**ECOLOGY**

Ecology is the study of the relationship of plants and animals with their physical and biological environment. The physical environment includes light and heat or solar radiation, moisture, wind, oxygen, carbon dioxide, nutrients in soil, water, and atmosphere. The biological environment includes organisms of the same kind as well as other plants and animals.

Because of the diverse approaches required to study organisms in their environment, ecology draws upon such fields as climatology, hydrology, oceanography, physics, chemistry, geology, and soil analysis. To study the relationships between organisms, ecology also involves such disparate sciences as animal behavior, taxonomy, physiology, and mathematics.

An increased public awareness of environmental problems has made ecology a common but often misused word. It is confused with environmental programs and environmental science. Although the field is a distinct scientific discipline, ecology does indeed contribute to the study and understanding of environmental problems.

The term "ecology" was introduced by the German biologist Ernst Heinrich Haeckel in 1866; it is derived from the Greek "oikos" ("household"), sharing the same root word as "economics". Thus, the term implies the study of the economy of nature. Modern ecology, in part, began with Charles Darwin. In developing his theory of evolution, Darwin stressed the adaptation of organisms to their environment through natural selection. Also making important contributions were plant geographers, such as Alexander von Humboldt, who were deeply interested in the "how" and "why" of vegetation distribution around the world.

The thin mantle of life that covers the earth is called the biosphere. Several approaches are used to classify its regions.

**BIOMES**

The broad units of vegetation are called "plant formations" by European ecologists and "biomes" by North American ecologists. The major difference between the two terms is that "biomes" include associated animal life. Major biomes, however, go by the name of the dominant forms of plant life.

Influenced by latitude, elevation, and associated moisture and temperature regimes, terrestrial biomes vary geographically from the tropics through the arctic and include various types of forest, grassland, shrub land, and desert. These biomes also include their associated freshwater communities: streams, lakes, ponds, and wetlands.

Marine environments, also considered biomes by some ecologists, comprise the open ocean, littoral (shallow water) regions, benthic (bottom) regions, rocky shores, sandy shores, estuaries, and associated tidal marshes.

**ECOSYSTEMS**

A more useful way of looking at the terrestrial and aquatic landscapes is to view them as ecosystems, a word coined in 1935 by the British plant ecologist Sir Arthur George Tansley to stress the concept of each locale or habitat as an integrated whole. A system is a collection of interdependent parts that function as a unit and involve inputs and outputs. The major parts of an ecosystem are the producers (green plants), the consumers (herbivores and carnivores), the decomposers (fungi and bacteria), and the nonliving, or abiotic, components, consisting of dead organic matter and nutrients in the soil and water. Inputs into the ecosystem are solar energy, water, oxygen, carbon dioxide, nitrogen, and other elements and compounds. Outputs from the ecosystem include water, oxygen, carbon dioxide, nutrient losses, and the heat released in cellular respiration, or heat of respiration. The major driving force is solar energy.

**ENERGY AND NUTRIENTS**

Ecosystems function with energy flowing in one direction from the sun, and through nutrients, which are continuously recycled. Light energy is used by plants, which, by the process of photosynthesis, convert it to chemical energy in the form of carbohydrates and other carbon compounds. This energy is then transferred through the ecosystem by a series of steps that involve eating and being eaten, or what is called a food web.

Each step in the transfer of energy involves several trophic, or feeding, levels: plants, herbivores (plant eaters), two or three levels of carnivores (meat eaters), and decomposers. Only a fraction of the energy fixed by plants follows this pathway, known as the grazing food web. Plant and animal matter not used in the grazing food chain, such as fallen leaves, twigs, roots, tree trunks, and the dead bodies of animals, support the decomposer food web. Bacteria, fungi, and animals that feed on dead material become the energy source for higher trophic levels that tie into the grazing food web. In this way, nature makes maximum use of energy originally fixed by plants.

The number of trophic levels is limited in both types of food webs, because at each transfer a great deal of energy is lost (such as heat of respiration) and is no longer usable or transferable to the next trophic level. Thus, each trophic level contains less energy than the trophic level supporting it. For this reason, as an example, deer or caribou (herbivores) are more abundant than wolves (carnivores).

Energy flow fuels the biogeochemical, or nutrient, cycles. The cycling of nutrients begins with their release from organic matter by weathering and decomposition in a form that can be picked up by plants. Plants incorporate nutrients available in soil and water and store them in their tissues. The nutrients are transferred from one trophic level to another through the food web. Because most plants and animals go uneaten, nutrients contained in their tissues, after passing through the decomposer food web, are ultimately released by bacterial and fungal decomposition, a process that reduces complex organic compounds into simple inorganic compounds available for reuse by plants.

**IMBALANCES**

Within an ecosystem, nutrients are cycled internally. But there are leakages or outputs, and these must be balanced by inputs, or the ecosystem will fail to function. Nutrient inputs to the system come from weathering of rocks, from windblown dust, and from precipitation, which can carry material great distances. Varying quantities of nutrients are carried from terrestrial ecosystems by the movement of water and deposited in aquatic ecosystems and associated lowlands. Erosion and the harvesting of timber and crops remove considerable quantities of nutrients that must be replaced. The failure to do so results in an impoverishment of the ecosystem.

This is why agricultural lands must be fertilized.

If inputs of any nutrient greatly exceed outputs, the nutrient cycle in the ecosystem becomes stressed or overloaded, resulting in pollution. Pollution can be considered an input of nutrients exceeding the capability of the ecosystem to process them. Nutrients eroded and leached from agricultural lands, along with sewage and industrial wastes accumulated from urban areas, all drain into streams, rivers, lakes, and estuaries. These pollutants destroy plants and animals that cannot tolerate their presence or the changed environmental conditions caused by them; at the same time, they favor a few organisms more tolerant to changed conditions. Thus, precipitation filled with sulfur dioxide and oxides of nitrogen from industrial areas converts to weak sulfuric and nitric acids, known as acid rain, and falls on large areas of terrestrial and aquatic ecosystems. This upsets acidbase relations in some ecosystems, killing fish and aquatic invertebrates, and increasing soil acidity, which reduces forest growth in northern and other ecosystems that lack limestone to neutralize the acid.

**POPULATIONS AND COMMUNITIES**

The functional units of an ecosystem are the populations of organisms through which energy and nutrients move. A population is a group of interbreeding organisms of the same kind living in the same place at the same time. Groups of populations within an ecosystem interact in various ways. These interdependent populations of plants and animals make up the community, which encompasses the biotic portion of the ecosystem.

**DIVERSITY**

The community has certain attributes, among them dominance and species diversity. Dominance results when one or several species control the environmental conditions that influence associated species. In a forest, for example, the dominant species may be one or more species of trees, such as oak or spruce; in a marine community, the dominant organisms frequently are animals such as mussels or oysters. Dominance can influence diversity of species in a community because diversity involves not only the number of species in a community, but also how numbers of individual species are apportioned.

The physical nature of a community is evidenced by layering, or stratification. In terrestrial communities, stratification is influenced by the growth form of the plants. Simple communities such as grasslands, with little vertical stratification, usually consist of two layers, the ground layer and the herbaceous layer. A forest has up to six layers: ground, herbaceous, low shrub, low tree and high shrub, lower canopy, and upper canopy. These strata influence the physical environment and diversity of habitats for wildlife. Vertical stratification of life in aquatic communities, by contrast, is influenced mostly by physical conditions: depth, light, temperature, pressure, salinity, oxygen, and carbon dioxide.

**HABITAT AND NICHE**

The community provides the habitat – the place where particular plants or animals live. Within the habitat, organisms occupy different niches.

A niche is the functional role of a species in a community – that is, its occupation, or how it earns its living. For example, the scarlet tanager lives in a deciduous forest habitat. Its niche, in part, is gleaning insects from the canopy foliage. The more a community is stratified, the more finely the habitat is divided into additional niches.

**ENVIRONMENT**

Environment comprises all of the external factors affecting an organism. These factors may be other living organisms (biotic factors) or nonliving variables (abiotic factors), such as temperature, rainfall, day length, wind, and ocean currents. The interactions of organisms with biotic and abiotic factors form an ecosystem.

Even minute changes in any one factor in an ecosystem can influence whether or not a particular plant or animal species will be successful in its environment.

Organisms and their environment constantly interact, and both are changed by this interaction. Like all other living creatures, humans have clearly changed their environment, but they have done so generally on a grander scale than have all other species. Some of these human-induced changes – such as the destruction of the world’s tropical rain forests to create farms or grazing land for cattle – have led to altered climate patterns. In turn, altered climate patterns have changed the way animals and plants are distributed in different ecosystems.

Scientists study the long-term consequences of human actions on the environment, while environmentalists-professionals in various fields, as well as concerned citizens-advocate ways to lessen the impact of human activity on the natural world.

**UNDERSTANDING THE ENVIRONMENT**

The science of ecology attempts to explain why plants and animals live where they do and why their populations are the sizes they are. Understanding the distribution and population size of organisms helps scientists evaluate the health of the environment.

In 1840 German chemist, Justus von Liebig first proposed that populations could not grow indefinitely, a basic principle now known as the Law of the Minimum. Biotic and abiotic factors, singly or in combination, ultimately limit the size that any population may attain. This size limit, known as a population’s carrying capacity, occurs when needed resources, such as food, breeding sites, and water, are in short supply. For example, the amount of nutrients in soil influences the amount of wheat that grows on a farm. If just one soil nutrient, such as nitrogen, is missing or below optimal levels, fewer healthy wheat plants will grow.

