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A Dictionary of Environmental History

Ian D. Whyte

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To the memory of Dr Peter John Vincent, 1944–2009.

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Abbreviations

AD	After Christ
BC	Before Christ
BP	Before present
c.	circa
C	century
CAP	Common Agricultural Policy
Co.	company
CO_2	carbon dioxide
km^3	cubic kilometres
DMV	deserted medieval village
E	East, eastern
EEC	European Economic Community
ENSO	El Niño/Southern Oscillation
EU	European Union
GCM	general circulation model
GIS	geographical information systems
H_2SO_4	sulphuric acid
ha	hectares
HEP	hydro-electric power
kg	kilograms
km	kilometres
kw	kilowatts
kya	thousands of years ago
L	Lake
m	metres
mph	miles per hour
Mts	mountains
mya	million years ago

N	North, northern
NGO	non-governmental organization
OSL	optically stimulated luminescence
pH	a measure of liquid and soil acidity
ppb	parts per billion
ppm	parts per million
R	River
RAF	Royal Air Force
RCAHMS	Royal Commission on the Ancient and Historical Monuments of Scotland
S	South, southern
SO_2	sulphur dioxide
km^2	square kilometres
t	tonnes
UN	United Nations
UP	University Press
USA	United States of America
USSR	Union of Soviet Socialist Republics
W	West, western
WW1	First World War
WW2	Second World War

Introduction
What is Environmental History?

One of the most challenging and stimulating developments in recent scholarship has been the emergence of environmental history as a new academic discipline. It is focused on the study of the past but has also evolved due to concerns about the impact of human societies at the present time. One of its most distinctive features has been the way in which it has embraced scholars from a wide range of backgrounds who have worked at integrating different sources of evidence and intellectual approaches – for example, palaeoecological data with documentary sources and geophysics with myth and folklore. One result of this is that environmental history has a rich and varied vocabulary. This dictionary attempts to assist those unfamiliar with the discipline to understand some of the terminology and approaches which have been used in the developing literature on the subject.

Environmental history is the study of the interactions between the physical environment and human societies in the past. It has three key elements:

- The discovery of the structure, distribution and characteristics of natural environments in the past. There is a need to understand the environment before understanding its history. This involves input particularly from the natural sciences, for example, ecology and palaeoecology.
- The study of how human activity has interacted with the environment. This embraces a range of disciplines including landscape history and archaeology, social and economic history and geography.
- More intangible than the first two is the study of perceptions of past environments, including aesthetics, ideologies, ethics, laws and myths, and how these have influenced the management and exploitation of environments.

Environmental history evolved in the 1960s and 1970s, particularly in North America, then in Europe, Australia, New Zealand, India and South Africa in the 1980s, and more recently in China, Japan and the Middle East. Its rise was linked with the development of the environmentalist movement and a growing awareness of global environmental problems, including initially deforestation, desertification and pollution, and then concern over the ozone layer and global warming. If one seminal book had to be selected to represent these new ideas, Rachel Carson's *Silent Spring* (1962) would be the choice of many. Nevertheless, environmental history had its earliest roots in a range of subject areas including anthropology, archaeology, ecology and geography, going back to the nineteenth century and beyond to ideas like James Hutton's late eighteenth-century *Theory of the Earth*.

Environmental history puts human history in its widest setting by focusing on its interactions with the environment the impacts of technological, political, economic, social and aesthetic changes on nature and the effects of environmental variations on past societies and cultures. How and why did people in particular places at particular times use and transform their environments? What form of production (e.g. hunting, gathering, farming, mining, forestry) evolved in particular habitats? What problems of pollution and resource depletion occurred? What were the impacts of industrialization and urbanization? How did perceptions of the environment and nature change over time?

In the past West European cultural traditions tried consistently to separate themselves from any association with the natural world, except as resources for exploitation. From medieval times at least Europeans saw mountains and forests as dangerous and their inhabitants as equally wild. These ideas were transferred to European colonies but then started to evolve. By the later nineteenth century in the USA interest in the environment, and the rate at which it was being modified by human societies, was a key theme in the work of George Perkins Marsh. The practical conservation work of John Muir, creator of the national park system, represented another strand in the development of environmental history. In Europe its roots can be identified in part in the French school of geography led by Paul Vidal de la Blache, which emphasized the study of *pays*, small regions in which there was a complex interaction between human and physical influences producing distinctive landscapes. French geography in turn influenced the Annales School of history from the 1930s onwards led by Marc Bloch, Fernand Braudel and Emmanuel Le Roy Ladurie. One of Ladurie's books in particular, published in translation in

1971 as *Times of Feast, Times of Famine* and subtitled *A History of Climate Since AD1000*, represents a classic attempt by a historian to dovetail the interpretation of historical records with scientific data. Braudel's *The Mediterranean and the Mediterranean World in the Age of Philip II* demonstrates the breadth of perspective available to historians who also understand the physical environment. Members of the Annales School, reacting against diplomatic and political history, stressed the need for 'total history', shifting their focus to subjects like agriculture, demography and disease.

Despite the modern origins of environmental history, much of the data which it uses has long been available; it merely needed to be organized and interpreted in new ways in response to new research questions. Previous generations of geographers, including Ellsworth Huntingdon, Ellen Semple and Alexander von Humboldt, reaching back to the early nineteenth century, had been concerned about the changing interactions between humans and their environments through time. In Britain landscape history, a discipline developed by historian W.G. Hoskins and other contemporaries in the 1950s and 1960s, was an important precursor of environmental history together with the work of contemporary historical geographers like Sir Clifford Darby, and a later generation including Alan Baker, Robin Butlin and Robert Dodgshon. From the 1970s onwards many physical geographers, including Andrew Goudie, Antoinette Mannion, Chris Park, Neil Roberts and Ian Simmons, produced overviews of global environmental change and were happy to call their work environmental history. Environmental history has tended to be geographically fragmented. The non-US environmental historiography focuses on colonialism and imperialism as environmental processes: this viewpoint is absent from or understated in the American literature.

It has long been recognized that relationships between human societies and nature are, and always have been, very complex, leading to concerns that currently we may be reducing the options for future generations to a dangerous degree. There is a modern trend, exemplified in the work of Jared Diamond, which uses case studies from environmental history to provide warnings about our possible global fate if we do not treat the environment with more understanding and respect.

Environmental history provides an opportunity to bridge the gap between the humanities and the sciences. An important contribution to environmental history has come from scientists, including palaeoecologists and palaeoclimatologists. H.H. Lamb, the celebrated meteorologist and climatic historian, emphasized that scientists needed a proper understanding of historical sources, the evidence that they contained and the

problems of interpreting them. Many environmental problems have their origins in human culture; to solve these problems insight into the humanities is also needed (Worster 1996). Interdisciplinary approaches are often discussed, even claimed to be practised, but less frequently are they actually realized. This does not mean that they should not be attempted though. Environmental history rejects the idea that human experience has been exempt from natural constraints, or that the ecological consequences of past deeds can be ignored. So environmental history illuminates political, social and economic history. Classics in this vein include William Cronon's *Changes in the Land* (1983) and Donald Worster's *Dust Bowl* (1979).

The origins of environmental history owe a good deal to the development of ideas relating to conservation, heritage and ecology. But human interest in and concern about the environment goes back to writers of classical times. Carolyn Merchant (2002) has emphasized that environmental history is one of the oldest and at the same time the newest fields in human history. Its challenge is to bring nature into the human story (Weiner 2005).

Environmental history involves a difficult interdisciplinary balancing act. Many of its tools are borrowed from other disciplines. One thing that has become abundantly clear in recent years is that human impact on the environment reaches much further back into the Holocene than was once supposed and occurred on a larger scale than previously suspected. We can no longer assume the existence until recently of 'pristine' landscapes, of stable climax communities in nature contrasting with dynamic and destructive recent human changes.

Environmental history is still a rapidly developing discipline. Much of the research by its practitioners appears in the journals of other disciplines, although there are now two major dedicated journals in print, *Environmental History* and *Environment and History*. Although there are some research groups and a handful of masters courses in this area there are, to the author's knowledge, as yet, no first degrees in environmental history. Much of the research output in this field has been strongly empirical in character and the subject has been described as under-theorized (Moore 2003a). A recent and welcome trend has, however, been the development of more strongly theoretical approaches, detecting underlying elements of environmental history in the work of theorists like Marx, Braudel and Wallerstein (Moore 2003a, 2003b).

The aim of this dictionary is to provide a clear introduction to the terminology of a discipline which is evolving steadily and which interfaces

with a wide range of other fields. It is intended as a reference text for the general reader, for undergraduates and as a starting point for more advanced study. It is acknowledged at the outset that a single volume cannot say it all. The aim is to keep the shorter entries as factual as possible but to treat the longer ones as mini research essays, linked to an extensive bibliography to encourage the reader to undertake further reading. Cross-referencing between entries, provided by the use of bold type, allows readers to move from one topic to related ones.

The biases and standpoints of the author, working in a British geography department and interfacing with archaeology, historical geography, landscape history, palaeoecology and socio-economic history, must be acknowledged as they affect the balance of the entries within the text. Every effort has, however, been made to make the coverage of entries as even as possible.

A

Aberfan

Village 8 km S of Merthyr Tydfil, S Wales. Scene of a major disaster on 21 October 1966 when a colliery spoil heap collapsed into the village, destroying a cottage and burying the Pantglas Junior School and 20 houses. 144 people were killed, 116 of them children. Half the pupils at the school and five of their teachers died. A tribunal of enquiry reported on 3 August 1967, blaming the National Coal Board at various levels for incompetence but not recommending criminal proceedings against any individual. The disaster drew attention to the dangers posed by mining and other industrial waste (Miller 1974).

acid rain

Most rainfall is slightly acidic due to carbonic acid formed from atmospheric CO_2. In acid rain pollution is due to SO_2 and nitrous oxides reacting to produce H_2SO_4 and nitric acid. Normal rainfall has a **pH** of around 5; anything lower than this is acid rain. Acid rain was first identified in 1872 in Manchester but has been a widespread phenomenon only from the 1960s. The term has been used since the 1970s to refer to contamination of the atmosphere by burning fossil fuels and from volcanic eruptions. Deposition can be wet, in precipitation, or dry, as wind-borne particles. A concentration of SO_2 of 0.2 ppm is harmful to vegetation and 1.0 ppm poses a risk to human health. Pollutants can be carried a long distance in the atmosphere and be deposited, via acid rain, far from their source. Norway has been concerned about acid rain from Britain since the 1860s. Half of Canada's acid rain comes from the USA. It is especially

concentrated in E USA and W Europe but is a growing problem in China, S Korea and Japan. In China acid rain had a limited distribution in the 1980s but has now spread over much of the country as a result of rapid industrialization. Acid rain leaches nutrients and minerals from upper soil horizons, affecting tree growth. In Europe in the 1970s and 1980s it caused widespread damage to vegetation, particularly trees, in the Netherlands, Germany, the Czech Republic, Poland and Scandinavia, a process known in Germany as *waldsterben*. In Scandinavia it has caused a decline in lichens, decreasing food supplies for reindeer. On a more local scale, the problem goes back to the early days of industrialization in areas like N England although the real impact only became clear in the late C20. It became a wider issue following the first UN Environmental Conference in Stockholm in 1972. Acid rain can also contaminate freshwater ecosystems, reducing fish stocks. Acid precipitation can attack the stonework of buildings, like the Acropolis in Athens or St Paul's Cathedral in London, and also affects human health. Measures to reduce acid deposition include removal of SO_2 produced in power stations using scrubbers (Howells 1995, Jenkins et al. 2007, Park 1987, Longhurst 1991, McCormick 1989). (See **pollution, air**.)

