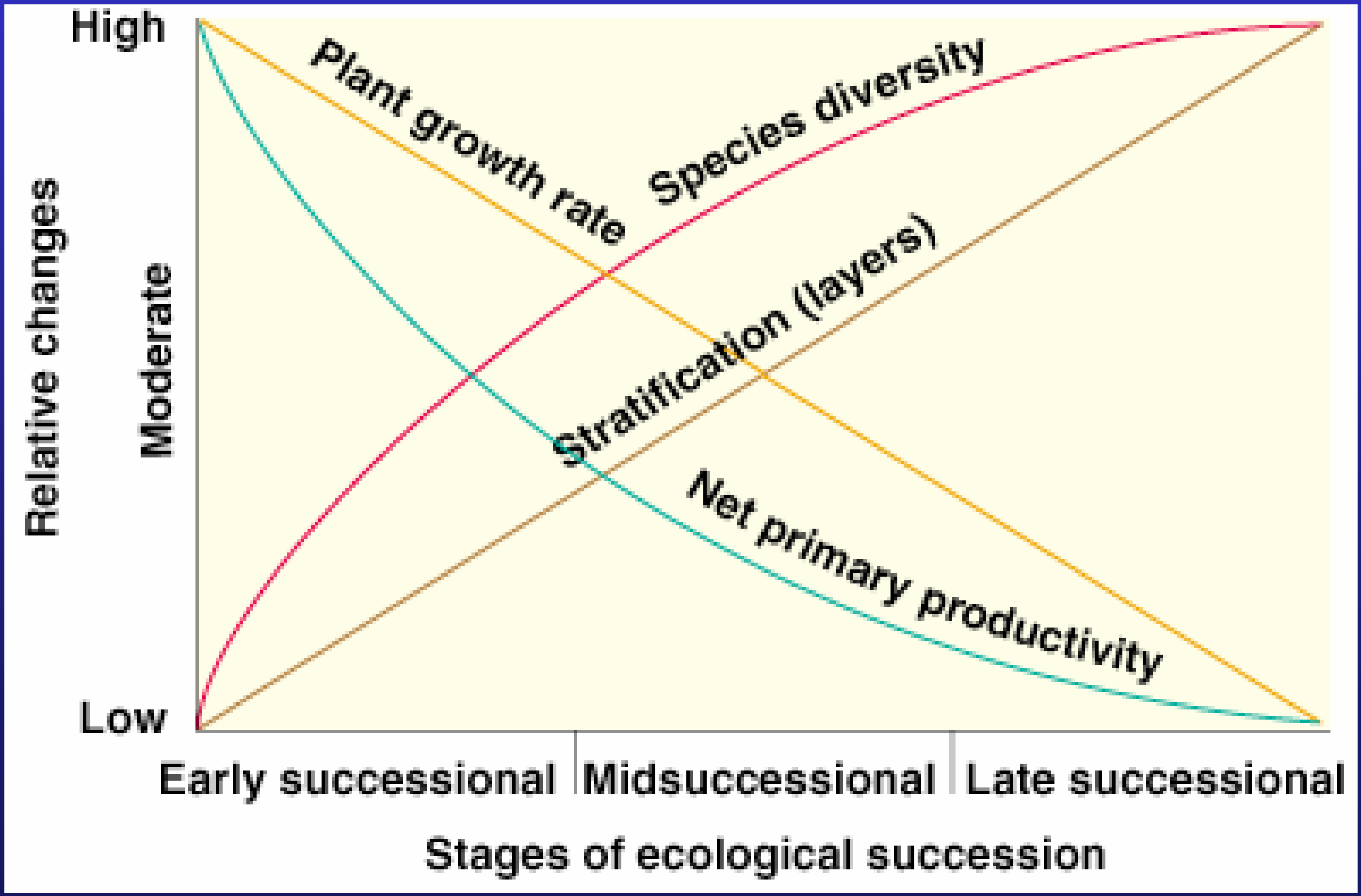
- **facilitiation**: a process by which an earlier successional species makes the environment suitable for later successional species; e.g., legumes fixing nitrogen can enable later successional species;
- **inhibition**: a process whereby one species hinders the establishment & growth of other species; e.g., shade of late successional trees inhibits the growth of early successional trees;
- **tolerance**: a process whereby later successional species are unaffected by earlier successional species.

•http://www.mantelsaat.com/images/rhizobium.jpg

•http://z.about.com/d/gardening/1/0/G/G/JapPaintedFernMohonk05.JPG

Changes During Succession

During succession species diversity & stratification tend to increase, while growth rates & primary productivity tend to decrease.



