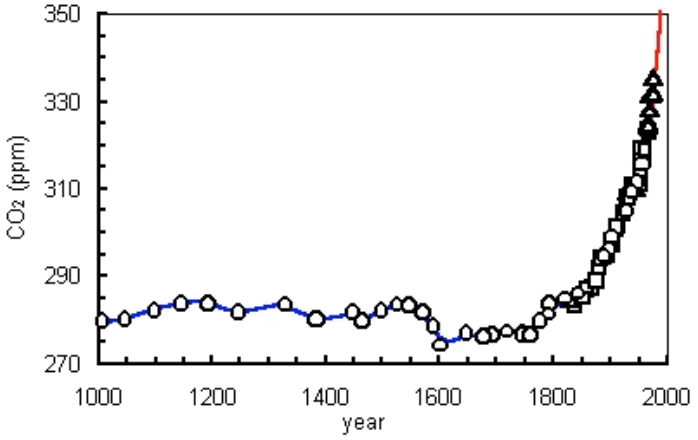
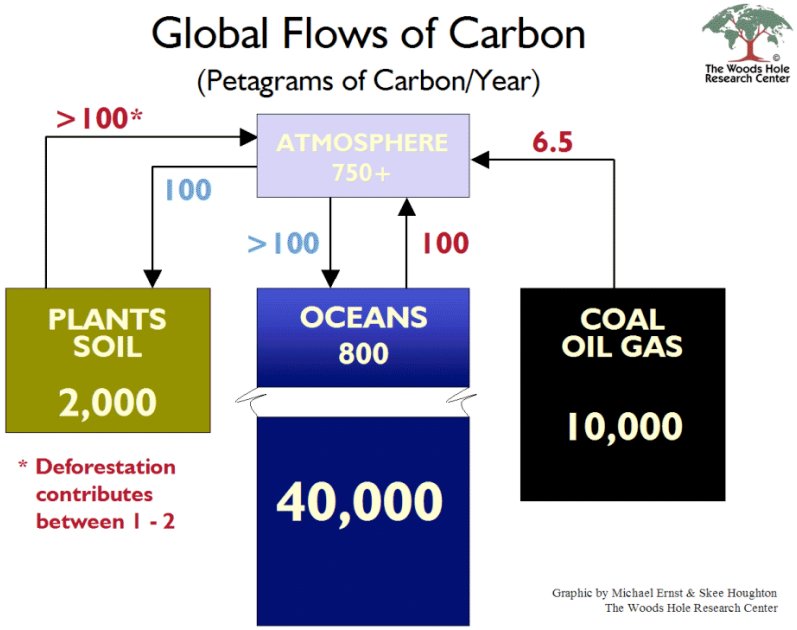
The carbon dioxide record in the Greenland Ice Core





There are three main types of fossil fuels:

(1) Oil and its derivatives

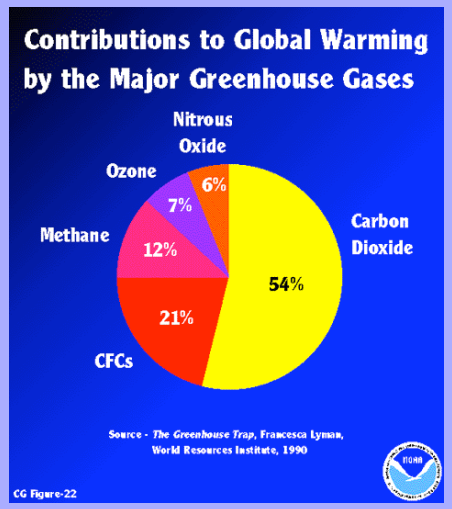
(2) Natural Gas

(3) Coal

Fossils fuels are typically composed of compounds containing hydrogen and carbon atoms. The process of burning fossil fuels always results in carbon dioxide being emitted into the atmosphere. Take the example of natural gas (methane).

