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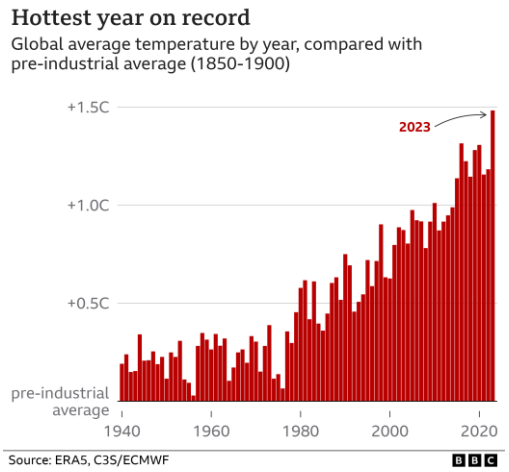
Climate Change Notes

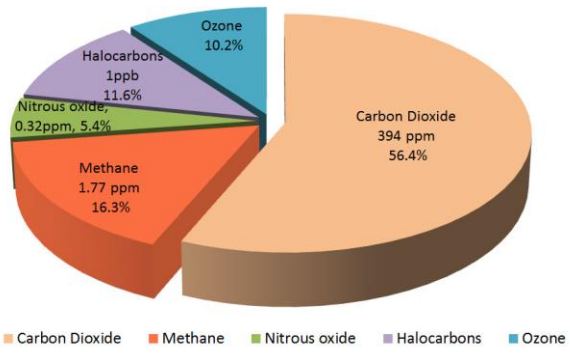
All species impact their environment in some way, whether it is beneficial or harmful. However, humans have affected their environment the most, unknowingly and knowingly causing a large amount of damage to all the spheres of Earth, causing mass climate change. **Climate change** is defined as any long-term change to typical temperature and weather patterns in a given place.

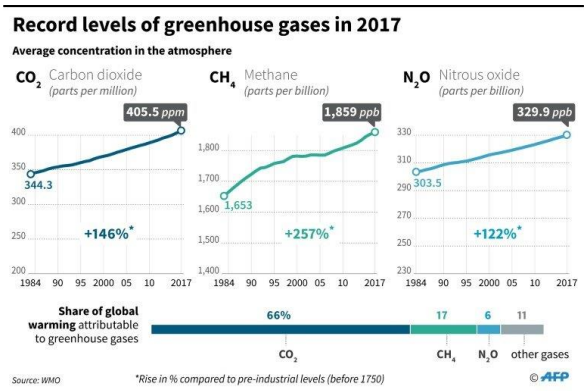
In particular, humans have notably changed the climate after the industrial revolution, where we began using more greenhouse gas emitting technology, as well as other environmentally damaging technology. The graph shows that since the industrialization period, the average temperature on Earth has risen as much as 1.5°C.



The main, specific greenhouse gases involved in climate change are:

- Carbon dioxide (CO_2) – Typically produced in combustion reactions that are found in fires. Carbon dioxide does not absorb as much energy as other greenhouse gases, but it is far more abundant in the atmosphere, especially due to human activity.
- Methane (CH_4) – Methane is 80 times more effective at global warming than carbon dioxide. Methane is produced by a few different sources: agriculture (40%), fossil fuel (35%), and waste (20%). It can also lead to destruction of ozone layer.
- Nitrous Oxide (N_2O) - There are a few compounds containing nitrogen in the atmosphere, but nitrous oxide is the main concern. It contributes 300 times more to climate change than carbon dioxide by absorbing more energy in its chemical bonds. Sources include natural plant matter, agricultural use, and factory/power plant emissions. Nitrous oxide can also <u>indirectly</u> destroy ozone molecules.





