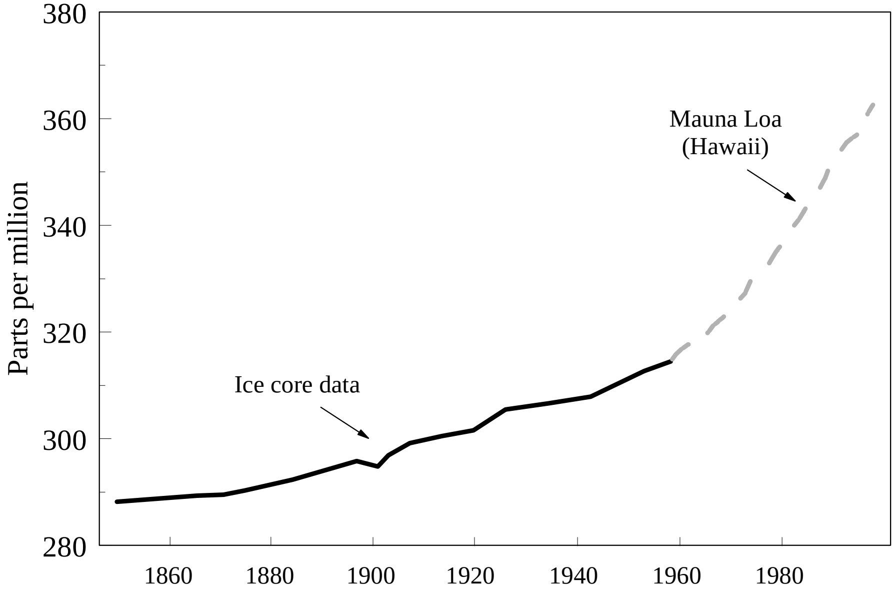
THE RISKS OF CLIMATE CHANGE

The greenhouse effect naturally warms the Earth's surface (see Figure 9). Without it, the Earth would be 60° F cooler than it is today -- uninhabitable for life as we know it. Water vapor, carbon dioxide, and other trace gases such as methane and nitrous oxide, trap solar heat by slowing the loss of heat by radiative cooling to space, thereby keeping the Earth's surface warmer than it otherwise would be.

Figure 9: The Greenhouse Effect

Since the beginning of the Industrial Era in the middle of the 19th century, the concentration of CO_2 in the atmosphere has been steadily increasing (Neftel et al. 1985, 1994; Keeling and Whorf 1997; see Figure 10). Beginning in 1958, continual measurements of atmospheric CO_2 concentrations have been made by scientists at an observatory on Mauna Loa, Hawaii (Keeling and Whorf 1997). The seasonal cycle of vegetation in Northern latitudes is evident in this record; each spring the vegetation "inhales" and absorbs CO_2, and each autumn most of that CO_2 is released back to the atmosphere. Overall, atmospheric CO_2 has increased over 30% from 280 parts per million (ppm) to over 360 ppm since 1860 (Schimel et al. 1996).

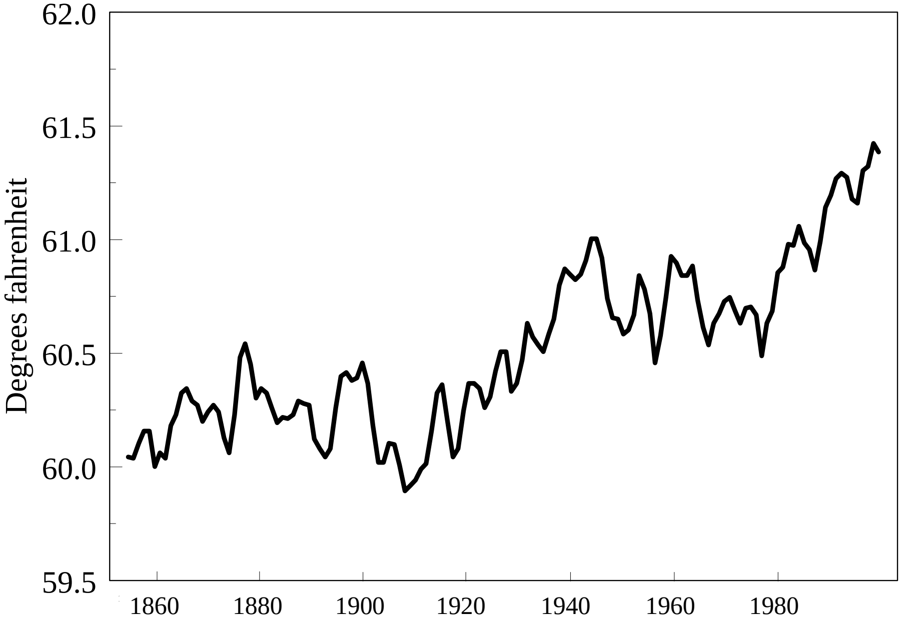
Figure 10. Atmospheric Carbon Dioxide Concentration