Either population size or distribution may also be affected, directly or indirectly, by the way species in an ecosystem interact with one another. In an experiment performed in the late 1960s in the rocky tidal zone along the Pacific Coast of the United States, American ecologist Robert Paine studied an area that contained 15 species of invertebrates, including starfish, mussels, limpets, barnacles, and chitons. Paine found that in this ecosystem one species of starfish preyed heavily on a species of mussel, preventing that mussel population from multiplying and monopolizing space in the tidal zone. When Paine removed the starfish from the area, he found that the mussel population quickly increased in size, crowding out most other organisms from rock surfaces.

The number of invertebrate species in the ecosystem soon dropped to eight species. Paine concluded that the loss of just one species, the starfish, indirectly led to the loss of an additional six species and a transformation of the ecosystem.

Typically, the species that coexist in ecosystems have evolved together for many generations. These populations have established balanced interactions with each other that enable all populations in the area to remain relatively stable. Occasionally, however, natural or human-made disruptions occur that have unforeseen consequences to populations in an ecosystem. For example, 17th-century sailors routinely introduced goats to isolated oceanic islands, intending for the goats to roam freely and serve as a source of meat when the sailors returned to the islands during future voyages. As non-native species free from all natural predators, the goats thrived and, in the process, overgrazed many of the islands. With a change in plant composition, many of the native animal species on the islands were driven to extinction. A simple action, the introduction of goats to an island, yielded many changes in the island ecosystem, demonstrating that all members of a community are closely interconnected.

To better understand the impact of natural and human disruptions on the Earth, in 1991, the National Aeronautics and Space Administration (NASA) began to use artificial satellites to study global change. NASA’s undertaking, called Earth Science Enterprise, and is a part of an international effort linking numerous satellites into a single Earth Observing System (EOS). EOS collects information about the interactions occurring in the atmosphere, on land, and in the oceans, and these data help scientists and lawmakers make sound environmental policy decisions.

**FACTORS THREATENING THE ENVIRONMENT**

The problems facing the environment are vast and diverse. Global warming, the depletion of the ozone layer in the atmosphere, and destruction of the world’s rain forests are just some of the problems that many scientists believe will reach critical proportions in the coming decades. All of these problems will be directly affected by the size of the human population.

**POPULATION GROWTH**

Human population growth is at the root of virtually all of the world’s environmental problems. Although the growth rate of the world’s population has slowed slightly since the 1990s, the world’s population increases by about 77 million human beings each year. As the number of people increases, crowding generates pollution, destroys more habitats, and uses up additional natural resources.

The Population Division of the United Nations (UN) predicts that the world’s population will increase from 6.23 billion people in 2000 to 9.3 billion people in 2050. The UN estimates that the population will stabilize at more than 11 billion in 2200. Other experts predict that numbers will continue to rise into the foreseeable future, to as many as 19 billion people by the year 2200.

Although rates of population increase are now much slower in the developed world than in the developing world, it would be a mistake to assume that population growth is primarily a problem of developing countries.

In fact, because larger amounts of resources per person are used in developed nations, each individual from the developed world has a much greater environmental impact than does a person from a developing country. Conservation strategies that would not significantly alter lifestyles but that would greatly lessen environmental impact are essential in the developed world.

In the developing world, meanwhile, the most important factors necessary to lower population growth rates are democracy and social justice. Studies show that population growth rates have fallen in developing areas where several social conditions exist. In these areas, literacy rates have increased and women receive economic status equal to that of men, enabling women to hold jobs and own property. In addition, birth control information in these areas is more widely available, and women are free to make their own reproductive decisions.

**GLOBAL WARMING**

Like the glass panes in a greenhouse, certain gases in the Earth’s atmosphere permit the Sun’s radiation to heat Earth. At the same time, these gases retard the escape into space of the infrared energy radiated back out by Earth. This process is referred to as the greenhouse effect. These gases, primarily carbon dioxide, methane, nitrous oxide, and water vapor, insulate Earth’s surface, helping to maintain warm temperatures. Without these gases, Earth would be a frozen planet with an average temperature of about –18 °C (about 0 °F) instead of a comfortable 15 °C (59 °F). If the concentration of these gases rises, they trap more heat within the atmosphere, causing worldwide temperatures to rise.

Within the last century, the amount of carbon dioxide in the atmosphere has increased dramatically, largely because people burn vast amounts of fossil fuels – coal and petroleum and its derivatives. Average global temperature also has increased – by about 0.6 Celsius degrees (1 Fahrenheit degree) within the past century. Atmospheric scientists have found that at least half of that temperature increase can be attributed to human activity. They predict that unless dramatic action is taken, global temperature will continue to rise by 1.4 to 5.8 Celsius degrees (2.5 to 10.4 Fahrenheit degrees) over the next century. Although such an increase may not seem like a great difference, during the last ice age the global temperature was only 2.2 Celsius degrees (4 Fahrenheit degrees) cooler than it is presently.

The consequences of such a modest increase in temperature may be devastating. Already scientists have detected a 40 percent reduction in the average thickness of Arctic ice. Other problems that may develop include a rise in sea levels that will completely inundate a number of low-lying island nations and flood many coastal cities, such as New York and Miami. Many plant and animal species will probably be driven into extinction, agriculture will be severely disrupted in many regions, and the frequency of severe hurricanes and droughts will likely increase.

**DEPLETION OF THE OZONE LAYER**

The ozone layer, a thin band in the stratosphere (layer of the upper atmosphere), serves to shield Earth from the Sun’s harmful ultraviolet rays. In the 1970s, scientists discovered that chlorofluorocarbons (CFCs)-chemicals used in refrigeration, air-conditioning systems, cleaning solvents, and aerosol sprays-destroy the ozone layer. CFCs release chlorine into the atmosphere; chlorine, in turn, breaks down ozone molecules. Because chlorine is not affected by its interaction with ozone, each chlorine molecule has the ability to destroy a large amount of ozone for an extended period of time.

The consequences of continued depletion of the ozone layer would be dramatic. Increased ultraviolet radiation would lead to a growing number of skin cancers and cataracts and also reduce the ability of immune systems to respond to infection. Additionally, growth of the world’s oceanic plankton, the base of most marine food chains, would decline. Plankton contains photosynthetic organisms that break down carbon dioxide. If plankton populations decline, it may lead to increased carbon dioxide levels in the atmosphere and thus to global warming. Recent studies suggest that global warming, in turn, may increase the amount of ozone destroyed. Even if the manufacture of CFCs is immediately banned, the chlorine already released into the atmosphere will continue to destroy the ozone layer for many decades.

In 1987, an international pact called the Montreal Protocol on Substances that Deplete the Ozone Layer set specific targets for all nations to achieve in order to reduce emissions of chemicals responsible for the destruction of the ozone layer. Many people had hoped that this treaty would cause ozone loss to peak and begin to decline by the year 2000. In fact, in the fall of 2000, the hole in the ozone layer over Antarctica was the largest ever recorded. The hole the following year was slightly smaller, leading some to believe that the depletion of ozone had stabilized. Even if the most stringent prohibitions against CFCs are implemented, however, scientists expect that it will take at least 50 more years for the hole over Antarctica to close completely.

**HABITAT DESTRUCTION AND SPECIES EXTINCTION**

Plant and animal species are dying out at an unprecedented rate. Estimates range that from 4,000 to as many as 50,000 species per year become extinct. The leading cause of extinction is habitat destruction, particularly of the world’s richest ecosystems-tropical rain forests and coral reefs. If the world’s rain forests continue to be cut down at the current rate, they may completely disappear by the year 2030. In addition, if the world’s population continues to grow at its present rate and puts even more pressure on these habitats, they might well be destroyed sooner.

**AIR POLLUTION**

A significant portion of industry and transportation burns fossil fuels, such as gasoline. When these fuels burn, chemicals and particulate matter are released into the atmosphere. Although a vast number of substances contribute to air pollution, the most common air pollutants contain carbon, sulfur, and nitrogen. These chemicals interact with one another and with ultraviolet radiation in sunlight in dangerous ways. Smog, usually found in urban areas with large numbers of automobiles, forms when nitrogen oxides react with hydrocarbons in the air to produce aldehydes and ketones. Smog can cause serious health problems.

Acid rain forms when sulfur dioxide and nitrous oxide transform into sulfuric acid and nitric acid in the atmosphere and come back to Earth in precipitation. Acid rain has made numerous lakes so acidic that they no longer support fish populations. Acid rain is also responsible for the decline of many forest ecosystems worldwide, including Germany’s Black Forest and forests throughout the eastern United States.

**WATER POLLUTION**

Estimates suggest that nearly 1.5 billion people worldwide lack safe drinking water and that at least 5 million deaths per year can be attributed to waterborne diseases. Water pollution may come from point sources or nonpoint sources. Point sources discharge pollutants from specific locations, such as factories, sewage treatment plants, and oil tankers. The technology exists to monitor and regulate point sources of pollution, although in some areas this occurs only sporadically. Pollution from nonpoint sources occurs when rainfall or snowmelt moves over and through the ground. As the runoff moves, it picks up and carries away pollutants, such as pesticides and fertilizers, depositing the pollutants into lakes, rivers, wetlands, coastal waters, and even underground sources of drinking water. Pollution arising from nonpoint sources accounts for a majority of the contaminants in streams and lakes.

