

What is *Ecology* ?

Increasing complexity



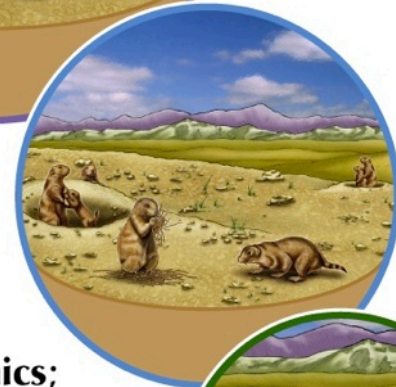
Biosphere:
Global processes



Ecosystem:
Energy flux and cycling
of nutrients



Community:
Interactions among
populations



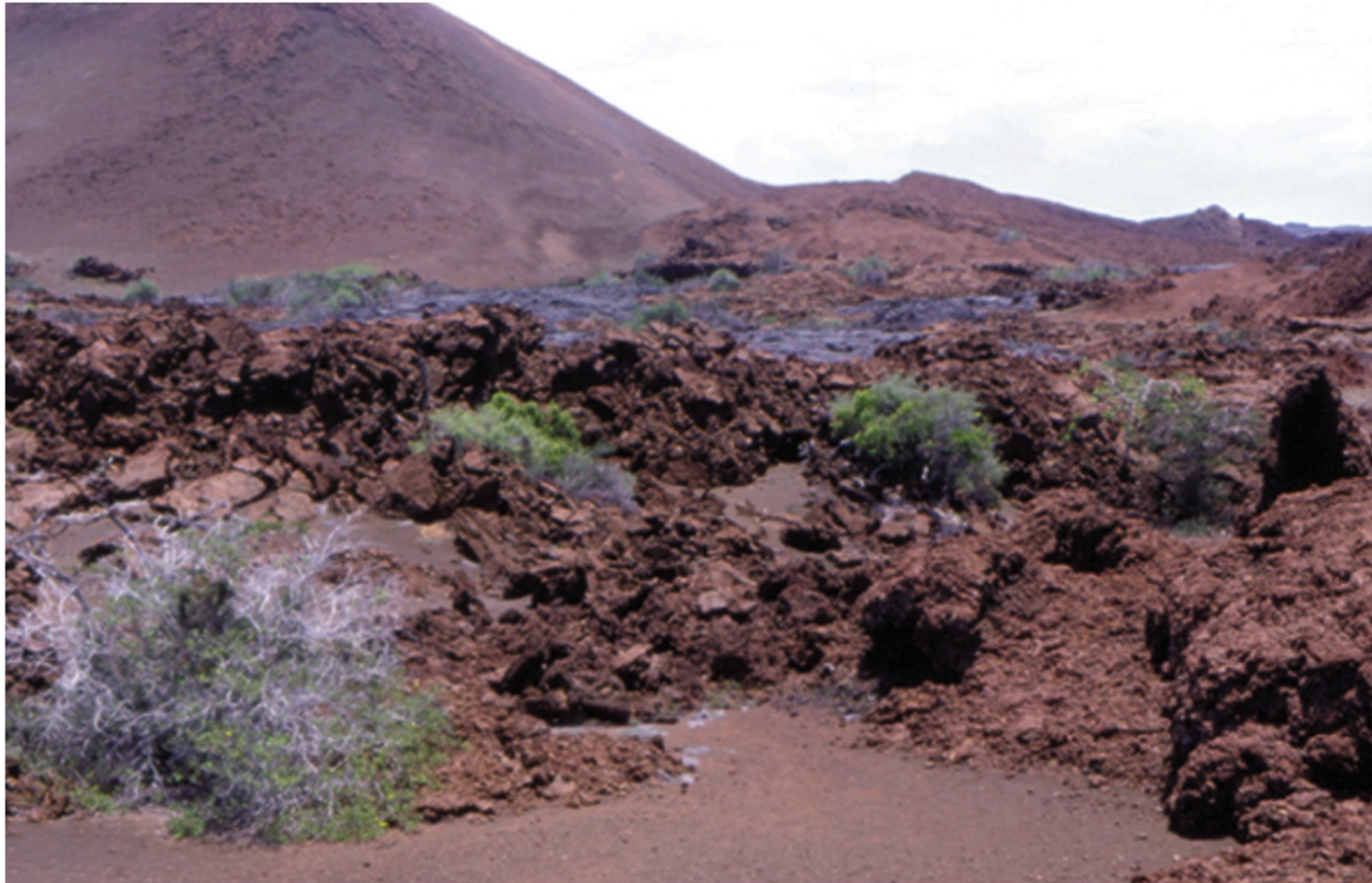
Population:
Population dynamics;
the unit of evolution



Individual:
Survival and reproduction;
the unit of natural selection

1. Distribution and abundance of organisms
2. Interactions between biotic and abiotic components of the environment
3. Energy and nutrient fluxes/cycles
4. Resource management, conservation, restoration, agriculture

Disturbance & Succession



Is nature a harmonious & peaceful place?



Examples of disturbance in nature



Examples of disturbance in nature



Glaciation – the “Little Ice Age” ca. 1300- 1750

Currently: Widespread glacial retreat

Examples of disturbance in nature



Avalanches, Landslides

Examples of disturbance in nature



Examples of disturbance in nature



beaver



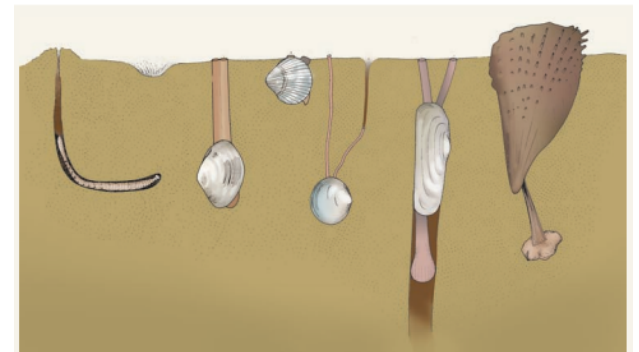
salmon nest digging

Many are biological!

Examples of disturbance in nature



‘Bioturbation’



Examples of disturbance in nature



Herbivory is a common disturbance (natural & anthropogenic)

Disturbance vs. Succession of ecological communities



- **Disturbance:** Abrupt change in the ecosystem, community, or population structure and resource availability, substrate availability, or the physical environment

cause, frequency, severity, scale

- **Succession:** Directional change in community composition or structure over time following a disturbance

Succession of ecological communities



- Change in species composition over time following a disturbance
 - ▣ Somewhat predictable sequence
 - ▣ Progresses from **pioneer species** to **climax community**
 - ▣ Plant-focused concept... but not always

Classic 'old field' succession



Field:
Crabgrass

Year 1
Crabgrass,
horseweed

Year 2
Ragweed,
heath aster

Years 3-25
Broomsedge,
perennial flowers,
shrubs, pines

Years 25-100
Pine forest,
hardwood
understorey

Years 100-200
Remnant pines
with young oak
and hickory trees

Years 200+
Oak-hickory
climax forest

**Annual
Plants**

**Perennial
Plants and
Grasses**

Shrubs

**Softwood
Trees - Pines**

**Hardwood
Trees**

Succession of ecological communities

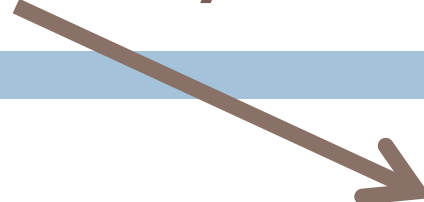


- Change in species composition over time following a disturbance
 - ▣ Somewhat predictable sequence
 - ▣ Progresses from **pioneer species** to **climax community**
 - ▣ Plant-focused concept... but not always

Primary succession— after catastrophic disturbance, in newly formed habitats (no plants or organic soil)

Secondary succession— after disturbances that remove plants (some/all), but soil & nutrients remain (moves away from climax)

Primary vs. Secondary Succession



(regeneration)



Which proceeds faster??

Is this distinction always clear?

Classic 'old field' succession



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Annual
Plants

Perennial
Plants and
Grasses

Shrubs

Softwood
Trees - Pines

Hardwood
Trees

What is the disturbance?

What kind of succession is this?

