

STAAR Science Tutorial 48

TEK 8.11C: Effects of Environmental Change

TEK 8.11C: Explore how short- and long-term environmental changes affect organisms and traits in subsequent populations.

- The biomes and ecosystems of Earth are not unchanging and static. Even without interference by humans, ecosystems constantly undergo change. If plant and animal species are to survive this change, they must adapt. The adaptation process, covered in *Tutorial 45: Natural Selection*, allows for the continuation of life on Earth.
- Environmental change can either be short-term, occurring in only a few months or years, or long-term, occurring over hundreds, thousands or even millions of years. The slower the change, the easier it is for living organisms to adapt.
- The causes of environmental change can either be natural or human-created. It is often difficult to determine why any single environmental change occurs, and even harder to understand the causes of large-scale ecological change. Global changes such as “global warming” or “climate change” are likely caused by a combination of natural and human causes.

Natural Environmental Change

- Short-term natural environmental change may be caused by catastrophic events such as large volcanic eruptions, earthquakes, tsunamis, small asteroid or comet impacts, and natural climate events and cycles, such as large hurricanes (also called typhoons or cyclones), periodic floods and droughts, and the El Niño and La Niña global weather cycles.
 - **Large volcanic eruptions** can put so much volcanic ash and dust into the atmosphere that it lowers the average temperature of Earth’s surface by several degrees. This can lead to several years with longer winters or shorter growing seasons, causing drops in human and animal populations. Volcanic eruptions can also cause mudflows (lahars) which can destroy river valley ecosystems within 100 kilometers of the volcano, and destroy all life within 25 kilometers of the volcano. Extremely large volcanic eruptions, such as the Yellowstone Caldera eruption about 640,000 years ago, can bury large areas in volcanic ash, destroying most life in the area for many decades. See *Tutorial 38: Succession* for a description of the primary succession process that would rebuild the ecosystem after a volcanic eruption.
 - **Earthquakes** can cause landslides and shifts in ground level, altering the course of rivers or flooding large areas. Earthquakes that occur in ocean subduction zones can cause underwater landslides that create **tsunamis**, large waves that can destroy coastal ecosystems and human development.

- **Small asteroid or comet impacts** can cause local mass-extinction events in which much of the life in an area or region is destroyed. An asteroid impact in Siberia, Russia in 1908 destroyed almost all life in a 2,150 square kilometer area. See *Tutorial 38: Succession* for a description of the primary succession process that would rebuild the ecosystem after a small asteroid impact.
- **Large hurricanes** can cause flooding and destruction of coastal ecosystems, and may lead to the extinction of plant or animal species found only in that area.
- **Weather cycles** such as extended **droughts** can cause the regional or local extinction of species, or shifts to different ecosystem communities. For example, many years of drought in a grassland area may lead to the disappearance of plant and animal species that need more rainfall, and an increase of desert species such as cacti that can survive with less rainfall. The Great Plains of the United States was a desert only a few hundred years ago, and may become a desert again in the future.
- The **El Niño / La Niña global weather cycles** can cause multi-year droughts or floods, depending on the cycle and location, in many different parts of the Earth. Populations of individual species may rise or fall with the changing conditions.
- Long-term natural environmental change may be caused by the cycles of the Earth's tilt and orbit shape that created past ice ages, the movement of tectonic plates changing the position of continents and ocean currents, volcanic mountain building, large asteroid or comet impacts, and changes in the Sun's solar energy output.
 - Cycles in the Earth's tilt angle, tilt direction and orbit shape are thought to control the **ice age / interglacial period cycle** that has occurred on Earth for the last two million years. The colder and dryer ice ages, lasting for 70,000 to 90,000 years, cause much of the Earth near the poles to be covered with continental glaciers, and have led to the extinction of some species, and to changes of population size and range for many others. We currently live in a warmer and wetter interglacial period, which has allowed the rapid population growth of humans, and the range expansion of many species towards the poles. Species adapt to this natural climate change cycle over many generations by changing camouflage colors, thickness of fur, habitat range, or hunting and migration behavior.
 - Over millions of years, **tectonic plate movement** has caused large changes in climate across the Earth, leading to the extinction or growth of many species. For example, tropical plants once lived on the continent of Antarctica, now almost completely covered by glaciers. Parts of Africa now close to the equator and covered with rain forest were once covered by glaciers, when the area was closer to the poles.
 - **Large asteroid or comet impacts** can cause mass-extinction events in which much of the Earth's life is destroyed. It is thought that an asteroid impact about 65 million years ago caused the extinction of the dinosaurs and set the stage for the development of mammals.

