Bio 1101 Lecture 18
Chapter 18: Introduction to Ecology

• Click here for video intro from Dr. Weyrauch

Intro to Ecology of Organisms and Populations

• Ecology: The scientific study of the interrelationships between organisms and their biotic and abiotic environment

Biotic = living (organisms)

Abiotic = nonliving (temperature, light, water, minerals, air, etc.)
• Hierarchy of Interactions
  – Organismal ecology: how individual organisms interact with their environment
  – Population ecology: how a population interacts with its environment
    • Population = a group of organisms of the same species living a specific area
  – Community ecology: how a community interacts with its environment
    • Community = all of the populations of all species inhabiting an area

– Ecosystem Ecology: studies how energy and nutrients flow through an ecosystem
  • Ecosystem = includes the community (all of the biotic factors) as well as the abiotic factors in an area
– Biosphere: the sum of all the planet’s ecosystems
Ecology and Environmentalism

- Environmentalism is not the same as ecology
- Ecology is a science
- Environmentalism is a political/social movement; it advocates certain actions to protect species and ecological interactions
  - Based on ecological science
– Rise of environmental movement in the 1960’s
  • Use of pesticides such as DDT leading to extinction of many species
  • Rachel Carson’s book “Silent Spring” (1962)
  • A phased-in ban on DDT beginning in 1972
  • Formation of the EPA (Environmental Protection Agency) in 1970
    – No longer would the Department of Agriculture, which used many of these chemicals, also regulate them

• Abiotic Factors of the Environment
  – **Sunlight**: the ultimate energy source of nearly all ecosystems on the planet
    • Amount of light reaching various parts of a habitat may be limited by shading by other organisms, or by depth of water
  – **Water**: all organisms need it!
    • Terrestrial organisms must have access to it and conserve it
    • Aquatic organisms must deal with water balance (remember osmosis… if they live in salt water, they may lose large amounts of water by osmosis)
– Wind
  • Can help organisms by dispersing food to them, or assisting in pollination
  • Severe wind can damage some communities (blowing down trees)

– Rocks and Soil
  • The substrate for plants
  • By affecting plant communities, also affects the animals that can live there
  • Also a substrate for some animals to burrow in

– Temperature: has effects on metabolism

  • Warm-blooded organisms must increase metabolism when cold in order to maintain body temperature
    – Allows them to be active at low temperatures

  • Cold-blooded organisms often hibernate in cold temperatures; are unable to be active when its too cold
    – More species of reptiles (such as lizards) in warmer, southern parts of North America than cooler, warmer regions
Abiotic factors like temperature can vary temporally (e.g., seasonally, from day-to-day, or from hour-to-hour) and spatially (e.g., from one part of an organism’s habitat to another).

Organisms may adjust to such changes immediately (e.g., a bird can fluff up its feathers to increase insulation in response to cold, or it may migrate to a warmer area).

Organisms may also acclimate to changing conditions; acclimation is a gradual process of physiological change that is reversible.

- for example, if you moved to Denver, which has lower $O_2$ levels in the air, your body would acclimate by producing more red blood cells)
– Periodic Disturbances
  • Fires, hurricanes, tornadoes, etc.
  • Can be good or bad
  • Some communities are adapted for disturbance (more on this next time…)

• Global Climate Patterns
  – The climate of an area influences the types of plants and animals that can live there
  – Different amount of light are received at different parts of the earth, due to its curvature
    • Most direct at equator
    • But what causes seasons?
• NEWS FLASH: 1 in 4 Americans doesn’t know the Earth circles the Sun! (Seriously!)

• https://www.youtube.com/watch?v=ca4-6VKgXI8

– Seasons are a result of the tilt of the earth on its axis
  • Earth travels around the sun once a year
  • When earth is positioned so that the Northern Hemisphere is tilted closest to the sun, we have summer; conversely, when it is tilted away from sun, it is winter
• Let’s refresh some really basic astronomy, in an attempt to improve America’s level of scientific literacy!
  – What causes the seasons?  
    http://www.youtube.com/watch?v=KUU7lyfR34o

• Local climates are also determined by factors such as proximity of mountain ranges, oceans, or elevation
  – Large bodies of water moderate temperature
  – Temperature decreases with elevation
  – Mountains can block flow of air; can create “rain shadows”
Biomes

- Major types of terrestrial or aquatic ecosystems that cover large geographic areas
  - Terrestrial biomes characterized by vegetation
  - Aquatic biomes characterized by physical environment
- Examples: tropical rainforests and deserts
- Determined in large part by climate
Freshwater Biomes