Studying succession



- Direct measures
 - ▣ Collect data at regular intervals following disturbance

Succession in oak-hornbeam forest in Poland

(a)



(b)



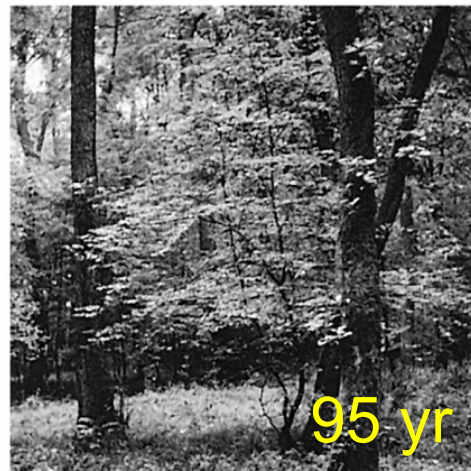
(c)



(d)



(e)



(f)



Studying succession

- Direct measures

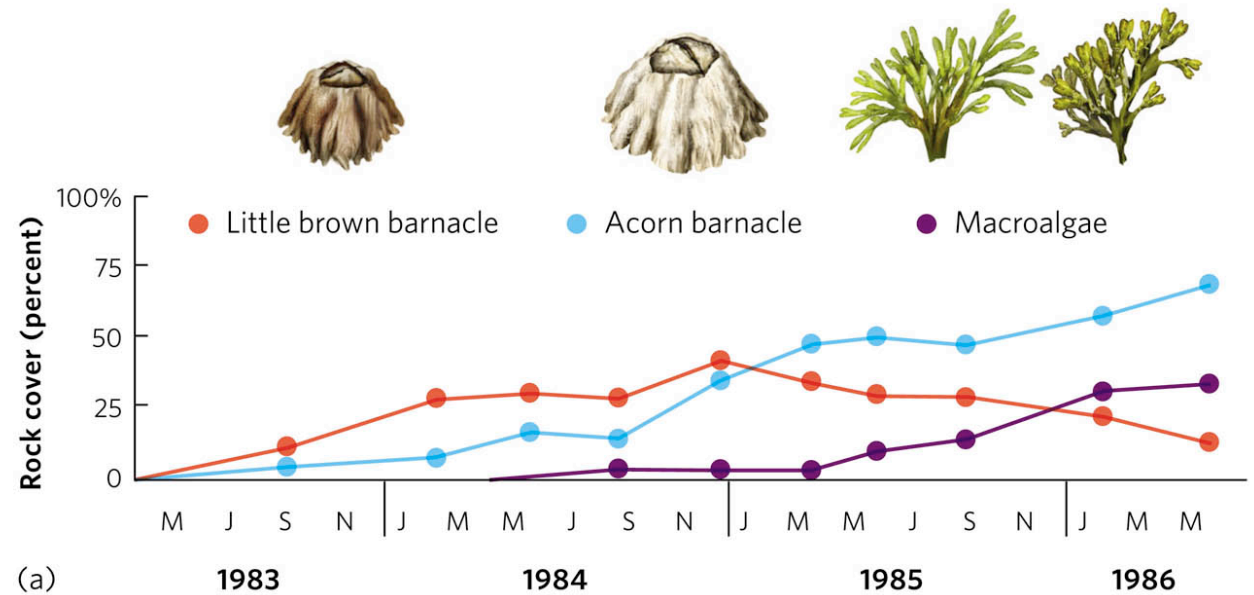
- Collect data at regular intervals following disturbance
- Experimentally induce disturbance or create 'new habitat' and monitor species colonization



Intertidal boulders

Experimental succession: intertidal communities

Exp. 1:
Control
Rocks scraped

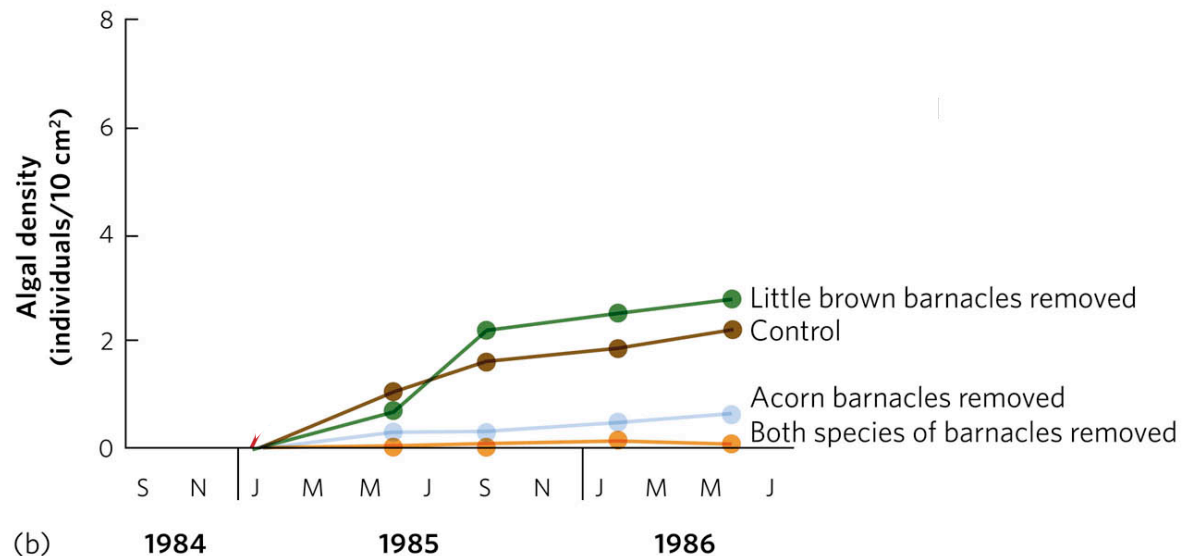
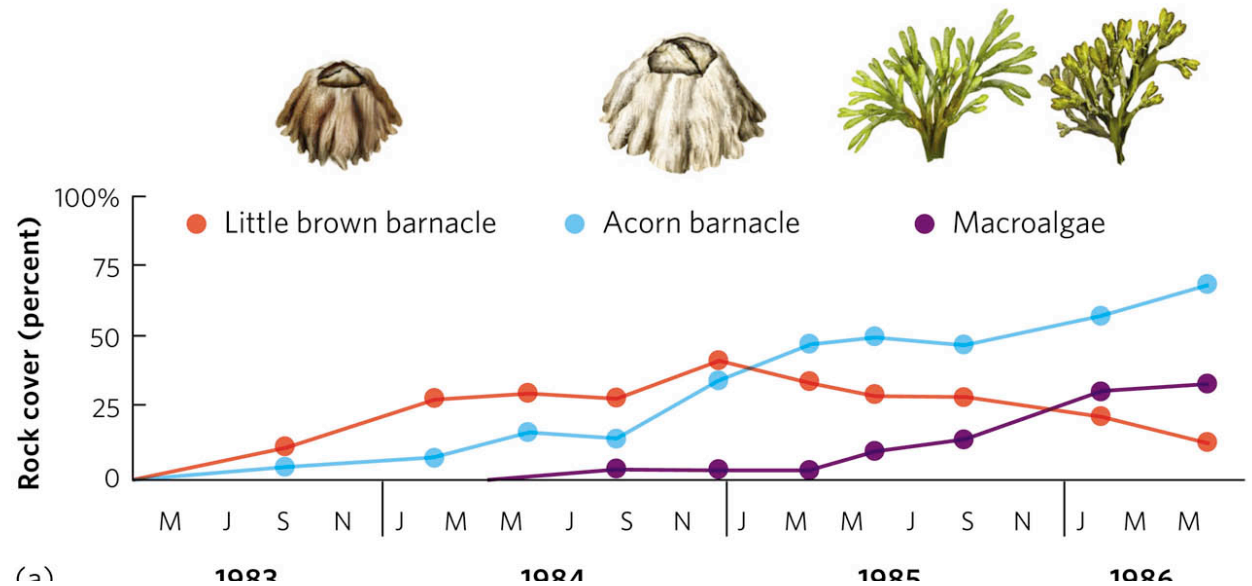


Experimental succession: intertidal communities

Exp. 1:
Control
Rocks scraped

Exp. 2:
Control
4 treatments

What's the 4th treatment?

