Lecture 12 – food webs and secondary productivity

READINGS:
- Text: Ch 24, 491-503, p. 670-676
- Optional and or Background for Lecture

Outline:
- Secondary Production
  - Production Efficiencies
  - Assimilation Efficiencies
  - Food Chain Efficiencies
- Grazing Food Webs vs. Decomposer Food Webs
- Analysis of efficiencies in a marine ecosystem

STUDY GUIDE
This lecture is designed to get you to think about the structure of food webs and how energy flows through an ecosystem...i.e. how one would construct an energy budget for an ecosystem if we could measure everything (which we can't, of course, except in model systems.).

- Construct an energy flow diagram for both an organism and a food web. What are the similarities? Differences?
- Could you measure energy flow through a food web? How might you try to do this?
- How does the flow of energy through a carnivore differ from that of a herbivore? An endotherm vs. an ectotherm?
- What does fish production in the sea have to do with the structure of food webs?
- There are two hypotheses for why the average length of a food chain is 5. One is energy limitation. What is the other? Can you find any evidence for the second one in the literature?
- Why is the world green? (see your textbook)
- How might the biosphere be changed if all humans were vegetarians? If all animals were herbivores?
- Some have argued that “game ranching” may give higher yields (secondary production) than that of livestock in the same area. What is the evidence for or against this (see your textbook)
ENERGY FLOW, FOOD WEBS, AND EFFICIENCIES:

\[ P_n = \text{Productivity at trophic level } n \text{ (net)} \]
\[ P_{n-1} = \text{Productivity (net) of trophic level } n-1 \]
\[ R_n = \text{Respiration at trophic level } n \]
\[ F_n = \text{Faecal material produced at trophic level } n \text{ (for microorganisms, this would be excreted organic carbon)} \]
\[ I_n = \text{Amount ingested by trophic level } n \]
\[ A_n = \text{Amount assimilated and available for metabolism} \]
\[ D_n = \text{Fraction of } P_{n-1} \text{ not consumed by trophic level } n \]
\[ B_n = \text{Biomass in trophic level } n \]

We can now define the following efficiencies (%):

**Exploitation Efficiency**
\[ EE = \frac{I_n}{P_{n-1}} \times 100 \]
(sometimes called consumption efficiency)

**Assimilation Efficiency**
\[ AE = \frac{A_n}{I_n} \times 100 \]

**Production Efficiency**
\[ PE = \frac{P_n}{A_n} = \frac{P_n}{P_n + R_n} \times 100 \]

**Ecological Efficiency**
\[ \frac{I_n}{P_{n-1}} \times \frac{A_n}{I_n} \times \frac{P_n}{A_n} = \frac{P_n}{P_{n-1}} \times 100 \]

- Tells you how much energy is lost in one trophic transfer in the grazing food chain
- Some of this goes to the detritus food web, some goes to respiration

<table>
<thead>
<tr>
<th>n-1</th>
<th>n</th>
<th>( \frac{I_n}{P_{n-1}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trees</td>
<td>Insects</td>
<td>1-10%</td>
</tr>
<tr>
<td>Grass</td>
<td>Animals</td>
<td>20%</td>
</tr>
<tr>
<td>Phytoplankton</td>
<td>Zooplankton</td>
<td>20-40%</td>
</tr>
</tbody>
</table>

Herbivores 20-50%
Carnivores 80%

Hamlet, IV, II, 17-35

King: Now, Hamlet, where’s Polonius?
Hamlet: At supper.
King: At supper! Where
Hamlet: Not where he eats, but where he is eaten: a certain convocation of politic worms are c’en at him. Your worm is your only emperor for diet: we fat all creatures else to fat us, and we fat ourselves for maggots: your fat king and lean beggar is but variable service; two dishes, but to one table: that’s the end.
King: Alas, alas!
Hamlet: A man may fish with the worm that hath eat of a king, and eat of the fish that hath fed of that worm.
King: What dost thou mean by this?
Hamlet: Nothing, but to show a king may go a progress through the guts of a beggar.