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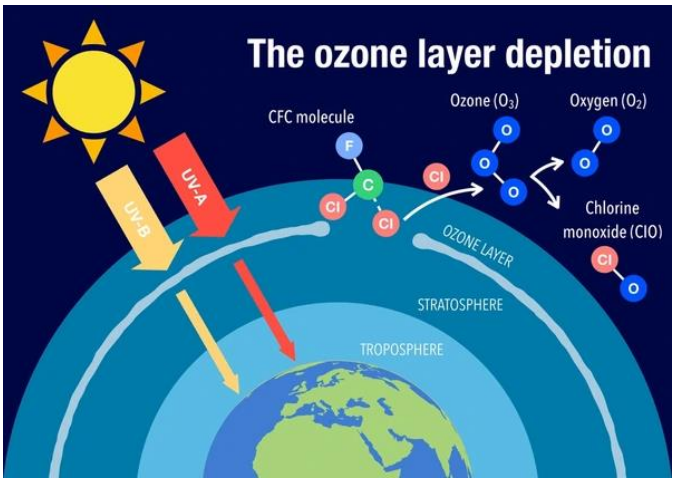
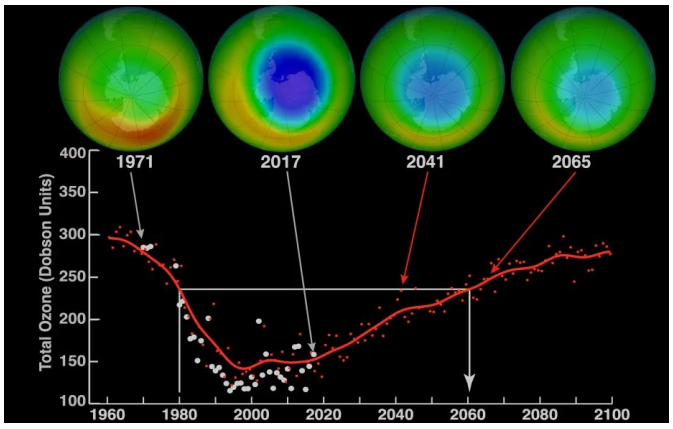
- Water vapor (H_2O) is also a greenhouse gas and contributes to half of the greenhouse gas effect on Earth.

There are other gases in the atmosphere that contribute to climate change. Some of these **trace** (small amount) compounds even have a higher greenhouse gas effect than the three mentioned. For example, the unnaturally occurring SF_6 (sulfur hexafluoride) has 23,500 times the effect on global warming compared to CO_2. Keeping these greenhouses gases to a minimum is important so that Earth can properly radiate some of the energy from the sun back to space.

While greenhouse gas emissions keep energy on Earth, the **ozone layer** (O_3) is just as important, as it prevents too much energy from arriving on Earth from the sun. It does so by absorbing specific wavelengths of energy in the stratosphere, preventing them from reaching Earth. Although the mentioned greenhouse gases do not directly damage the ozone layer, they can lead to other reactions that can.



Additionally, studies have found certain pollutants that can and have caused devastating damage to the ozone layer.



Chlorofluorocarbons (CFC's) are a class of molecules that contain chlorine, carbon, and fluorine. CFC's have a number of applications and began seeing use in 1931 in early air conditioning units. They were also used in refrigerators, propellants, fire suppression, and dissolving liquids.

CFC's were found to directly react with the ozone layer and after years of use, CFC's badly thinned the ozone layer over Antartica. CFC's were banned in 1985 after the ozone layer damage discovery, and projections say the "hole" won't fully disappear until the end of the 20th century.

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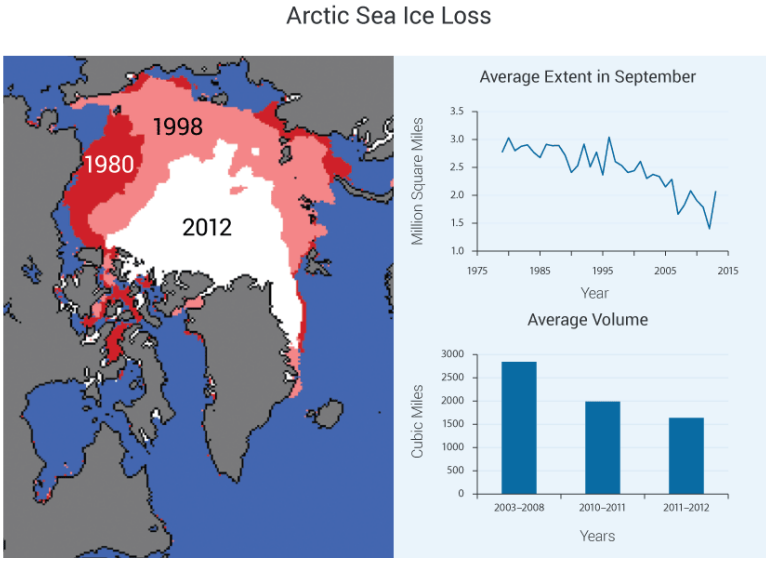
Effects of climate change