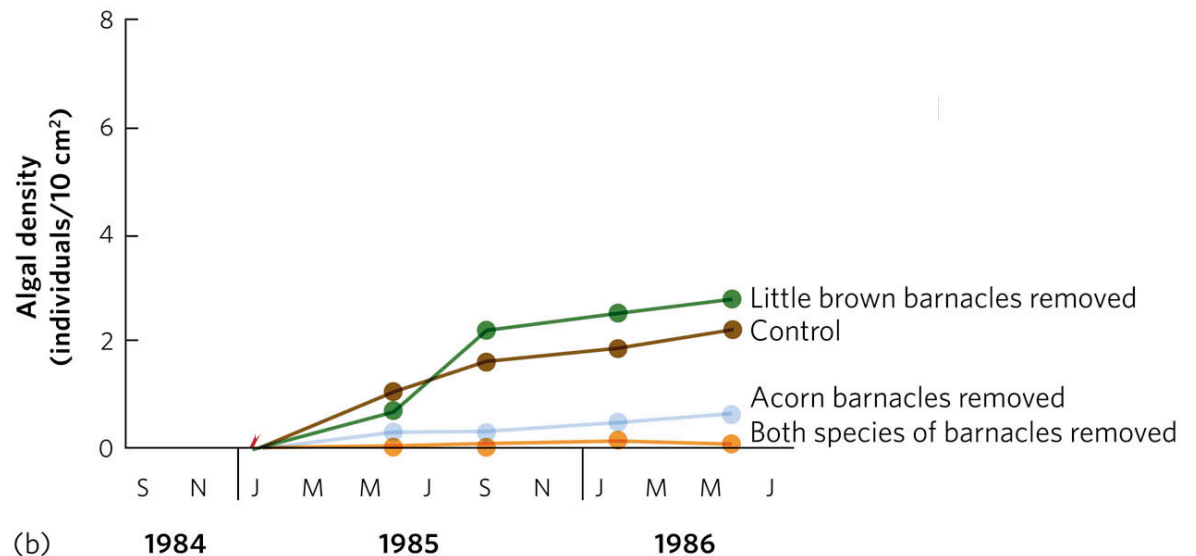
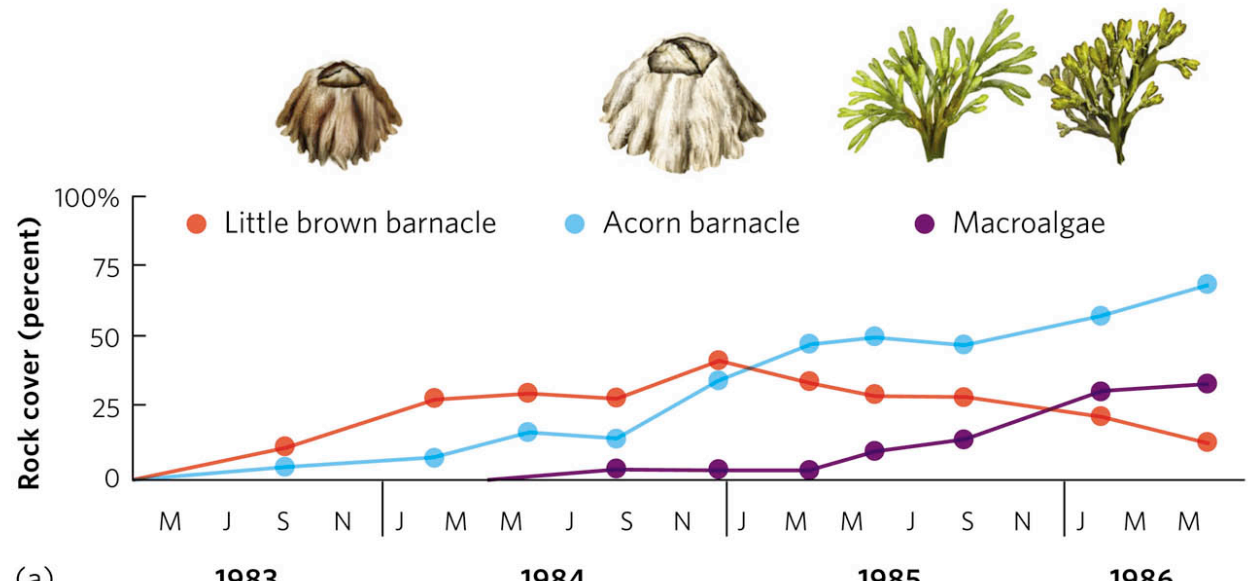


Experimental succession: intertidal communities

Exp. 1:
Control
Rocks scraped

Exp. 2:
Control
4 treatments

Pioneer species?
Inhibition?
Interaction between
algae and 2 barnacles ?



Studying succession



- Direct measures

- Collect data at regular intervals following disturbance
- Experimentally induce disturbance or create 'new habitat' and monitor species colonization

- Indirect measures

- Chronosequences: compare communities in same location with different 'start times'

Succession on sand dunes

(a)



(b)



(c)



(d)



Succession of ecological communities



Pioneer species– adapted/able to survive as first colonists

*often **facilitate** colonization by additional species

Climax community– ‘final’ group of species

the end point of succession

assumed to be stable... until the next disturbance

*often **inhibit** colonization by additional species

sensu Frederic Clements 1916

Facilitation by pioneer species (alder)

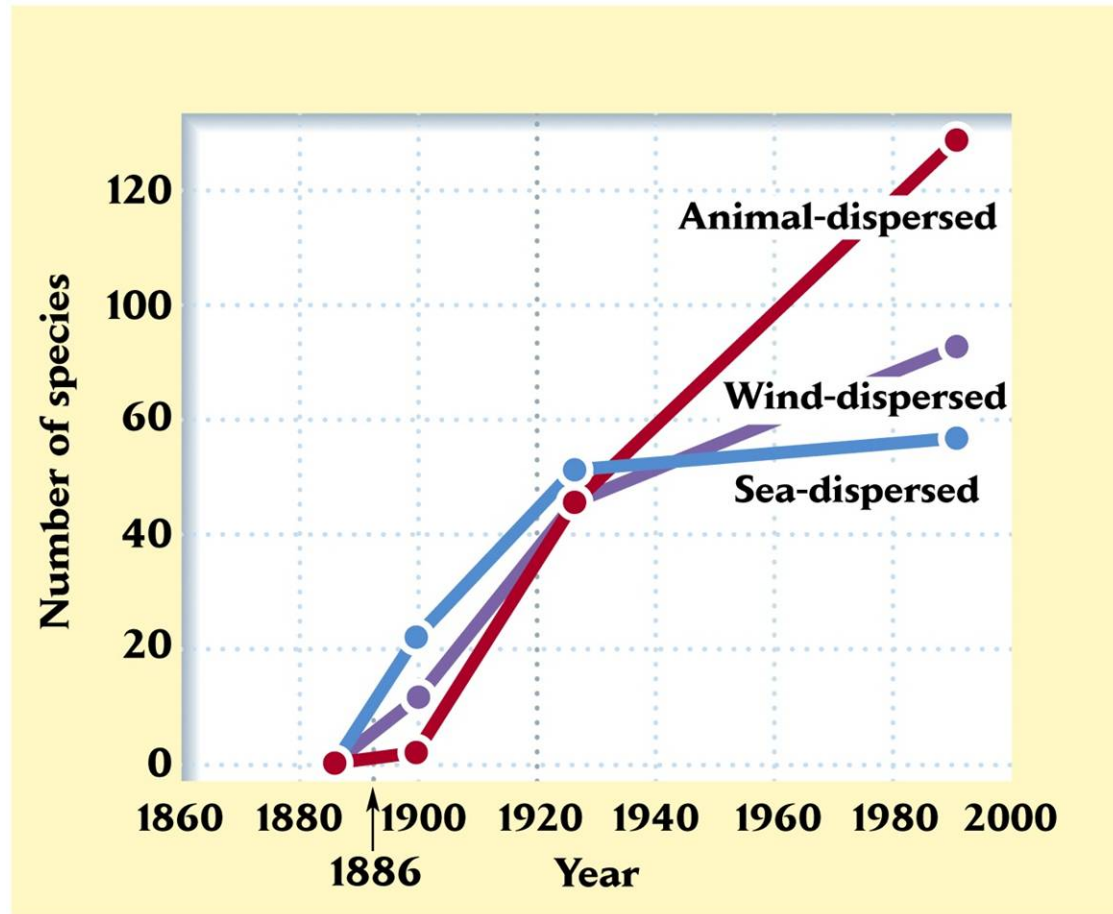


*N-fixing plant (via symbiosis with a filamentous bacterium)

Krakatoa Island, Indonesia 1883



What kind of succession is this?



Why might animal dispersed plants arrive later?

Characteristics of early vs. late successional plants



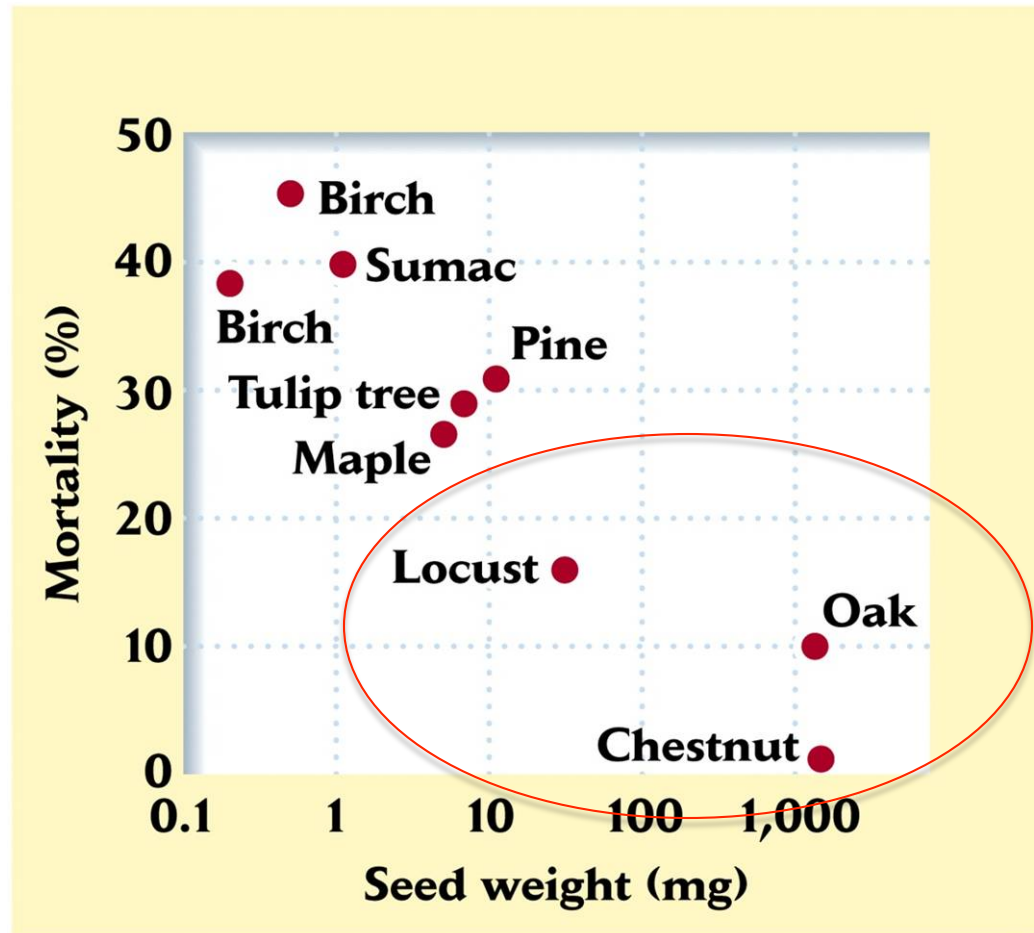
Characteristic	Early	Late
Number of seeds	Many	Few
Seed size	Small	Large
Dispersal	Wind, stuck to animals	Gravity, eaten by animals
Seed viability	Long, latent in soil	Short
Root : shoot ratio	Low	High
Growth rate	Rapid	Slow
Mature size	Small	Large
Shade tolerance	Low	High

