Lecture 18 Productivity and Food Webs

March 16, 2005

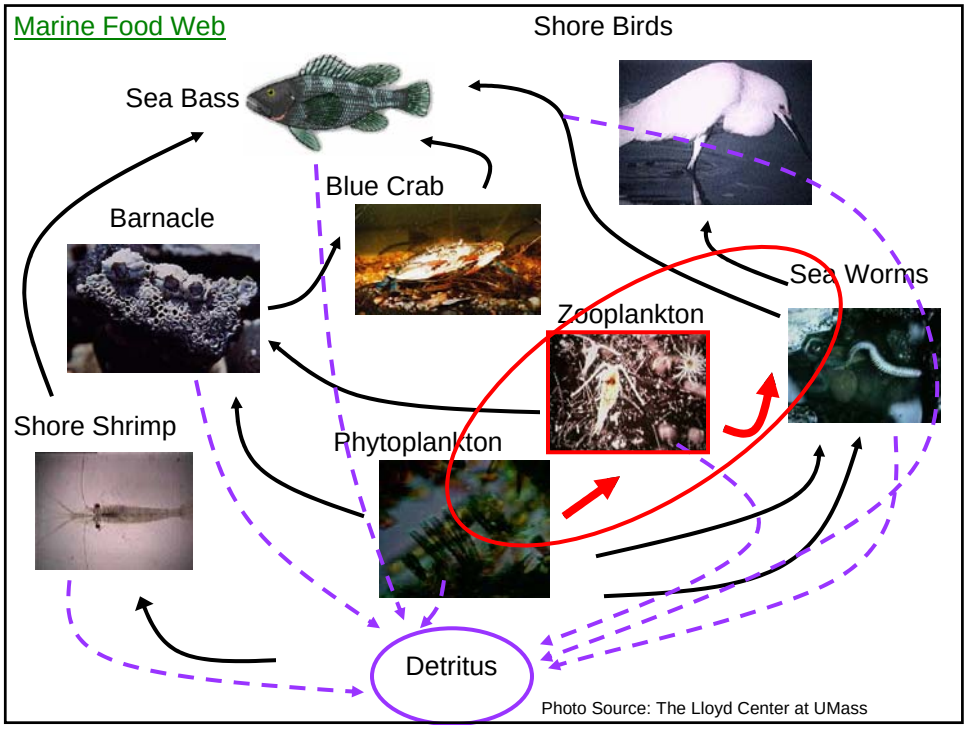
Photosynthesis and Respiration on ecosystem scales

- *Analysis of global productivity*
- *Energy flow through trophic levels and ecosystems*
- *Three weeks in the life of a food web (DVD)*

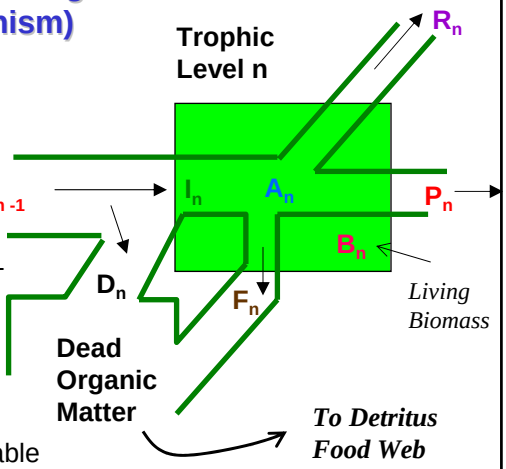
World Net Primary Productivity
(Rounded Estimates)

Ecosystem	NPP ($g\ m^{-2}\ y^{-1}$)	World NPP ($x10^{15}\ g\ y^{-1}$)	Biomass ($g\ m^{-2}$)	World Biomass ($x10^{15}\ g$)
Desert	50	2	720	15
Grassland, etc.	500	25	4000	125
Cultivated Land	1000	10	1000	14
Moist Forest	1000	40	30,000	900
Tropical Forest	2000	40	45,000	750
LAND TOTAL		**177**		**1804**
Estuaries	2000	4	1500	2.6
Continental Shelf	500	10	20	.3
Open Ocean	100	40	3	1.0
MARINE TOTAL		**54**		**3.9**

