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Learning Modules – Climate Change

What is Climate?

Climate is defined as an area's long-term weather patterns. The simplest way to describe climate is to look at average temperature and precipitation over time. Other useful elements for describing climate include the type and the timing of precipitation, amount of sunshine, average wind speeds and directions, number of days above freezing, weather extremes, and local geography.

While it's fairly easy to describe a location's climate by examining weather data, a greater challenge is figuring out *why* the climate of one place differs from that of another. To do so, you must consider all the factors that work together to determine climate.

Source: Exploring Earth (http://www.classzone.com/books/earth_science/terc/content/investigations/es2101/es2101page01.cfm)

What is Climate Change?

Climate change affects more than just a change in the weather; it refers to seasonal changes over a long period of time. These climate patterns play a fundamental role in shaping natural ecosystems, and the human economies and cultures that depend on them.

Because so many systems are tied to climate, a change in climate can affect many related aspects of where and how people, plants and animals live, such as food production, availability and use of water, and health risks.

For example, a change in the usual timing of rains or temperatures can affect when plants bloom and set fruit, when insects hatch or when streams are their fullest. This can affect historically synchronized pollination of crops, food for migrating birds, spawning of fish, water supplies for drinking and irrigation, forest health, and more.

Source: Department of Ecology – State of Washington (http://www.ecy.wa.gov/climatechange/whatis.htm)

What is Global Warming?

Global warming is when the earth heats up (the temperature rises). When greenhouse gases (carbon dioxide, water vapor, nitrous oxide, and methane) trap heat and light from the sun in the earth's atmosphere, this increases the temperature of the earth. This change in temperature can have widespread effect on many temperature-dependent processes and systems.

Source: Oracle – Think Quest (http://library.thinkquest.org/CR0215471/global_warming.htm)

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Are climate change and global warming the same thing?

Not exactly, but they are closely related. Some people use the terms interchangeably. Global warming causes climates to change. "Global warming" refers to rising global temperatures, while "climate change" includes other, more specific, kinds of changes. Warmer global temperatures in the atmosphere and oceans leads to climate changes affecting rainfall patterns, storms and droughts, growing seasons, humidity, and sea level.

Also, while "global warming" is planet-wide, "climate change" can refer to changes at the global, continental, regional and local levels. Even though a warming trend is global, different areas around the world will experience different specific changes in their climates, which will have unique impacts on their local plants, animals and people. A few areas might even get cooler rather than warmer.

Source: Department of Ecology – State of Washington (http://www.ecy.wa.gov/climatechange/whatis.htm)

What is Ecology?

Ecology is the scientific study of interactions of organisms with one another and with the physical and chemical environment. Although it includes the study of environmental problems such as pollution, the science of ecology mainly involves research on the natural world from many viewpoints, using many techniques. Modern ecology relies heavily on experiments, both in laboratory and in field settings. These techniques have proved useful in testing ecological theories, and in arriving at practical decisions concerning the management of natural resources.

An understanding of ecology is essential for the survival of the human species. Our populations are increasing rapidly, all around the world, and we are in grave danger of outstripping the earth's ability to supply the resources that we need for our long-term survival. Furthermore, social, economic and political factors often influence the short-term distribution of resources needed by a specific human population. An understanding of ecological principles can help us understand the global and regional consequences of competition among humans for the scarce natural resources that support us.

Ecology is a science that contributes considerably to our understanding of evolution, including our own evolution as a species. All evolutionary change takes place in response to ecological interactions that operate on the population, community, ecosystem, biome and biosphere levels. Studies conducted within the scientific discipline of ecology may therefore focus on one or more different levels: on populations of a single species, on an interacting community involving populations of many species, on the movement of matter and energy through a community within and ecosystem, on large scale processes within a biome, or on global patterns within the biosphere.

Source: The Department of Biodiversity & Conservation Biology – The University of the Western Cape

- http://www.bcb.uwc.ac.za/sci_ed/grade10/ecology/introduction.htm

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What is Coral Reef Bleaching?

Coral bleaching events have been increasing in both frequency and extent worldwide in the past 20 years. Global climate change may play a role in the increase in coral bleaching occurrences, and could cause the destruction of major reef tracts and the extinction of many coral species.
Coral reef bleaching is the loss of symbiotic protozoa (single-celled algae known as zooxanthellae) that live within coral tissues, providing nutrients to the coral while the coral provides the protozoa with protection. This loss results in a reduction in photosynthetic pigment concentrations in zooxanthellae, causing the host coral to look white.
Coral reef bleaching is caused by various stress-causing anthropogenic (caused by human influence) and natural variations in the reef environment including sea temperature, solar irradiance, sedimentation, xenobiotics, subaerial exposure, inorganic nutrients, freshwater dilution, and epizootics. Recent accelerated coral reef decline seems to be related mostly to anthropogenic impacts (overexploitation, overfishing, increased sedimentation and nutrient overloading). Natural disturbances which cause damage to coral reefs include violent storms, flooding, high and low temperature extremes, El Nino Southern Oscillation (ENSO) events, subaerial exposures, predatory outbreaks and epizootics.