dispersal, rapid
growth, early
reproduction

high competitive
ability

Which is more likely to have rapid population growth rates?

Experiment: Survival of seeds after 3 months of shade



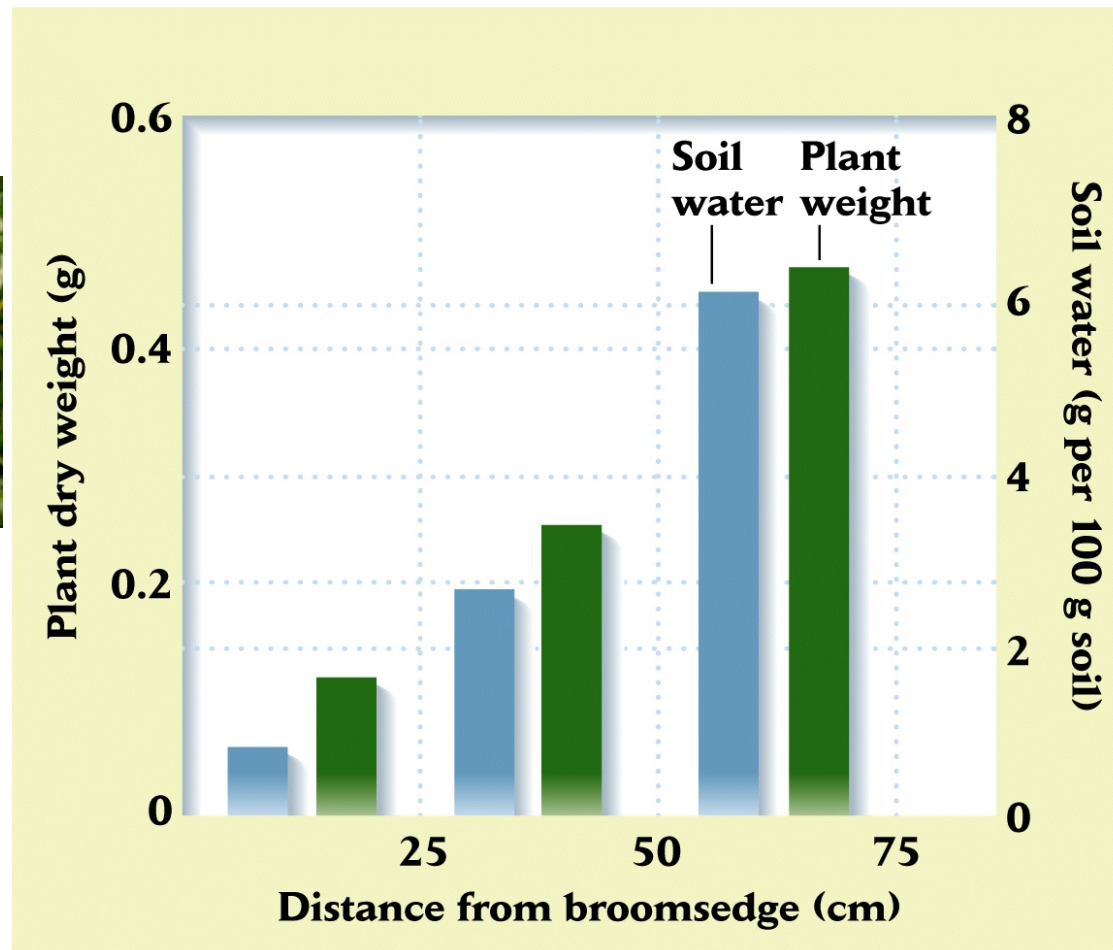
Which are more likely to be late successional species?

