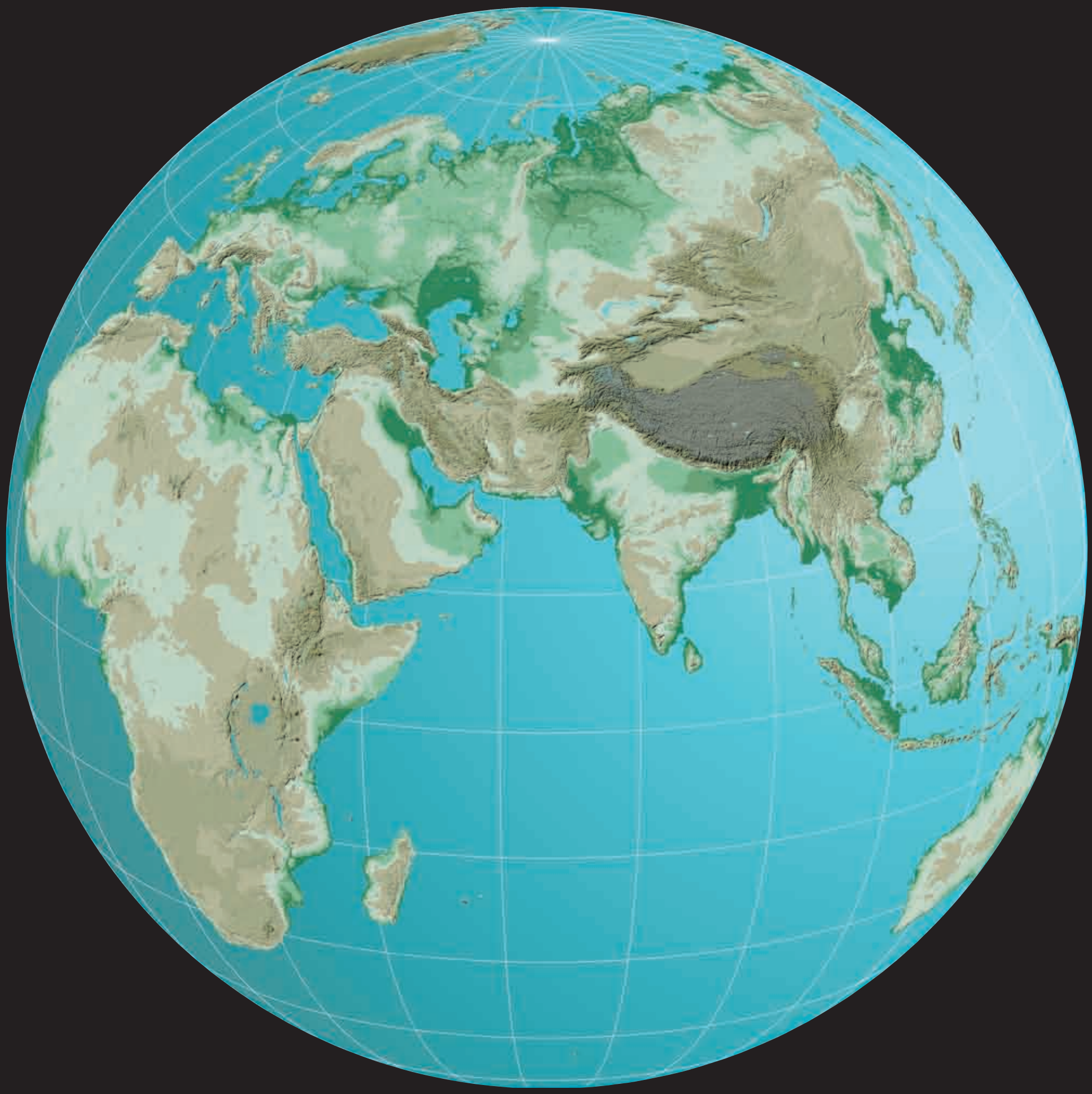
Topographic Map of the World

Credit: UNEP/NASA–GTOPO30



Credit: Mark Ernste/UNEP/UNEP-GRID Sioux Falls

1 Introducing the Planet

A Story of Change

In our solar system, a single planet—the Earth—supports human life. World population is increasing. Yet for the moment, the Earth remains the only home for the human species. The way in which we care for this planet will affect our future and the future of our children for generations to come.

Seen from space, the Earth is largely a blue planet around which swirls of white clouds constantly move. The Earth's blue areas are its oceans. Oceans account for approximately 70 per cent of the Earth's total surface area; the remaining 30 per cent is land. The total size of the terrestrial surface is approximately 149 million km² (59.6 million square miles) (McNeill 2000; Grace n.d.).

