Ecosystem IV: Disturbance and Herbivory

Disturbance

Keddy 2000: A short-lived event that causes a measurable change in the properties of an ecological community.

Properties of disturbance:

1. Duration
2. Intensity (severity)
3. Frequency (recurrence interval)
4. Area
Disturbance
Flooding & drought (water level fluctuations)

Figure 1. Location of managed and reference marshes on the Louisiana coast.
Kuhn, Mendelssohn & Reed 1999
Disturbance – altered water level fluctuations

Figure 5. Marsh surface sediment deposition in reference and managed marshes. Data are medians for each biweekly sample with arrows showing significant differences (p≤0.05) between two marshes for a given collection date (n = 18).

Kuhn, Mendelssohn & Reed 1999
Disturbance – erosion and scour

Auble & Scott 1998

Duration
Intensity
Frequency
Area

A. No Year-to-Year Change

First year: Normal peak
Future years: No change

Germination
Flooding mortality
Drought mortality

No Tree Recruitment

B. Narrowing

First year: Low peak
Future years: Continued low peaks:

Germination
Flooding mortality
Drought mortality

Tree Recruitment on Former Channel Bed

C. Meandering

First year: Moderate peak
Future years: Continued channel meandering

Germination
Flooding mortality
Drought mortality

Tree Recruitment on Accreting Point Bars

D. Flood Deposition

First year: Flood peak
Future years: Normal peaks

Germination
Flooding mortality
Drought mortality

Tree Recruitment on Flood Deposition Surfaces

Figure 4. Hydrogeomorphic control of cottonwood recruitment: diagrammatic representations of cottonwood seed germination, early seedling mortality, and tree recruitment in relation to annual high and low flow lines along a bottomland elevation gradient. Four idealized situations are depicted using a single bottomland cross-section: (A) little or no tree recruitment in the absence of inter-annual flow variability and channel movement, (B) channel narrowing with recruitment on the former channel bed, (C) recruitment on point bars of a meandering river, and (D) tree recruitment at high elevations associated with infrequent floods and no channel movement.
Disturbance – animals (hog rooting)

Arrington, Toth, and Koebel, Jr. 1999
Disturbance – fire

Ford and Grace 1998
Disturbance – ice scour

Duration
Intensity
Frequency
Area
Disturbance – waves

Duration
Intensity
Frequency
Area

Bedford 1992
Disturbance – burial

Duration
Intensity
Frequency
Area
Disturbance – burial

Dittmar and Neely 1999
Figure 6.19  Effects of experimental disturbance (removal of all biomass) upon five different wetland communities of increasing biomass and fertility (left). Z is a measure of departure from control plot values, and is scaled so all change is greater than 1. The greater Z, the greater the departure from control values. Effects had largely disappeared by year two, and so are not included in the figure (after Moore 1998).
Figure 6.20  Intensity and area plotted for an array of natural disturbances in wetlands.
Herbivory

Wetland herbivores:

- Invertebrates
- Waterfowl
- Muskrats
- Beaver
- Fish
- Small rodents
- Moose
- Nutria
- Others?

Does herbivory have a significant impact on wetland plants?

- < 10% of vegetation biomass consumed
- Very little physical protection created by plants

- Evidence from dietary studies
- Algae highly consumed
- More effect than just consumption
Herbivory

Dietary evidence:
• Fassett’s “Manual of aquatic plants”: has a 15 page appendix of the use of macrophytes by birds, mammals, and fish.
• Review by Gaeveskaya (1969) lists 620 species that eat live macrophytes.