adaptation to environmental change

Strategies undertaken by individuals, groups or societies in response to environmental changes, that are designed to reduce their vulnerability. They were a feature of human society from the earliest times, a response to environmental problems created by human activities or arising independently, but varying in the nature, speed and success of the adaptation. There has been considerable debate about what elements in societies have encouraged/discouraged successful adaptation. It is interesting to consider the extent to which people in past societies realized that environmental change was occurring, or whether they simply registered and tried to cope with its effects. Responses could be on different scales: individual, community, regional or national. Environmental changes may be periodic (effectively random like **flash floods**), or cyclical (e.g. **El Niño**), gradual (**sea level change**) or rapid (**earthquakes** or **volcanoes** erupting). Memories of past environmental changes and how ancestors coped with them may have been enshrined in folk myths (Noah's flood). Societies may have had inbuilt buffering systems to protect them from environmental change, e.g. **famine foods**. Some groups within past societies, such as the poor, elderly and very young, were particularly vulnerable to change. Adaptation might be limited by cost, by allocation of responsibility for

dealing with the problem, or by societal, political and religious constraints. Societies tended to have a built-in reluctance to change. A frequently cited example of the failure to adapt to environmental change is the Norse settlement of **Greenland**. Failure properly to evaluate and understand environmental change is also shown by the history of farming on the US **Great Plains**. Other frequently quoted examples of societies which appear to have collapsed through a failure to cope with environmental change include the inhabitants of **Easter Island** and the **Maya** (Diamond 2005). In contrast the development of agriculture in the Near E can be seen as a positive adaptation to environmental change. Diamond has identified five factors which contributed to the collapse of societies: environmental damage, climate change, hostile neighbours, collapse of trade and unsuitable cultural response. In the examples he cites a decline of the resource base as the main factor precipitating a population crash. The responses needed to adapt to environmental change will also depend on scale. An individual might want protection for their property from rising **sea level** but regional and national authorities might take a wider view of the greatest good of the greatest number (Brooks 2006, Davies 1996, Diamond 2005, Mortimore & Adams 2001, Scoones 1992). (See **resilience**.)

aerial photography/photographs

An early form of **remote sensing**. There are two kinds of photographs: oblique, taken at angles of less than 90°, which gives a better impression of relief, and vertical, which is more useful for mapping and survey. The first aerial photographs of sites like **Stonehenge** were taken from balloons. The scope offered by aerial perspectives for improving understanding of known archaeological sites and identifying previously unrecorded ones was appreciated during WW1 by pilots in the Middle E. Pioneer work in Britain in the 1920s and 1930s by people like O.G.S. **Crawford**, who had served as an observer in the Royal Flying Corps, demonstrated that new sites could be identified, even when obliterated at the surface by ploughing, due to their survival as **cropmarks** (differences in the growth of crops over buried ditches or stone foundations). The use of aerial photographs has become a standard approach in **landscape archaeology** and **history**. They can be used to study vegetation change or the development of landforms like gully systems. Surveys of many parts of Europe in the 1940s and 1950s capture traditional landscapes on the verge of rapid and far-reaching changes and may be the only record of many archaeological sites. Those of Britain taken by the RAF in the late 1940s form valuable records of environmental change

when compared with modern images: e.g. the removal of field boundaries with the rise of **agribusiness** (Agnoletti 2006a, Bewley 2001, Crawford 1953, St Joseph 1977, Wilson 1982).

afforestation

The deliberate establishment of forests on land not previously covered in trees in recent history. This excludes abandoning arable and pasture and letting woodland regenerate naturally. Planting often involves exotic species, uniform in age, chosen for quick growth rather than aesthetic appearance. Afforestation creates ecosystems which are less complex and biodiverse than natural forests but generally more diverse than the land use which forestry has replaced. It produces forests which are obviously artificial but which have many of the benefits of natural ones (see **deforestation**).

Africa

The second largest continent and the most populous after Asia. Although reliable demographic data are rare before the mid-C20 it is clear that in the recent past Africa was underpopulated: between AD1500 and AD1900 population grew very slowly, from c.50 million to c.100 million. Between 1900 and 2000 it rose to over 800 million. Since the origins of *Homo sapiens* were in Africa, early human impact on the environment can be postulated. Although its environments have often been seen as pristine wilderness, Africa's landscapes are in fact **anthropogenic**, shaped especially by the long-term use of **fire**. Human impacts on the African landscape in the past have certainly been considerable; yet its agricultural systems have been mobile, adapting to the environment as much as altering it. Thin populations scattered over great distances hindered transport and the development of states. Sub-Saharan Africa was isolated from Eurasia at various times by drought in the Sahara, yet not totally cut off like the Americas so that external influences filtered in slowly, developing distinctive African characteristics in the process. Although contacts developed between W and N Africa across the Sahara, especially following the spread of Islam, and down the E coast, for much of tropical Africa significant contact with the outside world began with the **slave trade**.

African environmental history suffers from a lack of early documentation: historians have had to rely on scientific, archaeological and linguistic evidence in reconstructing environmental history. Environmental historiography has focused on **erosion**, **deforestation** and desiccation

under human impact. Europeans have often misunderstood African environments: the forest islands in the **savanna** landscapes of Guinea were seen as the result of deforestation, the remnants of a once extensive forest cover. In fact they were partly human creations in a savanna that would otherwise have had little forest. African historiography has been less keen than elsewhere to blame humans for environmental change (Fairhead & Leach 1996, Leach & Mearns 1996, Maddox 1999).

Africa's ancient rocks, poor soils, variable rainfall and prevalence of diseases did not encourage **agriculture**. The dating of the development of agriculture and livestock herding (which in some areas like the N savannas seems to have developed earlier than crop growing) is difficult due to the paucity of evidence. Much **pastoralism** was nomadic, following seasonal patterns of moisture. Fire was widely used to modify environments, affecting the boundaries of savannas and forests.

Africa's long history of human evolution and abundant wildlife gave it a rich, diverse disease environment, much more than in tropical America. The penetration of Europeans into tropical Africa on any scale was delayed by the range of diseases to which they were susceptible in the 'White man's graveyard'. Endemic diseases include **malaria**, onchocirciasis (river blindness), **bilharzia**, trypanosomiasis (**sleeping sickness**). Major animal diseases include **rinderpest** and tsetse fly (passed to humans as sleeping sickness). More recently **smallpox**, **influenza** (1917–19), rinderpest (1889–92), and, from the 1980s, **AIDS**, Ebola and Lassa fever have been serious problems.

In the early C20 W Africa had 0.5 m/km^2 of coastal rainforest, which has since been heavily depleted by commercial logging and agriculture. In Central Africa 1.8 m/km^2 of tropical rain forest has been less affected, though logging and clearing have accelerated rapidly in recent times. In 1990 Africa still had one-third of the world's tropical forests.

Recent work on the environmental history of Africa has emphasized African initiative in the face of European conquest and capitalist exploitation. From the early C19 especially, Africa's landscapes have been shaped indirectly by influences operating at a global scale such as the creation of **plantations** for cash crops and the **mining** of minerals like diamonds and gold. Although some parts of E and W Africa have a long tradition of trading centres, in recent centuries is has been the least urbanized continent. More recently it has experienced rapid growth of cities. In 1950 14.5% of the population was urbanized, in 1990 28% and by 2010 over 33%.

There is a widespread view that environmental degradation has been a major feature of Africa in recent centuries, caused by deforestation, erosion and loss of soil fertility, these processes in turn being due to population growth, industrialization, agriculture, logging and urban development. This contrasted with how African peoples interacted with their surroundings in earlier centuries when there was thought to have been more harmony with nature. **Desertification** has been a particular problem in sub-Saharan Africa, blamed variously on local and regional human activities. Sub-Saharan Africa has long suffered from periodic drought leading to major famines in both early and recent times.

Central Africa has huge equatorial rain forests fringed with savannas covering much of the Congo and Zambesi basins. Around 8000BP people in the N savannas began to cultivate millet and sorghum and may have converted extensive areas of dry woodland to grassland. 2,000 years ago rain forest peoples cultivated bananas and yams as well as rearing livestock and hunting, affecting the composition of the forest vegetation. Histories of cultivation are linked to the spread of **Bantu**-speakers from W Africa over 2,000 years down to AD500–1000 through the rain forests into E and S Africa, disseminating the use of iron. The Portuguese introduced **cassava** from the Americas and it spread widely in central Africa over the next few centuries. In the C19 exports of manioc, palm oil, ivory and slaves developed. Colonial monopolies granted to private companies led to unregulated exploitation and environmental damage. Widespread recruitment of migrant labour spread diseases like sleeping sickness. Political conflicts over much of the Congo basin have led to modern depopulation and the collapse of infrastructure constructed during colonial times (Adams & McShane 1992, Birmingham & Martin 1983, Butcher 2008, McCann 1999a, 1999b, Anderson & Grove 1987, Giles-Vernick 2002, Richards 1996, Vansina 1990).

E Africa has a wide range of environments, most of which have been affected by varying combinations of hunting, agriculture and livestock rearing. Agriculture and pastoralism only took over from hunting and gathering within the last 2,000–3,000 years. In the drier uplands of Kenya and Tanzania pastoralism was more normal, though with some grain cultivation too. On the coast trade contacts with Asia introduced bananas, which spread throughout tropical Africa. The introduction of commercial monocultures of **coffee**, **cotton**, tea and **tobacco** further dislocated indigenous agriculture and extensive areas were expropriated from the native population. Colonial administrators blamed deforestation and soil erosion on African farmers. Agriculture and forestry services implemented

conservation programmes which were often ill-suited to environmental conditions. Attempts to make farmers construct terraces and adopt other anti-erosion measures were more successful (Anderson 1984, Conte 2004, Ehret 2000, Johnson & Anderson 1989, McCann 1990, McClanahan & Young 1996, Schmidt 1994, Sutton 1990).

The savanna areas of the Sudan were suitable for mixed farming. This, with the exploitation of ivory and gold, provided the foundations for the rise of the empires of Ghana, Mali and Songhai and the development of trade across the **Sahara**, with gold, slaves, ivory and hides being exported (Maddox 2006, McIntosh 1988). The rise of the slave trade in W Africa, particularly in the C17 and C18, disrupted economies due to the unrest it created and may have led to population stagnating or declining in many areas.

In S Africa indigenous agricultural practices were often sensitive to fragile environments. Imposition of colonial conservation techniques often overlooked local wisdom relating to soil conservation and accelerated soil erosion. Loss of flat fertile land to the Boers, change to commercial agriculture and overuse of steep slopes increased erosion and made agriculture less effective (Singh 2000, Dovers et al. 2003).

Agassiz, Lake

The largest proglacial lake in central N America during the retreat of the Laurentide ice sheet 13.7–8.2 kya. It covered extensive areas in Manitoba, Ontario, Saskatchewan, Minnesota and N Dakota. It underwent major changes in volume resulting from several cataclysmic outbursts as the ice retreated and the water burst through ice lobes and moraines blocking access to the St Lawrence. In its early stages it covered up to 170,000 km^2 with a volume of 13,000 km^3 (equal to modern L Superior). In its later stages it reached 841,000 km^2 and 163,000 km^3, seven times the size of the modern Great Lakes. Major outflows into the N Atlantic occurred at 12.9 kya (9,500 km^3), 11.3 kya (9,300 km^3) and 8.2 kya (163,000 km^3), coinciding with the cold phase of the **Younger Dryas**, the Preboreal Oscillation and the 8.2 kya Event, influencing N hemisphere climate through the circulation of the N Atlantic (Burroughs 2005).