With almost 80 percent of the planet covered by oceans, people have long acted as if those bodies of water could serve as a limitless dumping ground for wastes. However, raw sewage, garbage, and oil spills have begun to overwhelm the diluting capabilities of the oceans, and most coastal waters are now polluted, threatening marine wildlife. Beaches around the world close regularly, often because the surrounding waters contain high levels of bacteria from sewage disposal.

**HOW ECOSYSTEMS WORK. ECOSYSTEM MANAGEMENT**

Ecosystem comprises organisms living in a particular environment, such as a forest or a coral reef, and the physical parts of the environment that affect them. The term ecosystem was coined in 1935 by the British ecologist Sir Arthur George Tansley, who described natural systems in "constant interchange" among their living and nonliving parts.

The ecosystem concept fits into an ordered view of nature that was developed by scientists to simplify the study of the relationships between organisms and their physical environment, a field known as ecology. At the top of the hierarchy is the planet’s entire living environment, known as the biosphere. Within this biosphere are several large categories of living communities known as biomes that are usually characterized by their dominant vegetation, such as grasslands, tropical forests, or deserts. The biomes are in turn made up of ecosystems.

The living, or biotic, parts of an ecosystem, such as the plants, animals, and bacteria found in soil, are known as a community. The physical surroundings, or abiotic components, such as the minerals found in the soil, are known as the environment or habitat.

Any given place may have several different ecosystems that vary in size and complexity. A tropical island, for example, may have a rain forest ecosystem that covers hundreds of square miles, a mangrove swamp ecosystem along the coast, and an underwater coral reef ecosystem. No matter how the size or complexity of an ecosystem is characterized, all ecosystems exhibit a constant exchange of matter and energy between the biotic and abiotic community. Ecosystem components are so interconnected that a change in any one component of an ecosystem will cause subsequent changes throughout the system.

The living portion of an ecosystem is best described in terms of feeding levels known as trophic levels.

Green plants make up the first trophic level and are known as primary producers. Plants are able to convert energy from the sun into food in a process known as photosynthesis. In the second trophic level, the primary consumers – known as herbivores – are animals and insects that obtain their energy solely by eating the green plants. The third trophic level is composed of the secondary consumers, flesh-eating or carnivorous animals that feed on herbivores. At the fourth level are the tertiary consumers, carnivores that feed on other carnivores. Finally, the fifth trophic level consists of the decomposers, organisms such as fungi and bacteria that break down dead or dying matter into nutrients that can be used again.

Some or all of these trophic levels combine to form what is known as a food web, the ecosystem’s mechanism for circulating and recycling energy and materials. For example, in an aquatic ecosystem algae and other aquatic plants use sunlight to produce energy in the form of carbohydrates. Primary consumers such as insects and small fish may feed on some of this plant matter, and are in turn eaten by secondary consumers, such as salmon. A brown bear may play the role of the tertiary consumer by catching and eating salmon. Bacteria and fungi may then feed upon and decompose the salmon carcass left behind by the bear, enabling the valuable nonliving components of the ecosystem, such as chemical nutrients, to leach back into the soil and water, where they can be absorbed by the roots of plants. In this way, nutrients and the energy that green plants derive from sunlight are efficiently transferred and recycled throughout the ecosystem.

In addition to the exchange of energy, ecosystems are characterized by several other cycles. Elements such as carbon and nitrogen travel throughout the biotic and abiotic components of an ecosystem in processes known as nutrient cycles. For example, nitrogen traveling in the air may be snatched by tree-dwelling, or epiphytic, lichen that converts it to a form useful to plants. When rain drips through the lichen and falls to the ground, or the lichen itself falls to the forest floor, the nitrogen from the raindrops or the lichen is leached into the soil to be used by plants and trees. Another process important to ecosystems is the water cycle, the movement of water from ocean to atmosphere, to land and eventually back to the ocean. An ecosystem such as a forest or wetland plays a significant role in this cycle by storing, releasing, or filtering the water as it passes through the system.

Every ecosystem is also characterized by a disturbance cycle, a regular cycle of events such as fires, storms, floods, and landslides that keeps the ecosystem in a constant state of change and adaptation. Some species even depend on the disturbance cycle for survival or reproduction. For example, longleaf pine forests depend on frequent low-intensity fires for reproduction. The cones of the trees, which contain the reproductive structures, are sealed shut with a resin that melts away to release the seeds only under high heat.

**ECOSYSTEM MANAGEMENT**

Humans benefit from these smooth-functioning ecosystems in many ways. Healthy forests, streams, and wetlands contribute to clean air and clean water by trapping fast-moving air and water, enabling impurities to settle out or be converted to harmless compounds by plants or soil. The diversity of organisms, or biodiversity, in an ecosystem provides essential foods, medicines, and other materials. But as human populations increase and their encroachment on natural habitats expand, humans are having detrimental effects on the very ecosystems on which they depend. The survival of natural ecosystems around the world is threatened by many human activities: bulldozing wetlands and clear-cutting forests – the systematic cutting of all trees in a specific area – to make room for new housing and agricultural land; damming rivers to harness the energy for electricity and water for irrigation; and polluting the air, soil, and water.

Many organizations and government agencies have adopted a new approach to managing natural resources –naturally occurring materials that have economic or cultural value, such as commercial fisheries, timber, and water, in order to prevent their catastrophic depletion. This strategy, known as ecosystem management, treats resources as interdependent ecosystems rather than simply commodities to be extracted. Using advances in the study of ecology to protect the biodiversity of an ecosystem, ecosystem management encourages practices that enable humans to obtain necessary resources using methods that protect the whole ecosystem. Because regional economic prosperity may be linked to ecosystem health, the needs of the human community are also considered.

Ecosystem management often requires special measures to protect threatened or endangered species that play key roles in the ecosystem. In the commercial shrimp trawling industry, for example, ecosystem management techniques protect loggerhead sea turtles. In the last thirty years, populations of loggerhead turtles on the southeastern coasts of the United States have been declining at alarming rates due to beach development and the ensuing erosion, bright lights, and traffic, which make it nearly impossible for female turtles to build nests on beaches. At sea, loggerheads are threatened by oil spills and plastic debris, offshore dredging, injury from boat propellers, and being caught in fishing nets and equipment. In 1970, the species was listed as threatened under the Endangered Species Act.

When scientists learned that commercial shrimp trawling nets were trapping and killing between 5000 and 50,000 loggerhead sea turtles a year, they developed a large metal grid called a Turtle Excluder Device (TED) that fits into the trawl net, preventing 97 percent of trawl-related loggerhead turtle deaths while only minimally reducing the commercial shrimp harvest. In 1992, the National Marine Fisheries Service (NMFS) implemented regulations requiring commercial shrimp trawlers to use TEDs, effectively balancing the commercial demand for shrimp with the health and vitality of the loggerhead sea turtle population.

**ECOLOGY & ENVIRONMENT**

The three elements namely earth, water and space constitute the whole cosos therefore it re-affirms to work with people towards creating awareness and as a movement for perseverance, sustenance of flora and fauna and cosmic elements and to usher ecology and environment of this earth where integrity of creation will be a cherished value.

**AIR**

• Air pollution has now become a major killer with three million people dying of it every year.

• Carbon emissions doubled in three decades. Global warming is now a serious threat.

• US Carbon emissions are 16 % above 1990 levels making it a major polluter.

**WATER**

• Forty percent of world population now faces chronic shortage of fresh water for daily needs.

• Half the world’s wetlands have been lost and one-fifth of the 10,000 freshwater species is extinct.

• Contaminated water kills around 2.2 million people every year.

**LAND**

• Since 1990, 2,4 % of the world’s forests have been destroyed. The rate of loss is now 90,000 sq. km.

every year.

• Now two-thirds of the world’s farmlands suffer from soil degradation.

• Half the world’s grasslands are overgrazed. India is 25 % short of its fodder needs.

**WILDLIFE**

• 800 species have become extinct and 11,000 more are threatened.

• Almost 75 % of the world’s marine captures is over fished or fully utilized. In North America, 10 fish species went extinct in the 1990s.

• Of the 9,946 known bird species, 70 % has declined in numbers.

**PEOPLE**

• The world added 800 million people since 1990. In 2000, global population was 6 billion, up from 2.5 billion in 1950.

• In 10 years, the world will have to feed and house another billion

**CARING FOR THE NATURE**

"Nature has everything for man’s need but not his greed", – said once Mahatma Gandhiji. A large-scale deforestation that is taking place around the globe is causing tremendous ecological and environmental imbalances throughout the world. The resultant fury of the nature is witnessed all around through drastic change in the climate, flash, floods, failure of rain and many more, causing damage to thousands of lives and livestocks throughout the world.

**THE ENVIRONMENT IN THE NEW MILLENNIUM**: **THE WAY OF THE WORLD**

"The Economist", the famous magazine of the United Kingdom, has analyzed the trend of the world in the twentieth century. The environment of the past 100 years has not been as bad as the people have thought. On the contrary, the environment of the world has been good and will be so until the next century. Although the population of the world has been increasing quickly during the last century, it has not caused any serious problems as world production has also been highly increased. The environment of the world has not been a disaster (like the prophecy of many others) because of the changes of many factors. There is the change of resource prices and society. The development of democracy and the planning of environment are to meet the pressure from the people.

