Threats to Biodiversity

The American Museum of Natural History reports that seven out of ten biologists believe that the Earth is currently in the midst of a mass extinction with nearly 50% of species in danger of being wiped out within the next 100 years. The number of species on the World Conservation Union “red list” increased by 15% between 2002 and 2003, with more than 2,000 species of wildlife in danger of extinction added, bringing the list total to 12,259, a number many believe is only a very miniscule representation of those actually facing extinction. Currently one in eight plants and over 10% of birds are in danger of extinction. And these are just species known to scientists. We don’t know what species have been wiped out that we never even knew existed. At least five other major mass extinctions have occurred during Earth’s history. The most famous was at the end of the Cretaceous period (65 million years ago) when around 85% of species, including the majority of the large birdlike reptiles known as dinosaurs, went extinct, and during the Permian period (245 million years ago) when 96% of living species were wiped out. These extinctions were caused by cataclysmic natural disasters. The cause of the Cretaceous extinction is most commonly hypothesized to have been asteroid impact. The Permian extinction may have be the result of a similar collision or volcanic eruption leading to rapid and catastrophic climate change. The current mass extinction, however, is the only such event in the Earth’s history that we know of that has been caused by one of the species on this planet. Humans are the cause of the so-called sixth mass extinction.

Some kinds of organisms are more vulnerable to extinction than others. Organisms that are specialists and have very restricted diet or habitat requirements are less likely to survive disruptions, because they are unable to turn to other options should their preferred food or habitat become unavailable. Organisms that have small populations or limited distributions are also less likely to survive cataclysmic events, be they natural or human-produced. Organisms that take a long time to reach maturity or produce limited numbers of offspring are in greater danger of extinction because their populations cannot recover as quickly when large numbers die. These are only generalizations, though. Given the right conditions, any organism can become extinct. Passenger pigeons are one famous example. Once seen winging over North American in flocks of millions, they were hunted to extinction in the early 1900s. Frequently, the loss of a species results in a cascade effect leading to the loss of other species. Certain plants, for example, decline because the insects or birds that pollinate them are no longer present.

Some philosophers have argued that extinction can make room for new species. But consider that speciation can take much longer than extinction. It can take thousands and thousands of years for a new species to arise. By contrast, Stellar’s sea cow, a marine mammal similar to the manatee, was hunted to extinction within only 27 years of its discovery by humans. Consider also that the species that tend to survive extinction events are generalists, organisms that can survive in a wide range of conditions. Many of these generalists are familiar to us because they are common in many places due to

their ability to thrive under a wide range of conditions. Do you want to live in a world filled with rats, pigeons, and cockroaches?

When talking about ecology, many people have a sense that humans are not part of the ecosystem. The impact that they are having all over the world indicates that our species is a very big player in world ecology. Some humans have mastered the art of living in their environment and having a low impact, and certainly humans can have a positive impact upon the environment. All too often, the overwhelming majority of the time, humans cause a great deal of destruction to the environment and the organisms living there. Negative human impacts occur in a variety of ways. Consider that as conditions become less and less livable for other organisms, they also do so for humans. The large extinctions of other organisms can be an early warning to us that the planet may no longer be inhabitable to own our species in the near future.

- Acid rain is one form of pollution that occurs when airborne pollutants like smog enter clouds and join with raindrops to form acids. A measurement called pH describes how acidic or alkaline something is. pH is measured on a scale from 0 to 14, with 0 being considered extremely acidic and 14 very alkaline. The normal pH of pure, distilled water is 7, which is considered neutral. “Clean” or unpolluted rain actually has a lower, slightly acidic pH of about 5.6, because the carbon dioxide in the air reacts with water to produce a weak carbonic acid. But other substances in the air, like sulfur oxides, and nitrogen oxides can also react with rain to produce stronger acids like sulfuric and nitric acid that have a lower pH and can be very damaging to the environment. For example, surface waters of streams, ponds, and lakes can become acidified, endangering the life in these waters. Acid rain is one of the hypothesized causes of a current wave of extinctions among the amphibians. Because these organisms must lay their eggs in water, and also have permeable skins, they are especially vulnerable to disruptions in aquatic habitats.

