

# Biology 3445F – Community Ecology

Lecture 13  
November 2, 2015

# Today: Ecological Succession

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Historical approaches

Types of succession

- primary vs. secondary

Disturbance – overview (more in lecture 19)

Species change and species traits

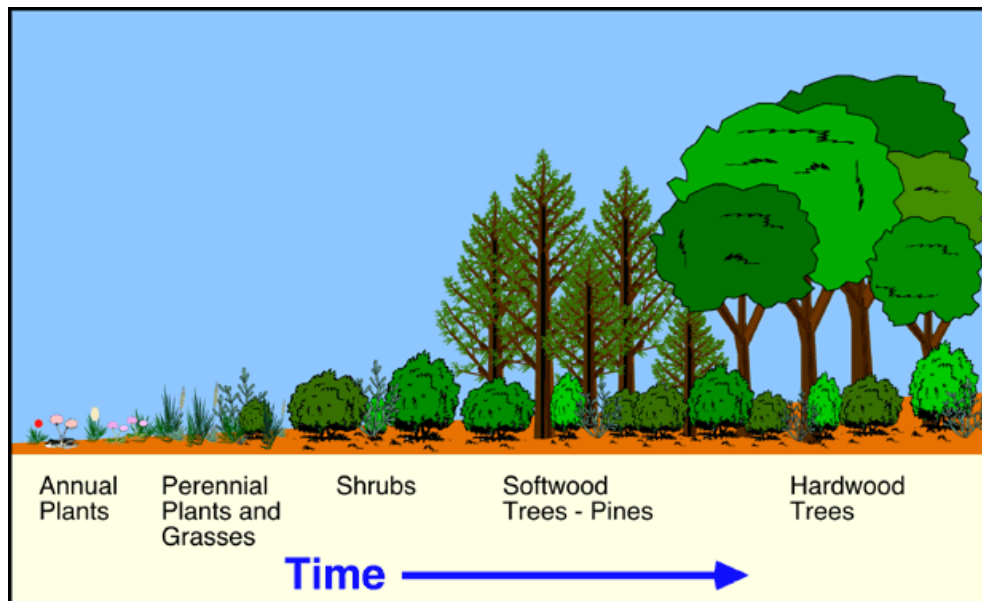
- Stages of ecological succession
  - Early – Seral – Climax
- Mechanisms of succession
- Resource-Ratio hypothesis

# Ecological Succession - Overview

## Ecological Succession:

changes in the physical environment as well  
all three of these changes happening at once

- Directional change in **species composition, structure, and resource availability** over time that is driven by biotic activity and interactions, and/or changes in the physical environment.  
*who is there? (species composition system)*
- (Re) occupation of species to an area – replacement of species through time – orderly or random?



# Historical approaches

exceedingly plant centric

from lecture 6

**Clements (1916)** – organismic concept of communities. *alot of stuff still heavily influenced by clements*

- Clusters or groups of species repeatedly associated together – which was indirect evidence for either positive or negative species interactions. As such, communities were viewed as integrated units.

*he thought different species in a community are like diff organs in a body... they coexist work together indirect evidence for positive or negative species interaction*



**Gleason (1926)** – individualistic continuum concept of communities. *exact opposite idea of clements*

*- each species respond individually to env conditions in the landscape*

- Relationships among species is a result of similarities in their requirements and tolerances, not a result of strong interactions or common evolutionary histories. *not having to do with species-species interactions... just a result of similarities in their requirements and tolerances*



# Primary Succession

formation of a new habitat/substrate

Primary succession occurs on a site previously unoccupied by a community

unoccupied by any other organisms

- Succession which takes place when bare substrate becomes available for colonization (VERY slow)

- soil under retreating glaciers

- emerging islands (e.g. volcanic islands)

- formation of new lake

- cement blocks in an intertidal zone

this colonization of organisms into this area are very very slow because very little resources in that habitat

can also be human induced



# Secondary Succession

Secondary succession occurs on previously occupied sites following disturbance.

- Re-colonization (much faster than primary succession).

E.g.:

- natural climate disturbances (fire, hurricane, wind)
- natural biotic disturbances (animal burrows, overgrazing)  
*can be very small scale*
- anthropogenic disturbance (forest harvest)



1980 eruption of Mt. St. Helens (WA)

