APES CH. 1 NOTES – MRS. BAUCK
ENVIRONMENTAL SCIENCE: STUDYING THE STATE OF OUR EARTH

"We must recognize the earth's limited capacity to provide for us. We must recognize its fragility. We must no longer allow it to be ravaged. This ethic must motivate a great movement, convincing reluctant leaders and reluctant governments and reluctant peoples themselves to affect the needed changes."

-- Union of Concerned Scientists, 1993 (over 1500 people, many Nobel Laureates)

Various statistics from World-O-Meter: http://www.worldometers.info/

MODULE 1 – Environmental Science

I. General environmental terms
- A. **Environment**—*the sum of all surrounding conditions or forces that influence living organisms' characteristics and ability to survive*
- B. **Environmental science**
  1) *the interdisciplinary field of study that examines the interactions between human systems and natural systems*
  2) an integrated science that includes agricultural science, biology, earth science, ecology, economics, chemistry, economics, ethics, politics, toxicology, etc.
- C. **ecology**—the branch of biology that deals with organisms relating to one another and to their surroundings (ecosystem interactions)
- D. Parts of the environment
  1) **biotic factors**—*living aspects of the environment (plants, animals, microbes)*
  2) **abiotic factors** (A-BIO: without life)—*nonliving, chemical, and/or physical aspects of the environment*; conditions and resources
- E. **Ecosystem**—*biotic and abiotic factors interacting in a specific area*

II. Human alteration of natural systems

Bozeman Science: Environmental Systems - https://www.youtube.com/watch?v=jfgE-LAJ8fA

- A. **System**—*a set of components, functioning and interacting in a regular and theoretically predictable way*; has structure and function
  1) **natural system** = *recycling of elements*
  2) **human system** = *one-directional flow of elements*
     a) landfills
     b) pollutants in stormwater and groundwater
     c) "disposable society"
- B. Examples of human impact:

desertification	salt water intrusion	genetic modification (GMO)
deforestation	air/water/land pollution	
overpopulation	anthropogenic chemical emissions	
biodiversity loss		
global warming	acid deposition	
climate change	ocean acidification	
decline of ecosystems	ozone depletion	

MODULE 2 – Environmental Indicators and Sustainability

Adapted from R. Costanza *et al.*, "The Value of the World's **Ecosystem Services** and **Natural Capital**," *Nature* Vol. 387 (1997). Annual global value of Ecosystems Services = values in trillion $ U.S.	
• 17.1 Soil formation • 3.0 Recreation • 2.3 Nutrient cycling • 2.3 Water regulation and supply • 1.8 Climate regulation • 1.4 Habitat	• 1.1 Flood and storm protection • 0.8 Food and raw materials production • 0.8 Genetic resources • 0.7 Atmospheric gas balance • 0.4 Pollination • 1.6 other
TOTAL = $ 33,000,000,000,000 (USD 1997)	

I. Monitoring natural systems for stress
(see chapters 2 and 3 for more on systems)

A. Ecosystem capital
1) **natural capital**—*natural resources*
2) economics involves production and distribution of goods and services
3) ecosystems provide goods and services
a) **ecosystem (natural) goods**—*what is produced or provided by ecosystems*
(food, fresh water, fuel wood, fiber, genetic resources)
b) **ecosystem (natural) services**
i. regulating services—benefits obtained from regulation of ecosystem processes (climate regulation, disease control, flood control, detoxification)
ii. supporting services—services that maintain conditions for life on Earth (soil formation, nutrient cycling, pollination, primary production, O_2 production, provision of habitats)
4) exploitation of natural systems is widespread and nonsustainable
5) natural ecosystems are undervalued because some functions they perform are not obvious
6) incremental value—how changes in goods or services affect humans

B. **Environmental indicator**—*describes the current condition of an environmental system* *** TABLE 2.1, 2.2***
1) biodiversity (chapters 5 and 18)
a) **biodiversity**— the variety of living organisms on the planet
b) genetic diversity—variation in the genome of a population
c) **species**—closely related *group of organisms (in the same genus) which can interbreed and produce viable offspring*
d) **speciation**—evolution of new species
e) **background extinction rate** *(average long-term extinction rate)* should be 1-5 species per million per year, but it is occurring 1,000 to **10,000 times** the background rate, with dozens going extinct every day (Center for Biological Diversity)
2) food production (chapter 11), soil issues (chapter 8)