World NPP = NPP × ∑Area
World Biomass = Biomass × ∑Area



Flow of Carbon (Energy) Through a Trophic Level (or organism)



P_{n-1} = Productivity of trophic level n-1

D_n = Portion of P_{n-1} not consumed

I_n = Amount Ingested

F_n = Fecal matter produced

A_n = Amount assimilated and available

R_n = Respiration

B_n = Biomass in trophic level n

P_n = Productivity at trophic level n

Ecological Efficiencies

Exploitation Efficiency (EE)

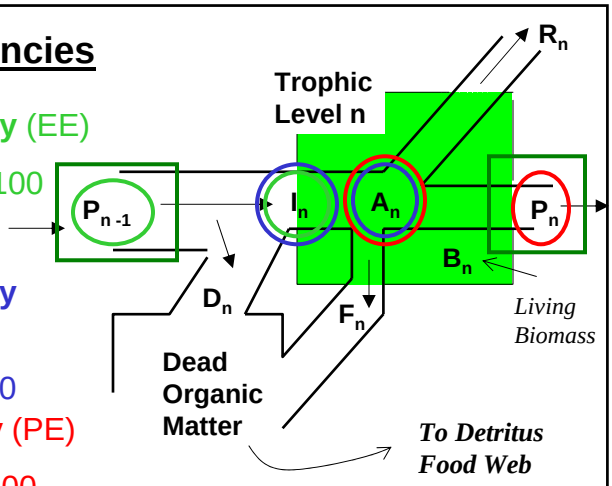
$EE = I_n / P_{n-1} \times 100$

Assimilation Efficiency (AE)

$AE = A_n / I_n \times 100$

Production Efficiency (PE)

