APES – Chapter 3 – Ecosystem Ecology

Intro: Reversing the Deforestation of Haiti

Why is Haiti cutting down its trees?
Use as fuel…convert to charcoal.

What are the consequences of deforestation?
As population increases, has gone from 60% to 2% forest cover. Trees are often cut before they grow, increased erosion, decreased soil quality, increased mudslides (disrupts hydrologic & nutrient cycles)

What are the solutions being put into play?
US Aid…planted 60,000,000 trees, planting mango trees for wood and a way to make a living selling mangos, also develop other fuel sources like "paper cakes"

I. Ecosystem Components

A combination of BIOTIC and ABIOTIC factors.
All of these factors are highly dependent on climate.
Biotic – living, once living, organic (Is it food?)

Abiotic – non-living, physical and chemical, inorganic (Determine what can live in an area.)

A. **Ecosystem Boundaries** – can be difficult to delineate the "edges" of many ecosystems. Basis could be topography, land/water interface, animal or plant "range".

From the standpoint of management the natural boundaries may not align with the administrative, municipal, state, national boundaries.

Ex: Yellowstone National Park and the Greater Yellowstone Ecosystem Book Fig. 3.2- Grizzly bears don't pay attention to national park boundaries! Book Fig. 3.1 – Cave is a simple with clear ecosystem boundaries (ususally)

B. **Ecosystem Processes** – energy and matter flow from one ecosystem to another.

II. Energy Flows Through Ecosystems – Fig. 3.3 – Energy flows (doesn't cycle…never returns to Sun)

A. **Photosynthesis** – the activities of solar-powered producers (green plants, algae, cyanobacteria/blue-green algae) Don't forget chemosynthesis by bacteria that breakdown CH4 or H2S to derive energy. Know formula for photosynthesis (reactants and products).

B. **Cellular Respiration** – unlocking the stored chemical energy from cells and organic molecules. Remember plants also use respiration! Know formula for respiration (reactants and products).

Note: Overall, because producers photosynthesize more than they respire, more (excess) oxygen is produced, and more carbon is stored in tissues. So in daytime, plants consume and produce O2, but produce more O2 overall and at nighttime, more O2 is consumed since photosynthesis not taking place.

C. **Trophic Levels** – (see fig. 3.5, page 61) "Trophe" is Greek for nourishment

Producers (Autotrophs) – may be photosynthetic or chemosynthetic

Consumers (Heterotrophs) – have evolved to exploit numerous feeding strategies.

Primary Consumers – Herbivores

Secondary Consumers – Carnivores that eat the herbivores

Tertiary Consumers – Higher level carnivores that eat secondary consumers, and so on…

Other Consumers:

Omnivores – generalist consumers such as bears, raccoons, humans, some fish, etc, that feed at various levels, based on necessity and opportunity.

Scavengers – specialized consumers that eat dead animals. Ex. Vultures, crows, crayfish

Detritivores – specialized consumers of detritus (dead plant matter and animal wastes) which is broken down into smaller particles. Usually have internal digestion. Ex. Pill bugs, worms, larvae, mites (higher level consumers of these would be centipedes, spiders, etc.) Know how detrivores fit into food webs.

Decomposers – fungi and bacteria that complete the breakdown and recycling of nutrients back into the ecosystem. Usually have external digestion. Know how decomposers fit into food webs.

III. Ecosystem Productivity – measured in g or kg of Carbon/m2/day or year.

A. **Gross Primary Productivity (GPP)** – the total amount of solar energy captured by producers in an ecosystem in a given amount of time. [Photosynthesis]

B. **Net Primary Productivity (NPP)** – the gross primary productivity minus the energy that is lost as organisms respire (metabolize, grow, reproduce, etc.)

So that means: NPP = GPP – R

[Biomass/growth energy = photosynthesis energy – respiration energy loss]
We can think of NPP as any new biomass* that is accumulated and stored during growth and reproduction. Fig. 6.7

As a rule, about **1%** of the incoming solar radiation is captured by Earth's producers during Photosynthesis…for GPP.

Most of that captured energy will be lost to Respiration (the cost of living). (~60%)

The remainder can be stored, supporting growth, repair, reproduction, and is available as food to consumers (as carbos, lipids, proteins, etc.)...i.e. NPP (~40%)

C. **Comparisons of NPP** for various ecosystems (See fig. 3.8, page 64)

Productivity is generally related to the availability of:

1. Sunlight (angle, intensity, duration…)

2. Water (pH, salinity, "hardness", amount…)

3. Nutrients (N, P, K, other trace elements…)

4. Warm temperatures (each ecosystem has optimal temps)

- **Biomass** = the total dry weight or organic matter in a defined area or organism.