Destruction of plant tissue:
• Many herbivores destroy more plant tissue than is consumed:
  • Crayfish
  • Muskrats
• Increased susceptibility to disease
Figure 30.6 Cyclic replacement of vegetation in a prairie glacial marsh. The cycle is initiated by periods of drought followed by periods of normal rainfall, but the key to replacement is the seed bank in the marsh mud. (After van der Valk and Davis 1978.)
Herbivory

Figure 8.7  Frequency distributions of the proportion of annual net primary productivity removed by herbivores in (a) aquatic algae (phytoplankton, n = 17, and reef periphyton, n = 8); (b) submerged (n = 5) and emergent (n = 14) vascular plants; and (c) terrestrial plants (n = 67). Arrows indicate median values (aquatic algae, 79%; aquatic macrophytes, 30%; terrestrial plants, 18%) (from Cyr and Pace 1993).
Herbivory

Shaffer et al. 1992
<table>
<thead>
<tr>
<th>Herbivory</th>
<th>Biomass</th>
<th>Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Submersed macrophytes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Invertebrates</td>
<td>0-100% (8 of 9)</td>
<td>Y (measured in 5)</td>
</tr>
<tr>
<td>Vertebrates</td>
<td>0-100% (5 of 5)</td>
<td>Not measured</td>
</tr>
<tr>
<td>Emergent macrophytes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Invertebrates</td>
<td>5-75% (2 of 2)</td>
<td>Not measured</td>
</tr>
<tr>
<td>Vertebrates</td>
<td>?-83% (6 of 8)</td>
<td>Y (measured in 6)</td>
</tr>
<tr>
<td>Floating-leaved</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Invertebrates</td>
<td>7-27% (1 of 1)</td>
<td>Not measured</td>
</tr>
<tr>
<td>Vertebrates</td>
<td>10-22% (1 of 1)</td>
<td>Not measured</td>
</tr>
</tbody>
</table>

All vegetation showed substantial biomass losses
Most biomass reduction not caused by consumption
Tissue destruction
Increased susceptibility to disease

Lodge 1991
Fig. 1. Mean nitrogen content (as a percentage of plant dry weight) in: (A) freshwater algae, (B) freshwater and estuarine emergent macrophytes, (C) freshwater floating or floating-leaved macrophytes, (D) freshwater submersed macrophytes, and (E–G) non-cultivated terrestrial plants. One mean is plotted for each plant species. For studies reporting temporal patterns of $N$, the mean of the temporal data was used. For studies reporting on multiple sites, a mean across sites is plotted. Values for emergent plants, floating plants, and trees and shrubs are for leaves. Means for submersed aquatic plants include combinations of values for whole plants (roots and shoots), above-ground biomass, 'shoots', and leaves. Similarly, means for forbs and grasses include values for leaves and shoots. Data sources are indicated with the relevant letter (A–G) at the end of each source entry in the references.
Herbivory

Productivity enhancement:
- Nutrient regeneration
- Less self-shading
- Removal of older tissue
- Grazer saliva stimulation
- Reduced competition
Figure 8.11  Mowing by humans can change species density in English sedge beds. Figure 7.5 provides the data on biomass (after Wheeler and Giller 1982).

Figure 8.12  Species richness plotted against time in European saltmarshes with three contrasting types of management ($n = 5, 2 \times 2 \text{ m}^2$ quadrats) (after Bakker 1985).
Herbivory

\[ \frac{dP}{dt} = gP \left[ \frac{(K-P)}{K} \right] - G \]

\( \frac{dP}{dt} = \) plant growth rate

\( g = \) rate of increase  \( K = \) carrying capacity

\( P = \) plant biomass  \( G = \) grazing
### Attributes of Developing vs. Mature Ecosystems

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Developing</th>
<th>Mature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Production (quality)</td>
<td>High (low)</td>
<td>Low (high)</td>
</tr>
<tr>
<td>Nutrient cycles</td>
<td>Leaky</td>
<td>Tight</td>
</tr>
<tr>
<td>Diversity</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Food webs</td>
<td>Simple</td>
<td>Complex</td>
</tr>
<tr>
<td>Life cycles</td>
<td>Simple</td>
<td>Complex</td>
</tr>
<tr>
<td>Detritus</td>
<td>Unimportant</td>
<td>Important</td>
</tr>
<tr>
<td>Organization</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>
Ecosystem Development

Development insulates the ecosystem from its environment

Biomass:
  - Modify & stabilize hydrologic regimes (riparian zones, peatlands)
  - Nutrient and energy storage
  - Regenerative ability (seed banks, energy reserves)
  - Physical protection (wave & wind energy)