GLOBAL WARMING

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Environment Now
August 2001

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THE PROBLEM

Since the Industrial Revolution, human activities have begun to alter the natural balance of many gases in the earth's atmosphere. These "greenhouse gases" are accumulating to unnatural levels, trapping warmth near the earth's surface. As a result, the average global temperature is slowly rising.

Background: The Greenhouse Effect

One of planet earth's unique characteristics is a warm average temperature of 57° F[1] that enables it to support the flourishing life that exists today. A phenomenon known as the greenhouse effect is responsible for maintaining this comfortable temperature. Unfortunately, human activities over the last century have disrupted the earth's natural balance by enhancing the greenhouse effect and initiating a frightening trend of global warming.

Under normal conditions, a delicate balance exists between incoming energy from the sun (solar radiation) and outgoing energy from the earth in the form of reflected light and heat (infrared radiation).[2] Some heat is naturally trapped inside the atmosphere by naturally occurring "greenhouse gases" such as carbon dioxide, water vapor, nitrous oxide, methane, and ozone.[3] This natural heat-trapping process is known as the "greenhouse effect," and is essential for maintaining the warm temperatures that support life on this planet. Without it, the earth's temperature would be about 0° F- too cold for most life forms.[4]

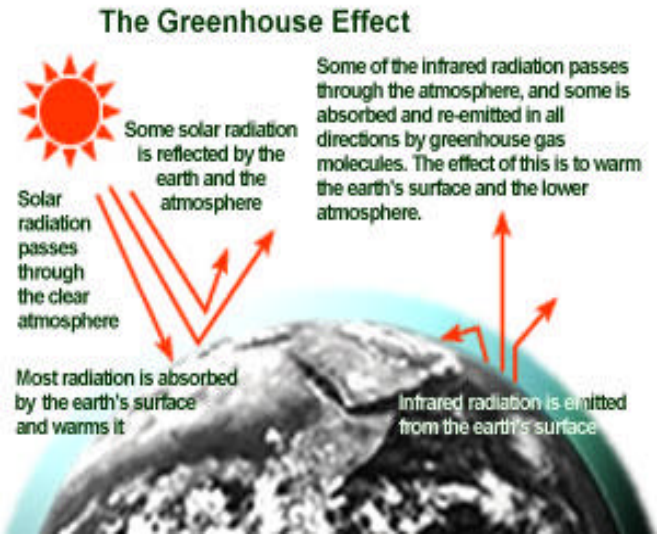


Illustration from the Environmental Protection Agency's Global Warming Website:
http://www.epa.gov/globalwarming/climate/index.html

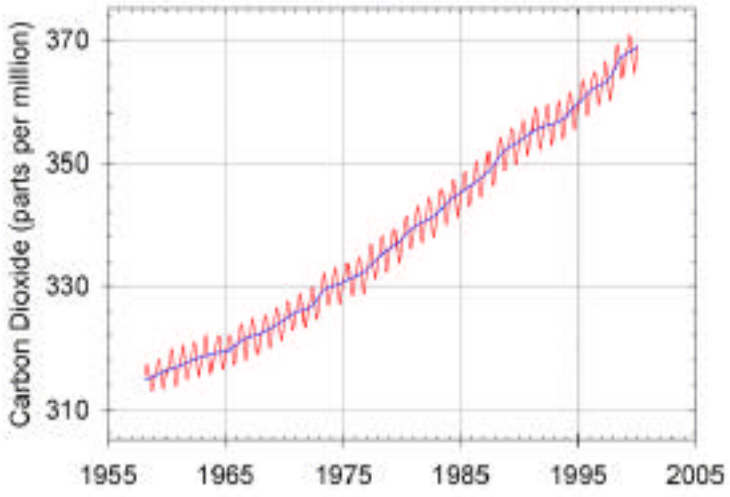
As mentioned above, most greenhouse gases (carbon dioxide, water vapor, nitrous oxide, methane, and ozone) are naturally occurring in certain amounts. Normally these gases are roughly balanced in global cycles; [5] atmospheric gases are emitted by sources

such as wetlands or decomposing biomass and absorbed by "sinks" such as forests and oceans. Over the last century, however, human activities have added abnormal amounts of these greenhouse gases into the atmosphere- far more than the earth's sinks are capable of absorbing. As atmospheric concentrations of these gases increase, the natural equilibrium is disrupted and the greenhouse effect is enhanced. The result is global warming, a gradual increase in the earth's overall average temperature.

Increasing Greenhouse Gases

Human activities have begun to alter global climate not only by increasing atmospheric concentrations of naturally occurring greenhouse gases, but also by creating artificial greenhouse gases through many industrial processes. This section examines each of the major greenhouse gases and discusses how human activities have contributed to their rising levels. (Note: Global Warming Potential, or GWP, is a value used to express the relative potency of each greenhouse gas. Because carbon dioxide has a GWP of 1, the strength of all other gases is measured in relation to it. For example, a GWP of 20 means that a gas is 20 times more effective than carbon dioxide at trapping heat in the atmosphere.)

Carbon dioxide (CO_2): Carbon dioxide, a naturally occurring gas, is released when fossil fuels, solid waste, and wood/wood products are burned.[6] It is the most abundant and therefore the most dangerous of the greenhouse gases, contributing 76% of the total predicted increase in the greenhouse effect.[7] Atmospheric concentrations of CO_2 have increased by 30% since the beginning of the Industrial Revolution,[8] and are continuing to rise steadily (as illustrated by the graph below).



Graph of Carbon Dioxide Record from the Hawaiian Mauna Loa Observatory from NOAA's Climate Monitoring and Diagnostics Laboratory web site: http://www.cmdl.noaa.gov/info/testimony.html

Burning fossil fuels (coal, oil, and natural gas) for energy production, transportation, and other industrial and residential uses is by far the greatest source of global CO_2 emissions. It is responsible for roughly 75% of worldwide anthropogenic CO_2

emissions during the past 20 years,[9] and contributes 98% of all CO_2 emissions in the United States.[10] (Incidentally, fossil fuel combustion also contributes 24% of all methane emissions and 18% of nitrous oxide emissions.[11]) Deforestation (logging, clearing and burning) is another major source, contributing approximately 25% of worldwide carbon dioxide emissions.[12] Other activities that emit less significant amounts of carbon dioxide include cement manufacture, lime manufacture, natural gas flaring, limestone and dolomite use, waste combustion, and biomass combustion.[13]

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In regards to atmospheric CO_2 levels, the damage inflicted by deforestation is twofold. Not only does the logging, clearing, and burning of trees release high levels of this greenhouse gas (as mentioned above), but it also reduces the area of forest that can serve as a natural carbon dioxide sink. The world's forests serve as the "lungs" of our planet, as trees and other plants absorb CO_2 and release oxygen during photosynthesis. The storage of carbon by biomass is referred to as "carbon sequestration." Unfortunately, deforestation has decreased the total worldwide forest cover by 20 to 50 percent since pre-agricultural times,[14] greatly reducing the earth's ability to absorb and store this harmful greenhouse gas.

Methane (CH_4): Methane, also a naturally occurring gas, is considered to be the second most dangerous greenhouse gas. Although methane emissions are much lower than CO_2 emissions, methane has a GWP of 21 (it is 21 times more powerful than CO_2 as a greenhouse gas) and has a longer lifetime of 12.2 years.[15] Atmospheric concentrations of CH_4 have more than doubled since the Industrial Revolution.[16]

Methane is released through a variety of human activities: landfill decomposition, agriculture (ruminant animal digestion, manure management, and rice cultivation), natural gas and petroleum systems (production, processing, transmission, and distribution), coal mining,[17] biomass burning and wastewater treatment.[18] These anthropogenic sources account for approximately 70% of global methane emissions, while the remaining 30% is released by natural sources: wetlands, gas hydrates and permafrost, termites, oceans, freshwater bodies, non-wetland soils, and other sources such as wildfires.[19]

Nitrous oxide (N_2O): Nitrous oxide is a naturally occurring gas that is released through both natural and anthropogenic processes. Nitrous oxide is considered a major greenhouse gas not because of its quantity but because of its power; it has a GWP of 310 and has a lifetime of 120 years.[20] During the past two centuries, atmospheric concentrations of nitrous oxide have increased by 13%.[21]

N_2O is released through a variety of activities. The largest contributor is agricultural soils, where microbial processes, application of fertilizers, nitrogen-fixing crops and other factors emitted 70% of U.S. N_2O emissions in 1998.[22] Other sources include fossil fuel combustion, acid production, manure management, human sewage, and

waste combustion.[23] Natural sources of nitrous oxide include a wide variety of biological sources in water and soils.[24]

Chlorofluorocarbons (CFC's): Chlorofluorocarbons are human-made chemicals that were created for use in refrigeration, solvents, foam packaging and aerosol propellants.[25] Although their levels in the atmosphere are relatively low, they are extremely powerful greenhouse gases: 12,000 times more powerful than CO_2.[26] CFC's not only contribute to the greenhouse effect, they are also responsible for ozone depletion. Due to their damaging effects on the ozone layer, CFC's were banned by 31 nations in the 1987 Montreal Protocol.[27] Unfortunately they will continue to act as major greenhouse gases well into the future as their residence time in the atmosphere is 75 to 100 years.[28]

Other gases- Hydrofluorocarbons (HFC's), Perfluorocarbons (PFC's), and Sulfur Hexafluoride (SF_6): These human-created gases are currently found in small concentrations, however they are on the rise and they are especially dangerous because they are extremely potent and have long residence times in the atmosphere.[29] HFC's were created as replacements for CFC's, and are increasing rapidly since the Montreal Protocol banned CFC's in 1987.[30] There are many different types of Hydrofluorocarbons, with atmospheric lifetimes of up to 264 years[31] and GWP's between 140 and 11,700.[32] PFC's are also used as replacements for CFC's as well as in the semiconductor manufacturing industry.[33] PFC's have GWP's between 6500 and 9200,[34] and an atmospheric lifetime of up to 50,000 years.[35] SF_6 is used as an insulator in electrical equipment,[36] and is extremely potent with a GWP of 23,900 and long lifetime of 3200 years.[37]