Sources: Neftel et al. 1985; Keeling and Whorf 1997.

Over the past century, the global average temperature has risen by approximately 1° F (Nicholls et al. 1996; Jones et al. 1998; see Figure 11).[9] Further, recent analyses have indicated that 1997 was the warmest year on record and that nine of the past eleven years have been the warmest on record (Quayle et al. 1998, Karl 1998). In addition, a recent study found that the Northern Hemisphere appears to have experienced its three warmest years since 1400 during the present decade (Mann et al. 1998).

Figure 11. Global Average Temperature

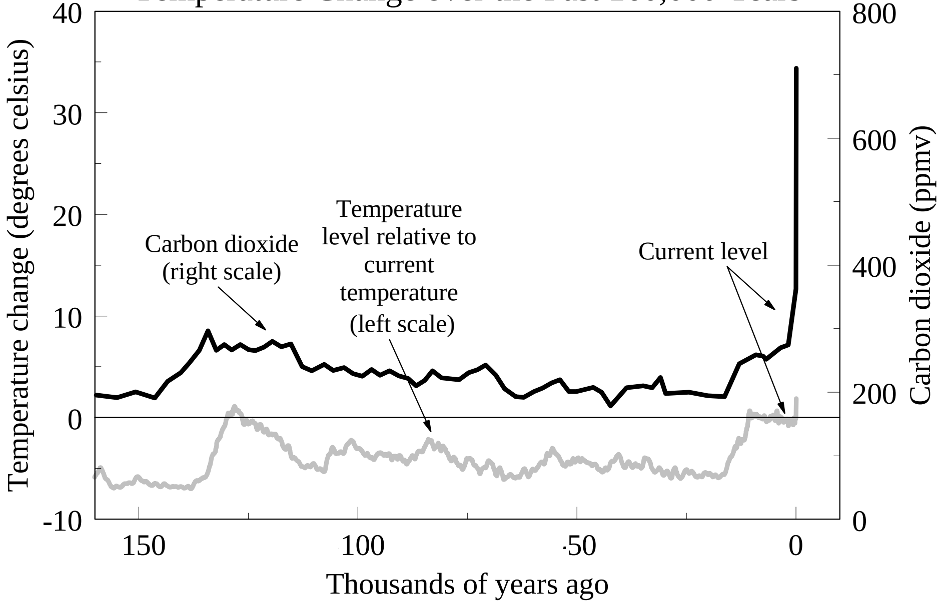


Note: Data are expressed as 3-year centered averages.
Source: Jones et al. 1998.

[9] The approximate 1° F temperature rise over the past century is derived from a regression analysis of the temporal data. Because the annual global average temperature is variable from year to year, it is inappropriate to simply select two years to quantify the increment. The trend or regression is a more appropriate means to calculate the century's temperature rise.

Temperature changes in recent decades bear out the close correlation between carbon dioxide concentration and temperature found in ice core data going back 160,000 years (Barnola et al. 1987, 1994). Since the beginning of the Industrial Era, the CO_2 level has increased steadily and is already outside the bounds of variability seen in the 160,000 year record (see Figure 12). Continuation of current levels of emissions is projected to raise concentrations to over 700 ppm by the year 2100, a level not experienced on Earth since about 50 million years ago. It is anticipated that if the CO_2 levels increase to this level, then the global average temperature will rise between 1.8 and 6.3° F by the year 2100 (Kattenberg et al. 1996). This range of temperature impacts was developed by the Intergovernmental Panel on Climate Change using a set of alternative plausible assumptions about climatic response to higher greenhouse gas concentrations, the effects of aerosols (such as sulfate particles) that can offset warming, and several economic parameters. In general, the temperature change experienced would be greater at higher latitudes than at lower latitudes, and greater over land than over the oceans (Kattenberg et al. 1996). Thus, temperature increases in much of the United States would be expected to be substantially greater than the average global increase.