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

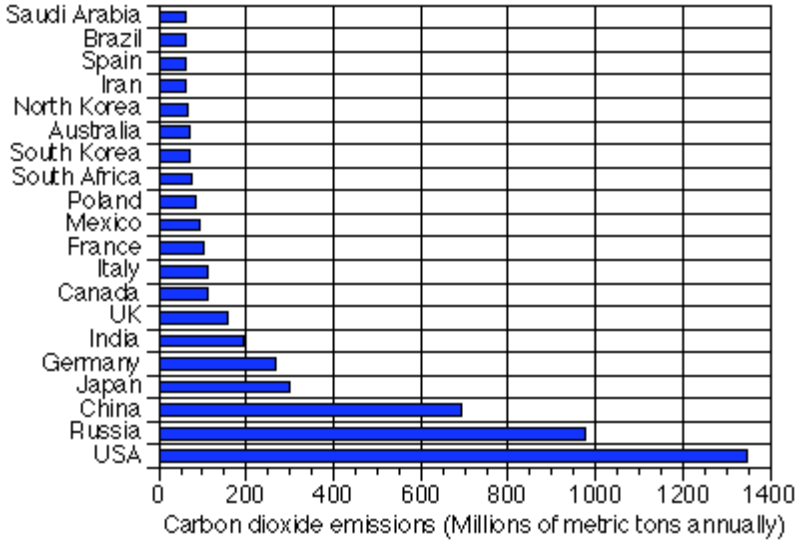
Water and carbon dioxide are the by-products



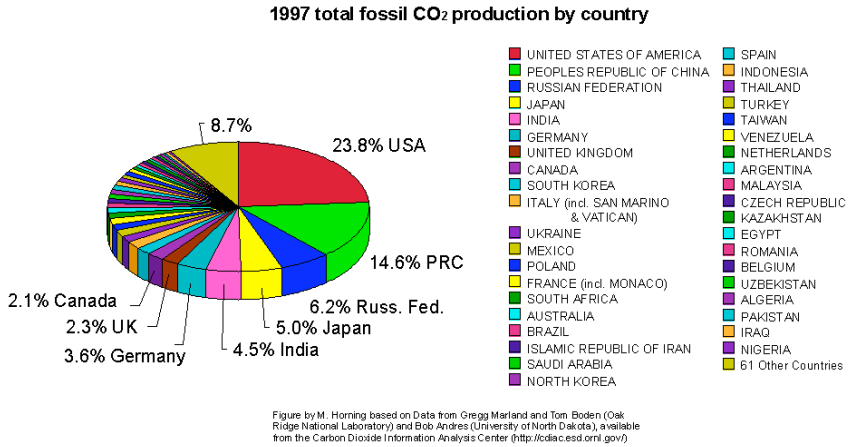
It is critical to understand what controls the CO_2 concentrations in the atmosphere, because the increase in CO_2 makes up more than half of the human enhancement of the greenhouse effect. This is the justification for studying the global carbon cycle.

Let's begin our examination of the carbon cycle by focusing on emissions of CO_2. Currently, about 6.3 gigatons of carbon are released into the atmosphere as a result of fossil fuel burning.

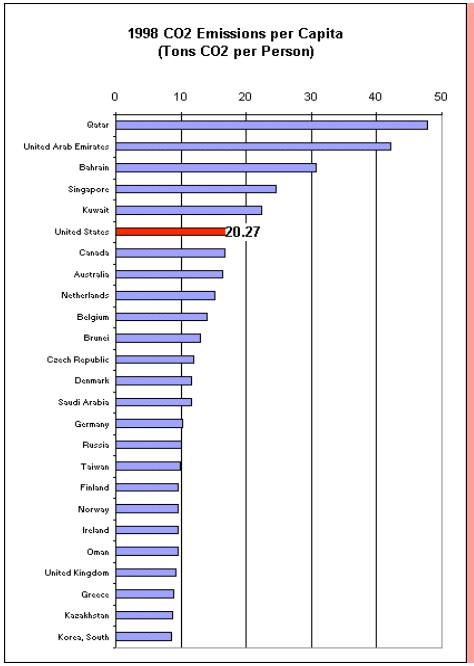
About 40% of this comes from coal burning, another 40% comes from burning of oil and oil derivatives (such as gasoline), and the remaining 20% comes from burning of natural gas (methane).