- Subduction zones at the convergent tectonic plate boundaries create **volcanic mountain building** over time. These mountains can change local or regional weather patterns by blocking moisture flow to the downwind side of the mountain, and increasing rainfall and water availability on the windward side of the mountains. The higher elevations of the mountains also create “islands” of cooler and wetter ecosystems usually found closer to the poles, leading to biodiversity. Volcanic mountain building can even change the global climate. Volcanic mountain building in Central America closed the connection between the Gulf of Mexico to the Pacific Ocean, changing global ocean currents and weather patterns. Scientists believe that the ice age cycle began two million years ago when this ocean connection was closed.
- Over very long spans of time, **varying solar energy output** has caused adaptive changes in species as the Earth’s temperature warmed or cooled.

Human-Caused Environmental Change

- Short-term human-caused environmental change is caused by habitat destruction, deforestation, introduction of wildlife hazards such as roads and wind generators, air, water & ground pollution, and non-sustainable human harvesting of natural resources, such as overfishing, overhunting and clear-cut logging.
 - **Habitat destruction** causes local populations of many species to be reduced, because human development replaces natural ecosystems and food webs with urban development—buildings and roads.
 - As the Earth’s human population increases, the need for more farming and ranching land leads to **deforestation**. As forests are cut down, whole ecosystems and their communities are destroyed, biodiversity is reduced, and some species are driven to extinction. Forests perform a critical service to the environment—the removal of carbon dioxide from the air, slowing global warming, and the creation of oxygen for animals to breathe.
 - **Wildlife hazards** such as roads can quickly lead to population changes for some species that do not learn to avoid cars, and even physical adaptations. For example, the average wing span of cliff swallows in Nebraska has shortened over a period of several decades, because birds with shorter wings can turn more quickly to avoid being hit by cars. Scientists also found that most “road-killed” cliff swallows have longer wings.
 - **Pollution** has led to the population reduction of some species, particularly in the ocean, where nitrogen fertilizer runoff causes algae blooms, fish kills and dead zones near large river deltas.
 - **Non-sustainable harvesting** of plant and animal species by humans has led to the extinction of many species. The bison (buffalo) of the Great Plains was almost wiped out in a few decades by uncontrolled hunting. Many species of fish and whales have been threatened with extinction by overfishing. Forests are clear-cut more quickly than they can regrow, causing a shortage of wood and forest habitat.

- Long-term human-caused environmental change is caused by deforestation, the burning of fossil fuels and other release of greenhouse gases into the atmosphere (“global warming” or “climate change”), destruction of the ozone layer by release of CFCs and other harmful pollutants into the atmosphere, and the mass-extinction of plant and animal species leading to large reductions in biodiversity and the potential collapse of natural food webs.
 - The single most important long-term environmental change on Earth is the warming of the Earth’s atmosphere, usually referred to as “global warming” or “**climate change**”. Scientists believe that human burning of fossil fuels and deforestation are the main causes of this warming. As the Earth’s atmosphere warms, the continental glaciers of Greenland and Antarctica will melt, causing sea levels to rise. More of the floating ice near the poles will melt during the summer, exposing more open water to absorb more solar heat. Melting permafrost in polar regions will release methane gas, an even stronger greenhouse gas than carbon dioxide, leading to even more warming. Plant and animal ranges will shift towards the poles, and many species not adapted to the warmer climate will likely become extinct in the wild. Tropical insect pests and diseases will spread to the temperate latitudes. The severity of storms will increase, as warmer temperatures fuel these storms. Both droughts and flooding will increase, disrupting human agriculture and natural ecosystems. Tropical rain forests such as in South America may turn into savannah, and grasslands may turn into deserts. The speed of the warming may make it difficult for plant and animal species to adapt enough to survive.
 - The Earth’s ozone layer in the stratosphere filters out much of the Sun’s ultraviolet (UV) radiation. Excessive UV radiation can cause genetic mutations or death to plants, and cancer and premature death in animals. Humans release various chemicals into the atmosphere, including chlorofluorocarbons (CFCs), commonly known as Freon, that cause **ozone layer destruction**.
 - The rapid increase of the human population over the last two hundred years has led to massive habitat destruction, deforestation, non-sustainable harvesting and climate change. The human population of Earth has increased from 2 billion to 7 billion in the just the last hundred years. Many scientists believe that we are now in a **human-created mass-extinction event**, less sudden than the asteroid impact that killed off the dinosaurs 65 million years ago, but potentially just as severe.

Practice Questions

1. Short-term natural ecological change is caused by _____

2. What are some of the possible consequences (effects) of short-term natural ecological change? _____

3. Long-term natural ecological change is caused by _____

4. What are some of the possible consequences (effects) of long-term natural ecological change? _____

5. Short-term human-caused ecological change is caused by _____

6. What are some of the possible consequences (effects) of short-term human-caused ecological change? _____

7. Long-term human-caused ecological change is caused by _____

8. What are some of the possible consequences (effects) of long-term human-caused ecological change? _____