The Earth's land surface is rich in its variety. The highest point on the Earth's land surface is Mount Everest, a breathtaking 8 850 m (29 035 ft) above sea level. The lowest point is the Dead Sea, which is, on average, about 400 m (1 312 ft) below sea level. Terrestrial surfaces gain and lose heat much more quickly than oceans and a region's distance from the equator dramatically affects its climate. Lands nearest the equator tend to be the warmest. Those that lie in the middle latitudes typically have cooler climates, but are not as cold as lands near the poles. Some 20 per cent of the Earth's terrestrial surface is covered by snow. Another 20 per cent is mountainous. Just 30 per cent of the Earth's land surface is suitable for farming.

Most people are accustomed to seeing the world around them as a relatively stable place, a generally nurturing environment that has allowed the human race to expand and develop in countless ways. In fact, the Earth is constantly changing, as is our understanding of it (Figure 1.1). Some changes to the Earth's surface occur on microscopic levels. Other changes take place on a scale so large as to be almost inconceivable. Some types of change are instantaneous, while other types occur slowly, unfolding over centuries, millennia, and even eons. Some changes are caused by the actions of people. Many others are part of natural, inexorable cycles that can only be perceived when cataclysmic events occur or through painstaking research.

> **"The only thing permanent is change."**
>
> — The Buddha (Siddartha Gautama)

Credit: Blue Marble/UNEP/NASA (2002)

Credit: Unknown/UNEP/Tapestries&More

Figure 1.1: The Earth's surface has changed dramatically over time—as has our understanding of it. Early ideas about the shapes and locations of the continents, for example, were far different from what is known about the land surface today.

Table 1.1 – Approximate change of the Earth's global vegetative cover in relation to human population (Adapted from McNeill 2000).

	Per cent of the Earth's Vegetated Land Area				
Year	*Forest and Woodland*	*Grassland*	*Pasture*	*Cropland*	*Human Population (Billions)*
8000 B.C.	51	49	0	0	0.005
1700 A.D.	47	47	4	2	0.6
1900	43	40	10	6	1.6
1920	43	38	12	7	1.9
1940	41	35	16	8	2.3
1960	40	31	20	9	3.0
1980	38	26	25	11	4.4
1990	36	27	26	11	5.3

Credit: Paul Fusco/UNEP/NRCS

Credit: Chatree Wanasan/UNEP/Topfoto

Agents of Environmental Change

From the Earth's earliest beginnings, forces such as climate, wind, water, fire, earthquakes, volcanic eruptions, and the impacts of meteors and comets have shaped the Earth's terrestrial environments. These same forces are at work today and will continue far into the future. In addition, every living thing influences its environment and is influenced by it. One species may lessen the chances for survival of the organisms it consumes for food. That same species, in turn, is affected by the actions of other organisms.

In order to survive, every organism must either adapt to its environment or modify the environment to make it more hospitable. Humans are particularly adept at modifying their environments. By their actions and interactions with the landscape, for example, people can increase the range of certain plant species, either by modifying existing environments or by dispersing seeds into new ones. Environmental modifications made by people may be beneficial or detrimental to a few or many other species. Large-scale environmental changes may not benefit or be to the liking of people themselves (Nott 1996). As world population has increased and the scope and nature of technology has changed, people have brought about environmental changes that may seriously impact their future well-being and even survival.

Humans began modifying their environment a long time ago (Table 1.1). Evidence of the existence of our first humanoid ancestors dates to the Pliocene Epoch, which extended from roughly 5 million to 1.8-1.6 million years ago (Wikipedia n.d.). These protohumans sought protection from the elements and from predators in natural shelters such as caves and rock overhangs. Over time—and possibly

Five Major Events in the History of the Earth

Throughout the Earth's history, events have occurred that dramatically impacted life on our planet. Five of those events stand out as having resulted in widespread extinctions, in some cases destroying more than 90 per cent of all living things (Eldredge 2001):

- Around 440 million years ago, a relatively severe and sudden global cooling caused a mass extinction of marine life (little terrestrial life existed at that time). An estimated 25 per cent of the existing taxonomic families were lost. (A family may consist of a few to thousands of species.)
- Near the end of the Devonian Period, some 370 million years ago, a second major extinction occurred. Roughly 19 per cent of the existing taxonomic families were wiped out. It is uncertain whether climate change was a driving factor.
- About 245 million years ago, a third major extinction took place. Scientists estimate that more than half (54 per cent) of all taxonomic families were lost. Climate change may have played a role, and that change may have been caused by a comet or meteor impacting the Earth.
- At the end of the Triassic Period, around 210 million years ago, roughly 23 per cent of existing taxonomic families suddenly became extinct. This event occurred shortly after the appearance of the first dinosaurs and mammals. Its causes are not yet fully understood.
- The fifth major extinction is the most well-known. It occurred about 65 million years ago at the end of the Cretaceous Period. The event led to the extinction of all terrestrial dinosaurs and marine ammonites, along with many other species occupying many different habitats. All told, approximately 17 per cent of all taxonomic families vanished in a very short time. Currently, the most widely accepted hypothesis to explain this mass extinction is that a comet or other large extra-terrestrial object struck the Earth. Another view proposes that a great volcanic event, or series of events, disrupted ecosystems so severely worldwide that many terrestrial and marine species rapidly succumbed to extinction.