Inhibition through shade tolerance

* Smaller seeds suffered higher mortality

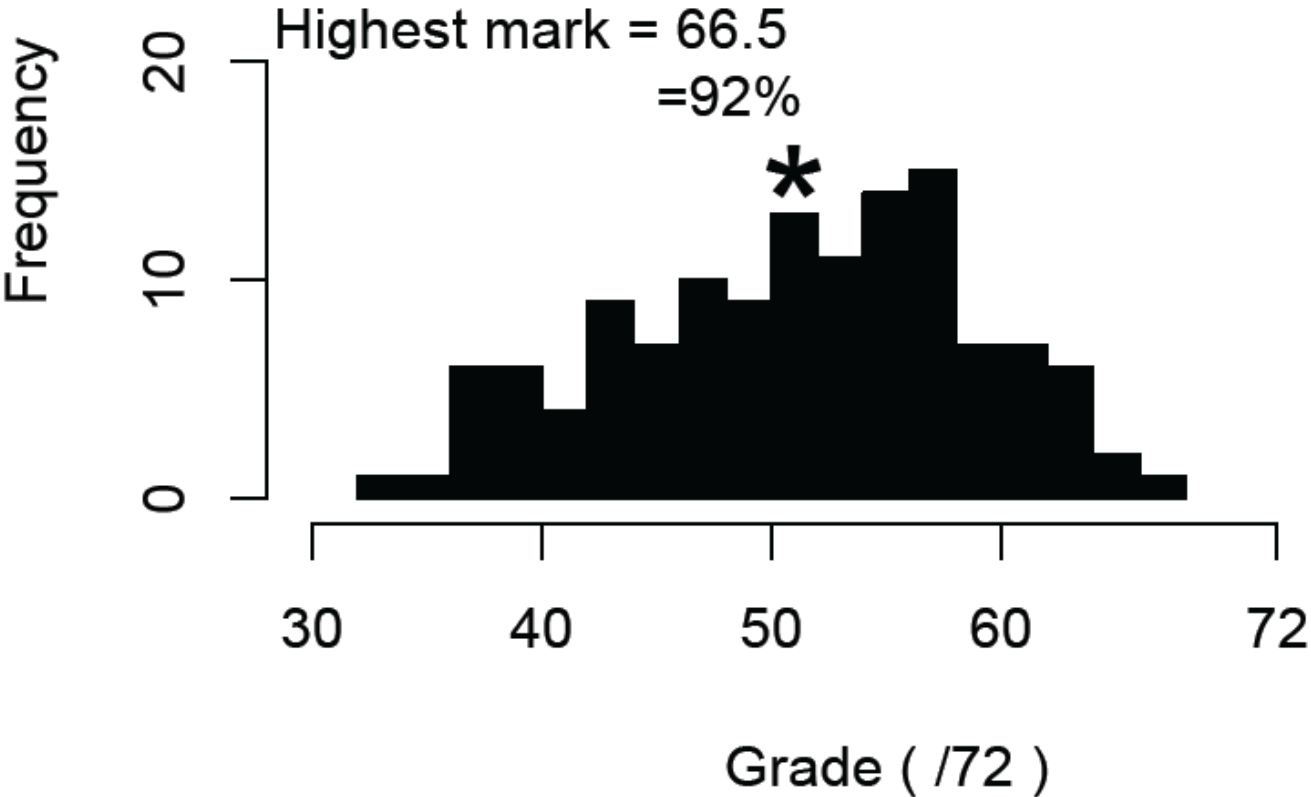
Inhibition by late successional species

Aster growth as a function of distance from broomsedge





Average = 51
=70%



Eruption of Mt. St. Helens

May 18, 1980



Video

Eruption of Mt. St. Helens May 18, 1980

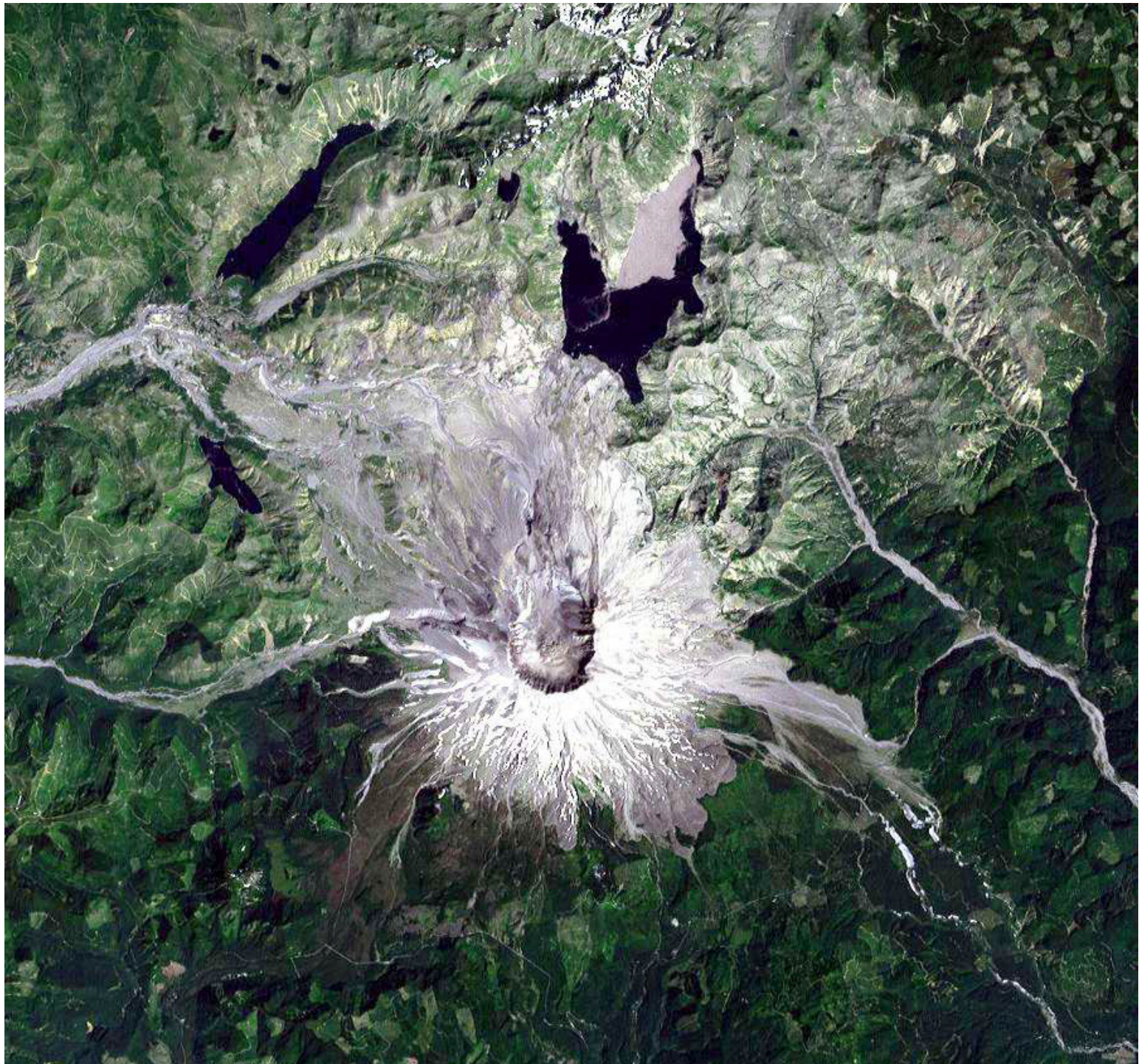


© Tom Dempsey / Photoseek.com

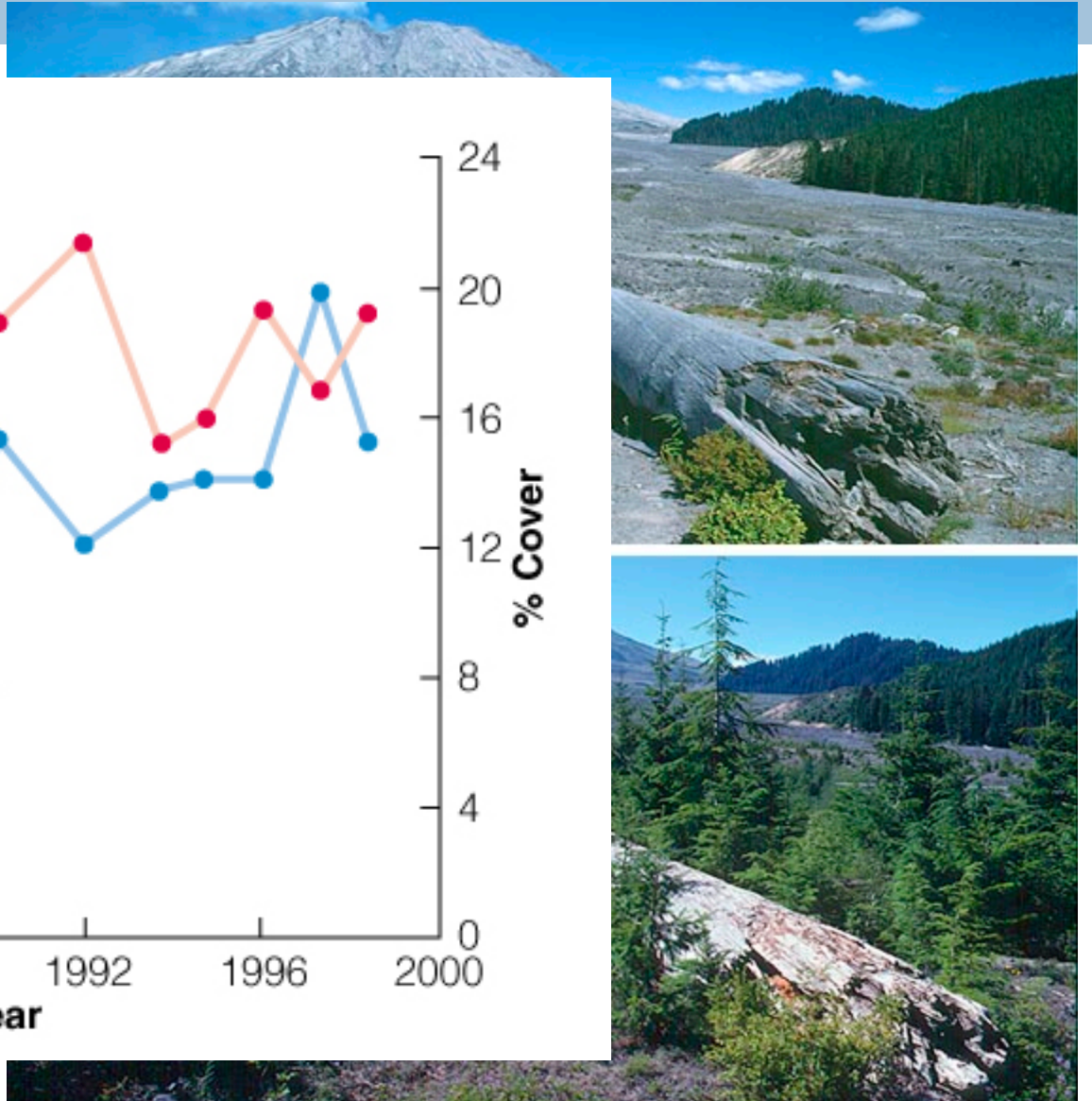
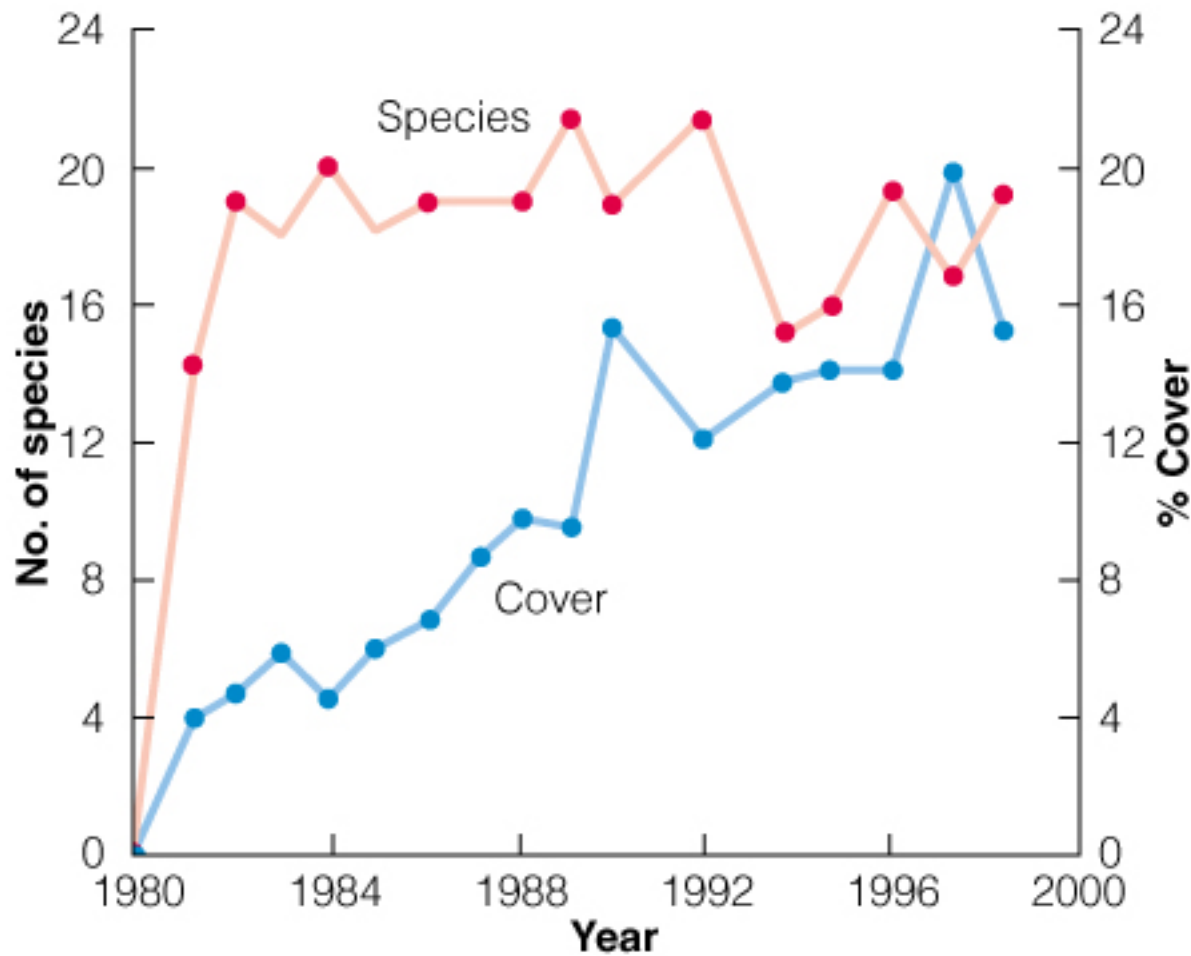
**Weyerhaeuser salvage logged 850 Million board feet
(68,000 acres 'destroyed')**