It is seen that when there are more people, more consuming, more production, the use of natural is increasing. The price goes up when there is the need. There is then the force of being economical in use, the need to find new resource sites, new kinds of resources, new technology, and new ways for humanity. The mechanism of prices has been quite efficient in solving the problems of natural resource.

However, we need to accept that marketing mechanisms have not been quite satisfactory in solving environmental problems, particularly, where there is something in nature, which does not belong to any one. There-fore, there is the tendency that resources will be used inconsiderately. There is no one to care for conservation.

There is the example that resources in the sea and the ocean will continue being in hazard in the next century.

Moreover, in some cases, the hazard in the environment has not been reflected in the way we can see like "price". There is the case that pollution is setting into air and water. The pollution occurs to the ecology and community. However, the price does not reflect any of these damages. It is because private business wants to decrease the capital amount and want to continue getting the highest profit. They let the disasters happen.

Communities, society and nature meet danger from the environment as we see in the developing countries all over the world

"The Economist" points out that in a country with advanced industry, pollution is not a big problem because they have developed democracy, which then has the checking, there is always the pressure from the people. The democratic government has answered the people’s needs with the awareness that something needs to be done and some things have already been done. We can see that air pollution in industrial society, which had been increasing for 300 years, is solved satisfactorily. This will be continued for a long time. In a developing country, this problem may continue to the next century.

**THE CRISIS OF ECOLOGY IN THE DEVELOPING WORLD**

In the analysis, "The Economist" may be too positive in assessing the environmental problem and regarding only one aspect like pollution in industry. There is the conclusion that the incidence of pollution in the air has been decreasing. Nothing is said about the pollution of toxic waste, which has been left, and keeps piling up in the environment for so long in the world of industry. This tendency will continue until the next century as the government in industrial countries like America, Japan and Germany have not been successful in solving the problems of toxic waste, which has been accumulating for so long. It is because the main environmental policy emphasizes only the problems, which are visible and can be felt. The emphasis is on short-term pollution, which has an immediate effect to on people’s health. The accumulating pollution cannot be seen easily, it is then neglected.

Besides, the analysis of the population of the world overlooks one main fact – although the growth rate is not as high as before the population of the world in this turn of the century will increase by approximately 80 million a year. (The amount is equal to the number of people in Germany.) It means that this amount of population among the impoverished and the deterioration of rural environment will heighten the environment crisis, which will have an effect on the production system and the ways of living of the people in developing countries. The very high increase of the population has affected the development in city and the living in urban areas. At present, there are 2.6 billion people living in cities. 1.7 billion of that amount live in the cities of developing countries. There is the prediction that the ratio will accelerate until the year 2015. Three quarters of the world population is in developing countries, which are very crowded, and the health problems are serious.

When we adopt the well-known "environmental formula" of Anne and Paul Ehrlich as the base on considering problems, we get the conclusion that the environment crisis has the tendency to become very critical. This formula says:

"Environment crisis (I) is settled by the amount of the population (P), the economic growth (A) and Production

Technology (T), that is I = P × A × T".

Economic growth is also another main variable. The more development, there is the more the increase in production. It heightens the ecology system. Moreover, the production of one unit may cause a large quantity of pollution because of the use of unclean (unhealthy) technology, which endangers the environment. It is worrying that the trading, the production and the consuming will enhance the squandering of resources and the environment will be seriously destroyed.

**DEMOCRACY AND ENVIRONMENT**

We can give the main conclusions for the future of the developing world as follows.

1. The worst pollution may occur among the poor countries. It reflects some basic problems. These countries hardly have democratic development, their people have no rights, no vote, they do not get information on the environment, and they are unable to force their government to be against the businesses threatening environmental conditions. The lack of democracy is then the main factor causing environmental crisis.

2. The seriousness of pollution has not occurred because of the over development of the economy. It is because the first part of the development by government and private business emphasizes only the economic enlargement (to increase population income and the export). After a certain period, people in various fields started to develop their conscience of "Green" and there is a large cry for the awareness of "Sustainable Development". During this time, the government has to respond to the starting of environmental planning with the aims of economic development along with environmental protection. However, there needs to be "Democracy of the environment" as the main base.

3. Regarding the long 100 years of experience of the West, we may look further ahead that in the 21st century the developing countries may be trying to solve environmental crises by themselves. However, there are many other factors for their success, particularly, the following:

– there needs to be information which is quite complete for the comparison of capital for the controlling of environment and the benefits from which society will gain;

– there are efficient criteria, which is the mixture of the standards of marketing and the price, and the criteria in setting up the environmental standards.

Finally, the solving of the crisis of the environment is not only the economic problems (e.g. the promulgation of Green Tax) but also the political problem. If there are too strict standards, it may not be accepted politically. The people may criticize. The business world may be against it and react (by decreasing the investment in employee’s wages or increasing the price so high that it causes people to be in trouble.) In a democracy, the politicians who plan the policy on environment do not usually like strict standards. There is no one being concerned about how much the standard and the policy on environment will be affected.

It is predicted that in the twenty-first century the green power group in developing countries will increase.

The movement will be in a wider scope and there will be the call for solving the problems down to the root.

This is because the environment problem is becoming serious while the reaction from the government is quite slow. It is because the government has the tendency not to have strict standard that they may have to be concerned with private business and the national economy.

**ENVIRONMENTAL INNOVATION**

Among the rich countries, it is assumed that it is not so hard to solve environmental problems of the 21st century. These countries will compete with each other in improving the quality of their products. There is always the search for innovation, environmental innovation, in particular, is an important instrument in encouraging the progress of the industrial world. At present, the rich countries have already had the high potentiality of developing new technology for the production process with the regard for environmental quality.

The innovative analyst regards that the ability of industry in responding to the environmental problems is the main indicator if that kind of industry can compete at the world level. Those who want to succeed must integrate the main idea with the production system. It means the protection of the environment, solving the problem of pollution, increasing the efficiency in using natural resources and power. The strict standard of the environment will enhance the thinking of production method, which will benefit the environment.

At present, the governments of the industrial world, like Sweden, agree with "Environment Innovation

Ways". There is a conclusion in the latest report of the national environment that "The policy on environment of the Swedish government is very important in enhancing the modernity in industrial business sectors. The improvement of the environment has turned out to be the main factor in accelerating the competition in this industry."

This is the entire new western concept, which emphasizes "How to bring about Ecological Modernization."

It is the new concept on new environmental technology and every step is used for the industrial production process. However, there needs to be adaptation of the whole production structure, which needs systematic «environmental planning», and the adapting of world vision and the conscience of the environment of the people in every field. The concept of "Ecological Innovation" does not emphasize only the technology but also regards the importance of "Environmental management" which needs to be done in both the governmental and private sectors. This can be seen in countries like Sweden, Denmark, Holland and Germany, which are regarded as the leaders in "Environmental Innovation".

**ENVIRONMENTALISM AND TECHNOLOGY**

Wait a minute, you might say, it is environmentalism against technology, for isn’t technology a fundamental source of environmental problems?

This has been the position of deep greens. In fact, some trace all environmental problems to the beginning of agriculture, arguing that it was the shift from hunter-gatherer to farming that created what they consider the human cancer consuming the globe. Even moderate greens can be anti-tech, reflecting both skepticism about capitalism and the counter cultural ideology that characterizes most environmental discourse.

Consider, for example, something as mainstream, as the precautionary principle, which holds that no new technology be introduced until it can be demonstrated to have no harmful environmental impacts. Taken at face value, this embeds within it a strong preference for "privileging the present" – that is, attempting to ban or limit technological evolution – for the potential implications of all but the most trivial technological innovations can-not be known in advance.

Positioning environmentalism against technology, however, has its problems. For one, it misunderstands the nature of complex cultural systems. These inevitably evolve, generally towards greater complexity; consider, for example, how much more complex international governance, information networks, or financial structures are now than just a few years ago.

And technologies are evolving rapidly as well, particularly in the three areas that promise to impact environmental systems the most: biotechnology, nanotechnology, and information technology. The first will, over time, give us design capabilities over life; the second will let us manipulate matter at the molecular level; the third will change how we perceive and understand the world within which the first two are accomplished.

Moreover, developing such capabilities will give the cultures that do so significant competitive advantages over those that opt for stability rather than technological evolution. There are historical examples of this process

– for example, China, from roughly the 11th to the 14th centuries. At that time, China was the most technically advanced society, but for a number of reasons its elite chose stability over the social and cultural confusion that development and diffusion of technologies (such as gunpowder and firearms) might have caused. Northern Europe, however, followed a more chaotic path, including the Enlightenment and the Industrial Revolution, which favored technological evolution. The result: Eurocentric, not Chinese, culture forms the basis of today’s globalization.

Applying this lesson to current conditions raises the question of whether deep-green opposition to certain technological advances, especially genetically modified organisms, could halt technological advance. Some societies –

Europe, in particular – may choose stasis over evolution. But biotech is such a powerful advance in human capabilities that other societies – especially developing countries with immediate needs that biotech can address – are not likely to forego its benefits. And to the extent, their cultures become more competitive by doing so, they may come to dominate global culture.

So is the answer then to simply give up and let technology evolve, as it will? Not at all. In fact, the essential problem with an ideological opposition to technology is that it prevents precisely the kind of dialog between the environmentalist and technological discourses required to create a rational and ethical anthropogenic earth. For technologies are not unproblematic, and their evolutionary paths are not preordained; rather, they are products of complex and little-known social, cultural, economic, and systems dynamics, it is important that they be questioned and understood.

