Fundamentals in Ecology

Week 5

Community ecology 2

Grossiord Charlotte

Bachelor 2 - SIE

Schedule of the lectures

Room for all lectures:

ELD020

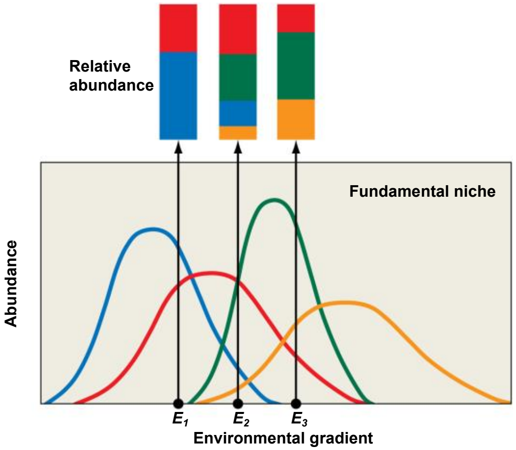
WEDNESDAY - LECTURES - ENV 220			Week	Teacher
19/2/2025	10h15-12h	The nature of ecology (introduction)	**1**	**T. Battin**
26/2/2025	10h15-12h	The physical environment	**2**	**T. Battin**
5/3/25	10h15-12h	Adaptations to the environment/Physiological ecology	**3**	**C. Grossiord**
12/3/25	10h15-12h	Population structure, dynamics, and regulation	**4**	**C. Grossiord**
19/3/25	10h15-12h	Community Ecology I	**5**	**C. Bachofen**
26/3/2026	10h15-12h	Community Ecology II	**6**	**C. Grossiord**
2/4/26	10h15-12h	Ecosystem ecology I	**7**	**T. Battin**
9/4/26	10h15-12h	Ecosystem ecology II	**8**	**T. Battin**
16/4/2026	10h15-12h	Biodiversity and conservation ecology	**9**	**C. Grossiord**
23/4/2025		**Easter Holiday**		
30/4/2025		**ENAC Week**		
7/5/24	10h15-12h	Climate Change impacts on terrestrial ecosystems	**10**	**C. Grossiord**
14/5/2024	10h15-12h	Climate Change impacts on aquatic ecosystems	**11**	**T. Battin**
21/5/2025	10h15-12h	Restoration ecology. Principles of ecosystem restoration, case studies	**12**	**T. Battin**
28/5/2025	10h15-12h	Applied ecology. Review and course wrap-up	**13**	**C. Grossiord**

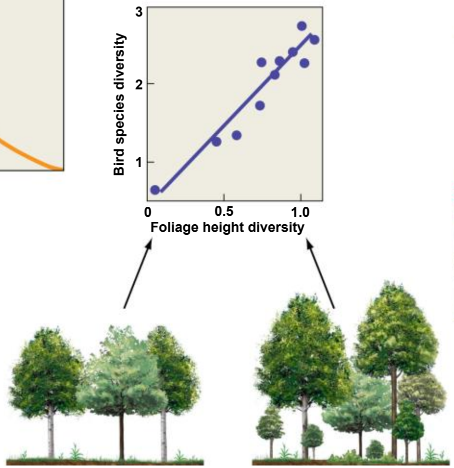
Schedule of the practicals

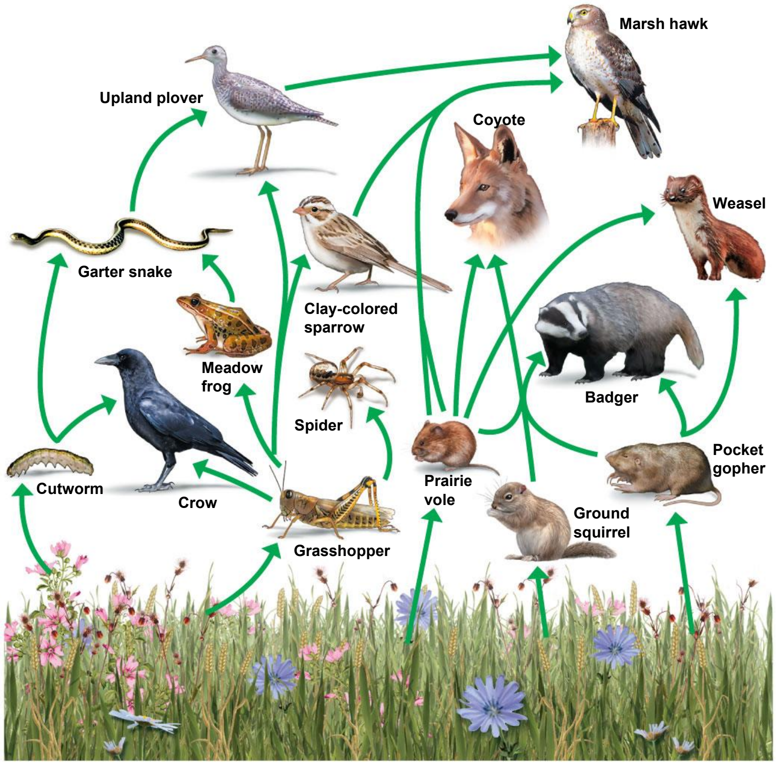
THURSDAY - PRACTICALS - ENV 220			Week	Important deadlines
20/02/25	11h15-13h	Introduction to practicals	1	
27/02/25	11h15-13h	Setting up experiments	2	Inform the experimental setup to TAs by email by 26/02/25
6/3/25	11h15-13h	How to write a report	3	
13/03/25	11h15-13h	Introduction to R	4	
20/03/25	11h15-13h	Field measurements 1	5	
27/03/25	11h15-13h	Data visualization in R	6	
3/4/25	11h15-13h	Field measurements 2	7	
10/4/25	11h15-13h	How to do statistical analyses	8	
17/04/25	11h15-13h	Field measurements 3	9	
24/04/25	Easter Holiday			
1/5/25	ENAC Week			
8/5/25	11h15-13h	Field measurements 4	10	
15/05/25	11h15-13h	Data Analysis/Interpretation	11	Weighting of plant material in GR B2 423 before 15/05/25
22/05/25	11h15-13h	Questions / Discussion	12	
REPORT SUBMITTED on MOODLE BY 06/06/25				

What you saw in the previous lecture

Community Ecology 1







Factors influencing the structure of communities

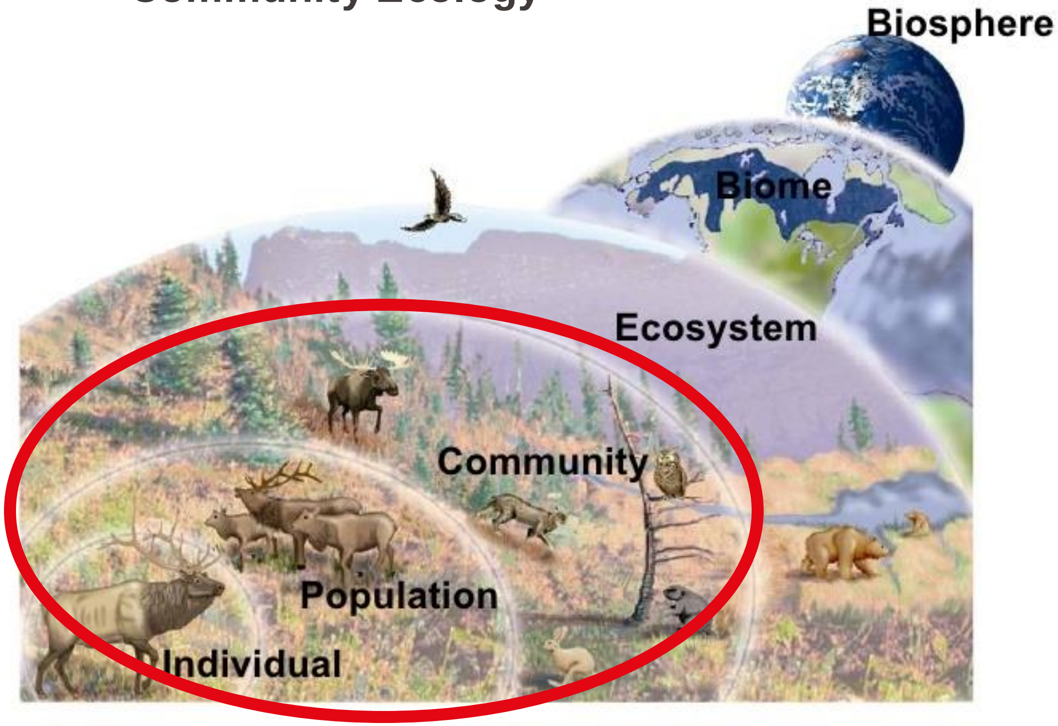
(1) Using the cards, recreate the trophic chain in the French countryside

(2) After the Second World War, France launched a large management plan to feed the country and increase agricultural yields (*Le grand remembrement*). Hedges and groves were removed to increase the size of fields and allow tractors to pass.

Exercise: Identify how that change in management affected the whole community.