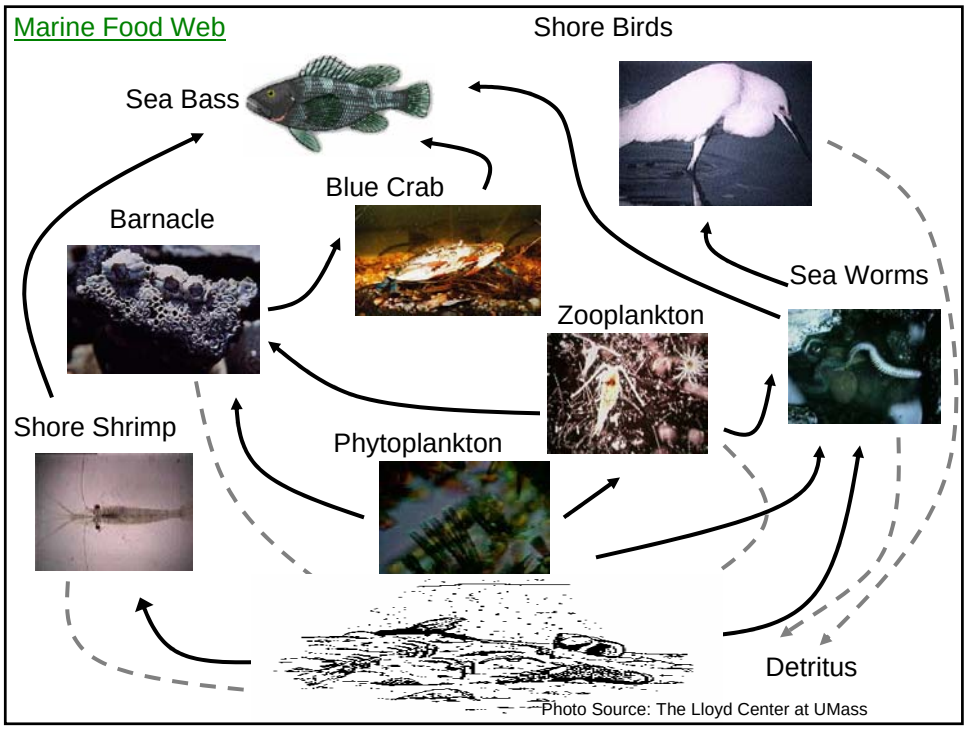
$PE = P_n / A_n \times 100$

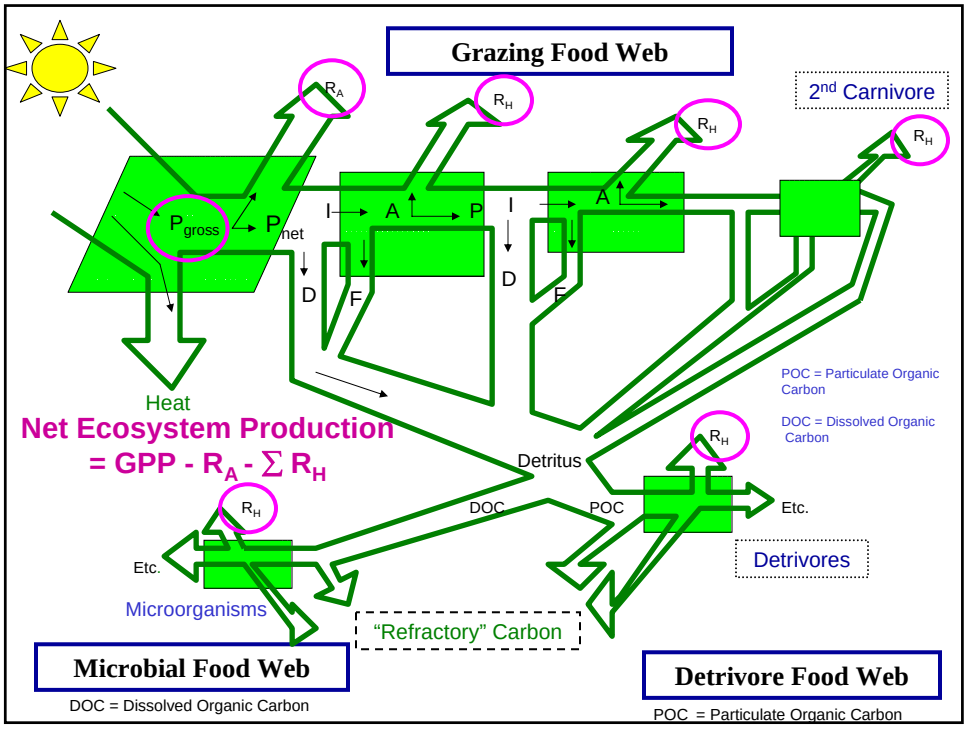


