APES Ch. 4 Notes Ecosystems: How They Change

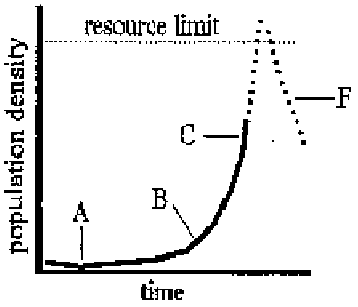
4.1 Notes

I. Dynamics of Natural Populations

A. Population Growth Curves

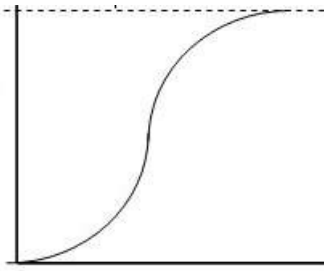
1) equilibrium = balance
2) **population equilibrium**—*balance* between births and deaths
3) *J-curve*
   a) **exponential increase =** a *geometric* progression
   b) **population explosion**—exponential growth in a population
   c) growth is eventually limited and will not increase forever
   d) J-curve is *nonsustainable*
   e) J-curves often repeat in pattern

   J-curve:



4) *S-curve* (sigmoid shape)
   a) a leveling of growth; population held in balance
   b) S-curve signifies *dynamic equilibrium*
   c) S-curve is *sustainable* and stable

   S-curve – population density vs. time:



5) Two options for what can happen to exponential population growth:
   a) population *levels off*
      - S-curve results
   b) population *crashes*: "*boom-and-bust"*
      - recovery can be observed over time
6) the human population
   a) ours is an exponential growth
   b) this cannot go on exponentially forever
      - Earth can only support so many people
      - http://www.census.gov/main/www/popclock.html
   c) scarce resources will eventually limit population size

B. Biotic Potential vs. Environmental Resistance

1) **biotic potential**
   a) the ability of populations to increase in number
   b) *number of possible offspring* produced under optimal conditions
2) **environmental resistance**—all biotic and abiotic factors that can limit population growth

The relationship between these two determines a population's status: growing, declining, or stable.

3) **recruitment**
   a) the *survival* of organisms to enter the *breeding* population
   b) this can be altered greatly
4) *reproductive strategies*
   a) *r strategy*: produce *many offspring* (high biotic potential) but many will die due to a variety of limiting factors
   b) *k strategy:* produce *few offspring* (low biotic potential) and nurture them all
5) **replacement level**—the rate at which organisms are "replaced" in the population after they die
6) **dynamic balance**
   a) *birth rate and death rate are approximately equal*
   b) minor fluctuations are seen
7) **carrying capacity (K)**
   a) the *maximum number* of organisms that can be supported by an ecosystem
   b) numbers of organisms decrease as carrying capacity approaches
   c) K is the maximum upper limit of the S-curve

C. Density Dependence and Critical Number

1) **population density**
   a) number of *individuals per unit area*
   b) population density is directly proportional to environmental resistance
2) *limiting factors*—biotic and abiotic factors which limit population growth
   a) *density-dependent* factors
      - limiting factors *affected by population size*
      - generally associated with an S-curve
      - food shortage, disease…
   b) *density-independent* factors
      - *not affected by population size*
      - generally associated with a J-curve
      - natural disasters, habitat damage…
3) **critical number**—the minimum number of individuals in a population needed to prevent extinction
4) species ** information from http://wdfw.wa.gov/
   a) *Species of Concern*

"include those species listed as State Endangered, State Threatened, State Sensitive, or State Candidate, as well as species listed or proposed for listing by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service."

   b) *candidate species*

"Include fish and wildlife species that the Department will review for possible listing as State Endangered, Threatened, or Sensitive. A species will be considered for designation as a State Candidate if sufficient evidence suggests that its status may meet the listing criteria..." **

c) *sensitive species*

"Any wildlife species native (to the area) that is vulnerable or declining and is likely to become endangered or threatened throughout a significant portion of its range (within the area) without cooperative management or removal of threats." **

d) **threatened species** have populations in a rapid decline

"Any wildlife species native (to the area) that is likely to become an endangered species within the foreseeable future throughout a significant portion of its range (within the area) without cooperative management or removal of threats." **

e) **endangered species**
- have populations nearing the estimated critical number
- "seriously threatened with extinction throughout all or a significant portion of its range"

f) *monitor species* are not considered Species of Concern but are monitored for status and distribution