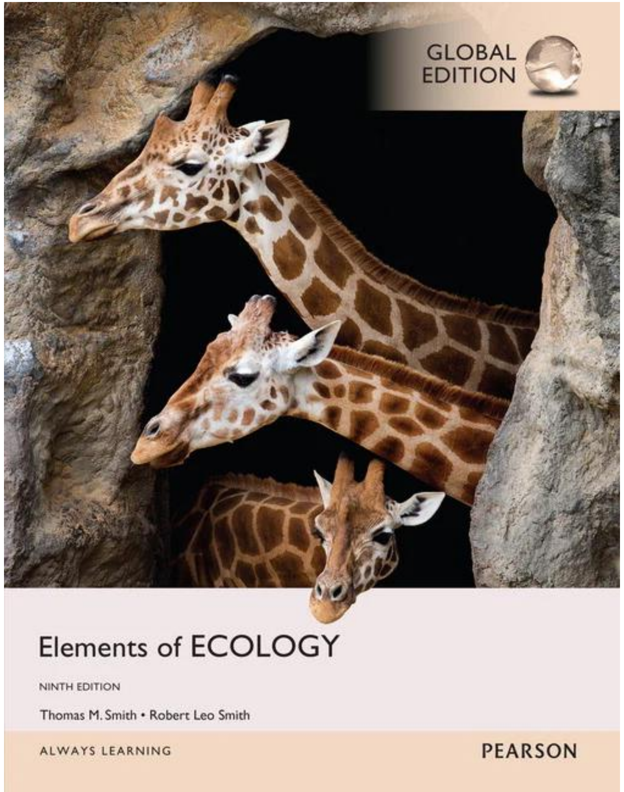
Overview of today's class

Community Ecology



I. Community Dynamics

References to today's class



Smith, TM. & Smith RL. Elements of Ecology, Global Edition (Pearson)

1. Community dynamics

As we saw last week, community structure changes **across space** (zonation) as populations respond to changing environmental conditions, influenced by species interactions.

Community structure (physical and biological components) varies also **in time.**

1. Community dynamics


Fig. 7.1a Muir Glacier, 1941


Fig. 7.1b Muir Glacier, 2004

1. Community dynamics

Succession - the temporal change in community structure at a given location.

Example on the right: abandoned cropland can go through succession once they are no longer tended.

- First, grasses and weedy herbaceous plants colonize.
- Then shrubs invade.
- Over time, shrubs are replaced by pine trees, eventually forming a closed-canopy forest.
- Hardwood trees begin to occupy the understory.
- Eventually, deciduous hardwoods dominate the landscape.

Generalized representation of succession on an abandoned agricultural field in eastern North America.

1. Community dynamics

A **sere** is the sequence of communities seen in succession, i.e., from grass, to shrub, to forest.

Each of the changes is a **seral stage**, a point on the continuum of vegetation through time.

These stages can often be recognized as distinct communities with distinct characteristic structures and species compositions:

- Stages may last years or decades.
- Some stages may be missed or abbreviated/altered.

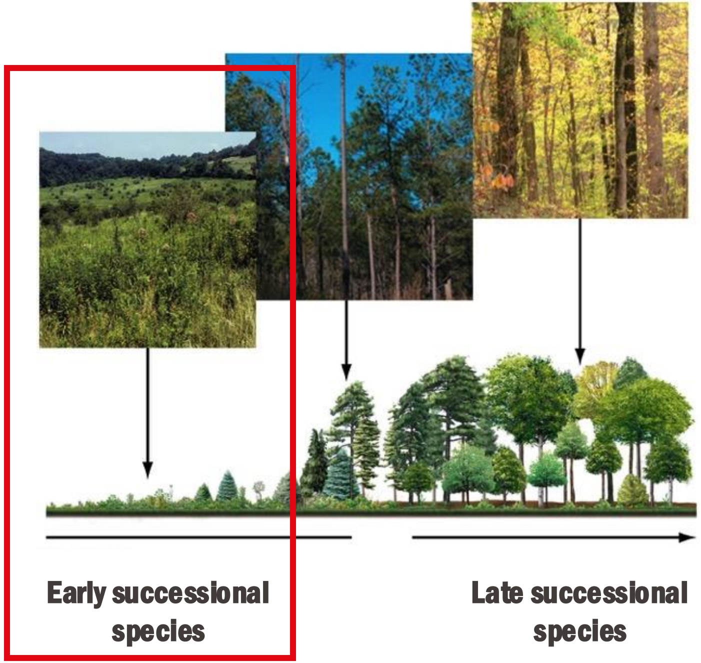
Like zonation, the succession process is seen in terrestrial and aquatic environments.

1. Community dynamics

Early successional species are the initial colonists, or pioneer species. They often share specific characteristics/traits:

- high growth rates
- smaller size
- high degree of dispersal and colonization
- high rates of per capita population growth.

Lichens are the ultimate early successional species

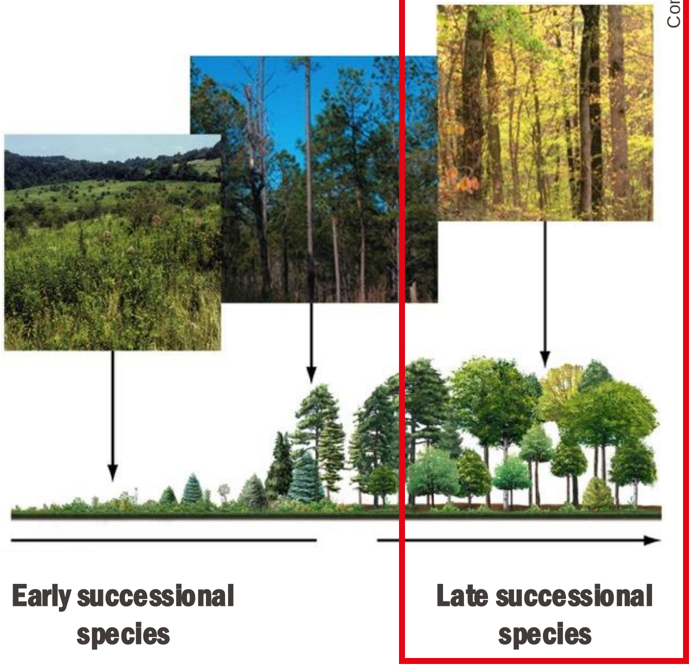


1. Community dynamics

Late successional species arrive later. They often have:

- longer lifespans
- larger size
- lower rates of dispersal and colonization
- lower rates of per capita population growth.

Hardwood tree species like oak are typical late successional species



These patterns of replacement through time are **not random**.

1. Community dynamics

Comparison of ecological and physiological characteristics of early and late successional plants:

- Seed dispersal
- Photosynthetic response
- Acclimation potential
- Recovery from disturbance

Early and late successional plants have contrasting physiological characteristics that allow survival in contrasting conditions of early and late habitats

Table 18.1 Physiological characteristics of early and late successional plants

Attribute	Early Successional	Late Successional
Seeds		
dispersal in time	long	short
secondary (induced) dormancy	common	uncommon
Seeds		
germination enhanced by light	yes	no
fluctuating temperatures	yes	no
high nitrogen concentrations	yes	no
Light saturation intensity	high	low
Light compensation point	high	low
Efficiency at low light	low	high
Photosynthetic rates	high	low
Respiration rates	high	low
Transpiration rates	high	low
Stomatal conductance	high	low
Acclimation potential	high	low
Recovery from resource limitation	fast	slow
Resource acquisition rates	fast	slow

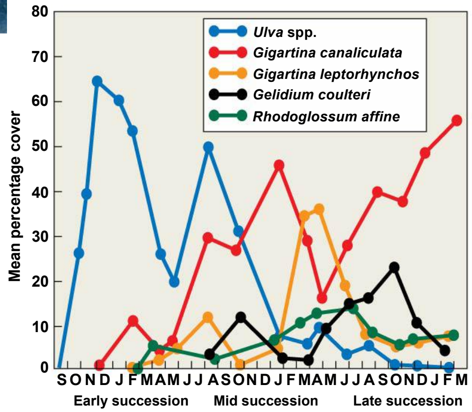
(Adapted from Bazzaz 1979.)

1. Community dynamics

Example of succession in a rocky intertidal algal community in Southern California:

- natural disturbance – wave action overturns rocks
- creates cleared surfaces that algae can colonize.

(a)



(b)

Experiment at the University of California-Berkeley, USA) – concrete blocks were placed along the shore to provide a new colonization surface.

A pattern of colonization and replacement was observed, with new species displacing populations that initially colonized the concrete blocks.

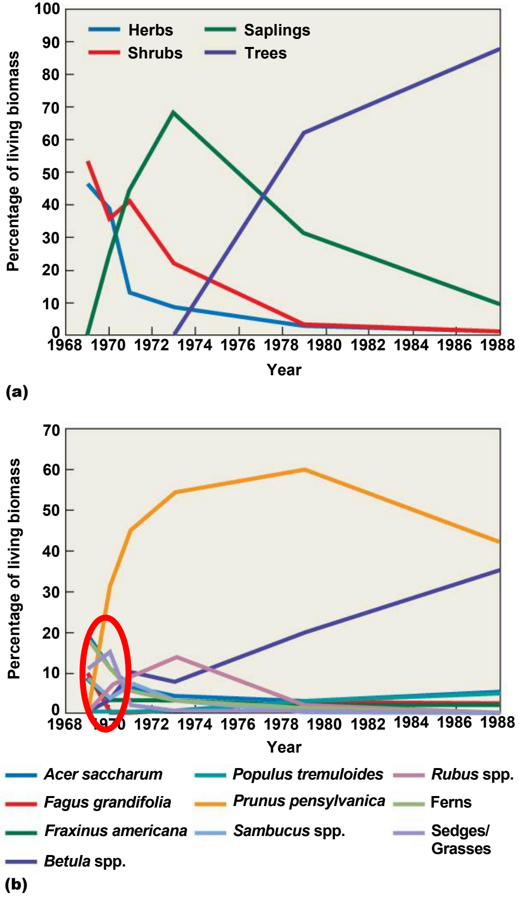
(a) Rocky intertidal zone along the California coast. (b) Mean percentage of five algal species that colonized the concrete blocks introduced into the rocky intertidal zone in September 1974. Note the change in species dominance over time.

