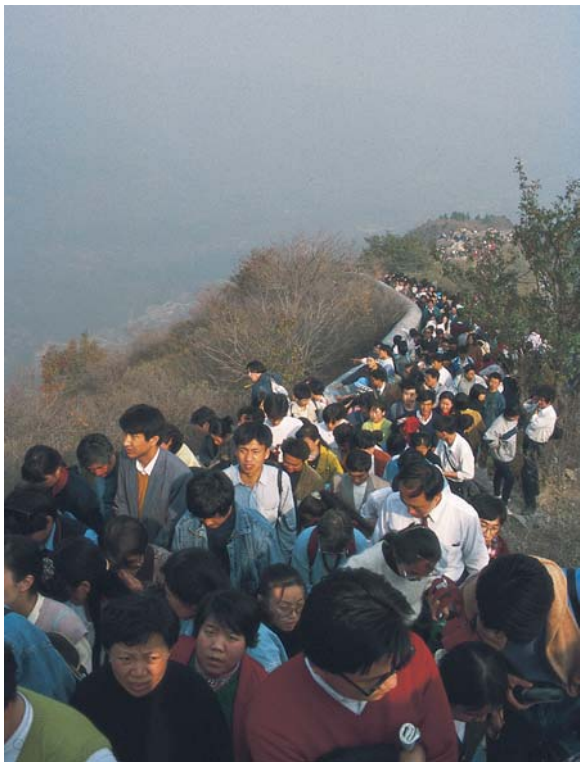
5.1

Global Change and Global Institutions



The study of global change is primarily concerned with the question: In what way has man interfered with the structure and functioning of natural ecosystems? How many people can the earth sustain, i.e. what resources can man use? The figure shows a stream of people leaving Beijing for the surrounding hills on a public holiday. A tight snake of patient, happily conversing people make their way up a narrow path to the top of the "Fragrant Hill" to admire the view. They return to the bottom on a parallel path and the surrounding vegetation remains largely undisturbed. Many people carry a single, autumnal, coloured leaf back to Beijing as a memento of their trip. In the background, barely visible in the photochemical smog, is Beijing with 10 million inhabitants. Photo E.-D. Schulze

Recommended Literature

For a summary of problems of global change, see *World in transition: conservation and sustainable use of the biosphere* (WBGU 2001 a) and *The terrestrial biosphere and global change* (Walker et al. 1999). Current knowledge on climate change is summarised in the third report of the IPCC-WG I (IPCC-WG I 2001).

Global change includes changes in land use and climate of the planet caused naturally and by man (anthropogenic; definition from IGBP: Walker et al. 1999):

global change =
change in climate + changes in land use

Land use and changes in land use may have many direct and indirect consequences, for example, destruction of soil, erosion, and desertification. During geological time, changes in the earth's climate and vegetation have always occurred independently of these human influences. However, the rate and extent of the changes caused by human activity have increased dramatically since the beginning of industrialisation, so that, within a very short period of about 50 years, the conditions required for human life are in jeopardy. The plant ecological aspect of global change may be formulated as:

- Questions about the interaction between climate and land ecosystems (IPCC-WG I, Chap. 9; Melillo et al. 1996)

