Chapter 6

6 THE GEOGRAPHY OF CARBON

The Earth's surface is characterized by abundant carbon in various repositories. These include the dynamic vegetation and animal communities that comprise global terrestrial biomes and their soils as well as aquatic ecosystems. However, these environments have been substantially modified by anthropogenic factors such as agriculture, forestry, fossil-fuel use, industrialization and urbanization. The natural and anthropogenic, or alternatively the ecological and economic, facets of carbon-cycle dynamics of the global environment involve carbon fluxes/flows all of which contribute to the ever-changing geography of carbon and its biogeochemical cycle (Section 2.3). In the last 50 years there has been increasing recognition that human impact on the Earth's surface is a threat to the very existence of organisms and even to humanity itself. Consequently several methods to express this impact have been devised, notably to illustrate the degree of national/regional/local sustainability. One such measure is the 'ecological footprint', the major inputs of which reflect carbon manipulation and the use of other natural resources such as water. The quantity and quality of the latter are indeed a concern worldwide but because carbon lies at the heart of anthropogenic impact a carbon index would be equally appropriate.

Natural biomes/ecosystems are dynamic entities that have emerged from the environmental changes of the 10,000 years of the present interglacial, the Holocene. They can be classified in various ways with an emphasis on the dominant vegetation type which is a function of climate and soils. Biomes also comprise fauna and micro-organisms which are also stores of carbon in living matter while soils, as well as providing a habitat, contain a large volume of carbon as dead organic matter. There are fluxes of carbon between the biome/ecosystem components and the atmosphere, via the processes of photosynthesis, respiration and decay (Section 3.6), as components of the carbon biogeochemical cycle which is described in Section 2. 3. Whilst natural environmental change has been ongoing, its pace has been relatively slow when compared with the rate of modification by human action, especially in the last 5,000 years. This anthropogenic factor continues to exert a significant and increasingly severe impact on the Earth's carbon geography. One aspect of this impact is agriculture which has implications for the distribution and function of natural ecosystems as these are either modified or replaced. Such alterations generally result in a reduction in carbon storage. As discussed in Section 5.2, agriculture has been a major cause of environmental change since its inception c. 10,000

years ago and one which has escalated in the last 350 years. Agricultural systems are not uniformly distributed on the Earth's surface because they are constrained by the same factors as natural ecosystems, i.e. climate and soils. Thus their distribution is another manifestation of the geography of carbon and its move from place of production to place of consumption.

Fossil-fuel production and consumption also influence the global geography of carbon. Fossil-fuel producers are not always the major consumers and so carbon flows occur between the two as is the case with many products of agriculture. The magnitude of flow, which is economic rather than ecological, depends largely on the degree of industrialization so this too is a consideration in the geography of carbon. The demand for wood and wood products worldwide also means that forestry is another source of economic carbon flows. The type of forestry defines how sustainable it is; poorly managed removal of primary forest will result in huge carbon losses, especially if the land is then used for agriculture, whereas managed plantation forestry not only provides a product but also acts as a carbon sink. Forestry is thus one means of managing the carbon cycle and is an important component of proposed carbon trading between nations. This is a component of the Kyoto Protocol (see Chapter 8) to tackle climatic change. It requires developed nations to reduce their greenhouse gas emissions to at least 5 percent below 1990 levels by 2008 and for those nations who do not reach this goal may offset a proportion of their emissions through forest planting. Concentrations of people in urban areas are the main sink for these carbon flows. Urban areas produce no carbon directly but they rely on carbon imports, especially wood, food and fossil fuels. They constitute what the US ecologist, Eugene Odum (1975) described as 'fuel-powered urban-industrial systems' which exist on the basis of imported organic and inorganic resources and produce organic and inorganic waste. Carbon dioxide is a major output, resulting in a gradual increase in its concentration in the atmosphere which is the chief cause of global warming. As entities, cities generate wealth but they are inherently unsustainable; they only become sustainable through reliance on their hinterlands for food, fuel, waste disposal etc. This hinterland may include other nations. The relationship between the producing and consuming components of a region or nation can be quantified to give a measure of sustainability. This provides a basis for quantifying human impact at various scales or by specific activity.

6.1 World ecosystems

An ecosystem comprises biotic and abiotic components between which there is interdependence and an exchange of materials. Biotic components are organisms, including micro-organisms while abiotic components include soil, rock and atmosphere. The relationships and exchange of