The challenge is thus not unthinking opposition, or maintenance of ideological purity, or even meaningless repetition of ambiguous phrases such as "precautionary principle." It is far more demanding. It is to learn to perceive and understand technology as a human practice and experience, and to help guide that experience in ways that are environmentally appropriate.

**BUT I WANT TO WORK ON ENVIRONMENTAL STUFF!**

One of the horrible existential challenges of being a student is that, in most cases, one must at some point leave school and begin work, presumably in an area for which one has been training these many years. For those reading this column, the area of interest is likely environmental, usually expanded these days to include sustainability. Put bluntly, the relevant questions are likely to be "How do I do well and what is the job market like?" Recognizing that planning your career on the basis of a 750-word column is probably not a great idea, here are some thoughts while you hit the books. First, the good news. There are plenty of opportunities to do great things: to help your employer (be it a private firm, government, or NGO), help the world, and feed yourself. Now, the bad news. Most of these opportunities are disguised, most have nothing to do with environment as currently taught and thought about at most schools, many of the opportunities have yet to be invented, and almost any worthwhile job will require that you develop it yourself, from inside.

To begin with, traditional environmental jobs that is, those based on current regulatory and policy structures, primarily cleanup and end-of-pipe emissions control will be with us for a long time, especially in developing countries. They are necessary. But this field is not growing, offers few intellectual challenges, and will have little to do with solving the larger problems of the anthropogenic world albeit improving health significantly in developing countries. So if you really want to help the environment in the broader sense – perturbed climatic and oceanic systems; anthropogenic carbon, nitrogen, sulfur, and hydrologic system changes; biosphere disruptions – this is not the place for you.

The next step up is a position in the "sustainability industry." Superficially, at least, such jobs, which are frequently with niche consulting firms, are broader in scope and offer more intellectual opportunities. But caution is in order. The term "sustainability" has now grown to be so politically correct, and at the same time flown so far beyond mere ambiguity, that there is no substantive content to much of this work. In too many cases, it now amounts to a somewhat patronizing, highly ingrown dialog within a small circle of friends that tend to regard themselves as the great and the good, and spend a lot of time reinforcing one another’s mental models.

The result is a nouveau utopianism that has tenuous connections with the real world, except for the few that are already True Believers. Thus, for example, I recently participated in a sustainability workshop where one conclusion was that firms should exist not for profit, but only to redistribute income (and that, by the way, money should be banned). Those with any historical background will recognize that this proposed policy closely tracks that of the early Leninist/Marxist Soviet Union. They did ban money – and the economy collapsed. Moreover, you can imagine how the typical executive would greet such a proposal as a model for how his/her firm could be "sustainable."

So, be careful if you want to work in this area. Before you jump in, you may want to work inside a firm first to get an idea of what companies really are like. It will help you maintain perspective. There are a few real opportunities – but caveat emptor.

So what to do? Back to first principles. The challenge of environmental (and related social) issues is precisely that they have become so all encompassing. They are not separable from the messy, multidisciplinary worlds of commerce, of ordinary life, of birth and death, of long natural cycles. So the kinds of things that contribute most to social and environmental progress – employee telework options, efficient network routing algorithms for air and ground transport systems, low-energy and reduced-water manufacturing technologies – come not from the environmental staff, but from the core operating competencies – engineers, business planners, product designers, and others. So, by all means remain committed to sustainability, but get expertise in international business, chemical engineering, or finance. Then, when you get your non-environmental, line position, you can start to change the world.

**WORKING FOR THE ENVIRONMENT – INDUSTRIAL COMPLEX**

A while ago, I was reading an article on pollution prevention written by an ex-EPA consultant, and was both amused and somewhat surprised to see "industrial ecology" identified as industry green wash.

My first response, of course, was dismissive: didn’t the author realize that meaningful environmental progress could be achieved only through such systematic approaches as industrial ecology, and its implementation through (for example) Design for Environment and Life Cycle Assessment methodologies?

Indeed, pollution prevention as usually interpreted by environmental regulators is a singularly limited concept, a relatively insignificant extension of end-of-pipe approaches, and it requires something like industrial ecology to energize it.

But my initial reaction was both unfair and superficial. The author was not really reacting to industrial ecology as laid out in existing texts or as being implemented in some firms today. Rather, the article implicitly made an important point about the nature of "environment" itself: the very concept (and closely related concepts such as "wilderness" and "nature") is constructed from underlying mental models, which may differ significantly and carry very different policy and governance implications.

Thus, "industrial ecology" does not enter the environmental discourse as an objective concept (although industrial ecology studies strive for objectivity and good science). Rather, an environmentalist will see it as a response to growing political pressure by powerful administrative and bureaucratic systems, with a belief system based on scientific and technical rationality – as, in short, a defensive thrust based on a state/corporatist managerialism mental model.

Seen in this light, the concept carries several implications which to an environmentalist may be problematic: a powerful (and polluting) elite co-opting "real" environmentalism; establishment of a playing field (high technology and industrial systems) which implicitly degrades the knowledge base and operational characteristics of traditional environmental NGOs; and, more subtle but all the more powerful for that, a vision of a future "sustainable" world based on a high technology, urbanized society as opposed to an agrarian, localized world with large portions of limits to people.

It was important, therefore, not to take that article as just a naive rejection of industrial ecology and its promise, but to understand it as a reflection of deeply conflicting worldviews which were all the more critical for being implicit and, to a large extent, even unconscious.

And, of course, these two mental models – call them the managerialistic and the edenistic – are not the only common ones. Others which might be identified include the "authoritarian" (environmental crises require centralized authoritarian institutions); "communal" (with the caution that some communities can be extraordinarily violent towards minorities and outsiders); "ecosocialist" (capitalistic exploitation of workers and commoditization of the world are the source of environmental degradation); "ecofeminist" (male exploitation of nature andм women derive from the same power drive, and must be addressed concomitantly) and "pluralistic liberalism" (open collaboration involving diverse interests is the proper process to achieve environmental progress).

All of these raise some very difficult questions. For example, ecosocialism is somewhat tarnished by the abysmal environmental record of Eastern European communist governments.

The obvious question for the manager blessed with the opportunity to manage among these minefields is which one of these mental models is "right"? The unfortunate truth is that we as a society are not ready to answer that question yet.

This is not just because most people – environmental professionals, environmentalists, regulators, industry leaders – are naive positivists, and therefore unwilling or unable for the most part to recognize their own mental models, much less to respect other parties’ mental models.

It also reflects a disturbing and almost complete ignorance about the implications of each model for the real world. What levels of human population, of biodiversity, of economic activity, would each mental model imply? What kind of governance structure? Who would win and who would lose (more precisely, what would the distributional effects of each model be)?

The important point, I think, is not the correctness of any particular model. Rather, it is the need to under- stand that differences among stakeholders in environmental disputes may arise not just from factual or economic disagreements, but from differences in fundamental worldviews – and that, at present, our current knowledge cannot anoint any particular one as "privileged."

A little sensitivity to how one’s position and practices are understood by others can go a long way towards facilitating collaborations, which are both necessary and plenty difficult as it is. Before one too readily criticizes others, one should recall the Socratic admonition and know thyself – and thy mental models.

**PRE-CAMBRIAN PERIOD**

The Earth formed under so much heat and pressure that it formed as a molten planet. For nearly the first billion years of its formation – called the Hadean Period (or "hellish" period) – Earth was bombarded continuously by the remnants of the dust and debris – like asteroids, meteors and comets – until it formed into a solid sphere, fell into an orbit around the sun, and began to cool down.

As Earth began to take solid form, it had no free oxygen in its atmosphere. It was so hot that the water droplets in its atmosphere could not settle to form surface water or ice. Its atmosphere was also so poisonous that nothing would have been able to survive.

Earth’s early atmosphere most likely resembled that of Jupiter’s atmosphere, which contains hydrogen, helium, methane and ammonia, and is poisonous to humans.

Earth’s atmosphere was formed mostly from the out gassing of such volatile compounds as water vapor, carbon monoxide, methane, ammonia, nitrogen, carbon dioxide, nitrogen, hydrochloric acid and sulfur produced by the constant volcanic eruptions that besieged the Earth. It had no free oxygen.

About 4.1 billion years ago, the Earth’s surface – or crust – began to cool and stabilize, creating the solid surface with its rocky terrain. Clouds formed as the Earth began to cool, producing enormous volumes of rain - water that formed the oceans. For the next 1.3 billion years (3.8 to 2.5 billion years ago), called the Archean Period, first life began to appear (at least as far as our fossil records tell us... there may have been life before this!) and the world’s landmasses began to form. Earth’s initial life forms were bacteria, which could survive in the highly toxic atmosphere that existed during this time. In fact, all life was bacteria during the Archean Period.

Toward the end of the Archean Period and at the beginning of the Proterozoic Period, about 2.5 billion years ago, oxygen-forming photosynthesis began to occur. The first fossils, in fact, were a type of blue-green algae that could photosynthesize.

Some of the most exciting events in Earth’s history and life occurred during this time, which spanned about two billion years until about 550 million years ago. The continents began to form and stabilize, creating the super continent Rodinia about 1.1 billion years ago. (Rodinia is widely accepted as the first super continent, but there were probably others before it.) Although Rodinia is composed of some of the same land fragments as the more popular super continent, Pangea, they are two different super continents. Pangea formed some 225 million years ago and would evolve into the seven continents we know today.

