Succession as Ecosystem Development

Succession is viewed as directional change in community composition

- Species composition during succession is driven by:
  - Life history traits
  - Facilitation
  - Competition (inhibition)
  - Stochastic events
  - What else?
- In early succession, communities are governed by dynamics of colonization
- Later, they are governed by competition for resources

Life history traits of dominant species change over succession

- More r-selected species initially
  - Rapid growth
  - Short life span
  - High assimilation rates
  - Lots of small seeds
- K species more common later
  - Slow growth
  - Long life span
  - Low assimilation rates
  - Fewer, larger seeds
  - More energy allocated to defense and persistance

Changes in life history traits at Glacier Bay

Successional Stage	Seed mass (ug/seed)	Max Height (m)	Age at First Reprod. (yr)	Max longevity (yr)
Pioneer	72	0.3	1	20
Dryas	97	0.1	7	50
Alder	494	4	8	100
spruce	2694	40	40	700

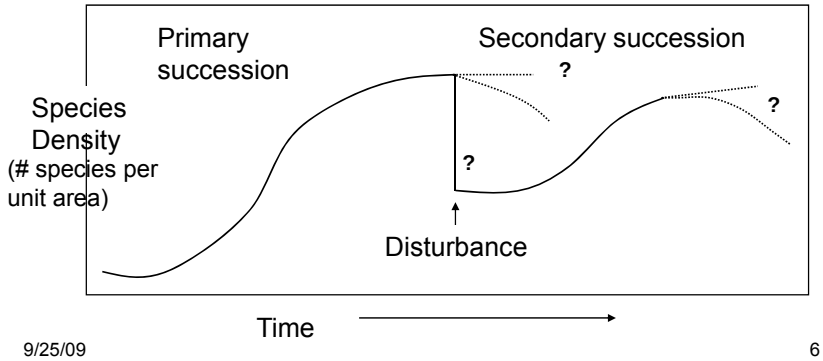
Chapin et al. 1994

Succession occurs at the ecosystem scale

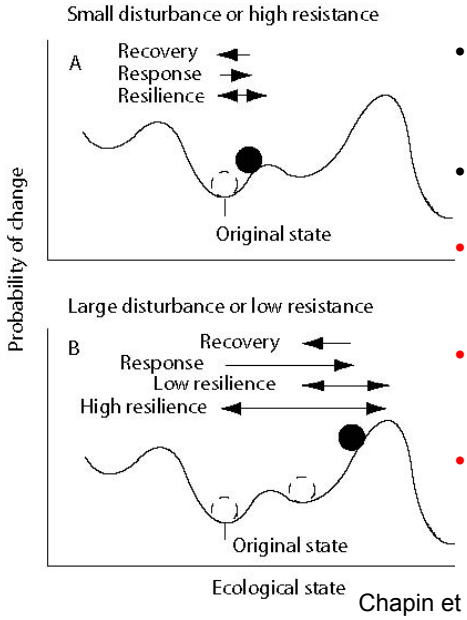
- Change in resource availability is an ecosystem-level process
  - Soil nutrient availability
  - Light
  - What else?
- Biotic interactions
  - Herbivory
  - Symbioses
- Changes in biomass accumulation, water cycling occur during succession

How does biodiversity change during succession?

How would this differ across biomes?



Ecosystem resilience and change



- Disturbances are followed by response and recovery
- Community/ecosystem stability includes 3 components:
- Resilience
  - Ability to return to an average condition following disturbance
- Resistance
  - Ability to remain unchanged during a period of stress
- Persistence
  - Ability to remain unchanged over time

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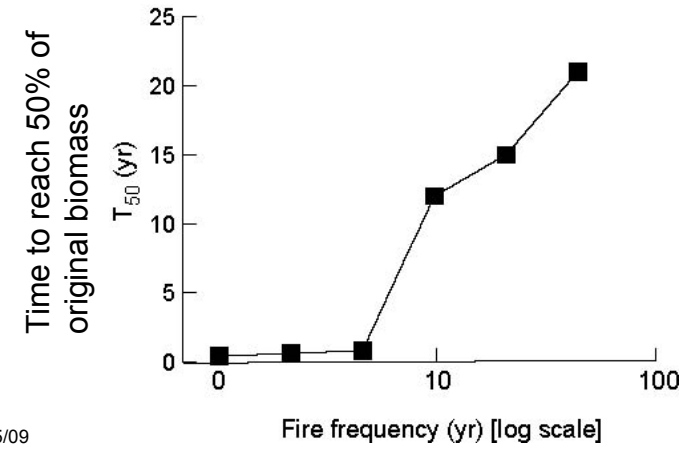
Chapin et al. 2002

What does this figure say about the relationship between disturbance frequency and resilience?



