Ecosystems and Biodiversity

I. Evolution of the Earth has involved the evolution of biogeochemical cycles **show slide**
  A. a complex set of processes that cycle elements among different reservoirs on the Earths surface
    1. involve biology and have geochemical consequences
  B. biology
    1. serve as a means of transferring energy (mainly solar energy) thru food chains
  C. geochemistry
    1. leads to a steady state system that is generally far from chemical equilibrium
    2. maintained by solar energy input
  D. the results of these processes eventually leave their "mark" on the earth
    1. in the atmosphere, in the sediments and eventually in the rock record
  E. microbial processes are more diverse than higher organisms
    1. higher organisms are mostly aerobic
    2. impacts on present day cycles and the info preserved in the rock record differ as a result

II. Structure of the biosphere
  A. hierarchy **Fig. 9.1**
  B. ecosystem
    1. assemblage of organisms that interact with each other and their surrounding physical environment
      a. some ecosystems can be defined by their environment
  C. interactions between organisms and the environment can change the environment
    1. Daisyworld
  D. alteration of the environments can impact the ecosystem
    1. ENSO events **Figs. 15-13 & 14**
    2. cessation of upwelling, inhibits phytoplankton growth
    3. this then cascades up the food chain
  E. physiological vs. ecological growth optima
    1. not always the same because of the interactions between physiology and environmental conditions
    2. phytoplankton growth in the ocean **NASA image and Fig. 23-7**
      a. in the lab, marine algae show a temp optimum for growth of 20-25°C
    3. evidence that most high prod. regions in the oceans are at high latitudes and/or upwelling regions
    4. <u>cold</u> not warm water are regions of optimal phyto growth
      a. ecological growth optimum is ~8°C
    5. appears to be related to ocean physics and nutrient availability
    6. if oceans are too warm the surface layer stratifies
      a. limits nutrient exchange from the deep via either upwelling or deep wind driven mixing
    7. increasing turbulence enhances upward mixing of nutrients
    8. may explain why prod. is generally highest at low latitudes
      a. compromise between colder temperatures and nutrient availability
    9. low productivity in the gyres

a. regions of downwelling (Ekman transport)

III. Biodiversity
A. ecosystem health and stability is often related to biodiversity
1. i.e., the number of species present in an area/ecosystem
2. the concept is actually a bit more complex
B. biodiversity is often thought of with deforestation
1. destruction of tropical habitats contributes to both
a. also separate issues related to only deforestation

IV. Biodiversity over geologic time
A. natural changes in biological diversity a function of the origination of new species and extinction of existing species **Figure 13-4 and 13-10**
B. general increase in biodiversity over time
1. several extinction "events"
2. may be a 26 my periodicity in extinction events
3. this tends to favor an extra-terrestrial cause
a. several suggestions for how this occurs, evidence in support of any of them is scant
4. extinction of species is a natural process
a. over 90% of the species that have evolved have gone extinct
b. increase over time is thus a net increase

V. Recent changes in biodiversity
A. recent extinctions are different
1. present-day rates of biological extinction vastly exceed geological rates
2. present-day extinction occurs more across the board
a. affects many different groups of plants and animals
3. other extinction events affected large numbers of species in a single group
a. other species in other groups survived
4. example - extinction at the end of the Cretaceous primarily affected dinosaurs
a. mammals and plants survived, thrived and continued to evolve
5. modern extinction seems to be associated with spread of human populations **Fig. 18-1**
a. over-hunting appears to play a predominant role in these trends
b. more recent extinctions associated less with over-hunting and more with habitat destruction - deforestation

VI. Deforestation and biodiversity
A. the tropics currently represents the area of greatest rate of species loss
B. this is of concern for more than biodiversity issues
1. global warming
a. addition of atmos CO_2
b. loss of CO_2 uptake mechanism
C. impact on regional climate

VII. Deforestation and soil nutrient cycling
A. distinct differences in nutrient cycling between temperate and tropical forests **Fig. 9.6**

B. temperate forests have thick, rich topsoils **Fig. 4-18**
1. A horizon is a mixture of subsoil (B horizon) and organic detritus
   a. forms a humus layer near the surface
2. much of the nutrient cycling occurs in soils
   a. soils store nutrients **back to Fig. 9-6**

C. tropical soils **Fig. 4-23**
1. soils are highly weathered
2. lateritic clays depleted in nutrients
3. humus layer much thinner
4. nutrients stored in biomass
   a. cycled rapidly through the soil back into the plants **Box Table 9-1**

D. loss of rainforest trees leads to loss of nutrients
1. quality of the soils decreases rapidly
2. very difficult to then use the soils for extended agriculture or cattle grazing

E. temperate forests recover from deforestation more quickly
1. appear to attain a similar level of biodiversity after re-growth
2. unclear whether this will be the case in tropical forests

VIII. Deforestation and water cycle and climate **Fig. 9.7**

A. elimination of tropical rainforests disrupts regional water cycle
1. minimizes the major source of water to the atmosphere – transpiration
2. decreases soil moisture and increases run-off

B. also generally thought to increases erosion rates
1. this is of some importance since soils generally form slowly
2. 200-1500 yrs to form 2.5 cm of topsoil from bedrock

C. can examine this problem with general circulation models **ch. 18 text box**
1. temperature – multiple feedbacks but net temp increase **(with anim.)**
2. also a significant decrease in soil moisture

IX. Biodiversity and deforestation of tropical areas

A. half the living species are found in rainforests

B. forest plants have been shown to have significant medical and agricultural value
1. medicines used to treat many diseases have come from plants
2. tropical rainforests represent a significant untapped resource in this area
3. a selfish but still important reason to preserve rainforests

C. biodiveristy is also important in terms of food supply and modern agriculture **Fig. 18-6**
1. need genetic diversity to maintain the long-term health of species
2. need different varieties of a species to limit its vulnerability to new strains of diseases and pests
3. modern agricultural practices tend to limit diversity
4. centers of genetic diversity for the world's crops come from areas threatened by development, population pressures, deforestation, etc.

X. Biodiversity and ecosystem stability

A. relationship between biodiversity and ecosystem stability is complex
1. in some settings environmental stability leads to high diversity

a. in others high diversity is though to be the result of disturbances of intermediate frequency and intensity

B. how will loss of biodiversity impact ecosystem?

1. think of biodiversity like rivets on an airplane
   a. remove rivets (species) and eventually the stress to the system becomes too great
   b. plane crashes/ecosystem collapses
2. may also be that many species are superfluous
   a. system maintained by a few keystone species
   b. loss of biodiversity not a problem unless you loose these key species

XI. Causes of deforestation

A. complex social, political and economic reasons

B. need to understand these reasons before attempting to solve deforestation issues

C. economic arguments need to consider obvious, direct costs and less obvious indirect costs

1. externalities
   a. costs of not taking some action
   b. who will bear these costs

D. Impacts of loss of biodiversity **Fig. 13-4**

1. Earth is robust and will "recover" from deleterious effects of human-induced long-term losses of diversity
2. how will the Earth ultimately change
   a. will humans survive (think dinosaurs)