# Disturbance

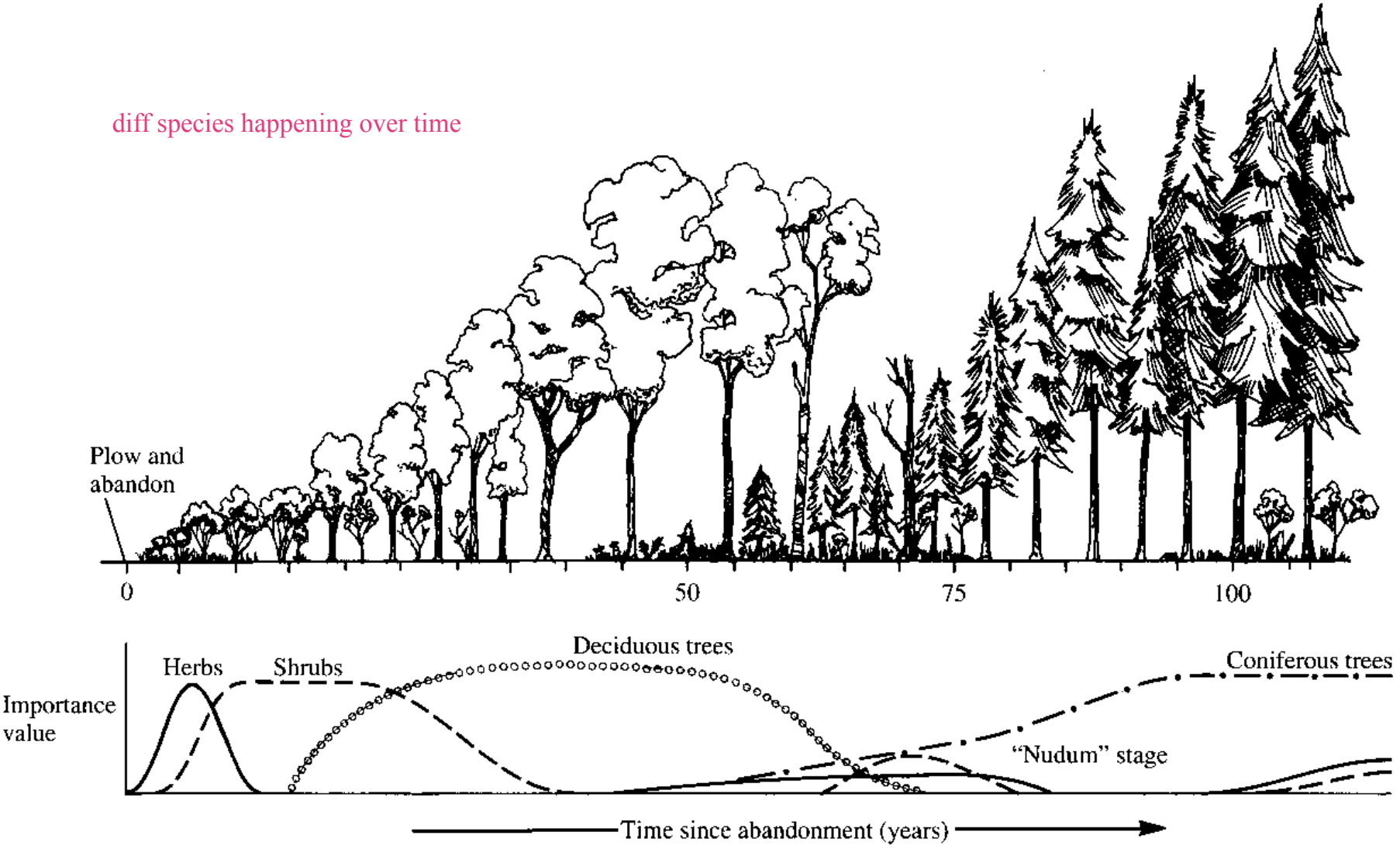
**Disturbance:** A discrete event in time that disrupts ecosystem, community and/or population structure and changes substrate and resource availability as well as the physical environment.

- Natural or anthropogenic *human induced*
- **Exogenous** – originates outside the system (e.g. fire)
- **Endogeneous** – originates inside the system (e.g. pathogens) *was always there in the system, and for whatever reason, rose to cause disturbance*



# Ecological Succession

diff species happening over time



(d)

# Species change in ecological succession

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## Life History Differences:

- species differ with respect to dispersal, establishment and population growth

dispersal, colonization, establishment, growth

disturbance has to do with changes physical landscape...

## Environmental Tolerances:

- species do not necessarily interact (low competition)
- first species to establish persists on site in harsh conditions

competition for resources may be very low following a disturbance because very few species but landscape altered, so considered harsh environment

differences in life history and differences in environmental tolerances

# Trade-offs during succession

PHYSIOLOGICAL AND LIFE HISTORY CHARACTERISTICS OF EARLY- AND LATE-SUCCESSIONAL PLANTS

Characteristic	Early Succession	Late Succession
Photosynthesis		
Light-saturation intensity	high	low
Light-compensation point	high	low
Efficiency at low light	low	high
Photosynthetic rate	high	low
Respiration rate	high	low
Water-use efficiency		
Transpiration rate	high	low
Mesophyll resistance	low	high
Seeds		
Number	many	few
Size	small	large
Dispersal distance	large	small
Dispersal mechanism	wind, birds, bats	gravity, mammals
Viability	long	short
Induced dormancy	common	uncommon?
Resource-acquisition rate	high	low?
Recovery from nutrient stress	fast	slow
Root-to-shoot ratio	low	high
Mature size	small	large
Structural strength	low	high
Growth rate	rapid	slow
Maximum life span	short	long

SOURCES.—Budowski 1965, 1970; Pianka 1970; Ricklefs 1973; Bazzaz 1979.

Table 1, Huston & Smith (1987)

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# r / K-selection theory

The combination of life history traits based on trade-offs between quantity and quality of offspring.

r-select organism = many offspring, most don't survive to adult hood

r-select:

- small body size
- not long lived, quick generation time

- Smaller body size, many offspring, short generation time
- Unstable or unpredictable environments

K-select:

K = concept of carrying capacity? in the population.... carrying capacity?