1. Community dynamics

Example of the Hubbard Brook Experimental Forest (USA): Forest understory and canopy were dominated by beech and sugar maple. The forest was cleared in the late 1960s (all the large dominant trees, mainly beech and maple, were harvested).

1. Community dynamics

(1) Beech and maple seedlings that dominated the understory started declining (shade-tolerant trees could not deal with high light intensity).

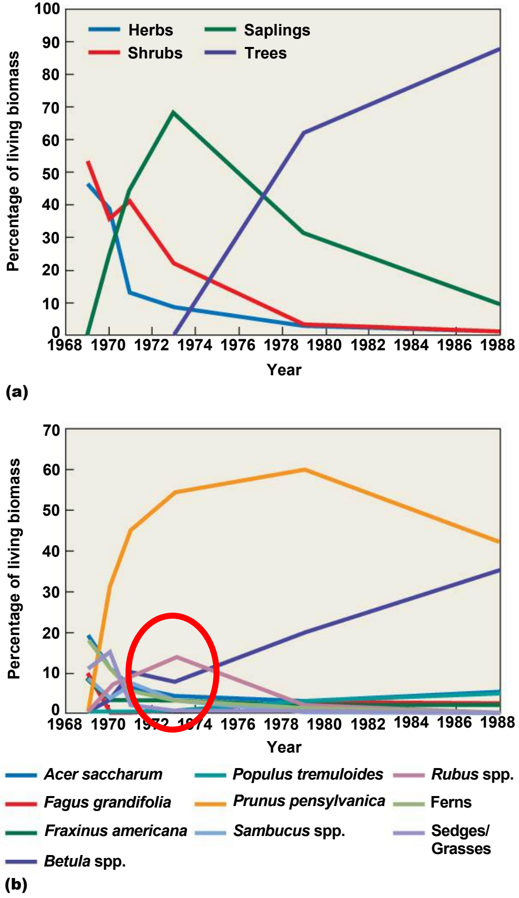


(a) Changes in the relative abundance (% of living biomass) of different plant growth forms in the Hubbard Brook Forest after a clear-cut. (b) Changes in the woody species that make up the sapling and tree categories over the same period.

1. Community dynamics

(1) Beech and maple seedlings that dominated the understory started declining (shade-tolerant trees could not deal with high light intensity).

(2) They were replaced by herbaceous species such as ferns, grasses, and seedlings of shade-intolerant, fast-growing tree species such as cherry and yellow birch.

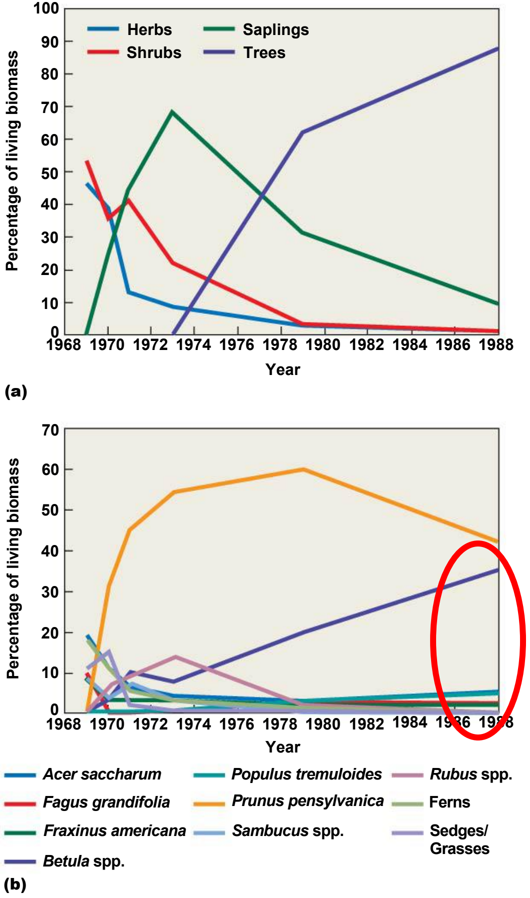


1. Community dynamics

(1) Beech and maple seedlings t
started declining (shade-tolerant
light intensity).

(2) They were replaced by herba
grasses, and seedlings of shad
species such as cherry and yello

(3) After 50 years, those early successional species are now being replaced by the later successional beech and sugar maple trees again.



(a) Changes in the relative abundance (% of living biomass) of different plant growth forms in the Hubbard Brook Forest after a clear-cut. (b) Changes in the woody species that make up the sapling and tree categories over the same period.

1. Community dynamics

These two studies illustrate the similarity of succession in two distinct environments. They also present examples of two different types of succession:

- **Primary succession** – occurs at a location that was not previously occupied by a community (with no soil); a newly exposed surface (rocky intertidal algal experiment).

- **Secondary succession** – occurs at a location previously occupied by a community and then underwent a disturbance that removed all or part of the existing community (Hubbard Brook Experimental Forest).

1. Community dynamics

Sites that can undergo **primary succession** include rock outcrops, cliffs, lava fields, sand dunes, and newly exposed glacial till.

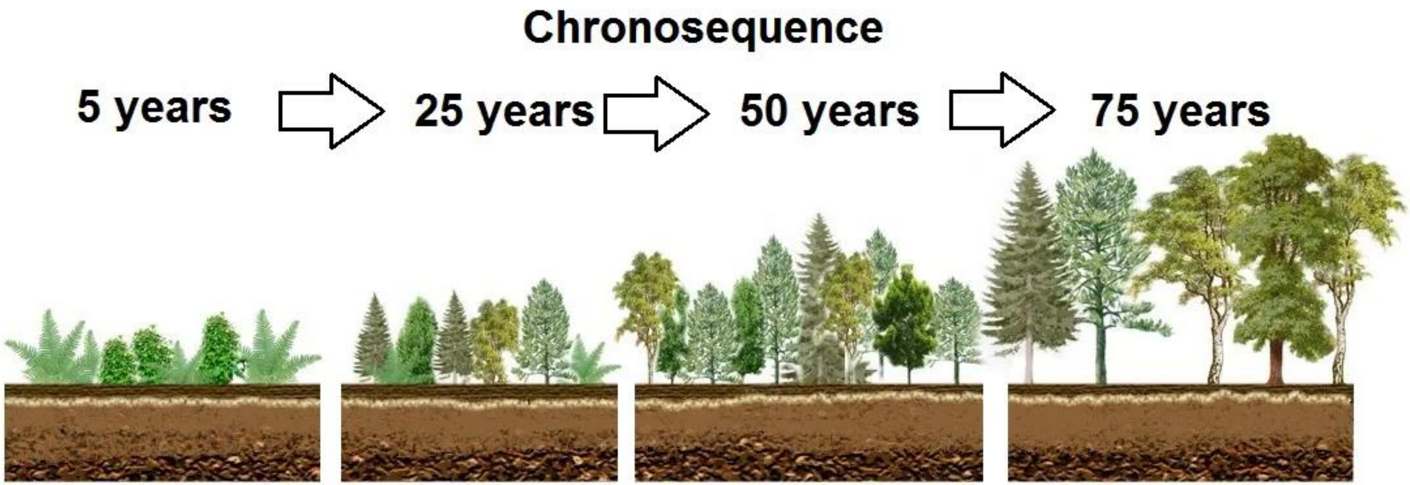
A sand dune is an inhospitable site that can undergo primary succession:

- Sand is a product of weathered rock, deposited by wind and water
- Often forms along the shores of lakes and oceans or on inland sand barrens
- Sand particles pile up in long, windward slopes.

1. Community dynamics

Example of a study that quantified the successional patterns in dunes by examining **a chronosequence.**

A **chronosequence** is a series of sites at different successional stages within an area.

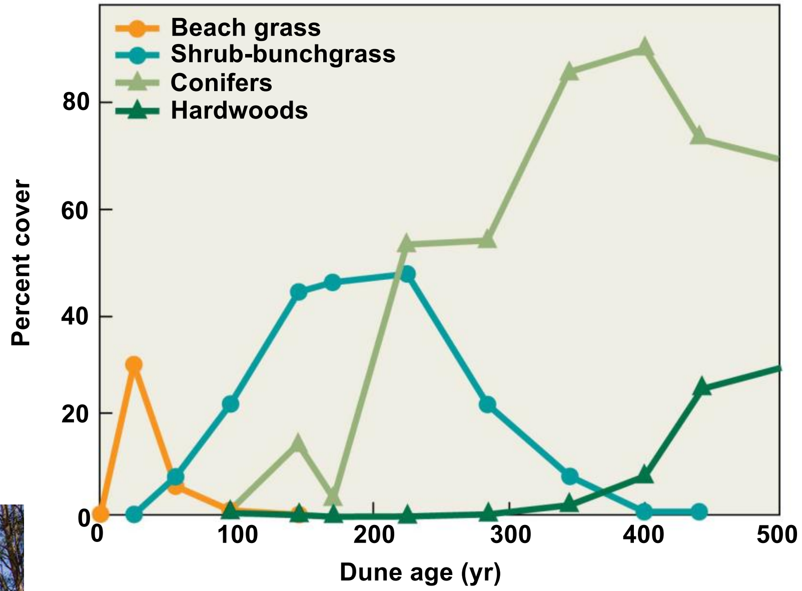


1. Community dynamics

→ First description of succession as an ecological phenomenon

In this example, the successional stages seen are like the order described earlier:

→ Pioneering species like grasses, mainly beach grass, stabilize the dune with extensive rhizomes
→ Mat-forming shrubs colonize
→ Trees invade (first pine, then oak).