Besides the warmer temperatures, climate change has effects that harm all life on Earth.

Changes to cold regions

Studies have shown these changes to the atmosphere have caused cold regions of Earth to shrink in ice/snow mass. This loss in ice has only increased global warming, as ice/snow can reflect some of the energy that comes from the sun. This leads to further global warming, causing more ice loss and repeating this cycle of increased global warming.

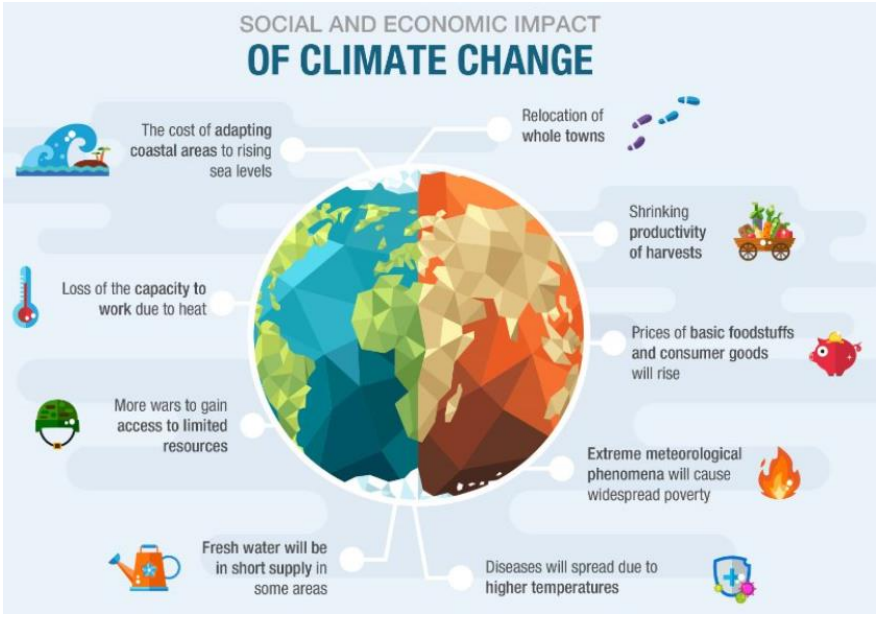


The disappearing ice caps will destroy artic habitats, disrupting their ecosystems. The ice will also enter the active water cycle, leading to a rise in global water levels and leading to flooding (causing more destruction of the environment and posing a threat to human society).

Other effects of climate change

Other effects that climate change can have on the world are:

- The shifting convection currents and water cycle can give rise to extreme weather that can cause damage to ecosystems and human life.



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- “Climate change is causing milder winters, warmer summers, and fewer frost days. This change in climate makes it easier for many animals, mosquitoes, ticks, and the infectious diseases they spread to expand into new geographic areas and infect more people.” - Center for disease control. This means that climate change will cause more diseases through optimal conditions for insects.
- Reduced crop yields caused by new climates will lead to more food shortages and higher prices.

Human Causes

As mentioned, many human actions directly lead to climate change, or indirectly to climate change through environmental damage since the biosphere is linked to the atmosphere. Some are through direct pollution of the atmosphere, while others are through other damage to the environment.