- Freshwater covers less than 1% of Earth
- Standing Water: Lakes and Ponds
  - **Photic zone**: the area of water that is shallow enough for photosynthesis
    - Algae, cyanobacteria, and plants (both rooted and floating) grow here
  - **Aphotic zone**: the area of water that is too deep and/or murky to support photosynthesis
  - **Benthic realm**: the bottom of all aquatic biomes
    - Organisms that live here called benthos
- **Phytoplankton** = algae and cyanobacteria that grow in aquatic biomes
  - Growth determined by amounts of nutrients, especially nitrogen and phosphorus

- **Eutrophication**: a process that occurs when overgrowth of algae (often caused by runoff of fertilizers) reduces light penetration
  - Algae then die
  - Decomposition results in depletion of oxygen
  - Aquatic animals then die, too

- **Running Water: Rivers and Streams**
  - Characteristics vary from beginning to end of stream
    - At source: colder, lower in nutrients, more rapid, and clearer
    - As you travel down stream, more nutrients get washed in
    - Downstream, channel narrows, flow slows, higher nutrients, murkier and warmer water
• Wetlands: a transitional biome between aquatic and terrestrial habitats
  – Swamps, bogs, and marshes
  – Covered by water permanently, or (more often), periodically
  – Rich in species diversity
  – Provide water storage areas, recharge aquifers, reduce flooding, and improve water quality

• A marsh is shown here, with some emergent vegetation such as reeds and cattails; marshes lack trees
• Here we see a swamp, which is a wetland with trees; the trees often have wide bases to help stabilize them in the soft ground

Marine Biomes

• **Benthic realm**: the seafloor
• **Pelagic realm**: the open water of the ocean
• Also divided into photic and aphotic zones
• **Coral reef biomes**: found in photic zones
  – Warm, tropical waters
  – Coral animals build the foundations
  – Many invertebrates and fishes live here
• **Intertidal zones**: where the ocean meets the land
  – Shore pounded by waves
  – Shore is wet/submerged at high tide, dry at low tide
  – Organisms like barnacles and mussels attach to rocks here
• **Estuaries:** a transitional area between a river and the ocean
  – Salinity varies (from fresh to salty water)
  – Nutrients wash in from the river
  – Very productive areas due to nutrients
  – Often home to many fish and nesting birds
  – May be bordered by salt marshes and mudflats

Terrestrial Biomes

• Classified by vegetation type
  – Which is largely driven by climate
  – See Figure 18.28
• **Tropical Rain Forest**
  – Found in equatorial areas
  – Temperature steadily warm
  – Receive 200-400 cm of rain per year (6.6-13 feet!)
  – Habitats stratified:
    • **Canopy** = the tree tops
      – Many organisms live here, including other plants (epiphytes) because light is available
    • **Understory** = the forest floor
      – Little light available
• **Savanna**
  - Dominated by grasses; few, scattered trees
  - Temperature warm year-round, but little rainfall (30-50cm; 12-20 inches)
    • Varies seasonally (wet and dry seasons)
  - Fire common; grasses here survive because the growing points of their shoots are below ground
  - Grazing mammals common
  - Example: African savannah, with zebras, antelope, and cheetahs
• Desert
  – Driest of all biomes
  – Less than 30cm (12 inches) per year rainfall
  – Not all are hot
    • Deserts west of Rocky Mountains, for example, are fairly cool
  – Vegetation is adapted for storing water (e.g., cacti)
  – Reptiles, rodents, and insects common
• **Chaparral**
  - Mild, rainy winters and hot, dry summers
  - 25-43cm (10-17 inches) rainfall per year, mostly in the winter
  - Found in some coastal areas, such as some parts of California, and some Mediterranean areas
  - Dense, spiny, evergreen shrubs are dominant
  - Animals include deer, birds, rodents, and snakes
  - Vegetation adapted for periodic fires
    - Some seeds only germinate after fire
• **Temperate Grassland**
  – Vegetation characterized by grasses
  – Mostly treeless, except along rivers/streems
  – Rainfall between 25-75cm (10-30 inches) per year
  – Frequent droughts
  – Periodic fires
  – Warm summers and cold winters
  – Supports grazing mammals
• **Temperate Broadleaf Forest**
  – Midlatitudes with relatively high rainfall (75-150cm, or 30-60 inches, per year) distributed fairly evenly throughout the year
  – Temperature varies seasonally
  – Dense stands of deciduous forests
  – Rich soil, thick leaf litter
  – Many mammals that live in these forests hibernate over the winter, and birds may migrate to warmer climates
• **Coniferous Forest**
  – Dominated by evergreen trees
  – Northern coniferous forest = *taiga*
    • The largest terrestrial biome
    • Found in northern North America and Asia
    • Also found at higher elevation in mountains
    • Long, snowy winters and short, wet summers
    • 30-84cm (12-33 inches) of rain per year
    • Animals include moose, bears, wolves, and elk
• **Tundra**
  – Covers large areas of the Arctic between taiga and polar ice
  – Has permanently frozen subsoil, called permafrost
  – Cold temperatures and high winds result in lack of trees and tall plants
  – Little annual precipitation
    • 15-25cm (6-10 inches, including melting snow)
  – Vegetation includes shrubs, grasses, mosses, and lichens
  – Rapid plant growth in summer
  – Caribou, wolves, lemmings, and migratory birds
• **Polar Ice**
  – Found at high latitudes in northern and southern hemispheres
  – Extremely cold temperatures
  – Low precipitation (less than 25cm, or 10 inches, liquid)
  – Most land covered by snow/ice, even during summer
  – Mosses and lichens can live at edge of ice
  – Polar bears (in the Arctic) and penguins (in the Antarctic), and seals live at edge of sea
Biomes Activity