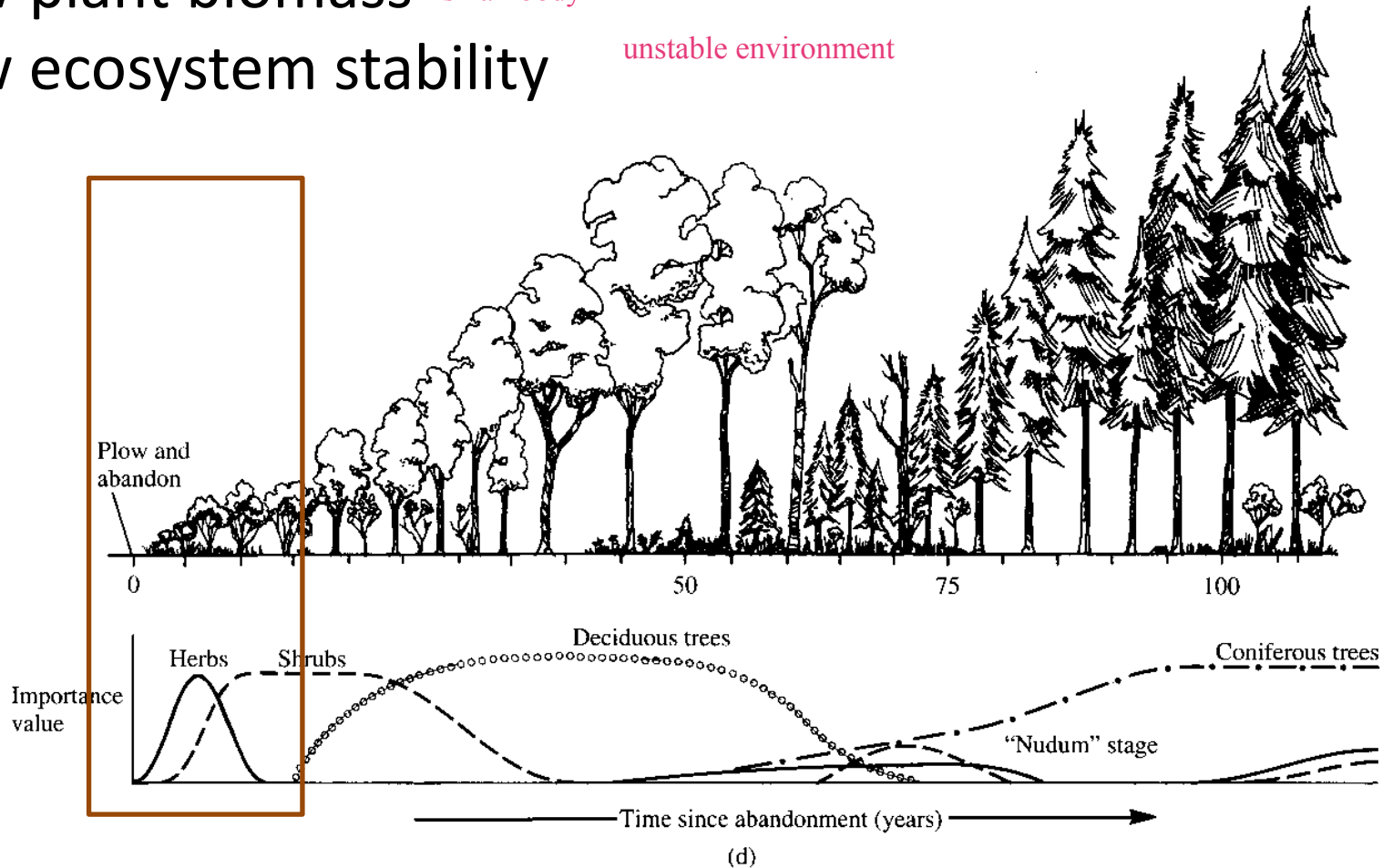
- Large body size, long lived, fewer offspring
  - Stable or predictable environments if they're animals, high investments in parental care
- do better in stable or predictable environments

