Nightlight Map of the World

Credit: UNEP/NOAA, NASA


Credit: Busakorn Buranabunpo/UNEP/Topfoto

People and Planet

2 Human Influences on the Planet

Humans are a prolific and opportunistic species, among the most successful of all the Earth's inhabitants. As the size of the human population has increased, people have spread across the globe into every imaginable habitat. Throughout human history, people have demonstrated an uncanny ability to adapt to and survive in some very harsh places, including, most recently, outer space and the ocean—at least for short periods of time.

As human culture has evolved, people have developed new ways of living in and using their environment, and of helping themselves to all that the Earth has to offer. Their ability to exploit the Earth's seemingly endless resources has been a vital key to the success of the human species.

However, many major advances in human culture—from the cultivation of crops and the development of cities to modern technologies—have tended to insulate people from the very environment that shaped them and upon which they depend. As a group, people have often forgotten that for every action taken there is a reaction, an impact.

The impacts of human activities on the Earth often have both negative and positive components. For example, when people convert forests or grasslands to cropland they improve the means by which to feed their ever-growing numbers. At the same time, they invariably reduce biological diversity in the converted areas. Over time, people have rarely been fully aware of the tremendous change they have wrought on the Earth or that their successes have often been achieved at the expense of other species and the environment.

Since the early 1970s, many excellent texts have been written about the plight of the world (Heywood 1995; Middleton 1997; WRI 2000; Chew 2001; FAO 2001; Harrison and Pearce 2001; IPCC 2001; McNeill 2001; UNEP 2002a). This atlas supplements these works by providing illustrations of both positive and negative human-caused changes that have taken place on the Earth. Satellite images, together with photographs, provide a unique view of how people are impacting the terrestrial environment and what the consequences of environmental change mean in terms of human well-being. The images and the changes they illustrate are diverse. But they are united by a common message: environmental change does matter.

Credit: Davoli Silvaho/UNEP/Topfoto

The International Conference on Population and Development Programme of Action noted that stabilization of world

Credit: Ed Simpson/UNEP/PhotoSpin

Population Change

Change in distribution of world population 1900 and 2000. *Source: http://www.newint.org/issue309/facts.html*

population is crucial to achieving sustainable development. Population stabilization is also necessary for managing human impacts on the Earth's environment and resources. In 1999, the Earth's human population reached 6 000 million, having grown during the mid-1990s at a rate of 13 per cent per year, with an average annual addition of 78 million individuals. As of 1999, countries with populations of 100 million or more included China, India, the United States, Indonesia, Brazil, Pakistan, the Russian Federation, Bangladesh, Japan, and Nigeria. According to the medium variant of the United Nations' population estimates and projections, world population will reach 7 200 million by the year 2015. Ninety-eight per cent of the population increase will take place in less-developed regions of the world. Africa will experience, by far, the most rapid rate of growth (Population Division 2000).

The overall impact that humans have on the global environment is proportional to the number of people on the Earth and the average influence of each individual. If that overall impact is to be reduced, addressing both of these factors is essential.

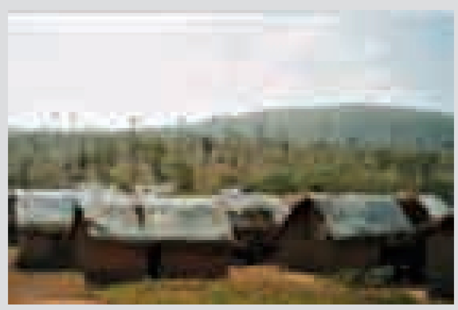
Case Study: Parrot's Beak

Between Sierra Leone and Liberia, there is a small strip of land belonging to Guinea known as the "Parrot's Beak." As civil wars raged in Sierra Leone and Liberia, hundreds of thousands of refugees have fled to relative safety in Guinea, many of them settling in the Parrot's Beak. The United Nations High Commissioner for Refugees (UNHCR) estimates that the refugee population constitutes up to 80 per cent of the local population there (UNEP 2000).

The 1974 image of the Parrot's Beak in Guinea (left) shows the surrounding territory of Liberia and Sierra Leone. Scattered throughout the deep green forest of the Parrot's Beak region are small flecks of light green, where compounds of villages with surrounding agricultural plots are located. Several dark spots in the upper left of the image are most likely burn scars.

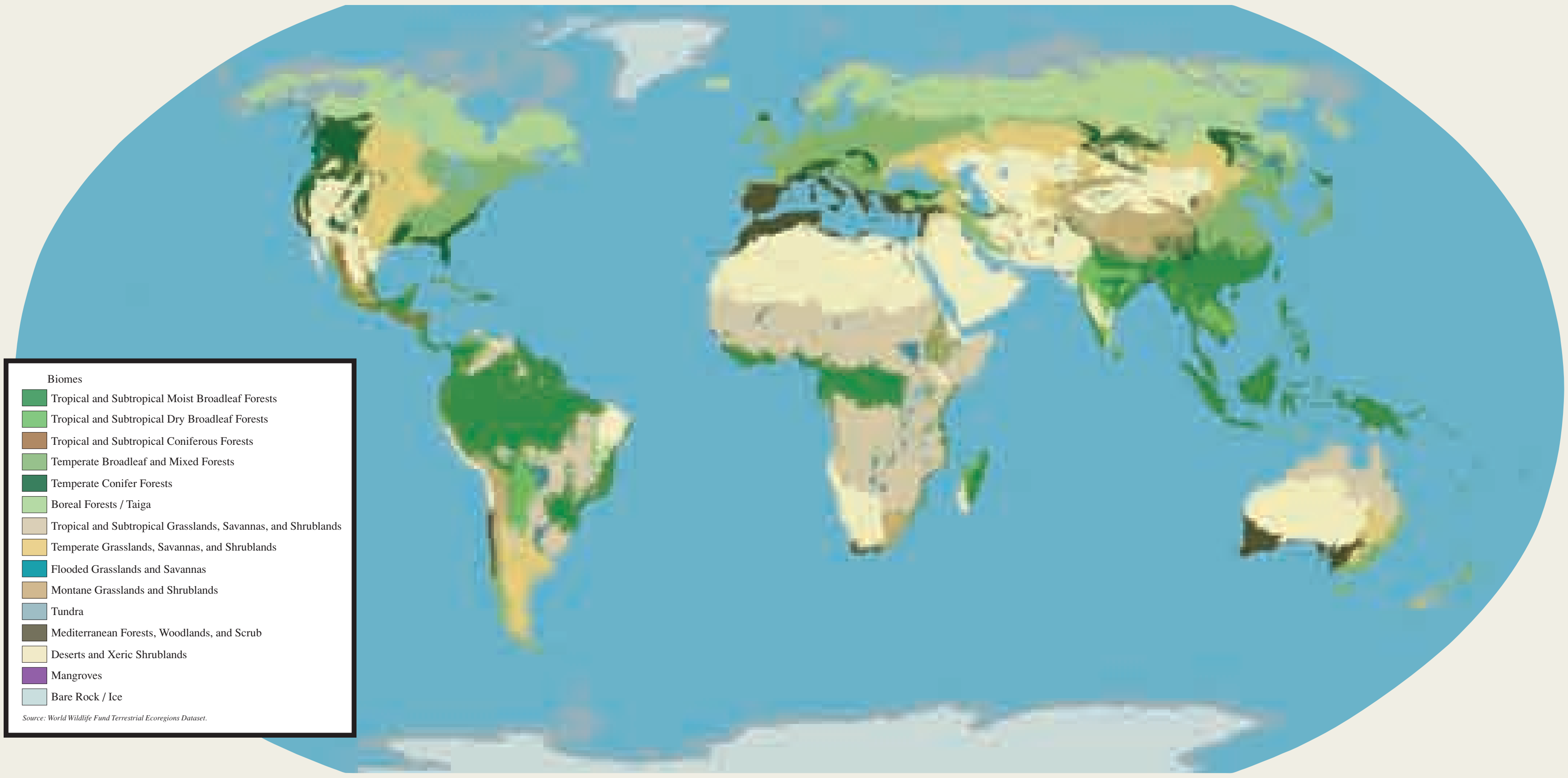
The 2002 image (facing page) shows the Parrot's Beak region clearly defined by its light green color surrounded by darker green forest. The light green

Deforestation of indigenous palm trees in the refugee camp has left barren hillsides.



