ECOLOGICAL SUCCESSION

Ecological Succession

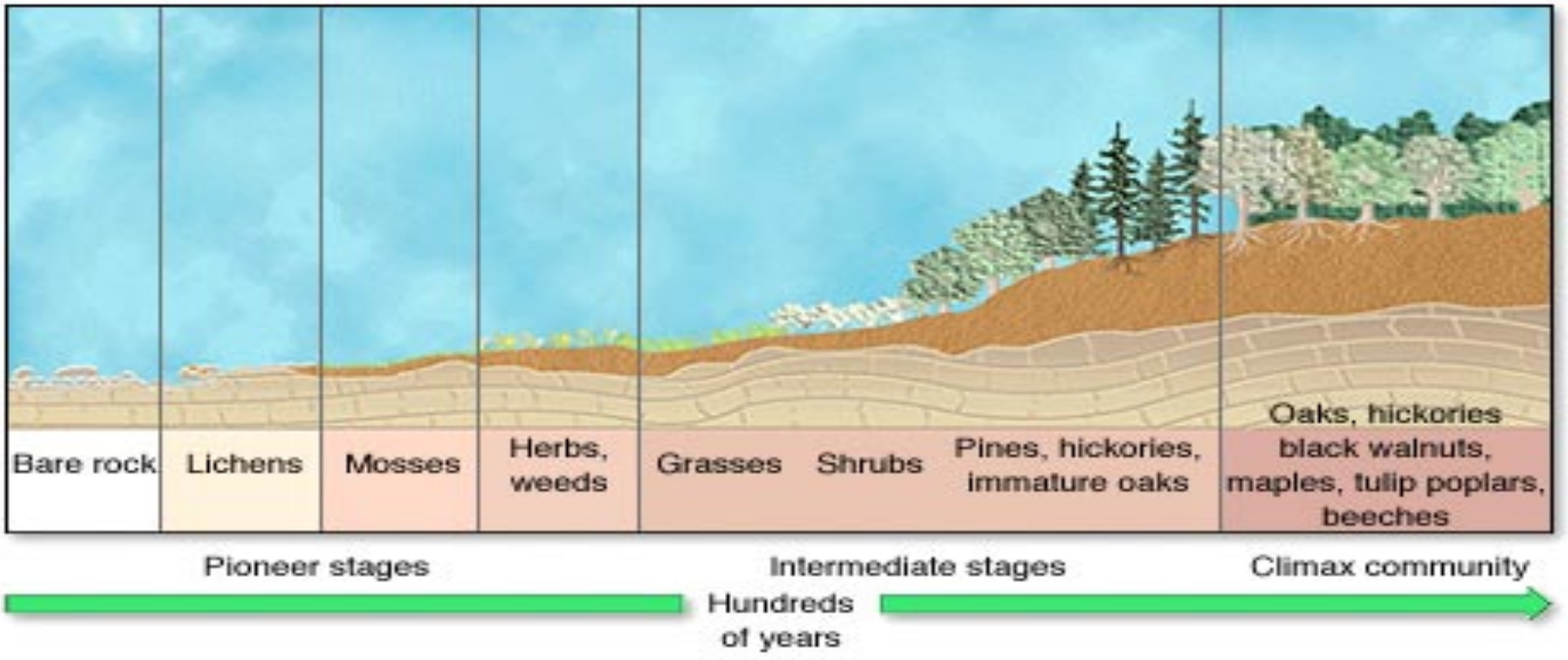
- Change of environment involving a series of species replacements in a community

  -refers to more or less predictable and orderly changes in the composition or structure of an ecological community.

- Initiated either by formation of new, unoccupied habitat (*e.g.*, a lava flow or a severe landslide) or by some form of disturbance (*e.g.* fire, logging) of an existing community.
- Two types:
  - **Primary**
  - **Secondary**

Primary Succession

- The development of an ecosystem in an area that has never had a community living within it occurs by a process called PRIMARY SUCCESSION.
- An example of an area in which a community has never lived before, would be a new lava or rock from a volcano that makes a new island.



- Simple plants first – no or shallow roots.
- In general, communities in early succession will be dominated by fast-growing, well-dispersed species (opportunist, fugitive, or r-selected life-histories)
- As succession proceeds, these species will tend to be replaced by more competitive (k-selected) species.

Lichens begin growing on the rocks. Over many years lichens break down rock into sand.
Weathering and erosion break down rock into sand.