Sources:

- Science Daily: http://www.sciencedaily.com/articles/c/coral_bleaching.htm
- Odyssey Expeditions – Marine Biology Learning Center Publications: http://www.marinebiology.org/coralbleaching.htm

What is Ecological Restoration?

Ecological restoration is an intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability. Frequently, the ecosystem that requires restoration has been degraded, damaged, transformed or entirely destroyed as the direct or indirect result of human activities. In some cases, these impacts to ecosystems have been caused or aggravated by natural factors such as wildfire, floods, storms, or volcanic eruption, to the point at which the ecosystem cannot recover its pre-disturbance state or its historic developmental trajectory.
Restoration attempts to return an ecosystem to its historic trajectory. Historic conditions are therefore the ideal starting point for restoration design. The restored ecosystem will not necessarily recover its former state, since contemporary constraints and conditions may cause it to develop along an altered trajectory. The historic trajectory of a severely impacted ecosystem may be difficult or impossible to determine with accuracy. Nevertheless, the general direction and boundaries of that trajectory can be established through a combination of knowledge of the damaged ecosystem's pre-existing structure, composition and functioning, studies on comparable intact ecosystems, information about regional environmental conditions, and analysis of other ecological, cultural and historical reference information. These combined sources allow the historic trajectory or reference conditions to be charted from baseline ecological data and predictive models, and its emulation in the restoration process should aid in piloting the ecosystem towards improved health and integrity.

Source: Society for Ecological Restoration International

- http://www.ser.org/content/ecological_restoration_primer.asp

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Teachers' Guide to High Quality Educational Materials on Climate Change and Global Warming
by Susan Joy Hassol, an environmental science writer http://hdgc.epp.cmu.edu/teachersguide/teachersguide.htm

Climate change is a great study topic because it integrates so many subjects including: energy, environment, geography, politics, chemistry, biology, economics, and more. It requires students to use analytical tools and math skills, and to exercise their abilities to research, think and understand complex issues. This guide for K-12 educators teaches about climate change and warming and provides extra resources that offer background material, detailed lesson plans and experiments. It begins with *Top Ten Things You Need to Know about Global Warming* and a note about why there is so much controversy surrounding this issue.
Below are excerpts from the site (http://hdgc.epp.cmu.edu/teachersguide/teachersguide.htm).

Here are the *Top Ten Things You Need to Know about Global Warming*

1. **Global warming is caused primarily by carbon dioxide from burning coal, oil and gas.**
   Certain gases that trap heat are building up in Earth's atmosphere. The primary culprit is carbon dioxide, released from burning coal, oil and natural gas in power plants, cars, factories, etc. (and to a lesser extent when forests are cleared). The second is methane, released from rice paddies, rotting garbage in landfills, mining operations, and gas pipelines. Third are chlorofluorocarbons (CFCs) and similar chemicals, which are also implicated in the separate problem of ozone depletion (see #5 below). Nitrous oxide (from fertilizers and other chemicals) is fourth.

2. **Earth's average temperature has risen about 1°F in the past 100 years and is projected to rise another 3 to 10° F in the next 100 years.** While Earth's climate has changed naturally throughout time, the current rate of change due to human activity is unprecedented during at least the last 10,000 years. The projected range of temperature rise is wide because it includes a variety of possible future conditions, such as whether or not we control greenhouse gas emissions and different ways the climate system might respond. Land areas closer to the poles are projected to warm faster than those nearer the equator.

3. **There is scientific consensus that global warming is real, is caused by human activities, and presents serious challenges.** Scientists working on this issue report that the observed global warming cannot be explained by natural variations such as changes in the sun's output or volcanic eruptions alone. The most authoritative source of information is the UN Intergovernmental Panel on Climate Change (IPCC) which draws upon the collective wisdom of many hundreds of scientists from around the world. The IPCC projects global temperature increases of 3-10°F in the next 100 years, reporting that human activity is the cause of most of the observed and projected warming.

4. **There's a difference between weather and climate.** Weather refers to the conditions at one particular time and place, and can change from hour to hour, day to day, and season to season. Climate, on the other hand, refers to the long-term average pattern of weather in a place. For example, we might say that the climate of South

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Florida is warm, moist and sunny, although the weather on a particular day could be quite different. Long-term data are needed to determine changes in climate, and such data indicate that Earth's climate has been warming at a rapid rate since the start of intensive use of coal and oil in the late 1800s.