Credit: Unknown/UNEP/UNEP-GRID Geneva

World Biomes



A biome is a major ecological community of plants and animals with similar life forms and environmental conditions. Some of the Earth's major terrestrial biomes include forests, grasslands, deserts, rain forests, and tundra. Different biomes are the source of different kinds of resources and processes (collectively called ecosystem services) such as water, soil, oil, natural gas and other fuels, minerals and other raw materials, wildlife habitat, erosion control, nutrient cycling, water filtration, food production, and genetic resources. The estimated global value of the Earth's biomes for ecosystem services alone ranges from US $16 trillion to US $54 trillion a year (Costanza et al. 1997).

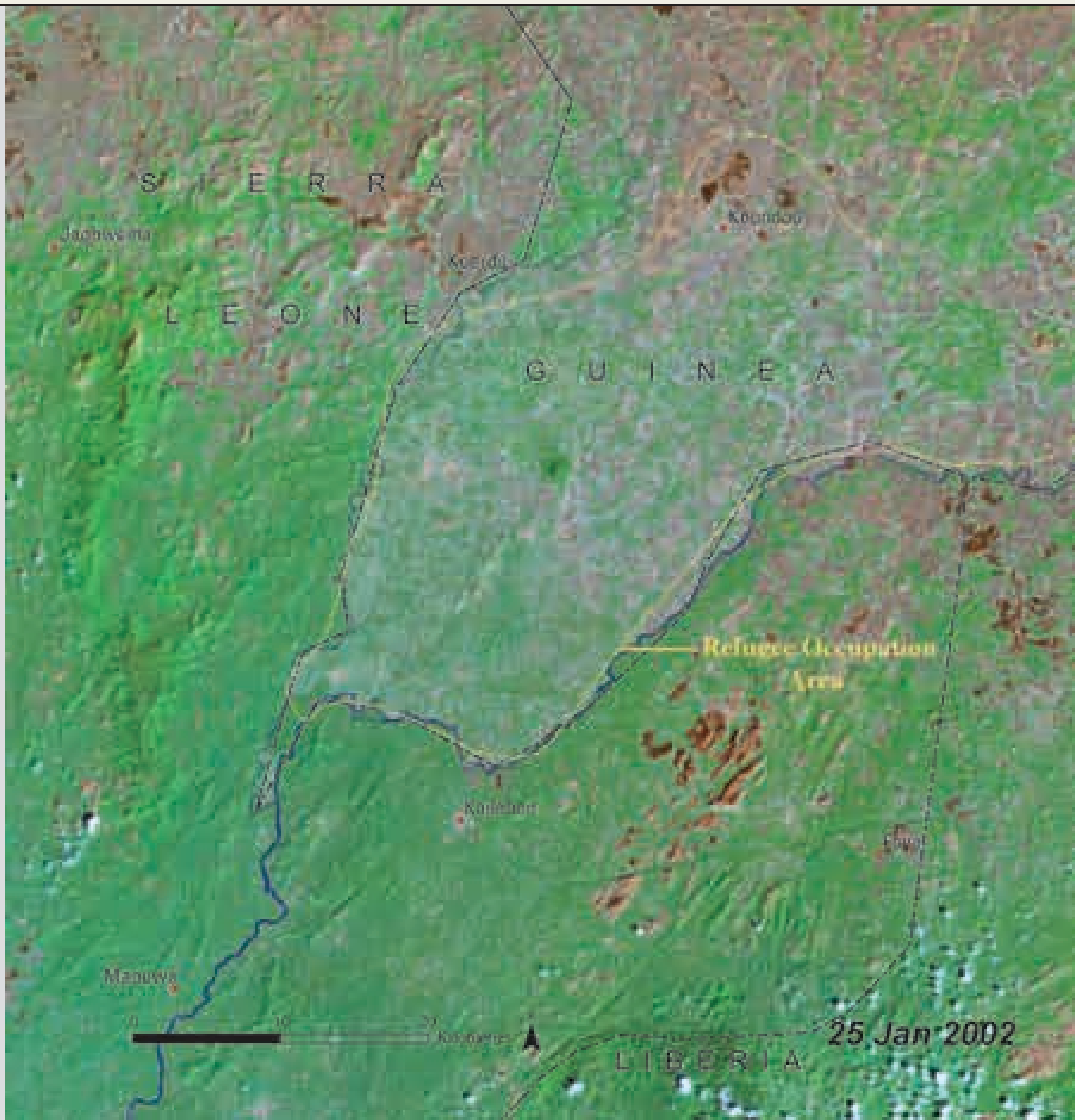
color is the result of deforestation in the "safe area" where refugees have set up camp. Many of the refugees integrated into local villages, created their own family plots, and expanded the zones of converted forest area until they all merged into the larger defined area. In the upper part of the 2002 image the forest devastation is especially obvious, as areas that were green in the 1974 image now appear gray. Logging interests also moved into the higher elevations of this region, expanding the deforested zone visible in the upper left corner of the image.

Overall impoverishment of the environment of the Parrot's Beak is directly related to the rapidly increasing population in the area, mainly due to immigration, and a growth rate of about three per cent among the indigenous population. Natural resources are being exploited to create more arable land for crops, wood for charcoal, firewood and construction materials, and commercial logging for revenue.

Source: UNEP 2000.

Deforestation is evident on the hills surrounding the refugee camp.

Credit: Unknown/UNEP/UNEP-GRID Geneva



2.1 World Population

A simple definition of world population is the number of people alive on the Earth at any given point in time. World population reached 6 400 million in 2004 and it continues to grow by some 80 million each year (Table 2.1). Since the 1950s, China has been the world's most populous country (Table 2.2). China's population is currently greater than that of some entire world regions (Global Population Profile 2002). By 2050, world population is estimated to reach 7 900 to 10 900 million, when stabilization of the Earth's population is likely to take place. Whether or not world population falls within that range by this middle of this century—rather than exceeding it—will depend upon many of the choices and commitments that people make in the coming years (UNFPA 2001).

Table 2.1 – World population for given points in time
Source: ESA 2003

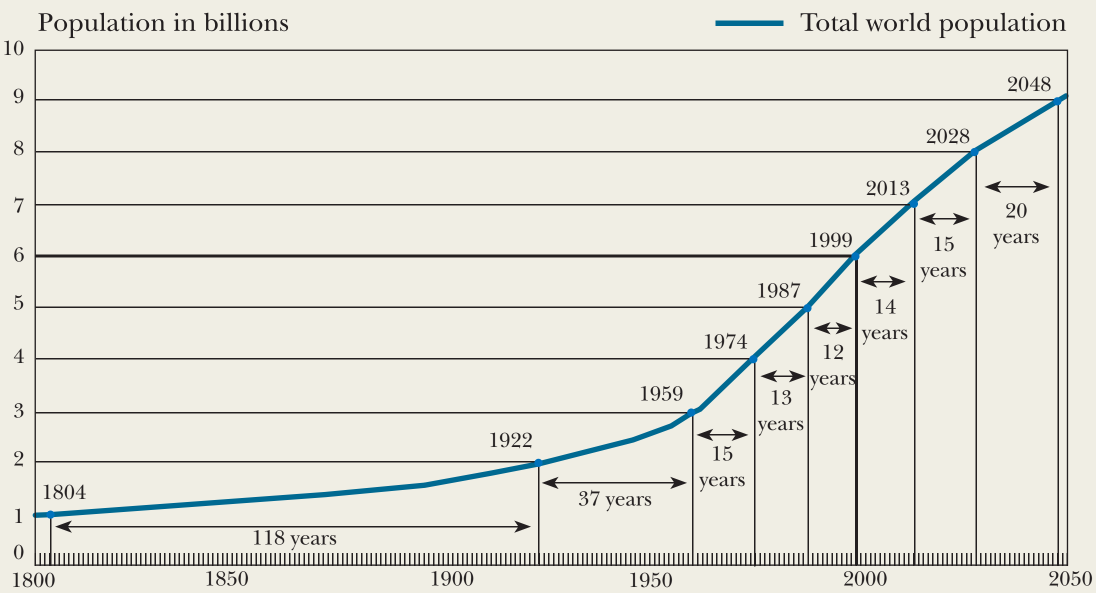
Year	*Population*
1970	3 692 492 000
1975	4 068 109 000
1980	4 434 682 000
1985	4 830 979 000
1990	5 263 593 000
1995	5 674 380 000
2000	6 070 581 000
2005	6 453 628 000
2010	6 830 283 000

Credit: Khin Aye Myat/UNEP/Topfoto

The size of any population changes as a result of fluctuations in three fundamental factors: birth rate, death rate, and immigration or emigration. When any or all of these factors deviate from zero, the size of the population will change (Global Population Profile 2002). The primary driving force of population change, whether in an individual country or for the entire world, is change in birth and death rates.