Credit: Unknown/UNEP/Bigfoto

Fire—A Tool for Humankind

For thousands of years humans have used fire for:

Hunting

By setting fire to parts of the landscape, people were able to drive game animals into smaller, more confined areas that made hunting easier. Fire was also used to drive animals into impoundments, chutes, river or lakes, or over cliffs. Fires also helped maintain open prairies and meadows by killing bushes and trees and encouraging rapid growth of grasses.

Improving plant growth and yields

Setting fires was a way to improve grass for grazing animals, both wild and domestic, and to promote the growth of certain desirable plant species.

Protection

Fire was used to protect human habitations.

Collecting insects

Some tribes used "fire surrounds" to collect and roast crickets, grasshoppers, and moths. People also used fire smoke to quiet bees while collecting honey.

Managing pests

Fire was a handy tool for reducing or driving away insect pests such as flies and mosquitoes as well as rodents. Fire was also effective for eliminating undesirable plants.

Warfare and signaling

Fire was both an effective defensive and offensive weapon. Offensively, it was used to deprive enemies of hiding places in tall grasses or underbrush. Used defensively, fire could provide cover during an escape. Smoke signals helped alert tribes to the presence of possible enemies or to gather forces to combat a foe. Large fires were set to signal a tribal gathering.

Clearing areas for travel

Fires were sometimes started to clear trails through dense vegetation. Burning helped to improve visibility in forests or grasslands for hunting and warfare.

Felling trees

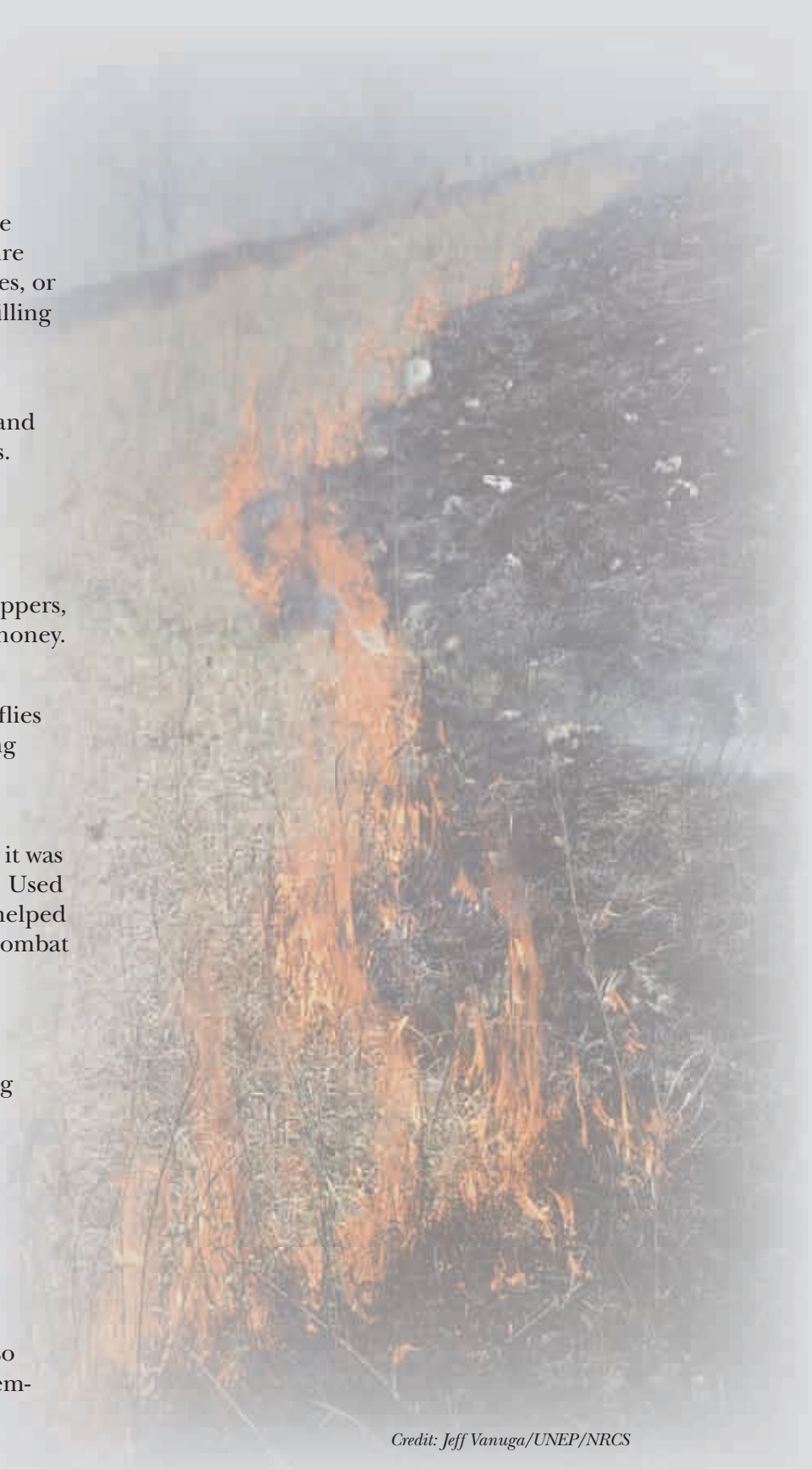
Singed or charred trees were easier to fell and to work with.