Photo: J. Means



Succession on Mt. St. Helens



Mt. St. Helens: Post eruption



- **inorganic substrates (rock, ash, etc.)**
- **low soil moisture (drought)**
- **high erosion (shifting surfaces)**
- **high sunlight (no shading)**
- **high availability of space**
- **no organic nutrients**

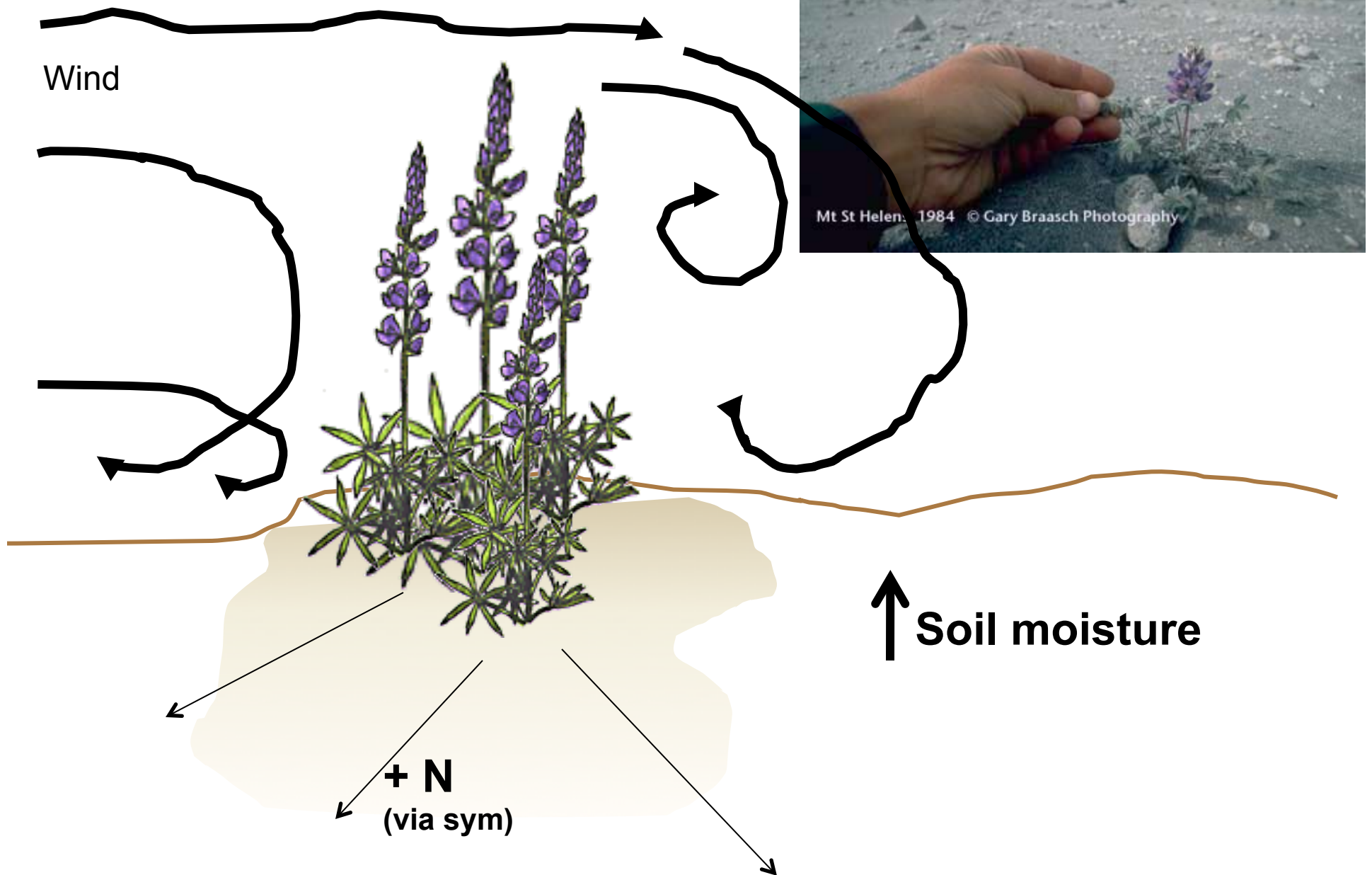
What might limit succession in this new environment?

- Dispersal**
- Inhospitable conditions**

What are the traits of the first plants to come back??

- Good dispersers**
 - small seeds = longer dispersal distances**
- Ability to withstand harsh conditions**
 - large seeds = better germination success**

Facilitation by lupine





Sun-loving prairie lupines thrived in dry, open areas. The lupine patches provided carbon and nitrogen to the nutrient-poor soil, which encouraged the establishment of other plants. As the green patches became more diverse, more animals were attracted to them, the animals unknowingly spread seeds and spores, and thus, a feedback loop was established .

Facilitation by animals



***Thomomys talpoides* (Northern Pocket Gopher)**

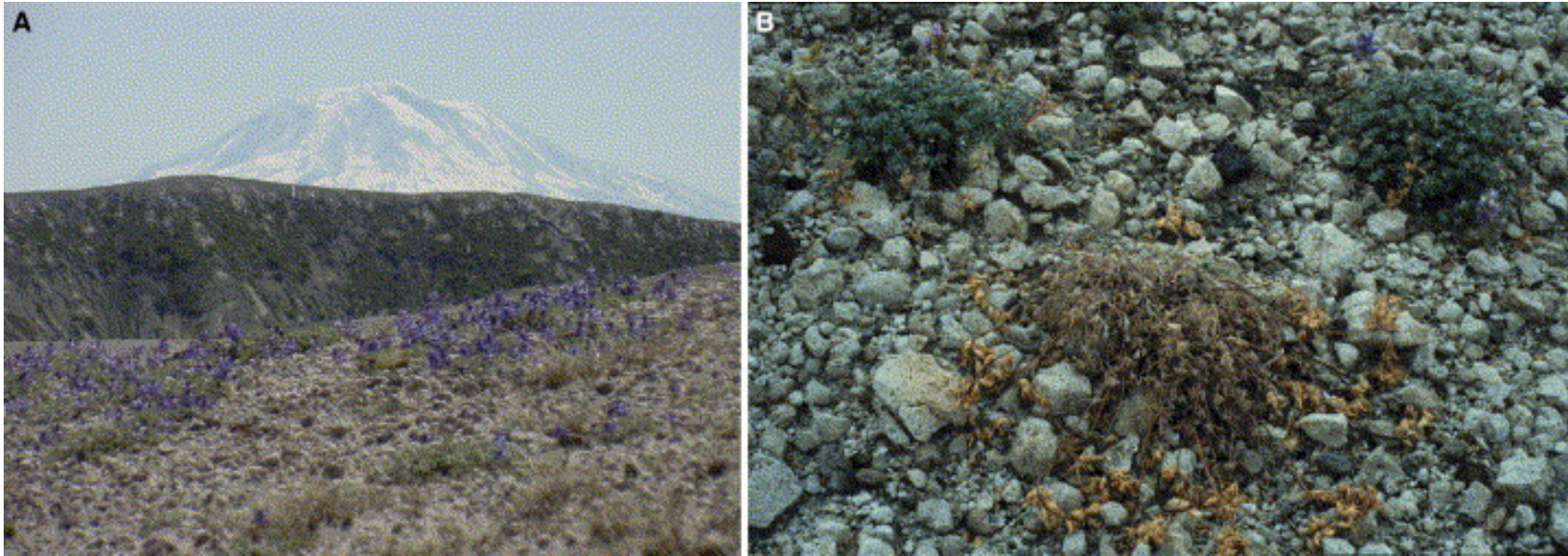
As surviving gophers tunneled, they mixed underlying soil with volcanic ash. Roots & seeds flourished in the mixed soil-ash layer (they also transported mycorrhizae spores between lupine patches).