Agassiz, Louis (1807–73)

Swiss geologist and glaciologist, known as the 'Father of Glaciology' though he built on ideas developed by John Playfair in Britain and Venetz and Charpentier in the Alps. He began studying alpine glaciers in 1836 and soon

realized that moraines and other features relating to glacial action could be seen in areas where there was now no ice. From this he developed the idea of an ice age. Visits to Scotland and N England in 1840 provided evidence of former glaciers in a country which now had none. He produced *Étude sur les Glaciers* in 1840 and *Système Glaciare* in 1847 (Lurie 1961).

Agenda 21

Action plan on environmental issues drawn up at the 1992 UN Conference on Environment and Development, being implemented globally, nationally and locally with the aim of reducing poverty in developing countries and encouraging sustainable development while preserving biodiversity.

aggradation

The building up of sediments by wind, marine or fluvial action. At the end of the **Pleistocene** large quantities of fluvio-glacial outwash were deposited in sheets, fans and valley fill as ice sheets retreated. As climate warmed, braided river channels choked with sediment gave way to deeper, meandering channels carrying far less silt. These channels cut into the earlier valley fill deposits. Periods of increased precipitation and more flooding led to further sediment deposition in phases of aggradation. These sediments were in turn dissected by rivers forming sets of **river terraces**.

agistment

In England renting out grazing on common pasture to people not designated as commoners, whether part of the community or outsiders. The introduction of livestock from outside the community, unless carefully controlled by an institution like a manorial court, could lead to abuses such as overgrazing (De Moor et al. 2002, Winchester 2000). (See **commons**.)

agribusiness

Treating agriculture as corporate farming with ruthlessly commercial enterprises, modifying the environment to accommodate this by amalgamating holdings, removing boundaries to allow field enlargement, using machinery and high inputs of chemical fertilizers, herbicides and insecticides to produce intensive monocultures. Produce is often sold to large retail organizations like supermarket chains. Characteristic of the USA, Australia and parts of the EU. Environmental impacts in Europe include loss of hedgerows, ancient woodlands and small wetlands, reduced biodiversity

and increased soil erosion (Shoard 1980). Caused by rising living standards increasing the demand for food, and the availability of new technology. The environmental cost of agribusiness is high (Brouwer et al. 1991, Robinson 1991).

Agricola, Georgius (1494–1555)

Father of mineralogy, born in Switzerland, his *De Re Metallica*, on the technology of mineral extraction and smelting, with its dramatic woodcut illustrations, provides much detail on late-medieval **mining** and its environmental impacts.

agricultural improvement, Britain

A feature of British agriculture, particularly from the 1730s, with increased use of agricultural machinery, better-balanced crop rotations, recuperative and clearing crops, improved livestock breeds, a wider range of **fertilizers** (**lime burning**, **guano**), turnips and sown grasses. **Enclosure** was vital to improved agriculture and in England and Wales from the C18 was undertaken mainly using acts of parliament (see **parliamentary enclosure**). Better-built and more efficiently designed farmsteads, with courtyard layouts, were also built (Wade Martins 1995). Farm amalgamation resulted in more efficient, capital-intensive working of the land. This period has been conventionally labelled the Agricultural Revolution but there were important elements of continuity as well as change. Agricultural improvement in Scotland was well behind England in the earlier C18 but proceeded more rapidly as Scottish landowners could remove tenants at the end of short leases, amalgamate farms and enclose land without reference to parliament (Whyte & Whyte 1991, Gibson 2007). 'Improvement' also had an aesthetic side relating to the **landscape parks** around neo-classical country mansions. Parks were embellished with deer, well-fed cattle and sheep and new crops, epitomised in Gainsborough's painting *Mr and Mrs Andrews* (c.1748). The landscaping of parks provided lucrative careers for landscape gardeners like Lancelot (Capability) **Brown** and Humphry **Repton**. Plantations of trees were an economic as well as an aesthetic resource and could be felled at need to avert a financial crisis (Daniels & Seymour 1990). During the French Revolutionary and Napoleonic Wars (1793–1815) agricultural improvement became a patriotic duty, a way of fighting the French. Writers on agricultural improvement like Arthur Young and Sir John Sinclair were widely known and respected figures in late C18 and early C19 Britain.

agricultural origins

Agriculture involves the cultivation of crops and livestock rearing. The domestication of plants and animals has been the single most important change in human history, providing a cushion against environmental fluctuations but, in the process, having major effects on the environment. It has been suggested that **hunter-gatherers** would have had better diets, more easily won, than farmers and that no one would willingly have exchanged the former lifestyle for the latter unless they were forced to, e.g. by environmental change. Hunter-gatherers may have modified their environments by burning but agriculture involved morphological changes in the crops and livestock due to the deliberate human selection of specific genetic traits. Agriculture has major impacts on natural ecosystems and the environment generally, e.g. **soil erosion**. The transition from hunting and gathering to farming probably started with attempts to increase yields of wild plants rather than deliberately selecting them for human-friendly characteristics. The earliest domesticated wheat and barley in SW Asia was c.9250BC, a few centuries after the rapid warming at the end of the **Holocene**. The domestication of sheep and goats seems to have occurred 1,000 years or more later in that area (Grigg 1995, Smith 1999). The term 'Neolithic Revolution' has been used to describe the origins of agriculture in the Near E but it was not a true revolution, occurring over 4,000–5,000 years. Moreover, the term implies that the development of agriculture was a deliberate goal. The rise and spread of agriculture had broadly the same effects throughout the world:

- Increased food surpluses.
- The rise of stratified societies with religious and political elites and craftsmen.
- Sedentary settlement.
- The development of writing.
- The rise of urban centres.
- Increasing political control and war.

agricultural origins: Africa

The origins of agriculture in Africa are contentious. The lack of archaeological evidence limits understanding of agricultural origins compared with the Near E (McCann 1991). There has been considerable debate over the importance of independent invention within Africa and diffusion from the Near E via the Nile valley (Clark et al. 1975). African

agriculture involves a mosaic of crops and traditions. Between 12000 and 7500BP the N half of Africa was wetter than now. Herding cattle may have occurred as early as c.7000BC, though this is disputed. It has also been claimed that the cultivation of **wheat**, **barley** and possibly **sorghum** and **millet** may have had earlier origins S of the **Sahara** than in the lower Nile valley. There are at least three areas of probable independent origins: the uplands of Ethiopia (millet, coffee), the **Sahel** (millet, **rice**, sorghum) and W Africa (African yams, **cassava**, kola nut, oil palm, rice). In the Sahel agriculture seems to have emerged as early as 5000BC (though wild barley may have been tended and even cultivated as early as 10000BC in Nubia and parts of **Egypt**) and in the rain forest by 2000BC. S of the Sahara, millet and sorghum were being cultivated by the 3rd millennium BC (Zohary 2001). The origins of African rice cultivation are likely to have been in the Niger delta (Andah 1993, Bedaux et al. 2001, Harlan et al. 1976). By c.5200BC the Sahara was becoming moister allowing pearl millet, sorghum and cowpeas to be domesticated and to spread through W Africa and the Sahel. In the **savanna** the domestication of animals seems to have preceded agriculture, unlike other areas: domestic **sheep** and **goats** arrived from SW Asia by the 6th millennium BC and a drier climatic phase between 5500 and 4500BC may have forced hunters into herding. The wheat and barley of Egypt were unsuited to the summer rains of the Khartoum area and sorghum and millet had to be domesticated instead, but not before the C1AD. In Ethiopia cattle were herded from c.2000BC (Bellwood 2005). **Maize** was introduced by the Portuguese and has since become a major staple, replacing traditional millets and sorghums, while some millets were exported from Africa to India in the last centuries BC (Murdock 1959).

agricultural origins: the Americas

Agriculture in the Americas was based on the cultivation of a variety of plants including chilli peppers, tomatoes, avocados, guava, squash, beans and gourds in garden plots rather than on wild cereals. The development of agriculture was delayed by the lack of suitable animals for domestication, so hunting remained important in societies practising agriculture. **Maize**, squash and beans were domesticated somewhere in Central America from c.6000BC but took centuries to spread to other parts of the continent. Beans, squash, peppers and some grasses were cultivated in **Peru** by 7000BC or even 8000BC and in Central America by 7000BC (Smith 1997). Maize began to be cultivated in **Mexico** c.5,600 years ago. Maize had spread S to Peru by c.1000BC. with the potato it became the central element in diet. The first

high-yielding varieties of maize were not developed until c.2000BC. The evolution of complex societies began 4,000 years later than in Europe and Asia; settled communities did not develop in Meso-America until c.2000BC. From c.400–300BC there was an increase in food production when varieties of maize with a cob twice as long as previous ones developed, leading to the rise of Teotihuacan (Mexico) with a population of c.100,000. The climate of central America made hunting and gathering high-risk subsistence strategies; agriculture provided more predictable food supplies. Rising population densities may have caused environmental degradation, encouraging the adoption of agriculture. Storage of crops could have offset seasonal shortages of food from other sources. The date of arrival of maize in the SW USA may have been as early as the 2nd millennium BC, possibly during a wetter period c1500–1000BC. The key development was the introduction of maize ocho, higher yielding and adapted to dry conditions, from at least 1250BC (Fagan 1991).

Evidence emerged in the 1980s that the woodlands of E USA were also a separate hearth of agriculture (Williams 2003). There were three phases of development: (1) from c.5000BC domestication of the sunflower, ragweed and possibly squash in river bottoms; (2) c.2500BC–AD200, Hopewellian farming societies with full-scale agriculture leading to the rise of villages; and (3) AD800–1000, maize imported from tropical areas. When the Europeans arrived full-scale agriculture had only been in operation for c.500 years on the E coast. Villages of 50–1,500 people surrounded by palisades with long houses were consuming huge amounts of timber. In another 500 years, if left alone, the Indians would have had a major impact on the forests of the E USA.

agricultural origins: the British Isles

When agriculture reached the British Isles it had to be adapted to a moister climate and heavier soils than on the European continent. Traditional techniques like clearing woodland by burning were probably more difficult to use. Agriculture is first recorded from Ireland c.5750BP (3800BC. and in Britain 5300BP. Archaeologists now suggest that agriculture was adopted by indigenous **hunter-gatherers** rather than being brought by a massive wave of immigrants. In Ireland, which lacked large post-glacial mammals, the environmental impact of the arrival of domestic cattle was considerable. Throughout the early Neolithic, between 4000BC and 3000BC, the landscape remained predominately wooded and clearings were still small.

Settlement sites remain elusive and many are likely to have been only seasonal.

Woodland clearance may have been accomplished by ring barking the trees then leaving the stumps to rot. The rest of the vegetation may have been piled up and burnt. The clearings, once created, would have been kept in being by grazing of the saplings. There is some evidence of small-scale disturbance of the woodlands before the **Elm Decline**, due to natural changes or the first signs of farming. The discovery of bones of domesticated cattle in a Mesolithic context from the Dingle Peninsula in SW Ireland points to pre-Elm Decline contacts with Neolithic incomers.

After the Elm Decline in Ireland there was a rapid rise in the pollen of tree species which exploited open woodland, especially yew, but this was followed by a major expansion of the cleared area with an increase in the percentage of pollen of grasses, heather, bracken and plants of disturbed ground like ribwort plantain (*Plantago lanceolata*). The light **loess** soils of the **Burren**, with their thinner tree cover, may have been particularly attractive to farming communities. Once cleared of woodland many areas remained open for centuries before farming declined and woodland regeneration occurred. The farming system in Ireland seems to have involved only limited cereal cultivation and was mainly concerned with raising cattle, sheep, goats and pigs.