Example of an early ecological study (1899) describing plant succession in coastal dunes along Lake Michigan. Changes in the percentage of cover of the dominant plant groups during primary succession of the dune systems along Lake Michigan. Data represent changes observed along a chronosequence of sites ranging in age from 25 to 440 years.

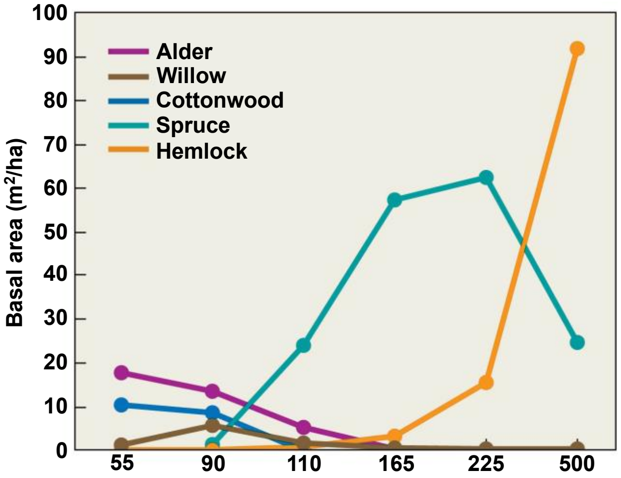
1. Community dynamics

Another example of primary succession is Glacier Bay National Park, Alaska (USA).

In Glacier Bay National Park, the glacier has been retreating for the past 200 years

- Various species, such as alder and cottonwood, initially colonize the newly exposed landscape.

- Late-successional species like spruce and hemlock replaced the early-successional ones.



Primary succession along riverine environments of Glacier Bay National Park. As the ice retreats, it leaves moraines along the edge of the bay in which primary succession occurs. The figure shows the changes in community composition (basal area of woody plant species) with age of sites (time since sediments first exposed).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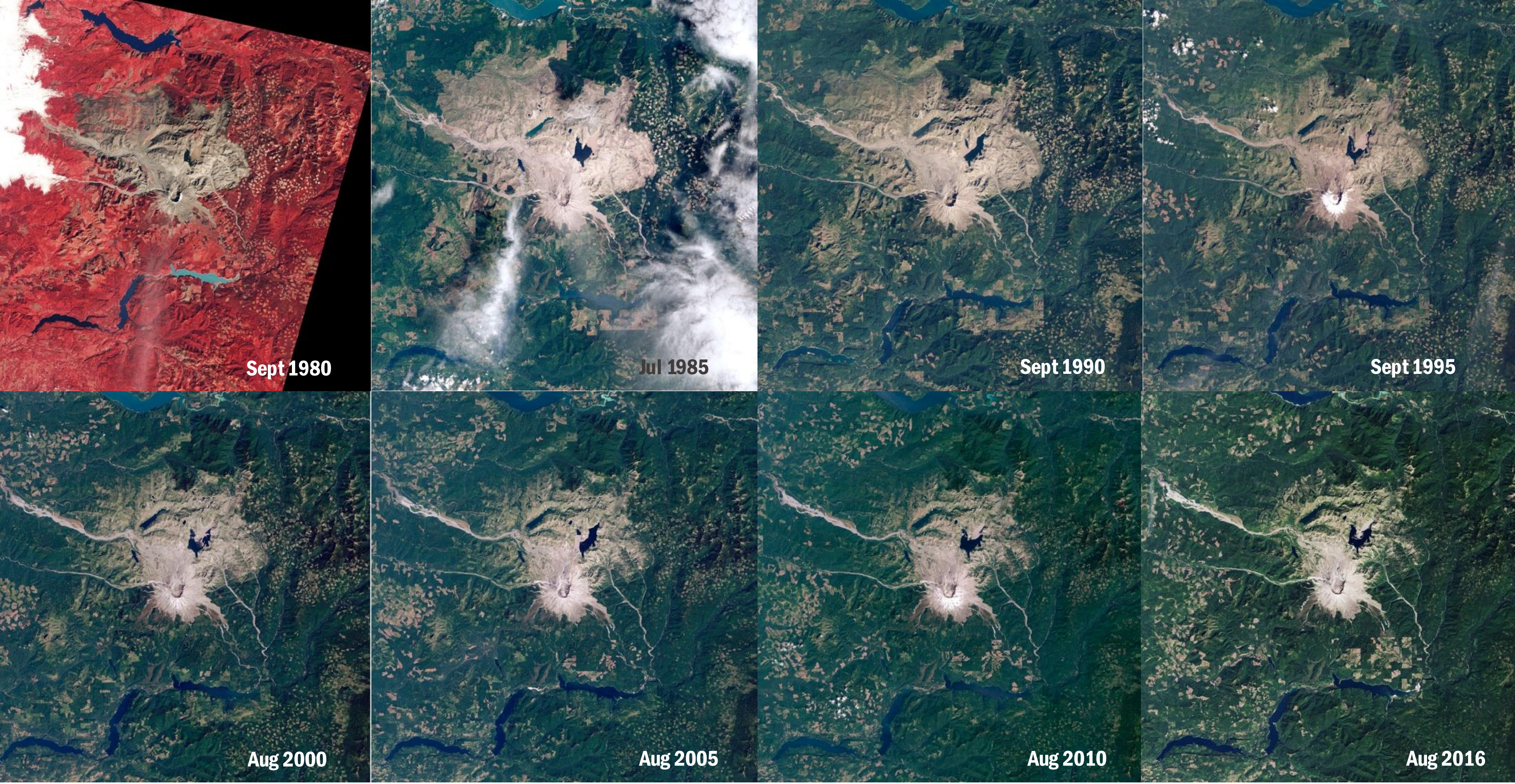


https://earthobservatory.nasa.gov/world-of-change/StHelens

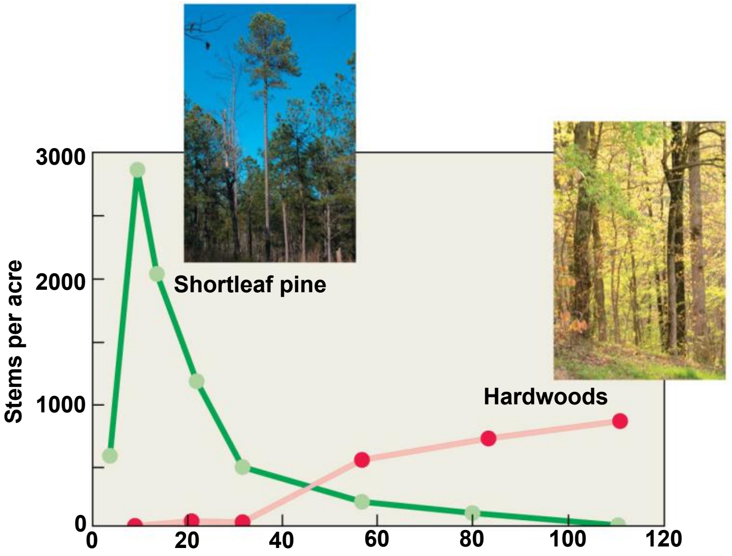
1. Community dynamics

Secondary succession takes place at a site that was previously occupied by a community (e.g. a site that underwent a disturbance that removed all or part of the existing community).

1. Community dynamics

Example from an old farmland :

- **First year** – crabgrass claimed the ground. Dormant seeds in the soil receive light and moisture and germinate. Horseweed seeds are blown in by the wind, germinate, and begin to grow in early winter. In the spring, it outcompetes the crabgrass.
- **Second year** – other plants begin to invade such as white aster, ragweed.
- **Third year** – broomsedge, a perennial bunchgrass, colonizes the field, which now has abundant organic material. Broomsedge can exploit soil moisture and dominates the field. Pine seedlings begin to grow in open areas.