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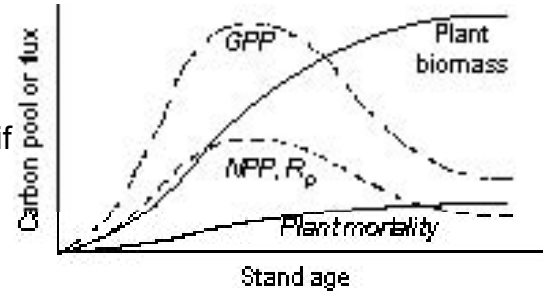
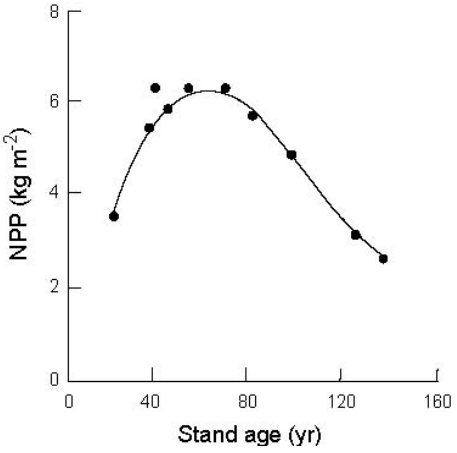
Carbon balance over succession

- GPP - R_p = NPP
- GPP = gross primary production (photosynthesis)
- R_p = plant respiration
- NPP = net PP; annual flux
- Biomass pools accumulate over time if GPP/Rp >1
- Would you expect biomass always to reach steady state?
- How would this differ for secondary succession?



Carbon balance over succession (2)

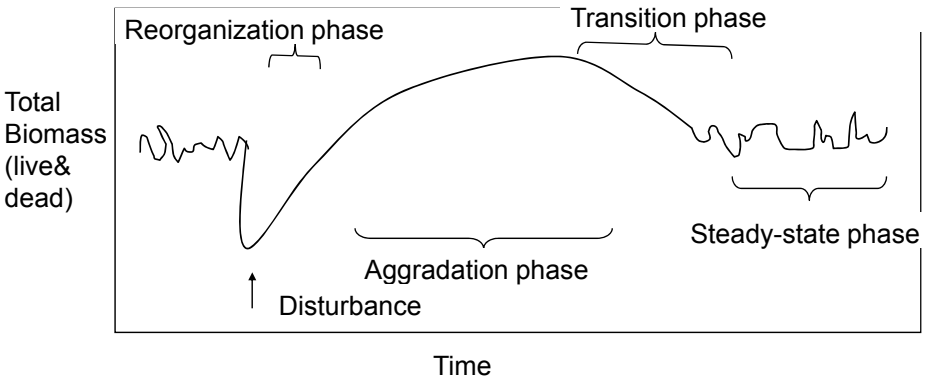
Fig. 13.8, Chapin et al. 2002



- **Forest NPP often greatest in mid-succession**
- **Declines following canopy closure (maximum LAI)**
  - **decreased hydraulic conductance**
  - **decreased nutrient availability**

Carbon balance over succession (3)

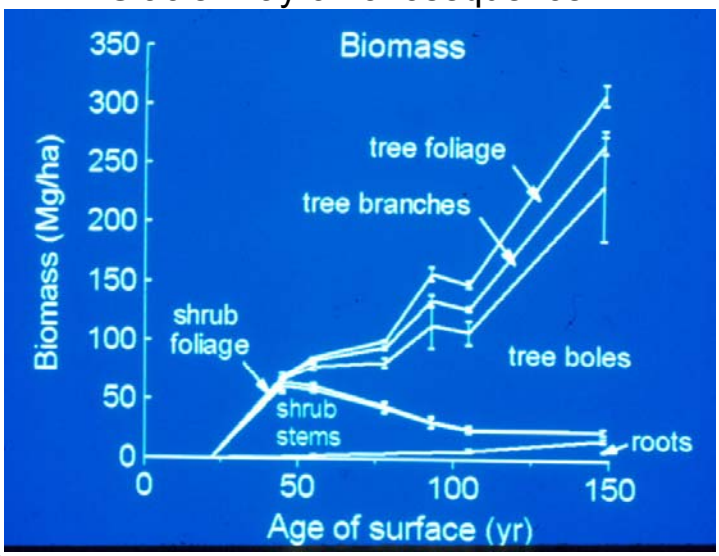
- Biomass changes during secondary succession: Bormann & Likens, 1979