World population is growing more slowly than was expected (Figure 2.1) as a result of aid, family planning programs, and educational and economic programs directed at women. People are also healthier and living longer than they did in the past; average life expectancy has increased while crude birth rate and death rate are following a downward trend (Tables 2.3, 2.4, 2.5 and 2.6).

Figure 2.1: Time to successive billions in world population: 1800-2050.



Source: United Nations (1995b); U.S. Census Bureau, International Programs Center, International Data Base and unpublished tables.

Source: Global Population Profile 2002

Most future population growth is likely to be in countries that have relatively large numbers of young people and where large families are still the norm. Furthermore, declining mortality and increased longevity have resulted in, and will continue to lead to, the expansion of older populations. Worldwide,

Table 2.2 – The Top Ten Most Populous Countries: 1950, 2002, 2050

1950	2002	2050
1. China	1. China	1. India
2. India	2. India	2. China
3. United States	3. United States	3. United States
4. Russia	4. Indonesia	4. Indonesia
5. Japan	5. Brazil	5. Nigeria
6. Indonesia	6. Pakistan	6. Bangladesh
7. Germany	7. Russia	7. Pakistan
8. Brazil	8. Bangladesh	8. Brazil
9. United Kingdom	9. Nigeria	9. Congo (Kinshasa)
10. Italy	10. Japan	10. Mexico

Source: U.S. Census Bureau, International Programs Center, International Data Base are unpublished tables.

Table 2.3 – Median age for given points in time *Source: ESA 2003.*

Year	*Median age*
1970	21.7
1975	22.0
1980	22.7
1985	23.4
1990	24.3
1995	25.3
2000	26.4
2005	27.4
2010	28.4

Table 2.4 – Average life expectancy at birth - Medium variant *Source: ESA 2003.*

Period	*Both sexes combined*	*Male*	*Female*
1970-1975	58.0	56.5	59.5
1975-1980	59.8	58.1	61.5
1980-1985	61.3	59.4	63.2
1985-1990	62.9	60.9	64.8
1990-1995	63.8	61.7	65.9
1995-2000	64.6	62.5	66.9
2000-2005	65.4	63.3	67.6
2005-2010	66.3	64.2	68.4

Table 2.5 – Crude birth rate per 1 000 population - Medium variant *Source: ESA 2003.*

Period	*Crude birth rate*
1970-1975	30.9
1975-1980	28.1
1980-1985	27.4
1985-1990	26.8
1990-1995	24.5
1995-2000	22.7
2000-2005	21.3
2005-2010	20.4

Table 2.6 – Crude death rate per 1 000 population - Medium variant *Source: ESA 2003.*

Period	*Crude death rate*
1970-1975	11.6
1975-1980	10.9
1980-1985	10.3
1985-1990	9.7
1990-1995	9.5
1995-2000	9.2
2000-2005	9.1
2005-2010	9.0

the average life expectancy in 1950 was 46 years; in 2050, it is projected to be 76 years (Hunter 2001).

While an increase in life expectancy is a positive development, it presents a new set of challenges. In Europe, for example, where women give birth to an average of 1.4 children, governments are concerned that there will be too few workers in future years to support the growing number of retirees in the population. An aging population strains a nation's social security system and pension plans, and puts pressure on health budgets because of higher health care costs for the elderly. Some governments are also concerned that a shortage of working-age individuals may lead to increased immigration, and that a decline in population may signal a weakening of a country's political and economic clout (Ashford 2004).

One of the main reasons that world population has grown so rapidly over the last 200 years is that mortality rates have declined faster than fertility rates. Improved sanitation, health care, medicine, shelter, and nutrition have all led to dramatic increases in life expectancy. Fertility rates, on the other hand, declined more recently than mortality rates did (UNEP 1999).

There is a striking paradox in global population trends: for more than two decades, many developing countries have experienced a rapid decline in fertility while fertility rates in most highly developed nations have remained very low (Figures 2.3 and 2.4). Yet in the coming years, a massive increase of the world population is almost certain (Heilig 1996).

The Demographic Transition Model (Figure 2.2) shows how a country's population can change as the country develops. However, this model does not take into account migration. Worldwide, migration of people out of rural areas is accelerating, making internal and international

Credit: Ed Simpson/UNEP/PhotoSpin

Credit: Unknown/UNEP/Topfoto

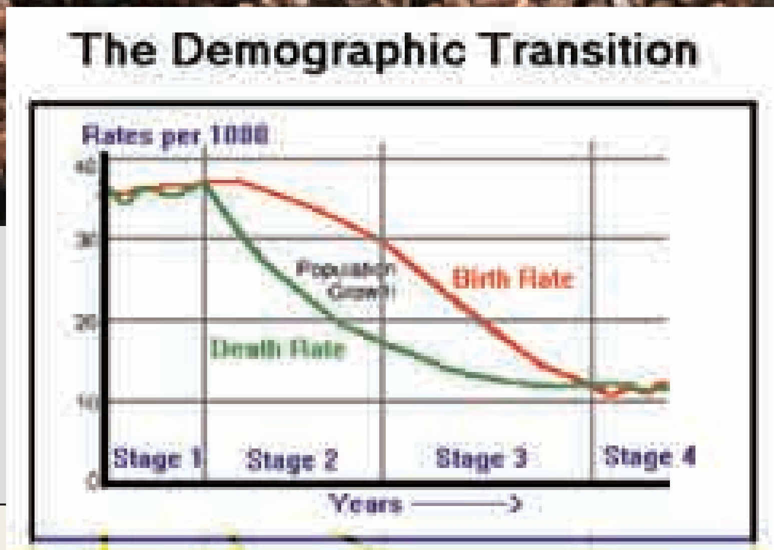
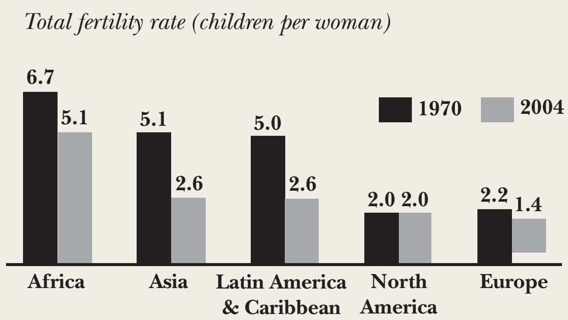


Figure 2.2: The Demographic Transition Model shows how population growth occurs naturally in four stages. Stage 1: Birth rate and death rate are high, limiting both the rate of increase and total population. Stage 2: Birth rate remains relatively high but death rate begins to fall, causing the population to grow rapidly. Stage 3: Declining birth rate and low death rate maintain continued population growth. Stage 4: Both birth rate and death rate are low, slowing population growth, but leaving a large total population. *Source: http://www.geography.learnontheinternet.co.uk/topics/growth*

Figure 2.3: Childbearing trends in major world regions, 1970 and 2004

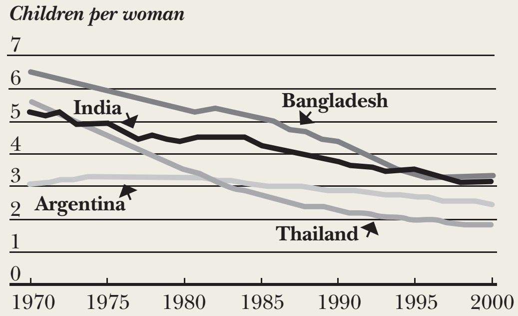


Source: UN Population Division. World Population Prospects: The 2002 Revision (1970 data), and C. Haub, 2004 World Population Data Sheet (2004 data).

migration potentially one of the most important development and policy issues of this century. The migration of labor geographically, out of rural areas, and occupationally, out of farm jobs, is one of the most pervasive features of agricultural transformations and economic growth. Yet in a world of complete and well-functioning markets, there is little or no economic rationale for policies to reduce migration; the movement of labor out of agriculture is both a quintessential feature of agricultural transformations and a prerequisite for efficient and balanced economic growth (Taylor and Martin 2002).