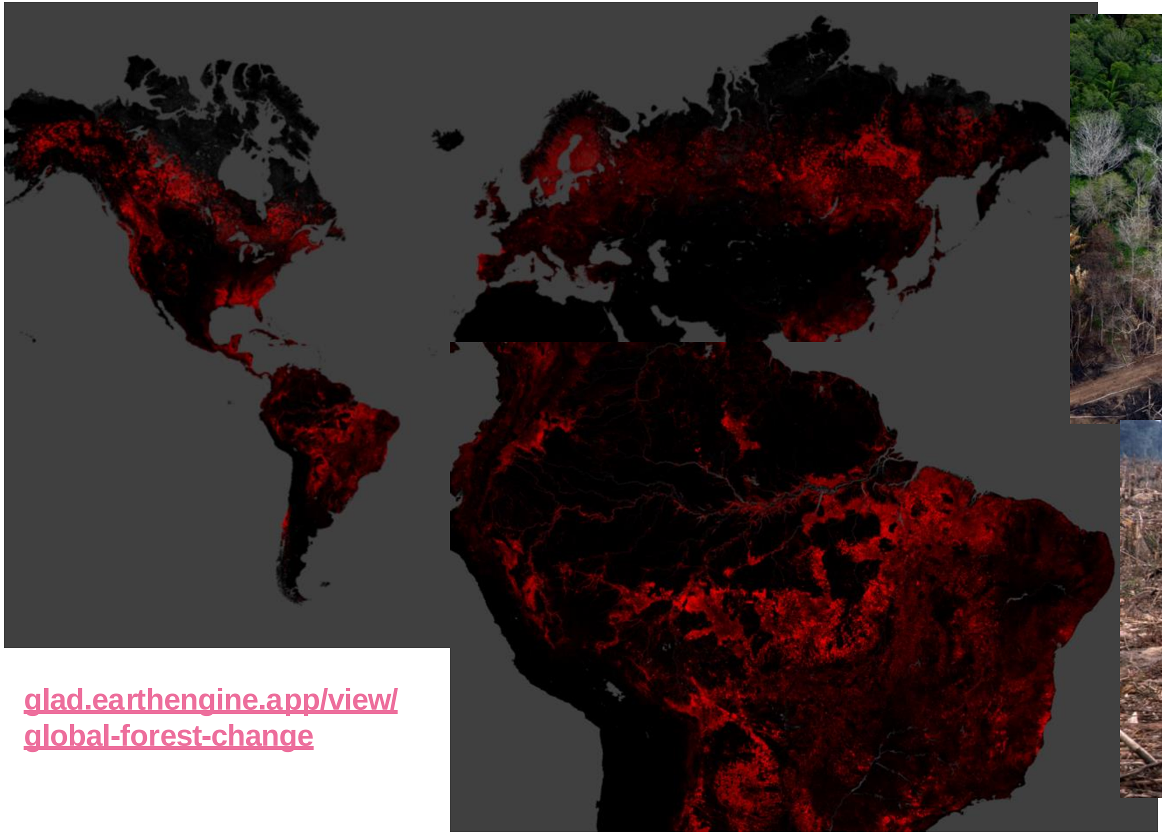


Decline in the abundance of shortleaf pine and increase in the density of hardwood species during secondary succession on abandoned farmland.

- **Five to ten years** – pines trees shade the broomsedge. Eventually, hardwood trees (ash and oak) grow up through the pines, replacing them as they die.

1. Community dynamics

Deforestation creates secondary succession worldwide



glad.earthengine.app/view/global-forest-change

1. Community dynamics

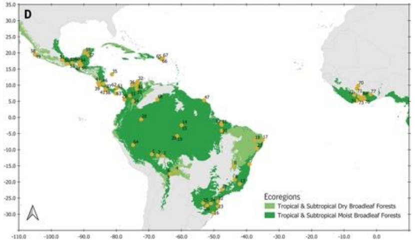
Restauration efforts through plantations cannot replace secondary succession

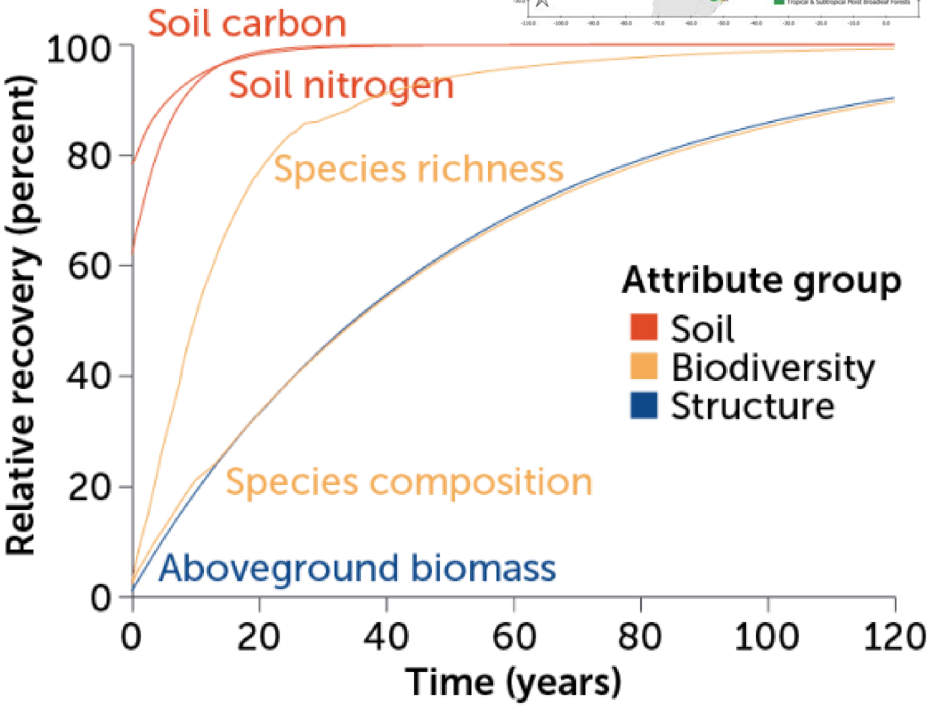
1. Community dynamics

How long does natural recovery take?

Recovery to old-growth values is fastest for soil (<1 decade) and plant functioning (<2.5 decades), intermediate for structure and species diversity (2.5 to 6 decades), and slowest for biomass and species composition (>12 decades)

Chronosequence data from 77 sites





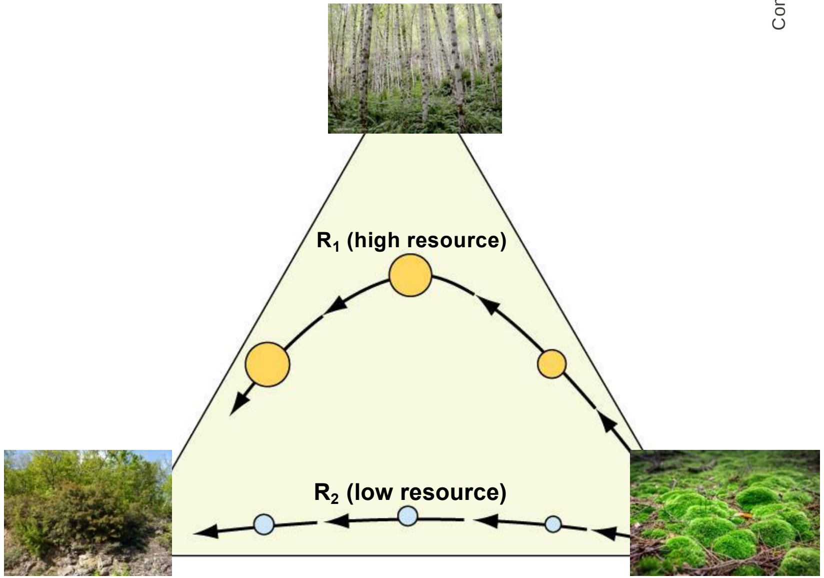
Predicted relative recovery trajectories over time for 12 forest attributes.

Poorter et al., 2021

1. Community dynamics

In 1979, J.P. Grime proposed three primary plant strategies to explain succession:

- ***R* (ruderal)** – species that can rapidly colonize disturbed sites. Small, short lived, resources allocated mainly to reproduction. Characteristics allow wide dispersal to newly disturbed sites.
- ***C* (competitive)** – species that live in predictable habitats with abundant resources. Resources are allocated mainly to growth, favoring resource acquisition and competitive ability.
- ***S* (stress)** – species that are stress-tolerant. Resources are allocated mainly to maintenance, characteristic of habitats with limited resources.

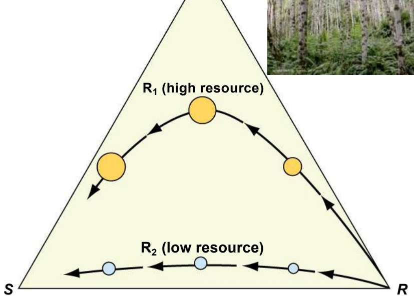


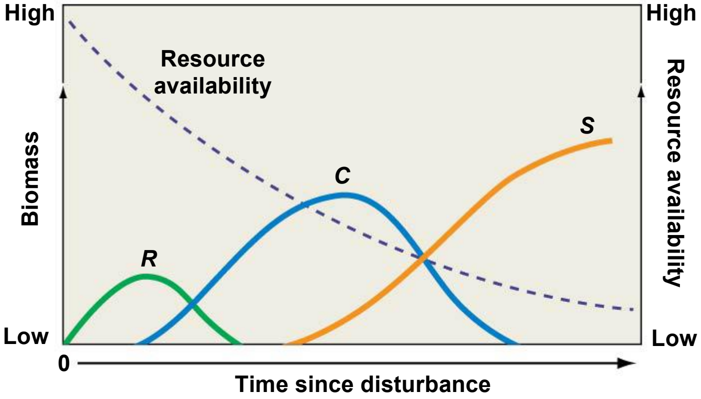
Grime's triangular model of plant strategies. The circles indicate the total amount of plant biomass at each stage of succession. The letters at each triangle corner represent the three primary plant strategies (*R*, *C*, and *S*). The trajectory for R_1 shows the greater importance of competitive species when resource availability is high. The role of *C* (competitive) species under low resources (curve R_2) would be low or absent.

1. Community dynamics

Succession is **a shift in dominance** of these three plant strategies in response to environmental conditions (habitat) changes.

- After a disturbance that initiates secondary succession, initially, R species are favored – essential resources are abundant; these species quickly colonize.
- Plant biomass increases, resource competition begins, C species are favored – better competitors.
- Eventually, resources become depleted, and S species replace the C species – stress tolerant can persist under low resources.





1. Community dynamics

The changes in environmental conditions that bring about shifts in the physical and biological structures of communities are varied. They can be grouped into two major classes:

- **Autogenic** environmental change results from the presence and activities of organisms within the community (e.g., vertical light gradients in forests).