An oversimplification, but patterns inversely correlated traits

# Stages of ecological succession

## Early successional species (pioneer species):

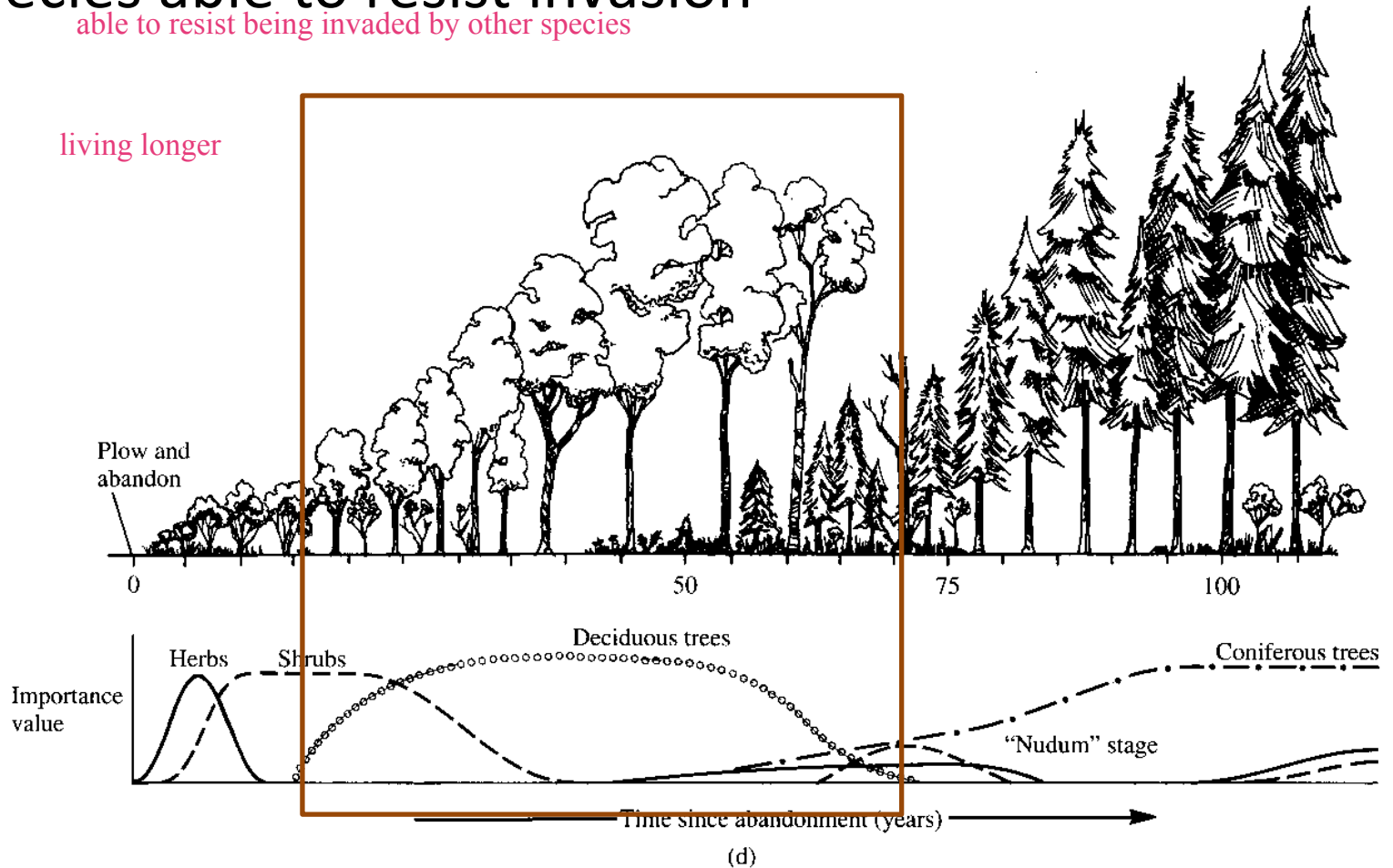
- r-select organisms *r-select quickest... pumping out seeds everywhere... exploit new env*
- Low plant biomass *small body*
- Low ecosystem stability *unstable environment*



# Stages of ecological succession

## Mid-successional species (seral stage):

- Body size increases
- Species able to resist invasion seral stage  
able to resist being invaded by other species



# Stages of ecological succession

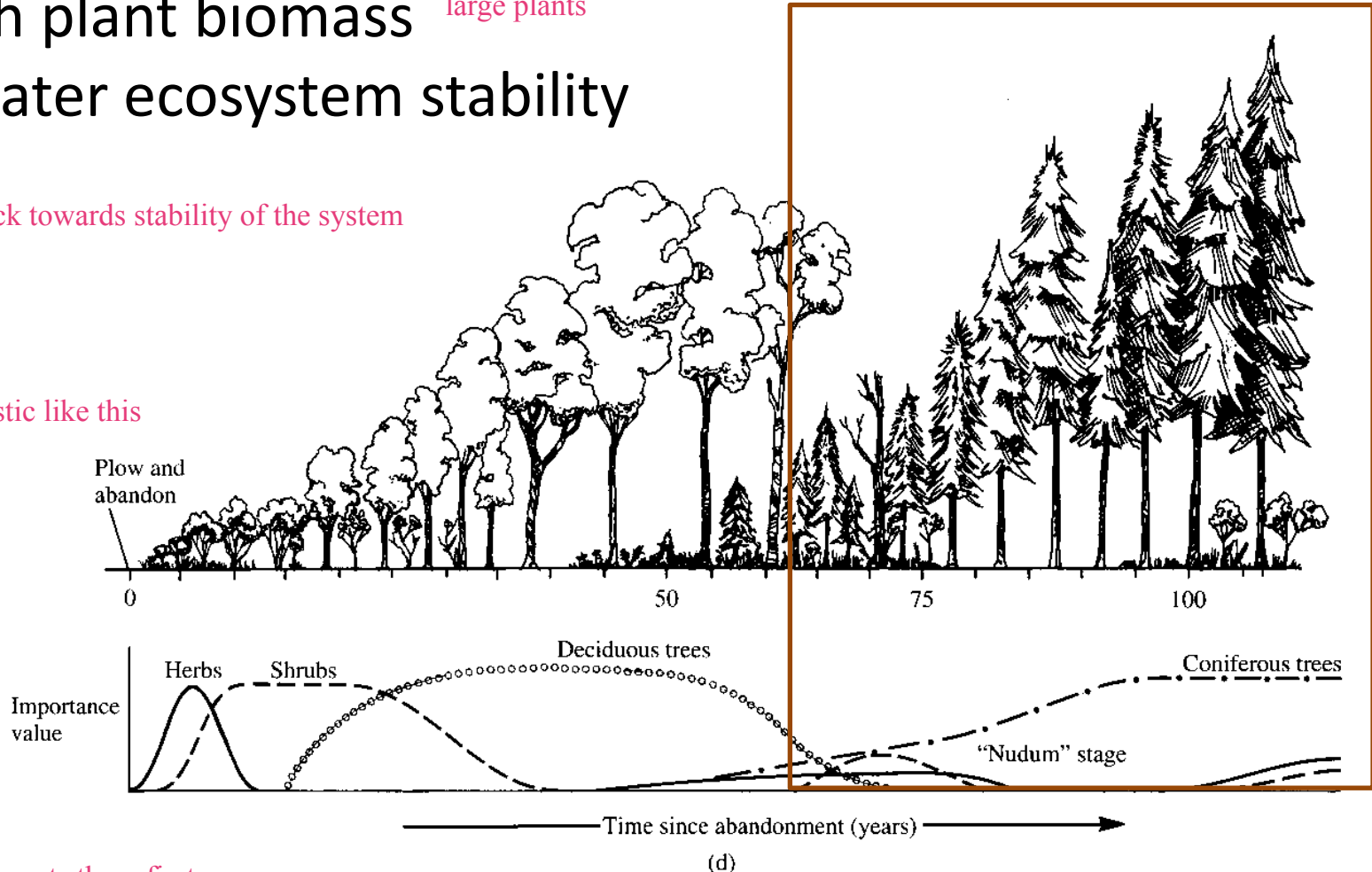
## Late successional species (climax species):