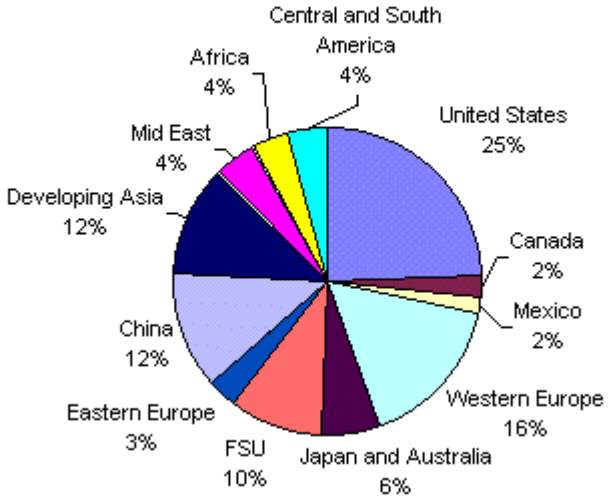
Summary Table of Major Greenhouse Gases

Greenhouse Gas	GWP	Lifetime (years)
Carbon Dioxide (CO_2)	1	120[38]
Methane (CH_4)	21	12.2
Nitrous Oxide (N_2O)	310	120
Chlorofluorocarbons (CFC)	12,000	75-100
Hydrofluorocarbons (HFC)	140-11,700	264
Perfluorocarbons (PFC)	6500-9200	50,000
Sulfur Hexafluoride (SF_6)	23,900	3200

** For more information, please see the following sites:*

- *U.S. Greenhouse Gas Emissions: http://www.eia.doe.gov/oiaf/1605/ggrpt/index.html*
- *U.S. Greenhouse Gas Inventories: http://www.epa.gov/globalwarming/publications/emissions/*

The composition of our atmosphere is now very different than it was 250, or even 100 years ago. As populations grow and developing nations become more industrialized, humans are emitting more and more greenhouse gases (particularly CO_2) every year. The



following chart shows carbon dioxide emissions of various countries and regions throughout the world.

Illustration from the Environmental Protection Agency's Global Warming Website, http://www.epa.gov/globalwarming/emissions/international/inventories.html

As evidenced by the chart, the United States emits more carbon dioxide than any other country. In fact, with less than 5% of the world population, the U.S. also accounts for about 25% of total global greenhouse gas emissions.[39] Total greenhouse gas emissions for selected countries in the 1990's were as follows:

Total Greenhouse Gas Emissions, Excluding Land-Use Change and Forestry (Measured in Million Metric Tons of CO_2 Equivalent)

Country	1990	1992	1994	1996	1998	% Change
US	5984.4	6032.4	6281.7	6357.6	6727.0	11.2
Germany	1208.8	1103.6	1065.6	1077.1	1019.7	-15.6
Canada	611.8	620.5	643.7	676.6	692.2	13.2
UK	741.5	718.7	694.7	705.7	679.9	-8.3
France	553.8	561.3	532.5	551.4	558.7	0.9
Australia	424.3	424.3	428.4	452.9	448.7	14.5
Greece	105.3	106.7	109.7	114.7	124.3	18.0
Sweden	69.4	65.7	67.7	77.0	73.8	6.4

Norway	52.1	48.2	52.4	55.3	56.1	7.7
Latvia	35.7	25.5	19.2	18.1	11.5	-67.7

Chart modified from Environmental Protection Agency's Website:
http://www.epa.gov/globalwarming/emissions/international/inventories.html

These illustrations clearly show that the United States is responsible for the lion's share of global greenhouse gas emissions. Additional statistics regarding greenhouse gas emissions on both a national and worldwide scale include:

- In the United States, each person emits 6.6 tons of greenhouse gases per year,[40] compared to a global average of only 1 ton per person.[41]
- If U.S. automobiles alone made up a single country, it would be the world's fifth largest global warming polluter (surpassed only by the U.S. itself, China, Russia, and Japan).[42]
- The average annual increase in U.S. greenhouse gas emissions is 1.1%,[43] but the nation's CO_2 emissions jumped 3% in 2000.[44]
- Worldwide, atmospheric greenhouse gases have increased from about 280 ppmv (parts per million by volume) in pre-industrial times to about 370 ppmv, an increase of over 30%.[45]
- Worldwide pollution releases 60 million tons of CO_2 daily.[46]
- The number of cars on earth is expected to double by 2030.[47]

Rising Temperatures

As a result of rising greenhouse gas levels, the earth's temperature is slowly rising. Since 1880, the global average temperature has risen somewhere between .5 and 1°F.[48] More importantly, the 10 hottest years of the 20th century occurred in the last 15 years, and 1998 was the hottest year on record.[49]

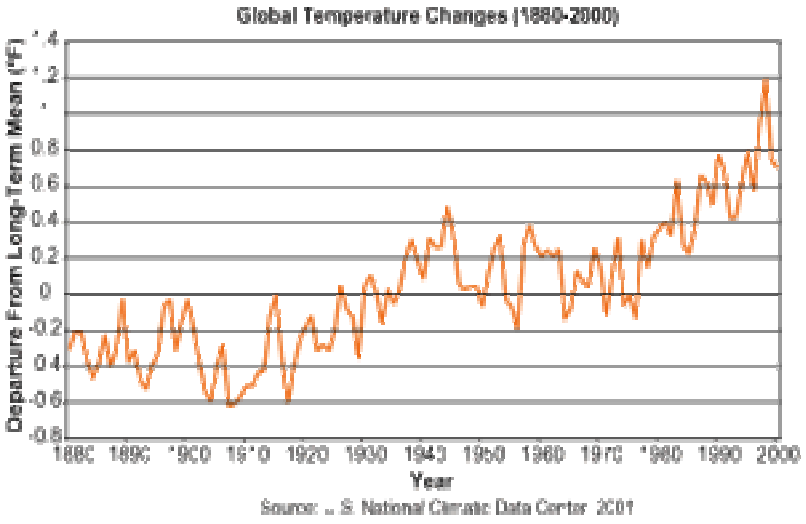


Illustration from the Environmental Protection Agency's Global Warming Website:
http://www.epa.gov/globalwarming/climate/index.html

Because global warming is determined by a global average, it has not occurred evenly throughout the world: some areas have actually cooled while parts of North America and Eurasia have experienced the most warming.[50] Although this overall warming has not yet caused many serious problems, it has already begun to manifest itself in various ways. The current and future impacts of global warming are discussed in the next section.

The actual extent of global warming will depend greatly on the future of greenhouse gas emissions, particularly emissions of carbon dioxide.[51] According to projections by the Intergovernmental Panel on Climate Change (IPCC), the following changes are likely in the next century:[52]

- Atmospheric CO_2 levels will increase 2 to 7 times as much as they increased in the last century.
- Methane concentrations will double.
- Nitrous oxide will increase 3 to 4 times as much as it increased in the last century.

Scientists predict that if current warming trends continue, average global temperatures will rise 1° to 4.5°F (.6° to 2.5° C) in the next 50 years, and 2.5° to10.4°F (1.4° to 5.8° C) by the year 2100.[53] The following graph shows three possible scenarios for future increases in temperature, compared to historic temperature ranges.

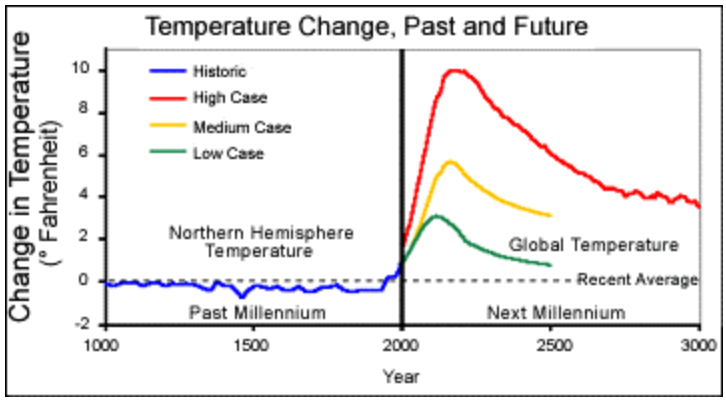


Illustration from Environmental Defense Website:
http://www.environmentaldefense.org/programs/GRAP/y3k/

At first glance, these small numbers may seem insignificant. However it is important to realize that these are global averages, and that a seemingly small increase can cause widespread climatic changes with tremendous consequences. This is best illustrated by the fact that the difference in global average temperature between the last ice age and the present day is only about 9°F.[54] Predictions from various sources demonstrate how small changes in global temperature can cause drastic changes in the human and natural world. For example, a change of only 3°F may nearly double the number of heat-related

deaths in Los Angeles.[55] And an increase of 3°C, if sustained for a millennium, would completely melt the Greenland ice sheet and cause a 7-meter rise in sea level.[56]

Clearly these predictions are reason for great alarm; if current trends are not reversed, the consequences could be catastrophic for the entire planet.

** For more information, see the following sites:*

- *IPCC Third Assessment Report: The Scientific Basis: http://www.ipcc.ch/pub/spm22-01.pdf*
- *EPA- Future Climate: http://www.epa.gov/globalwarming/climate/future/index.html*
- *EPA- International Emissions Inventories: http://www.epa.gov/globalwarming/emissions/international/inventories.html*
- *National Academy Of Sciences- Climate Change Science: http://books.nap.edu/html/climatechange/*

IMPACTS

Already planet earth is beginning to see the signs of a warming climate. These indicators, along with computer models, have enabled experts to make forecasts about the most likely future impacts of global warming. Although these predictions are made using the best available science, many uncertainties remain about the ultimate changes the earth and its inhabitants will face.