4.2 Notes

II. Mechanisms of Population Equilibrium

- Population density depends on the relationship of a species with their *food* source and their **natural enemies**

A. *Predator-Prey* Dynamics

- *predation*—the action of predators upon their prey

1) predation on animals
   a) what happens to the prey population affects the predators and vice versa (*cyclical* nature)
   b) *the simpler the ecosystem, the simpler the predator-prey interactions*—the more cyclical the graph
   c) predation is a *density-dependent* action
   d) *other biotic and abiotic factors can affect the populations too* (other predators, snowstorms, drought, disease)
   e) *predators often can't attack mature, healthy members of their prey population*—they prey upon the young and the weak
2) parasites
   a) highly diverse group:
      - bacteria
      - fungi
      - viruses (can be classified as parasites even though not alive)
      - protozoans
      - worms (tapeworms, roundworms, hookworms…)
   b) parasitism is a *density-dependent* action
   c) *vector*—an agent carrying the parasite from one host to another
3) plant-herbivore dynamics
   a) *herbivores* are natural enemies of *plants*
   b) **overgrazing**
      - herbivores' *depletion of plants* faster than they can grow back
      - the depletion of some types of vegetation *may affect the entire ecosystem*

- *human action* has contributed to this problem
- in nature, herbivores rarely increase in population size so much as to overgraze

c) fluctuations in predator populations will affect plant-herbivore relationships

THIRD BASIC PRINCIPLE OF ECOSYSTEM SUSTAINABILITY:
The size of consumer populations in ecosystems is maintained such that overgrazing and other forms of overuse do not occur.

B. Competition

1) review
   a) *niche overlap* occurs when species compete for *similar resources*
   b) *competitive exclusion*—one species is forced out of the niche
2) competition between plant species
   a) **interspecific competition**—competition between *different species*

      HOW THIS CAN OCCUR:
      - the *adaptation of a species to specific conditions* (microclimate) may enable that species to thrive and overcome competition in one location but not in another
      - a single species usually can't use all resources in a specific area, leaving resources for other species
      - *different root systems* (fibrous vs. tap)
      - *mutualism* (beneficial symbiosis)
        - **epiphytes**—air plants live on other tree's limbs; they are not parasitic
      - maintaining a **balanced herbivory**

   b) **balanced herbivory**—*a balance among competing plant populations, kept in check by herbivores*
      - **monoculture**—growth of a *single species* in an area; prone to attack by **host-specific** organisms
      - this is not stable in the natural world

   c) **riparian**— relating to, living, or located on the bank of a natural *watercourse* (as a river) or sometimes of a lake or a tidewater
3) **territoriality**
   a) organisms *defending* an area against members of their *own species*, usually over resources for breeding and raising young
   b) **intraspecific competiton**—competition between members of the same species

C. *Introduced species* ("Cats of Borneo" activity)

1) examples
   a) rabbits introduced to Australia for hunting; population explosion
   b) American chestnut trees being decimated by a fungal chestnut blight from introduced Chinese chestnut trees
   c) Cuban brown anole invading FL from being introduced by boat
   d) Water hyacinth introduced into Florida
   e) Kudzu vine in the Southeastern U.S.
2) Solutions? Tricky, indeed, with strong implications…

a) introducing a natural enemy of the invasive species
b) chemical--pesticides
c) biological

GENETICS REVIEW…

A. Background info
1) **traits**—characteristics of an organism
2) *DNA*—deoxyribonucleic acid
a) double helix molecule comprising **chromosomes**
b) contains *genetic material*
c) *nucleotides*: composed of sugar, phosphate, nitrogen base

DNA sugar = *deoxyribose* bases = *adenine (A) , guanine (G), cytosine (C), thymine(T)*
RNA sugar = *ribose* bases = *adenine (A) , guanine (G), cytosine (C), uracil (U)*

d) genetic code (arrangement) is translated into proteins
e) **gene**—*segment of DNA* coding for a specific protein
3) *mitosis*—cell division
4) *meiosis*—formation of gametes