5. **The ozone hole does not cause global warming.** Ozone depletion is a different problem, caused mainly by CFCs (like Freon) once used in refrigerators and air conditioners. In the past, CFCs were also used in aerosol spray cans, but have been banned in the US since 1978. CFCs deplete the stratospheric ozone layer that protects life on Earth from excess ultraviolet light that can cause skin cancer and cataracts in humans and other damage to plants and animals. An international agreement has phased out most uses of CFCs, but the ozone layer is only just beginning to recover, partly because these chemicals remain in the atmosphere for a long time. Although ozone depletion is not the cause of global warming, there are a number of connections between the two. For example, many ozone-depleting compounds are also greenhouse gases. Some of the compounds now replacing CFCs in order to protect ozone are also greenhouse gases. And ozone itself is a greenhouse gas. In addition, while greenhouse gas build-up cause temperatures close to Earth's surface to rise, it causes temperatures higher up in the stratosphere, to fall. This stratospheric cooling speeds ozone depletion, delaying the recovery of the ozone hole.

6. **Global warming will have significant impacts on people and nature.** As temperatures continue to rise, precipitation is projected to come more frequently in the form of heavy downpours. We can probably expect more extreme wet and dry conditions. In the western US, where snowpack provides free storage of most of the water supply, reduced snowpack will make less water available in summer. Coastal areas will become more vulnerable to storm surges as sea level rises. Plant and animal species will migrate or disappear in response to changes in climate; New England may lose its lobsters and maple trees as they move north into Canada. Natural ecosystems such as coral reefs, mangrove swamps, arctic tundra, and alpine meadows are especially vulnerable and may disappear entirely in some areas. While global warming will have impacts on natural and human systems all around the world, the largest impacts will be on many natural ecosystems and on people who live in developing countries and have few resources and little ability to adapt. On the positive side, warmer winters will reduce cold-related stresses and growing seasons will lengthen. And there will be tradeoffs in some areas, such as less skiing but more hiking; and fewer killing frosts but more bugs.

7. **Sea level has already risen due to warming and is projected to rise much more.** Many people are under the mistaken impression that only if the polar ice caps melt will sea levels rise. In fact, average sea level around the world has already risen 4 to 8 inches in the past 100 years due to global warming and is expected to rise another 4 to 35 inches (with a best guess of around 19 inches) by 2100. The primary reason for this rise is that water expands as it warms. The second reason is that glaciers all over the world are melting, and when land-based ice melts, the water runs to the sea and increases its level. Thousands of small islands are threatened by the projected sea-level rise for the 21st century, as are low-lying coastal areas such as southern Florida. Of course, if

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there is any significant melting of the polar ice sheets, the additional rise in sea level would be enormous (measured in feet not inches). This is projected to occur on a time scale of millennia rather than centuries.

8. **Saving energy and developing alternative energy sources would help.** Each of us can reduce our contribution to global warming by using less greenhouse-gas-producing energy: driving less, choosing fuel efficient cars and appliances (like refrigerators and water heaters), and using solar energy where feasible for water and space heat. We can encourage our political and business leaders to institute policies that will save energy and develop alternative energy sources that do not release carbon dioxide. We can preserve existing forests and plant new ones. But even if we take aggressive action now, we cannot completely prevent climate change because once carbon dioxide is in the atmosphere, it remains there for about a century, and the climate system takes a long time to respond to changes. But our actions now and in the coming decades will have enormous implications for future generations.

9. **An international agreement known as the Kyoto Protocol has been negotiated to reduce greenhouse gas emissions, but the US is not participating in it.** Because of its high energy consumption, the US has long emitted more carbon dioxide than any other country. Because carbon dioxide remains in the atmosphere for about 120 years, it accumulates, becomes equally distributed around the world, and has global effects. Thus, while using large amounts of energy to achieve economic growth, the US and other wealthy nations have unintentionally burdened the rest of the world with a long-term problem. And many negative impacts of climate change are likely to be more severe for poorer countries that lack the resources to adapt. The US has more technological and financial resources than other nations. The role of the US in reducing its own emissions and sharing its technologies with other nations will thus be critical to the success of international efforts to limit climate change. Meanwhile, we do not have to wait for the government to take action. Some companies, governments and individuals have already committed to reducing their emissions of greenhouse gases without laws or treaties requiring them to do so.

10. **Protecting the world's climate by stabilizing atmospheric concentrations of greenhouse gases will require enormous reductions in current emissions.** Even if ratified, the Kyoto Protocol in its present form is only a start and would not be nearly enough to stabilize climate. It is estimated that greenhouse gas emissions would have to be reduced to less than one third of current levels to stabilize atmospheric concentrations. This would require a major transformation of the energy sector. A mix of new and existing energy technologies will be needed to achieve this, including large increases in energy efficiency and renewable energy. Researchers are also developing technology to capture and bury carbon dioxide thousands of feet underground. Major increases in public and private research and development are needed to make the necessary technologies available as rapidly and economically as possible.

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Looking for more?

ARM Climate Research Facility Education Page (The Atmospheric Radiation Measurement (ARM) Climate Research Facility Education and Outreach Program) http://education.arm.gov/
At this website, students can ask questions and scientists will answer them, and teachers can find facts and resources and tools like heat index calculators, relative humidity calculators, etc.