Ecosystem Changes During Succession

Characteristic	**Early Succession**	**Late Succession**
Plant size	small	large
Species diversity	low	high
Trophic structure	mostly producers	mixture of producers, consumers, & decomposers
Ecological niches	few, more generalized	many, more specialized
Community organization (# links)	low	high
Biomass	low	high
Net Primary Productivity	high	low
Food web	simple	complex
Efficiency for nutrient cycling	low	high
Efficiency of energy use	low	high

What is the role of disturbance in succession?

- **disturbance**: a discrete event that disrupts an ecosystem or community;
- examples of *natural disturbance*: fires, hurricanes, tornadoes, droughts, & floods;
- examples of *human–caused disturbance*: deforestation, overgrazing, plowing;
- disturbance initiates secondary succession by eliminating part or all of the existing community, & by changing conditions & releasing resources.

•http://www.uoregon.edu/~donovan/images/Forest%20Fire.bmp

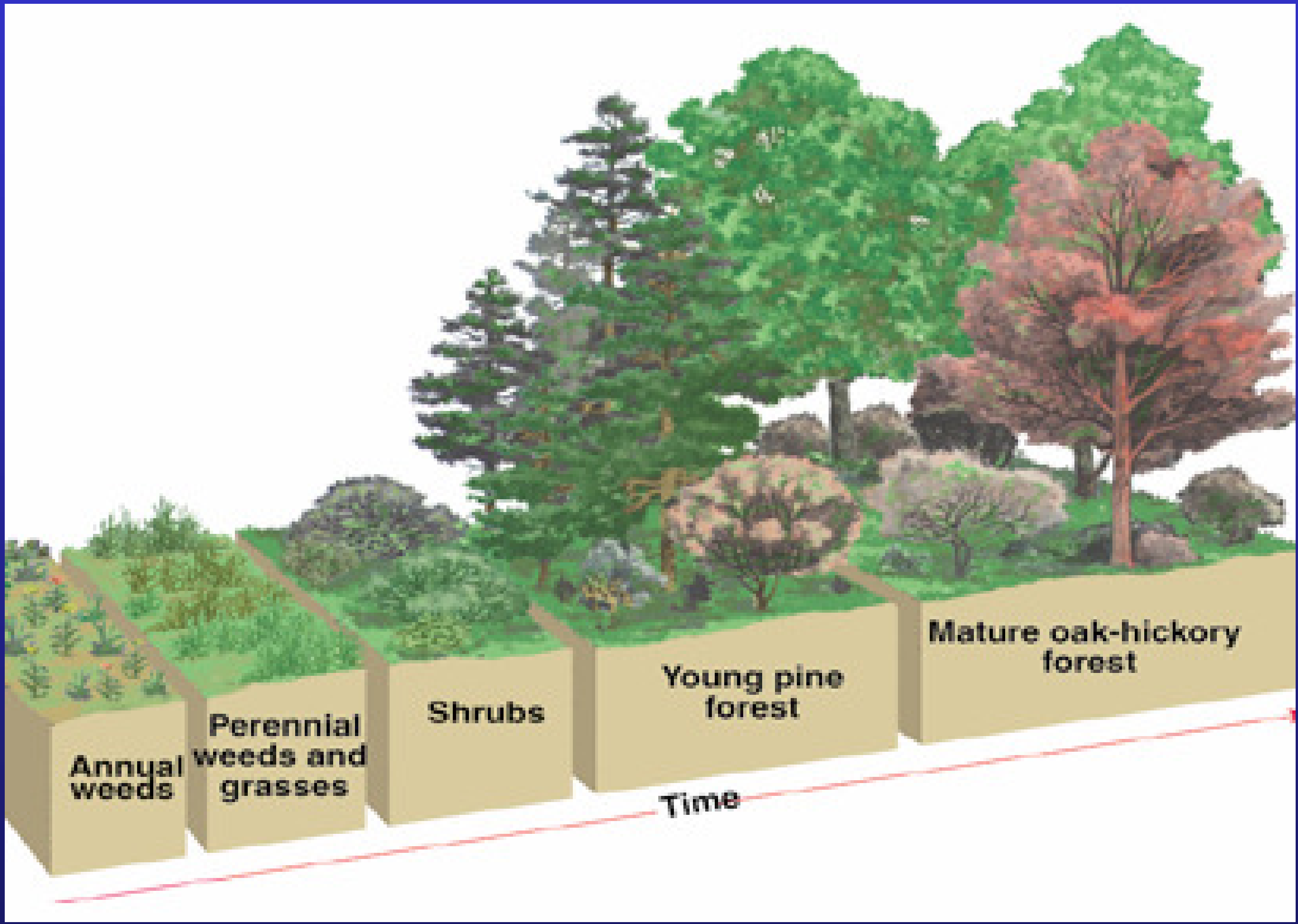
Secondary Succession

Secondary succession occurs where the natural community of organisms has been disturbed, removed, or destroyed.