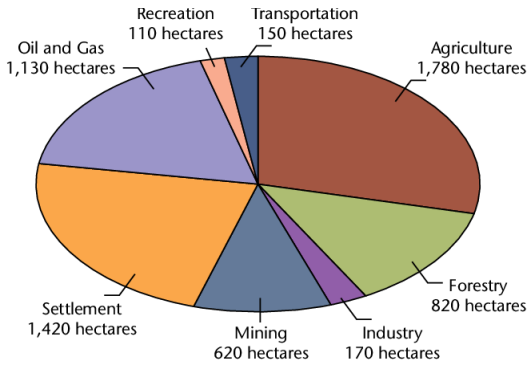
Atmosphere

For the atmosphere, the use of CFCs, burning of carbon-based fossil fuels (such as coal and natural gas power plants and combustion vehicles), and the use of nitrogen products especially in agriculture have increased greenhouse gas emissions and damaged the ozone layer.

Deforestation

Plant life is vital to taking carbon dioxide out of the atmosphere through photosynthesis. Plants are also the primary way energy enters the biosphere storage. Humans use regularly need large amounts of lumber for construction and other purposes. A clear space for buildings and farms is also often required for cities.

As such, massive areas of the world have been gone through deforestation, completely destroying the ecosystems they contain. This destroys animal habitats and food supplies. Two examples of which are British Columbia and the Amazon rainforest in Brazil, which has lost large amounts of forest for many years. In BC, old growth forests that contain trees that are hundreds of years old are under protection by provincial policies. Nevertheless, companies are still cutting them down, as 45,700 hectares of BC’s old-growth forests were cut in 2021.



BC lumber usage graph (2008)

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As for the Amazon rainforest, in 2021, 13 thousand square kilometers of trees were cut down.

On top of human destruction, forest fires also cause massive loss of trees, especially in the conditions found in BC. Typically, they are caused by either lightning strikes, or careless campers.

Once deforestation has been completed, it is difficult to repair the damage as a long amount of time is needed to regrow (20+ years). On top of that, other vital parts of the ecosystem must be restored at the same time, such as bacteria that worked alongside the plant life.

<u>Polluting the environment</u>

Whether the pollution is trash in landfills or waste from factories and other industries, pollution is damaging to most biological life. Some of the worst offending pollutants include:

- Plastics – Plastics are incredibly useful in human society, yet horrendously damaging to the environment. They are made of strong covalent compounds that take a very long time to degrade. Depending on the plastic, it can take hundreds of years to break down. While in the environment, it can kill animals through suffocation and digestion.

  Plastic can also be toxic if made with chemicals such as Bisphenols (BPA) and phthalates, damaging the nervous and reproductive systems. Additionally, microplastic fibers are also damaging to lungs if inhaled.

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Although damage to animals may seem like it helps plants and therefore helps global warming, it actually hurts plants. Plants rely on animals for sexual reproduction and the ability to spread around. Additionally, if a predator that eats herbivores goes extinct, it will lower the plant population. Additionally, less animals will lead to less fertile soil, as the decomposers will have less to break down into plant nutrients.

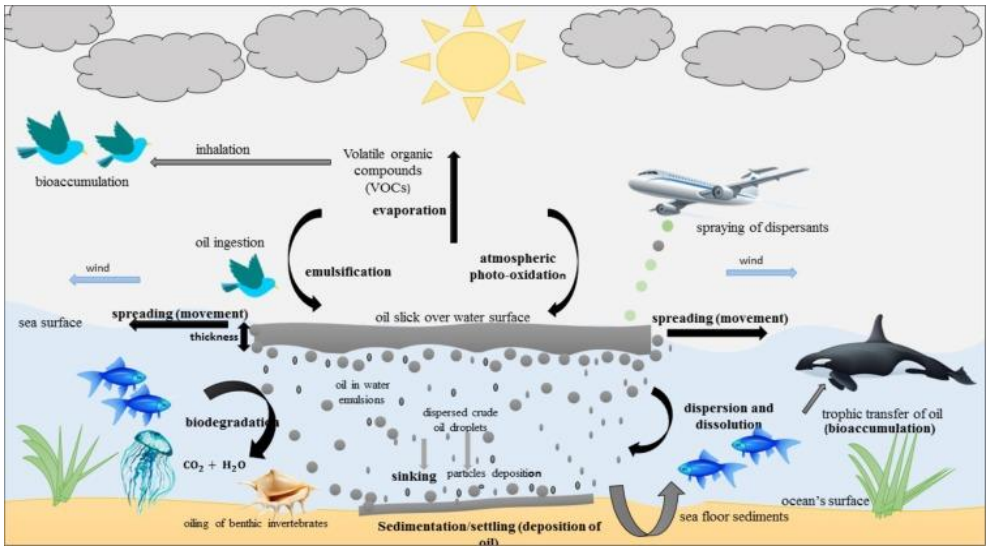
- Garbage can damage ecosystems by harming many species, including keystone species. Each year, 2.01 billion tons of municipal solid waste is produced on Earth, and the number is rising due to an increasing population.