Carbon balance over succession (4): Photosynthesis to Respiration ratio (P/R)

- This drives changes in biomass
- Gross primary production = Photosynthesis = P and ecosystem respiration = R
- At steady state, P/R ≈ 1
- During reorganization, P/R < 1
- In aggradation phase, P/R >1,
- In transition phase, P/R declines slowly
- Describe the mechanisms responsible for these changes

Biomass accumulation along the Glacier Bay chronosequence

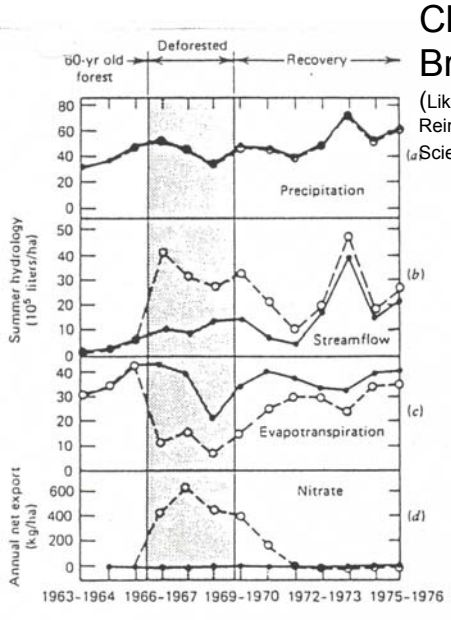


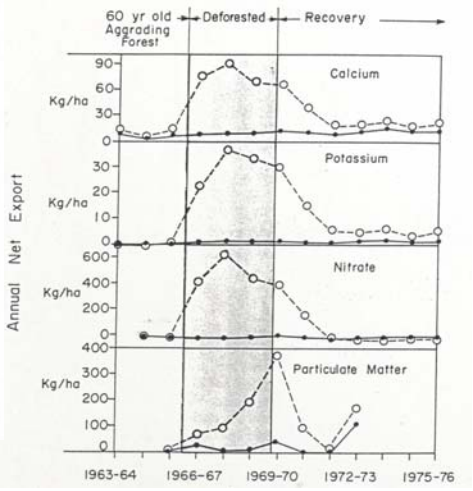
Nutrient Cycling over Succession

- Leaky in pioneer ecosystems; tight in climax systems
- Major sites of nutrient storage
  - Soil initially
  - Biomass later
  - Nutrient availability declines
- Importance of detritus
  - Minor to begin with
  - Coarse woody debris accumulates in forests

Classic data from Hubbard Brook watershed studies

(Likens, G. E., F. H. Bormann, R. S. Pierce and W. A. Reiners. 1978. Recovery of a deforested ecosystem. Science 199:492-496)





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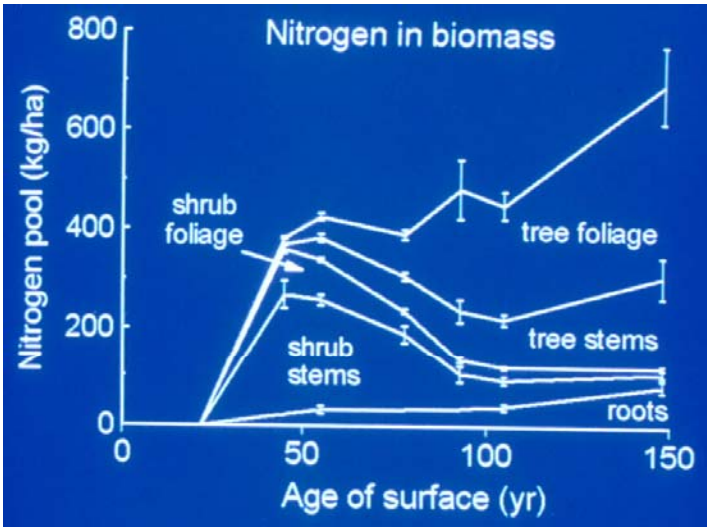
N in biomass along the Glacier Bay chronosequence



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Some “take-home” messages

- Succession is a process of ecosystem change through time (allogenic or autogenic)
- Vegetation and ecosystem properties are the cumulative product of response to past disturbances
- Vegetation and habitat management will benefit from recognizing dynamics as well as more stable stages
- Evaluate dynamics of ecosystem properties in addition to plant community composition