  Standing crop = the amount of biomass present in ecosystem at any time.
  Vs. Productivity which is the RATE of energy capture

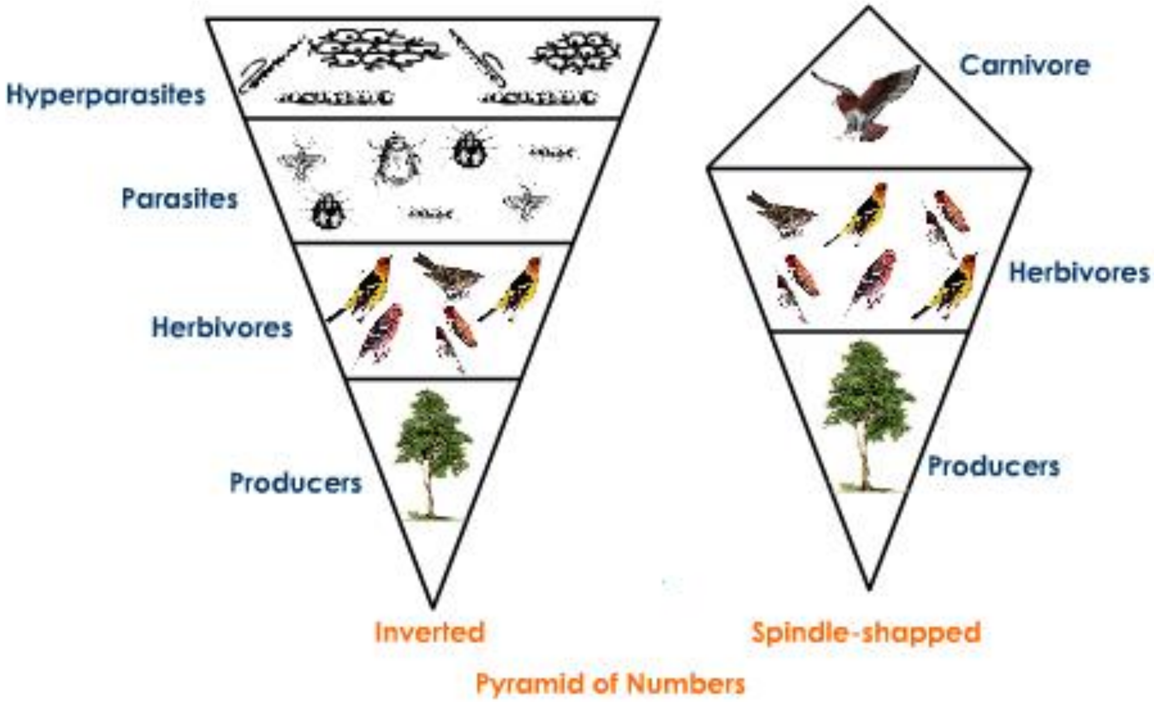
	Slow-growing forest	Open Ocean algae
Productivity	Low – only add small amount per year	High – small, quick Reproducers (open water Lots of sun)
Standing Crop	High – long-lived trees Accumulate biomass for 100s of years	Low – quickly consumed primary consumers

Changes in NPP are often used to assess the health of ecosystems.

D. **Energy Transfer Efficiency** – the proportion of consumed energy that can be passed from one trophic level to another.
Energy Efficiencies tend to range from 5 to 20% in ecosystems.
The average is about 10%, hence **"the 10% Rule"** (see fig. 3.9, p. 65), but be able to note when a different efficiency is given and be able to use that percentage to calculate the energy transfer to the next trophic level.

Trophic Pyramids
In general, most of the Energy (and Biomass) is at producer level (base).

Often a **Pyramid of Numbers** (Populations) at each level will mirror Pyramid of Energy. There are exceptions: When producers is large but low numbers:



Ecological Efficiency – implications for human diet…
Read the example on p. 65 about soybeans and beef…consider variations on this theme. What is more efficient?

IV. Matter Cycles Through the Biosphere

Biosphere = combination of all ecosystems on Earth

Biogeochemical Cycles involve process that are…
Biological – Photosynthesis, Respiration, transpiration, decomposition

Geological – Vulcanism, Erosion, Run-off, Burial, Sedimentation, Plate tectonics

Chemical – Oxidation/Reduction, combustion, carbonation

Some basic terms:

Pools = components that contain matter such as air, water, organisms

Flows = processes that move matter between pools

Sinks = very long-term pools where nutrients remain nutrients remain "out of circulation".