Earth’s atmosphere was first supplied by the gasses expelled from the massive volcanic eruptions of the Hadean Era. These gases were so poisonous, and the world was so hot, that nothing could survive. As the planet began to cool, its surface solidified as a rocky terrain, much like Mar’s surface and the oceans began to form as the water vapor condensed into rain. First life came from the oceans. Free oxygen began to build up around the middle of the Proterozoic Period around 1.8 billion years ago – and made way for the emergence of life, as we know it today. This event, of course, created conditions that would not allow most of the existing life to survive and thus made way for the more oxygen dependent life forms.

By the end of the Proterozoic Period, Earth was well along in its evolutionary processes leading to our current period, the Holocene Period, also known as the Age of Man. Thus, about 550 million years ago, the Cambrian Period began. During this period, life "exploded" developing almost all of the major groups of plants and animals in a relatively short time. It ended with the massive extinction of most of the existing species about 500 million years ago, making room for the future appearance and evolution of new plant and animal species.

And then, about 498 million years later – 2.2 million years ago – the first modern human species emerged.

**EARTH’S TRUE VITAL SIGNS REVEALED FROM SPACE**

Circling the Earth 16 times a day 438 miles above the surface, new satellite technology is revolutionizing earth science and now scientists are able to understand the health of the planet and distinguish between human impact and natural phenomenon. On February 4, scientists began collecting images of the earth’s vital signs from its bus-sized Terra satellite, the flagship of NASA’s 15-year Earth Observing System (EOS). EOS is an international collaboration designed to help scientists develop those answers about Earth’s climate and environmental changes that have not been available before.

Though the earth is approximately 4.5 billion years old, the earliest ancestors of the human race only appeared between three and four million years ago, according to most scientists. This is only one-tenth of one percent of Earth’s time span, a relatively insignificant period. Even the first known civilization did not appear until about 6,000 BC. But since the dawn of humankind, the earth supplied all of their wants and needs, which led to settled life in groups or villages. Yet during the entire lifespan of the earth, natural geologic forces have constantly been changing and rearranging the planet’s features, climate and environment. And now, there is "compelling evidence that human activities have attained the magnitude of geological force and are speeding up the rates of global change," according to Dr. Yoram Kaufman, Terra Project Scientist.

According to Dr. Kaufman, these changes have occurred without much knowledge at all about their impact on earth’s life systems. "Scientists don’t understand the cause-and-effect relationships among Earth’s lands, oceans, and atmosphere well enough to predict what, if any, impacts these rapid changes will have on future climate conditions," he said.

This image from Terra shows chlorophyll concentrations and phytoplankton health in the Arabian Sea via its MODIS instrument.

"There are some basic questions about the Earth system that need to be answered in order to understand our world’s climate system well enough to predict future changes, and how those changes may impact our quality of life," – said Dr. Kaufman during a recent NASA news briefing in Washington, DC. "Terra data, along with other measurements, will feed earth science models so we can predict climate variations and climate change, and prepare for the future. We anticipate that Terra data will revolutionize our understanding of the Earth’s climate system and help show the human impact," – he continued. "Terra is measuring a wide array of vital signs, many of them for the first time, to help us understand our planet, to distinguish between natural and man-made climate change, and to show us how the Earth’s climate affects the quality of our lives."

Dr. Kaufman describes that this revolution in earth science is necessary to help in the understanding of our world’s climate systems enough to accurately predict changes and how those changes will impact quality of life. Questions, which need to be answered, include "How are the soils and vegetation types changing around the world?"

"What are the changes in the extent of snow and ice, and why are 2 – 3 of the world’s glaciers disappearing each week?"

"What are the variations in the phytoplankton in the ocean and how are these plants affected by windblown Saharan dust?"

"What is the concentration of atmospheric airborne particles and gaseous pollutants, and how do they affect the ability of the atmosphere to cleanse itself?"

"What fraction originates from natural or man-made sources?"

"How do the availability of water vapor and the presence of pollutants affect cloud formation, properties and precipitation?"

"Is the Earth system taking in more radiant energy than it reflects and emits back into space, or is the radiation budget in balance (global warming)?"

"Is there a change in the frequency of wild fires, floods & volcanic eruptions?"

"Is the frequency related to climate change?"

The Terra observatory uses five instruments to thoroughly study and track Earth’s vital systems: Land,

Ocean, Atmosphere, and the life, exchange of nutrients, carbon, heat, moisture and pollution among them. The first instrument is called the Moderate-resolution Imaging SpectroRadiometer (MODIS). MODIS provides frequent global views of changes occurring within the Earth system, including the study of snow and ice cover, cloud cover and cloud type, vegetation cover and other land covers, the temperature of the oceans, and the study of plant life on land and in the oceans.

This thermal infrared image shows the urban heat island effect in the San Francisco Bay area through Terra’s ASTER instrument.

The second instrument is the Multi-angle Imaging SpectroRadiometer (MISR) that physically characterizes the Earth’s surface, atmosphere, and clouds, and how they interact with sunlight, the primary energy source for Earth’s climate system. The third instrument, the Advanced Space borne Thermal Emission and Reflection radiometer (ASTER) is a joint US-Japan project provided by Japan’s Ministry of International Trade and Industry. It is the zoom lens of the Terra satellite. The primary goals of ASTER are to characterize the Earth’s surface and to monitor dynamic events and processes that influence habitability at human scales. The Measurements of Pollution in the Troposphere (MOPITT) is a fourth instrument that helps scientists to determine the amount of carbon monoxide and methane at different altitudes in the atmosphere. MOPITT is a joint effort of the US and Canada.

The final instrument is called Clouds and the Earth’s Radiant Energy System (CERES), which measures reflective sunlight. Measuring the energy emitted by the surface and atmosphere of the Earth, CERES monitors the balance of the "radiation budget" which indicates whether the earth is warming or cooling. If the radiation budget if perfectly balanced, the earth should neither be warming nor cooling.

**THE OZONE LAYER**

Although ozone (O3) is present in small concentrations throughout the atmosphere, most ozone (about 90 %) exists in the stratosphere, in a layer between 10 and 50 km above the surface of the earth. This ozone layer performs the essential task of filtering out most of the sun’s biologically harmful ultraviolet (UV-B) radiation. Concentrations of ozone in the atmosphere vary naturally according to temperature, weather, latitude and altitude. Furthermore, aerosols and other particles ejected by natural events such as volcanic eruptions can have measurable impacts on ozone levels.

**THE OZONE HOLE**

In 1985, scientists identified a thinning of the ozone layer over the Antarctic during the spring months, which became known as the "ozone hole". The scientific evidence shows that human-made chemicals are responsible for the creation of the Antarctic ozone hole and are also likely to play a role in global ozone losses.

Ozone Depleting Substances (ODS) have been used in many products which take advantage of their physical properties (e.g. chlorofluorocarbons (CFCs) have been used as aerosol propellants and refrigerants).

CFCs are broken down by sunlight in the stratosphere, producing halogen (e.g. chlorine) atoms, which subsequently destroy ozone through a complex catalytic cycle. Ozone destruction is greatest at the South Pole where very low stratospheric temperatures in winter create polar stratospheric clouds (PSCs). Ice crystals formed in PSCs provide a large surface area for chemical reactions, accelerating catalytic cycles. The destruction of ozone also involves sunlight, so the process intensifies during springtime, when the levels of solar radiation at the pole are highest, and PSCs are continually present.

Although ozone levels vary seasonally, stratospheric ozone levels have been observed to be decreasing annually since the 1970s. Mid-latitudes have experienced greater losses than equatorial regions. In 1997, the Antarctic ozone hole covered 24 million km2 in October, with an average of 40 % ozone depletion and ozone levels in Scandinavia, Greenland and Siberia reached an unprecedented 45 % depletion in 1996.

**ENVIRONMENTAL AND HEALTH EFFECTS**

The amount of UV reaching the earth’s surface has been shown to correlate with the extent of ozone depletion. In 1997, UV-B levels continued to rise at a rate of 2 % per annum. Increased UV levels at the earth’s surface are damaging to human health, air quality, biological life, and certain materials such as plastics. Human health effects include increases in the incidence of certain types of skin cancers, cataracts and immune deficiency disorders. Increased penetration of UV results in additional production of ground level ozone, which causes respiratory illnesses. Biologically, UV affects terrestrial and aquatic ecosystems, altering growth, food chains and biochemical cycles. In particular, aquatic life occurring just below the surface of the water, where plant species forming the basis of the food chain are most abundant, are adversely affected by elevated levels of UV radiation. The tensile properties of certain plastics can be affected by exposure to UV radiation. Depletion of stratospheric ozone also alters the temperature distribution in the atmosphere, resulting in indeterminate environmental and climatic impacts.

**FUTURE PERSPECTIVE**

Despite existing regulation of ODS, there continues to be severe ozone depletion and maximum stratospheric levels of chlorine and bromine are predicted to occur only during the next decade. Without further measures, the ozone hole will continue to exist beyond 2050. However, the success of the Montreal Protocol has already been observed in terms of changes in the concentrations of man-made chlorine-containing chemicals in the troposphere (i.e. the rates of release of ODS to the atmosphere have been reduced). Additional measures are currently being proposed by the European Commission to accelerate the phase out of various ODS and there by to provide much-needed additional protection for the ozone layer.