The early Neolithic in Britain was characterized by a mobile lifestyle with an absence of large, permanent settlements like farming communities in the Near E. Herding was more significant than cultivation and the use of permanent, walled fields seems to have been rare. Although there was an increase in the amount of woodland clearance people still lived in a woodland environment. Nevertheless within 1,500 years in areas like the chalk country around **Stonehenge** and **Avebury** the woodlands had been reduced to small patches in an open, parkland landscape (Malone 1989). Much of this was probably due to the impact of grazing animals preventing trees from regenerating rather than direct clearance for crops.

agricultural origins: China

Agriculture in China appears to have developed in two distinct areas, the drier loess plains of the N, dominated by millet and wheat, and the wetter south, where rice became the most important crop. Until quite recently it was thought that agriculture had evolved in China relatively late – c.7000BP – but more recent research has pushed the date much further back. The origins of plant domestication in N China, which has been identified as a

separate agricultural 'hearth', have been extended back to the boundary between the Pleistocene and Holocene with the discovery at a site named Cishan of two varieties of millet which seem to have been domesticated soon after c.10400–10100BP (Cowan & Watson 2006, Crawford 2009). This takes agriculture back to the climatic changes associated with the **Younger Dryas** event. There are many possible similarities in the type of environment and the ways in which it changed, with a fluctuating boundary between woodlands and grasslands, between the Near E and N China (Barton et al. 2009). Rice cultivation in the S seems to go back to a similar early period with paddies from c.8000BP (Crawford 2009, Gupta 2004). Barley and wheat are thought by some specialists to have been introduced from SW Asia. On the semi-arid loess plateaus of N China with rain during the summer growing period wheat was not introduced until c.1300BC and barley even later; agriculture was based on **millet** and dry-land **rice**, the former the staple, the latter a luxury. Millet was domesticated c.6000BC.

agricultural origins: Europe

A major controversy has been whether the diffusion of agriculture through Europe from the Near E was due to a spread of ideas or people. The latter theory has been widely held since the work of V.G. **Childe** (1968) but more recent research suggests a complex picture combining the two elements in varying degrees at different times and places. The rate of movement appears to have been around 0.6–1.3 km/y: it took 3,000 years or 100 generations for agriculture to reach NW Europe from the Near E. From its original heartland farming spread into S and E Europe. A major natural event which may have helped propel agriculture into E Europe was the flooding of the **Black Sea** basin c.5500BC, displacing farming communities up the Danube valley. The spread of farming across Europe between 8000BP and 5000BP appears to have been partly the result of the migration of farming communities in search of new land but may also have involved the transfer of the idea of farming to indigenous **hunter-gatherer** societies (Chikhi et al. 2002, Harris 1996, Harris & Hillman 1989).

In SE and central Europe, an immigrant Neolithic population is suggested by the sudden appearance of pottery manufacture and a marked change in styles of houses, settlement patterns and burials. Other sites, like ones in the Danube gorges between Serbia and Romania, suggest the transformation of a native **Mesolithic** population. In Britain and S Scandinavia, more weight is now given to the transmission of new skills

and technologies to an indigenous Mesolithic population by limited numbers of immigrants.

The slow pace of migration N and W across Europe was punctuated by more rapid advances, especially around 5500BC and 4000BC. Some Mediterranean islands, such as Crete and Cyprus, settled by Neolithic communities c.7000BC, may not previously have been occupied. Within c.500 years the frontier of agriculture seems to have shifted from the Ukraine to E France. Archaeologists have associated the settlements of the so-called LBK culture (from the German *Linienbandkeramik* relating to their distinctive banded pottery) with the cultivation of small plots of land for cereals. It was originally believed that the earliest farmers in Europe used **swidden** systems or shifting cultivation; they are now thought to have been more sedentary (Williams 2003). Forest herding fits in better with the evidence for relatively limited clearance of woodland in the early phase of settlement. The livestock of the LBK people were probably often stall-fed due to a lack of open grazing. The LBK culture adapted agriculture to a very different climate from that of the Near E. Cultivation involved **emmer** and **einkorn** wheat with legumes and some barley. Fields were probably small with perhaps 10–30 ha for a community with a population of 20–60. Livestock rearing focused on cattle with some sheep and goats. New strains of cereals were developed to cope with moister conditions. They had a preference for particular habitats with well-drained, easily-cultivated soils developed on deposits of windblown **loess** which had accumulated at the end of the ice age. Other soils, even ones which would have proved fertile and easy to cultivate, were not colonized until much later. The impact of the first farmers on the thickly wooded environments of NW Europe has been debated. Even in the early days of farming the scale of woodland clearance was much greater than in Mesolithic times. The transition from Mesolithic to Neolithic seems often to have been swift, with abandonment in some areas of coastal sites in favour of inland locations (Whittle 2002).

agricultural origins: the Near East

The oldest source area or 'hearth' of agriculture was the 'Fertile Crescent' in the Near E running from the R Jordan N through Syria into SE Turkey and then E towards the headwaters of the R Tigris and R Euphrates in modern Iraq (Maisels 1990). Although the wild ancestors of the first domesticated forms of wheat and barley, as well as wild sheep, goats, cattle and pigs, can all be located within this area the reasons for the development of

agriculture remain a puzzle (Binford 1968, Braidwood & Howe 1961, Hillman et al. 2001, Maisels 1990). The change to agriculture involved not only an alteration in how food was obtained, but also the development of new relationships between humans and nature, and more sophisticated and stratified social structures. Environmental changes caused by **hunter-gatherers** were modest but the first farmers started a chain of events which transformed the environment, leading to major changes in social organization, including the rise of the first cities.

The switch from hunting and gathering to farming, especially cultivating cereals, involved more sustained hard work. The more intensive agriculture became the more labour was required per volume of food produced (Boserup 1965). It seems unlikely that people would have voluntarily adopted a life of harder physical labour with a poorer, less nutritious diet; so what pressures led people to develop agriculture? Growing population is one possibility but the evidence is far from convincing. The current consensus is that population growth was an effect rather than a cause of the shift to farming. Environmental stress has been favoured by many archaeologists. In the 1920s and 1930s Prof. Gordon **Childe**, believing that ice ages in higher latitudes were accompanied by wet **pluvial** periods nearer the equator, suggested that conditions became drier in the Near E after the ice retreated, causing scarcity of game and forcing hunters to adopt other strategies to survive (Childe 1942). This simple theory has long since been exploded but it is likely that the rapid re-adjustment of climates at the end of the ice age caused considerable changes to Near E vegetation zones putting pressure on human populations.

At the end of the ice age the landscape of the Near E was not as dry as today. In the Levant there was more woodland and open parkland with plentiful game. The woodlands were also rich in edible fruits, seeds, leaves and tubers. On the uphill fringes were extensive stands of wild grasses; ancestors of modern cereal crops. Modern research suggests that the cultivation of crops and the domestication of animals developed in different areas; the former among the woodland and parkland of the R Jordan valley, the latter further N and E on the fringes of the Zagros Mts. Farming seems to have developed as a supplement in areas where diet was already diverse and rich, rather than on the fringes of viable settlement (Harris 1996, Harris & Hillman 1989).

The glacial readvance of the **Younger Dryas** (11000–10000BP) when precipitation decreased, may have been the key to the origins of farming. Another environmental pressure in the Levant was the loss of good-quality land with rising **sea levels** as ice caps melted, reducing the width of the

coastal plain by many km. The wild ancestors of the first cultivated cereals were adapted to open sites, poor soils and dry summers. The first known domesticated forms of barley and wheat are recorded from **Jericho** around 10000BP. Sheep are thought to have been domesticated by c.9000BC, goats by c.7500BC, pigs from c.7000BC and cattle from c.6000BC. Early farming communities may also have herded semi-domesticated gazelles (see **Natufian culture**) (Bar-Yousef 1998, Bellwood 2005, Byrd 1994, Sherrat 1980).

agricultural origins: South Asia

In S Asia there were indigenous centres of domestication in India as well as diffusion from SW Asia. There were moving frontiers of colonization by agricultural populations as well as static frontiers of interaction between hunter-gatherers and agriculturalists. The body of evidence for the origins of agriculture is nevertheless remarkably small for such a large area. In particular there is a lack of knowledge about the environmental changes which occurred in the early **Holocene** and how they affected agricultural origins. A number of source areas for domesticated crops have been suggested: horsegram in arid savanna areas of E and SE India, mungbean in the W Himalayan foothills or the E Ghats, urdbean in the W Ghats, wild rice somewhere in Bangladesh.

A SW Asian agricultural package was widespread by the time of the Harappan phase of urbanization in the **Indus Valley** though some herding of animals may have developed locally in S Asia: goats seem to have been domesticated at the earliest Neolithic levels in Mehrgarh on the River Bolan, a tributary of the Indus. This package spread E into the middle Ganges basin by c.3500BC. The winter-sown crops were added to existing farming systems based on locally domesticated **monsoon** crops: centres in Gujerat and the Ganges basin have been proposed. **Rice** may have been domesticated in N India before other crops spread from the W Agricultural evolution in E India but this has been little studied. The S Deccan may have been a separate hearth for millets and pulses, spreading S and E to other regions. In S India hunter-gatherers could choose from coastal rice-based agriculture and the Deccan millet-pulse package. There is an overall lack of reliable **radiocarbon** dates for key phases of agricultural development in S Asia. Wheat and barley were domesticated in India by 9000BC during a wetter phase which probably prevented the cultivation of wet season crops like millet and lentils. The cultivation of millet in S India may have developed due to the onset of more arid conditions. Sheep and goats were

domesticated soon after 9000BC. The Asian elephant, unlike its African counterpart, was domesticated c.8000–6000BC. **Irrigation** was being practised in the Indus Valley by 4500BC (Fuller 2006).

agriculture: mechanization

Agricultural **improvement** until the C19 involved little mechanization beyond better ploughs such as Small's (1763), and Jethro Tull's seed drill (1701). The threshing machine was invented c.1784 in SE Scotland and was quickly adapted to horse, water, wind and steam power. The brick chimneys of steam threshing machines still dominate large arable farms in SE Scotland and NE England. The C19 brought steam traction engines that could be used for ploughing, threshing and a range of other activities. Horse-drawn threshers and reapers began to spread from the 1830s and petrol-driven tractors were first developed in 1892. **Combine harvesters** had a major impact on the environment, requiring larger fields with fewer boundaries for maximum efficiency (see **agribusiness**).

Tractors (millions)

Date	USA	USSR	World
1920	0.25	0	0.3
1950	3.4	0.6	6
1990	4.6	2.7	26

(McNeill 2000).

Mechanization has led to widespread hedgerow removal in W Europe and a focus on crops that can be harvested mechanically, encouraging monoculture and an increase in farm sizes along with a decline in the amount of land used for producing animal feed. The mechanization of cotton harvesting in the USA in the late 1940s increased the migration of African-Americans to the cities (McNeill 2000).

agroforestry

A combination of agriculture and forestry on the same land allowing animals to be pastured or crops to be grown while maintaining enough woodland to protect soils and generate some woodland products. Agroforestry has been divided into silvopasture (see **wood pasture**) and silvoarable, where the space between the trees is quite extensive, and forest

farming and forest gardening, where crops are produced from between more closely spaced trees. A traditional form of farming in many tropical areas but also in parts of Europe (Abbot & Homewood 1999, Allan 1967, Franzel & Scherr (2002). Increasingly favoured as a more sustainable system of farming than **swidden**.

AIDS (acquired immune deficiency syndrome)

First identified in the 1980s, caused by the HIV (human immunodeficiency virus) and now a major cause of death globally. Its origins may lie in **Africa**, having passed from chimpanzees to humans at some time between the 1930s and 1950s. It is transmitted between humans by sexual intercourse, contaminated needles or infected blood products causing a breakdown of the immune system. It has killed c.25 million people to date. At first doctors thought that it was confined to particular high-risk groups like homosexuals, especially in the W, but at the same time the disease was spreading rapidly among the heterosexual population of sub-Saharan Africa. Antiretroviral drugs can slow the spread of the disease and prevent AIDS from rapidly destroying immune systems but they are expensive: there is no vaccine as yet (Dobson 2007).