Here's how the total emissions break down by country.

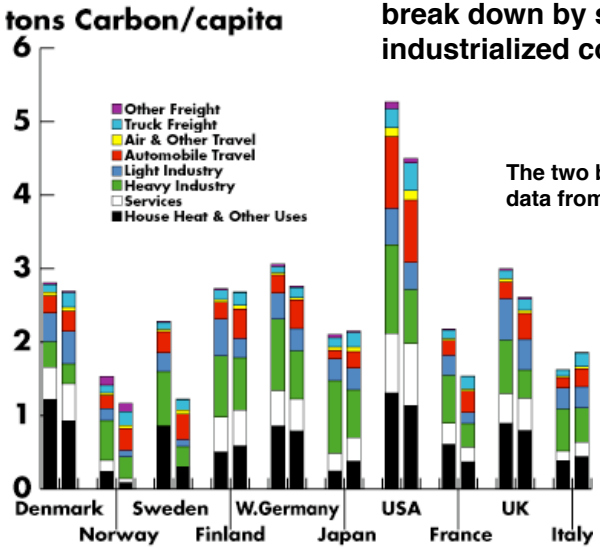


Here's how each country's emissions break down as a percentage of the total.

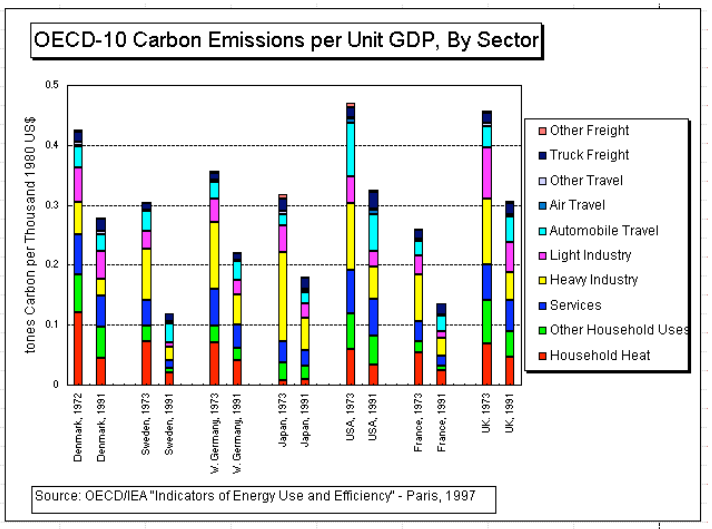


We've seen that the U.S. produces by far the most emissions of CO2 of any country in the world. How does the U.S. compare to other countries on a per capita basis?

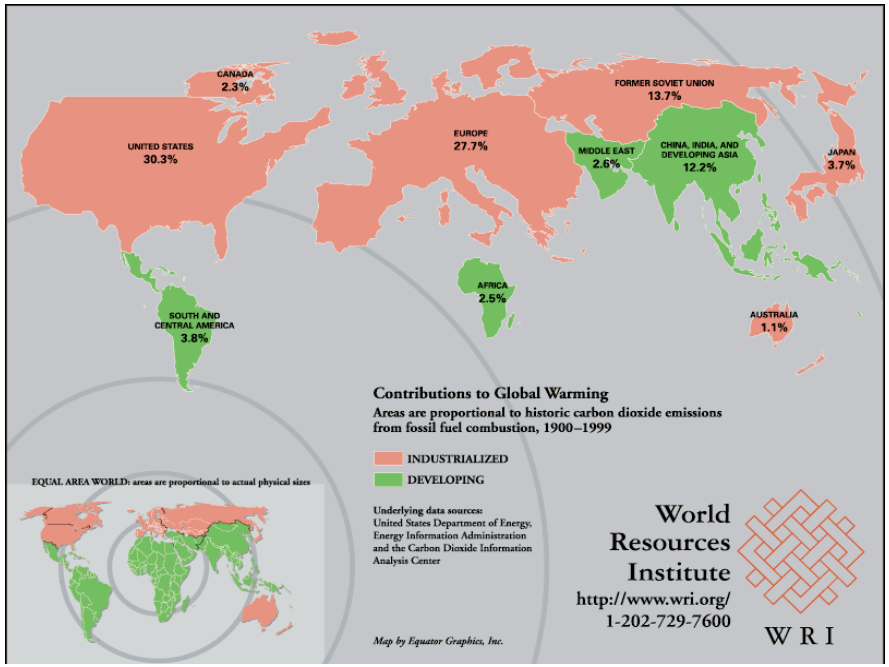
Here's how the emissions break down by sector for industrialized countries.