Clearly, human numbers cannot continue to increase indefi nitely. The more people there are and the longer they live,

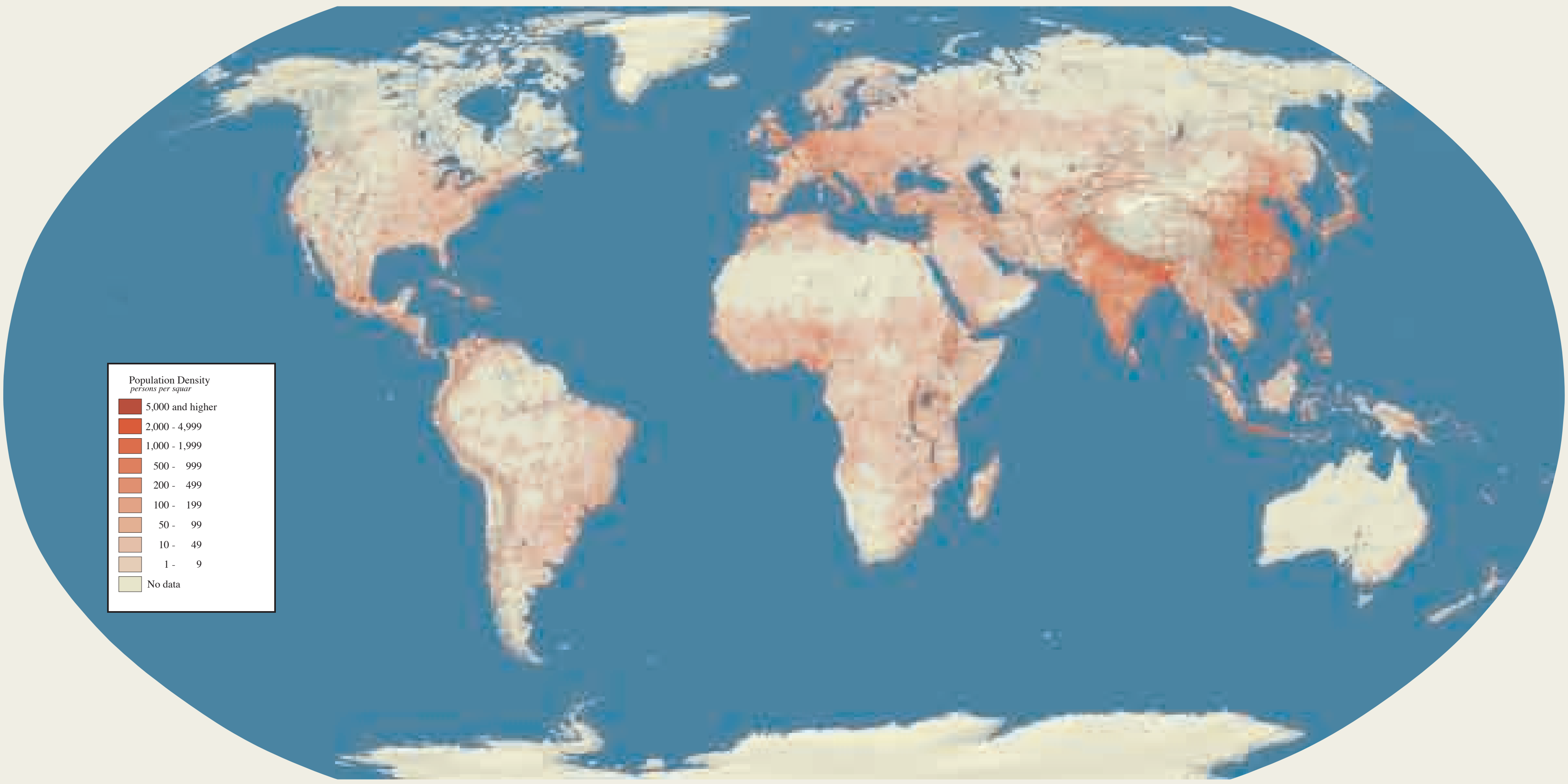
Figure 2.4: Different patterns of fertility decline, 1970-2000



Sources: Registrar General of India; Instituto Nacional de Estadística (Argentina); United Nations Population Division; Institute of Population and Social Research, Mahidol University, Thailand; Demographic and Health Surveys; and Population Reference Bureau estimates.

the more competition there will be for the Earth's limited resources. Unless all nations adopt more sustainable methods of

Population Density Map



Source: http://beta.sedac.ciesin.columbia.edu/

Global Urban Extent Map

The map portrays the boundaries of urban areas with defined populations of 5 000 persons or more. *Source: Modified from http://beta.sedac.ciesin.columbia.edu/gpw/global.jsp*

production and consumption, the planet's carrying capacity will be exceeded (UNEP 1999).

Natural resources are already severely limited, and there is emerging evidence that natural forces are already starting to control human population numbers through malnutrition and disease (Pimentel et al. 1999).

The environmental challenges that people now face and most likely will continue to face in the future would be less difficult if world population were growing very slowly or not at all. The number of people on the Earth and the rate at which that number increases (Table 2.7) dramatically impact the availability of water, soil, arable land, minerals, fuels, and many other natural resources worldwide. Access to and use of family planning services can help lower fertility rates and delay child-bearing

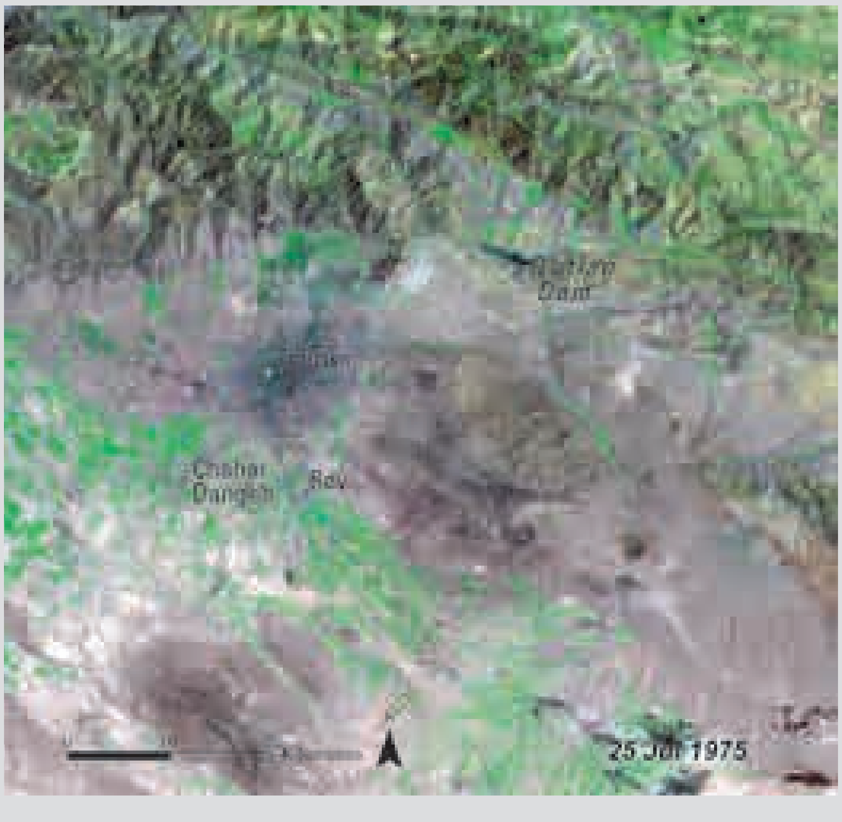
Case Study: Monitoring Rapid Urban Expansion of Tehran, Iran
1975 and 2000