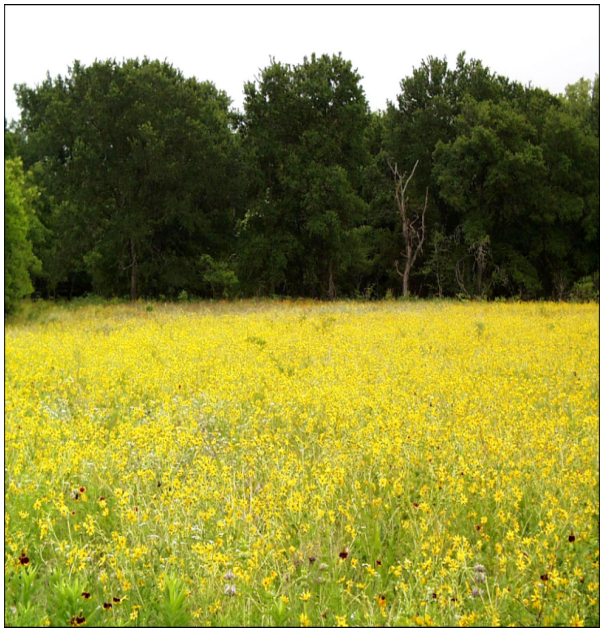
Lichens that do not need soil to survive
Called **PIONEER SPECIES**
(Why?)

Pioneer species—first species to begin a succession.

Lichens grow larger. Some die. Decomposers arrive and break down the lichens. The dead lichens and waste materials of the decomposers enrich the sand. Nitrogen cycle begins. Eventually enough nutrients enter the sand and it becomes soil.

Herbs and weeds can grow in the thicker, enriched soil

The simple plants die, adding more organic material
The soil layer thickens, and grasses, wildflowers, and other plants begin to take over



Medium sized animals and birds make this their habitat.
The vegetation grows closer together, reducing the amount of space available for growing.
Competition between lichen and shrubs for the same space. Eventually one species (lichen) will die out (or move) and the other species will survive (shrubs).

These plants die, and they add more nutrients to the soil

Shrubs and trees can survive now

Insects, small birds, and mammals have begun to move in….
What was once bare rock now supports a variety of life

These plants die, and they add more nutrients to the soil
Now larger trees can grow

The climax community

A climax community is a mature, stable community that is the final stage of ecological succession.

In an ecosystem with a climax community, the conditions continue to be suitable for all the members of the community.

Any particular region has its own set of climax species, which are the plants that are best adapted for the area and will persist after succession has finished, until another disturbance clears the area.

Does not always mean big trees

- -Grasses in prairies
- -Cacti in deserts

Two main physical factors determine the nature of the climax community that develops in an area. These are temperature and the amount of rainfall.

If we place the amount of rainfall on a graph's "x" axis, from 0-10, 10-20,and 20-30+ inches and the temperature along the "y" axis from hot, moderate, to cold, the various types of ecosystems will fit into the graph based on the conditions that they require.

Temperature			
Cold	Cold desert	Tundra	Taiga
Moderate	Temperate forest	Grassland	Deciduous forest
Hot	Hot desert	Savanna	Tropical forest
Rainfall (inches)	0-10	10-20	20-30+

Summary of changes that occur during succession

- Pioneer species colonize a bare or disturbed site. Soil building.
- Changes in the physical environment occur (e.g., light, moisture).
- New species of plants displace existing plants
  -because their seedlings are better able to become established in the changed environment.
- Newly arriving species alter the physical conditions, often in ways that enable other species to become established.

- Animals come in with or after the plants they need to survive.
- Eventually a climax community that is more or less stable will become established and have the ability to reproduce itself.
- Disturbances will start the process of succession again.

General trends..