The two bars represent data from 1973 and 1991

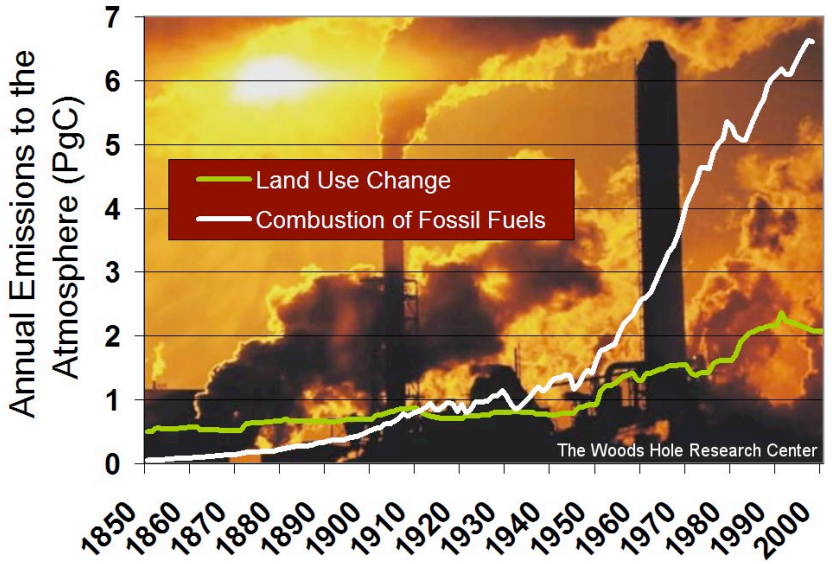


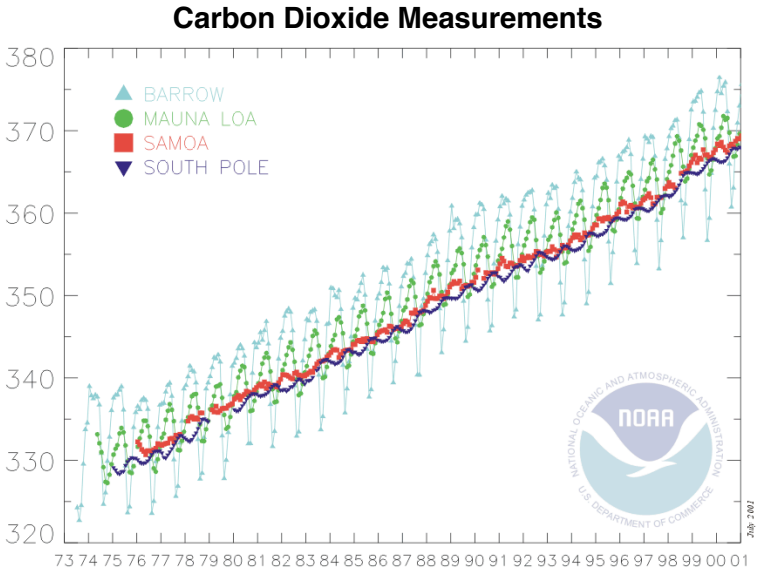
The U.S. does a little better when emissions are normalized by economic output.



Human activity is also adding CO_2 to the atmosphere through deforestation. When tropical forests are clear cut, the land is typically converted to pasture. The original forest and its soil have a much higher carbon content than the pastureland, so the process of burning the forest must result in a significant release of carbon to the atmosphere.