B. Genetic Variation and Gene Pools
1) **allele**—*alternate forms* of the same gene
2) inheritance patterns
a) common Mendelian pattern = dominant and recessive
b) incomplete dominance = traits mask one another
c) codominance = traits are equally expressed
d) multiple alleles = inheritance pattern (human blood types)
e) polygenic inheritance = complex inheritance pattern involving multiple genes interacting to produce the traits
f) sex-linked = traits in question are carried only by the X chromosome

C. Mutations: The Source of New Alleles
mutation—a random *mistake* in the gene sequence
(remember, the sequence is read in sets of three)
1) point mutation (add one)
THE DOG BIT THE CAT = THE DOG BIT THE BAT
2) deletion (one or more is missing)
THE DOG BIT THE CAT = THE DO_B ITT HEC AT
3) insertion (add extra)
TH_E DOG BIT THE CAT = THX EDO GBI TTH ECA T
4) inversion (taken out and reinserted backwards)
THE DOG BIT THE CAT = THE DOG BIT THE TAC
5) frame shift mutation—when a mutation changes the meaning of the sequence, rendering it meaningless
6) **lethal mutation**—results in the *death* of the individual
7) **neutral mutation**—does not benefit or harm the individual

4.3 Notes

III. Mechanisms of Species Adaptation
A. Change through Natural Selection
1) **selective pressures**—biotic and abiotic limiting factors of *environmental resistance*

2) **natural selection**—natural modification of the gene pool

(from Evolution 101)

"In biology, *evolution* is the process by which populations of organisms acquire and pass on novel traits from generation to generation, affecting the overall makeup of the population and even leading to the emergence of new species. Darwin and Wallace proposed that evolution occurs because a heritable trait that increases an individual's chance of successfully reproducing will become more common, by inheritance, from one generation to the next, and likewise a heritable trait that decreases an individual's chance of reproducing will become rarer...

The *modern evolutionary synthesis* generally denotes the combination of Charles Darwin's theory of the evolution of species by natural selection, Gregor Mendel's theory of genetics as the basis for biological inheritance, and mathematical population genetics. Essentially, the modern synthesis (or neo-Darwinism) introduced the connection between two important discoveries; the units of evolution (*genes*) with the mechanism of evolution (*selection*)…

Biological evolution, simply put, is *descent with modification.*"

B. Adaptation to the Environment to promote **fitness**— survival and reproduction
   1) *deal with limiting factors of environmental resistance*
   2) *obtain food (nutrients) and water*
   3) *avoid/escape predators*
   4) resi*st parasites and disease*
   5) *attract mates (or pollinate)*
   6) *migrate (or disperse seeds)*

C. Change through Selective Breeding
   1) **genetic variation**—*genetic differences* between individuals in a population
   2) **gene pool**—*all the genes* in a population
   3) **differential reproduction**—some members of a species *reproduce more than others*
   4) **biological evolution**—*changes* in the gene pool *over time*
   5) **selective breeding**—breeding is done to bring out specific traits; an example of **artificial selection**

D. The Limits of Change
   1) choices

THREE CHOICES WHEN FACED WITH SELECTIVE PRESSURE:

- **adaptation** (change)
- **migration** (leave)
- **extinction** (gone forever)

   2) species adapt to deal with environmental resistance
   3) species adapt to each other
   4) ecosystems can change in character and composition

E. **speciation**—adaptation to the point of becoming a new species
   1) through *natural selection* and *mutations*
   2) through **reproductive isolation**
   3) new species are formed by *gradual modification* of existing species
   4) pace of speciation
      a) *gradualism* (old view)
      b) *punctuated equilibrium*—alternating periods of stasis and rapid change
   5) Darwin's finches: beak specialization for different tasks

Galápagos background info (from Galapagos.org and Galapagos.com)

The Galápagos Islands are located on the equator, 600 miles from the coast of Ecuador. The climate is considered to be cool and sub-tropical, with hot, arid coastal zones and cooler, humid highland areas. The highlands receive moisture year-round, which supports lush vegetation. Galápagos gets an average of ten inches of rainfall per year.