Current Indicators

In recent years, the symptoms of global climate change have become increasingly apparent. Some of the ways in which global warming has already begun to directly affect the planet include:[57]

- Heat waves and unusually warm weather- Heat waves and record temperatures have become more frequent and more severe, mostly in North America.
- Sea level rise and coastal flooding- Global sea level has risen 4 to 10 inches over the past 100 years. This rate is about three times faster than the rate for the previous 3,000 years.[58]
- Glaciers melting- The majority of mountain glaciers are shrinking and many low-latitude glaciers are completely disappearing, mostly in Europe and Asia.
- Arctic and Antarctic warming- Permafrost is melting, sea ice is thinning, and weather conditions are changing. Research has shown Arctic ice thinning at a rate of 4 inches per year.[59]

In addition, the planet has begun to experience many "harbingers", or events that foreshadow the types of impacts likely to become more frequent and widespread with continued warming. These include:[60]

- Spreading disease- Mosquito-borne disease outbreaks are on the rise.
- Early spring arrival- Earlier thaw dates, earlier plant blooming, and earlier animal egg laying is occurring in many parts of the world.
- Plant and animal range shifts and population declines- Many species are already beginning to move to higher elevations and latitudes to escape warming temperatures.
- Coral reef bleaching- Coral in 32 countries has experienced dramatic bleaching in recent years.
- Downpours, heavy snowfall, and flooding- Precipitation has been increasing in many regions worldwide.
- Droughts and fires- The incidence and severity of droughts and fires has increased in many dry regions.

These recent events are helping scientists to predict the potential global impacts should global warming be allowed to continue.

** For more information, see Climate Hot Map: http://www.climatehotmap.org/*

Future Impacts

The natural world is extremely complex, as all living things and natural processes are somehow linked to one another. As John Muir once stated, "Tug on anything at all and you'll find it connected to everything else in the universe."[61] Consequently, it is very difficult to predict how the world will react to rising global temperatures; in some cases nature and humans may be able to adapt and in other cases the results may be catastrophic, causing reactions that could easily destroy entire ecosystems and/or human settlements.

It is important to note that most impacts will fall disparately among different regions, natural systems, and human populations. The first reason for this is simple: the physical impacts of global warming will vary depending on the geographic region. As summarized in the IPCC's 2001 Report, "Regional differences in baseline climate give rise to different exposures to climate stimuli across regions."[62] This is illustrated by several examples:

- Disproportionate warming has been occurring over mid- to high- latitude continents, and this trend is expected to continue. However, other regions are expected to cool.[63]
- Polar regions will experience serious and rapid changes, including reduction in sea-ice cover and degradation of permafrost.[64]
- Small islands and low-lying coastal areas will be the most impacted by sea level rise.[65]
- Some regions (such as central Asia, southern Africa, and Australia) are expected to experience decreased streamflow and groundwater recharge, while other areas (high latitudes and southeast Asia) will likely experience the opposite effect.[66]

The second reason for disparate impacts is that all types of human settlements have varying abilities to adapt to climate change, and therefore some populations are more vulnerable to it. In general, it is the less-developed regions that will suffer the most from global warming. This is summarized by the IPCC:

> "Most less-developed regions are especially vulnerable because a larger share of their economies are in climate-sensitive sectors and their adaptive capacity is low due to low levels of human, financial, and natural resources, as well as limited institutional and technological capability."[67]

Conversely, developed regions such as North America or Europe have many characteristics that will enable them to better adapt to climate change: diversified economies, strong public health infrastructure, disaster relief programs, etc. As a result, these human populations will be less vulnerable to climate change than those in less-developed regions.

Lastly, some of the worst impacts may fall disproportionately on the natural world because of limited adaptive capacity.[68] According to the IPCC, natural systems

that are most at risk include glaciers, coral reefs and atolls, mangroves, boreal and tropical forests, polar and alpine ecosystems, prairie wetlands, and remnant native grasslands.[69] These and other ecosystems have little or no ability to adapt adequately or rapidly enough to survive major changes in climate.

Although it is impossible to determine exactly how the earth and its inhabitants will be affected by global warming, extensive scientific studies and models have helped experts to predict its most likely impacts. The following paragraphs summarize the most widely accepted theories on the potential impacts of future climate change, and discuss how these impacts will affect both humans and the environment.

Higher Temperatures, Severe Heat Waves and Droughts: Scientific models predict that nearly all regions of the world will experience higher overall temperatures as a result of global warming. More specifically, this means higher minimum and maximum temperatures, more hot days, and fewer cold days and frost days.[70] Consequently, extreme heat events such as heat waves and droughts are expected to occur more frequently, particularly over most mid-latitude continental interiors.[71] As mentioned earlier, temperatures are expected to rise anywhere from 2.5° to 10.4° F by the year 2100, and are expected to reach their highest levels between 2110 and 2160.[72]

Environment: Higher temperatures are likely to cause the conversion of many habitat types that are unable to adapt or shift to a new location. For example, desertification will become more widespread (particularly in Africa and Asia) causing loss of rangelands and other habitats as soils and vegetation become dessicated.[73] Wetlands will also be affected; non-tidal wetlands may dry up as water tables drop and tidal wetlands will become more saline.[74] Heat waves and droughts may cause death in many species that are unable to withstand high temperatures or are unable to find adequate water or food sources.

Freshwater aquatic ecosystems are expected to suffer many adverse impacts from warmer temperatures and lower water levels. As droughts occur, pollution in rivers, streams and lakes will worsen as water levels drop and pollutants become more concentrated.[75] In addition, warmer temperatures decrease the solubility of oxygen in water; if dissolved oxygen levels are not adequate, fish may suffocate. One study estimated that in most Southeastern U.S. rivers, warmer tempertaures will push dissolved oxygen levels below the level necessary to support most fish.[76]

Humans: Many aspects of human lives may be affected by warmer temperatures, heat waves, and droughts. Most directly, extremely hot weather will cause an increase in heat-related mortality and illness, particularly among the elderly, sick, and those without access to air conditioning.[77] For example, studies estimate that in Atlanta, even a warming of only 2°F would increase the number of heat-related deaths from 78 to anywhere between 96 and 247 per year.[78]

Air and water pollution may worsen as a result of higher temperatures and droughts. Droughts will threaten not only the quantity, but also the quality of drinking water supplies; lower water levels cause increased concentrations of pollutants, leading to

an increase in water-borne diseases and parasites.[79] In addition, air quality will be affected as higher temperatures increase the ground level concentration of ozone- a harmful pollutant that damages lung tissue and can cause chest pain, nausea, and pulmonary congestion in humans.[80]

Humans may also be impacted on many economic levels. Impacts will be the most severe in less-developed regions where many economies are not diversified and are highly dependent on climate-sensitive resource industries such as agriculture, forestry and fisheries.[81] Agriculture may suffer greatly as crops and livestock are damaged by severe heat and drought, particularly in tropical locations where many crops are already near their maximum temperature tolerance.[82] All sectors could be affected by water shortages and/or higher prices as water supplies become less dependable. Similarly, energy prices may soar and blackouts may occur as energy demand rises for cooling needs.[83]

Increased Precipitation, Severe Storms: While many regions are expected to experience droughts, models predict that northern mid- to high latitudes and Antarctica will likely see an overall increase in precipitation.[84] Furthermore, precipitation events are expected to become more variable and more extreme, with an increase in the intensity of severe storms such as tropical cyclones.[85] Severe storm events can cause major floods, landslides, and coastal surges that can damage both the natural environment and human settlements.

Environment: The direct impacts of floods and landslides on the environment are obvious: habitat will be destroyed and plants and animals will be killed. Floods can also severely degrade both fresh and salt water ecosystems by increasing runoff into lakes, streams, rivers, estuaries and oceans.[86] Pollutants such as trash, chemicals, nutrients, and sediments are washed from urban, agricultural, and other nearby areas into aquatic ecosystems, threatening the living species within them.

Humans: Intense storms can have devastating effects on human settlements as floods and landslides can destroy human lives and property. Coastal zones are particularly at risk as storm surges can cause severe coastal flooding, particularly when combined with the predicted sea level rise. Floods can also increase the risk of diarrhoeal and respiratory diseases, hunger, and malnutrition.[87] The extent of life and property losses will depend greatly on the particular region's adaptive capability, for example the ability to construct dams or other flood control measures.[88]

Drinking water supplies will also be threatened as increased precipitation and runoff adds higher pollutant and sediment loads to freshwater sources.[89] Furthermore, there is concern that waste facilities could overflow, threatening water supplies and human health.