- K-select organisms
- High plant biomass *large plants*
- Greater ecosystem stability

this is clements vs gleason!

feedback towards stability of the system

that its deterministic like this



priority effects:  
- depends on who gets there first

# Mechanisms of Ecological Succession

stimulation for this change is really just about abiotic conditions. env is changing

**Allogenic succession** – stimulus for change from outside the community. Change comes from progression of physical (abiotic) processes:

nobody's there yet

E.g. Weathering of “parent material” (lava, ash, glacial till, talus, etc.) by wind and water

**Autogenic succession** – stimulus for change from w/in the community (organisms change the environment). Change comes from biotic processes.

E.g. abandoned field → forest

Primary succession starts with allogenic, proceeds to autogenic.  
Secondary succession starts with autogenic.

# Autogenic processes

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**Facilitation:** some species arrive earlier and make it **easier** for species to invade later. E.g. nitrogen fixing plants.

**Inhibition:** some species arrive earlier and make it **harder** for species to invade later.

**Tolerance: no interactions**, some species tolerant early conditions, some species tolerate late conditions--may depend on life histories, but NOT on species interactions.

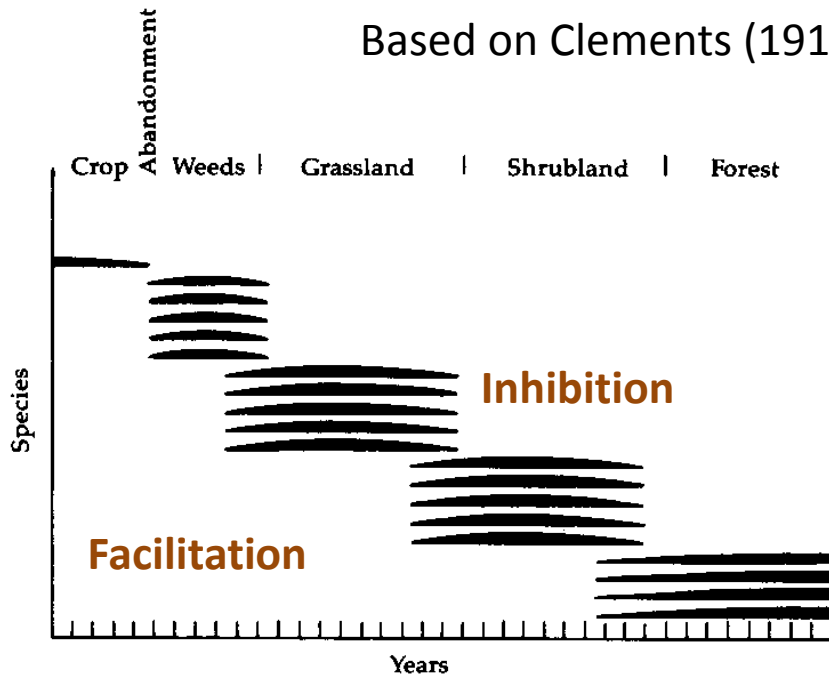
Long-term studies have found that all three types of processes may co-occur in the same successional sequence (but inhibition is most common mechanism)

Based on: Connell and Slatyer (1977)

# Ecological Succession - Models

## Relay Floristic Model

Based on Clements (1916)