**WHAT YOU CAN DO TO PROTECT THE OZONE LAYER**

You have already taken the first steps to help protect the ozone layer by informing yourself of the problem and its causes. Try to find out as much as you can about the problem from publications, schools or public libraries. The only way to mend the ozone hole is to stop the release of CFCs and other ozone depleting substances (ODS) into the atmosphere. European legislation aims to achieve this by phasing out ODS as soon as viable alternatives become available, and where no such alternatives are available, restricting the use of these substances as far as possible. However, there are a number of practical initiatives, which can be taken at the individual level to help protect the ozone layer: try to use products, which are labeled "ozone-friendly".

Ensure technicians repairing your refrigerator or air conditioner recover and recycle the old CFCs so they are not released into the atmosphere.

Vehicle air conditioning units should regularly be checked for leaks.

Ask about converting your car to a substitute refrigerant if the a/c system needs major repair.

Remove the refrigerant from refrigerators, air conditioners, and dehumidifiers before disposing of them.

Help start a refrigerant recovery and recycling program in your area if none already exists.

Suggest school activities to increase awareness of the problem and to initiate local action.

**PROTECTING YOURSELF FROM UV RADIATION**

There is a direct link between increased exposure to UV radiation and elevated risk of contracting certain types of skin cancers. Risk factors include skin type, sunburn during childhood, and exposure to intense sunlight. Recent changes in lifestyle, with more people going on holiday and deliberately increasing their exposure to strong sunlight, are partly responsible for an increase in malignant skin cancers. In order to minimize the risk of contracting skin cancer, cover exposed skin with clothing or with a suitable sunscreen, wear a hat, and wear UV-certified sunglasses to protect the eyes.

**CARBON MONOXIDE IN THE ATMOSPHERE**

Human activities cause nearly half of the world’s carbon monoxide pollution. It is produced by the deficient or incomplete combustion of gasoline and other fossil fuels such as used in automobiles, furnaces and industry, as well as by the burning of natural organic matter such as wood and grasses (from fireplaces to forest fires). Not only is carbon monoxide dangerous by itself, but it also produces ozone, a greenhouse gas that forms naturally in the upper atmosphere but is dangerous to humans.

According to NASA, Terra has allowed scientists to observe carbon monoxide in the atmosphere from two to three miles above the Earth’s surface where it forms ozone through interaction with other gases. Once the pollutant moves higher in the atmosphere, high winds can blow it rapidly across great distances. By tracking this movement, scientists can also track the movement of other pollutants that are also produced by combustion but are not easily detected from space.

Using the Data Such technology not only gives scientists details on the state of the Earth’s current condition, but the information it produces will help scientists, engineers, researchers, consumers and industry plan a course of action to correct the problems. People have known for years that the burning of fossil fuels and organic matter creates pollution, but technology such as the Terra satellite provides specific detail on what happens to that pollution. Contrary to many theories and common beliefs that air pollution simply dissipates in the atmosphere or is remedied by Earth’s natural processes, we have learned that these pollutants not only can remain in the atmosphere for very long periods of time, but they can reach anywhere in the world. The Antarctic is a very good example. This pristine, ice-covered continent is untouched by industry and dense human populations that are strong sources of pollution. Yet, traces of these pollutants can be found in Antarctica’s ice shelves and the seawaters that surround it.

Methane hydrates, found in large deposits underneath ocean floors, could meet the world’s energy needs for centuries, but mining them and their environmental impact are still questionable.

Armed with this information, scientists and engineers – supported by industry – are racing to develop alternative energy to the point where it can effectively and affordably replace the need for fossil fuels, and to find ways to burn fossil fuels more efficiently. Already, hybrid combustion cars – which operate primarily from an electric engine and is supported by a separate combustion engine when needed – have entered the mass market- place and are expected to develop firm roots among consumer over the next ten years. The hybrid automobile is seen as a bridge between today’s all-combustion engines and the non-combustion engines of the future. Solar energy is slowly becoming utilized as a feasible alternative form of energy, but has not yet been able to meet the extraordinary energy demands of industry. Water and wind have been tapped as energy sources throughout history, and they will continue to serve as important sources for part of the world’s energy needs.

The key challenges may not be pollution so much as the dwindling fossil fuel reserves that remain. With fossil fuels being consumed faster than they form, we can expect to deplete them before the end of this century.

Methane hydrates could solve the planet’s energy needs for centuries to come, but the impact they could have on the environment is poorly understood.

**THE PROJECT: REDUCE POLLUTION**

What are SО2, NOx, and CO2? How do they contribute to pollution?

CO2. Carbon dioxide is the principle "greenhouse gas" implicated in global warming. CO2 is released into the atmosphere as a result of burning fossil fuels such as coal, oil and natural gas. Coal is particularly dirty, producing about twice as much CO2 for the same amount of power as natural gas. CO2 is also generated in smaller amounts by forest clearing and cement production.

NOx. Nitrogen oxides cause smog, irritate the lungs and lower resistance to respiratory infections such as influenza. Smog is formed when nitrogen oxides, which are emitted by burning fossil fuels at electric power plants and in automobiles, mix with other chemicals in the air, sunlight, and heat. The two largest sources of smog-forming pollution are motor vehicles (30 %) and power plants (26 %).

The effects of short-term exposure to nitrogen oxides are still unclear, but continued or frequent exposure to concentrations higher than normal may cause increased incidence of acute respiratory disease in children.

Nitrogen oxides are an important precursor to both ozone and acidic acid rain and can affect both land and water ecosystems.

SO2. Sulfur dioxide comes from the combustion of fuel containing sulfur, mostly coal and oil. It is also produced during metal smelting and other industrial processes. The major health concerns associated with exposure to high concentrations of SO2 include effects on breathing, respiratory illness, alterations in the lung’s defenses, and aggravation of existing cardiovascular disease. While everybody is adversely impacted by SO2 to some degree, people that are particularly at risk include asthmatics and individuals with cardiovascular disease or chronic lung disease, as well as children and the elderly.

**WHAT IS GLOBAL WARMING AND WHY ARE GREENHOUSE GAS EMISSIONS RAISING THE EARTH’S TEMPERATURE?**

Increases in concentrations of carbon dioxide and other pollutants contribute to global warming, which is predicted to raise average temperatures, alter precipitation patterns, and raise sea levels. These changes may negatively impact our quality of life, including increases in infectious diseases, respiratory illness, and weather-related deaths. Global warming may also decrease crop yields, water quality, and regional forest health and productivity. Atmospheric concentrations of CO2 have been increasing at a rate of about 0.5 % per year and are now about 30 % above pre-industrial levels.

**HOW DOES SO2 CREATE ACID RAIN?**

Scientists have confirmed that sulfur dioxide (SO2) and nitrogen oxides (NOx) are the primary causes of acid rain. Acid rain occurs when these gases react in the atmosphere with water, oxygen, and other chemicals to form various acidic compounds. Sunlight increases the rate of most of these reactions. The result is a mild solution of sulfuric acid and nitric acid.

**WHAT IS THE ELPC?**

The Environmental Law and Policy Center (ELPC) is the Midwest’s leading public interest environmental legal advocacy and eco-business innovation organization. We develop and lead successful strategic environmental advocacy campaigns to protect our natural resources and improve environmental quality. We are public interest environmental entrepreneurs who engage in creative business deal making with diverse interests to put into practice our belief that environmental progress and economic development can be achieved together. ELPC’s multidisciplinary staff of experienced public interests attorneys, environmental business specialists, and policy advocates and communications specialists brings a strong and effective combination of skills to solve environmental problems. ELPC promotes development of clean energy efficiency and renewable energy resources to reduce pollution from coal and nuclear plants, advocates high-speed rail and smart growth planning solutions to combat sprawl, and implements sound environmental management practices to preserve natural resources and improve the quality of life in our communities. Our vision embraces both smart, persuasive advocacy and sustainable development principles to win the most important environmental cases and issues in the Midwest.

**AS THE EARTH WARMS: THE THINNING OF THE ARCTIC ICE CAP**

The geographic North Pole was last covered with water about 50 million years ago, during the early part of the present Cenozoic Era. Known as the age of Mammalsо and the recent Life Era, this modern age, which saw the dawn of human beings began 65 million years ago.

This global view of the Arctic Ocean, captured using advanced radar that sees through all weather conditions, is enabling researchers to determine how global warming may be affecting the Polar Ice Cap. The Arctic sea ice is providing clues to the Earth’s overall climatic condition.

During the Cenozoic Era, the continents that formed Pangea, the super continent, had begun to move into their present positions. As these continents drifted northward, they formed the shoreline of the Arctic Ocean, which lies directly over and around the geographic North Pole.

About 15 million years into the Cenozoic Era (about 50 million years ago), the Arctic Ice Cap formed over the Arctic Ocean, virtually covering the entire sea with a sheet of ice. As the continents continued to move, climatic changes brought about by shifts in water and air currents caused the Earth to gradually cool down. This created the glaciers that mostly dominated the land masses through the end of the Great Ice Age in the Pleistocene Epoch, about 10,000 to 1.8 million years ago, and that still exist today on Greenland.

The same climatic conditions that created the glaciers, which are essentially great ice sheets formed on land, also formed the Arctic Ice Cap. Yet the ice sheet covering the Arctic Ocean rests directly on top of the ocean instead of land, and it has remained relatively stable and frozen since it was formed...

The Arctic Ice Cap is shrinking dramatically. Roughly the size of the United States, it has lost an area roughly the combined size of Massachusetts and Connecticut each year since the late 1970s. Since the 1950s, when data was first collected on the Arctic, the ice cap has lost nearly 22 % of its volume. It is projected that in another 50 years, nearly half of the Arctic Ice Cap will be gone.