- **Allogenic** environmental change results from a feature of the physical environment, i.e., is governed by physical rather than biological processes (e.g., decline in temperature with increased elevation, decrease in temperature with increased water depth).

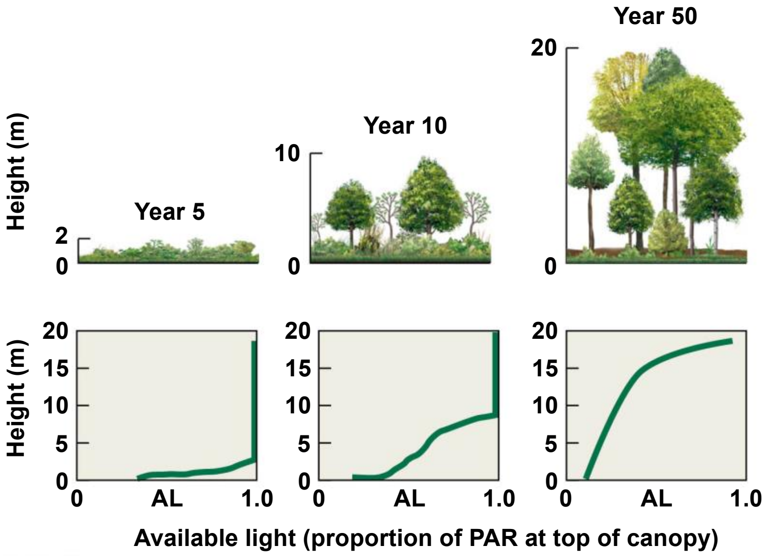
1. Community dynamics

Autogenic environmental change is a feature common to all plant succession, both primary and secondary.

Colonization alters environmental conditions like the light environment:

Early succession – high availability of light at the ground level; seedlings are successful

Later succession – taller plants reduce light availability at ground level, decrease the rate of photosynthesis, and slow the growth of shaded plants. This may benefit some slower-growing species that require reduced light levels when young.

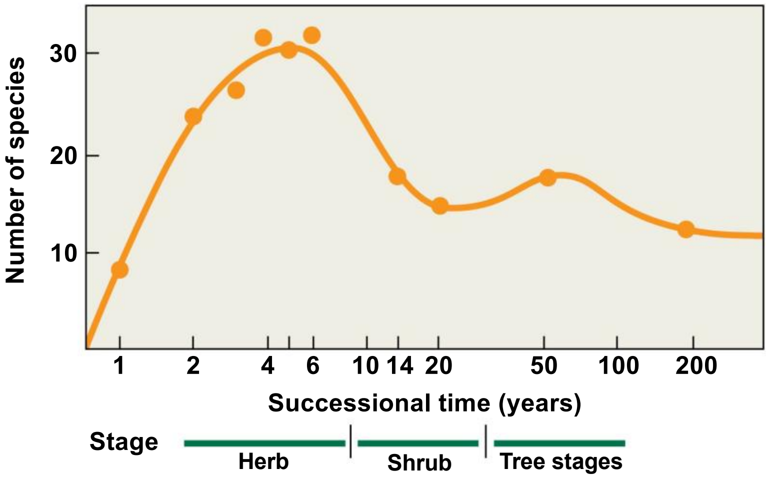


Changing vertical light profile through succession. Following the disturbance, the site is dominated by low-stature herbaceous vegetation. As time progresses, the stature of the vegetation increases, and as the canopy height increases, the vertical profile of light changes, reflecting the increased leaf area and range of height over which the leaf area is distributed.

1. Community dynamics

In addition to shifts in species dominance during succession, **patterns of plant diversity change** throughout succession.

- During the early phases of succession, diversity increases as new species colonize a site (see figure).
- As time progresses, species become replaced by slower-growing, shade-tolerant species.
- The peak in diversity during the middle stages of succession corresponds to the transition period (after the arrival of later successional species but before the decline of early successional species, i.e., when both types are still present).



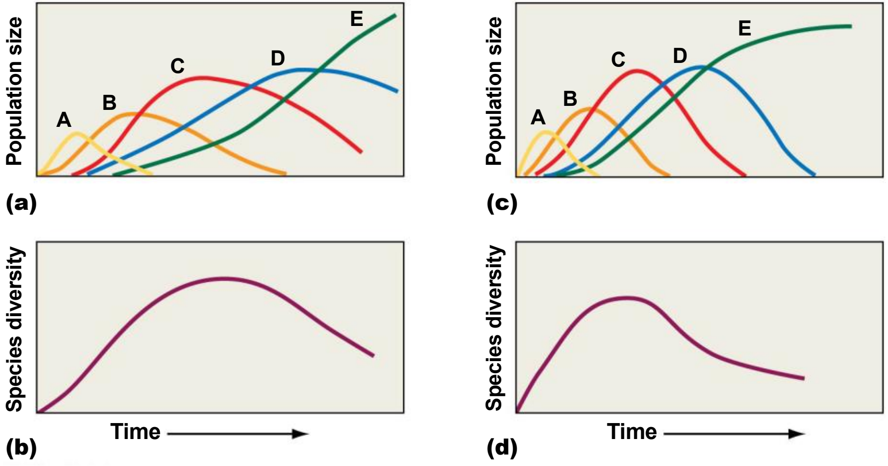
Changes in plant diversity during secondary succession in an oak–pine forest.

1. Community dynamics

The rate of species displacement, and thus variation in species diversity, is influenced by the growth rates of the species involved in the succession:

- Slow growth rates – displacement is slower (a)
- Fast growth rates – displacement is faster (c)

If the growth rate of competitors that displace early successional species is slowed, the period of coexistence (i.e., corresponding to a period of high species diversity) is extended (a,b *vs*. c,d).



(a) Hypothetical succession involving five plant species (A–E), and (b) the associated temporal pattern of species diversity. When the growth rates of the five species are doubled (c), the succession progresses more quickly, and (d) the pattern of species diversity reflects the earlier onset of competition and more rapid displacement of early successional species.

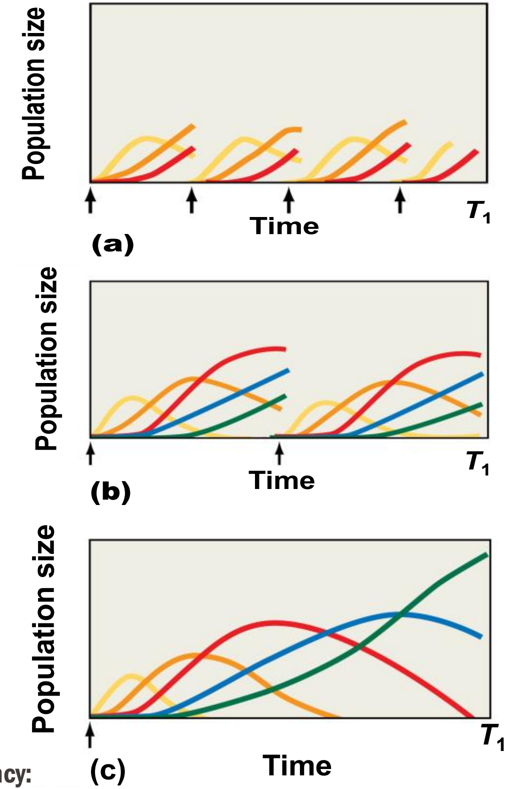
1. Community dynamics

The effect of disturbance can be similar to that of growth rates, extending/reducing the time of species coexistence.

(a) Under high disturbance frequency, the absence of later successional species reduces overall diversity.

(b) All species coexist at an intermediate frequency of disturbance, and diversity is at a maximum.

(c) When disturbance is absent, later successional species eventually displace the earlier ones, and again, diversity is low.



Patterns of succession for hive hypothetical plant species under three levels of disturbance. Frequency: frequent, intermediate and none. Time of the disturbance is shown as an arrow on the *x*-axis.

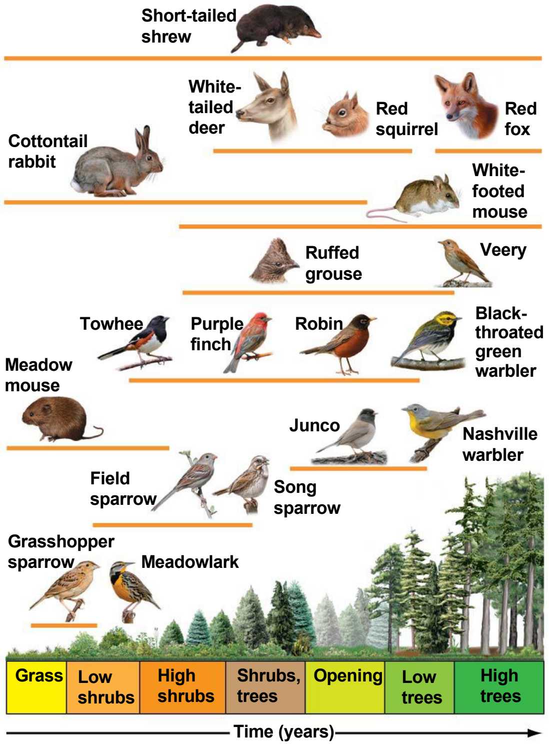
1. Community dynamics

As the plant community undergoes succession, the changes in the structure and composition of the vegetation affect the animals and other organisms that depend on the vegetation for habitat.

As seen in this example to the right, different species are seen in the early stages of succession than in the later stages:

- Grassland species disappear
- Shrubland species colonize
- Eventually, the shrubland species disappear and are replaced by forest animals.

The complexity of the vertical structure increases through succession, leading to higher animal diversity.



