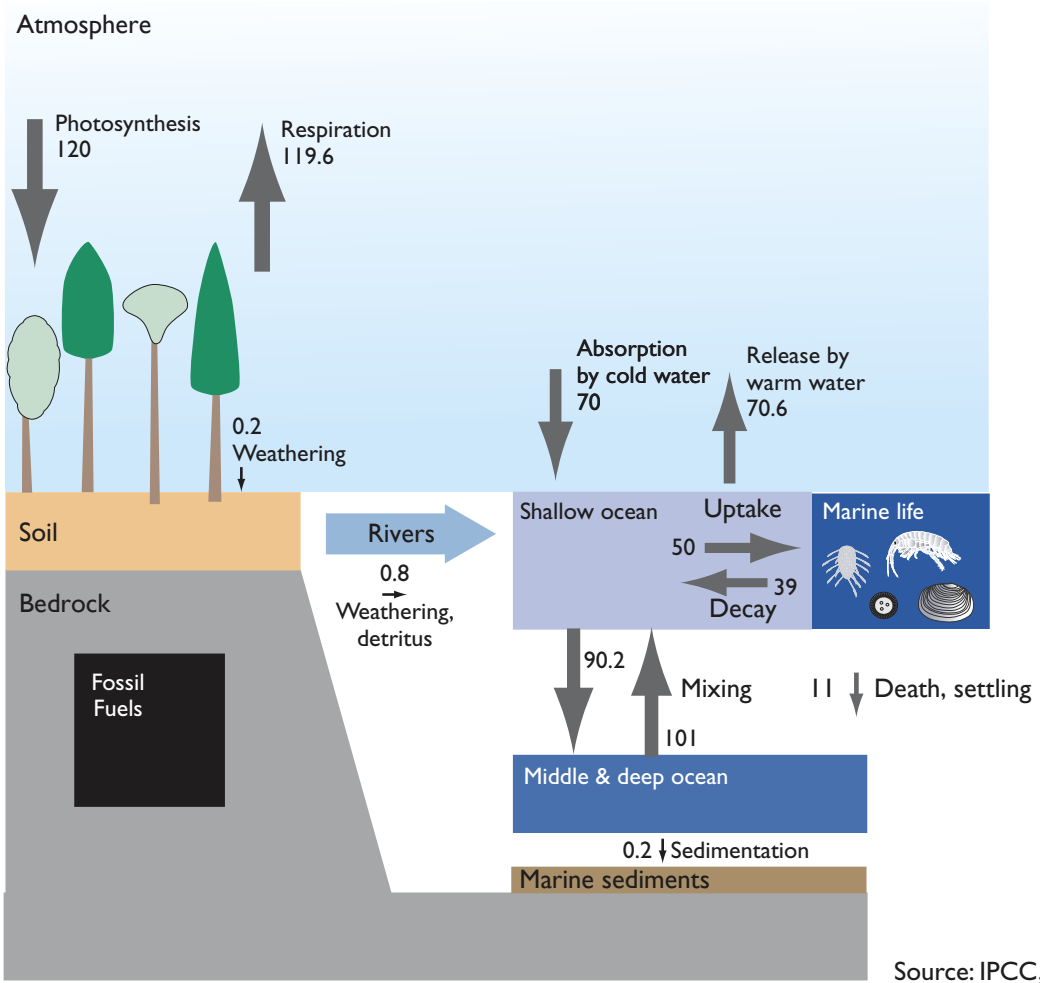
CARBON CYCLE GRAPHS

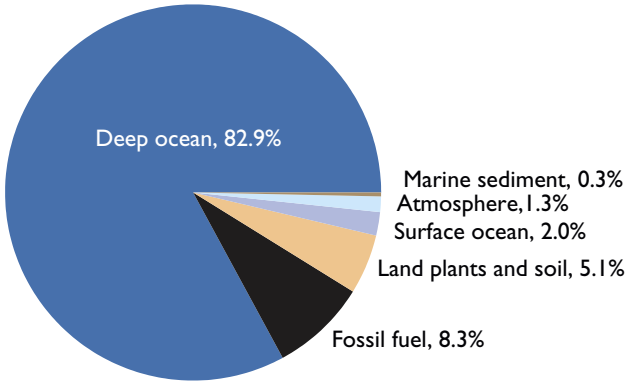
Jerry Jenkins, May 08

WORLD CARBON CYCLING BEFORE FOSSIL FUEL USE



Quantities are fluxes of carbon, in bnillion of tons (gigatons) per year.

WORLD CARBON POOLS BEFORE FOSSIL FUEL USE



Total, 44,750 billion tons carbon

An estimate of the world pools of carbon before the burning of fossil fuels. Fossil fuels include conventional oil, oil sands and oil shales, coal, and natural gas. Marine life, totaling about 3 billion tons of carbon, is too small to show. There is six times as much carbon in locked up in fossil fuels as as there is in the atmosphere.

Source: IPCC, *Climate Change 2007:The Physical Science Basis*, pp. 511-533.

