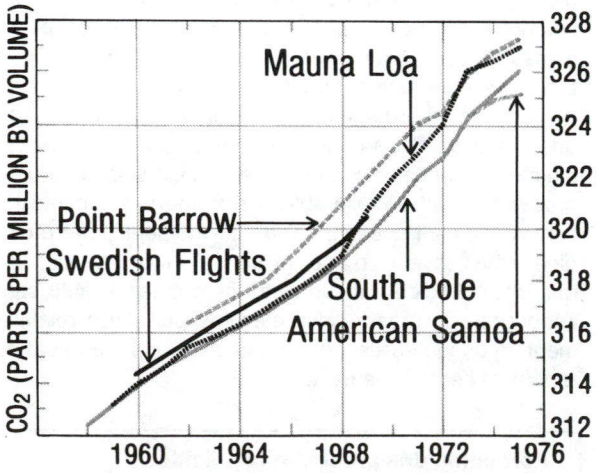
Figure 4-1: THE CONCENTRATION OF CARBON DIOXIDE IN THE EARTH'S ATMOSPHERE



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this dynamic cycle over millions and millions of years. The CO_2 which was removed from circulation and stored underground in the remains of once-living organisms is now termed fossil fuel. Thus, when we burn fossil fuels we release carbon which was taken up from the atmosphere by living plants and stored millions of years ago. When we cut down trees we aggravate the problem further because (1) this reduces total photosynthetic activity; (2) the trees release CO_2 when they are burned or decompose; and (3) their removal bares the soil's surface and allows the humus content of the soil to decompose, releasing even more CO_2 to the atmosphere.

Measurements have shown that the annual harvesting of forest biomass releases approximately the same amount of CO_2 as does the combustion of fossil fuels. This means that no great global dependence upon biomass for energy can be tolerated and that for the biomass which is used there must be a policy of *complete replacement.* Unfortunately, this seems to be an unlikely prospect because even without a large-scale commitment to biomass energy the size of the Earth's forests is rapidly diminishing.

It is perhaps difficult for many to think of carbon dioxide as a pollutant because it is a natural and essential component of our atmosphere. But it is not the gas itself which is the problem; it is its atmospheric *concentration* which is potentially environmentally disruptive. This is because there is an intimate relationship between the amount of CO_2 in the air and the Earth's temperature and climate.

The Greenhouse Effect

The atmosphere is composed of molecules we are all familiar with (oxygen, nitrogen, carbon dioxide, water vapour and so forth), but not everyone is aware that these molecules have the ability to absorb energy of certain wavelengths. Most atmospheric gases, including carbon dioxide, are transparent to the relatively short wavelengths of incoming solar radiation; thus much of the incoming energy passes through the atmosphere to be absorbed or reflected by the Earth's surface. At longer wavelengths — the wavelengths at which the Earth reradiates — CO_2 and water vapour are the two main energy-absorbing molecular species in the atmosphere.

When these molecules absorb energy, they cause general atmospheric warming, a phenomenon commonly called the "greenhouse effect" because it is roughly analogous to the warming of a glassed enclosure. A greenhouse is transparent to incoming solar radiation but it impedes heat loss (in this case by preventing convection) and consequently warms up. If the atmosphere warms because of increased energy absorption due to elevated concentrations of CO_2, the surface temperature of the Earth will also rise by means of heat transfer.

The oceans contain a tremendous amount of carbon and they have traditionally been called a sink for or absorber of CO_2, but it is now becoming apparent that the seas may not be the answer to reducing or even controlling the steadily increasing concentration of atmospheric carbon dioxide. (In 1980, the combustion of fossil fuels was expected to release the equivalent of 5.57 billion tonnes of CO_2 (Munn *et al,* 1980) and deforestation probably released an equivalent amount.) There seems to be little dispute that the world's oceanic reservoirs could absorb all the CO_2 man is ever likely to generate, even if he burns the Earth's entire fossil fuel resources. The question is one of time.

Various research techniques have indicated that the rate of turnover of the ocean's thermally stratified waters is very slow. The warm surface waters (some 100 to 200 meters deep) mix with colder deep waters with an exchange time in the order of a thousand years or so. Thus if the surface waters of the oceans did become saturated with carbon dioxide, the removal of elevated levels of atmospheric CO_2 could take an amount of time in the order of several human lifetimes.

What will the effects of this carbon dioxide accumulation be? Scientists indicate that if the air's concentration of CO_2 were to double, this would have the potential