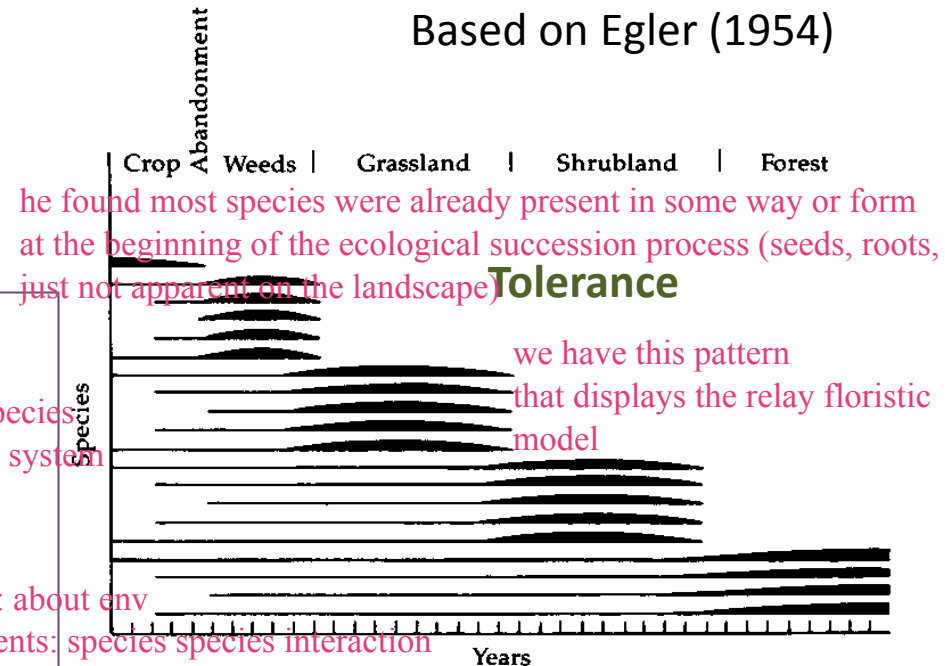


discrete entities of time?  
organismic concept

these communities resisting and inhibiting invasion of other species

## Initial Floristic Model

Based on Egler (1954)



he found most species were already present in some way or form at the beginning of the ecological succession process (seeds, roots, just not apparent on the landscape)

**Tolerance**

we have this pattern that displays the relay floristic model

egler: about env  
clements: species species interaction

### Difference between models:

- Timing of immigration
- Importance of sequential changes to environment

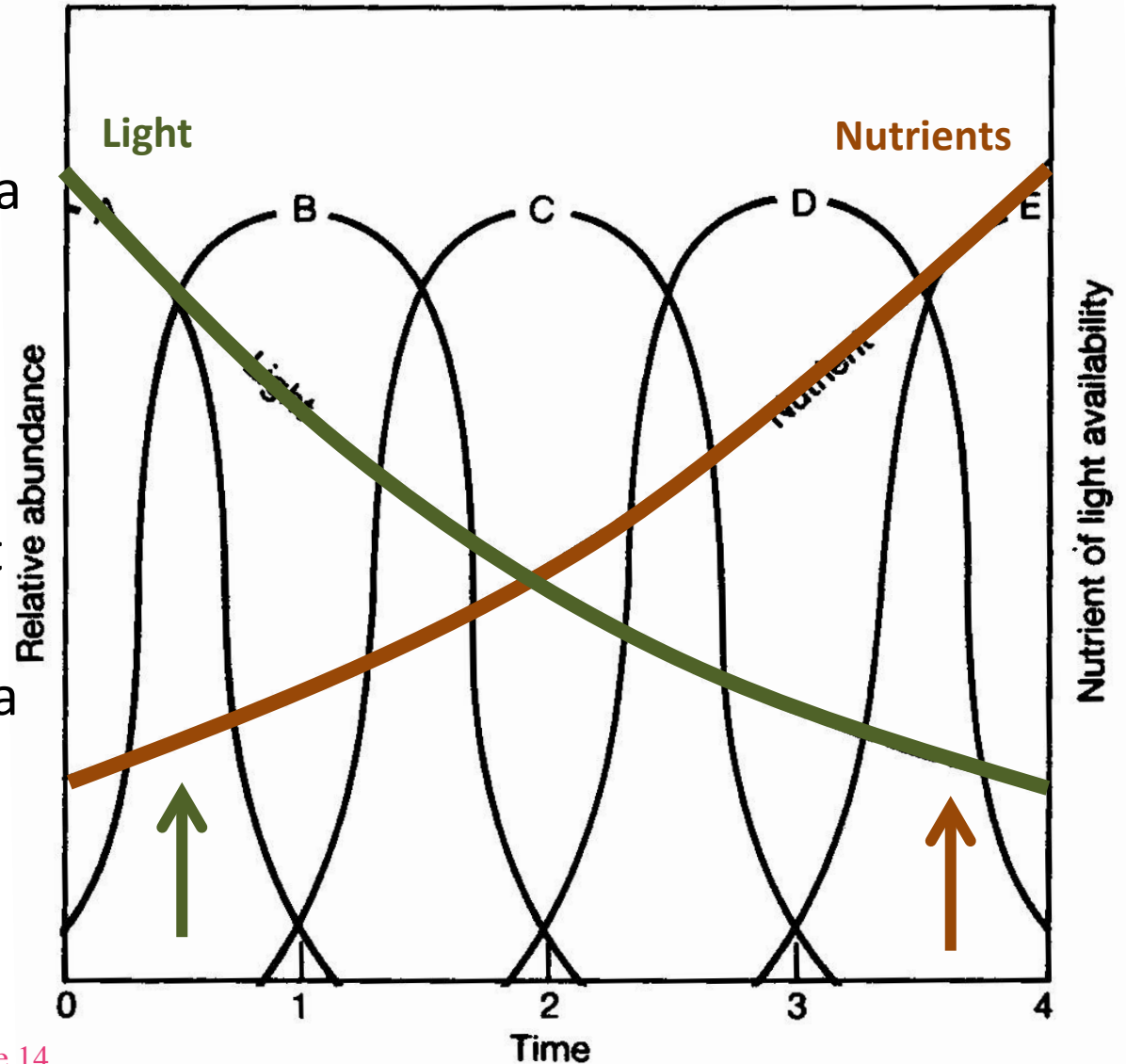
when the species came in the system

# Resource-Ratio hypothesis

Succession is a result of turnover in the identity of competitively dominant species along a **soil-light resource ratio** gradient.