Alaska

Comprises 20% of the area of continental USA, twice the size of Texas. When the American West vanished at the end of the C19 Alaska was left (before *Star Trek*) as the final frontier. The resulting image has been one of rugged men triumphing over a harsh environment; a white, male, middle-class American view influenced by the writings of Jack London (1876–1916) and Robert Service (1874–1958) who both immortalised the region and its **gold rushes**.

The first significant European contact with Alaska was in 1741 with the Russian expedition of Vitus Bering. Following this, fur trading with the Aleuts led to permanent settlement from 1784. The Russian America Company carried out a colonization programme in the early-mid-C19 after 80% of the Aleuts were destroyed by European diseases and violence. Alaska was purchased from Russia by the USA in 1867 for $7.2 million. In the 1890s gold rushes in Alaska and the Yukon Territory brought thousands of immigrants. In 1896 a small group of prospectors found a rich pocket of gold at the confluence of the Klondike and Yukon rivers. Waves of immigrants brought profound environmental changes. Alaska was granted territorial status in 1912 and statehood in 1959. Denali National Park and

Preserve was established as Mount Mackinlay National Park in 1917. Oil was discovered at Prudhoe Bay in the 1950s. In 1979 the Alaskan National Interest Land and Conservation Act (ANILCA) was passed protecting over 40 million ha of federal land, tripling the area designated as wilderness. The 1,280 km long Trans Alaska Pipeline was opened in 1977. As well as oil spills from pipelines there have been recent problems with cruise ships discharging waste water, oily bilge and refuse into sensitive marine environments. But because of state regulations cruise lines now use their most environmentally friendly vessels following a series of multi-million dollar fines (Berry 1975).

Since the 1880s most people who came to the region did so to make money then leave; this transient viewpoint shaped environmental attitudes. Most Alaskans saw no intrinsic value in nature, equating progress with converting nature into commodities, despoiling the landscape and its resources in the process. The arrival of extractive industries like **mining** and salmon processing in the 1880s started the 'modern economy' (Coates 1991, Haycox 2002, Nelson 1995, Webb 1985).

algal bloom

The large-scale spread of algae in lakes or the sea due to changes in water chemistry and/or temperature. Such blooms can be caused by pollution of nitrates and phosphates from fertilizers. The decay of algae can remove oxygen from water, endangering fish stocks, and may also release toxins. (See **eutrophication**.)

Allerød

A milder phase towards the end of the last glaciation in NW Europe (c.14–13 kya). Forest, mainly birch and pine, reached N England and S Sweden though an ice cap remained over central and N Scandinavia. A similar climatic phase, followed by the **Younger Dryas** cooling, has been identified outside Europe in areas like E Africa and S America.

allotment

Small plots of land in or adjoining urban areas, usually leased by individuals from local authorities for the intensive cultivation of garden produce. In Britain the Allotments and Gardens Compensation for Crops Act 1857 obliged local authorities to provide allotments on demand, which increased greatly in WW1. Railway companies often provided allotments for their

workers on surplus land. Demand rose again in WW2 with 1.4 million being provided. This fell to under 300,000 by 1996 but has been increasing again since then (Crouch & Ward 1997). Alternatively 'allotment' refers to areas of land allotted to proprietors in C18–C19 **parliamentary enclosure** awards in lieu of extinguished common rights.

alluvial fan

A triangular spread of alluvium and coarser material deposited when the gradient of a stream suddenly lessens, e.g. where a tributary on a steep valley side reaches the valley floor. Alluvial fans may be attractive to cultivation and settlement on account of their fertility, if not too stony, but are potentially vulnerable to **flash floods**.

alluviation

The deposition of alluvium in river valleys and flood plains. Variations in the rate of alluviation may be due to natural processes such as climate change causing periods of higher precipitation and flood frequency, or the result of human activity with deposition following phases of deforestation and soil erosion higher in a catchment. Periods of alluviation occurred in river valleys in lowland Britain between 9600BP and 8400BP and 4800BP–4200BP. One effect of alluviation is to bury lowland archaeological sites from earlier periods (Simmons 2001).

alluvium

Sediments deposited by running water ranging from clay and silt to sand and gravel, deposited in layers on river floodplains, as **alluvial fans** or as **deltas**. Valley floor alluvial deposits may be eroded to form river terraces, which may be datable using incorporated organic material providing evidence of phases of erosion and deposition in the catchment.

Alps

Mountain range running E–W across Europe, separating the N European Plain from the Mediterranean. The highest summit is Mont Blanc (4,808 m). The Alps provided a major barrier to the movement N of plants and animals from **refuge** areas after the last glaciation and also to humans through prehistory and history with most of the passes being blocked in winter. Lower passes like the Brenner were major arteries for trade but none of the passes was easy, explaining why Hannibal's crossing of the Alps in

218BC to attack Rome was such a celebrated achievement. The Alps were rich in minerals and the first Iron Age culture in Europe is named Hallstat after a site S of Salzburg. Many high alpine valleys were colonized during the **medieval climatic optimum** period of population growth. In early-modern times different valleys and regions began to specialize in beef production or dairying, and many areas developed domestic industries as additional supports. From medieval times seasonal migration from high alpine valleys to surrounding lowlands and towns developed as another source of income (Netting 1981, Viazzo 1989). In medieval and Renaissance times the Alps were viewed with fear by outsiders, the abode of danger and horror, yet at the same time crossed by routes carrying large volumes of traffic between the cities of Italy, the Low Countries and Germany. Remoteness brought the benefits of clean water and relative isolation from epidemics but marginal conditions could make agriculture precarious before the spread of the potato. Although the mountain environment seemed to offer only a poor living, the availability of gold, silver, lead, copper and salt provided wealth for some.

Population growth in the C18 led to large-scale deforestation, causing compaction and waterlogging of soils and increased erosion, landslides and flooding. Since the late C19 government initiatives in many Alpine countries have encouraged replanting. At the same time major changes occurred in agriculture. Many parts of the Alps had already moved from a mixed subsistence economy to commercial livestock rearing by the C19. The introduction of dairies led to the abandonment of many alpine pastures and their re-colonization by woodland. Growing commercialization of agriculture in lowland areas and the collapse of local cottage industries under competition from outside manufacturers led in the late C19 and early C20 to large-scale depopulation. With the abandonment of high-level marginal land the upper limit of permanent settlement in parts of the Alps fell by 300 m (Lichtenberger 1975, Frey 1976). The continuing depopulation of farming communities accelerated erosion and landslides as traditional farming practices had provided protection against landscape degradation.

From the later C18 the growing interest in sublime mountain landscapes attracted visitors on the **Grand Tour** and Alpine tourism was born (Schama 1995). Its full development had to wait until the **railway** network penetrated the high valleys in the later C19. Centres like Bad Gastein and Bad Ischl in Austria developed as **spas**, attracting wealthy invalids. Other settlements, notably Chamonix and Zermat, became famous as mountaineering centres (Ring 2000). After WW2, with the rise of package holidays,

skiing developed rapidly from a minority sport for a wealthy elite to a mass pastime. The technical expertise of engineers in constructing roads, mountain railways and cable cars opened the valleys and the mountains to summer as well as winter visitors, leading to the development of resorts and their associated infrastructure of access roads, hotels, ski lifts, and ski runs (Elsasser & Messerli 2001, Kariel & Kariel 1982).

Tourist development came at an environmental cost. Forest clearance to create ski runs and high-level access roads scarred the landscape, increasing runoff, erosion, the risk of flooding and avalanche damage. Resorts have caused traffic congestion and pollution and increased demand for water and waste disposal. The proliferation of ski runs, roads, tracks and paths damaged alpine meadows, threatening many plant species. The need to keep resorts operating all year to make them pay led to the expansion of summer activities like walking, mountain biking, riding and white water rafting, which spread the landscape impacts of tourism even further.

The Alps are one of the world's most saturated tourist areas. For a long time tourism was seen as a more benign source of income for mountain communities than industry. There was a rapid shift of employment in Alpine communities from farming to tourism and in the process traditional social structures were altered. Some of the most striking areas of alpine landscape receive protection as national and regional parks. But only around 10% of the Alps are protected by such designations and the creation of **national parks** often leads to conflicts (Thompson 1999, Weiss 2001).

Amazon

The Amazon basin covers 5.8 million km^2 in Brazil, Peru and Colombia. **Pollen** evidence and sediment cores suggest that its climate was unstable in the **Holocene**, alternating between wetter and drier phases. The early Holocene was c.5°C cooler than recent times and more temperate in character. Until recently it was thought that much of the Amazon basin was dry during the greater part of the **Pleistocene** and dominated by savanna, with forests concentrated in relatively small refuges. It is now thought that the tremendous **biodiversity** was due to high levels of natural disturbance and the stability of forest ecosystems. Humans have been recorded in the Amazon basin from c.5,000 years ago; their impact has been longer and more extensive than previously believed, with earlier burning of the forest for agriculture. The Amazon **rain forests** are not then a pristine **wilderness** but an environment which has long been managed. It has been assumed that the Amazon rain forests were not suited to large-scale

human settlement due to the poorness of the soils away from floodplains and based on the lack of major archaeological sites. Settlement has recently been shown to have been earlier and more widespread than previously thought: by c.9000BC there was a stone tool-making tradition and the occupation of the lower Amazon appears to date from c.10000BC. Agriculture was established on the coast by c.2000BC. The landscape of Amazonia in the last 350 years represents a return to wilderness due to the reduction of native population in colonial times. Recent archaeological research using satellite imagery and radar has discovered in the upper Amazon evidence of large pre-Columbian settlements with roads, bridges, avenues and squares, some possibly dating from the C13AD others to the C2BC. civilizations perhaps comparable to the **Aztecs** or **Maya** and implying disturbance of the rain forest on a previously unsuspected scale (Denevan 1998). Agriculture made some complex adaptations to the wide range of local environments. Terra preta (black earth) soil found near the main rivers is anthropogenic caused by the cultivation of soils and dense settlement. The early C19 rubber boom brought an influx of population: the boom collapsed after 1912 with the development of rubber **plantations** in SE Asia, grown from seedlings taken from the Amazon. With the decline in rubber production colonization halted temporarily, only to be renewed with the construction of networks of roads from the 1960s bringing millions of incomers into the region. But growing colonization with **slash and burn** agriculture and cattle ranching also caused a major increase in forest clearance. About 12% of the forest cover had been cleared by AD2000 to be replaced by ranches and smallholdings whose success was often short lived (Cleary 2001, Dean 1987, Little 2001, Moran 1993, Roosevelt 1994, Van der Hammen & Adsy 1994, Whitehead 1996).

Amsterdam

From medieval origins as a small settlement beside the R Amstel, Amsterdam flourished during the Dutch 'Golden Age' of the later C16 and early C17. In the late C12 and C13 fishermen on the banks of the Amstel build a bridge across it close to where it flowed into the River Ij. The mouth of the Amstel, where the street called the Damrak now runs, became a safe harbour. Until the C16 the town remained small but then expanded outwards in a series of concentric semi-circular canals with an outer line of defences. Amsterdam developed as a burgher city with rows of tall narrow-fronted canalside houses built to a similar general style but each one individual in detail. Like **Venice** these were built on wooden piles driven

into the mud; subsidence has made some of the canal houses lean. The packed frontages often conceal gardens and courtyards at the rear. In the C17 extensive reclamation of freshwater lakes around the city assured local food supplies (Roegholt 1997).

anaerobic

In environments like waterlogged soils, peat bogs and marshes the decomposition of organic matter is due to anaerobic bacteria which live without oxygen: this is the main source of atmospheric methane.