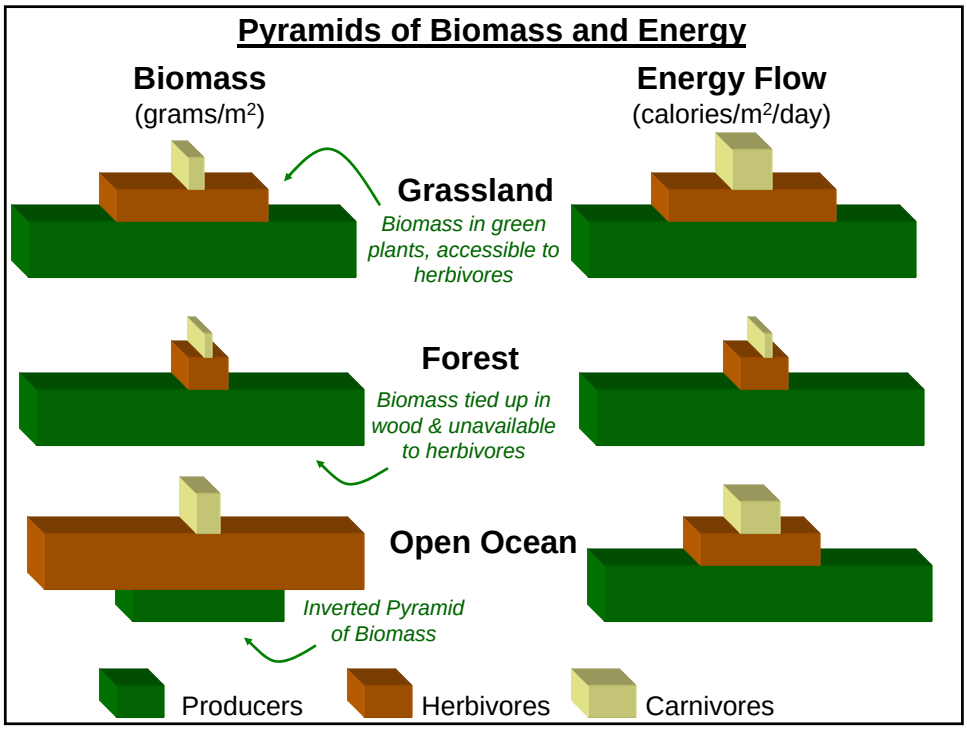
Ecological Efficiency = (EE)(AE)(PE)