Clearing riparian areas

Fire was used to clear vegetation from the edges of lakes and rivers.

Managing crops

Burning was later used to harvest crops and collect grass seeds. Fire also helped prevent abandoned fields from becoming overgrown and was employed to clear areas for planting.



Credit: Jeff Vanuga/UNEP/NRCS

influenced by the onset of colder weather during the Ice Ages—they created dwelling places for themselves in locations that had no natural shelter.

The oldest surviving traces of such a human-made habitation date to about 2 million years ago from Olduvai Gorge in central Africa. There, a small circle of stones was found stacked in such a way as to apparently have held branches in position. This early example of modification of the environment was the work of *Homo habilis*, a tool–making human ancestor (Kowalski n.d.).

The Pleistocene Epoch, including the Paleolithic and Mesolithic Periods (Wikipedia n.d.), is usually dated from the end of the Pliocene to 10 000 years ago. The Paleolithic Period, or Old Stone Age, is a term coined in the 19th century to define the oldest period in the history of humankind. It lasted for some 2.5 million years, from the time human ancestors created and used the first stone tools to the end of the last glacial period some 10 000 years ago. *Homo erectus*, thought by many to be the direct ancestor of modern humans, lived from approximately 2 million to around 400 000 years ago. As a species, *Homo erectus* was very successful in developing tools that helped in adapting to new environments. They were pioneers in developing human culture, ultimately moving out of Africa to populate tropical and sub-tropical environmental zones in the Old World, possibly as early as 1.8 million years ago.

Homo erectus may also have mastered the use of fire around 1.6 million years ago (Mcrone 2000). Fire is an exceptionally powerful tool. Since most animals, including large predators, are afraid of fire, early humans quickly discovered that campfires offered protection from attack during the night. Control of fire allowed them to move into colder regions as it provided warmth as well as security. Fire also changed the way food was prepared. Food that is cooked is less likely to carry disease organisms and its softer texture makes it easier to eat, enhancing the survival of young children and old members of a population.

The use of fire almost certainly increased during the Paleolithic Period. At that time, humans were primarily hunter-gatherers. The role of fire in modern hunter-gatherer cultures gives us some idea of its importance during the Paleolithic and how people then most likely used

it (Williams 2001). Fire was an important tool in everyday life. It was also a tool with great potential to modify and change the environment.

The transition from *Homo erectus* to *Homo sapiens*—our modern human species—occurred approximately 300 000 to 400 000 years ago. Throughout the Paleolithic Period, humans survived by exploiting resources in their environment through subsistence activities such as fishing, hunting, and plant gathering. From ethnographic studies of modern hunter-gatherers, we can infer that the basic social unit of Paleolithic times was the band: a loosely bound, relatively small group (25 people on average) formed by the voluntary aggregation of a few families. Bands were mobile, regularly changing residence inside a delimited territory according to fluctuations in the abundance of different food sources. Inter-regional migrations, such as those within the Western Hemisphere, probably took place during this time.

This mobile life was punctuated by episodes of reunion, when several allied bands would meet and perform religious ceremonies. Such occasions would have provided a time and place for the transmission of techniques and artistic fashions, promoting their spread across vast expanses of territory.

Some 10 000 years ago, a new geological time period, the Holocene, began. World sea levels rose about 35 m (116 ft) in the early Holocene due to melting glaciers. As the ice melted and glaciers receded, many land areas that had been depressed by glacial weight slowly rose as much as 180 m (594 ft) above their late-Pleistocene and early-Holocene levels. Both sea-level rise and depressions in the landscape allowed temporary ocean-water incursions into regions that are today far from any sea. Climatic shifts also were very large during this period. Habitable zones expanded northwards. Large, mid-latitude areas such as the Sahara that were previously productive became deserts. At the start of the Holocene, large lakes covered many areas that are now quite arid.