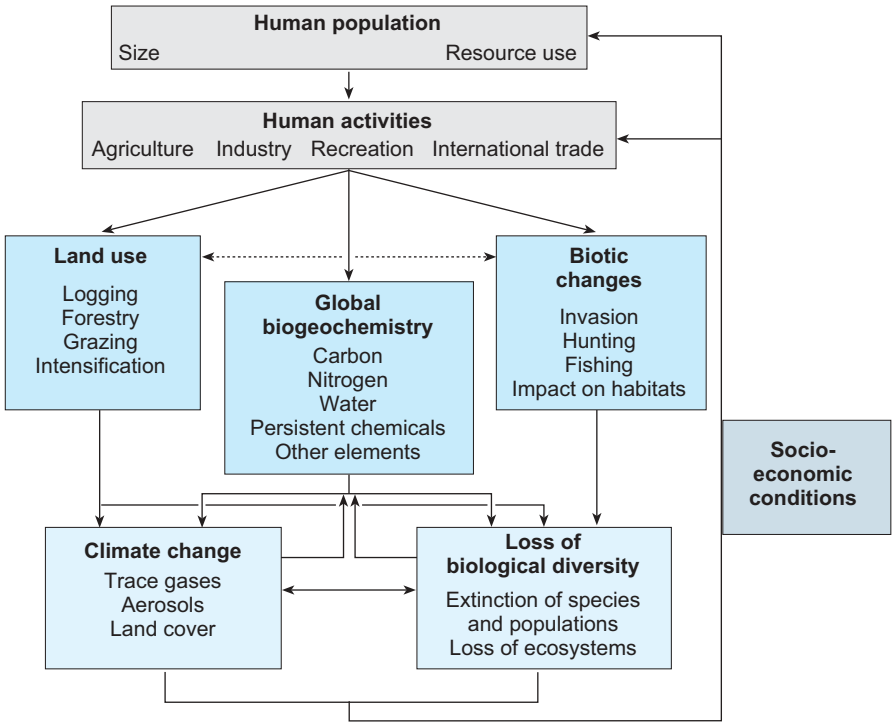


Fig. 5.1.1. Schematic illustration of the interaction between human activity and global change. Human population size and use of resources via specific activities (agriculture, industry, leisure and trade) have effects on land use, the global biogeochemical cycles and biodiversity. These influences initiate changes in climate and in biodiversity and both, in turn, influence populations and resources used by people. How this feedback occurs, and how strong it is, depends on socio-economic parameters. Thus it is difficult to predict scientifically how climate change will affect the situation in developed and in developing countries. After Vitousek et al. (1997)

  - What are the effects on terrestrial ecosystems of changes in climate and land use?
  - What are the effects on the climate of feedback reactions resulting from changes in terrestrial ecosystems?
- Questions about the importance of species for ecosystem function (GBA 1996, Chap. 7; Mooney et al. 1996)
  - Does the presence of many or few species have any effects on the "functioning" of ecosystems?
  - Are species with similar functions in ecosystems exchangeable, or are there effects on the material turnover in these ecosystems?

"Functions" of ecosystems are understood to be the many processes that are important to man, for example, biological productivity, filtration and purification of air and water, replacement of ground water, storage of carbon dioxide, etc.

The questions mentioned above are discussed at different levels elsewhere this volume (ecosystems: Chap. 3; synecology: Chap. 4). Some of these questions will be discussed in the following at a global level with particular emphasis on the interactions between emissions, climate and global material cycles. Considering these aspects, plant ecology is part of other scientific subject areas particularly geo-ecology which considers anthropogenic pollutants, in addition to natural material changes. Also biogeochemistry examines material cycles between atmosphere, ocean and land. These global material cycles are regulated by organisms particularly with respect to changes at the boundary layer between atmosphere and land.

The influence of man on natural material cycles is determined by the population size and consumption of resources (Fig. 5.1.1; Vitousek et al. 1997) shown by "activities" in agriculture and forestry, industrial production, world trade and tourism. These activities are expressed as:

- land use,
- changes of the biological conditions in natural ecosystems,
- changes in global material cycles.

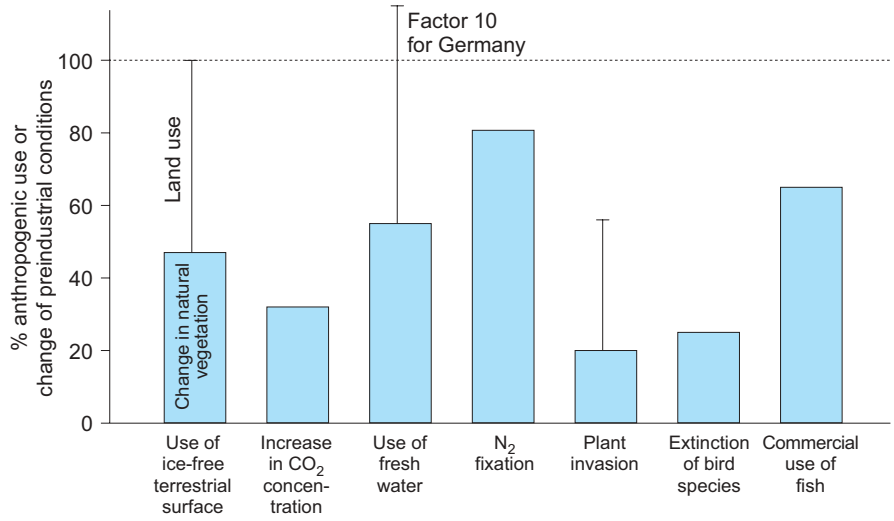


Fig. 5.1.2. An example of the influence of man on global processes in comparison to the period before industrialisation (conditions in 1880 = 100%). Here, the use of land area, the rise in CO_2 concentration, the extent of freshwater usage (in Germany one water molecule that falls as rain is used ten times, including as cooling water, before it reaches the sea), biological and industrial N_2 fixation, changes in natural flora by invasion of foreign species, loss of bird species and the use of natural fish stocks are shown. (After Vitousek et al. 1997)

