Box 1.6 Carbon Storage

Carbon is the basis of life, cycling through the oceans, atmosphere, vegetation, and soils. Through photosynthesis, plants take up carbon as carbon dioxide (CO_2) and convert it to sugar for energy; animals consume the plants; and when both plants and animals die, carbon is returned to the atmosphere as the organisms decay. But ever-increasing emissions of carbon from fossil fuel combustion and deforestation are unbalancing the global carbon cycle; there's less carbon in the soil and vegetation and more in the atmosphere. Because CO_2 in the atmosphere captures the sun's heat, increasing amounts destabilize the global climate.

It is estimated that prior to the 18th century, increases in atmospheric carbon were less than 0.01 billion metric tons of carbon (GtC) per year (Ciaias 1999). The Industrial Revolution and subsequent global development greatly increased fossil fuel emissions, as did the clearing of forests and other land-use changes that release carbon. By 1998, there was approximately 176 GtC more carbon in the atmosphere than in 1850, an increase of nearly 30 percent (IPCC 2000:4). Today, human activities emit an estimated 7.9 GtC to the atmosphere annually (IPCC 2000:5). The oceans absorb slightly less than 30 percent of this carbon and terrestrial ecosystems absorb slightly more, but that leaves 40 percent of yearly emissions to accumulate in the atmosphere (IPCC 2000:5).

Earth's Annual Carbon Budget, 1989–98

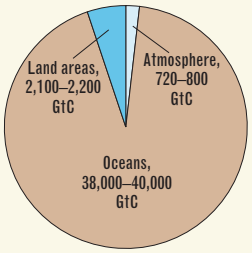
Type of emission or uptake	Gigatons of carbon per year
Human-induced emissions into the atmosphere	
Emissions from consumption and production (fossil fuel combustion and cement production)	6.3 ± 0.6
Net emissions from land use change (fires, deforestation, agriculture)	1.6 ± 0.8
Ocean and terrestrial capture from the atmosphere	
Net uptake by oceans (photosynthesis and ocean capture minus ocean release)	2.3 ± 0.8
Net uptake by terrestrial ecosystems (photosynthesis and terrestrial storage minus decay and respiration)	2.3 ± 1.3
Carbon added to the atmosphere each year	3.3 ± 0.2

Source: IPCC, 2000:5. Error limits correspond to an estimated 90 percent confidence interval. Emissions from consumption and production are calculated with high confidence. Net emissions from land use change are estimated from observed data and models. Uptake by oceans is based on models. Carbon added to the atmosphere each year is measured with high accuracy. Uptake by terrestrial ecosystems is an imputed amount (the difference between total emissions and estimated uptake by oceans and atmosphere).

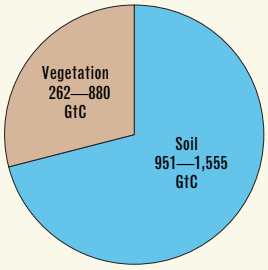
Reducing anthropogenic carbon emissions is one way to mitigate climate change. Other ways depend on maintaining the ability of ecosystems to absorb carbon. Through photosynthesis, plants provide the most effective and efficient way to recapture and store atmospheric carbon.

- Oceans are the major carbon reservoir or "sink." Through chemical and biological processes, including phytoplankton's growth and decay, oceans store roughly 50 times more carbon than is in the atmosphere, mostly as dissolved inorganic carbon (IPCC 2000:30).
- Soil and its organic layer store about 75 percent of total terrestrial carbon (Brown 1998:16). Most of the carbon released to the atmosphere in the last 2 centuries occurred as grasslands and forests were converted to agricultural uses.
- Forests are the most effective terrestrial ecosystem for recapturing carbon, but not all forests offer the same sequestration benefits. Faster-growing young trees absorb about 30 percent more carbon than mature wood, but an older forest stores more carbon overall in the soil and in above- and below-ground vegetation than a tree plantation of the same size. Latitude, climate, species mix, and other biological and ecosystem factors also affect carbon fluxes in forests (see Brown 1998:10).

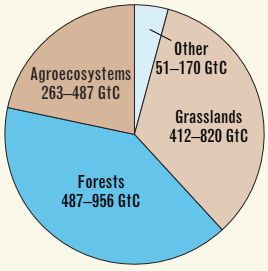
Global Carbon Storage



Carbon Stored in Soil versus Vegetation



Carbon Storage in Terrestrial Ecosystems



Sources: IPCC 1996:63; Matthews et al. [PAGE] 2000. Data on carbon stored in soil versus vegetation and in terrestrial ecosystems is derived from the International Geosphere-Biosphere Programme. Thus estimated share of carbon in each ecosystem varies slightly from PAGE results in Chapter 2, because PAGE definitions of ecosystems accommodate some overlap of transitional areas.