Animals and plants did not undergo major evolutionary changes during the Holocene, but there were significant shifts in their distribution. Several types of large mammals including mammoths, mastodons, saber-toothed cats, and giant sloths went extinct in the late Pleistocene and early Holocene. Ecological "islands" of isolated species were created throughout the world, including high-altitude remnants of cooler, previously regional climate ecosystems.

The period from 10 000 to 5 000 or 4 000 years ago is recognized as the Neolithic Period (New Stone Age). It was preceded by the Mesolithic Period (Middle Stone Age), which roughly corresponds with the beginning of the Holocene. The Mesolithic Period formed a transition between the Paleolithic and Neolithic Periods, that is, from the end of the Pleistocene to the introduction of agriculture in any given geographical region (Wikipedia n.d.).

The size of the world's human population 10 000 years ago is estimated to have been around 5 million (IPC 2003a). This period saw the beginning of agriculture and the domestication of animals. People learned to cultivate crops rather than to simply gather what nature provided in the wild and to tame and raise animals such as sheep, goats, cattle, horses, and dogs, rather than hunt them. These activities helped ensure better food supplies and resulted in wide-ranging cultural consequences. Permanent communities were now established, since people were no longer dependent on following wild animals or moving with the seasons. Day-to-day existence changed from a life of nomadic foraging to one of permanence. This allowed some individuals to explore tool production to refine rude stone tools and improve implements such as stone-blade knives, bow drills with flints for starting fires, fish hooks, axes, and plows. Other people found time to improve agricultural and pastoral techniques, enabling communities to grow more food and tend livestock more effectively.

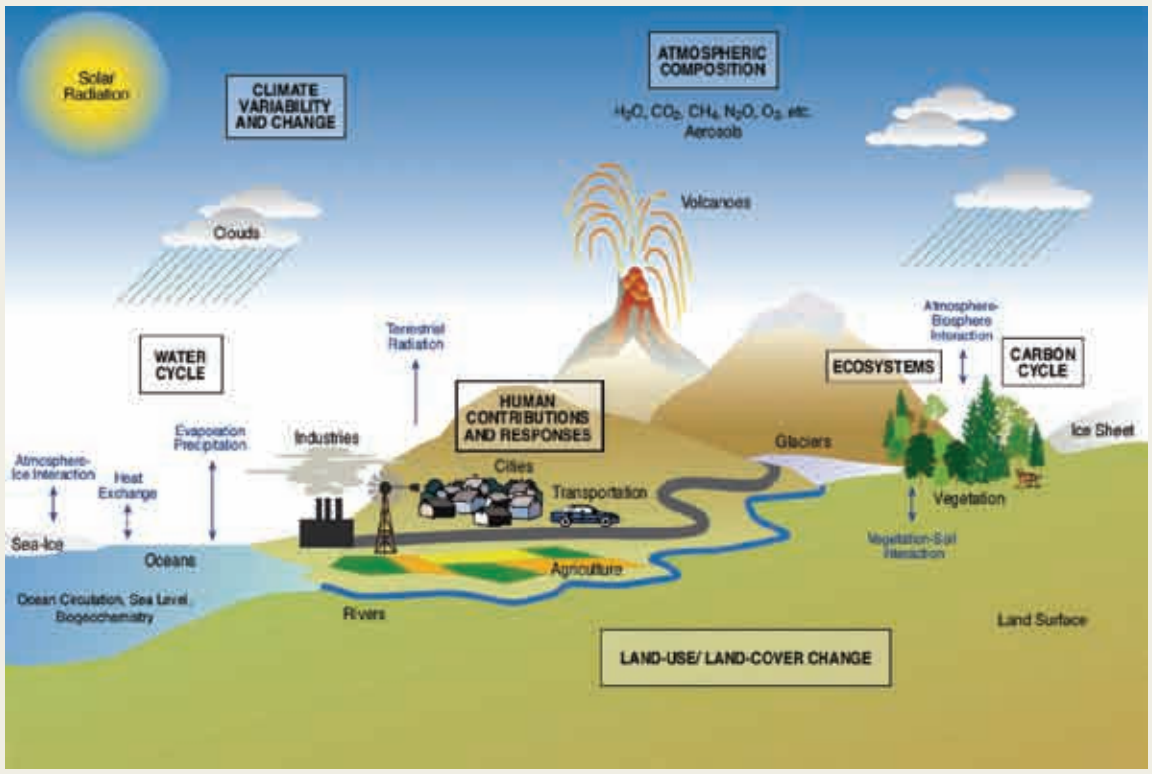
The cultivation of plants and the domestication of animals dramatically

Credit: Pune Yanachot/UNEP/Topfoto

Credit: T. Revter/UNEP/Topfoto

impacted human lifestyles during the Neolithic Period. People left their temporary rock and wooden shelters and began to build more permanent homes in close proximity to their farms and gardens, where they started producing cereal grains which became an important part of their diet (Wadley and Martin 1993).