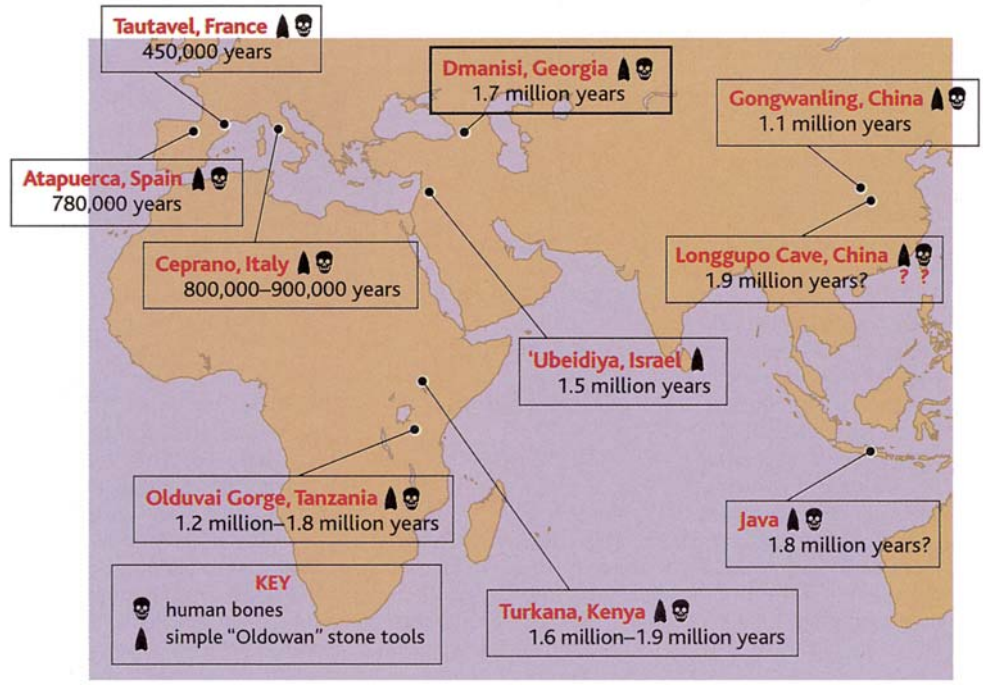
These changes influence global climate and biodiversity and, by feedback reactions, may affect humanity. How these feedback reactions operate essentially depends on socio-economic parameters in the future (see below).

The extent of man's use of natural resources can no longer be neglected (Fig. 5.1.2, after Vitousek et al. 1997). At present, there is no spot on the ice-free surface of the earth that is not used by man for food production, raw material extraction and processing, settlements, infrastructure or tourism. Natural vegetation has been entirely displaced by man from about 50% of the earth's surface, and the other half is used for grazing, hunting, gathering and for tourism. This massive exploitation of the globe, together with industrialisation, is the cause of the CO_2 concentration of the earth's atmosphere to have increased by a third since industrialisation. Globally, about 50% of fresh water is used by humans. In Germany, the same litre of water is used two to three times before it reaches the sea (Lehn et al. 1996). On a global scale, industrial nitrogen fixation at present is similar in magnitude to natural N_2 fixation. Invading plants replace 20% of natural plants in ecosystems (up to 50% in some types of vegetation). About 20% of bird species are extinct, 60% of fish stocks is overused by man for food or to provide fish meal as food for farmed fish (Naylor et al. 2000). Thus, globally, man has intervened in all aspects of life without evaluating the natural resources, let alone any consideration of planned management on a global scale.

Yet man's influence is not restricted to the present time (see also Chap. 4.2). Man's war of conquest against nature started at the transition from Pliocene to Pleistocene and reached Europe approximately 1.7 million years ago (China 1.9 million years ago and Java 1.8 million years ago; Fig. 5.1.3 A; Balter and Gibbons 2000). These are not individual immigration waves, but different immigrations by different subspecies of man (Balter 2001). Intensive settlement in the Mediterranean region occurred 30,000 years ago, when *Homo sapiens* lived together with *Homo neanderthalensis* in southern Europe (Gibbons 2001); probably at that time the first settlements occurred. North America was reached by man about 19,000 years ago.