3) global surface temperature and CO_2 concentration (chapters 4 and 19)
   a) **Greenhouse gases (GHG)**— most important is CO_2
   b) **anthropogenic**— human-made, as opposed to naturally occurring
4) human population (chapter 7)

U.S. Census: http://www.census.gov/ipc/www/popclockworld.html
Various statistics from World-O-Meter: http://www.worldometers.info/

5) resource depletion (chapters 7, 12, 13)
   a) developed vs. developing countries
   b) **development**—improvements in state of humanity due to advancement in economics; improvements in the standard of living
   c) renewable vs. nonrenewable resources

II. Sustainable practices for humanity

A. **Sustainability**
   1) *long-term solutions to environmental problems (not a "quick fix")*
   2) *least negative environmental impact as possible*
   3) **stewardship**—taking care of the earth for future generations
   4) sensible resource management: nonrenewable resources used sparingly, and renewable resources used at a sensible place for regeneration
   5) avoiding damage to environmental systems to the extent that they cannot recover
   6) **biophilia**— love of life, our need to be connected to the environment and each other
   7) examples
      a) **sustainable yields** in commercial fishing and forestry
      b) **sustainable agriculture—***promotes environmental health, economic profit, and social and economic equity*
      c) **sustainable ecosystems** *use solar energy, recycle nutrients and maintain biodiversity*
      d) **sustainable societies**—societies that are in balance with nature

B. **Sustainable development**
   1) a balance between human well-being, economic advancements, and resource management; harmony of ecology, sociology, and economics
   2) from the U.N.) *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs."*

C. **Ecological footprint—** *an indicator showing how big an area of productive land and water is needed to produce the resources required to maintain a person's standard of living*
   1) *Food footprint*
      a) frequency of animal-based product consumption
      b) amount of processed, packaged, not locally grown (> 200 mi.) food
   2) *Goods footprint*—amount of trash generated
   3) *Shelter footprint*
      a) number of people in dwelling
      b) size of dwelling
      c) type of dwelling
      d) electrical conservation measures in place

4) *Mobility footprint*
    a) type of dwelling
    b) public transportation usage
    c) vehicle usage
    d) types of land vehicles used
    e) mpg of land vehicles used
    f) frequency of carpooling
    g) frequency of air travel
    h) bicycles, walking, horses, etc.

Key Messages from www.LivingBeyondOurMeans.pdf

■ "Everyone in the world depends on nature and ecosystem services to provide the conditions for a decent, healthy, and secure life.
■ Humans have made unprecedented changes to ecosystems in recent decades to meet growing demands for food, fresh water, fiber, and energy. These changes have helped to improve the lives of billions, but at the same time they *weakened nature's ability to deliver other key services such as purification of air and water, protection from disasters, and the provision of medicines.*
■ Among the outstanding problems… are the *dire state of many of the world's fish stocks; the intense vulnerability of the two billion people living in dry regions to the loss of ecosystem services, including water supply; and the growing threat to ecosystems from climate change and nutrient pollution.*
■ *Human activities have taken the planet to the edge of a massive wave of species extinctions, further threatening our own well-being.*
■ The pressures on ecosystems will increase globally in coming decades unless human attitudes and actions change…
■ Today's technology and knowledge can reduce considerably the human impact on ecosystems. They are unlikely to be deployed fully, however, until ecosystem services cease to be perceived as free and limitless, and their full value is taken into account.
■ Better protection of natural assets will require coordinated efforts across all sections of governments, businesses, and international institutions. The productivity of ecosystems depends on policy choices on investment, trade, subsidy, taxation, and regulation, among others."