Notes: On land, carbon is taken up by green plants. About half of of what they take up is released by their respiration, and the other half by decay, which is microbial respiration.

The weathering of rocks absorbs a small amount of carbon from the atmosphere, and releases small amounts from rocks. Detritus and weathering products are transported by rivers to the sea.

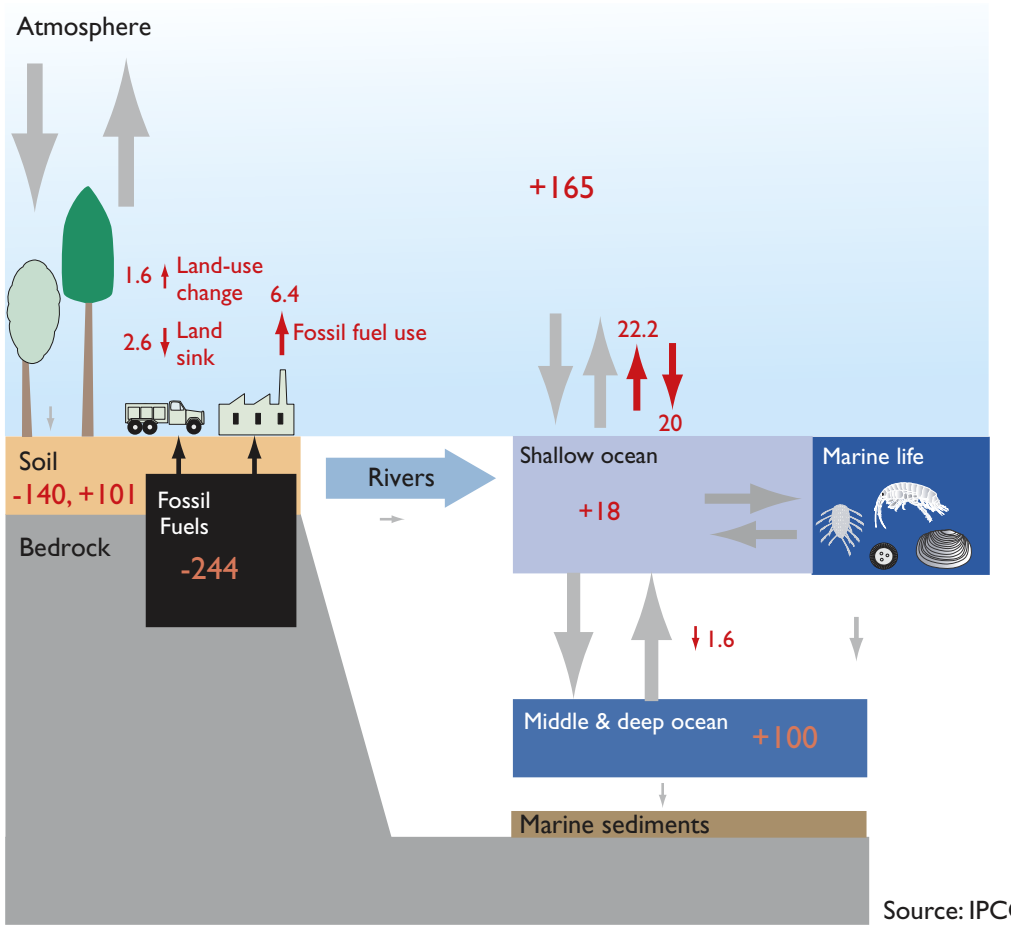
Gasses are more soluble in cold water than warm, and so the sea takes up carbon dioxide near the poles and releases it near the equator. This is called the solubility pump.

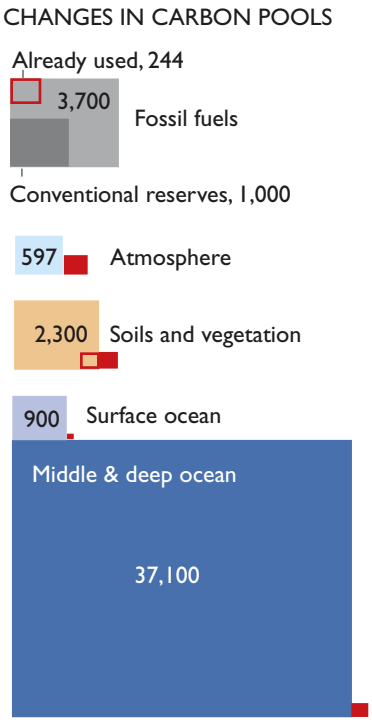
Marine plants use dissolved carbon for photosynthesis, and release it again when they decay. This is called the organic carbon pump. Most of the carbon is recycled by mixing, but a tiny amount settles ro the ocean bottom and accumulates as sediment.

Many marine animals use bicarbonate ions to make shells. When they do this, one molecule of carbon dioxide is released for every carbon molecule that goes into their shells. Since this process generates carbon dioxide, it is called the counter pump. When the shells settle in deep water they eventually dissolve, and their carbon is returned to the surface by mixing.