The terms "environment" and "environmental change" have several meanings in the context of global change. Biological aspects need not necessarily be the most important. The following aspects should be distinguished:

- Conditions under which the individual lives and works (job security, social security, indoor climate, etc.). These social environmental conditions can be improved, independently of global ecological environmental problems. Social well-being does not mean a "healthy"



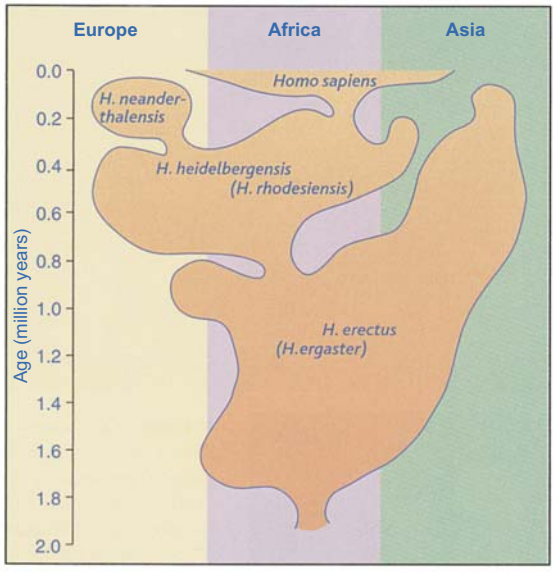


Fig. 5.1.3. A The oldest human fossils and tools in southern Europe and Asia (Balter and Gibbons 2000). B Development of the human species and subspecies in the last 2 million years and their distribution in Africa, Europe and Asia (Balter 2001). C The migration of modern man into southern Europe via the Middle East. (Gibbons 2001)

environment. Prosperous nations contribute substantially to global ecological and climatological problems even though the individual may live in a secure environment.

- Conditions of the economy at the national level. This includes exhaustion of resources, e.g. by clearing forests, use of mineral resources and increasing industrial production, where economic growth and intervention in the biological environment are closely linked.
- Effects of certain measures on global cycles, particularly on emissions. This aspect is closely coupled with the points mentioned before but it is dealt with separately here, because of the effects of most emissions on climate.

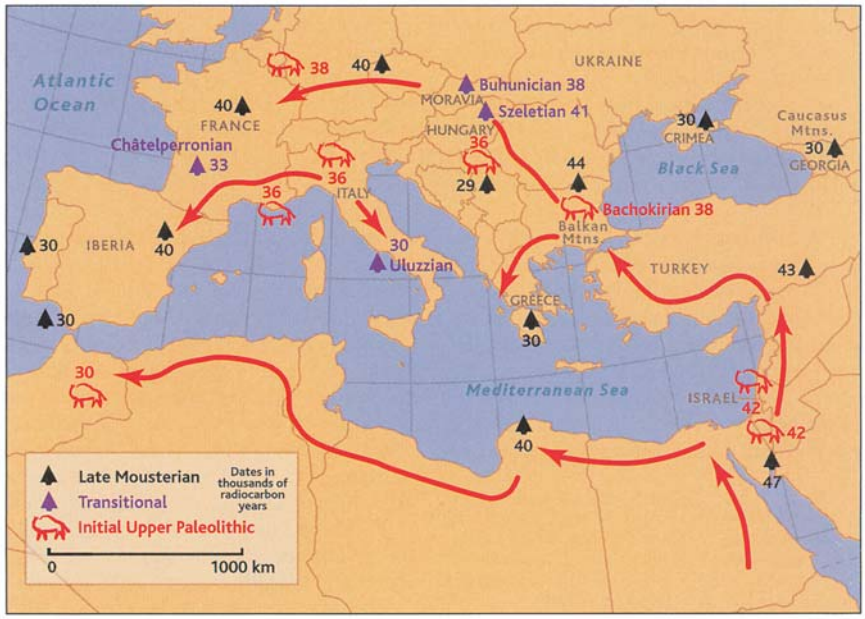


Fig. 5.1.3C

Box 5.1.1 International organisations and analyses of global change

Global change is initiated by

1. Decisions made at national and international level
2. The sum of many small individual decisions: This ranges from individuals to the world society (see Fig. 5.4.3). Within this range are a number of organisations that have particular interest in global change (WBGU 2001b), those that have direct influence on land use, e.g. FAO (Food and Agriculture Organisation), or indirectly through the decisions it makes, e.g. the WTO (World Trade Organisation). Between these types of organisation are the financial organisations that have no direct contact with agriculture and forestry, but that distribute resources and so have a more direct impact on nations than the WTO. A few examples are the World Bank, IMF (International Monetary Fund) and the GEF (Global Environmental Facility, which finances projects in the area of biodiversity and energy saving), as well as the UNDP (United Nations Development Programme).

Parallel to these are organisations that scientifically study and analyse global change. These include:

- organisations of the UN (UN Environment Programme, UNEP), the World Meteorological Organisation (WMO) and the UN Educational, Scientific and Cultural Organisation (UNESCO);
- organisations that are financially involved also in the global environmental audits (e.g. World Bank);
- scientific organisations: ICSU (International Committee of Scientific Unions) and the ISSC (International Social Science Committee).

There are various organisations supporting worldwide studies of global change:

- WCRP (World Climate Research Programme), initiated by the WMO and supported directly by nations within WMO;
- IGBP (International Geosphere Biosphere Programme), a branch of the ICSU;