Facilitation by animals



Photo: C. Tonn

Effects of consumers on community succession

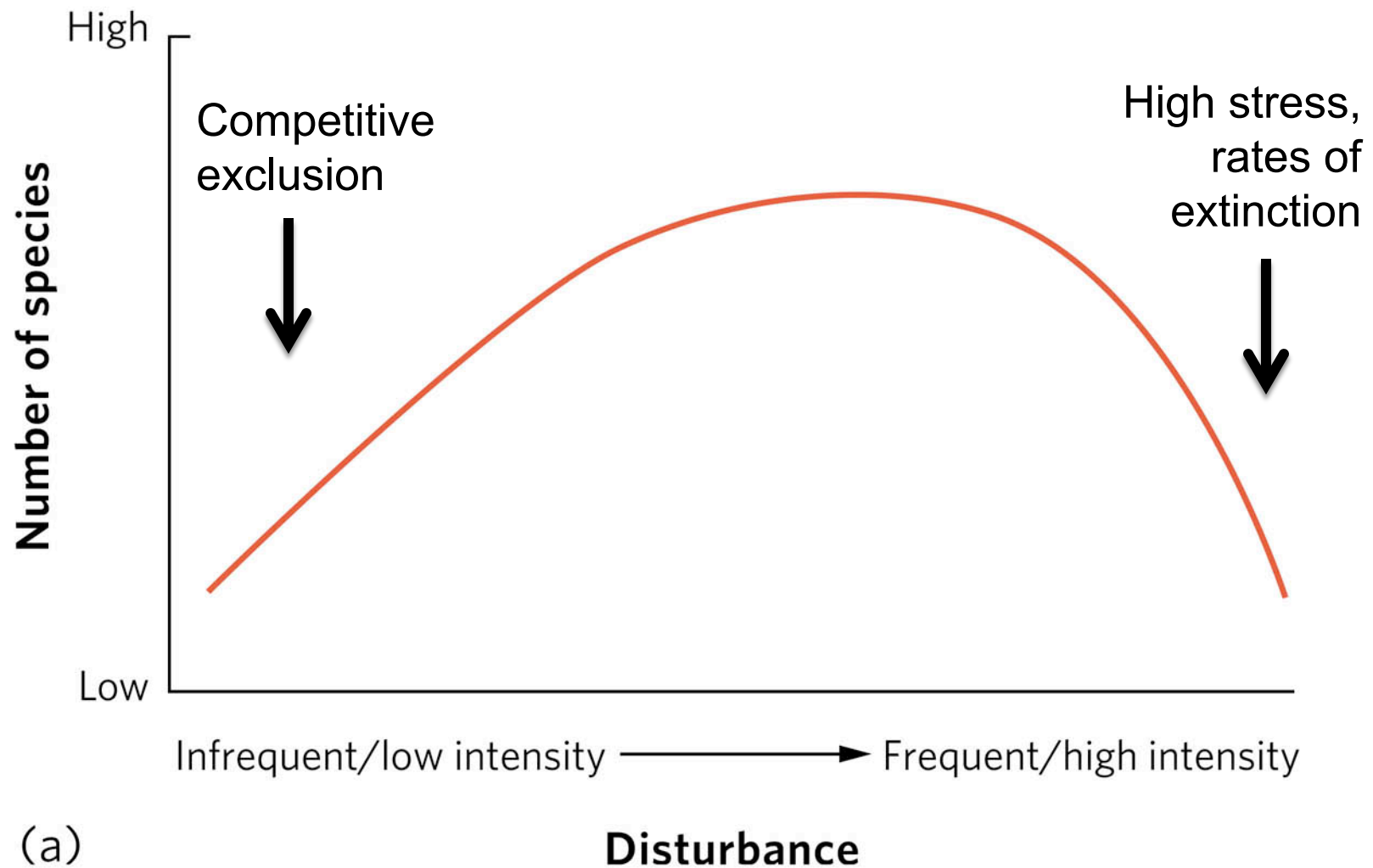


Once lupine reached a certain density (~1M plants in blast zone) a specialist caterpillar colonized

Prefers isolated lupine clumps – tend to be at the edge of re-colonization

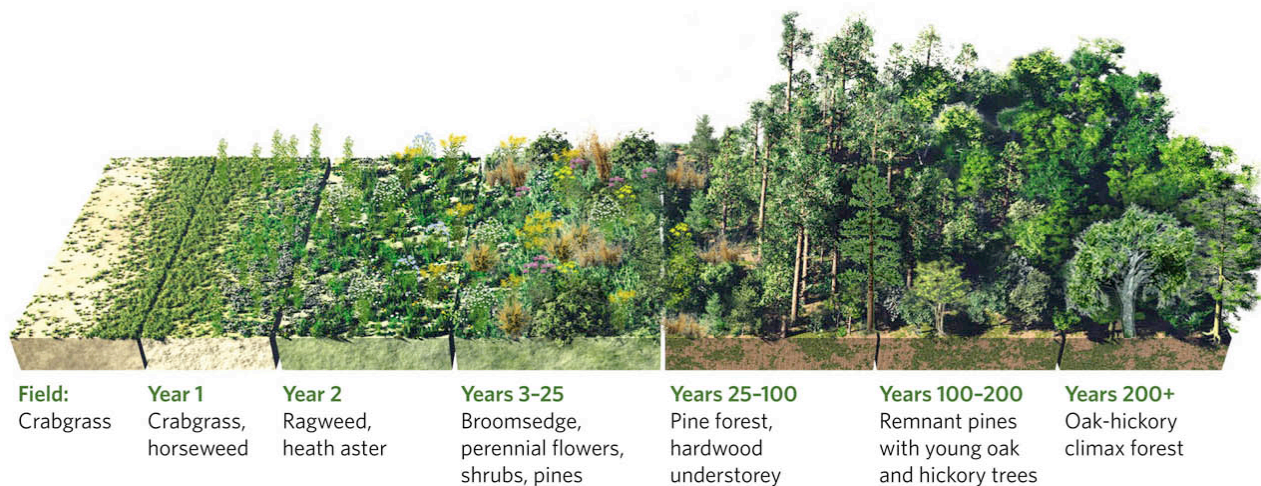
= lower growth + seed production, depresses colonization, **slows rate of succession**

Intermediate Disturbance Hypothesis



Climax communities represent the ‘final’ stage

- final, stable community in a successional series
- self-perpetuating and in equilibrium with the physical and biological environment

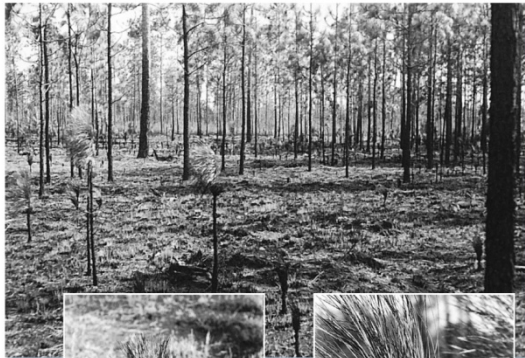


How often do ecosystems reach the climax stage??

Fire as an organizing disturbance (can maintain climax community)



(a)



(b)



(c)



© Gary D. Tonhous

Multiple, and cyclical or random disturbance keeps communities from reaching climax state



What role do humans play in succession?



Examples of disturbance in nature



Examples of disturbance in nature

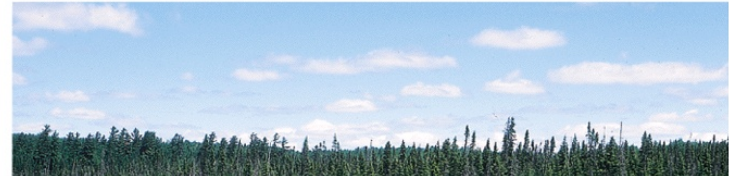


Succession in boreal ponds & lakes

(a)

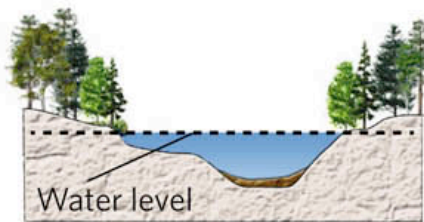


(b)

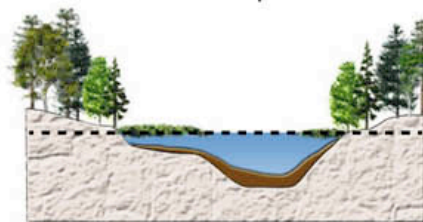


(a)

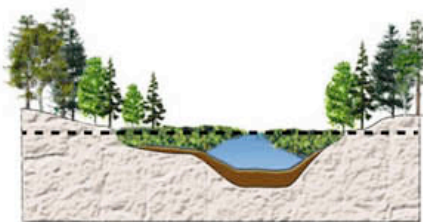
The lake edge is colonized by plants.