Anasazi

The 'ancient ones': civilization of SW USA which constructed the tallest buildings in N America before the Chicago skyscrapers of the 1880s. **Agriculture** arrived here from **Mexico**, with corn being grown by 2000BC, squash from c.800BC, then beans and cotton by c.AD400. By the C1AD village societies based on **irrigation** of agriculture had appeared and population was rising steadily. Most of their homeland lay at 1,200–2,400 m; temperature fell with height but rain increased. Corn could grow at up to 2,130 m but needed irrigation below 1,700 m. Moisture came from the Pacific and Gulf of Mexico, both strongly influenced by **ENSO** cycles. Summer rain between July and September came from both areas, winter rain from the Pacific from December to March. There were three types of agriculture: dryland farming at higher elevations where rainfall was greater (as with the **Mogollon** and Mesa Verde peoples), in canyon bottoms where the water table was close to the surface (**Mimbre** and Pueblo 2, **Chaco Canyon**), and using irrigation, especially the **Hohokam** who developed the most extensive systems in America outside **Peru** based on hundreds of km of secondary canals fed from main ones 18 km long, 5 m deep and 30 m wide. The Anasazi of Chaco Canyon flourished from c.AD600 to AD1150–1200. Around AD700 they developed massive stone construction and between the C10 and C12 buildings with up to six storeys. Chaco Canyon developed into a mini-empire linked by hundreds of km of local roads, supported by a peasantry and ruled by an elite. The last dated buildings at **Pueblo Bonito** are c.AD1117 and in Chaco Canyon c.AD1170. A combination of population pressure and periodic severe **drought** from c.AD1130 seems to have precipitated social stress with evidence of war, burnt settlements and cannibalism. Between c.AD1150 and AD1200 Chaco Canyon was virtually abandoned and when the Navajo arrived c.600 years later they attributed the construction of the ruined buildings to the 'ancient

ones'. The Anasazi did not collapse totally; they dispersed in the face of environmental pressures during two major drought cycles AD1130–80 and AD1275–99. With a population nearly at carrying capacity the Anasazi were vulnerable to short-term events (**El Niño** events or droughts) and especially to long-term climatic changes (Axtell et al. 2002, Diamond 2005, Fagan 1991, Stuart 2000).

ancient and planned countryside

A division of England into two broad landscape categories recognized by early-modern topographers as woodland and champion (open field) areas. Later landscape specialists recognized that **parliamentary enclosure** in England was concentrated in a belt of country from S England through the Midlands to the NE with regions of old enclosures on either side. This belt had been transformed in medieval times by the creation of **open field** systems, many of which survived until **enclosure** in the C18. The distinction between 'ancient' and 'planned' was emphasized by **Rackham** (1986) who itemised the distinctive features of both types of area. Ancient countryside, which had not been transformed in medieval times by the widespread adoption of open field systems, was characterized by dispersed settlement in farms and hamlets and had considerable continuity from earlier, even prehistoric times. Planned countryside developed in early historic times with the establishment of nucleated villages and open field systems (not necessarily together). The possible reasons for this contrast have been discussed by Williamson (2003).

ancient woodland

A term coined by **Rackham** (1986) to describe British woodlands on sites known to have been continuously wooded since AD1600, on the basis that records of land use from this time onwards are usually fairly complete while those for earlier periods are increasingly fragmentary. Woodlands created since AD1600 are 'recent'. Some species, such as small-leaved lime (*Tilia cordata*), are confined to ancient woodlands and a few hedges and are valuable as indicator species (Anderson 1990, Rackham 1986, 2006).

Andes

Mountain chain 7,000 km long in S America. From c.4000BC, if not earlier, the domestication of the **potato** and other plants allowed a sedentary lifestyle, with the creation of **terrace cultivation** and **irrigation**

systems and significant alteration to the landscape. Around L Titicaca and the Bolivian-Peruvian altiplano agriculture emerged c.1500BC. before this time aridity prevented intensive agriculture. Between c.1500BC and AD1100 the Tiwanaku developed agriculture and population grew. They developed a distinctive high-yield farming technique based on growing crops on raised mounds surrounded by irrigation water which released heat at night to provide warmth for the crops. Between AD600 and AD800 Tiwanuku developed on an urban scale with a population of up to 30,000 and impressive monumental architecture. Around AD950 there was a significant fall in precipitation around L Titicaca and agriculture seems to have collapsed, leaving a vacuum which was eventually to be filled by the **Incas**. The Inca empire developed from the mid-C14 until the mid-1530s but collapsed spectacularly under the impact of the Conquistadors. More recent native culture represents a fusion of traditional and introduced elements. **Deforestation** was widespread by the Inca period and continued under Spanish rule. **Desertification** has been especially bad in Bolivia due to overgrazing and the cultivation of steep slopes has encouraged erosion (Binfold et al. 1997, Gade 1999).

Angkor Wat, Cambodia

City and temple complex built by the Khmers from the C9AD at a time when the **monsoon** circulation brought a rich influx of fish creating what may have been the world's largest pre-industrial city with a population of 1 million spread over c.1,000 km^2 as a huge low-density urban complex. To feed the inhabitants extensive areas of woodland were cleared for **rice** cultivation and a vast, complex **irrigation** system developed, including three artificial **reservoirs** which were among the greatest engineering achievements of the pre-industrial world. The city survived until the C15 but it has been suggested that **deforestation** caused erosion that choked the hydraulic system, which gradually fell into disrepair and led to population decline.

Annales School

French school of historical research and writing which emerged in the late 1920s, named from the journal *Annales d'Histoire Économique et Sociale* (now called *Annales: Économies, Sociétés, Civilisations*) founded by Marc Bloch and Lucien Febvre. It represented a reaction against the dominance of political and diplomatic history and emphasized the need for 'total history', considering the underlying long-term structures which influenced everyday

life as well as day-to-day events. It was much more concerned with environmental influences and changes than previous historical approaches and was strongly influenced by contemporary French geography. The Annales School emphasized new directions, such as comparative and quantitative history, but also stressed closer links with geography and other social sciences, considering environmental history in some detail and absorbing approaches from geographers like **Vidal de la Blache**. It developed the concept of different wavelengths of time. The *longue durée* or geographical time comprised deep underlying rhythms, including environmental change, influencing human society. Above this were medium-scale cycles, including demographic, economic and agrarian ones. Together these formed the structures against which individual human lives were played out in short-term cycles, including diplomatic and political events. The school included such celebrated historians as Emmanuel Le Roy **Ladurie**, Fernand **Braudel** and Marc Bloch. Its particular focus has been on France and Western Europe. Braudel's *The Mediterranean and the Mediterranean World in the Age of Philip II* (1972) is a classic of this genre (Burke 1990). Braudel has sometimes been accused of regarding the environment as a mere backdrop to economic history but Moore (2003b) has suggested that he saw ecology and economics as being intimately related and was a pioneer of ecohistorical approaches.

Antarctic

95% covered in ice over 2,000 m thick in places; a cold desert with low precipitation. In 1773 James **Cook**'s second voyage of exploration penetrated S of the Arctic Circle, establishing that a S continent did not exist in more temperate latitudes and that any land further south was likely to be of little economic value. 1821 saw the first known landing on Antarctica by American sealers. In 1823 a British whaler, James Weddell, discovered the Weddell Sea, reaching over 74° S. The later C19 saw an expansion of sealing and **whaling** in Antarctic waters. S Georgia had been discovered in 1675 and claimed for Britain by Cook in 1775. British and American sealers sometimes overwintered there in the C18 and C19. The island later became a major whaling centre with factory settlements at Grytviken and other locations (Headland 1984). Scientific exploration of the continent began in the early C20 with Captain Scott's first expedition in 1902. In 1907–9 Ernest Shackleton got to within 155 km of the S Pole: the first to reach it was Amundsen in 1911. By 1957–8, the International Geophysical Year, 12 nations had established over 60 bases. The Antarctic

Treaty, signed in 1959, dedicated the continent to scientific research and limited military activity in support of science.

Although the Antarctic was once widely believed to be virtually immune to the impacts of global warming, recent research has demonstrated otherwise. In March 2002 5,500 km^2 broke off the Larsen B ice shelf in the Antarctic Peninsula; only 40% of the ice shelf that existed in 1995 is still there and ice shelves throughout the peninsula have lost 113,500 km^2 since 1974. The Antarctic Peninsula is seemingly especially sensitive to climate change. Average temperatures here have risen 2.5°C in the last 50 years, two or three times the global average, but there have not been comparable rises in the main part of Antarctica. From the 1960s a number of cores have been drilled in the Antarctic ice sheet reaching depths of 2,500 m and ice over 200,000 years old; **oxygen isotope** analysis of the layers has provided indications of temperature variations throughout the last glaciation and the interglacials on either side of it.

Although the Antarctic environment has experienced less modification caused by human activity than the other continents, changes have nevertheless occurred. The killing of c.90% of the great whales in Antarctic waters removed almost an entire trophic layer and has had widespread repercussions on marine **ecosystems**. There are concerns about pollution from the increasing number of cruise ships visiting the area (Bertrand 1971, Walton 1987).

anthrax

A disease caused by the bacterium *Bacillus anthracis* which can affect both animals and humans. It can be passed on to humans by infection via the skin during the butchering and skinning of animals, killing around one-fifth of those infected. It can also be transmitted through eating infected meat, with mortality levels being as high as 100%. Inhalation of spores is a third source of infection which, if untreated, can cause heavy mortality. It is thought by some scholars to have been the cause of the **Black Death** rather than **bubonic plague**. Until the C20 it killed large numbers of domestic animals and people in Europe, Africa, Asia, N America and Australia before Louis Pasteur developed a vaccine in 1881. As a result of vaccination programmes it is now rare. In the C20 experiments in its use as a biological weapon were undertaken. Gruinard Island, off the W coast of **Scotland**, was contaminated by anthrax testing during WW2 and was only decontaminated in 1986–90. Anthrax spores can survive dormant in soils for many decades.

anthropocene

Suggested by Paul Crutzen and Eugene Stoermer (2000) as a new geological epoch characterized by the dominant impact of humans on the global environment. They proposed that it started at the end of the C18 with the beginning of the **Industrial Revolution** in Britain and was characterized by rapid **population** increase, **urbanization**, increasing consumption of fossil fuels, **deforestation**, **pollution**, habitat change and global warming.

anthropogenic

Environmental changes resulting from human activities rather than purely natural forces.