The resource-ratio hypothesis assumes that each plant species is a superior competitor for a particular proportion of the limiting resources.

competition for light or competition for soil or nutrients

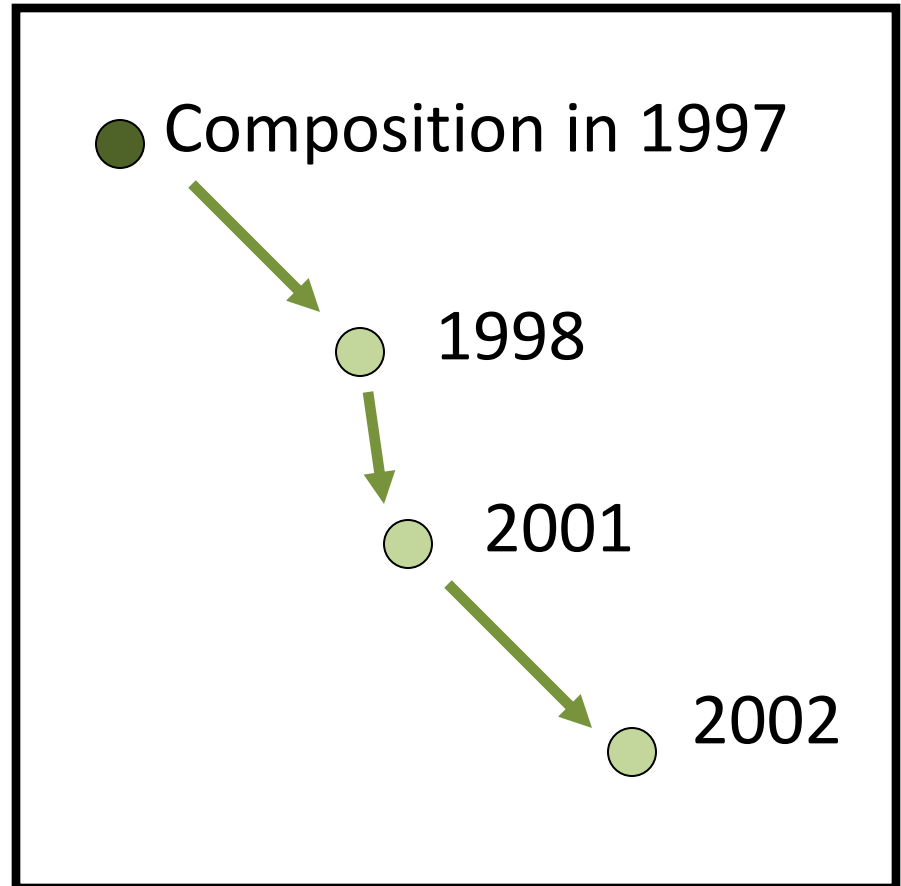


# How do we illustrate these changes?

Can use simple ordination diagrams to illustrate changes

- Each point represents the same plot at different dates
- This chart shows ongoing changes, with composition continually changing

when dots are closer together,  
communities more similar than  
when further apart

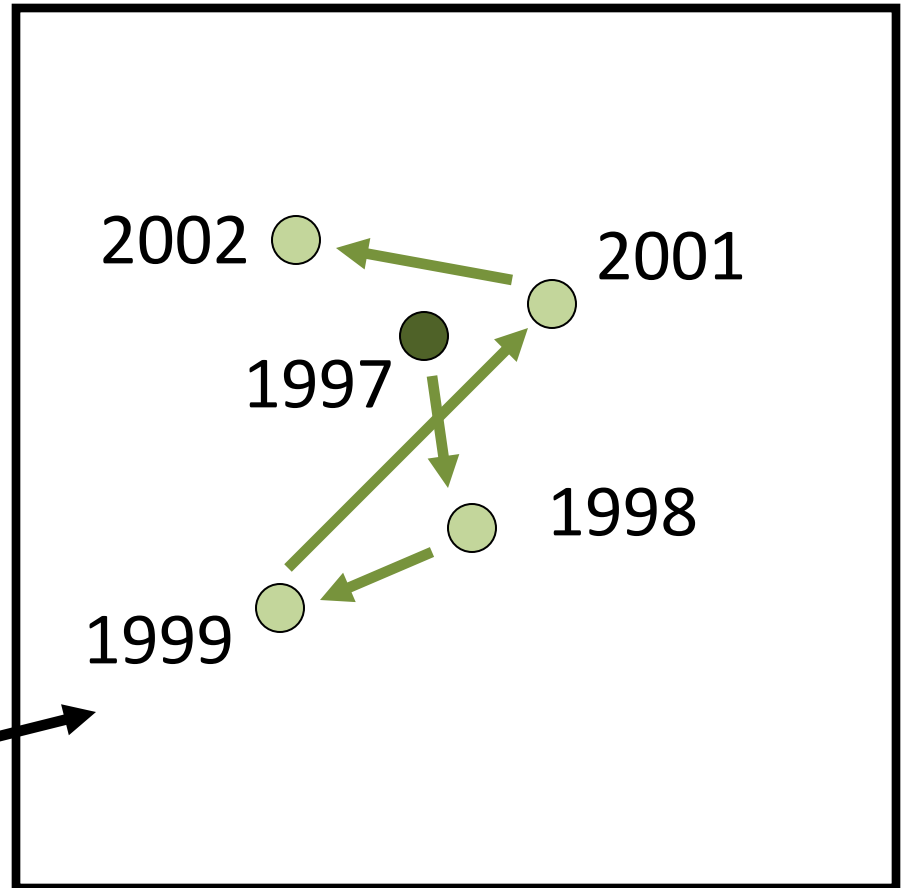


E.g. NMDS Ordination plot of communities over time

# Fluctuations vs. Succession

- Minor, short-term, reversible changes in composition are called fluctuations, rather than succession.
- Plant succession is a directional change in the species composition or structure of a community over time.