- Eutrophication is also sometimes referred to as overnutrification. This is a unique form of pollution in which too many nutrients are added to the environment. Nitrates and phosphates are necessary nutrients for most organisms. But if there is an overabundance of them in the environment, rapidly growing algae will use them in a population explosion. As these die off, bacteria that decompose their dead bodies will use up all available oxygen, suffocating fish and other animals. As more dead bodies pile up and decompose the area becomes a stagnant, oxygen depleted dead zone. Even in less extreme cases, eutrophication can be problematic and disruptive. In Kaneohe Bay on the windward shore of Oahu in the late 1960s and early 1970s sewage, a rich source of nutrients, was dumped directly into the bay. A rapidly growing alga called *Dictyosphaeria* began to overgrow and smother corals in the bay. Diversion of the sewage outfall outside the bay in the late 1970s helped ameliorate the problem to the point where the corals in Kaneohe Bay have been able to reclaim ground from *Dictyosphaeria*. Where do these nutrients come from? Surprisingly, the largest source of nutrient pollution is something called non point-source pollution. That means that

pollutants come from many small sources rather than one single large point. People fertilizing and watering their lawns, animal droppings, detergent (a source of phosphate) runoff, among other things, contribute to the non point-source nutrient pollution.

- Poisons and toxins are what most people think of when they think of pollution. These pollutants are more obviously harmful than the nutrients that contribute to eutrophication. Their effects, however, are not always immediate. Some pollutants like mercury and other heavy metals and DDT and other pesticides are referred to as persistent. This means that they remain for a long time in the body of an organism that has consumed. They are often stored in bodily tissues like fat and are metabolized or excreted very slowly. This can lead to a phenomenon called biomagnification. Because persistent toxins are maintained in the bodies of organisms, they can become more and more concentrated at each level of the food chain. The reason this happens is simple. At each level of the food chain, animals are consuming multiple individuals at the level below theirs. If each of these individuals has accumulated a small amount of toxin, the collective amount taken in at each level will continue to increase until the level of top predators that may have concentrations of toxins up to a million times higher than in the environment. Also, because the toxins are persistent, they can build up over time. For example, a minnow might eat a dozen mosquito larvae in a day, but it will eat thousands over its lifetime. If significant portions of those larvae contain toxins, the cumulative effect of the toxin on the minnow is substantial.

- The greenhouse effect is a controversial term that is poorly understood by many people. This naturally occurring phenomenon is actually necessary for life on earth. The greenhouse effect is considered by some scientists to be a part of the reason Earth is much more hospitable than our nearest neighbor in the solar system, Mars. Gasses like carbon dioxide and methane trap solar energy in atmosphere. Mars, lacking an atmosphere, does not have much solar energy trapped near the surface. The problem with the greenhouse effect is that human activities have caused an unnatural elevation of the level of greenhouse gases in our atmosphere. Combustion (burning) of fossil fuels like coal, oil, and gasoline, and the release of large quantities of methane gas from livestock like cattle in feedlots. Slash and burn deforestation to clear land for agriculture and housing not only eliminates green plants that remove carbon dioxide from atmosphere, the burning of those same plants releases large amounts of carbon dioxide.