Appalachians

Mountain range in E N America; 2,550 km long with extensive, varied woodland cover including one of world's greatest hardwood forests. Areas like the Great Smoky Mountains have a great variety of plant and animal species. The N–S direction of the range facilitated the N spread of plants and animals after the last glaciation from refuges in the S part of the mountains. Most of the woodlands S of the White Mts are hardwoods while conifers are more frequent in the N of the area. In the S especially most of the woods are secondary growth following 300 years of logging but there are a few areas of virgin forest from pre-Colombian times. The mountains were settled from c.8000BP. with extensive woodland clearance for native **agriculture**, then again by Europeans from the early C19 with some areas transformed by **coal mining** and logging. By the 1890s forests in the N Appalachians had been heavily cleared and logging was moving S. A growing conservation movement led to the creation of national parks, while by the mid-C20 extensive areas were in the hands of the US Forest Service. Underfunding of national parks has caused conservation problems. Open summit species-rich grasslands, or balds, which may have been created by earlier summer grazing, are now becoming covered with scrub. Forests and river life are being threatened by acid rain and by diseases such as the one which has attacked American chestnuts since the early C20 resulting in a loss of 4 billion trees in 35 years. The landscapes of the **Hudson River** provided an early attraction to tourists as did the White Mts from the mid-C19. A distinctive type of coal mining, mountaintop mining, has been practised since the 1960s, especially in W Virginia and E Kentucky, where the top of a

mountain or ridge is removed to access coal seams and the overburden then replaced. This reduces biodiversity and often results in waste material being dumped in nearby valleys (Silver 2003, Williams 2002b). The Appalachian Trail, 3,505 km long and designated in 1968, is the longest marked footpath in the USA and its popularity has done a lot for conservation in the region, as has Bill **Bryson**'s popular book *A Walk in the Woods* (1998).

aquifer

An underground stratum of porous rock, e.g. sandstone, in which water collects naturally and which can be tapped for irrigation or domestic use, especially by drilling wells. Many have been overexploited in recent times, leading to a reduction of supplies and sometimes land. The discovery of the Oglala Aquifer underlying some 250,000 km^2 of Colorado, Nebraska and Texas, USA held out major possibilities for agriculture. But the water in the aquifer accumulated over 1 million years ago and is not being replenished under present climatic conditions. It is a finite resource which is being used up at an increasing rate. In **Australia** the Great Artesian Basin is one of the largest groundwater aquifers in the world, covering c.1.7 million km^2, and supplies much of Queensland and parts of South Australia with water. There are also major aquifers below the **Sahara**, one underlying all of Egypt W of the **Nile**, and others below Libya, much of Chad and the Sudan. These have been estimated to contain the equivalent of 3,750 years' flow of the Nile. Much of the water accumulated during a wetter phase 50–20,000 years ago but some of it goes back over 1 million years.

Aral Sea

The world's 4th largest inland sea after the **Caspian**, L Superior and L **Victoria**, situated in the semi-desert borders of Kazakhstan and Uzbekistan in Central Asia. Its drying up in recent decades has been described as one of the greatest environmental disasters of the C20 (Glantz 1999). In the 1950s it had a surface area of 66,000 km^2, a volume of c.1,090 km^3 and a maximum depth of 68 m. Since the 1960s its area and volume have shrunk steadily. Between 1960 and 1987 its level dropped by nearly 13 m and its area by 40%. By the opening of the C21 there had been a 53% decrease in surface area and a 70% drop in volume (Micklin 1998, 2000). The level of the sea's surface has fallen from 53 m to 28 m.

Shrinkage has been due to reduced inflow, mainly due to abstraction for irrigation. Annual inflow in 1960 was 63–65 km^3. Now it is only c.1.5 km^3,

though a minimum of 10 km^3 is needed to prevent further shrinkage. Major changes in the volume of the sea are not new: former shorelines show that it has risen and fallen throughout the **Holocene**, with a range of at least 20 m and possibly over 40 m due to variations in climate and alterations in the courses of the rivers flowing into it. Within the last 3,000 years human societies have played an increasing role through diverting water for **irrigation** and other purposes. However, between the late C18 and the early C20 fluctuations were quite small. In the early C20 the level of the lake was relatively high, resulting in a time lag in the late 1950s and early 1960s before the impact of the new irrigation systems on the sea's hydrology became apparent. Shrinkage since the 1960s has been the fastest in over 1,000 years. On present trends only a small saline remnant will survive within the next decade or two.

The drying up of the sea has caused severe environmental economic, social and health problems. Shrinkage has had a significant impact on the regional climate. From the mid-1960s until the end of the 1970s a drier phase set in, but as the sea shrank **anthropogenic** influences pushed the climate further towards aridity. The sea at its 1950s level exerted a moderating effect on climate, reducing cold conditions in winter and high temperatures in summer. With shrinkage winters have become longer and colder but snowless; summers shorter, hotter and rainless. This has shortened the growing season, putting **cotton** production at risk: some farmers have been forced to switch to growing **rice**. Ironically, it was for the expanding cotton production that water was diverted from the sea in the first place.

The key factor in causing continued shrinkage has been the abstraction of water for irrigation. Irrigated land in the Aral Sea basin rose from 3 million ha in 1900 to 7.6 million ha by 1987. The Karakum Canal was constructed from the mid-1950s – the longest irrigation canal in the Soviet Union, running for 1,300 km from the Amu Dar'ya into the Kara-Kum desert – and has been the most significant user of water, withdrawing up to 13 km^3 a year (Glantz 1999). The irrigation systems were badly designed, inefficient and poorly maintained. 50–60% of the water never reached the fields, being lost by seepage and evaporation. The cotton crop required half the available water resources of the two river basins (Glantz 1999). Over-intensive cropping led to a fall in soil fertility, which was tackled by increased use of **fertilizers**, herbicides and pesticides. When these were flushed into the Aral Sea they caused ecological complications.

Some reduction of the sea had been expected in the original irrigation plan but impacts on local climate and ecosystems were underestimated.

Few scientists had foreseen that large amounts of salt would be blown from the dried-out lake bed on to agricultural land, causing salinization and loss of productivity. Between 1960 and 1987 around 27,000 km^2 of lake bed became exposed. Around 43 million t of salt have been blown off the exposed lake bed each year and deposited over an area of 200,000 km^2, damaging crops and harming soils. By the end of the 1990s over 2 million ha of agricultural land in the Amu Dar'ya delta suffered from **desertification** and the unique tugai forest ecosystem of the area had been largely destroyed.

Within the sea fish stocks have been devastated. Fisheries declined from an annual catch of 48,000 t in 1957 to almost zero in 1980. By 1982 commercial fishing had ceased, local canning plants had closed and fishing villages were abandoned, their boats stranded far from water by the retreating sea. Damage has been especially severe in the delta areas. Not only did they once have a rich flora and fauna, they were also a vital source of grazing for livestock, a spawning area for fish and a major supplier of reeds for industrial uses.

The shrinkage of the Aral Sea was a human health tragedy too. The exposure of former seabed increased the incidence of dust storms. This probably lies behind the growing problem of respiratory illness in the region (Wiggs et al. 2003). The region has the highest infant and maternal mortality in the former Soviet Union. Over 70% of women aged 13–19 have kidney diseases, 23% have thyroid problems and over 80% are anaemic (Small et al. 2001). Supplies of good-quality drinking water have become scarce, forcing many people to drink water from the irrigation canals contaminated with salts, bacteria and pesticides. There have been outbreaks of typhoid and viral hepatitis as a result. A drop in the quality of drinking water has also been linked to the spread of intestinal diseases and throat cancer (Micklin 1988, Perera 1993, Stone 1999).

Aran Islands

Not to be confused with the Scottish island of Arran. The Aran Islands are a group of three islands in Galway Bay, W Ireland. Essentially, tilted limestone slabs with steep cliffs facing the Atlantic, similar to the **Burren**. Populated early in prehistory because of their light, well-drained soils. Many stone-walled ring forts survive from later prehistory in a good state of preservation, like Dun Aengus. The landscape is criss-crossed by a dense network of irregular stone walls. Artificial soil was created by carrying sand and seaweed up from the shore for **potatoes** and other vegetables.

Otherwise the islands provided pasture for cattle and sheep (from which was produced traditional Aran knitwear). The distinctive landscape and traditional lifestyle of the islanders has attracted many visitors and commentators, including Robert J. Flaherty's 1934 documentary *Man of Aran* and J.M. Synge's *The Aran Islands* (1907) (Waddell et al. 1994).

Arctic sea ice

Satellite records are available from 1979 and show that the long-term trend in the extent of the ice is downwards. In the five years to 2009 the five lowest summer extents have been recorded. In 2009 there was 1.7 million km^2 less than in 1970, even though the cloudier summer of 2009 preserved more ice (Kwok & Rothrock, 2009). Arctic sea ice cover over the last 30,000 years can be established from the analysis of fossil algae in marine sediments. Between E Greenland and Spitzbergen there was permanent sea ice 20000BP at the last glacial maximum but significant warming from 15000BP. Data from Icelandic records provide indications of summer Arctic sea ice limits in the N Atlantic from the C10 onwards (Ogilvie 1984). When **Iceland** was discovered in the late C9 sea ice limits appear to have been further S, helping to give the island its name. By the time Norse settlement occurred, summer sea ice had retreated and the passage from Iceland to Greenland was generally clear in the C11. European exploration in search of gold and the **North West Passage** began from the C16 and continued during some of the worst phases of the **Little Ice Age**. From the C13 as climate shifted into the earliest phase of the Little Ice Age sea ice limits advanced, making the crossing to Greenland more difficult and closing off the Greenland fjords entirely in some years. For post-medieval times **ships' logs** provide data on ice limits in the Davis Strait and Hudson Bay area. During the late 1690s, the nadir of the Little Ice Age, for a few years summer sea ice limits lay S of Iceland (Ogilvie & Jonsdottir 2000). Fluctuating sea ice limits around Iceland affected fisheries which were good in medieval times when limits were well to the N. Between the C17 and C19 fisheries around Iceland failed as ice limits pushed S.

Today Arctic sea ice covers c.14 million km^2 at its February maximum and about half that area at its September minimum. Weekly satellite observations since 1972 show that the maximum extent has been shrinking by about 3.6% per decade, with a tendency for the rate to accelerate in recent years. Most of the decline has occurred in the Barents, Kara and E Siberian seas N of Russia and the Sea of Okhotsk NW of Japan. Conversely there has been

an increase in sea ice in the Davis Strait and the Labrador Sea. These trends have been linked with atmospheric warming during the last 30 years over much of Siberia, Alaska and W Canada, coupled with a weaker cooling trend over W Greenland and the Labrador Sea. These trends have caused changes in air circulation which have increased the penetration of warm air into the Arctic. In 2005 the sea ice cover was the lowest in over a century. In 2007 Arctic sea ice was again at its smallest recorded extent since satellite records began in 1972. Reduction in the extent of Arctic sea ice has been c.100,000 km^2/yr. On current trends the Arctic could be totally free of ice in summer by the end of the C21.

ard

See **light plough**.

Areas of Outstanding Natural Beauty

Covering 6% of England and Wales: designated under the National Parks and Access to the Countryside Act 1949 as a second tier of protected areas. Smaller, less highly valued and sometimes less accessible than national parks.

arroyo

Systems of gullies in SW USA cut into fertile valley-floor deposits. Widely believed to have been the result of human activity; a range of processes have been blamed, including logging, **overgrazing** and soil compaction. Detailed study of the history of valley fills in this area has shown that there have been several phases of deposition and incision, some occurring before the advent of Europeans, suggesting that environmental factors like cyclical climatic change may have been responsible (Cooke & Reeves 1976).

asbestos

A set of metamorphic minerals with a fibrous character valued since Roman times for resistance to fire. Much of the world's production in recent times has come from Canada, the Appalachians and the S Ural Mts Used widely in building construction, production has fallen substantially in recent years due to its carcinogenic properties. Major efforts are being made to remove it from older buildings due to its health risks, which were known from the C19 but were identified more clearly in the 1960s.