Warming Seas, Melting Ice, and Sea Level Rise: As temperatures rise, polar sea ice, glaciers, and ice caps will continue melting. Warming oceans will also cause thermal expansion, and the combined result will be a worldwide rise in sea level. Over the last 1000 years, sea level has risen at the rate of approximately 1 inch per century. However, more recently this rate has increased to about 4-10 inches per century.[90] Globally averaged sea levels are expected to rise anywhere from 9 to 88cm by the year 2100,

according to the IPCC.[91] Other subsequent effects will probably include changes in salinity, wave conditions, and ocean circulation.[92] The following illustration shows the medium-case scenario for sea level rise as projected by Environmental Defense:

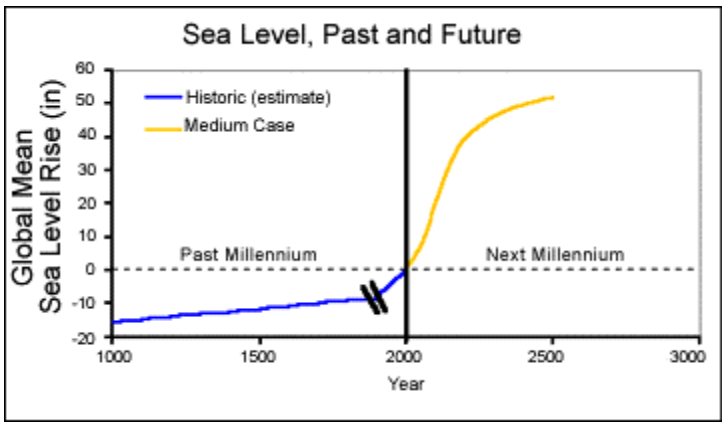


Illustration from Environmental Defense Website:
http://www.environmentaldefense.org/programs/GRAP/y3k/

Environment: As sea levels rise many low-lying coastal zones will be inundated with water resulting in the loss of valuable habitats, particularly coastal wetlands and mangroves.[93] Even those habitats that are not completely inundated will suffer; for example beaches may face severe erosion and estuaries will become more saline. Estuary-dependent species (particularly birds and fish) that rely on these areas for breeding, food, shelter, or migration will be threatened as their habitats are gradually degraded and destroyed. For example, populations of many finfish and shellfish are expected to suffer as approximately 50% of ocean fish are dependent on estuaries for some part of their lives.[94]

As a result of warmer temperatures underwater, coral reefs (considered to be one of the most diverse ecosystems on earth) will experience widespread coral bleaching.[95] Coral bleaching is caused when warm temperatures kill the algae that live in and feed the coral, resulting in a loss of color and eventual death.[96] This phenomenon has already been occurring throughout the world, and has been linked to temperature increases of only 2 or 3°F.[97]

Global ice melt, particularly at the poles, is already harming wildlife in a number of ways. Marine mammals, seabirds, and others that depend on food sources found at the ice edge are suffering food shortages.[98] Hunger in polar bears, as well as changing breeding and feeding patterns in penguins and seals, have all been linked to sea ice melt and other effects of global warming.[99]

Humans: The most obvious impact of rising sea levels is the loss of coastal land, as human lives and property are destroyed from flooding. Models from the IPCC estimate that a rise of 40cm by the 2080s would flood 75 to 200 million people per year.[100] Low-lying countries such as Bangladesh, Indonesia, Pakistan, Thailand, Gambia, Maldives, Mozambique, Senegal, Egypt, and Surinam are the most vulnerable to coastal

flooding.[101] Furthermore, higher sea levels will exacerbate the damage inflicted by extreme weather events in these regions such as hurricanes and tropical cyclones.[102] The extent to which human settlements will be affected will depend greatly on each region's financial and technological ability to mitigate the impacts.

Rising sea levels will also threaten drinking water supplies in coastal zones. Saltwater intrusion occurs when seawater is forced into coastal aquifers, contaminating the freshwater and rendering it useless for drinking, irrigation, and many other human uses.

The thawing ice itself may also directly impact humans in various ways. Arctic settlements may suffer loss of land as well as physical damage to buildings and transportation infrastructure as permafrost thaws and sea-ice melts or crumbles.[103] On the other hand, rapid glacial retreat poses very different threats. In some cases, rapid glacial melting forms glacial lakes that can burst and cause devastating floods; this occurred in Nepal in 1985 and is expected to repeat in the next five years.[104] Conversely, disappearing glaciers are threatening fresh water supplies in other regions such as Lima, Peru and northern India where large populations are dependent on glacier-fed rivers for their drinking and other water needs.[105]

Changing Plant and Animal Ranges: As temperatures change, plants and animals will be forced to migrate to higher latitudes and altitudes in order to continue living in their normal temperature ranges.

Environment: Forcing flora and fauna to relocate could have potentially devastating impacts for many reasons. First, some species (particularly plants) may lack the ability to move fast enough (or far enough) to escape the warming temperatures and may go extinct as a result.[106] Although this may not be difficult for plants whose seeds are spread by birds, it will be nearly impossible for those dependent on wind or other means for seed dispersal.[107] It is estimated that most American forest tree species would need to migrate 2 miles per year to survive if temperatures rise 3.6ºF in the next 100 years.[108] Second, even if plant and animal species are physically able to migrate quickly enough, there may not be adequate habitat space available for them at the new location due to human development or simple lack of space. For example, in the Arctic, cold-habitat animals such as muskox and caribou will be squeezed into smaller and smaller areas as they are forced to move poleward.[109] Lastly, changing plant and animal distribution will have many additional effects on wildlife such as habitat shifts, changing food sources, new migratory routes, altered mating habits, etc.[110] These changing ecosystem dynamics could be extremely straining for many species and would likely result in many extinctions.

A few species with tolerances for wide temperature ranges may actually flourish with higher temperatures. Unfortunately, many of these species are pest species such as mosquitoes (which spread disease) and spruce bark beetles (which destroy forests).[111]

Humans: As temperatures rise, food crops and/or livestock may no longer be suited for their current ranges and as a result, many regions (particularly in the tropics) may suffer food shortages or be forced to make major changes in agricultural production.

Adaptations may be difficult (particularly in poorer regions) but could include switching to different crop and/or livestock types or shifting growing seasons.[112]

As mosquitoes and other warm-climate insects expand their current ranges, vector-borne diseases such as malaria, encephalitis, yellow fever and dengue fever will become more widespread.[113] These diseases will have a greater impact in poorer regions with inadequate health care.

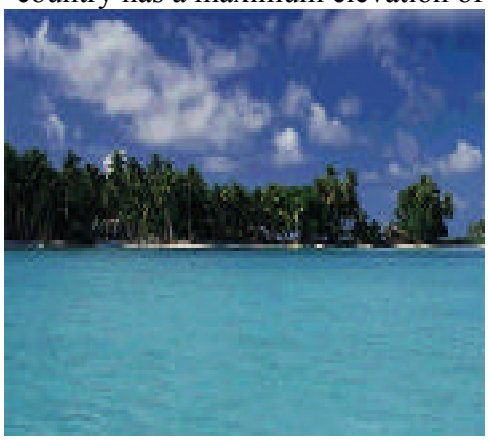
** For more information, see the following sites:*

- *IPCC Third Assessment Report: Impacts, Adaptation, and Vulnerability: http://www.ipcc.ch/pub/wg2SPMfinal.pdf*
- *EPA- Impacts: http://www.epa.gov/globalwarming/impacts/index.html*

Case Studies

Several regions of the world are already experiencing severe problems related to climate change. The following case studies demonstrate how global warming is already threatening land, lives, and historic cultures in three very different parts of the world.

Sea Level Rise in Tuvalu: Tuvalu is a small island nation in the South Pacific covering only 26 square miles of land, with a population of around 10,000 people. The country has a maximum elevation of 4.5 meters, but most of its land lies only 2 meters above sea level.[114] Rising sea levels have already begun to threaten this extremely vulnerable nation, earning it the title "the world's first victim of climate change"[115] despite the fact that it contributes virtually nothing to the problem of rising greenhouse gases.[116]



www.tcsp.com/destinations/tuvalu/gallery.shtml

Higher overall sea levels have contaminated soils, reducing agricultural production and forcing residents to grow crops in tin cans filled with compost.[117] Groundwater has become undrinkable due to seawater intrusion.[118] During storm surges and high tides, waves crash at the doorsteps of coastal homes and large areas of land are submerged.[119] Beaches are disappearing, and coastal roads and other infrastructure are being destroyed.[120] In February 2000, record high tides of 3.2 meters flooded the nation's only airport and cut telephone service for weeks. Furthermore, concern is growing that warming ocean temperatures will harm the marine life that sustains local communities and provides almost half of the revenue to the nation's budget.[121] Many of Tuvalu's residents have already been forced to move inland and even relocate to other countries.[122]

At the UNFCCC's Kyoto Conference in 1997 Tuvalu's previous Prime Minister Bikenibeu Paeniu pled to the international community to help protect Tuvalu and other

small island nations by taking serious measures to combat global climate change. In his speech, Paeniu described the damage caused by a series of storms:

> **"**It is almost unbearable. Not only were houses and whole villages damaged, but also vegetation and food crops were completely destroyed. In one recent incident an entire island community was left homeless and its vegetation damaged so much so that the island is uninhabitable right now. In another incident, one whole islet completely disappeared into thin air. Erosion to coastal areas of our already scarce land is further worsened, and the increased salinity in underground water is seriously affecting not only vegetation and traditional food crops but also the health and lives of the people."[123]

Scientists warn that eventually rising seas will submerge the entire nation. Tuvalu's current Prime Minister Ionatana Ionatana is appealing to its Pacific neighbors, Fiji, Australia and New Zealand, to provide sanctuary for its 10,000 residents.[124]

Melting sea ice in Shishmaref, Alaska: Shishmaref is a small Eskimo village of 600 residents built on a narrow barrier island off the Seward Peninsula in Alaska. Melting permafrost, receding glaciers, and unusually high wave and tide action are threatening the safety and livelihood of local residents.[125]

According to Gunter Weller, director of the Center for Global Change and Arctic System Research at the University of Alaska in Fairbanks, Alaska has recently undergone drastic changes that are severely affecting the physical environment. Over the last 30 years, the state's mean summer temperature has increased by 5° and mean winter temperature has increased by 10° degrees. Furthermore, the Arctic ice field has lost 10% of its thickness and has shrunk by 40% to 50% overall.[126]