- example: "old field succession" in eastern North America, where agricultural fields go through succession from herbaceous plants, to shrubs & early successional trees, to mid–successional forest, to oak–hickory forest;
- according to the classic view, succession proceeds until an area is occupied by a **climax community**, however recent views recognize that succession is influenced by variability & chaotic events such that a single climax is not predictable.

Secondary Succession

Secondary succession over 150–200 years in an abandoned farm field in North Carolina.



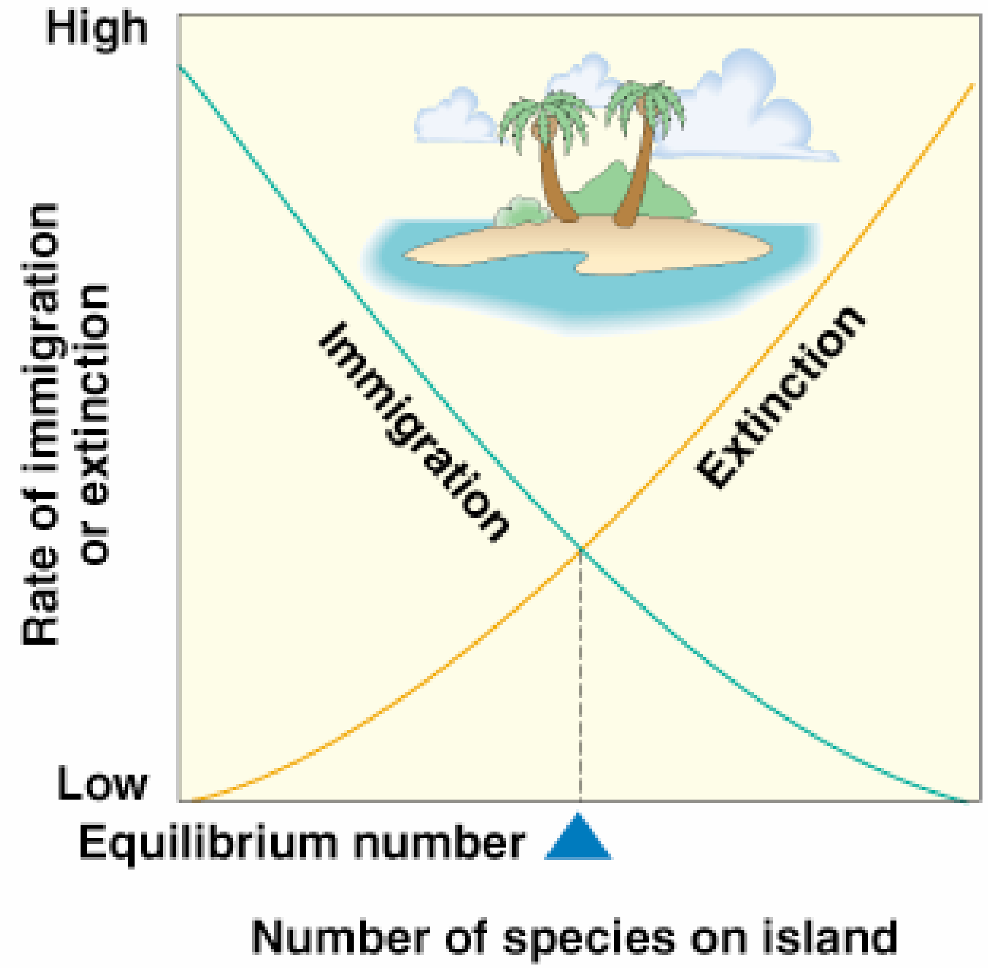
6. Island Biogeography

An international conservation group is interested in establishing an island habitat as a natural preserve. To ensure that the island will contain as much biodiversity as possible, several factors have to be considered. Which of the following sites would be the best choice for a biologically diverse natural preserve and why?