The Neolithic Period marked the beginning of true civilization, laying the foundations for major developments in social evolution such as permanent settlements, village life, formalized religion, art, architecture, farming, and the production of advanced tools and weapons.



Agriculture

The first cultivation of wild grains some 12 000 to 10 000 years ago turned hunter-gatherers into farmers. The transition gave people a more abundant and dependable source of food and changed the world forever (Wilford 1997). The practice of agriculture first developed in the Fertile Crescent of Mesopotamia (part of present-day Iraq, Turkey, Syria, and Jordan). This region, which was much wetter then than it is today, was home to a great diversity of annual plants and 32 of the 56 largest seed-producing grasses (Primal Seeds n.d.).

Around 11 000 years ago, much of the Earth experienced long dry seasons, probably as a consequence of the major climate change that took place at the end of the last Ice Age. These conditions favored annual plants that die off in the long dry season, leaving a dormant seed or tuber. Such plants put more energy into producing seeds than into woody growth. An abundance of readily storable wild grains

Figure 1.2: The Earth's climate system involves complex interactions among many elements and processes. *Source: http://www.usgcrp.gov/usgcrp/Library/ocp2004-5/ocp2004-5.pdf*

and other edible seeds enabled hunter-gatherers in some areas to form permanently settled villages at this time (Primal Seeds n.d.).

Theories vary as to how agriculture came into being. Some scientists argue that rising global temperatures created favorable conditions for agriculture. Others propose that an increase in seasonality after the last Ice Age encouraged people to domesticate plants. Still other researchers maintain that ecological changes, social development, or a growing human population intensified the exploitation of specific plant species (Baldia 2000).

Another suggestion is that an increase in carbon dioxide (CO_2) on a global scale may have played a critical role in bringing about the synchrony of agricultural origins around the globe (Sage 1995). Studies have shown that a rise in atmospheric CO_2 levels would have increased productivity of many plants by as much as 50 per cent. Furthermore, the water efficiency of cultivated plants increased, giving these plants a competitive advantage over wild species.

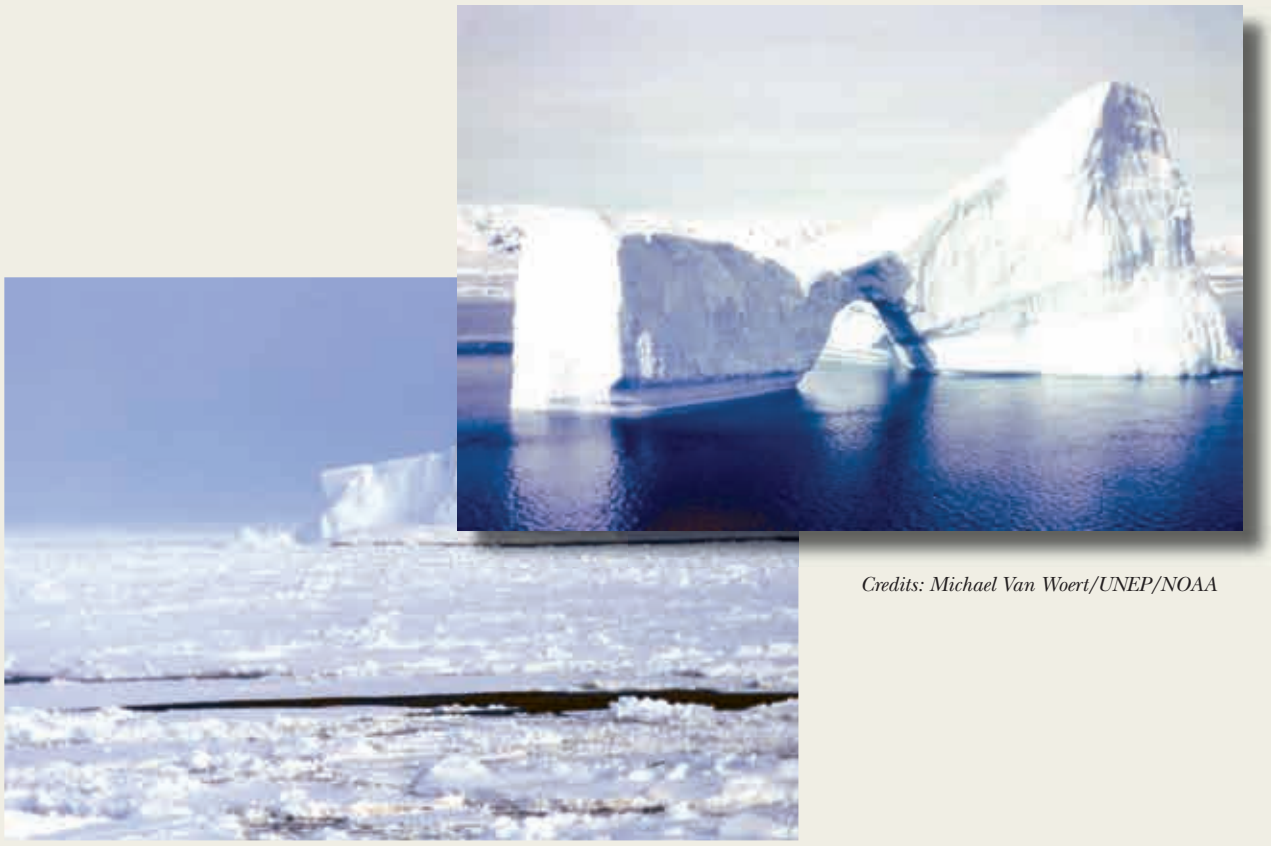
A few scientists have proposed that climatic changes at the end of the last glacial period led to an increase in the size and concentration of patches of wild cereals in certain areas (Wadley and Martin 1993). Increased availability of cereal grains provided people with an incentive to make a meal of them. Those who ate sizable amounts of cereal grains inadvertently discovered the rewards of consuming the various chemical compounds that cereal grains contain. As processing methods