The great pacific garbage patch

Landfills take up large amounts of space that are only available by destroying the ecosystems that were once there. Garbage can also include toxic materials, like toxic heavy metals (Cadmium, lead, mercury,…) that cause major health risks to the environment.

To get rid of the garbage, we sometimes use solid waste combustion facilities that burn it in combustion. This release nitrogen oxide into the atmosphere, adding to global warming. And even if it is not burned, some garbage is decomposed by bacteria into other greenhouse gases like methane.

- Oil spills can occur when oil is being transported across land or water. In general, oil spills are poisonous to most plants and animals in an ecosystem, causing massive environmental damage. In addition, there are other effects.



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Oil spills are especially harmful in the water, as they block out sunlight needed by the local aquatic plant life. It also lowers the dissolved oxygen in the water, killing aquatic organisms in the area. On land, oil spills can also prevent plant photosynthesis by covering them off from sunlight and can prevent water absorption.

- Nuclear technology has also led to damage in many places around the world. Nuclear energy is great as it produces large amounts of energy with low atmosphere pollution. However, nuclear power plants use nuclear fission, which produces radioactive waste that can cause DNA damage to biological organisms, usually killing them overtime.

Most nuclear waste is buried in safer storage locations, but when a nuclear powerplant malfunctions or when the waste is exposed to the environment, airborne nuclear waste can be spread and harm biological life. The two major examples of this are the Chernobyl power plant meltdown in 1986 and the Fukushima's power plant meltdown in 2011 (caused by a Tsunami from the earthquake).

On the left: New completely black frog mutated by Chernobyl's meltdown

- Some other forms of pollution include noise pollution (disrupts species sensitive to noise like whales), soil pollution and displacement (often times during mining) and city sewage/factory wastewater.

Bioaccumulation and Biomagnification

Bioaccumulation is the process in which toxins/chemicals build up in an organism overtime as it lives and eats. **Biomagnification** is the idea that as you go up a food chain, the concentration of the toxins/chemicals build up, as each time you go up a level, the amount of contaminated food that the species eats goes up in order to have enough energy to survive.

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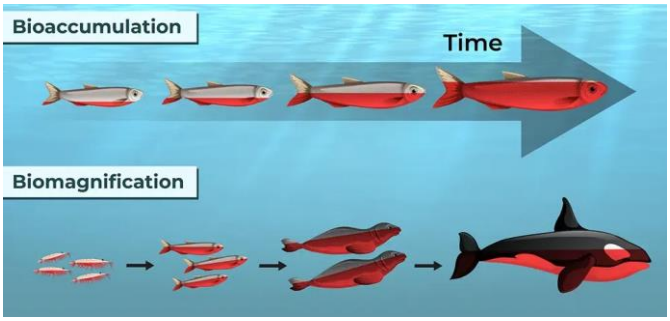
This means that pollution from things like garbage and radioactive material may enter the ecosystem in small amounts. However, because of these two concepts, the tertiary consumers will be greatly affected, including humans!