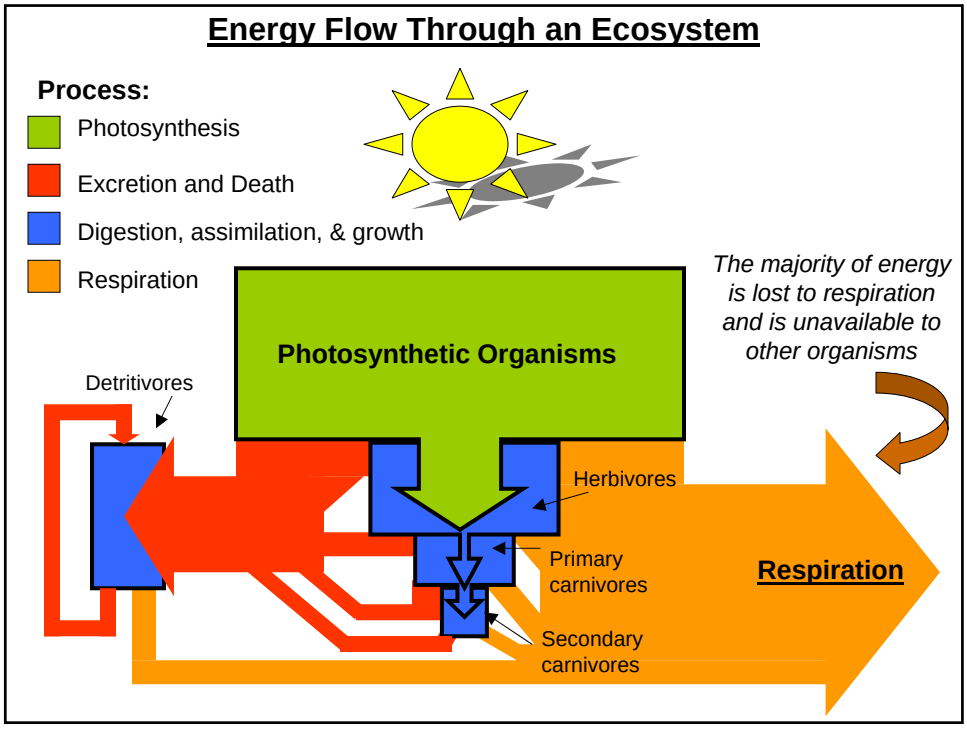
$= P_n / P_{n-1} \times 100$

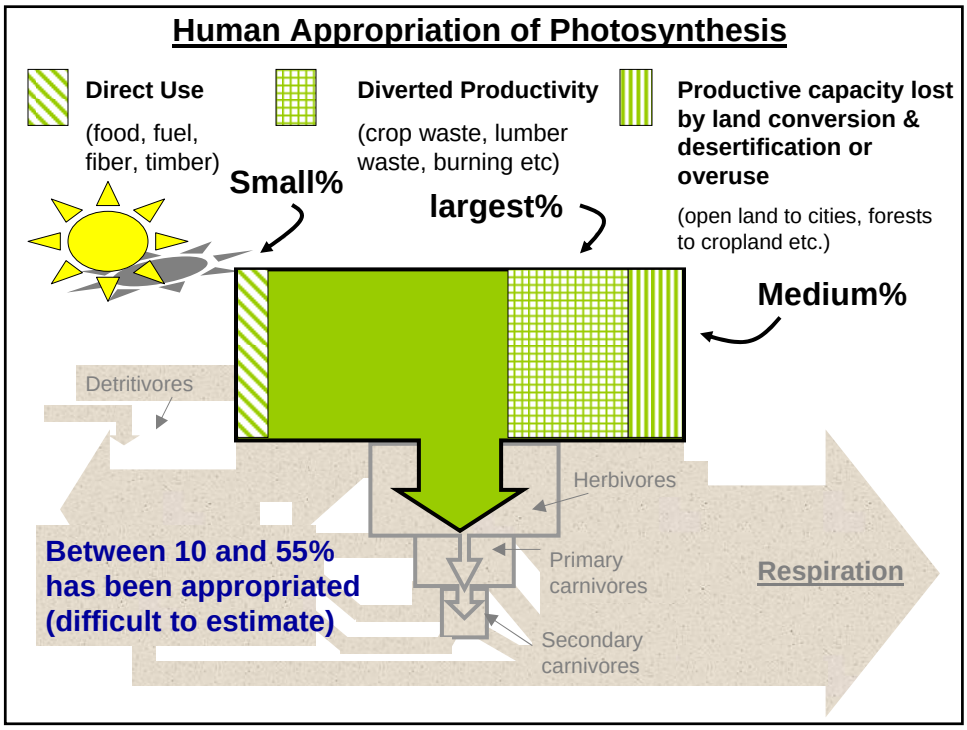
$\approx$ 10 % to 20 %




Grazing Food Web
2nd Carnivore
R_A
R_H
P_{gross}
P_{net}
I
A
P
D
F
Heat
Net Ecosystem Production
= GPP - R_A - ∑ R_H
POC = Particulate Organic Carbon
DOC = Dissolved Organic Carbon
Detritus
DOC
POC
Etc.
Detrivores
Microorganisms
"Refractory" Carbon
Microbial Food Web
Detrivore Food Web
DOC = Dissolved Organic Carbon
POC = Particulate Organic Carbon


Pyramids of Biomass and Energy
Biomass
(grams/m²)
Energy Flow
(calories/m²/day)
Grassland
Biomass in green plants, accessible to herbivores
Forest
Biomass tied up in wood & unavailable to herbivores
Open Ocean
Inverted Pyramid of Biomass
Producers
Herbivores
Carnivores


Energy Flow Through an Ecosystem
Process:
Photosynthesis
Excretion and Death
Digestion, assimilation, & growth
Respiration
The majority of energy is lost to respiration and is unavailable to other organisms
Photosynthetic Organisms
Detritivores
Herbivores
Primary carnivores
Secondary carnivores
Respiration


Human Appropriation of Photosynthesis
Direct Use
(food, fuel, fiber, timber)
Diverted Productivity
(crop waste, lumber waste, burning etc)
Productive capacity lost by land conversion & desertification or overuse
(open land to cities, forests to cropland etc.)
Small%
largest%
Medium%
Detritivores
Herbivores
Primary carnivores
Secondary carnivores
Respiration
Between 10 and 55% has been appropriated (difficult to estimate)

Blue Planet DVD
Three weeks in the life of a Marine Food Web

Think About:

- The massive amount of energy and carbon the phytoplankton must be processing to support such a diversity and biomass at higher trophic levels
- How the information in DNA could be controlling all of these complex processes