So what is going on? We know that the Arctic Ice Cap, frozen for 50 million years, is melting. We also know that above normal Arctic temperatures from the ocean water to the air currents account for the melting. Global warming is real, and the melting of the Arctic Ice Cap is one of its symptoms.

Scientists have determined that the Earth’s surface temperature has increased an average of 1 °F since the beginning of the 20th century, which is enough to trigger significant global climatic changes. According to the United States Environmental Protection Agency (EPA), the 20th century was the warmest century of the last millennium, and the 1990s was the warmest decade. Increased average temperatures have been recorded in both the southern and northern hemispheres, although some regions have recorded cooler temperatures.

Using the best available data, many scientists believe this warming trend will cause an additional 5 – 10 °F increase in the average global temperature in the next century. Still, there are many scientists who believe the global warming trend may reverse itself within the next century. The fact is, there is not enough known about WHY the climate is changing the way it is for scientists to determine what really is going on or what will happen in the future.

But there is enough information to tell us several things.

1. Human activity, such as the burning of fossil fuels, is releasing enormous volumes of carbon dioxide and other greenhouse gases that are contributing to the Earth’s natural greenhouse effect, the Earth’s natural process of trapping the sun’s warmth. About 5 – 6 billion tons of carbon dioxide are emitted each year due to human activity. This increase results in additional heat being trapped within the Earth’s atmosphere.

2. The Polar Ice Cap itself reflects sunlight energy (heat) back into space, rather than the heat being absorbed by the Earth. This is called albedo, the amount of sunlight reflected by an object. As the Ice Cap melts however, the albedo is reduced and the Earth absorbs the energy that is not reflected. Thus, more heat is retained in the Arctic.

3. The Earth’s natural carbon cycling process the amount of carbon dioxide that enters and leaves the atmosphere as a result of the natural cycle of water exchange from and back into the sea and plants account for about 95 % of the carbon dioxide in the atmosphere which contributes to the greenhouse effect.

4. Ocean waters constantly move along a giant oceanic conveyer belt, which travels, from the North Atlantic to the Atlantic, Pacific and Indian Oceans. This circulation distributes warm tropical waters northward, which are then chilled and returned to the warmer southern oceans. This heat exchange also has a significant impact on global weather patterns.

Ocean waters are constantly on the move, carrying warmer waters north toward the Arctic and cooler waters south to the temperate and tropical zones. This ocean circulation is referred to as the great oceanic conveyer belt, which is a single continuous current that carries chilled water from the North Atlantic into the Atlantic, Indian and Pacific basins. The conveyer belt returns water warmed in the tropics back to the North Atlantic.

Ocean currents also affect global heat exchange by redistributing heat, especially in coastal regions. In fact, the oceans have the greatest impact on the Earth’s climate.

**PUTTING IT ALL TOGETHER**

The point is that while all of these things are taking place at the same time none of them exists in a vacuum. They are all interrelated and can have a reciprocating effect on each other. To what extent, scientists do not know at this point.

The climatic changes that are taking place can have profound impacts on the Earth’s ecosystems, human health, plant and animal species. Scientists fear that continued melting of sea ice could weaken the North Atlantic Current, the northward continuation of the Gulf Stream. The Gulf Stream transports 25 times more water than all the Earth’s rivers, and a diversion could result in extremely cold winters in the North Atlantic regions, especially in northern Europe.

There are many-fold scenarios; however, human-induced global warming is one that we should pay close attention to because we can control it. If we can reduce carbon-dioxide emissions, it could have a penetrating effect on the natural climatic occurrences that have been affected by human activity. Scientists project that the amount of carbon dioxide released into the atmosphere in the next 30 years will double or triple. The number of cars in operation around the world will double by the year 2030.

**ARCTIC ICE DELUGE**

One concern that most people have with regard to the melting of the Arctic Ice Cap is the eventual flooding of the landmasses. What is commonly misunderstood is that the Arctic Ice Cap is relatively thin, about 10 feet thick on average.

And about 90 % of that is already displacing the water (taking up space that would otherwise be occupied by water). Thus, even a complete melting of the Arctic Ice Cap would only result in a small increase in sea water level.

Antarctica is a continental landmass 98 % covered by thick ice sheets. It contains 70 % of Earth’s fresh water and 90 % of Earth’s ice. The average ice thickness is 1.5 miles, reaching 3 miles deep in some regions.

The major concern, however, would be the increase of fresh, cold water into the marine environment. This would alter ecosystems and the food chain dependent on the saline waters would funnel more cold water into the oceanic conveyer belt. As a result, you would see a global climate change due to the introduction of the additional cold water into the southern oceans, and you would see a displacement of plant and animals species dependent on the more saline ecosystems. Some animal species will, of course, retreat to the land-based ecosystems.

**TRACKING AIR POLLUTION FROM SPACE**

NASA’s Terra spacecraft is providing scientists the most complete view of global pollution. Terra sees C in the atmosphere from 2 – 3 miles above the surface, where it interacts with other gases and forms ozone.

NASA’s Terra Spacecraft has assembled the first ever-complete view of the world’s air pollution as it treks around the globe. Terra’s new global air pollution monitor, contributed by the Canadian Space Agency, allows scientists to identify the major sources of air pollution and see what happens to it anywhere on the planet.

Terra is one of the United State’s major Earth-observing satellite systems (EOS), designed for the accumulation of data needed to predict future changes in the global environment.

It takes pictures with digital cameras, about 435 miles (700 km) above the Earth, basically to catch reflected sunlight and released heat on or from the Earth, rather than scanning the global surface by microwaves.

Unlike other satellites, Terra travels in a North-South polar orbit.

Through Terra, which launched in December 1999, air pollution is clearly identified as a global problem, with pollution from sources in one region having a dramatic impact on others. Among the greatest impacts observed so far there is the transcontinental drift of an immense carbon monoxide plume from a source in South-east Asia across the Pacific to North America. The pollution reaches North America in fairly high concentrations. In the winter, a major source of pollution captured by Terra is the burning of fossil fuels for mass transportation and business and residential heating in the northern regions of the planet, which is observed traversing a majority of the hemisphere.

**A NEW LOOK AT HUMAN EXTINCTION**

The very powerful technologies of the new Millennium – from robotics, genetic engineering and nanotechnologies – "are threatening to make humans an endangered species," according to the April 2000 issue of

"Wired Magazine" ("Why the Future Doesn’t Need Us") in an article by Billy Joy, co-founder and chief scientist of Sun Microsystems. As man’s dependence on technology continues to substantially increase, so does his progress in developing intelligent machines that can and will do all things better than humans can do them-selves. In a way, it is the technological version of Charles Darwin’s "survival of the fitted." If technological evolution reaches the point where sophisticated systems of machines can function on a cognitive level, and make decisions and perform tasks without the need for any human intervention whatsoever, then, as Mr. Joy points out, the human race would be at the mercy of machines.

So, why doesn’t the future need us? Mr. Joy covers this possibility in extraordinary thought which considers a simple theme in our efforts to improve the quality of our lives, we – humans – strive to make things that can do things better than we can ourselves. In so doing, we create things that replace what humans once did exclusively. Just consider such simple creations as the calculator, remote control devices, personal computers and microwave ovens.

Yet, the 21st century will provide such compelling technologies as genetic engineering and nanotechnologies (work at the atomic, as opposed to the molecular level) that have the potential to threaten any human involvement whatsoever – far more than the simpler technologies of yore. According to Joy, "Specifically, robots, engineered organisms, and nanobots (robots on the atomic level) share a dangerous amplifying factor: they can self-replicate. A bomb is blown up only once – but one can become many, and quickly get out of control." And the risk of this would be substantial damage to the physical world, the environment on which humans and all of

Earth’s other organic co-inhabitants depend.

The promises of these new technologies are equally powerful: virtual immortality, providing treatments and cures for almost every disease, and solutions and advances that could expand the human life span indefinitely and improve the quality of our lives – particularly the environment. All the while, Joy says, "with each of these technologies, a sequence of small, individually sensible advances leads to an accumulation of great power, and, concomitantly [coupled with], real danger."

Simply getting rid of machines would be suicide, Joy points out. So perhaps an equally viable option is that human progress be tempered with the care of ensuring that human involvement remains essential to that progress, thereby ensuring that human needs are maintained and the quality of life improved. While it’s true that machines and other products of our technologies have no consciousness, it does not mean that they will not some day have the cognitive qualities to perform tasks as humans do. Today, that is called science fiction.

But as we have learned from our science fiction literature of the past, such things are based on real possibilities, many of which we have already witnessed in our lifetime, such as space travel, visiting other planets, the creation of the atomic bomb, nuclear power and machines that will talk to you. Perhaps English author H.G.

Wells, considered by many to be the father of modern science fiction, could foresee such human decline "at a time when civilization passes it zenith," when he authored his first literary work, "The Time Machine" in 1895.

In speaking of the result of human progress witnessed far into the future by the Time Traveler, he wrote: "The great triumph of Humanity I had dreamed of took a different shape in my mind. It had been no such triumph of moral education and general co-operation as I had imagined. Instead, I saw a real aristocracy, armed with a perfected science and working to a logical conclusion the industrial system of today. Its triumph had not been simply a truth over Nature, but a triumph over Nature and the fellow man."