- **Site A**: Several islands clustered together approximately 200 miles off the western coast of Australia (Latitude 30° S) measuring a total of 603,547 square kilometers
- **Site B**: One island approximately 100 miles off the eastern coast of Brazil (Latitude 5° S) measuring 756,092 square kilometers
- **Site C**: One island approximately 300 miles off the southern coast of Thailand (Latitude 10° N) measuring 134,289 square kilometers

Island Biogeography

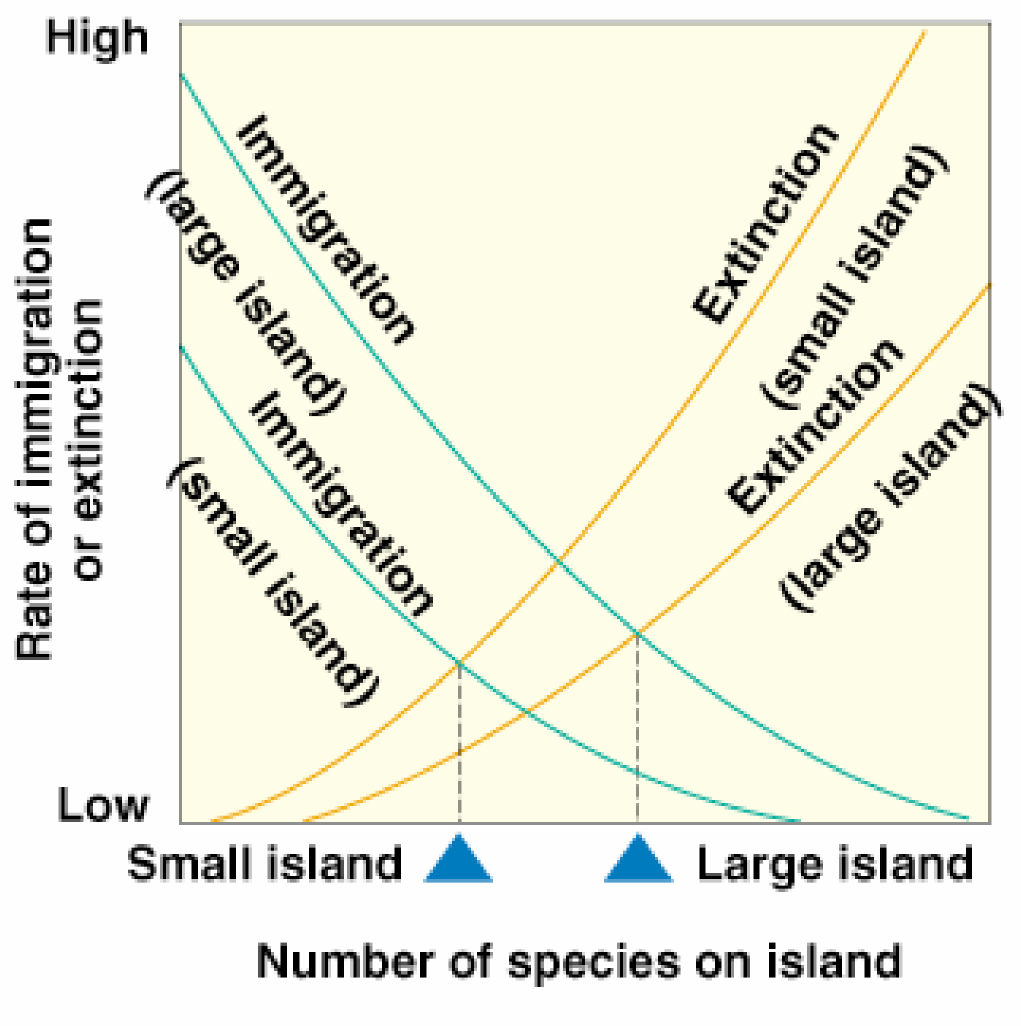
In the species equilibrium model of island biogeography (developed by Robert MacArthur & Edward O. Wilson) the number of species on an island is determined by the balance between immigration & extinction.