Asia, Central

A loosely defined area forming the core of Eurasia with a wide range of environments embracing deserts like the Kara Kum, mountains providing snowmelt for the plains and huge areas of steppe as well as river valleys and oases with intensive irrigated agriculture. It is generally acknowledged to comprise the republics of Kyrgystan, Kazakhstan, Tajikistan, Turkmenistan and Uzbekistan, formerly parts of the USSR, covering c.2.5 million km^2, and is often expanded to include parts of Iran, Afghanistan, Mongolia and Tibet. Central Asia forms part of a huge arid belt stretching from North Africa to Manchuria. In this area agriculture was probably introduced from Mesopotamia but the region was particularly characterized by nomadic pastoralism, which emerged between c.8500BC and 6500BC in the S Levant. Livestock herds and horses provided the nomads with all their basic needs – transport for people and goods, food, drink, clothing, homes (yurts) and heating (burning animal dung). Mobility allowed them to respond to short- and medium-term climatic shifts. Nomadic herders and sedentary farmers were often in conflict but also co-operated in more symbiotic ways – e.g. in relation to trade, which was funded by urban merchants and protected by the pastoralists. From c.2000BC Central Asia became the hub of a huge trade network linking China with Europe and the Near East. Warmer, wetter climatic phases encouraged pastoralists to become more sedentary but Central Asia was also characterized by large-scale population movements into peripheral areas. These fluxes led Ellsworth **Huntingdon** to develop his 'pulse of Asia' theory which linked eruptions of nomads into the periphery of Central Asia to periods of drought at the core. The silk road, as the 4,500 km long trade route came to be known, continued to function into medieval times and later using caravans of **camels**. The caravans also carried with them religions such as Buddhism and Islam, as well as diseases like **bubonic plague** (most notoriously the **Black Death**). Behoet's disease, described by the ancient Greeks, has been shown to be related almost exclusively to populations living along the line of the former silk road. The actual trade in silk began under the Han dynasty (206BC–AD229). The steppe horse riders, armed with bows and lances, became a military force to be reckoned with during the relatively brief periods when large areas of Central Asia could be united politically, as during the C13–C14AD when the Mongols created the largest contiguous empire in history – 2.4 million km^2. At its peak the Mongol empire extended from E Europe to the Sea of Japan. At other times powers on the periphery – the Chinese empire, Russia or Persia – tried to annex Central Asia. Russian military conquest

annexed huge areas of Central Asia between the 1860s and 1890s for the development of cotton production. Agriculture nevertheless remained traditional in character until the 1930s when soviet industrialization and irrigation began to transform vast areas with the creation of collective farms, the replacement of local irrigation schemes by giant region-wide projects and the major development of industry. The discovery of oil around Baku on the **Caspian Sea** brought major environmental changes, including pollution of the Sea itself. A major problem throughout the region has always been the availability of water. In the post-1945 period this was tackled with grandiose projects which had unexpected and often highly undesirable environmental impacts (see **Aral Sea**). Attempts to expand cotton production in this area on a massive scale were undermined by falls in world prices and salinization of soils in irrigated areas so that production peaked around 1980 and then started to fall. Plans to divert water from major N-flowing rivers like the Irtysh and Ob via a 22 km long irrigation canal were mooted in the 1970s but abandoned in 1986. An over-optimistic assessment of the fertility of steppe soil and its suitability for cropping led to the ill-fated Virgin Lands Scheme in the 1950s and 1960s. In addition, between 1949 and 1989 large areas of Kazakhstan were used for nuclear testing, leading to the contamination of extensive areas. Since the demise of the USSR and its collective farms there has been a resurgence of nomadic pastoralism in the former soviet republics (Barfield 1993, Christian 2000).

assart

From the French *essarter*, 'to grub up'; in medieval times an area of land taken in and cultivated from woodland, hunting forest and waste by an individual or group of cultivators.

asteroid impacts

Impacts on earth by large asteroids and comets are rare but are known to have occurred in the past, though they are outside recorded human experience. The Barringer Crater in Arizona, dating from c.50 kya, was probably caused by a meteor c.50 m diameter. An event at Tungushka in Siberia in 1908 may have been caused by the airburst of a comet or asteroid 5–10 km above the surface, felling 80 million trees over 2,150 km^2. Asteroid impacts have sometimes been invoked to account for otherwise unexplained environmental crises such as mass species extinctions at the end of the Permian and Cretaceous and, more recently, the disappearance of the

Clovis culture in N America and extreme weather events in the N hemisphere in AD533–4.

Aswan High Dam, Egypt

Completed in 1970, it was designed to control the waters of the Nile to prevent major flooding and to supply water during droughts. The **dam** is nearly 5 km long and almost 1 km thick at its base, having required 18 times as much material as the Great Pyramid. Its turbines produce 10 billion kw hours of electricity a year. Around 90,000 Nubians had to be moved to create the 550 km long reservoir, Lake Nasser. The dam allowed an expansion of irrigation for cash crops like **cotton**. Unfortunately the **reservoir** traps the silt formerly brought down by the Nile's annual floods and despite increasing input of artificial fertilizer the condition of Egypt's soils has declined, a problem increased by the tendency of **irrigation** water to draw up salts to the surface. The Nile **Delta** is also declining in fertility due to the lack of deposition of silt, while its coasts are being eroded by the sea at a rate of 70–90 m a year due to the lack of sediment to maintain them. The loss of nutrients into the E **Mediterranean** has had detrimental impacts on fisheries. Between 1977 and 1990 the dam produced one-third of Egypt's electricity but much of this went to powering fertilizer factories which had previously not been needed. The Mediterranean has become saltier, encouraging an invasion of Red Sea fish species via the Suez Canal; these have colonized the Mediterranean as far W as Sicily.

Athens

Grew from 50,000 inhabitants in the mid-C19 to 750,000 in 2001. The city is located in the Attica Basin and, like **Los Angeles** and **Mexico City**, is surrounded by mountains which encouraged temperature inversions and **air pollution**. By the 1970s pollution was causing severe damage to carvings on the Parthenon and other classical monuments. Anti-pollution measures by the urban authorities in the 1990s improved the situation but problems remain. Wildfires in the surrounding woodland and scrub have also become a hazard.

Atlantic islands

Including Madeira, the Canary Islands, the Azores, Cape Verde islands and St Helena. The settlement of the Atlantic islands provides the first example

of the effects of a relatively technologically advanced society on environments which were either previously unsettled by humans, like St Helena or Madeira, or only lightly touched by them, as with the Canaries. The rapid changes in vegetation, soils and even climate that followed European settlement provided a cautionary tale for later generations. The human impact on these fragile environments was frequently similar to neighbouring mainland areas but its intensity was greater because of their smaller scale. In particular, it was the introduction of **plantation** agriculture which altered the islands' ecosystems. The Atlantic islands were Europe's first tropical laboratories in which European crops and farming systems were tried out and modified and new techniques developed.

Portuguese navigators in the C15 pioneered a route down the W coast of Africa and around the Cape of Good Hope. This process led to the discovery of the Atlantic islands. The Canaries were known to the Romans (who may also have discovered Madeira and the Azores). Lanzarote was rediscovered in 1336. The Canaries already had an indigenous human population, known to the Spaniards as Guanches, who appeared to have originated from N Africa. They were hunter-gatherers, but constituted an opposition to the first European settlers. Between 1402 and 1496 a series of campaigns was waged against them and they gradually succumbed to European weapons and diseases. Survivors were enslaved, some being sent to the plantations in Madeira. The Guanches were the first non-European victims of European imperialism. The introduction of sugar cane from the **Mediterranean** transformed the Canary Islands (Fernandez-Arnesto 1982, Braudel 1972). The first sugar mill was established in 1484. In a pattern repeated on both sides of the Atlantic, deforestation to make way for sugar plantations led to a rapid decrease in moisture (Crosby 1986). By the early C16 wood was becoming scarce and regulations to protect the remaining forests were introduced (Parsons 1981).

The Cape Verde Islands, 500 km from W Africa, were uninhabited, though known to Senegalese fishermen. Europeans first landed in 1456 and the islands were claimed by Portugal in 1460. Once covered by dry forest and scrub, their volcanic soils were quite fertile but large parts of the islands were too dry for agriculture. Slaves were imported to work on sugar plantations. Overgrazing by goats and cultivation of the steep slopes led to soil erosion and desertification, which were made worse by a climate with marked wet and dry seasons, periodic droughts and water shortages. From a well-wooded savanna much of the islands were converted to near-desert (Lindskog & Delaite 1996).

The island of Porto Santo E of Madeira was discovered in 1418 by Gonçalvez Zarco and Tristaö vaz Texeira while on a voyage to Guinea. A few colonists were left behind while the expedition reported the discovery. On their return in 1419 the people that they had left told of having seen distant high land, the island which came to be called Madeira, 'the wooded isle'. Before leaving Madeira Zarco, according to tradition, set fire to the forests; the fires are said to have burnt for seven years. The first act of European explorers in Madeira then was woodland clearance on a catastrophic scale.

Two years later Zarco and Texeira returned to initiate full-scale colonization. The climate and fertile soil were ideally suited to the growth of sugar cane. From 1452, when the first sugar mill was authorised by the Portuguese government, sugar production expanded rapidly and within a few decades the island was the world's foremost producer. The **plantations** were increasingly worked by **slave** labour from W Africa and the Canaries. Madeira, like the Canaries, was covered by sub-humid mountain forest of a kind once widespread in S Europe and NW Africa. The removal of this reduced soil moisture and precipitation. Most perennial streams dried up. As early as the C15 irrigation canals, or levadas, were dug to distribute water from the moister areas in the N of the island to the drier, more sunny areas of the S, in a network which eventually extended to over 2,150 km. One of the problems of colonization then was the provision of sufficient water for agriculture (Galloway 1989, Greenfield 1977).

The Canaries and Madeira had a basically Mediterranean climate but the Azores, discovered c.AD1432, lay more to the N: cooler winds there did not suit the cultivation of sugar cane. A mixed farming system rather than plantation agriculture was developed there following settlement in the 1440s. More remote still was St Helena, 1,920 km from Africa and 2,880 km from Brazil. Volcanic in origin, it was colonized only by birds and insects, and plants whose seeds had been blown there or washed ashore. As a result the island developed a distinctive isolated flora and fauna. Many of St Helena's plants had as their closest relatives plants in Africa which had long been extinct. Distinctive woodlands developed dominated at different altitudes by characteristic species – scrubwood (*Commdendrum rugosum*) at lower levels, gumwood (*Commdendrum rubustum*) at 400–600 m and *Trochetiopsis erythdoxylon* up to 650 m. It was the tragedy of this and other Atlantic islands that their unique ecosystems were so vulnerable to human interference.

St Helena was discovered in AD1502 by the Portuguese. It became a staging post and watering point on the route to the Cape of Good Hope. The interior of the island was largely covered by forest. It did not experience

plantation agriculture as early or on such a scale as Madeira or the Canaries. The first Portuguese settlers in the mid-C16 introduced goats, which were highly effective agents of **deforestation**. During the C17 Anglo–Dutch rivalry led to rival crews of visiting ships cutting down groves of fruit trees to deny them to their enemies. Development by the English East India Company in the later C17 led to rapid land degradation. When the Dutch annexed the Cape of Good Hope the English established a permanent colony on the island in 1659 leading to the rapid development of plantations. The effect of this on a mountainous island with variable rainfall was devastating. Erosion was reported as early as 1670. Today over 60% of the island is barren, known appropriately as the Crown Wastes. The colony's early administration seemed unaware of contemporary developments in the West Indies where the undesirable impact of deforestation and the establishment of plantations was rapidly becoming evident (Grove 1995). The danger of adopting stocking densities and land use methods derived from England, under different conditions of climate and terrain, was not appreciated.

Atlantic period

A period of warm, oceanic climate in NW Europe c.9,500–7,000 kya.

Atlantis

Plato's account of a lost civilization destroyed by a catastrophe and sunk in the ocean in a single day and night has been attributed by some to a folk memory of the eruption of **Thera**, transposed by artistic licence beyond the Pillars of Hercules and into the Atlantic. The story was revived in the C19 with various possible locations suggested, including the **Mayan** and **Aztec** empires. The development of plate tectonics theories from the 1960s made a lost continent seem increasingly improbable but a range of locations in almost every ocean has nevertheless been put forward (Burroughs 2005, Zangger 1993).

Audubon, John James (1791–1851)

French naturalist and artist famous for his illustrations of N American wildlife, especially birds. His interests in birds developed into a project to paint every bird species in N America. His *Birds of America* (1827–38) showed them in their natural habitats. His example encouraged the