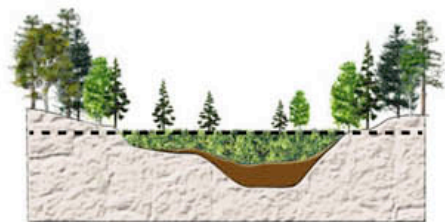
The plants expand laterally across open water and begin accumulating dead plant matter known as peat.



The plants continue to expand laterally and the peat layer becomes thicker.



Lateral expansion of plants eventually covers the lake surface and peat sediments fill in the basin.



Gradual change over millennia

“bog succession”
1000’s of years



Succession & accumulation of peat in boreal ecosystems



Other interactions can affect succession

Consumer response to successional state

(a)



(b)



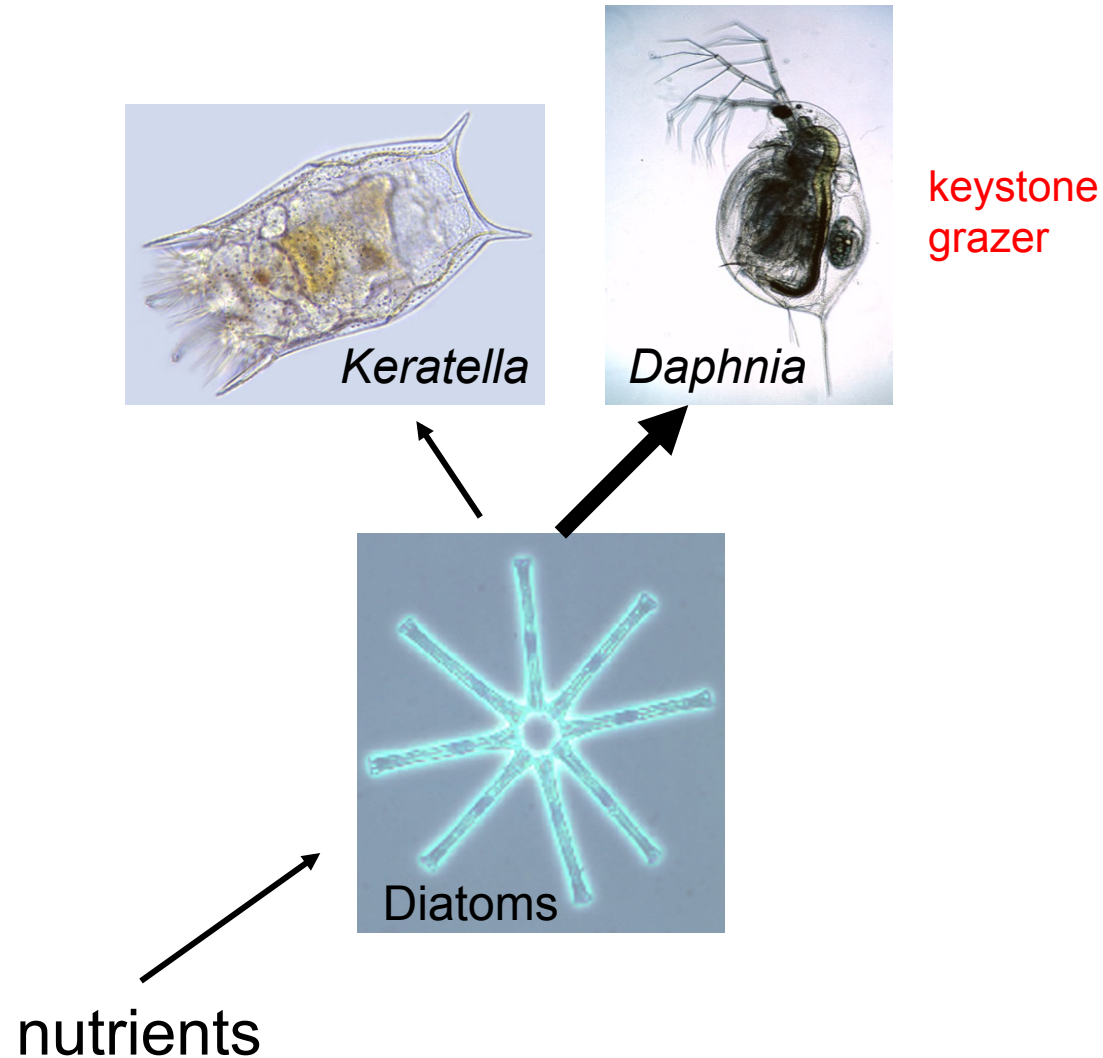
Gazelle's prefer to feed in areas previously grazed by large herbivores (highly disturbed)

Succession through time on temporary resources:

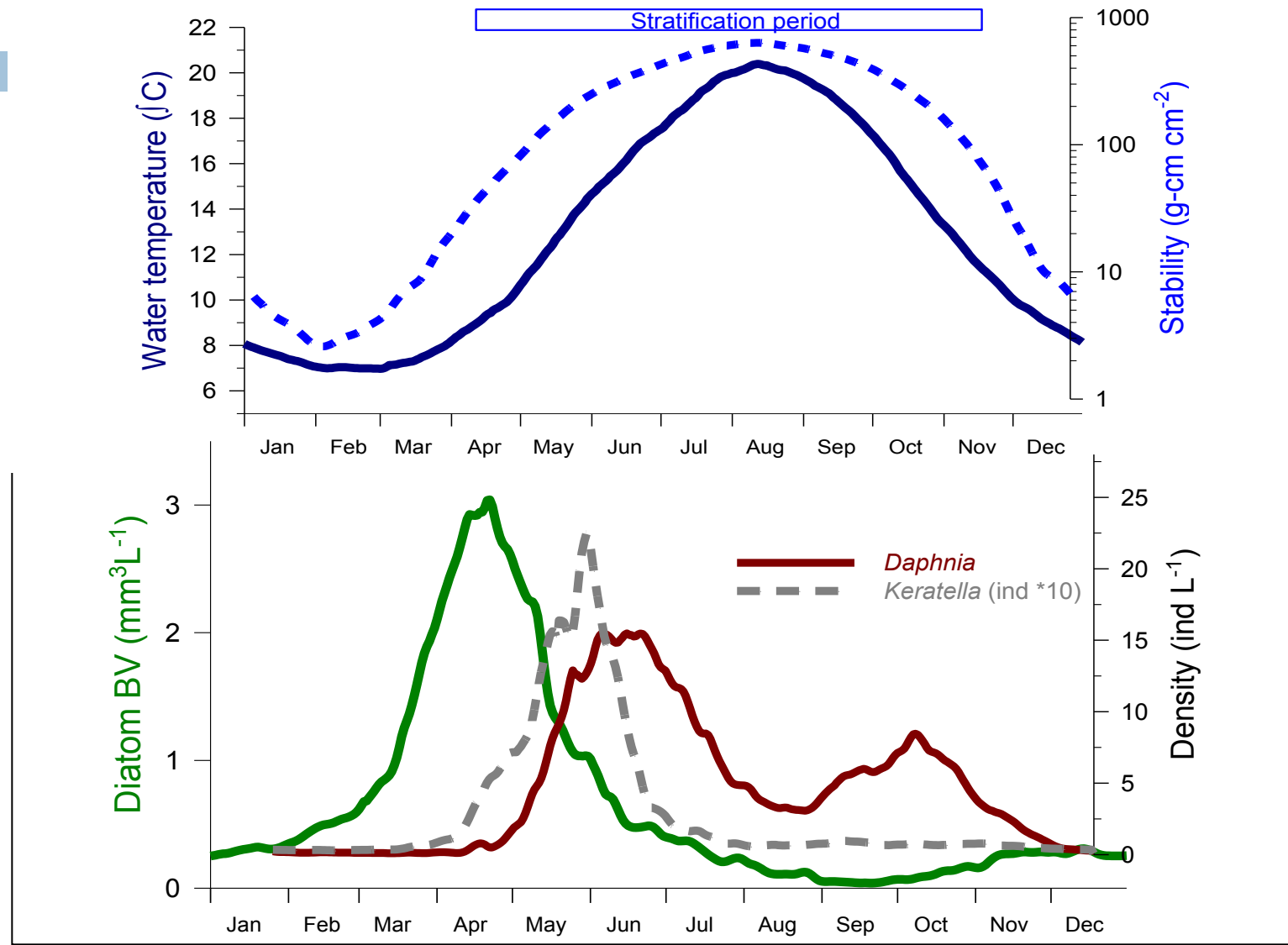
Scavengers on carcasses



Seasonal plankton succession in lakes



Seasonal plankton succession in Lake Washington



Classic 'old field' succession... with animals