No clear directional changes



year to year variations E.g. NMDS Ordination plot of communities over time

# Successional time-frames

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- Successional changes can occur over all time scales
  - From weeks and months ...
    - e.g. colonisation of bare mud on a lakebed
  - to geological time
    - e.g. evolution of earth's vegetation
- Typically, successional studies focus on decadal or century-scale changes

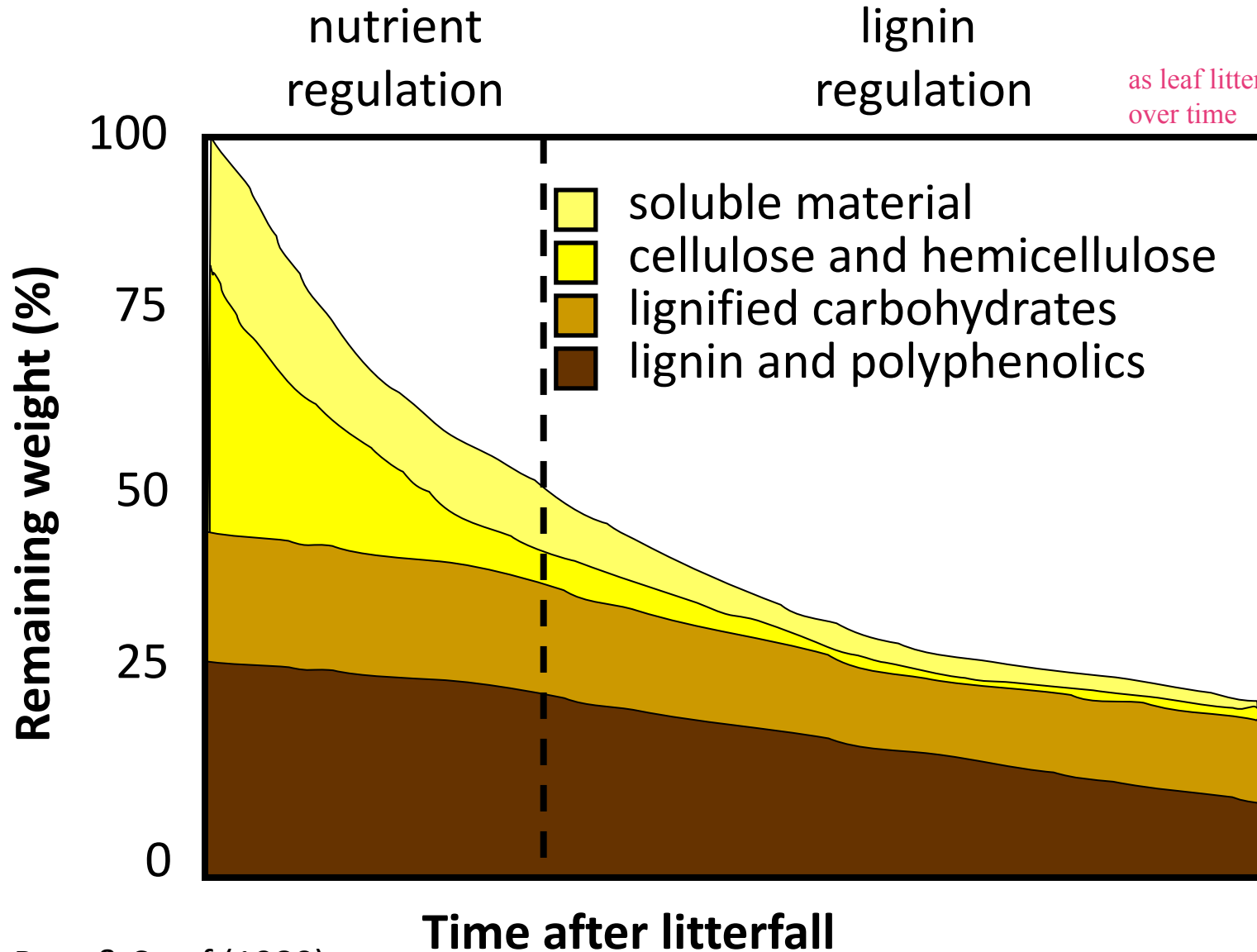
time is harder to study than space

# Degradative succession

also happens in animal communities

harder to study than plants because plants don't move

as leaf litter decomposes over time



From: Berg & Staaf (1980)

# Take home

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- Community structure varies not only in space but also time.
- Succession can be primary or secondary, and involve heterotrophic as well as autotrophic species.
- Despite a long history, we still aren't sure how succession 'works':
  - the relative importance of allogenic versus autogenic factors varies among systems
  - the relative importance of facilitation, inhibition, and tolerance varies among systems
  - a true 'climax' community may not even exist

# Terms and Concepts

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## Lecture 14

Organismic vs. individualistic continuum concepts

Primary vs. secondary

Disturbance (exogenous, endogenous)

r vs. K-select species

Pioneer species

Seral and climax stages

Allogenic vs. autogenic

Facilitation, inhibition, tolerance

Rely vs. Initial floristic models

Resource-Ratio hypothesis