- Invasive species are ones that have been transported outside their natural range. This can happen purposefully when new species are brought in as ornamental or food species, as pets, or to help control another species. Invasive species may also be transported accidentally as hitchhikers. Although some invasive species seem to have very little impact, many can be extremely harmful, either eating or competing with native species. They may carry diseases to which native organisms are not accustomed or immune, or they can change the nature of entire ecosystems. Mangrove trees for example, trap sediments within their

roots, and can cause land buildup, changing a coastline considerably. Consider that species have evolved over time under a specific regime of selective pressures. They are not prepared to handle the sudden introduction of new pressures. For example, Hawaiian mint lacks the minty flavor and Hawaiian blackberries lack thorns, which most members of these species have. Thorns and minty flavors evolved as a defense against grazing animals. The introduction of grazers into Hawaii found these plants completely unprepared to defend themselves against those animals. By similar reasoning, invasive species entering a new area may be suddenly released from pressures that have held their population in check and may be wildly successful. Even under the best of intentions, the introduction of species into a system can have unforeseen and far-reaching consequences. The introduction of the Nile perch into Lake Victoria was intended to provide a new food source for the people in the area. Unfortunately the group of native fishes called cichlids living in the lake were easy victims for the predatory perch and over 200 species of them went extinct in the lake following the perch's introduction. These cichlids had been an important part of the food supply in the lake, in part because their flesh dried well and was easy to store. The oily flesh of the perch did not dry, and required smoking for storage. This led to the cutting down and burning of many of the trees in surrounding forests. Thus, the introduction of a species had many severe and unintended impacts both within and outside of the lake.

- Ozone, O_3, is a chemical present in the stratosphere of the earth's atmosphere. Ozone is formed when ultraviolet light strikes molecular oxygen, O_2, and splits it into two oxygen atoms, one of which rapidly combines with another molecule to form O_3, ozone. In addition to being formed by UV radiation, ozone is also able to absorb it. Ultraviolet radiation is a high energy form of solar energy, and can cause damage to plant and animal tissues (sunburn for example). It can also act as a mutagen, causing mutations in the chromosomal structure of organisms exposed to it (including mutations that lead to skin cancer). By absorbing much of the ultraviolet radiation reaching earth, the ozone layer helps shield the organisms living there. Chloroflurocarbons (CFCs) are chemicals released through a variety of human activities- coolants and propellants. Like ozone, CFCs react when struck by ultraviolet light, they also split, which produces a chlorine ion. This chlorine ion reacts with ozone to produce molecular oxygen O_2, and a choride molecule, ClO. This reaction leads to depletion of the ozone layer, and a reduction in the amount of UV that is absorbed, thus more of the harmful radiation strikes the earth's surface, including the plants and animals living there. Ozone depletion tends to happen under certain conditions, and these conditions, extreme cold, darkness, and isolation, occur at the poles, so these areas are where the ozone hole forms. The "hole" is actually an area that has less ozone in it than other parts of the atmosphere, it is not a real hole. Recent research has shown that coral bleaching is in part due to overexposure to UV.

- Exploitation refers to how humans use animals and plants for many things. The obvious use is for food. Exploitation becomes problematic when it is not practiced

wisely. Sustainable use of resources only takes out enough that it can be replaced by reproduction or recruitment (in fishing, recruitment is considered to be a more effective measure of sustainability because it refers to the number of fish surviving the high mortality of the larval period). Over-harvesting of resources occurs when more individuals are removed from the population than can be naturally replaced. This is especially a problem at top levels of the food chain since those organisms represent a massive energy investment. Weigh-back refers to individuals of the target species that are very small. Since small size indicates young age, weigh-back is usually comprised of juvenile individuals that have not had an opportunity to reproduce. By-catch refers to non-target species that are accidentally captured or harvested along with the target. Oftentimes, by-catch species are ones that are not considered valuable food, and although they may be killed, they are not eaten. Sharks, turtles, and even seabirds, for example are commonly caught as by-catch by the tuna and swordfish long-line fishing boats.

- Habitat degradation could summarize many of these impacts. In general, habitat degradation refers to extreme changes in the environment that render it unlivable or at a minimum, more stressful for an organism.

Refer back to the community web you built in the Food Web activity. What happens if one of these factors impacts even one of the organisms in your web? What will happen to the others?