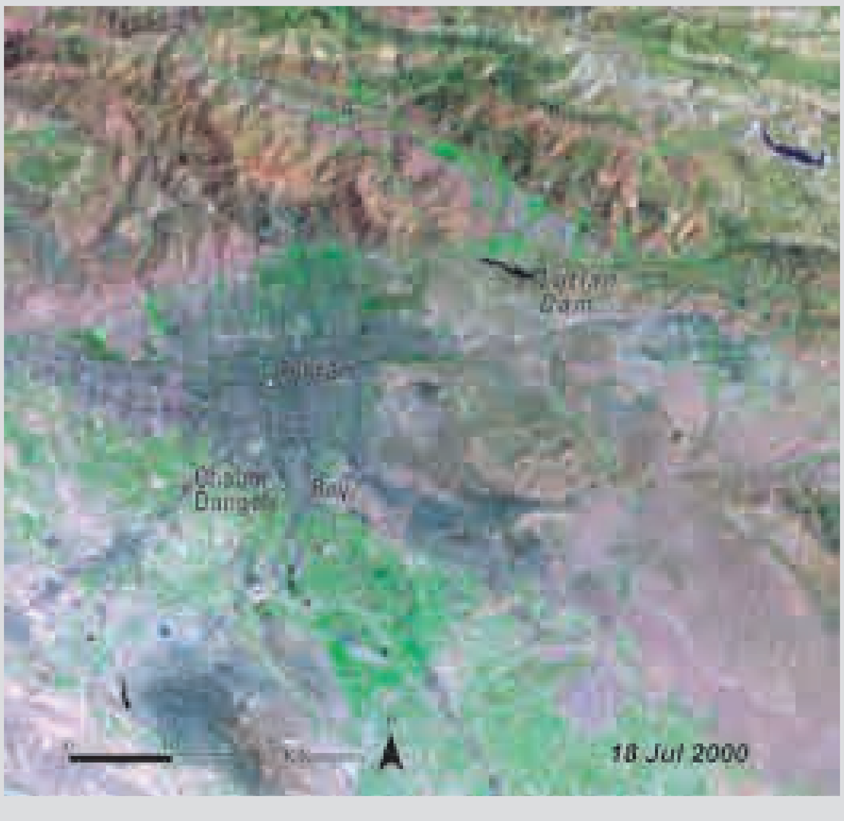
Tehran is located at the foot of the Alborz Mountains. The city occupies the northern part of the alluvial Tehran Plain, sloping from the mountains to the flat Great Salt Desert. The urban area is bounded by mountains to the north and east making it difficult to differentiate the urban area from the mountainous and desert area that surrounds Tehran.

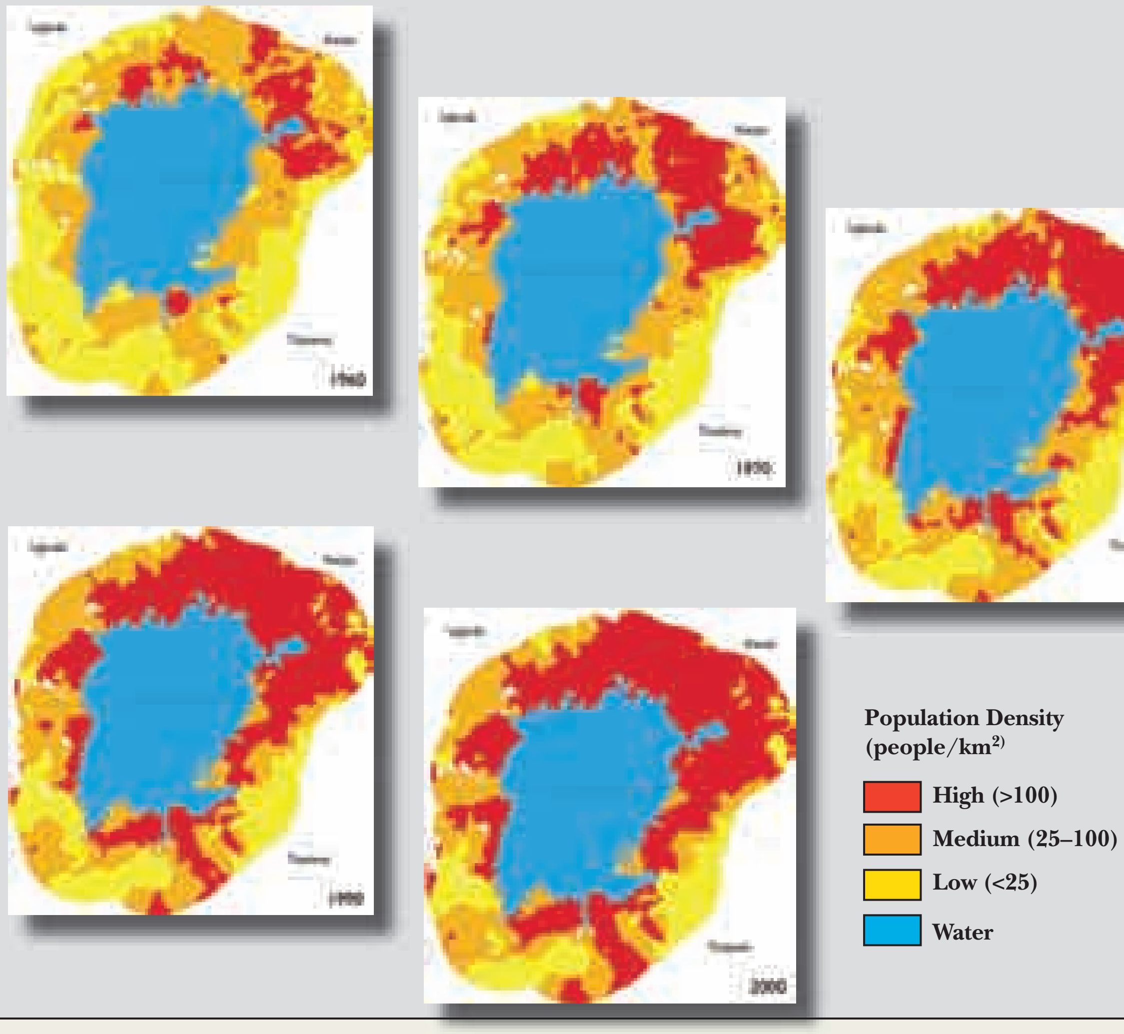
The population of Tehran has grown threefold since 1970 when the population was three million. In 1987, the city had grown to more than seven million people and covered an area of 575 km^2 (230 square miles). Today the city has nine million residents.

The rapid expansion of Tehran, as well as its sharp population growth in recent decades, has had many adverse impacts on the environment. Air and water pollution are major problems in the city. Urban areas are replacing farms and water resources. A major concern is its location on a recognized zone of active faulting with a modest to high seismic risk. Recent planning and construction techniques are designed to improve the resistance to a major earthquake that could threaten the city.

Credit: Saman Salari Sharif/UNEP/UNEP-GRID Geneva







Credit: Ed Simpson/UNEP/PhotoSpin

Lake Victoria, Kenya

Population growth around Lake Victoria, Kenya, is significantly higher than in the rest of Africa because of the wealth of natural resources and economic benefits the lake region offers. Note the increase in population in a 100-km (62 miles) buffer zone around Lake Victoria between 1960 and 2000. During each decade, population growth within this zone outpaced the continental average.
Source: UNEP/GRID- Sioux Falls

years, years, thereby helping to slow population growth. Comprehensive population policies are an essential element in a world development strategy that combines access to reproductive health services, education and economic opportunities, improved energy and natural resource technologies, and more reasonable models of consumption and what constitutes "the good life." Such a strategy has the potential to bring humanity into an enduring balance with the environment and the natural resources upon which people will always depend (Population Fact Sheet 2000).

