Community Change: disturbance and succession

Reading: Chap. 13

I. Disturbance
A. Disturbance: type, time, severity, and scale
B. Stability: resistance/resilience

II. Succession
A. Primary and secondary succession
B. Changes in species composition
C. Changes in C cycling
D. Changes in nutrient cycling
E. Changes in trophic interactions
F. Changes in water and energy balance
I. Disturbance
A. Disturbance:

CMM - “a discrete event in time and space that alters the structure of populations, communities, and ecosystems and causes changes in resource availability or the physical environment.”

Any physical force that results in mortality of organisms or loss of biomass.

Any physical force? What qualifies as “disturbance”?

What about?
- A single tree fall?
  - A log rolling against rocks in the intertidal zone?
  - A gopher mound?
  - An outbreak of gypsy moths?

I. Disturbance
A. Disturbance:

Any physical force that results in mortality of organisms or loss of biomass.

Type – what kind of disturbance event occurs
Timing: - frequency (how often)
  - when, relative to other events
Severity - how much mortality/change is caused
  (Intensity - how strong the force is [energy/area/time].)
Scale - how large an area it covers
How do biotic communities respond to disturbance?

B. Stability: resistance, resilience

- Resistance: the ability of a community or ecosystem to maintain structure and/or function in the face of potential disturbance
- Resilience: the ability of a community or ecosystem to return to its original conditions following disturbance

What affects resistance and resilience?

Grasslands, California

Dry forest, Hawai’i

- Non-native, easy burning, fire-tolerant grasses
- Ohia (*Metrosideros polymorpha*)
- Native trees
Effects of fire suppression

II. Succession
Directional change in ecosystem structure and functioning over time following disturbance.

Results from changes in species composition in response to biotically-driven changes in resource availability

A. Primary and Secondary Succession

- Primary succession - growth on a new mineral substrate
  - Volcanic deposition
  - Glaciation
  - Landslide
  - Sand dunes
  - River bars

- Secondary succession - new organisms but soil remains intact from previous community.
  - Fire
  - Clearcut
  - Insect outbreak
  - Hurricane/storm damage
  - Agriculture - old fields
Receding glacier

Bare talus (rock)
White spruce
Alder
Lichens and small herbaceous plants

Severity of disturbance

B. Changes in species composition

1. Early and late successional species
Early and late successional species – Glacier Bay

See this site: http://glacierbay.areaparks.com/parkinfo.html?pid=8410

Early and late successional species

Climax communities

Early successional species: pioneer species

Late successional species: climax community
- monoclimax: one community type, determined by climate
- polyclimax: many community types depending on soils, topography, etc.

Monoclimax communities BC coastal forests – many different successional trajectories lead to similar western hemlock/red cedar community

Polyclimax, California grasslands: same climate, but very different plant communities because of different soil types
- Sandstone soils – Eurasian annual grasses and clovers
- Serpentine soils – mostly native perennial perennials

2. Mechanisms of succession

Facilitation
Inhibition
Functional traits
Herbivory
- First two influence changes in abiotic conditions and resource availability.
- All can operate simultaneously
Facilitation and inhibition can operate simultaneously.

3. Changes in resources

BIOTIC INFLUENCES:
Light availability declines and N availability increases.

Lake Michigan dunes, primary succession (Lichter 1998)

C. Changes in Carbon Cycling

1. Biomass

2. GPP, NPP

3. Het. respiration, NEP

C. Changes in Carbon Cycling

2. NPP – typically maximum in mid-succession

Why?
  a. Increased plant resp.?
C. Changes in Carbon Cycling

2. GPP, NPP - summary

Fig. 13.9

![Graph showing GPP, NPP, and NEP over stand age]

C. Changes in Carbon Cycling

3. NEP – peaks in mid-succession, ~0 in late succession (GPP = R_{total})
Heterotrophic respiration – increases to a max

![Graph showing carbon cycle through primary and secondary succession]

3. Heterotrophic resp. and NEP
a. Primary Succession

![Graph showing carbon dynamics in primary succession]

3. Heterotrophic respiration, NEP
b. Secondary Succession

![Graph showing carbon dynamics in secondary succession]

Can we pull more CO₂ out of the atmosphere by converting old growth forests to young forests?

- GPP higher in young than old forests
- NPP higher in young than old forests
- NEP higher in young than old forests

- So, should we cut old growth forests that aren’t pulling CO₂ out of the atmosphere and replace them with young tree plantations?

But, total C storage higher in old than young growth forests

<table>
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<th>Component</th>
<th>60-year-old forest</th>
<th>450-year-old forest</th>
<th>References</th>
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<tr>
<td>Folage</td>
<td>5.5</td>
<td>6.2</td>
<td>(60)</td>
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<tr>
<td>Brachwood</td>
<td>7.0</td>
<td>7.0</td>
<td>(60)</td>
</tr>
<tr>
<td>Solid wood and bark</td>
<td>145</td>
<td>123</td>
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<tr>
<td>Crude wood</td>
<td>29</td>
<td>71</td>
<td>(60)</td>
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<tr>
<td>Fine wood</td>
<td>5.6</td>
<td>5.6</td>
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<tr>
<td>Fine wood debris</td>
<td>7.1</td>
<td>26</td>
<td>(60)</td>
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<tr>
<td>Crude wood debris</td>
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<td>97</td>
<td>(27)</td>
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<tr>
<td>Soil carbon</td>
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<td>56</td>
<td>(66)</td>
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<tr>
<td>Total</td>
<td>289 to 274</td>
<td>611 to 682</td>
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</table>

*Range given because of variation in estimates for folage and coarse woody debris.

Harmon et al. 1990 Science
Where does the C go from logging?

Over half goes to fast turnover pools, then to the atmosphere.

Harmon et al. 1990 Science

Most rotations are 60-80 years

D. Changes in nutrient cycling
1. Primary succession
   - Increased N availability early (inputs)
   - Open → closed
   - Decreased N availability late (litter quality)

Harmon et al. 1990 Science

Soil properties - Glacier Bay: increased soil C leads to increased CEC

(Lichter 1998)
D. Changes in nutrient cycling

2. Secondary succession
   - Nutrient loss following disturbance removing plant biomass.
   - Results from both decreased plant uptake and decreased microbial immobilization.

And increased runoff:

Runoff increases after disturbance
Less transpiration
More runoff (leftovers after plant water uptake)

See book (pp. 298-301):
E. Changes in trophic interactions
F. Changes in water and energy balance