Credit: Ed Simpson/UNEP/PhotoSpin

such as grinding and cooking made cereal grains more palatable, greater quantities were consumed.

At first these patches of wild cereals were protected and harvested. People began to settle around these food sources. They gradually abandoned their nomadic lifestyle and began working together more cooperatively. Later, land was cleared, seeds were planted, and seedlings tended to increase the quantity and reliability of cereal grain supply.

The rise of more permanent settlements intensified the domestication of



Credits: Michael Van Woert/UNEP/NOAA

animals. The first candidate for domestication, around 11 000 years ago, was probably the dog. The cow was domesticated around 10 000 years ago. Goats, sheep, and pigs were added to the growing list of domesticated animals around 8 000 years ago in western Asia. The horse was first domesticated in northern Russia around 4 000 years ago. Local equivalents and smaller species were increasingly domesticated from 2 500 years ago (Wikipedia n.d.).

Farming and herding facilitated the growth of larger settled human populations and led to increased competition for productive lands, laying the foundation for organized warfare. Food surpluses freed people to specialize in various crafts, such as weaving, and, in larger communities, supported the emergence of a privileged elite class. Archaeologists and historians agree that the rise of agriculture, including the domestication of animals for food and labor, produced the most important transformation in the interaction between the environment and human culture since the last Ice Age—perhaps the most significant development in human history since the control of fire (Wilford 1997).

Other milestones in human history that benefited people and changed the environment include:

The Bronze and Iron Ages (roughly 3300 B.C. to 0 A.D.)

The world population approximately 5 000 years ago is estimated to have been about 7 million (IPC 2003a). This period saw the introduction of metallurgy and mining, the invention of the wheel, and the domestication of the horse.

Classical Greece and Rome (0 to about 500 A.D.)

The world population at the beginning of this period was roughly 200 million (IPC 2003a). During this period, glass was invented and map-making developed.

Middle Ages to the Renaissance (500 to about 1700)

By this point, world population had grown to about 250 million (IPC 2003a). The clock, compass, telescope, thermometer, and barometer were developed, enabling people to expand their knowledge of the Earth and the Universe.

The Industrial Revolution (1700 – present)

By 1700, world population had risen to about 600 million (IPC 2003a). This period witnessed the development of mechanization and the beginning of serious air pollution. Industrial changes also led to an agricultural revolution.

The Agricultural Revolution (1750 – 1900)

By 1750, world population had risen to 790 million (IPC 2003a). In many countries the way in which farmers produced food began to change. New crops were exploited using new technologies such as the seed drill and the iron plow. These methods of production produced greater quantities of more nutritious foods, thereby improving peoples' diets and health. Better, more efficient farming methods also meant that fewer people were needed to farm. As a result, unemployed farmers formed a large new labor force.

The Green Revolution (1944 – present)

In 1944, world population reached 2 350 million (Anon n.d.). A breakthrough in wheat and rice production in Asia in the mid-1960s, which came to be known as the Green Revolution, symbolized the progress of agricultural science as it developed modern techniques for use in developing countries. The Green Revolution had its origin in Mexico, where a "quiet" wheat revolution began in the 1940s (Borlaug 2000).

The goal of the Green Revolution is to enhance the efficiency of agricultural processes in order to increase the productivity of crops, thereby helping developing countries to meet the needs of their growing populations. The Revolution consisted of three primary elements: continuing expansion of farming areas, double-cropping existing farmlands, and using genetically improved seeds. Thanks to the Green Revolution, we are able to grow more crops on less land.