• Take the Biomes Activity Quiz on Carmen Canvas by midnight, Monday, April 13\textsuperscript{th}, for three activity points!

• Don’t forget – we have an active Discussion Board every Monday and Wednesday morning, where you can ask questions about the lecture material or the course in general! If you post a comment before the end of the semester, you’ll earn three extra activity points!

• Break here, and we’ll continue with Lecture 18 Part B next time…
Human Impact on the Atmosphere and Climate

Depletion of the Ozone Layer

• The ozone layer is a thin layer of ozone gas (O3) in our atmosphere
• Ozone molecules block the passage of harmful UV rays from the sun
  – UV-A: least harmful; contributes to suntans; partially blocked by ozone layer
  – UV-B: very harmful; causes sunburns, cataracts, and melanoma; partially blocked by ozone layer
  – UV-C: extremely harmful; germicidal; almost totally blocked by ozone layer
– Emission of chemicals such as chlorofluorocarbons (CFCs), used in refrigerants and propellants in aerosol cans
– These chemicals break down ozone into oxygen; the chlorine atoms in the CFCs remain in the atmosphere, however, and continue to break down ozone for decades

– Scientists from the British Antarctic Survey first started to notice a decrease in stratospheric ozone in the 1970s
– A hole in the ozone layer was first detected in 1985, over Antarctica (thought their equipment was malfunctioning!)
– A rise in chlorine compounds (the by-products of CFCs breaking down ozone) was detected simultaneously
– Not just a problem at the poles; the ozone layer has thinned all around the world
What effects can increased UV-B have on humans?

- A thinner ozone layer means more harmful UV-B rays reaching your eyes and skin
- More skin cancer and cataracts
  - EPA estimates a 2% increase in UV-B radiation can cause a 2-6% increase in skin cancers
  - Since the 1970s, UV-B levels have increased between 4-7% (depending on the time of year)
  - Also damages the eye, leading to cataracts and blindness
  - 100,000 to 150,000 more cases of blindness each year for every 1% decrease in ozone layer (Environmental Effects Panel, U.N. Environment Programme)
What effects can increased UV-B have on other animals and plants?

• Reduces photosynthesis in plants
  – Can reduce crop yields
• Damages the skin of non-human animals, just as it does human skin
  – Some animals especially sensitive
  – Aquatic stages of amphibians are especially susceptible

Can we fix the ozone layer?

• Yes!
• Stop producing the chemicals that destroy it
• Ozone will re-form in the stratosphere, as UV strikes oxygen molecules
• The Montreal Protocol of 1987
  – Signed by 24 countries and the European Economic Community
  – Phases out use and production of CFC’s and other chemicals
  – Enforced by trade sanctions; first international environmental agreement of its kind
Global Warming/Climate Change

- Before 1850, carbon dioxide concentration was 280 ppm
- Monitoring Station established in 1958 by Dr. Keeling; CO₂ was at 316 ppm
- Today, CO₂ concentration is over 400 ppm
- Because CO₂ is a greenhouse gas, this increase is likely influencing the heat budget of the earth
"Keeling Curve"

Atmospheric CO₂ at Mauna Loa Observatory

Scripps Institution of Oceanography
NOAA Earth System Research Laboratory

RECENT MONTHLY MEAN CO₂ AT MAUNA LOA

https://www.esrl.noaa.gov/gmd/ccgg/trends/

- Projected changes in greenhouse gas concentrations (EPA)
Projected changes in temperature under four different greenhouse gas emissions pathways

How will global warming impact weather patterns?