In Shishmaref, three homes have tumbled into the sea and seven have had to be relocated; engineers estimate that the entire village could fall within the next few decades. Seawater is already threatening the local airport runway, which is the only way to transport wintertime food and supplies in from Anchorage. Historically villagers could hunt for ice-bound sea mammals such as walrus and seals, but unstable sea ice has rendered traditional methods extremely difficult and dangerous. Perhaps the greatest potential hazards are the fuel storage tanks and the town dump which are dangerously close to the encroaching seawater. The storage tanks, which hold 80,000 gallons of gasoline and stove oil, were recently located 300 feet from a seaside bluff. Now all that stands between the tanks and the ocean is 35 feet of fine sand.[127]

http://www.dced.state.ak.us/mra/Photos/Shishmar Photos.htm

The villagers may soon be forced to relocate to the outskirts of a large town, a fate which they claim would mean death to their historic culture. " We've been here since before Jesus," said Daniel Iyatunguk, the mayor of Shishmaref. "We know this area. We know where to hunt, we know where to pick berries, we know where to fish. We can't move to another town…The lifestyle of [the other town] is not for us."[128]

Sea Level Rise in the United States: Here in the United States the impacts of global warming are less apparent thus far, however they are certain to increase in frequency and severity as global temperatures continues to rise. Much concern surrounds the future of the country's coastal zones, as sea levels are rising faster in the US than anywhere else in the world.[129] Several studies indicate that along the Gulf and Atlantic coasts, a 1-foot rise in sea level is likely by 2050 and could occur as soon as 2025. In the next century, a 2-foot rise is most likely, but a 4-foot rise is possible.[130] And in Southern California, other studies estimate a 1-foot rise by the 2050's and a 1 to 3-foot rise by the 2090's.[131] Rising sea levels and the resulting changes in the coastal zones will undoubtedly affect large numbers of people: 53% of the U.S. population lives within 50 miles of the coast and the net coastal population increases by 3000 people per day.[132] Even more astounding is the concentration of California's population: 80% of the state's residents currently live within 30 miles of the coast.[133]

The potential impacts to coastal zones as a result of sea level rise are varied and uncertain. The most direct impacts will surely include severe beach and cliff erosion as well as the flooding of low-lying coastal land; it is estimated that a 2-foot rise in sea level will eliminate roughly 10,000 square miles of land nationwide.[134] This loss/erosion of land will most likely lead to the following indirect impacts:

- Loss or degradation of valuable coastal habitat due to inundation and/or increased salinity. A 2-foot rise in sea level could eliminate 17-43% of U.S. wetlands.[135]
- Destruction of human developments such as homes, resorts, harbors, and port cities.
  - Major port cities with low areas include Boston, New York, Charleston, Miami, and New Orleans. The average elevation of New Orleans is about 2 meters below sea level, and parts of Texas City, San Jose, and Long Beach, California are about one meter below sea level.[136]
  - Estimates of the cumulative impacts of a 50cm (about 1.64 feet) sea level rise by 2100 on coastal property range from about $20 billion to about $150 billion.[137]
  - Recreational resorts on the barrier islands of the Gulf and Atlantic coasts are often located less than 2 feet above the high water line, and are already flooded regularly.[138]
- Increase in flooding. The Federal Emergency Management Agency has estimated that a rise in sea level of one foot would greatly increase the size of U.S. floodplains and increase flood damages by 36-58 percent.[139]
- Severe decline in coastal-related tourism, which translates into loss of revenue and jobs:
  - The coastal recreation and tourism industry is the second largest employer in

the nation, serving 180 million Americans visiting the coasts every year.[140]

- In California, beach tourism spending contributes over $10 billion in direct benefits to the state and another $17 million in indirect benefits. Beach tourism jobs account for 3.5% of the state's total employment.[141]
- In Delaware, beach erosion results in an estimated loss of 471,282 visitor days per year.[142]

While many of these impacts can be mitigated through activities such as beach nourishment or armoring (building "hard" protective structures), these actions are expensive and may not be effective in combating the effects of rising sea levels.

**For more information, see the following sites:*

- *Union of Concerned Scientists- Climate Change in California: http://www.ucsusa.org/warming/*
- *Environmental Defense- Hot Prospects: http://www.environmentaldefense.org/HotLA/*
- *EPA- Coastal Zone Impacts: http://www.epa.gov/globalwarming/impacts/coastal/index.html*

Uncertainty

Although the majority of scientists and experts agree that global warming is indeed occurring, there is an enormous amount of uncertainty about exactly how it will affect the earth. Among the biggest questions are the rate, extent, and specific local impacts that will accompany global climate change.

As mentioned earlier, scientists know that the physical impacts of global warming will vary greatly depending on geographic region. Using models, experts are able to predict large-scale impacts over general regions, such as global temperature and precipitation change or average sea level rise.[143] Unfortunately, it is nearly impossible to predict more localized impacts such as local precipitation and temperature changes, changing soil conditions, or changing weather patterns.[144] In fact, for many regions, scientists cannot even determine whether the climate is expected to become wetter or drier.[145] This uncertainty is due to the inability of computer models to simulate small-scale effects of global climate change.[146]

Also mentioned earlier is the uncertainty regarding future greenhouse gas levels in the atmosphere. Although many computer models and forecasts have estimated future concentrations of these gases, the extent of warming will depend greatly on the actual increase that occurs.

One of the greatest questions facing experts is the potential role of feedback mechanisms: To what extent will positive and negative feedbacks enhance or neutralize the effects of global warming? Not until this question is answered will scientists be able to predict the rate and severity of future global warming. While many scientists believe that positive feedbacks will amplify the global warming effect by as much as 2.5 times, others believe that negative feedbacks may tend to neutralize the effect or even result in a net cooling.[147] Some examples of potential feedback mechanisms include:

- The "ice-albedo" positive feedback: As temperatures rise and ice caps melt, ice will be replaced with water and land. Because ice is very reflective, it produces a net cooling effect by reflecting solar radiation back into space. However land and water tend to absorb heat, causing a net increase in heat trapped near the earth's surface and enhancing global warming.[148]
- Increased cloud cover- negative feedback: Higher temperatures will cause increased evaporation from water bodies, creating more clouds that shade and cool the earth.[149]
- Increased water vapor- positive feedback: As mentioned above, higher temperatures will cause increased evaporation, adding more water vapor to the atmosphere. Water vapor is a greenhouse gas, and will therefore enhance the greenhouse effect.[150]
- Carbon sequestration in forests- negative feedback: Vegetation needs carbon dioxide to grow. Increased CO_2 may stimulate faster forest growth, which in turn will continue absorbing more and more CO_2 from the atmosphere, reducing this harmful greenhouse gas and possible resulting in a cooling effect.[151]

According to the National Academy of Sciences' Climate Change Science,

> "Reducing the wide range of uncertainty inherent in current model predictions of global climate change will require major advances in understanding and modeling of both (1) the factors that determine atmospheric concentrations of greenhouse gases and aerosols, and (2) the so-called 'feedbacks' that determine the sensitivity of the climate system to a prescribed increase in greenhouse gases."

Until these questions are answered, the ultimate extent of global warming will remain unknown.

** For more information, see EPA- Uncertainties: http://www.epa.gov/globalwarming/uncertainties.html*

SOLUTIONS

There are several major areas in which improvements can be made to reduce greenhouse gas emissions and combat global warming: transportation, the energy sector, land use, and waste reduction. This section will discuss general concepts regarding greenhouse gas reduction in these areas, while the next section will address specific actions that can be taken by various sectors of society.

Transportation

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As mentioned earlier, if U.S. automobiles alone made up an entire country, it would be the fifth largest global warming polluter in the world. Moreover, transportation is the fastest growing sector of global warming pollution in the nation. The transportation sector contributes an enormous percentage of our nation's total CO_2 pollution, with estimates ranging from 32% (Rocky Mountain Institute[152]) to 42% (U.S. Department of Energy's Office of Transportation Technologies[153]). Total CO_2 emissions from transportation can be broken down into the following categories:[154]

CO2 Emissions in the Transportation Sector by Type

Transportation Type	% of Total Emissions
Personal Automobiles	49%
Other Highway	29%
Air Travel	11%
All Others	11%

The amount of CO_2 pollution released by a vehicle is directly proportional with the amount of fuel burned: for every gallon of gas used, 28 pounds of carbon is emitted into the atmosphere.[155] For this reason, there is great disparity between the emissions of regular cars and vehicles categorized as "light trucks." Light trucks, which include sport utility vehicles (SUV's) and minivans, make up almost half of all new vehicles sold in the United States.[156] Unfortunately these vehicles are extremely fuel-inefficient; some SUV's get as little as 13 miles per gallon.[157] In fact, according to the Sierra Club, switching from a regular car to a 13 mpg SUV for one year would waste more energy than:

- leaving a refrigerator door open for 6 years
- leaving a bathroom light burning for 30 years
- leaving a color television turned on for 28 years.[158]

As a result of their poor fuel efficiency, SUV's emit 43% more global warming pollution than average cars.[159]

There are three major ways to reduce CO_2 emissions in the transportation sector: increasing fuel efficiency, encouraging alternative transportation, and promoting alternative-fuel vehicles.