However, the Green Revolution has impacted biodiversity and in some areas water quality and coastal ecosystems. The new techniques encouraged large-scale industrial agriculture at the expense of small farmers who were unable to compete with high-efficiency Green Revolution crops (Wikipedia n.d.). Nevertheless, the Green Revolution is a success. We are able to feed more people now, than ever before.

The Present Day

World population now stands at 6 billion people (IPC 2003b). While global resources were sufficient to support the Earth's human population as a whole prior to the Industrial Revolution, individual groups or even entire civilizations sometimes reached environmental limits for a particular resource; a number collapsed as a result of unsustainable hunting, fishing, logging, or land use practices. The ever-increasing cultural globalization of the 20th and 21st centuries has brought with it globalization of resource degradation, making current environmental problems an issue for the entire world rather than for individual, isolated groups. Although perceived environmental limits can sometimes be overcome, neither science nor technology has yet made possible unlimited supplies of natural resources or depositories for waste (Casagrande and Zaidman 1999).

Moderate projections put world population at around 8 300 million by 2025 (Figure 1.3), with the hope that it will stabilize at roughly 10 000 to 11 000 million by the end of the century. It took approximately 10 000 years to expand global food production to the current level of about 5 000 million metric tonnes per year. By 2025, production must be nearly doubled. In order to feed the world's people through 2025, an additional 1 000 million metric tonnes of grain must be produced annually. Most of this increase will have to be supplied by improving crop yields on land already in production.

This will not be possible unless farmers worldwide have access to existing high-yield crop production methods as well as biotechnological breakthroughs that increase the yield, dependability, and nutritional quality of our basic food crops (Borlaug 2000).

Credit: Lee Tsunhua/UNEP/Topfoto

Credit: Paulus Suwito/UNEP/Topfoto

Figure 1.3: Earth's shrinking biosphere land area (ha)/capita 1900-2000 AD
Currently, the Earth is the only home we have. With each new person added to our growing population, the amount of our living space decreases. Thus we have less land available but an increasing need to feed more people. This puts more pressure on our limited resources and exacerbates changes in the environment. *Source: Lund and Iremonger 2000*

Human beings have been very successful in exploiting the Earth's resources. In the process, however, they have brought about major changes in the Earth's ecosystems, especially in recent years:

- half the world's wetlands were lost during the last century;
- logging and land use conversion have reduced forest cover by at least 20 per cent, and possibly as much as 50 per cent;
- nearly 70 per cent of the world's major marine fish stocks are either over-fished or being fished at the biological limit;
- over the last half century, soil degradation has affected two-thirds of the world's agricultural land. It is estimated that each year some 25 000 million metric tonnes of fertile topsoil—the equivalent of all of the wheat fields in Australia— is lost globally (Casagrande and Zaidman 1999);
- each year, an estimated 27 000 species disappear from the planet—approximately one every 20 minutes (Casagrande and Zaidman 1999);
- the Earth now appears to be experiencing a sixth mass extinction event that began about 50 000 years ago with the expanding role of humans in the world (Recer 2004). Unlike past events, this mass extinction is being caused by human activities such as transforming the landscape, overexploiting species, pollution, and alien species introductions (Eldredge 2001);
- dams and engineering works have fragmented 60 per cent of the world's large river systems. They have so impeded water flow that the time it takes for a drop of water to reach the sea has tripled;
- human activities are significantly altering the basic chemical cycles upon which all ecosystems depend (Kirby 2000).

Historian J.R. McNeill recently wrote (McNeill 2000): "It is impossible to know whether humankind has entered a genuine ecological crisis. It is clear enough that our current ways are ecologically unsustainable, but we cannot know for how long we can yet sustain

Credit: Noguchi Yoshi/UNEP/Topfoto

them or what might happen if we do." In the past, humanity trod relatively lightly on the Earth, even though civilizations were intensely concentrated in some places such as Mesopotamia and the Nile River valley. Today, however, the evidence from space shows signs of the human presence in almost every corner of the planet.

Global concern about the environment and the fate of the Earth emerged in the 1970s, as did international initiatives to address those concerns. In roughly the past 30 years, the environment has borne the stresses imposed by a four-fold increase in human population and an eighteen-fold increase in world economic output (UNEP 2002). Not surprisingly, when scientists compare recent satellite images of the Earth's surface with those taken one or several decades ago, the impact people have had on the planet is obvious and often disturbing.

This atlas vividly illustrates some of the changes the human race has brought about on the Earth—both good and bad—over the past 30 years. In doing so, it also serves as an early warning for environmental events that may occur. We hope it will be useful as a basis for developing policy decisions and promoting individual actions to help sustain the Earth and ensure the well-being of its inhabitants.

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