Deforestation is thought to be releasing about 2.2 gigatons of carbon every year into the atmosphere.





Now let's consider what happens to all that CO_2 that is emitted into the atmosphere.

Of the 6.3 gigatons of carbon being put into the atmosphere every year by fossil fuel burning and the 2.2 gigatons being put there by deforestation (total 8.5 gigatons), only about 3.2 gigatons actually remains there.

The amount remaining can be calculated directly from the increase in atmospheric CO_2.

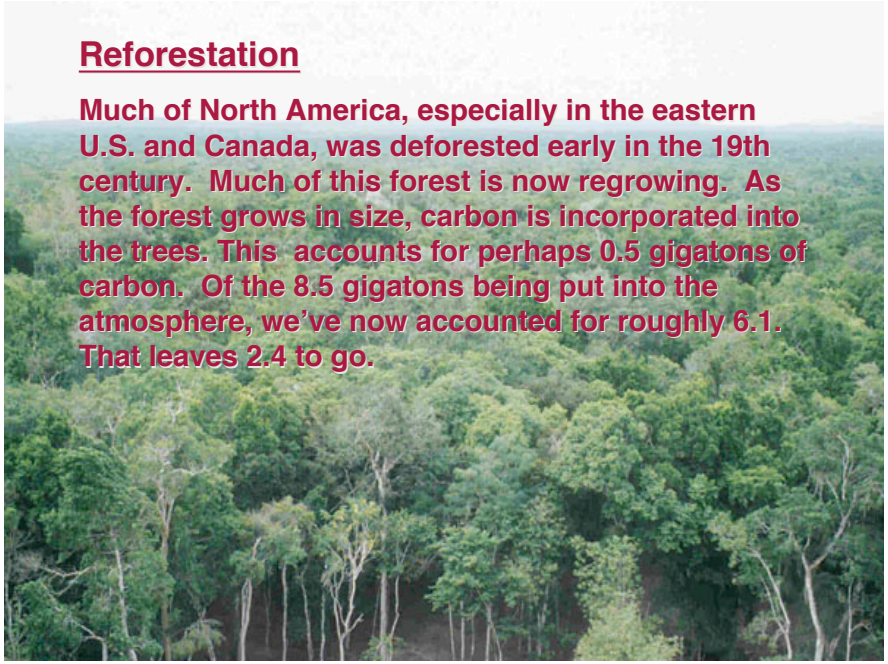
So where is all the excess CO_2 going?

Uptake by the Ocean

The main way anthropogenic CO_2 is removed from the atmosphere is through oceanic uptake. This occurs because CO_2 dissolves in seawater. The excess carbon is eventually incorporated into the skeletons of marine organisms and buried in deep sea sediments as the organisms die and fall to the bottom of the ocean.

This process is thought to remove about 2.4 gigatons of carbon per year from the atmosphere. So we started with 8.5 gigatons, 3.2 are in the atmosphere, 2.4 are taken up by the ocean, leaving us with 2.9 gigatons still to be accounted for.

Reforestation



Much of North America, especially in the eastern U.S. and Canada, was deforested early in the 19th century. Much of this forest is now regrowing. As the forest grows in size, carbon is incorporated into the trees. This accounts for perhaps 0.5 gigatons of carbon. Of the 8.5 gigatons being put into the atmosphere, we've now accounted for roughly 6.1. That leaves 2.4 to go.

CO_2 fertilization

Plants need CO_2 for photosynthesis. They generally obtain this CO_2 through stomata, small openings on their leaves. But plants also lose water, another critical substance for their survival, through their stomata. This makes it essential that they be able to control the size of the stomata. When the CO_2 concentration is increased, the stomata do not have to be as large to take in the same amount of CO_2. So the plants can survive and continue to grow under drier conditions.

It is possible that increased CO_2 levels in the atmosphere are leading to enhanced growth rates of terrestrial plants, accounting for some of the missing carbon.

Microscopic view of the underside of a leaf surface