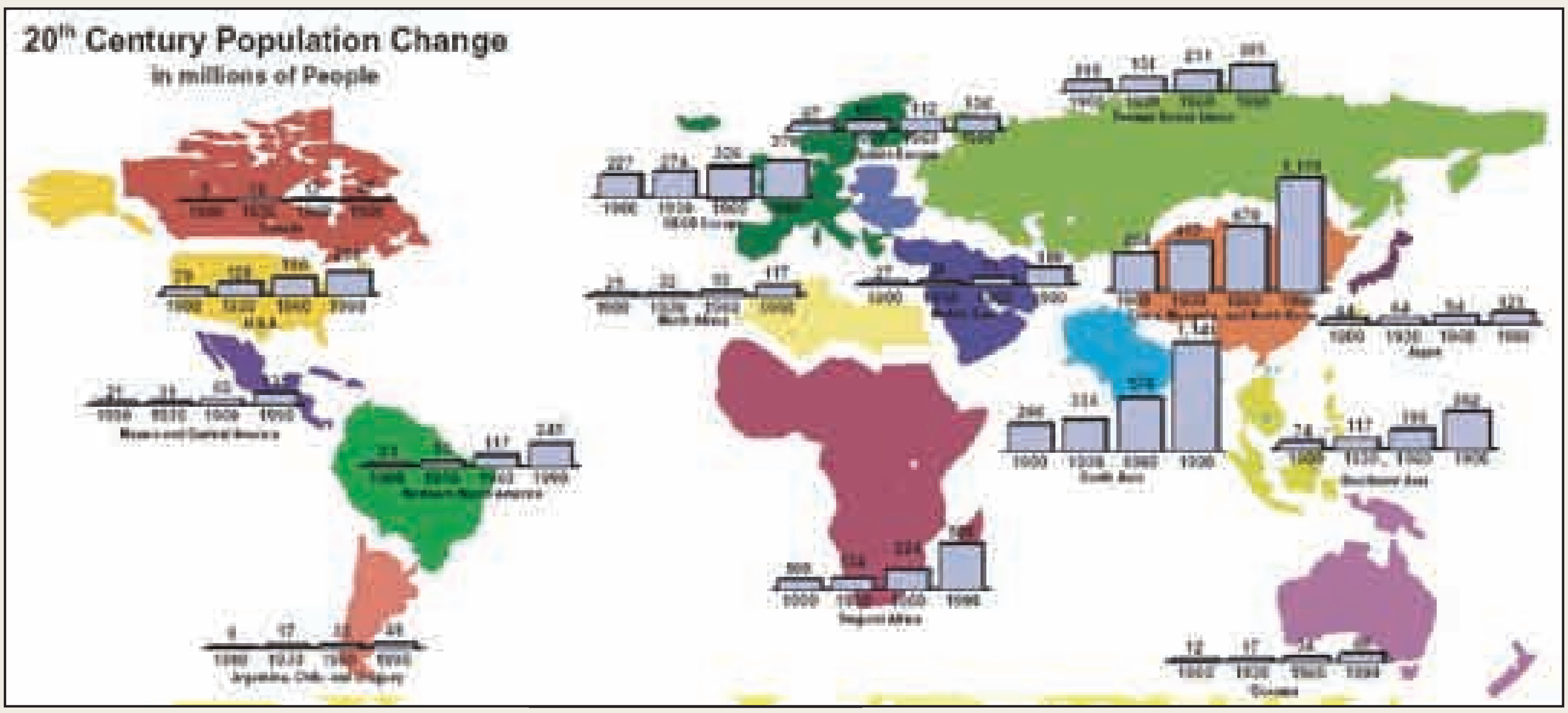
Table 2.7 – World Vital Events Per Time Unit: 2004
(Figures may not add to totals due to rounding)

Time unit	*Births*	*Natural Death*	*Population Increase*
Year	29 358 036	56 150 533	73 207 503
Month	10 779 836	4 679 211	6 100 625
Day	353 437	153 417	200 021
Hour	14 727	6 392	8 334
Minute	245	107	139
Second	4.1	1.8	2.3

Source: http://www.census.gov/cgi-bin/ipc/pcwe

In addition to the overall global increases in population, the geographic distribution of human population underwent massive changes during the 20th century (Figure 2.5). For example, between 1900 and 1990, the population of northern South America increased by 214 million, or 681 per cent, compared to the global average population increase of 3 700 million, or 236 per cent (Ramankutty and Olejniczak 2002).

Figure 2.5: Population change in the 20th century
Source: http://www.bioone.org/pdfserv/i0044-7447-031-03-0251.pdf



2.2 Culture

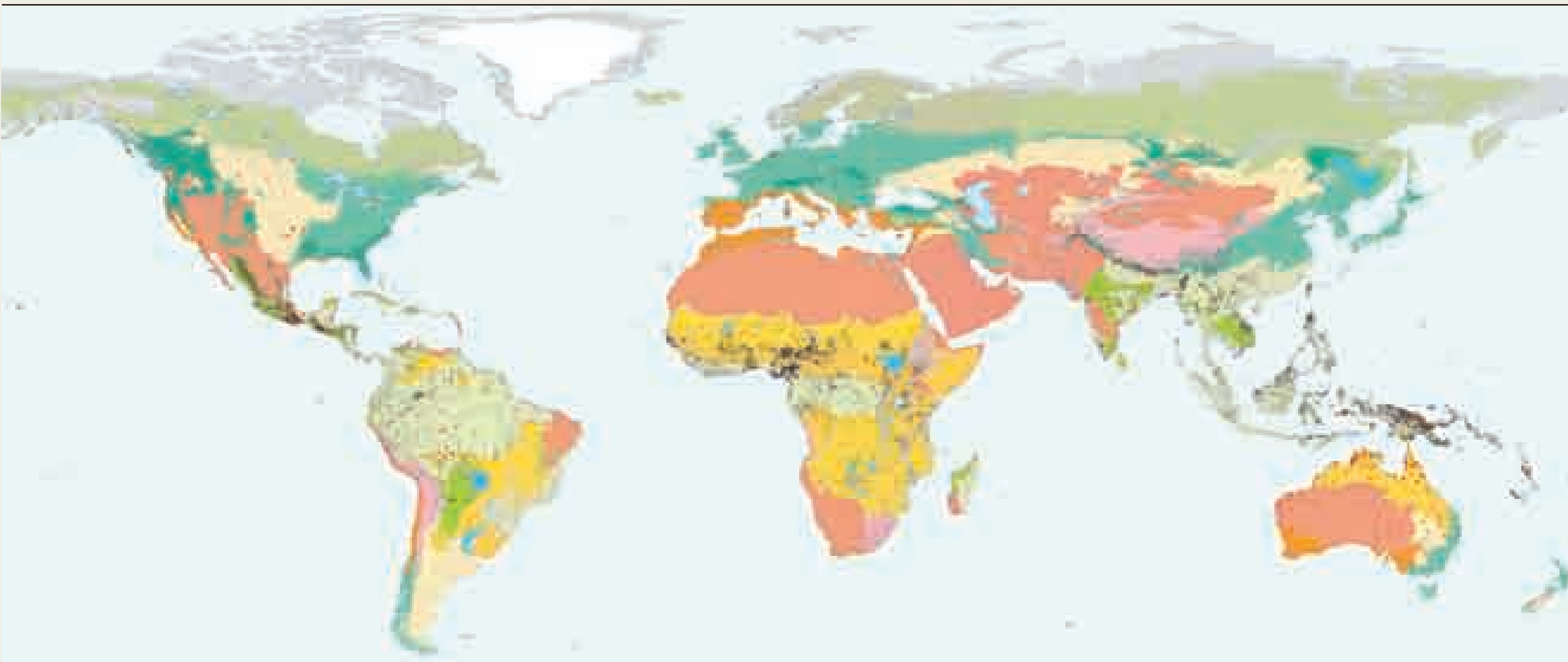
Culture encompasses the customary beliefs, social forms, and material traits of a racial, religious, or social group. Culture includes the set of values and institutions that enable a society to develop and maintain its identity. Cultural signatures differ around the globe and often hold to very different ideals and ideas, such as the role of economics as an integrating system of values or the importance of technology and technological change as springboards for human progress. Different cultures also differ in their concepts of justice and fairness and their beliefs about the relationship between people and the natural and spiritual world (UNEP 2002a).

Many of these differences are disappearing as cultures worldwide become increasingly homogeneous. Major steps in this direction occurred in the fifteenth century with European exploration and colonization and in the nineteenth century with the Industrial Revolution. In recent decades the creation of the European Union and spread of globalization has lowered many international barriers and concurrently impacted cultural diversity. Following the collapse of the Eastern Bloc in 1989, capitalism became more pervasive and less nationally limited.

Globally, world-spanning communication networks, and inexpensive air travel have reduced the costs of cross-cultural connections of all kinds, boosting television, tourism, and emigration to new levels. Global financial integration has proceeded at a furious pace, along with the international fl ow of goods and services as countries become increasingly dependent on one

Credit: Unknown/UNEP/Bigfoto

The World's Biocultural Diversity. People, Languages and Ecosystems



Source: Terralingua, UNESCO, and WWF 2003

Languages of the World

Source: http://highered.mcgraw-hill.com/site/dl/free/007248179x/35299/map12.pdf

another for food and basic commodities (Wilk 2000). Explosive development of electronic media has intensified cultural homogenization by promoting the ideals of a handful of cultures over those of many others (Gary and Rubino 2001). The technological expansion of the media, in particular the Internet, is bringing different cultures and civilisations ever closer; while this increases the possibility of dialogue, it can also be perceived as a threat to cultural diversity, In short, current globalization of trade and mass culture, together with unprecedented demand for consumer goods, has significantly impacted indigenous cultures around the globe.