Fuel Efficiency: Because CO_2 emissions are directly proportional to the amount of fuel used by a vehicle, increasing fuel efficiency will easily reduce the amount of carbon dioxide emissions in this sector. Over the last few decades, great achievements have been made in increasing energy efficiency in the transportation sector: today's cars and trucks burn fuel 35% more efficiently than their counterparts did 30 years ago.[160] Unfortunately, total CO_2 emissions have continued to increase for two reasons: 1) Americans have shifted towards larger, less efficient vehicles such as SUV's and 2) the number of miles driven by Americans has risen by 33% since 1987.[161]

The technology *already exists* to make additional, far-reaching improvements in fuel efficiency. For example:

- Gasoline-electric hybrid vehicles currently get 70 miles per gallon (mpg) of gas.[162]
- The technology exists to make the country's best-selling SUV 56% more efficient.[163]

Alternative Transportation: Walking, bicycling, using mass-transit, and even carpooling reduces global warming pollution by decreasing the total number of vehicle miles traveled. Some interesting facts about alternative transportation include:

- The Federal Highway Administration estimates that 60% of all automobile trips are less than five miles in length- a short distance that could easily be traveled by walking or bicycling.[164]
- One full, 40-foot bus takes 58 cars off the road.[165]
- A 10 percent nationwide increase in mass-transit ridership would save 135 million gallons of gasoline a year, and therefore greatly reduce CO_2 emissions.[166]
- By carpooling to work, one person can cut carbon dioxide emissions by 1480 pounds annually.[167]

Alternative Fuel Vehicles: Using vehicles that run on alternative fuels such as compressed gas, ethanol, methanol, biodiesel, hydrogen, and electricity can greatly decrease greenhouse gas emissions as well as other types of air pollution.[168] Converting large fleets of buses, shuttles, or other types of mass-transportation to alternative fuel types provides an excellent opportunity for lowering harmful emissions, particularly of carbon dioxide. For example, in Chattanooga, Tennessee, the city's downtown electric bus fleet decreases annual CO_2 emissions by 3.5 million pounds.[169]

Energy Sector

Today, most power plants worldwide are fired by fossil fuels: coal, oil, and natural gas. Unfortunately these fossil fuels, particularly coal, have high carbon contents and consequently emit large quantities of CO_2 and other greenhouse gases into the atmosphere when burned. In fact, fossil fuel power plants are responsible for about 60% of all greenhouse gas emissions worldwide[170] and 36% of CO_2 emissions in the U.S.[171] There are

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several ways to decrease emissions in the energy sector: improving energy conservation/efficiency, "cleaning up" fossil fuel power plants, and promoting clean energy.

Energy Conservation/Efficiency: Quite simply, the less energy we use, the less carbon dioxide we produce. There are countless ways to reduce energy consumption, either by conserving electricity or by increasing energy efficiency in all sectors. In recent decades, American industries and consumers have fostered this cause by switching to more efficient appliances, motors, vehicles, and even industrial processes.[172] These successes are commendable, however it is possible to make even greater improvements in many areas.

Cleaner Power Plants: Roughly 70% of electricity generation in the United States comes from fossil fuels.[173] The approximate emissions of CO_2 from each type of fuel used to generate electricity are as follows:[174]

1999 Total U.S. Electricity Generation: Fuels and Emissions

Type of Fuel	% of Total U.S. Electricity Generation	% of Total U.S. CO_2 Emissions from Electricity Generation	CO_2 Emission Rate*
Coal	51%	80%	2.095
Petroleum	3.2%	4.7%	1.969
Natural Gas	15.2%	15%	1.321
Non-Fossil	30%	0%	0
Other**	.6%	.3%	1.378

* Emission Rate is measured in Pounds per Kilowatthour
** Other fuels include municipal solid waste, tires, and other fuels that emit CO_2 when burned to generate electricity

This table clearly shows that coal is by far the most polluting fuel used in electricity generation. Therefore one way to clean up existing power plants is to convert old, coal-fired plants to burn natural gas, a much cleaner fuel.[175]

Despite the fact that electricity generation accounts for 36% of total CO_2 emissions in the United States, there are currently no standards in place to limit these emissions.[176] A simple option for cleaning up old fossil fuel burning power plants is to create and enforce strict CO_2 emissions standards. Improving efficiency in energy generation, transmission, and distribution would also reduce the amount of CO_2 released by outdated power plants.[177]

Clean Energy: Renewable energy sources such as wind, solar, geothermal, biomass, hydropower, and ocean energy emit little or no carbon dioxide.[178] Although biomass emits a great deal of CO_2 when burned, it also removes the gas from the atmosphere as it grows. As a result, the net carbon dioxide emissions will remain zero as long as new biomass

crops are continually replenished.[179] Promoting these clean energy sources will lessen the need for dirty, non-renewable fossil fuels in the energy sector.

**For more information, please see the following sites:*

- *CO_2 Emissions from Electric Power Generation: http://www.eia.doe.gov/cneaf/electricity/page/co2_report/co2report.html*
- *Renewable Energy Sources: http://www.nrel.gov/clean_energy/*

Land Use

Many types of land use such as agriculture and forestry can have both positive and negative impacts on greenhouse gas levels. For example, as mentioned earlier, forests absorb large amounts of carbon dioxide from the atmosphere and store it in wood in a process called "carbon sequestration." Therefore healthy, standing forests are very beneficial in reducing CO_2 concentrations in the atmosphere. Conversely, when forests are destroyed through logging, clearing, and burning, all of this stored carbon is released as carbon dioxide. For these reasons, proper forest management can serve as a tool for controlling CO_2 levels.

Many agricultural practices can also affect atmospheric greenhouse gas concentrations. For example, rice paddies and livestock release methane while agricultural soils (fertilizers, microbes, etc.) release nitrous oxide. In fact, roughly 70% of U.S. nitrous oxide emissions come from agricultural soils.[180] However there are many ways to modify agricultural practices to reduce these emissions and even remove harmful greenhouse gases from the atmosphere. These options will be discussed in the following section.

Waste Reduction

Although the concept is less known, there is a very real link between the trash we produce and the concentration of greenhouse gases in our atmosphere. There are many ways in which recycling and re-using products (and therefore reducing waste) can help reduce greenhouse gas emissions and help prevent global warming. Some examples include:[181]

- Energy: Manufacturing products out of raw materials is a very energy-intensive process. Recycling and re-using goods lessens the need for new products, therefore conserving energy. As mentioned earlier, the less energy is used, the less carbon dioxide is produced.
- Incinerators: When waste is burned in incinerators, large amounts of greenhouse gases are released. Reducing waste by recycling and re-using products decreases the amount of trash that will be incinerated, in turn reducing emissions.
- Landfills: As less trash is produced, less waste is left to decompose in landfills, and less methane is produced as a result.
- Carbon Sequestration: As mentioned earlier, trees absorb carbon dioxide and store it in wood. If paper waste is reduced, more trees will be left standing to help remove CO_2 from the atmosphere.

ACTION

The previous section, Solutions, discussed general concepts regarding the reduction of greenhouse gases. This section will focus on past efforts and specific future actions that can be taken by various sectors of society in order to combat global warming.

International Efforts

In 1988, the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP) established the Intergovernmental Panel on Climate Change (IPCC) as the worldwide leader in global warming assessment.[182] The IPCC's First Assessment Report, which was completed in 1990, found much international consensus that human activities were affecting global climate.[183] In response to this report, the UN General Assembly established the Intergovernmental Negotiating Committee for a UN Framework Convention on Climate Change (UNFCCC).[184] The UNFCCC, which provides the overall policy framework for addressing climate change, was signed by over 150 countries at the Rio Earth Summit in 1992.[185]

Since that time, the 170-plus Parties to the UNFCCC have met at 6 major conferences, including the 1997 Conference of Parties in Kyoto, Japan where the Kyoto Protocol was created.[186] The agreement committed industrialized countries to an overall reduction of greenhouse gas emissions to 5.2% below 1990 levels for the period 2008-2012.[187] After several years of debate and controversy, more than 180 countries officially adopted the Protocol at a landmark session of the UNFCCC in July 2001.[188] Unfortunately, many concessions were made at this conference that seriously reduced the overall reduction goals of the agreement. However, many still see the Protocol's adoption as a positive symbol of commitment and cooperation amongst international leaders.

U.S. President Bush has rejected the Kyoto Protocol, claiming it sets unrealistic goals and will be harmful to the nation's economy. Calling the agreement "fatally flawed", President Bush also criticized the plan for failing to address emissions from developing countries.

Other recent contributions from the international community include the IPCC's Second and Third Assessment Reports. The most recent (Third) report "provides a comprehensive and up-to-date assessment of the policy-relevant scientific, technical, and socio-economic dimensions of climate change"[189] and is considered by many to be the most current and most reliable information available on the subject.

Whatever the outcome of the Kyoto Protocol, it is critical that all countries begin taking the issue of global warming seriously. Perhaps more than any other environmental issue, a changing climate will affect every part of the globe from the largest continents to the smallest islands regardless of their individual contribution to the overall problem. Vulnerable regions like Tuvalu and Shishmaref (discussed earlier) cannot be ignored; all leaders in the international community must work together to insure the well being of all of earth's inhabitants.

**For more information, please see the following sites:*

- *IPCC (Third Assessment Report): http://www.ipcc.ch/index.html*
- *UNFCCC: http://www.unfccc.de/*

Federal and State Government

The U.S. is by far the world's largest greenhouse gas producer- with less than 5% of the world's population, it accounts for roughly 25% of total greenhouse gas emissions. Thus it is critical that both the federal and state governments take effective actions to reduce these emissions. There are four main types of action by which government can influence the behaviors of America's society in regards to greenhouse gases:[190]

- Impose government regulations
- Implement market based incentives such as taxes and subsidies
- Provide information and education
- Support research and development

Government can utilize these actions in more specific ways to reduce America's impact on the global climate. Some of the most effective actions that can be taken include:

Improve Fuel Efficiency: U.S. automobiles are the fifth largest greenhouse gas polluters in the world. There are several ways that government can reduce the emissions released from this source.

First, the U.S. should strengthen Corporate Average Fuel Efficiency (CAFE) standards. Current CAFE standards (27.5 mpg for cars and 20.7 mpg for light trucks) save 3 million barrels of oil per day.[191] While this is a great accomplishment, these outdated standards were adopted many years ago and do not take advantage of modern technology that greatly improves efficiency.[192] By raising standards to 45 mpg (cars) and 34 mpg (trucks), for example, an additional 3 million barrels could be saved each day, cutting CO_2 pollution by 600 million tons per year.[193]

Government can also encourage automakers to produce more fuel efficient cars, and encourage the general public to purchase them. This can be done through financial incentive programs such as taxes and subsidies as well as public education. Finally, leaders can support research and development efforts to continue improving fuel-efficiency technology.