- Newland→ primary succession → pioneers→ seral stage→ subclimax→ climax

Examples

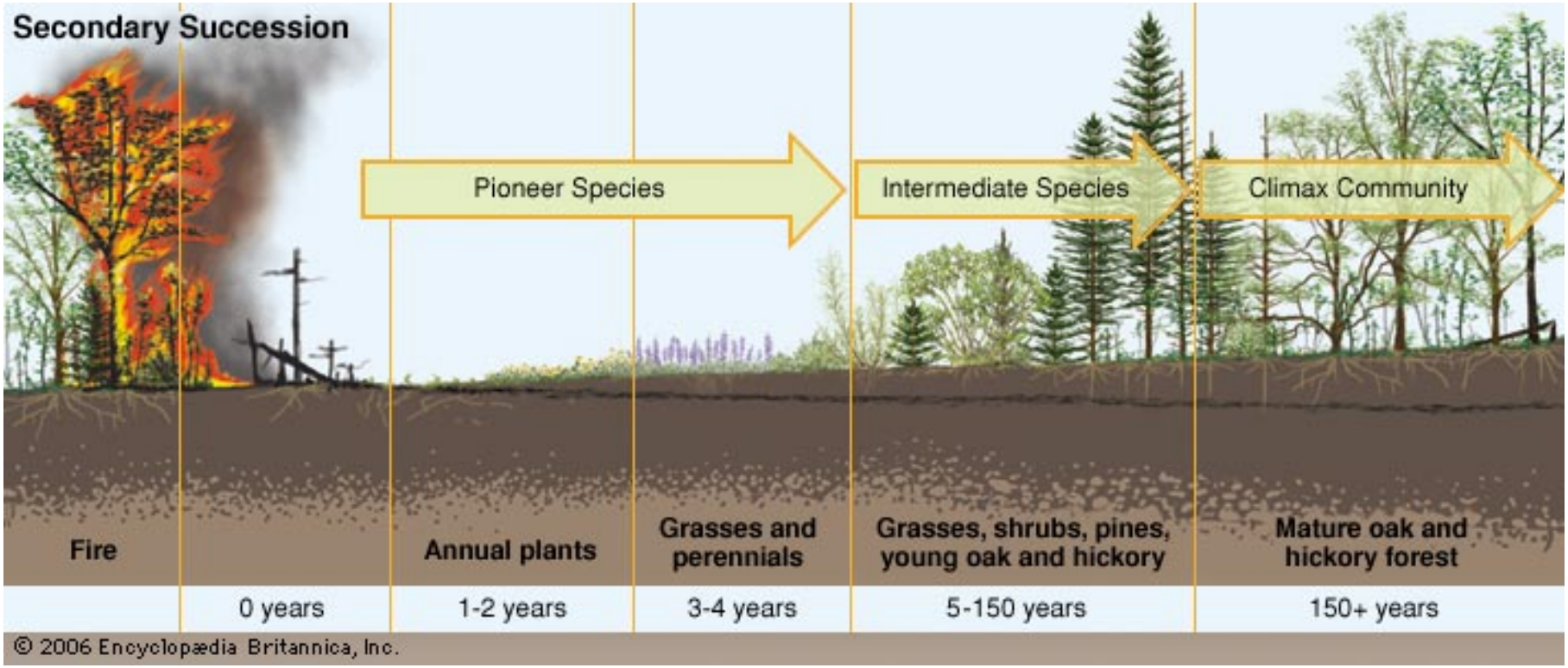
General trend of primary succession in a terrestrial and aquatic environment

- Bare rock→ Lichens (pioneer) →mosses →herbs and grasses →shrubs (woody plants) → trees→ forest (stable stage).

- Water pond →water plants(floating and submerged) →papyrus and grasses →forest(stable stage)

Secondary succession

Organisms are destroyed but the soil is safe.
The soil already contains the seeds of weeds, grasses, and trees.
More seeds are carried to the area by wind and birds.
Succession begins again but the primary species are different.
Because soil is present, this succession is faster.



An abandoned corn field

a.

b.

c.

d.

e.

Process:

Disturbance, s.a bush fires clears the area of vegetation

1. Some seeds in the soil begin to grow.
2. Larger shrubs move in.
3. Fast growing trees (such as pines) move in.
4. These are followed by slower-growing hardwood trees

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Process of community change in secondary succession

- forest→ cultivation grasses→ shrubs→ trees→ forest→ stable stage
- Secondary succession is usually more rapid as the colonizing area is rich in leftover soil, organic matter and seeds of the previous vegetation.

Causes of plant succession

- May be ***autogenic*** or ***allogenic***
- *Autogenic succession* is brought by changes in the soil caused by the organisms there. E.g.

  -accumulation of organic matter in litter or humic layer,

  -alteration of soil nutrients, change in pH of soil by plants growing there.
- The structure of the plants themselves can also alter the community.

  -For example, when larger species like trees mature, they produce shade on to the developing forest floor that tends to exclude light-requiring species.

S.no.	Autogenic Succession	Allogenic Succession
1.	Succession in which the species themselves bring a change in the environment during the process of succession.	Succession in which external environmental factors bring a change in the environment during succession.
2.	Changes are caused by endogenous factors.	Changes are caused by exogenous factors.
3.	Driven by biotic components of the ecosystem.	Driven by abiotic components of the ecosystem.

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- *Allogenic changes* are caused by external env't influences and not by the vegetation e.g.

-soil changes due to erosion, leaching or the deposition of silt and clays can alter the nutrient content and water relationships in the ecosystems.

-Animals also play an important role in allogenic changes as they are pollinators, seed dispersers and herbivores. can also increase nutrient content of the soil in certain areas, or shift soil about (as termites, ants, and moles do) creating patches in the habitat.

This may create regeneration sites that favor certain species.

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-*Climatic factors may be very important, but on a much longer time-scale than any other e.g. temp and rainfall patterns.*

-*As the climate warmed at the end of each ice age, great successional changes took place. The tundra vegetation and bare glacial till deposits underwent succession to mixed deciduous forest.*

-*The greenhouse effect resulting in increase in temperature is likely to bring profound allogenic changes in the next century.*

-*Geological and climatic catastrophes such as volcanic eruptions, earthquakes, avalanches, meteors, floods, fires, and high wind also bring allogenic changes.*

Climax concept

"Succession stops when the sere has arrived at an equilibrium or steady state with the physical and biotic environment"

- Barring major disturbances, it will persist indefinitely.
- This end point of succession is called climax.
- The final or stable community in a sere is the *climax community* or *climatic vegetation*.
- It is self-perpetuating and in equilibrium with the physical habitat.