Every civilisation and culture is uniqu and irreplaceable, in that all cultures and civilisations are part of the common legacy of humankind (UN 2000). In many parts of the world, English has become the dominant language, having displaced native tongues and dialects. According to a recent UNEP report (UNEP, 2001) there were 5 000 to 7 000 spoken languages in the world with 4 000 to 5 000 of these classified as indigenous. Thirty-two per cent

Source: Modified from http://www.neiu.edu/~ejhowens/104/6/cultur.gif

Credit: Unknown/UNEP/Bigfoto

Table 2.8 – The most common languages in the world

	Language	Approximate number of native speakers (in the year 2000)	Countries with substantial numbers of native speakers
1.	Mandarin Chinese	874 000 000	16
2.	Hindi (India)	366 000 000	17
3.	English	341 000 000	104
4.	Spanish	322-358 000 000	43
5.	Bengali (India and Bangladesh)	207 000 000	9
6.	Portuguese	176 000 000	33
7.	Russian	167 000 000	30
8.	Japanese	125 000 000	26
9.	German (standard)	100 000 000	40
10.	Korean	78 000 000	31
11.	French	77 000 000	53
12.	Wu Chinese	77 000 000	1
13.	Javanese	75 000 000	4
14.	Yue Chinese	71 000 000	20
15.	Telegu (India)	69 000 000	7

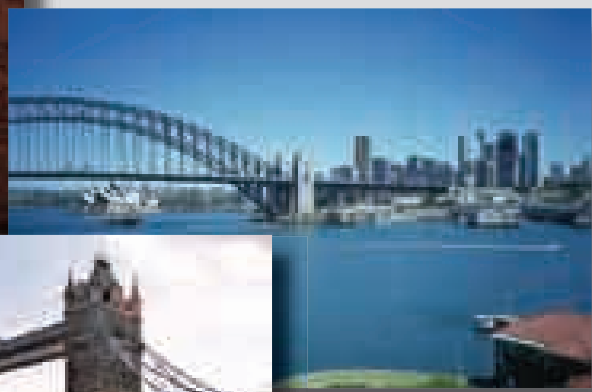
Note: These statistics are only rough approximations in most cases.
(Source: The World Almanac and Book of Facts, 2003)

of the world's spoken languages are found in Asia, 30 per cent in Africa, 19 per cent in the Pacific, 15 per cent in the Americas, and three per cent in Europe. More than 2 500 languages are in danger of immediate extinction, while 234 have already died out and many more were losing their connection to the modern world. Some researchers estimate that over the next century 90 per cent of the world's languages will have become extinct or virtually extinct. More than 350 languages already have fewer than 50 speakers (Table 2.8). Such rare languages are more likely to decline or disappear than those that are more common (Sutherland 2003). The disappearance of any language represents an irreparable loss for the heritage of all humankind (Wurm 1970). The loss has been likened to the extinction of a species—an unfortunate cultural analog to the alarming events now occuring in the biological world. In fact,

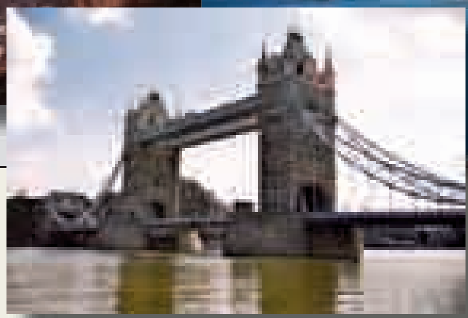
Religions of the World

Source: http://highered.mcgraw-hill.com/site/dl/free/007248179x/35299/map11.pdf

Credit: W.R. Hansen/UNEP/USGS



Credit: Unknown/UNEP/ Bigfoto



Credit: Unknown/UNEP/Bigfoto

A natural wonder formed by natural processes, Rainbow Bridge (far left) straddles a tributary of the Colorado River in southern Utah in the United States. Two contemporary bridges, one from Sydney, Australia (left), and the other from London, England (below left), echo the natural form of Rainbow Bridge, but are the obvious byproducts of modern culture.

the number of “living” languages spoken on the Earth is dwindling faster than the planet’s biodiversity.

Culture is an aspect and a means of development. Much has been said about the expansion of Western culture to the detriment of others. It is clear that many individuals aspire to Western lifestyles, while others associate Western cultural values with selfish individualism and excessive consumption. The spread of Western culture is both a cause and an effect of economic globalization, aided by the far-reaching penetration of information technologies and electronic media. At the same time, there have been nationalist and religious reactions against that culture, sometimes resulting in terrorist activities and in open warfare within or between nations (UNEP 2002a).

The World has some 6 000 communities. The international migration rate is growing every year and the number of migrants has doubled since the 1970s. While the reasons for migration vary, it is safe to say that we live in an increasingly heterogeneous society. Difference naturally leads to diversity of vision, values, beliefs, practices and expression, which all deserve equal respect and dignity (UNESCO 2003). While highlighting the role of culture in development, there is also a need to emphasize the role of culture in promoting peace (UNESCO n.d).

Just as biodiversity enriches our natural environment and is essential for its protection, cultural diversity is a treasure of humanity and a prerequisite for human development (UN 2000). Cultural Diversity presupposes respect of fundamental freedoms, namely freedom of thought, conscience and religion, freedom of opinion and expression, and freedom to participate in the cultural life of one’s choice. Cultural Diversity is not just a natural fact that we need simply recognize and respect. It is about plurality of knowledge, wisdom and energy, all of which contribute to improving and moving the World forward (UNESCO n.d.).

Variety in all aspects of life has been a source of wonder and celebration for countless centuries, and the loss of that variety is an unfortunate prospect (Gary and Rubino 2001).

Credit: Ed Simpson/UNEP/PhotoSpin

2.3 Land Use and Degradation

Growing crops, clearing land, planting trees, draining a wetland—these and many other activities fall into the broad category of land use, or how people use land. Land-use intensity is the extent to which land is used. It is an indication of the amount and degree of development in an area, and a reflection of the effects generated by that development (Planning Department 2001).