Reduce Power Plant Emissions: As mentioned earlier, fossil fuel power plants account for 36% of all U.S. carbon dioxide emissions. Despite this fact, there are currently no laws regulating these emissions. Government should create and enforce controls on CO_2 emissions under the Clean Air Act.

Another option is to create market based incentives such as emissions trading systems. In these programs, pollution "credits" can be bought and sold, financially rewarding those who reduce their emissions and punishing those who continue polluting heavily. If implemented correctly, emissions trading programs have great potential to reduce greenhouse gas emissions, however they are often controversial and can be used ineffectively.


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Promote Clean Energy: Government policy should encourage the use of clean, renewable energy sources such as wind, solar, geothermal, and sustainably grown biomass. For example, a state or nation's energy policy should focus less on the use of fossil fuels and more on the development of clean, renewable energy. Government policy can also require a certain percentage of electricity to come from renewable sources. Incentives such as government subsidies or other financial support can encourage all levels of society to support renewable energy sources. Furthermore, educating corporations, businesses, institutions, and the general public about the feasibility and cost effectiveness of using renewable energy can also promote more widespread use.

The U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy is the federal body responsible for energy research and development. It's mission is "to lead the nation in the research, development, and deployment of advanced energy efficiency and clean power technologies and practices, providing Americans with a stronger economy, healthier environment, and more secure future."[194] This type of research is critical in advancing clean energy as a cost effective, reliable alternative to traditional fossil fuel use.

Improve Overall Energy Efficiency: The government currently regulates the energy efficiency of products (mainly home appliances) that Americans use every day. The Department of Energy's Office of Codes and Standards sets minimum efficiency standards at levels that ensure that the energy savings outweigh any additional costs for added efficiency measures.[195] It is estimated that these standards saved approximately $20 billion in energy costs prior to the year 2000, and are expected to save an additional $58 billion for appliances installed between 1990 and 2015.[196] Continuing this program and setting higher standards for efficiency will continue to save large amounts of energy, therefore reducing CO_2 emissions.

Public education regarding energy efficiency can be extremely beneficial as well. The Energy Star Program discussed earlier identifies and labels the most energy efficient products with the goal of reducing greenhouse gas emissions. Programs such as this enable Americans to make wise decisions when purchasing new household appliances that will save money, conserve energy, and reduce greenhouse gas emissions.

** For more information on efficiency standards, see the US DOE Energy Efficiency and Renewable Energy Network: http://www.eren.doe.gov/buildings/consumer_information/index.html*

Improve Forest and Agricultural Lands Management: Government can encourage wise land use practices largely through education. Not only do wise land use decisions reduce atmospheric greenhouse gases, but they can also benefit land owners/managers both private and public. For example:

- Large, healthy forests not only remove carbon dioxide from the atmosphere but they also provide great recreational and environmental benefits that can translate into economic profit. Therefore, preserving forests can benefit both the landowner and the global climate.
- Modifications to agricultural practices, such as methane recovery systems, can reduce greenhouse gas emissions. However if this methane is re-used to produce electricity, the program also benefits the landowner by saving him energy and money.

Therefore, providing information and education to land managers about the many benefits of wise land use decisions can provide them with great incentive to reduce their greenhouse gas emissions.

It is also possible to impose government regulations to improve land use. For example, government could require forest managers to preserve a certain percentage of trees for carbon sequestration purposes, or set methane or nitrogen oxide emission limits for agricultural practices.

Transfer Technology to Developing Countries: In addition to reducing domestic greenhouse gas emissions, the U.S. government can further help to combat this global problem by sharing advanced clean energy technologies with developing countries.[197] As these nations try to build their economies, they will naturally be inclined to utilize cheap, readily available fossil fuels in their development. It is critical that more industrialized countries share with them the clean energy technologies that will eventually enable everyone to phase out dirty fossil fuels.

State Government: Although the previous paragraphs focused mainly on federal programs, it is important to note that the states also have countless projects aimed at reducing greenhouse gases. The EPA's global warming web site contains a "State Actions List" that provides information on all of these programs, with topics ranging from agricultural efficiency to solar training and certification.[198] While some of these programs are similar to the federal ones mentioned above, many are very different and innovative. Some brief examples of existing and recommended programs include:

- Traffic Light Coordination Programs (NH, AL): Coordinating traffic lights to help reduce urban traffic and idling cars.
- Landfill Gas to Energy Project (RI): Uses landfill gas as a source of electricity.
- Solar Access Laws (CA, CO, HI, IN, MA…): Laws restricting the height of buildings and trees to protect access to sun rays for solar photovoltaic systems.
- Telecommuting Promotion Programs (MA, MT, NE, OR, VT): Promotes telecommuting to area businesses.
- Tree Planting Initiatives (23 states): Programs supporting tree planting in order to promote storage of carbon (thus acting as a carbon sink) and to provide shade and cooling for communities (thus reducing energy demand).

**For a full list of State Actions, see http://yosemite.epa.gov/globalwarming/ghg.nsf/StatePolicyOptionsSearch?OpenForm*

Industry and Business

There are a wide variety of opportunities available for industries and businesses to reduce their impact on global climate. The four major areas for improvement are increasing energy efficiency, removing greenhouse gas emissions from industrial processes, supporting clean energy, saving energy in buildings and reducing waste.

Increase Industrial Energy Efficiency: Industry uses almost 1/3 of all the energy in the United States, therefore it is a perfect candidate for improvements in efficiency.[199] General opportunities for energy savings include:[200]

- Using combined heat and power systems (cogeneration)
- Using energy efficient motors
- Improving steam system efficiency by insulating steam and condensate return lines, stopping leaks and utilizing steam traps
- Optimizing compressed air systems (using variable speed drives, detecting and repairing leaks, etc.)
- Using advanced burners that operate more efficiently
- Using advanced sensors and control systems that allow processes to operate at their optimal conditions
- Improving efficiency of heating and cooling processes[201]

Improving the energy efficiency of these processes will in turn reduce greenhouse gas emissions, particularly of carbon dioxide.

**For more information, please see the following sites:*

- *US DOE's Energy Efficiency and Renewable Energy Network: http://www.eren.doe.gov/EE/industry.html*
- *US EPA: http://www.epa.gov/globalwarming/actions/industry/wiserules.html*

Remove Greenhouse Gas Emissions: Many greenhouse gases (such as carbon dioxide[202] and methane[203]) given off by industrial processes or other systems can be recovered and either re-used or disposed of. This will directly decrease the amount of greenhouse gases being released into the atmosphere by specific product lines or entire companies.

Support Clean Energy: Business and industry can switch to renewable forms of energy (for example, a solar-powered water heater) that emit little or no greenhouse gases.[204] An excellent opportunity to apply clean energy technology is to convert large vehicle fleets to alternative fuels such as electric, hybrid or natural gas.

Saving Energy in Buildings: Many opportunities exist for decreasing energy use in most buildings. Once again, the less energy is used, the less carbon dioxide is created and released. Ways to conserve energy in buildings include:[205]

- Building Envelope: Install energy-efficient windows, walls, ceilings, foundations, and insulation.

- Space Heating and Cooling: Use automated controls, ventilation, improved duct systems and other advanced technologies to increase the efficiency of space heating and cooling systems.
- Water Systems: Use efficient water heaters and appliances to save energy and water
- Lighting: Install energy-efficient light fixtures such as compact fluorescent bulbs.
- Appliances: Use appliances that are energy-efficient (clothes washers and dryers, refrigerators, freezers, dishwashers, ovens, and stoves. The EPA's Energy Star Program identifies and promotes energy-efficient products in order to help reduce greenhouse gas emissions.[206]
- Office Equipment: Utilize "low-power" modes on computers and other equipment when appropriate.

**For more information, please see the following sites:*

- *EPA's Energy Star Program: http://www.energystar.gov/*
- *US DOE's Energy Efficiency and Renewable Energy Network: http://www.eren.doe.gov/EE/buildings.html*

Reducing Waste: There are three major ways in which reducing waste from business and industry can help combat global warming: waste prevention, recycling collection, and buying or manufacturing recycled products.[207]

- Waste Prevention: This refers to using smaller amounts of raw materials to do the same job or produce the same product. Not only does waste prevention conserve raw materials, but it saves the energy that would have been used to retrieve, process, and manufacture them into products. Furthermore, reducing waste means reducing the amount of materials decomposing and releasing methane in landfills.
- Recycling Collection: Recycling and re-using materials also diverts waste from landfills, therefore lessening the gases released from their decomposition.
- Buying or Manufacturing Recycled Products: By promoting the use of recycled products, business and industry are once again diverting waste from landfills and saving energy required for manufacturing products from raw materials. In fact, manufacturing recycled products uses 70-90% less energy and creates far less greenhouse gas pollution than using virgin materials.[208]

Partnership Programs: Climate Wise, a private-public partnership program, is a Federal initiative aimed at reducing greenhouse gas emissions from industry and business. The collaborative effort between the Department of Energy's Office of Industrial Technologies and the Environmental Protection Agency's Office of Policy, Planning, and Evaluation "encourages industrial companies to take innovative approaches to turning energy efficiency and environmental performance into corporate assets."[209] The Climate Wise Case Study Compendium contains specific examples of how various businesses throughout the United States have successfully implemented cost-effective programs that have helped to increase efficiency and reduce greenhouse gas emissions.

Waste Wise is a similar program designed to encourage business, industry, institutions, organizations, and local governments to reduce solid waste. Although this program is not aimed directly at reducing greenhouse gas emissions, it would certainly be helpful to any business wishing to reduce emissions through waste reduction.