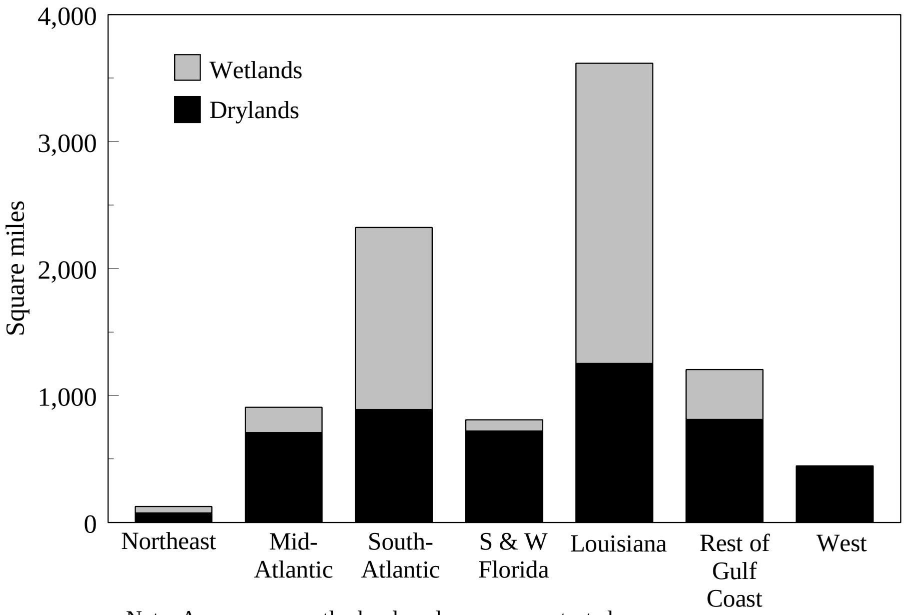
Figure 12. Atmospheric Carbon Dioxide Concentration and Temperature Change over the Past 160,000 Years



Sources: Barnola et al. 1994; Chapellaz and Jouzel 1992.

Global warming of the magnitude projected by the IPCC will have many effects due to changes in local temperature and precipitation patterns, an induced rise in sea level, and altered distribution of freshwater supplies. By 2100, sea level is expected to rise by 6 to 37 inches (Warrick et al. 1996). An average 20-inch sea level rise would result in substantial loss of coastal land in the United States especially along the southern Atlantic and Gulf Coasts, which are currently subsiding and are particularly vulnerable (Titus et al. 1991; Smith and Tirpak 1989; see Figure 13). Even if greenhouse gas concentrations were stabilized at about 560 ppm (double the pre-industrial concentration) within the next century, the sea level would continue to rise for several centuries because of the large inertia in the coupled ocean-atmosphere-climate system (Warrick et al. 1996). If the carbon dioxide concentration were to increase 1% per year until it reached approximately 560 ppm, and then were to stabilize, the sea level would continue to rise from thermal expansion alone (Manabe and Stouffer 1993, 1994).

Figure 13. U.S. Coastal Lands at Risk from a 20-inch Sea Level Rise in 2100



Note: Assumes currently developed areas are protected.
Source: Titus et al. 1991.

The effects of the global climate system described above do not include potential non-linearities in the relationships between greenhouse gas concentrations and temperature, between temperature and economic damages, or in the various other complicated relationships governing interactions among greenhouse gas emissions, the climate, and the economy. Three possibilities serve as illustrations. Warming of Northern tundra might release large amounts of methane from the subarctic permafrost, thereby acting as a positive feedback on the climate, leading to potentially devastating acceleration of an otherwise controllable global warming process (Nisbet and Ingham 1995). Second, evidence from the historic record suggests that some types of climate change might lead to abrupt changes in ocean currents, including displacement of the currents that warm Western Europe. Evidence from ocean core samples suggests such changes of ocean currents have occurred in previous ice ages (Broeker 1997). Third, warming might cause accelerated melting of the Antarctic ice sheet causing even more substantial increases in sea levels (Rott et al. 1996; Vaughan and Doake 1996). These potential nonlinearities strengthen the argument for taking prompt, reasonable steps to mitigate climate change.