Before farming and fossil fuels, the major pools of carbon were largely stabile. The land lost a small amount of carbon to the sea each year; some of this remained in the sea, and some was deposited in sediments on the sea bottom.

WORLD CARBON CYCLING CA. 2002





In each of these figures the red squares represent the amount of carbon gained (solid) or lost (hollow) as a result of the burning of fossil fuels.

Source: IPCC, *Climate Change 2007:The Physical Science Basis*, pp. 511-533.

Quantities are pools or fluxes of carbon, in billion tons per year. Gray arrows are the fluxes before fossil fuel use, as in the previous diagram. Red arrows are the new fluxes caused by human activity. Red numbers with pluses and minuses show how much each pool has changed.

Notes: Currently there are thought to be perhaps 1,000 gigatons of carbon in "conventional" fossil fuel reserves (oil, coal, natural gas) and 1,000 to 3,000 gigatons more in "unconventional" reserves like oil sands and oil shales that are hard to extract. There are no exact ways of measuring reserves and no exact definition of what deposits are reserves and what aren't, and so these numbers are uncertain.

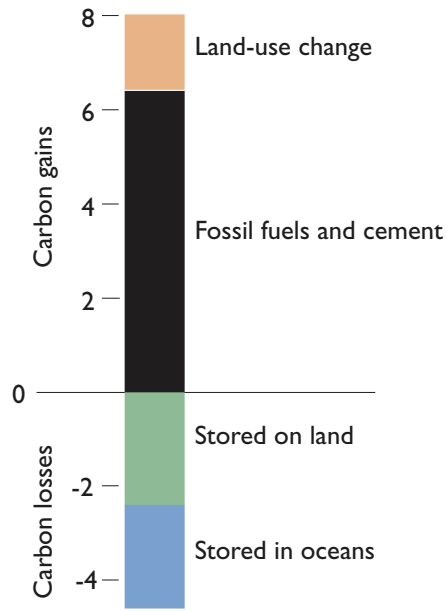
Thus far 244 billion tons of carbon have been released to the atmosphere. This represents about a quarter of the original store of coal, conventional oil, and natural gas.

In addition to the carbon from fossil fuels, approximately 140 tons of carbon have been released by land-use changes, particularly the clearing of tropical forests.

About 43% of the carbon that has been released has remained in the atmosphere. The remainder has been divided between terrestrial vegetation (101 billion tons) where it has offset the land-use changes, and the oceans (118 billion tons). The new terrestrial carbon is most likely in wood plants, especially in regrowing forests and woody scrublands. The new marine carbon is mostly in the middle and deep oceans, where it is changing the pH and altering the ecology.

The carbon that has remained in the atmosphere has increased the carbon dioxide content of the atmosphere by 28%, and is the main cause of global climate change.

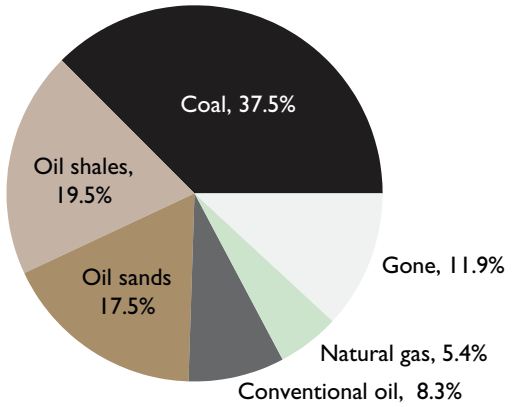
THE CARBON BALANCE OF THE ATMOSPHERE



Gigatons carbon per year

The net increase, after subtracting the losses, is 3.2 gigatons carbon per year. Only the net increase and the emissions from fossil fuels and cement can be measured directly. The other terms are estimated. Source: IPCC, *Climate Change 2007: The Physical Science Basis*, pp. 516.

ESTIMATES OF CARBON IN FOSSIL FUEL RESERVES



Total, 1,810 gigatons carbon

Approximate estimates for remaining and already consumed stocks of fossil fuels. The fuels differ how they are extracted. Conventional oil and natural gas are obtained by drilling, which is cheap and relatively clean. Coal is obtained by either surface or deep mining. Surface mining is relatively cheap, but highly destructive and polluting.

Oil sands are are sand deposits that contain bitumen, a thick form of petroleum. Oil shales are sedimentary rocks with keragen, a solid hydrocarbon, in the pores. Both are mostly extracted by surface mining, followed by heating to extract the hydrocarbons and convert them to oil. They are expensive to extract, and only a portion of the reserves are in use at present. As with the surface mining of coal, the mining operations tend to be large, destructive, and polluting.

The estimate of the fossil fuels already consumed is from IPCC, *Climate Change 2007: The Physical Science Basis*, pp. 516. The estimates of reserves are from Wickipedia, and are consistent with other on-line sources. All estimates of reserves are uncertain and many are politicized. The figures given above are in common use, but may not be right.