Changes in the composition of animal species inhabiting various stages of plant succession, from old-field to conifer forest. Species appear or disappear as vegetation density and height change.

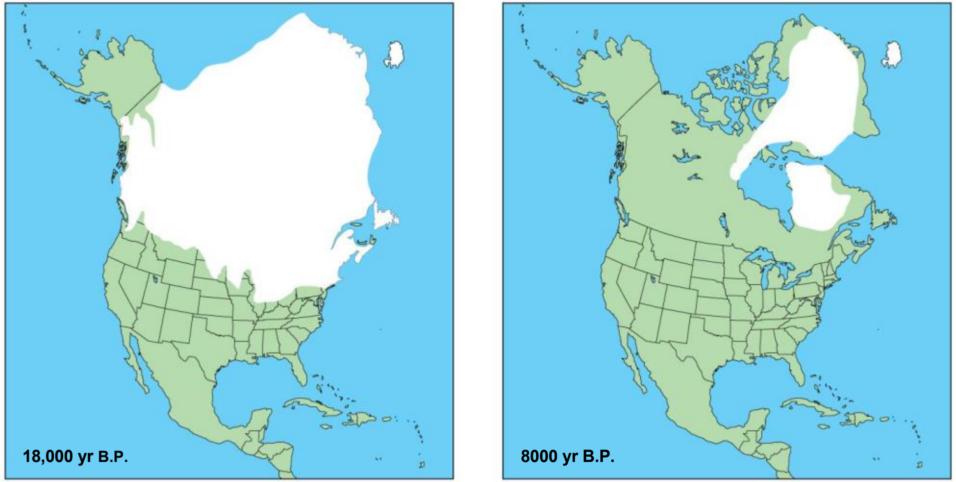
1. Community dynamics

Changes that have occurred during Earth's history have affected the climate and environmental conditions across Earth, affecting the distribution and abundance of plant and animal species.

Paleoecology is the study of the distribution and abundance of ancient organisms and their relationship to the environment.

About 20 glacial cycles occurred during the Pleistocene (2.6 million to 11,700 years B.P.)

- Ice sheets advanced and then retreated.
- At glacial maximum, ice covered about 30% of Earth's surface.

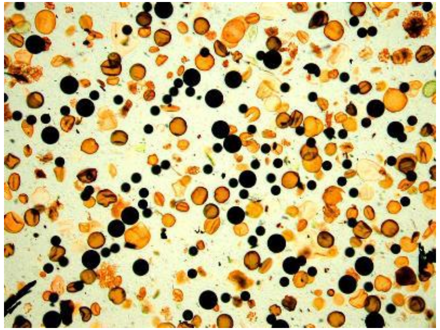


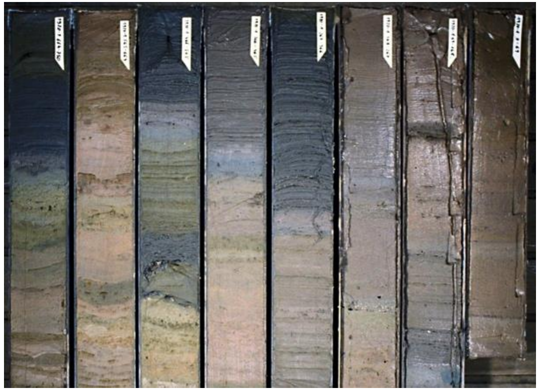
(a) (b)

1. Community dynamics

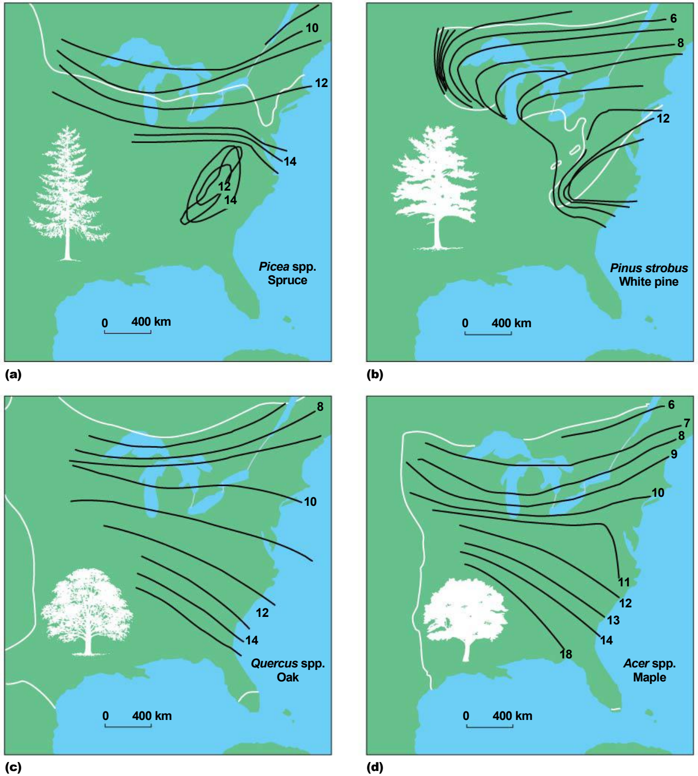
Fossils provide information on the composition of past communities such as bones, insect exoskeletons, plant impressions, and pollen grains.

For instance, pollen from tree species settled into lake sediments.





Cores from these sediments (dated by radiocarbon dating) can be used to map the northward advances of different genera of trees over the past 18,000 years.

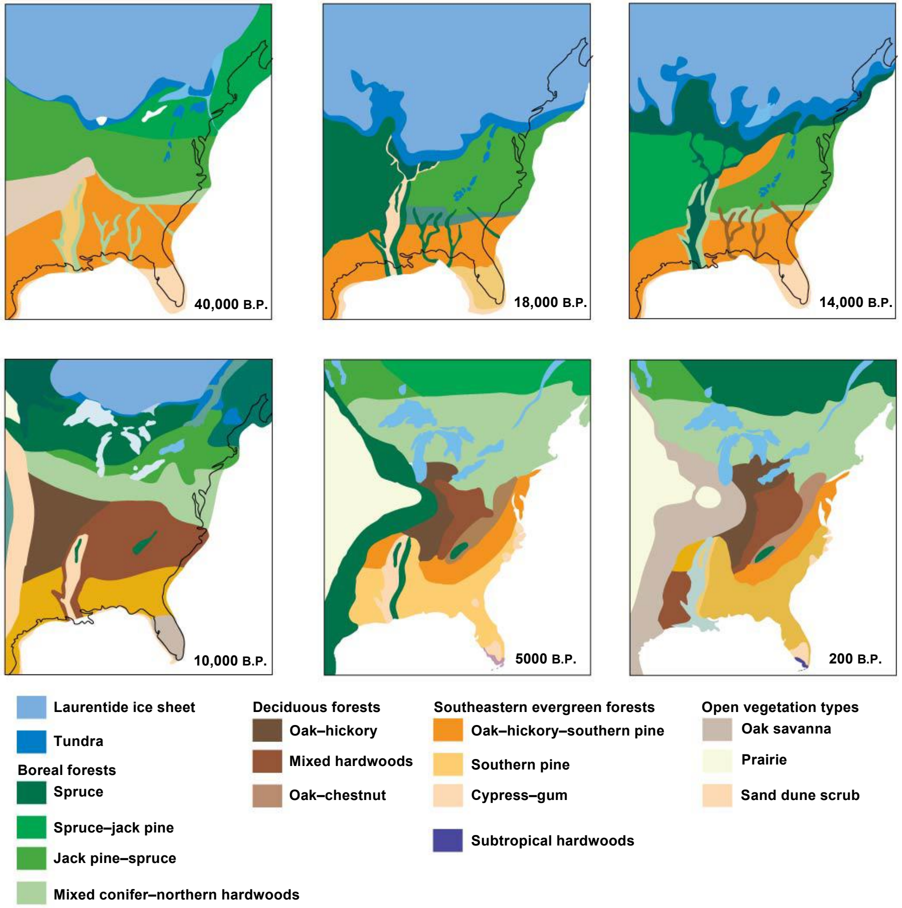


Postglacial migration of four tree genera: (a) spruce, (b) white pine, (c) oak, and (d) maple. Dark lines represent the leading edges of the northward-expanding populations. White lines indicate the boundaries of the present-day ranges. The numbers are thousands of years before present (B.P.).

1. Community dynamics

These variation in the rate of expansion of tree species led to changes in the structure of forest communities in eastern North America over the past 18,000 years.

Differences in expansion rate between species are probably the result of a combination of differences in temperature responses of the species, distances and rate at which seeds can disperse, and interactions among species.

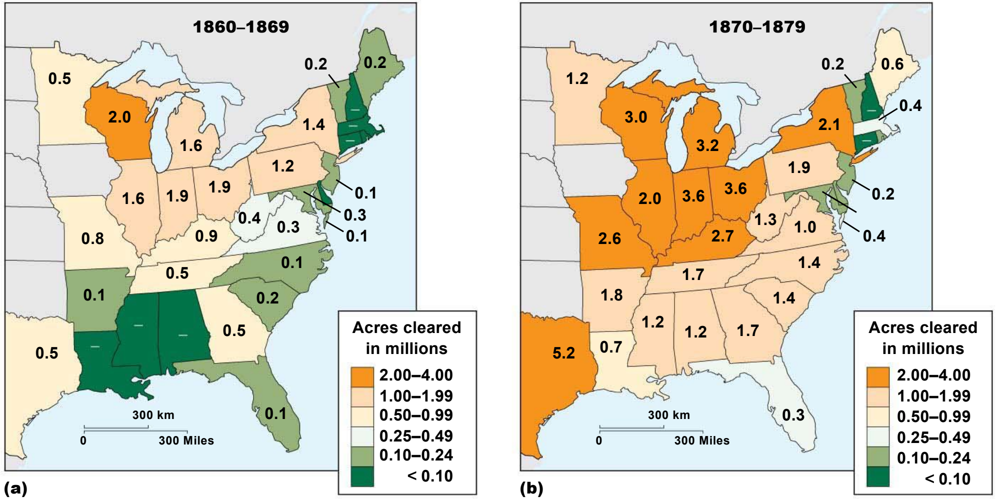


Changes in the distribution of plant communities during and after the retreat of the Wisconsin ice sheet. The changes are reconstructed from pollen analysis at sites throughout eastern North America.