Islands and their features:

- Bartolome—lava tubes, Pinnacle Rock; penguins
- Espanola—albatross, sea lions…
- Fernandina— pristine; rare species; flightless cormorants (fish-eating birds), marine iguanas…
- Floreana—Devil's Crown crater; flamingoes, sea turtles…
- Isabela—largest island; active volcanoes; marine iguanas, flightless cormorants, dolphins…
- North Seymour—nesting site; forests; marine iguanas, sea lions…
- Rabida—red beaches; nesting site; pelicans, flamingoes…
- San Cristobal—tourist port; birds and other wildlife…
- Santa Cruz (research center)—tortoises, iguanas, birds…
- Santa Fe—coves; sea turtles, manta rays, cacti; marine iguanas…
- Santiago—tide pools on the equator; lava fields; fur seals; feral goats
- South Plaza—cliffs; sea lions, birds, iguanas…
- Tower—birding island

F. Plate Tectonics
   1) **tectonic plates**—slabs of rock moving on top of an elastic molten rock layer
      a) *10 major plates*: African, Antarctic, Caribbean, Cocos, Eurasian, Indo-Australian, North American, South American, Pacific, Nazca
      b) *4 minor plates*: Caroline, Fiji, Juan de Fuca, Phillippine
   2) plate movement
      a) *convergent plate boundary*—plates meet ("converge"), and one goes underneath, creating a *subduction zone*
         - *subduction: oceanic plate* slides underneath a *continental plate*
         - earthquakes; volcanism
      b) *divergent plate boundary*—plates move apart (sea floor spreading at mid-ocean ridge)
      c) *transform fault*—plated move past each other laterally
      d) *continental plate collision*—two plates converge and push upward (earthquakes are observed and mountain ranges will form)

G. Evolution In Perspective
   A. the fossil record (Geologic Time Scale at the end of the notes)
      a) age of Earth: ~4.55 billion years old (4,550,000,000)
      b) oldest rocks found on Earth: ~3.8 billion yrs. old (3,800,000,000)
      c) age of our solar system: ~4.559 billion yrs. old (4,559,000,000)
      d) age of our sun: ~4.49 billion yrs. old (4,490,000,000)
   2) **"Cambrian explosion"**—most major groups of animals first appear in the fossil record
   3) **macroevolution**—*evolutionary change at or above the species level*
   4) **microevolution—** *evolutionary change below the species level (allelic frequency)*

5) stewardship of life—to *prevent extinction* and *preserve biodiversity*
6) **mass extinction**—a cyclical event; five major ones in Earth's history (some say we may be in the middle of the sixth one now)

4.4 Notes

IV. Ecosystem Response to Disturbance

A. Equilibrium ideas

1) *Equilibrium theory*—ecosystems are *stable environments* with competition and predation occurring (*biotic interactions*)
2) *Nonequilibrium theory*—ecosystems are in a constant state of *change*
   a) Early-stage species enter an area from surrounding areas in stages of succession
   b) Later-stage species come from species in later stages of succession
   c) *If any biotic or abiotic factors change, this causes a shifting in equilibrium, as species must adjust due to favorable or unfavorable impact on them*

B. **Ecological (Natural) Succession**—the *transition* from one biotic community to another

1) **primary succession**—*the first species colonizations in a previously barren area*
   a) examples: after volcanic eruptions or glacial retreats
   b) *soil profile has been destroyed*
   c) general sequence of events:

lichen → grass → shrub → coniferous tree → hardwood tree → climax ecosystem

   d) *lichen community*
      - **lichen** ("like-un")—*mutualistic algae and fungi*
      - lichen's *acids break down rock into soil*
   e) **climax ecosystem**—a *stable, balanced ecosystem* not undergoing further succession
   f) not all ecosystems achieve a "climax ecosystem" level