(a) Immigration and extinction rates

Island Biogeography

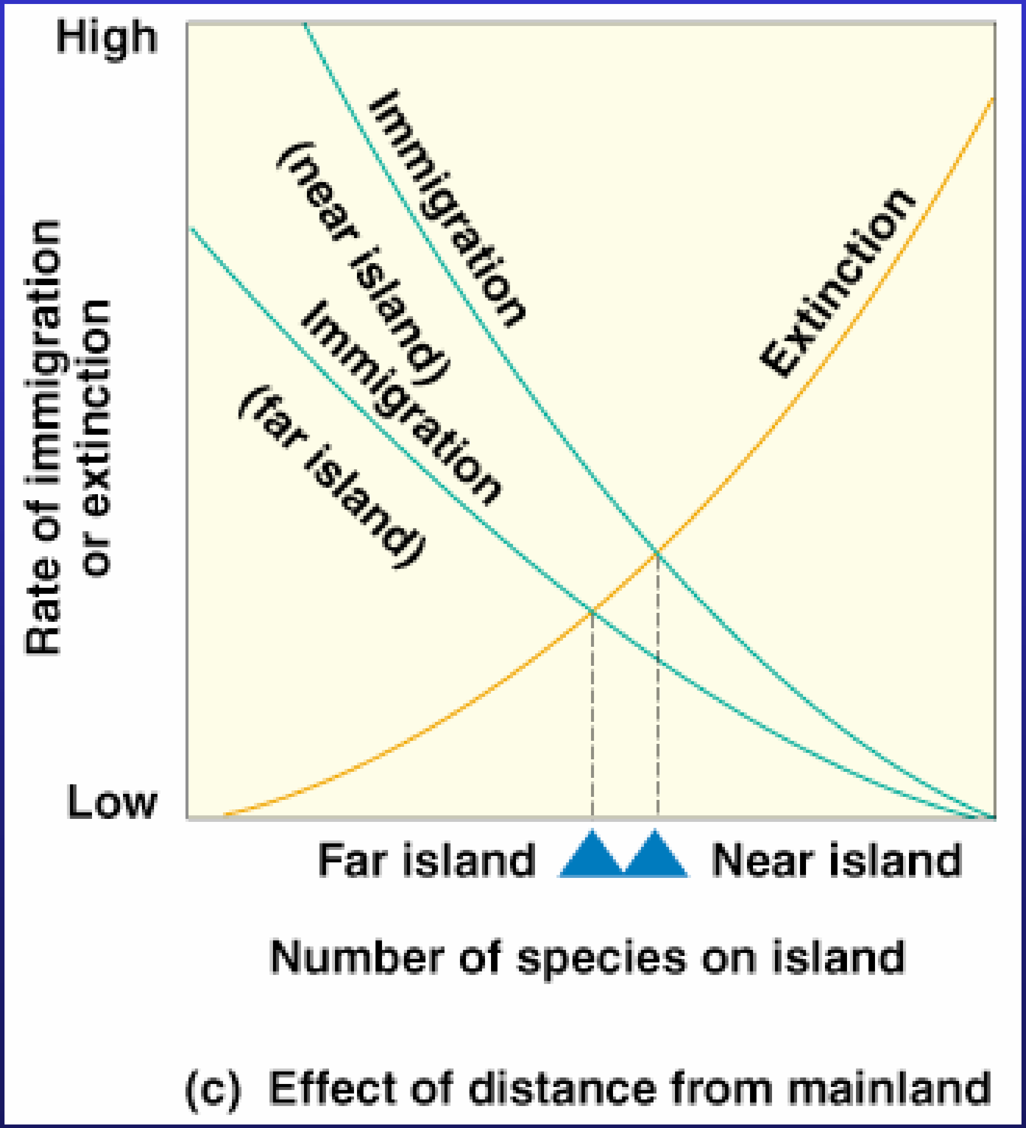
Small islands are expected to have lower immigration rates & higher extinction rates, & hence less species than large islands.



(b) Effect of island size

Island Biogeography

Far islands are expected to have lower immigration rates, & hence less species than near islands.



Island Biogeography

The model of island biogeography has been widely applied in conservation biology by viewing the landscape as composed of habitat islands separated by an ocean of degraded or unsuitable habitat modified by human activity.

- large habitat patches tend to have more species;
- habitat patches that are near larger intact habitat areas tend to have more species;
- these principles can be applied to land preservation & management efforts.

7. Stability & Sustainability

Stability has three aspects:

- **inertia** (or **persistence**): the ability of a system to resist being disturbed or altered;
- **constancy**: the ability of a living system to maintain a certain size or state;
- **resilience**: the ability of a living system to recover after a disturbance;

Signs of poor health or stressed ecosystems:

- decrease in primary productivity;
- increased nutrient losses;
- decline or extinction of indicator species;
- increased populations of pests or disease organisms;
- decline in species diversity;
- presence of contaminants.