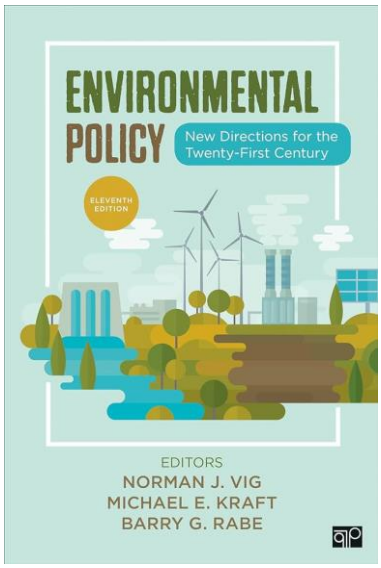


Climate change reduction

Climate change affects all life on the planet with effects that last for years. Thus, reducing climate change is essential for the longevity of the environment, including humans. We can reduce the effects of climate change by using new policies/plans to change activity.

Examples:

- When proper recycling programs are implemented, we can reuse old materials for new products, reducing the amount of waste in landfills.
- We can create incentive plans to encourage the population to make good choices for the environment. An example of this would be a tax or price reduction for people who buy environmentally friendly options like electric cars or things made of recycled materials. BC hydro has reduced rates if you are beneath a certain threshold of energy usage. They also reduce the bill if you generated energy with your own solar panels.



- We can also instate penalties for people who are making choices that damage the environment for personal gain or quality of life.

  This can include fines for companies that pollute, although the fine must be more expensive than the money they save by polluting. At a smaller level, most plastic purchases in BC have a recycling fee included with every purchase. In Korea, garbage is charged by weight, penalizing people who create a lot of waste.
- We can invest in clean energy solutions rather than coal and other pollution producing energy production.

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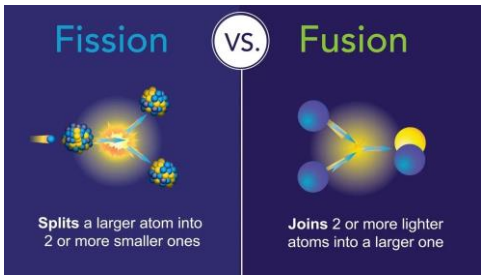
We can also continue to develop new technologies that either reverse the effects of climate change or reduce our future impact.

Examples:

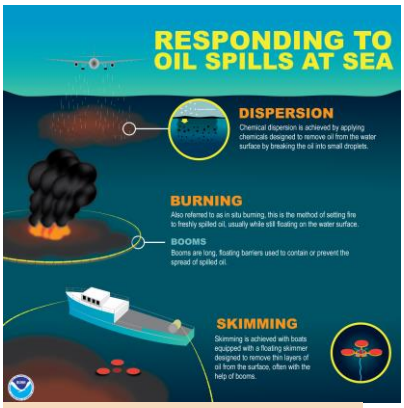
Efficiency	Least			Most
Bulb Type	Standard	Halogen	CFL	LED
450 Lumens	40W	29W	9W	6W
800 Lumens	60W	42W	14W	9W
1100 Lumens	75W	53W	18W	11W
1600 Lumens	100W	72W	23W	14W

- We can phase out old technology in favour of new, environmentally friendly technologies. The best example of this is phasing out old light bulb types (like the incandescent tungsten bulbs) that have a high energy usage, in favour of new light bulbs (like LED light bulbs) that have a much lower energy cost.
- Next year, you will learn about two nuclear physics processes that generate large amounts of energy: nuclear fission and nuclear fusion.



Our current nuclear fission power plants do help reduce climate change by producing large amounts of energy without polluting the atmosphere like a coal power plant. However, nuclear fission produces nuclear waste that is harmful to biological life. We one day hope to understand how to use nuclear fusion, where we fuse atoms together instead of breaking them apart. Nuclear fusion produces even more energy than fission with **NO** radioactive waste. For now, nuclear fusion is only found in stars like the sun.

- We have found/modified bacteria that process and break down both oil and plastic. The study of removing contamination using organisms is called **bioremediation**. It is an expensive solution and takes a long time, but bacteria can remove oil spills more environmentally than the chemicals used to break down oil. It is also more thorough than oil skimming with boats. Additionally, plastic-eating bacteria are a promising way to reduce plastic waste.



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