1. Community dynamics

Humans also influence community dynamics. For example, community dynamics in Eastern North America over the past two centuries are a result of changing patterns of land use:

- When North America was first colonized by Europeans in the 1600s, forests dominated the landscape.

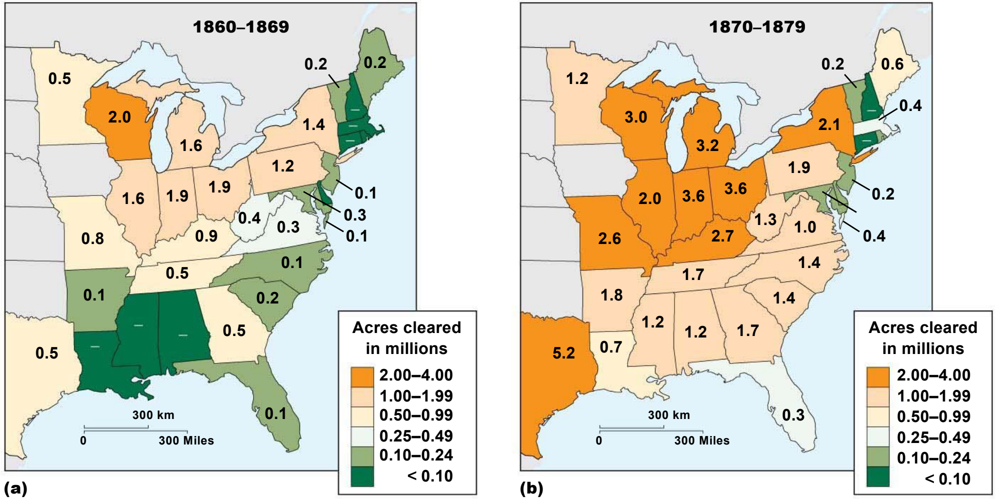


Millions of acres of forest lands were cleared for agriculture during the decades of (a) 1860–1869 and (b) 1870–1879 in the eastern United States. Note the westward expansion and accelerating rate of clearing during this period.

1. Community dynamics

Humans also influence community dynamics. For example, community dynamics in Eastern North America over the past two centuries are a result of changing patterns of land use:

- Forests were cleared for agriculture and forest products as the colonist population grew and expanded to the west.



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1. Community dynamics

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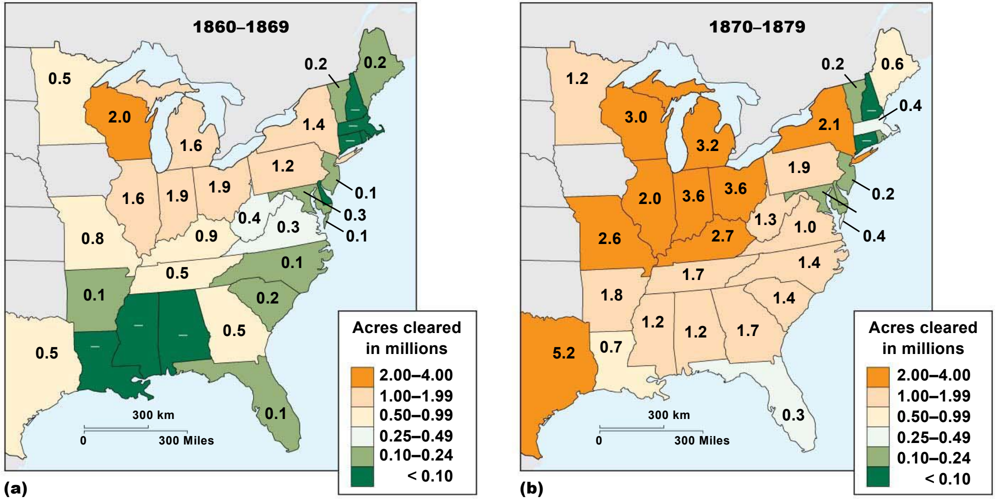
- By the 19th century most of the forests in eastern North America had been cleared. Most forest communities east of the Mississippi are less than 100 years old.



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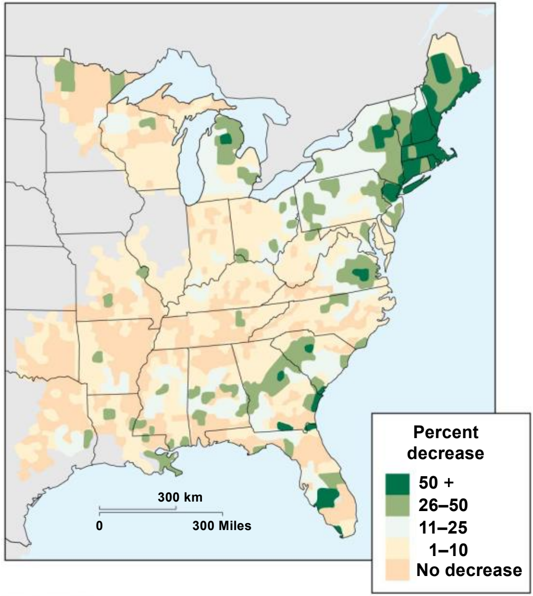
1. Community dynamics

The 1930s began the decline in small family farms in agricultural areas west of the Mississippi. Mechanization and large-scale production of chemical fertilizers in the 1940s aided the transition to large commercial farms.



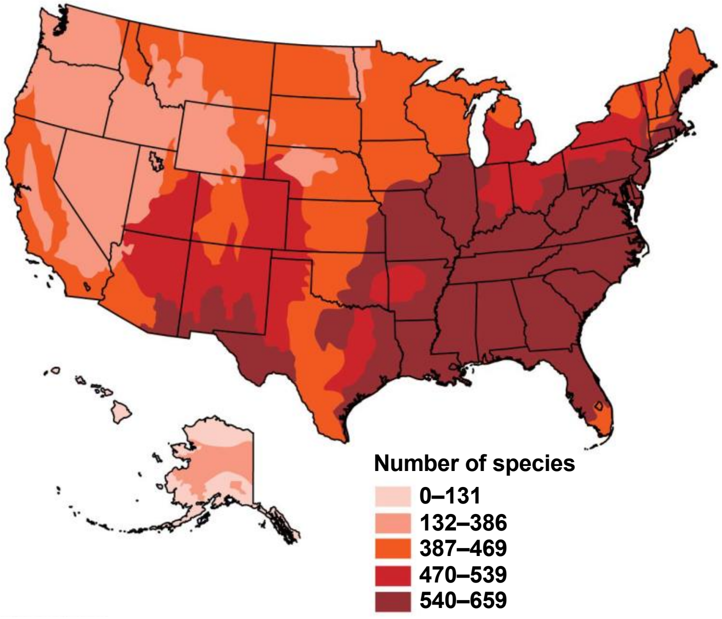
Percentage of decrease in agricultural land in the eastern United States since its peak in 1930.

Rise of large-scale commercial agriculture in the West hastened the agricultural decline in the East. This had begun in the 1800s with the waning of the large plantations in the South.

1. Community dynamics

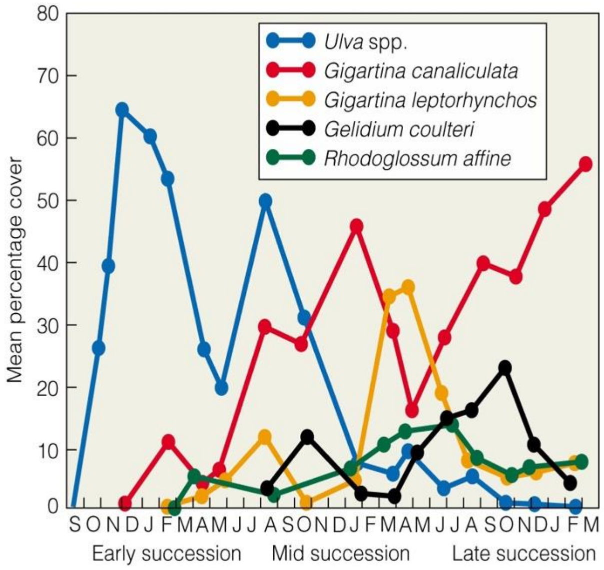
It resulted in a pattern of secondary succession in the eastern United States on a regional scale: from agricultural lands to old-field communities and eventually to forests.

This also had implications for species composition and patterns of species diversity: plant and animal populations that depend on forests increased.



Geographic variation in the number of forest-associated species (all taxa).

2. Exercices



According to the figure, which species is considered a pioneer species?

A) Ulva spp.

B) Gigartina canaliculata

C) Gigartina coulteri

D) Gigartina leptorhynchos

Next week

Ecosystem Ecology