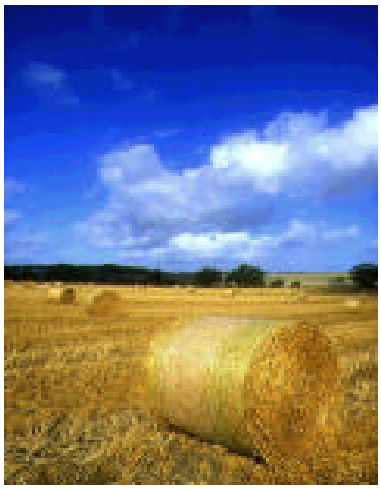
Several other partnerships, including Climate Challenge, Energy Star Buildings, Green Lights, Best Practices, and others can be found on the EPA's website.

**For more information, please see the EPA Climate Change Partnerships Website: http://www.epa.gov/globalwarming/actions/national/partnership.html*

Agriculture

Many agricultural systems release a wide variety of greenhouse gases, as mentioned earlier. However there are many opportunities for agricultural managers to modify their practices to reduce these emissions. Examples include:[210]

- Conserving fuel by limiting the number and intensity of field operations
- Using no-till cultivation systems to reduce carbon dioxide emissions from soil
- Reducing fertilizer use in order to reduce nitrous oxide emissions
- Correctly managing livestock systems to reduce methane emissions from ruminant animal digestion
- Using methane recovery systems
- Using aerobic systems such as composting to reduce manure methane production



www.freefoto.com

There are also opportunities for agricultural systems to have a positive, rather than a negative impact on greenhouse gas emissions. Growing biofuels as a substitute for fossil fuels can reduce net carbon dioxide emissions. Biofuels can include traditional agricultural crops such as corn and soybeans or crops grown specifically for fuel purposes such as switchgrass and short rotation trees. In addition, tree planting and certain conservation practices can increase carbon sequestration therefore reducing atmospheric CO_2.[211]

Non-Governmental Organizations

Throughout the nation and the world, there are countless organizations that are working to combat climate change through education, activism and research. The following list contains some of the more prominent organizations with brief descriptions of their efforts to fight climate change.

- Climate Action Network: **www.climatenetwork.org/**
  "The Climate Action Network (CAN) is a global network of over 287 Non-Governmental Organizations (NGOs) working to promote government and individual action to limit human-induced climate change to ecologically sustainable levels. CAN members work to achieve this goal through the coordination of information exchange and NGO strategy on international, regional and national climate issues."[212]
- The Climate Institute: **www.climate.org**
  The goal of the Climate Institute is to "serve as a bridge between policymakers and scientists around the world and [is] dedicated to being the world's foremost authority on climate change information, science and responses." They aim to promote climate balance through "practical and cooperative approaches."[213]
- World Resources Institute: **www.wri.org**

The World Resources Institute works to promote innovative and effective policies to prevent climate change. It aims to "set the world on a new course, one characterized by cleaner energy sources, healthier ecosystems and societies, technological innovation, and economic opportunity."[214]

- Union of Concerned Scientists: **www.ucsusa.org**
  Union of Concerned Scientists seeks to **"**bring sound scientific information to policymakers and the public to educate them about global warming, its impacts, and about available practical solutions." In addition, they promote policies to combat the problem over the long term.[215]
- Natural Resources Defense Council: **www.nrdc.org**
  The NRDC is "spearheading efforts to reduce greenhouse gas pollution, both in the U.S. and internationally." Its methods include building public awareness, promoting energy efficiency, promoting clean energy, and demanding an effective global warming treaty from governments.[216]
- The Pew Center on Global Climate Change: **www.pewclimate.org**
  "The objective of the Pew Center on Global Climate Change is to educate the public and key policy makers about the causes and potential consequences of climate change, and to encourage the domestic and international community to reduce emissions of greenhouse gases. To accomplish this objective, the Pew Center will: (1) release highly publicized reports on environmental impacts, economics and policy issues; (2) educate the public through advertising, public-speaking events and conferences; and (3) advance international negotiations on climate change by coordinating cross-country policy, industry and government discussions."[217]
- Sierra Club: **www.sierraclub.org**
  The Sierra Club's Global Warming Campaign focuses its efforts on increasing public awareness about global warming, and providing information on how individuals can decrease their greenhouse gas emissions.[218]
- World Wildlife Fund: **www.panda.org**
  "WWF's campaign is raising public concern about the need to cut emissions, pressing policymakers to introduce effective measures, and forming innovative partnerships with progressive businesses."[219]
- Greenpeace: **http://www.greenpeace.org/**
  Greenpeace seeks to halt climate change by protesting new oil exploration, promoting clean, renewable energy, and campaigning for governments to address this urgent problem.[220]

Individual

Per capita greenhouse gas emissions in the United States are higher than any other country.[221] The following quote from the EPA's Global Warming website describes the typical trends and sources for today's individual emissions:

> "In the United States, approximately 6.6 tons (almost 15,000 pounds carbon equivalent) of greenhouse gases are emitted per person every year. And emissions per person have increased about 3.4% between 1990 and 1997. Most of these

emissions, about 82%, are from burning fossil fuels to generate electricity and power our cars. The remaining emissions are from methane from wastes in our landfills, raising livestock, natural gas pipelines, and coal, as well as from industrial chemicals and other sources."[222]

Individuals can take many actions in their every day lives to help reduce greenhouse gas emissions, from buying energy-efficient appliances to carpooling to planting trees. Some of the best ideas include the following:

In the Home:

- Increase a home's energy efficiency by adding insulation and air sealing. While insulation reduces heat loss through walls and roofs, air sealing will block drafts so that heat does not easily escape in winter or enter in summer.[223] Insulating walls and ceilings can save 2000 pounds of CO_2 per year, while insulating a 5+-year-old water heater can save 1000 pounds.[224]
- Recycle, re-use, and buy recycled products. This not only diverts waste from landfills, but also saves energy needed to manufacture products from raw materials. Recycling can reduce a home's carbon dioxide emissions by 850 pounds per year.[225]
- Conserve energy by conserving water; pumping and distributing water is an extremely energy-intensive process.[226] Home water use can be cut dramatically by installing low-flow showerheads, faucets, and toilets.
- When re-modeling or purchasing a new home, consider incorporating renewable energy sources such as solar-powered water heaters or photovoltaic electricity generators.[227]
- Purchase "Green Power" if it is available from the local utility. Green Power is generated from renewable sources such as solar, wind, geothermal or biomass.[228]
- Buy energy-efficient electronics and appliances. The EPA's Energy Star Program identifies and promotes efficient products in order to help reduce greenhouse gas emissions.[229]
  - An Energy Star labeled clothes washer uses 50% less energy than conventional clothes washers.[230]
  - Compact fluorescent light bulbs use 75% less energy than standard bulbs and last up to 10 times longer.[231]
  - A home computer monitor labeled by Energy Star uses 90% less energy than those without power management features.[232]

Transportation:

- Reduce driving by carpooling, telecommuting, walking, bicycling, or taking mass-transit. Carpooling to work or reducing travel by 15% can decrease a person's annual greenhouse gas emissions by 1480 pounds.[233]
- Purchase a fuel-efficient car- this can decrease an individual's greenhouse gas emissions by 2960 pounds per year.[234] Gas mileage can vary from a gas-guzzling 9 mpg to an extremely efficient 68 mpg.[235]
- Increase fuel efficiency by keeping cars well tuned and tires properly inflated.[236]

In the Yard:

- Plant deciduous trees around the house to increase shade. Not only will this save energy, but the trees will also sequester additional carbon from the atmosphere.[237]
- Use "Xeriscape" techniques in the yard- plant vegetation that requires little or no water. This will conserve both water and energy.[238]
- Compost food scraps and yard waste for use in the yard. This will divert this waste from landfills, therefore decreasing methane emissions.[239]

** For more information, see the following sites:*

- *Energy Star products: http://www.energystar.gov/*
- *Home CO_2 Savings: http://www.epa.gov/globalwarming/actions/individual/actionsteps/index.html*

CONCLUSION

> *Climate change is a threat to mankind. But no one is certain about its future effects or their severity. Responding to the threat is expected to be expensive, complicated, and difficult. There is even some disagreement over whether any problem exists at all: while many people worry that the effects will be extremely serious, others argue that scientists cannot prove that what they suspect will happen will actually happen. In addition, it is not clear who (in the various regions of the world) will suffer most. Yet if the nations of the world wait until the consequences and victims are clear, it will probably be too late to act. What should we do?*[240]

This excerpt from the UNFCCC's web site represents one of the greatest challenges facing the global warming debate. Despite the continually mounting evidence of increasing greenhouse gases and rising temperatures, the uncertainties involved have left many reluctant to take much needed action on this crucial issue. While everyone knows that it is impossible to predict the precise impacts of global warming, perhaps the most important fact to remember is that considerable potential exists for global catastrophe. As stated in the IPCC's 2001 report, "Projected climate changes during the 21st century have the potential to lead to future large-scale and possibly irreversible changes in earth systems resulting in impacts at continental and global scales."[241]

The reality is that the earlier we act, the less chance we have for global disaster. As stated in the National Academy of Science's Climate Change Science, "National policy decisions made now and in the longer-term future will influence the extent of any damage suffered by vulnerable human populations and ecosystems later in this century."[242] Considering the potential for global disaster, we must err on the side of caution. Conversely if the world sits idle, waiting and watching for definitive answers, it will be too late. This is the basis of the "precautionary principle", an idea that promotes the protection of the environment and public health in the face of an uncertain future. It states, "When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically."[243]

Ignoring the problem of global climate change and deferring action means gambling with human lives, historic cultures, natural systems, and the future of our planet. As the Sierra Club states, "The human race is engaged in the largest and most dangerous experiment in history."[244]

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