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- **However, the idea has been largely abandoned by modern ecologists in favor of non-equilibrium ideas of how ecosystems function.**

Why???

>>most natural ecosystems experience disturbance at a rate that makes a "climax" community unattainable.

>>Climate change often occurs at a rate and frequency sufficient to prevent arrival at a climax state.

>>additions to available species pools through range expansions and introductions can also continually reshape communities.

- **Coupled with the stochastic nature of disturbance events and other long-term (e.g., climatic) changes, such dynamics make it doubtful whether the 'climax' concept ever applies or is particularly useful in considering actual vegetation.**

Characteristics of climax

- The vegetation is tolerant of environmental conditions.
- It has a wide diversity of species, a well-drained spatial structure, and complex food chains.
- The climax ecosystem is balanced.

  -gross pri. pdn and total resp.,

  -energy used from sunlight and energy released by decomposition,

  -uptake of nutrients from the soil and the return of nutrient by litterfall to the soil.
- Individuals in the climax stage are replaced by others of the same kind. Thus the species composition maintains equilibrium.
- It is an index of the climate of the area. The life or growth forms indicate the climatic type.

Types of climax

- *Climatic Climax*

If there is only a single climax and the development of climax community is controlled by the climate of the region, it is termed as climatic climax.

Climatic climax is theoretical and develops where physical conditions of the substrate are not so extreme as to modify the effects of the prevailing regional climate.

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Edaphic Climax

When there are more than one climax communities in the region, modified by local conditions of the substrate such as soil moisture, soil nutrients, topography, slope exposure, it is called *edaphic climax*.

Succession ends in an edaphic climax where topography, soil, water, fire, or other disturbances are such that a climatic climax cannot develop.

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Disclimax

- When a stable community, which is not the climatic or edaphic climax for the given site, is maintained by man or his domestic animals, it is designated as Disclimax (disturbance climax) or anthropogenic subclimax (man-generated).
- For example, overgrazing by stock may produce a desert community of bushes and cacti where the local climate actually would allow grassland to maintain itself.

Mechanism/Driving forces of succession

F.E. Clement (1916)

- Clement's concept is usually termed '*classical ecological theory*'.
- According to Clement, succession is a process involving several phases:

1. *Nudation*: Succession begins with the development of a bare site i.e. exposure of a land surface, called nudation (disturbance).
2. *Migration*: It refers to arrival of propagules e.g. seeds, spores etc.
3. *Ecesis:* It involves establishment and initial growth of vegetation. The seeds and spores germinate and get established.

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4. *Competition:* As vegetation become well established, grow, and spread, various species begin to compete for space, light and nutrients (both intra and interspecific)
5. *Reaction:* During this phase autogenic changes affect the habitat resulting in replacement of one plant community by another.

   In other words the living community starts to modify the physical environment i.e. the habitat which is the primary cause of succession.
6. *Stabilization:* Reaction phase leads to development of a climax community.

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Seral communities

- A seral community is an intermediate stage found in an ecosystem advancing towards its climax community.
- In many cases more than one seral stage evolves until climax conditions are attained.
- Depending on the substratum and climate, a seral community can be one of the following:

  -Hydrosere- Community in water

  -Lithosere-Community on rock

  -Psammosere- Community on sand

  -Xerosere - Community in dry area

  -Halosere-Community in saline body (e.g. a marsh)

General changes during succession

- Species composition changes continuously but the change is more rapid in the earlier than in the later stages of succession
- The total number of species represented increases initially and then becomes stable and declines in the older stages
- Biomass and non-living organic matter increases until a stable stage is reached(production=respiration)
- The food web become more complex and feeding becomes specialized due to increase in diversity and ecological niches

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- Proportion of structures e.g. burrows parts and territory markers-considered as stores of information tend to increase.
- As diversity of species increase, there is corresponding increases in resource partitioning.
- Trophic specialization increase overall efficiency in the advanced stages of succession (less wastage).
- In the later stages, relative constancy of numbers is achieved. Natural trends are towards a reduction in the number of offspring produced and better protection for the young.

Changes in animal life

- Animal life also exhibit changes with changing communities.
- In lichen stage the fauna is sparse. It comprises few mites, ants and spiders living in the cracks and crevices.
- The fauna undergoes a qualitative increase during herb and grass stage. The animals found during this stage include nematodes, insects' larvae, ants, spiders, mites, etc.
- The animal population increases and diversifies with the development of forest climax community.

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