We'll be going over these Cycles in detail later:

A. **Hydrologic Cycle** – essential to the cycling of elements in the nutrient cycles.
See fig. 3.10, p. 67 – know all processes, trace a molecule thru cycle…
What human activities influence this cycle?
What are consequences of human changes to the natural cycling of water?

B. **Carbon Cycle –** (see fig. 3.11, p. 68)
Know all processes, trace a Carbon atom thru the cycle…
How does fast cycling of Carbon differ from slow cycling?
What are the major sinks for Carbon?
What forms does Carbon take?
What human activities disrupt the steady state of this cycle?
What are the consequences of these human-induced alterations?

C. **Nitrogen Cycle –** (see fig. 3.12, p. 70)
Know all processes, trace a Nitrogen atom thru the cycle…
In what ways is this cycle dominated by specialized bacteria?
Chemistry of these processes – describe role of oxidation and reduction.
What are the major sinks for Nitrogen?
What forms does Nitrogen take?
What human activities disrupt the steady state of this cycle?
What are the consequences of these human-induced alterations?

D. **Phosphorus Cycle –** (see fig. 3.13, p. 72)
Know all processes, trace a Phosphorus atom thru the cycle…
Why is P considered a limiting factor in ecosystems?
What are the major sinks for Phosphorus?
What forms does Phophorus take?
What human activities disrupt the steady state of this cycle?
What are the consequences of these human-induced alterations, especially with respect to aquatic ecosystems and terrestrial plant communities?

E. Other Nutrients: Calcium, Magnesium, Potassium, Sulfur

Importance of Ca, Mg, K?

Importance of S?

What human activities disrupt the steady state of Sulfur cycling?
What are the consequences of excess Sulfur in the atmosphere?

V. Ecosystems Respond to Disturbance

What is disturbance? Events caused by biological, geological, chemical changes in population or community composition. Can be both natural and anthropogenic. Not every disturbance is a disaster.

Natural: fires, storms, mudslides, etc.
Anthropogenic: buildings, pollution, construction, etc.

A. **Watershed Studies** – what is a watershed? Water that flows over a land area into streams, rivers, lakes, oceans.

Ex: Hubbard Brook – where is it, and what is going on there? Since 1960 studying disturbance (logging techniques) in 6 large watersheds…examining how deforestation affects nutrients leaving the system. Heavily deforested areas lost many nutrients.

B. **Resistance vs. Resilience**
Resistance – how well an ecosystem resists a disturbance that can affect the flows of energy and matter i.e. productivity. Populations/communities can be affected, but the overall ecosystem energy and matter remains the same.

Resilience – how well/rate at which an ecosystem returns to its original state after a disturbance.

C. **The Intermediate Disturbance Hypothesis** (see 3.19, p. 76)

Ecosystems with intermediate levels of disturbance are more diverse than those with higher or lower disturbance levels. High disturbance never gives populations a chance to increase. Low disturbance might let one species become dominant and it crowds out other other species. Intermediate disturbance allows for more evenness and richness.

VI. Ecosystems Provide Valuable Services

A. **Instrumental Values: has worth as an instrument or tool that can be used**

1. Provisions – goods we can use directly (Ex, lumber, food, crops, rubber, fur, medicinal plants)

2. Regulatory Services – regulating environmental conditions (Ex, carbon sequestration (removing carbon from atmosphere), flood control, etc.

3. Support Systems – lend support to ecosystem/environment (Ex, pollinators, habitat, pest control, air and water filtration)

4. Resilience – species diversity that provides back-up for providing services should some species go extinct

5. Cultural Services – cultural/aesthetic benefits (beauty of nature, enjoying outdoors, research support

B. **Intrinsic Values** – stem from religious or philosophical convictions
Ecosystems / organisms have value independent of human benefit.
Ecosystems / organisms have inherent moral right to exist.
We (humans) have a moral obligation to protect ecosystems / organisms.

Working Toward Sustainability-
Can We Make Golf Greens Green? (p. 80-81)

List reasons why golf courses have had bad environmental reputation?
Bad practices: short mowing of grass, excessive water use, fertilizer lost after rains affects other ecosystems

Recommendations from Audubon Cooperative Sanctuary Program:

Run-off treatment systems, less water use, less close mowing, deep rooted plants in the "rough" to retain water, less chemical use, more natural plants more habitat and pest control

Challenges for the future?