- Difficult to predict, due to many possible positive and negative feedbacks
- Precipitation patterns will likely change
  - “Bread basket” areas of the US may become very dry, making agriculture difficult
– Extreme weather events will likely become more common
  • Floods
  • Droughts
  • Heat waves
  • Intense hurricanes

Feeling the Heat

– Instrumented meteorological record keeping began in 1880
– Top 10 hottest years on record all since 1998
– 2016 was the hottest year on record
  • 2019 was 2nd hottest year on record, according to NASA
  • The five hottest years on record have all been in the last five years
• Sea levels will continue to rise for two reasons
  – Thermal Expansion: warmer water takes up more space
  – Increased Volume of Water: melting of polar ice caps (already happening) adds more water to the oceans
  – 2017 global mean sea level was 3 inches above 1993 average
  – How far will they rise? According to NOAA (2018), between 8 inches and 6.6 feet by 2100!
    • A rise of 3 feet would flood 90 miles or more inland
    • Large parts of Caribbean Islands inundated
    • Maldives Islands almost completely inundated
    • In New York, subway system and sanitation facilities could be devastated
    • Many coastal cities will face similar problems
  – 40% of United States population lives in coastal areas; 8 of 10 largest cities in world are on a coast
How is global warming affecting plant and animal species?

- The Arctic ecosystem is already dealing with rapid climate change
- Seals and polar bears
- The melting of the arctic ice is reducing critical hunting grounds for polar bears

- Click below for audio:
– Coral reefs suffering from coral bleaching
– Amphibians are suffering from a variety of interactions with increasing temperature
  • Reduced precipitation
  • Concentrated pollutants
  • Spreading disease
– Many species will need to migrate to areas with more appropriate climate
  • But global warming is causing rapid climate change
  • Habitats are fragmented; how can species move across urban settlements, agricultural fields, and highways?
  • Could result in an even more severe extinction crisis
– Data from recent International Panel on Climate Change found that changes in solar irradiance have not contributed to global warming from 1986 to 2008

What is the Kyoto Protocol?

– An amendment to the international treaty of climate change, negotiated in Japan in 1997
– Sets mandatory targets for reductions in greenhouse gases
  • Signatory nations may either reduce their own emissions, or if they exceed their limits, engage in emissions trading
– Currently covers 163 countries
– If a country fails to meet its greenhouse reduction target, it is fined and its reduction target is increased by 30%
By 2008-2012, developed countries must reduce their greenhouse gas emissions by around 5% below their 1990 levels.

Controversial, in part, because developing countries are not penalized for continuing to produce greenhouse gases.

Notably missing from signatories: the United States.

Goal of Kyoto Protocol
- To begin to stabilize “greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system”

Is it realistic?
- As currently written, will only reduce projected warming (of 1.4°C to 5.8°C) by 0.02 °C to 0.28 °C
- However, it is a start, and it can be modified until objectives are met.
• There have been a number of conferences after Kyoto
  – Dec. 2009 post-Kyoto conference was held in Copenhagen, Denmark
    • Resulted in Copenhagen Accord, an agreement that global warming is serious and actions should be taken to keep temp increases below 2 C
  – November 2015, there was another conference in Paris
    • Goal: to obtain legally binding, universal agreement on climate from all nations

• Paris Accord (2015):
  – Paris produced an agreement hailed as “historic, durable and ambitious”. Developed and developing countries alike are required to limit their emissions to relatively safe levels, of 2C with an aspiration of 1.5C, with regular reviews to ensure these commitments can be increased in line with scientific advice. Finance will be provided to poor nations to help them cut emissions and cope with the effects of extreme weather. Countries affected by climate-related disasters will gain urgent aid. (— The Guardian, Dec. 2015)
  – 196 countries signed on (including the United States, BUT in 2019 we began the process of withdrawing from the accord)
Global Warming Activity

• Complete the Global Warming Activity Quiz on Carmen Canvas by midnight on Wednesday, April 15, for three activity points

Movie!

• Watch the film “Years of Living Dangerously” on YouTube at: https://www.youtube.com/watch?v=dA41EGRyJJl&list=PL7LXYo3OxRIWfdHGWVgfHNP6QZf6i2
• Complete the Notes Sheet for the film, and be sure to study it for the final exam