MODULE 3 – Scientific Method

I. Science is a process
A. "sound science" vs. "junk science"
    1) *junk science* or *bunk science* is a term used to describe purportedly scientific data, research, analyses or claims which are perceived to be driven by political, financial or other questionable motives (invalid experimentations, falsifying or distorting data, not following the scientific method)
    2) *pseudoscience*—body of alleged knowledge, methodology, belief, or practice that is portrayed as scientific but diverges from the required standards for scientific work or is unsupported by sufficient scientific research
    3) *controversial science*—ideas and theories at odds with mainstream science; often advanced by individuals either from outside the field of science or by scientists outside the mainstream of their own disciplines

B. the scientific method
    1) **scientific method**—a systematic way of solving problems
        a) well-known steps: *observe, hypothesize, experiment, theorize…*

b) human thought processes: *drawing conclusions, gaining insights, posing questions, testing and re-testing ideas…*

2) experimental and control setups
   a) **experiment**—a controlled test of a hypothesis
      i. a **controlled experiment** tests one variable at a time
      ii. **natural experiment**—a natural event acting as an experimental situation in an ecosystem
   b) *experimental group*: the variable being tested is present
   c) *control group*: the variable being tested is absent
3) variables
   a) anything affecting the outcome of the experiment
   b) only one can be tested at a time for the experiment to be valid
   c) **independent variable** *is changed by the experimenter (x)*
   d) **dependent variable** *changes based on what the independent variable does (y)*

3) **hypothesis—** an educated guess about how something works
   a) can be accepted or rejected
   b) **null hypothesis**— there is *no difference* between groups or conditions
4) **observation—**direct or indirect *recording of information*
   a) **direct observation**— made with the *senses*
   b) **indirect observation**—made with *measuring instruments*
5) **data—***verbal (words) or numerical (numbers) information*
   a) descriptive research contains verbal data
   b) data handling must be accurate
   c) **replication**—recording of several sets of measurements; **sample size (n)** cannot be too low
   d) data can be anecdotal logs, pictures, graphs, tables, charts, etc.
   e) **accuracy** vs. **precision**
      i. **accuracy**—how close a measurement comes to the actual true value
      ii. **precision**—how consistent and repeatable are the trials
      iii. high accuracy and high precision are desired
      iv. **uncertainty**—how much an experimentally measured or calculated value differs from the true value
6) **research**
   a) review the existing literature
   b) experimental results are shared with the scientific community
   c) repeat experiments to see if results are consistent
7) **theory**
   a) *repeatedly and thoroughly tested; substantial scientific evidence to support it*
   b) *wide acceptance among the scientific community*
   c) long description which tells *why*
   d) cannot be proven
   e) constructed with *objectivity* and *rationality*
8) **scientific law**
   a) concise statement which tells *what*
   b) can be proven
9) scientific controversies: fueled by new information, complex phenomena, bias, and subjective values

10) evaluating science
   a) Can the data be verified?
   b) Check the rationale: is the explanation logical?
   c) Is the explanation objective, taking into account all observations?
   d) Is the conclusion widely accepted by the scientific community?

If you are asked to design an experiment, include the following:

- Your hypothesis and/or predictions/expected results
- The independent variable - what treatments will you apply
- The dependent variable - what will you measure
- The variables to be manipulated and controlled (very important)
- The organism/materials/apparatus to be used
- Describe what you will actually do
- Describe how you will actually take and record data
- Describe how the data will be graphed and analyzed
- State how you will draw a conclusion (compare results to hypothesis and predictions)

Note: Your experimental design needs to be at least theoretically possible, and it is very important that your conclusions/predictions be consistent with the principles involved and with the way you set up the experiment.

II. Challenges of Environmental Science
   A. *Lack of baseline data*—no "control planet" for comparison
   B. *Subjectivity*—value judgments and opinions
   C. Multiple *interactions* in environmental systems
   D. Human well-being
      1) justice and equity: the **environmental justice (EJ) movement**

from http://nonoise.org/library/execords/eo-12898.htm
"*Environmental justice is a movement promoting the fair treatment of people of all races, income, and culture with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies*. Fair treatment implies that no person or group of people should shoulder a disproportionate share of the negative environmental impacts resulting from the execution of this country's domestic and foreign policy programs. (The environmental justice movement is also occasionally referred to as **Environmental Equity**—which EPA defines as the equal treatment of all individuals, groups or communities regardless of race, ethnicity, or economic status, from environmental hazards)." (combating **environmental racism**)

      2) justice for developing countries
         "No one is free when others are oppressed." (author unknown)
   a) over 1 billion people in the world live in extreme poverty
   b) political corruption
   c) U.N. resolutions

"There are no passengers on spaceship Earth. We are all crew."
-- Marshall McLuhan, Canadian philosopher (1911-1980)