2) **secondary succession**— *re-colonization of an area after disturbance*
   a) examples of disturbance: fire, flood, human interference
   b) secondary succession *must have a soil base* to build upon
   c) general sequence of events:

grass → shrub → coniferous tree → hardwood tree → climax ecosystem

   d) not all ecosystems achieve a "climax ecosystem" level

3) *aquatic succession*
   a) lakes and ponds are gradually taken over and filled
   b) soil/detritus contributions

shore water plants →
organic matter collects →
surface water plants →
marsh →
land plants →
meadow →
forest

4) *island succession*
   a) *many possible niches* to fill
   b) water, wind, or other organisms bring new species to islands

5) climate change
   a) gradual warming over time
   b) *Greenhouse Effect*
      - CO_2 as a Greenhouse gas
      - other Greenhouse gases
         - *methane* CH_4
         - *nitrous oxide* N_2O
         - CFC's *(chlorofluorocarbons)* CCl_3F, CCl_2F_2

C. Balance in the Ecosystem
   1) biotic and abiotic factors exchange matter and energy
   2) **chaos theory**—*first stages of ecosystem development are extremely important; ecosystems are very sensitive to small changes*
   3) *human interference* is causing more species to become *extinct* than ever

D. Disturbance and Resilience
   1) fire and succession
      a) fire
         - major terrestrial disturbance
         - often caused by *lightning*
         - important abiotic limiting factor
         - *beneficial effects* of fire
            - *favors pines, grasses, redwoods*
            - *clears out underbrush*
            - *releases nutrients from dead wood*
            - *activates germination of some seed cones*
      b) fire used to be viewed as bad to all ecosystems
      c) *detrimental effects* of natural fire prevention
         - *trees of less economic value displacing other trees*
         - *grasslands overtaken by woodier plants*
         - *dry, dead vegetation piles up*
         - *dead tree trunks pile up*
            - *increase of wood-eating insects which can attack live trees*
      d) **fire climax ecosystems**
         - ecosystems which depend on fire to maintain balance
         - grasslands and pine forests
      e) types of fires
         - *ground fire (bog fire)*—a slowly spreading, smoldering fire that burns in dried, decomposed leaves; twig; or pine needles that have fallen from the trees to the ground (from www.vincentdunn.com)
         - *brush fire*—a fast-moving fire that ignites grass, shrubs, bushes, scrub oak, chaparral, marsh grass (cattails) and grain fields (from www.vincentdunn.com)

- *crown fire*—a fire which "crowns" or spreads to the tops of trees; usually caused by the vertical spread of flames of a brush fire (from www.vincentdunn.com)

2) nonequilibrium sources
   a) **resilience**—maintenance of *normal functioning* and integrity even *though a disturbance*
   b) **resilience mechanisms**—how an ecosystem "recovers" and deals with a disturbance

FOURTH BASIC PRINCIPLE OF ECOSYSTEM SUSTAINABILITY: Ecosystems show resilience when subject to disturbance.

   c) Ecosystems can only be pushed so far: human interventions may cause them to revert to a *degraded state.*

3) **biodiversity**—*a diversity of species; contributes to resilience, stability, and succession*

FIFTH BASIC PRINCIPLE OF ECOSYSTEM SUSTAINABILITY: Ecosystems depend on biodiversity.

4.5 Notes

V. Implications for Humans

A. *ecosystem adaptive management*

1) descriptions from www. http://www.for.gov.bc.ca/hfp/amhome/Amdefs.htm
   - acknowledgement of uncertainty about what policy or practice is "best" for the particular management issue
   - thoughtful selection of the policies or practices to be applied (the assessment and design stages of the cycle)
   - careful implementation of a plan of action designed to reveal the critical knowledge that is currently lacking
   - monitoring of key response indicators
   - analysis of the management outcomes in consideration of the original objectives
   - incorporation of the results into future decisions

2) Ecological Society of America (ESA)'s suggestions:
   - Plan for long-term change and unexpected events
   - Avoid land uses that deplete natural resources
   - Minimize the introduction and spread of alien species
   - Implement land-use and management practices compatible with the natural potential of the area
   - Examine impacts of local decisions in a regional context
   - Retain large connected areas that contain critical habitats

B. the pressures of population

1) the human global population is a J-curve, which is unsustainable
2) our population behaves as one in the wild without natural enemies
3) What is the carrying capacity of humans on Earth?