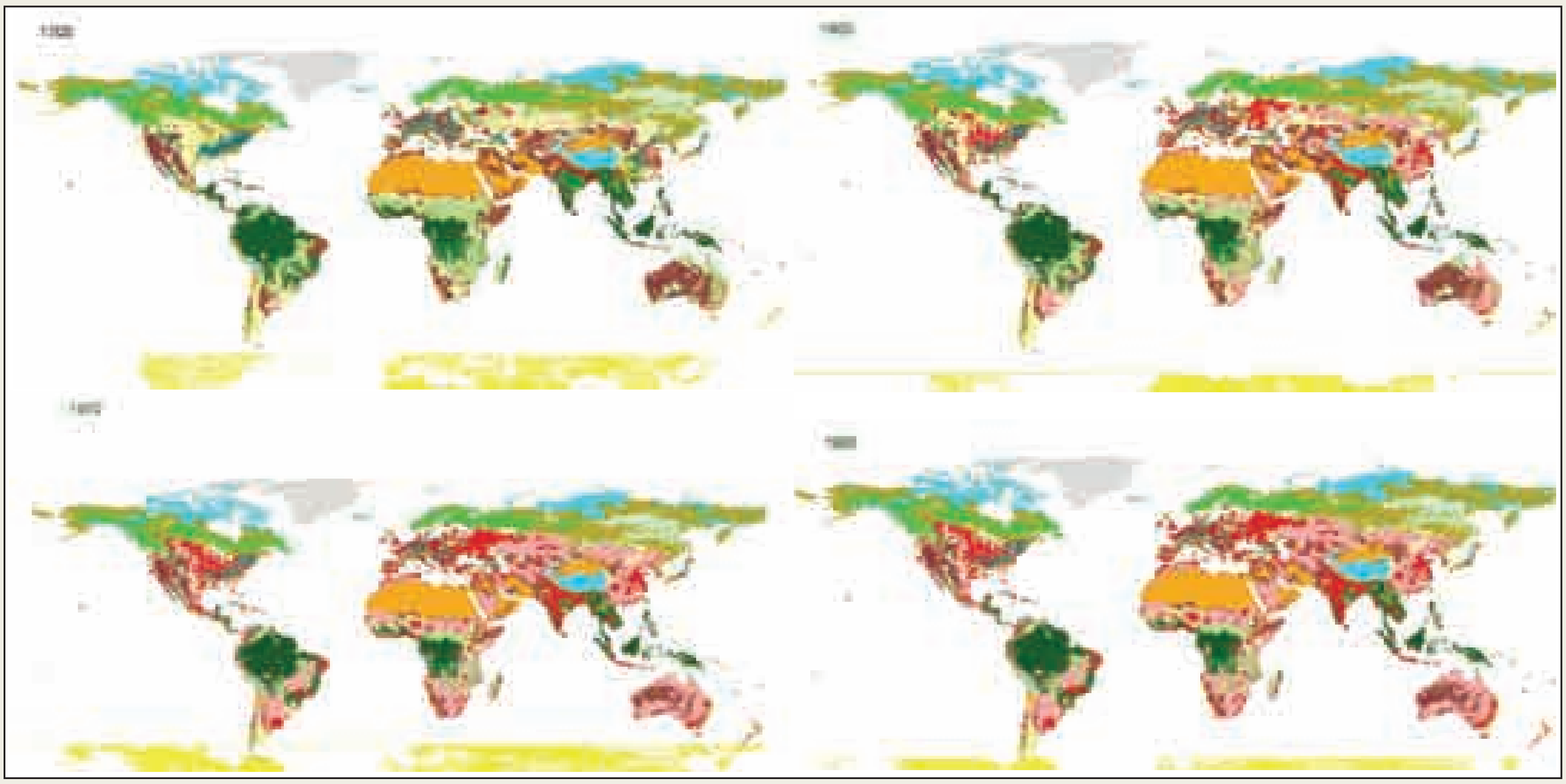
As a measure of activity, land-use intensity can range from very low (for example, a pristine wilderness area) to intermediate (a managed forest ecosystem) to very high (urban and industrial settings) (Lebel and Steffen 1998). From a global change perspective (Figure 2.6), land-use intensity is an important characteristic in assessing change and its impact (Berka et al. 1995). Land-use intensity is determined by the spatial requirements of a land-use activity, relationship to open space, requirements for infrastructure (transportation routes, water, sewer, electricity, and communications), and environmental impact. Parameters for measuring land-use intensity typically include:

- type of land-use activity, such as agriculture, grazing, wood production, or residential, commercial or industrial usage,
- duration of use,
- number of people, animals, plants, structures, or machines that occupy the land during a given period, and
- amount of land involved.

Credit: Andre Louzas/UNEP/Topfoto

Figure 2.6: This series of illustrations depicts global land-use change, particularly the expansion of cropland and grazing land, between 1700 and 1990. *Credit: Klein Goldewijk, K., 2001. Source: NASA 2002, http://www.gsfc.nasa.gov/topstory/20020926landcover.html*

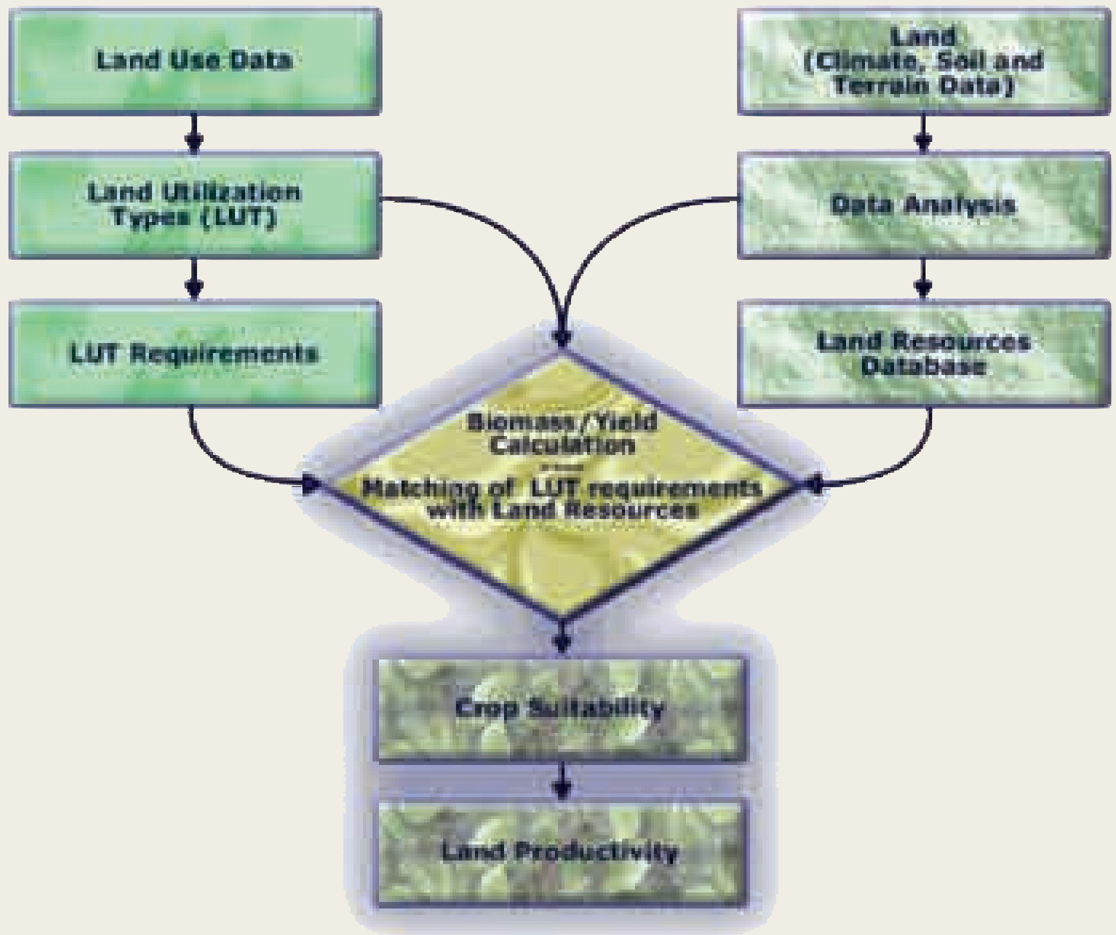
- tropical evergreen/deciduous forest
- savana
- grassland and steppe
- intensive agriculture
- desert
- open shrub land
- temperate deciduous forest
- temperate needle-leaf evergreen forest
- marginal cropland used for grazing



Also important in assessing land-use intensity is to examine the relative imperviousness of the landscape. Impervious surfaces, such as paved roads, inhibit or entirely block the absorption of water by underlying soil (Forney et al. 2001). Once paved or otherwise made impervious, land is not easily reclaimed. As environmentalist Rupert Cutler noted (Brown 2001), "Asphalt is the land's last crop."

Land-use intensity trends are usually expressed through changes in inputs, management, or number of harvests over a given period of time. Only changes within the same land-use category and on the same area (change of intensity)—as opposed to changes from one type of land use to another (for example, forest to cropland)—are taken into account when assessing trends (van Lynden et al. n.d.; FAO 2002).

Figure 2.7: Conceptual framework of the Agro-Ecological Zones methodology



Source: FAO 2000, http://www.fao.org/ag/agl/agll/gaez/index.htm

The Agro-Ecological Zones (AEZ) methodology (Figure 2.7) is a system developed by the Food and Agriculture Organization of the United Nations (FAO) with the collaboration of the International Institute for Applied Systems Analysis (IIASA), that enables rational land use planning on the basis of an inventory of land resources and evaluation of biophysical limitations and potentials. This methodology utilizes a land resources inventory to assess, for specified management conditions and levels of inputs, all feasible agricultural land-use options and to quantify expected production of cropping activities relevant

Figure 2.8: A satellite image reveals a typical "feather" or "fishbone" pattern of deforestation in Brazil. The pattern follows the construction of a new road through the rain forest. Roads provide easy access for mechanicized logging to clear cut forest sections. Clear cut sections can then be turned into agricultural fields as roads provide easy access to local markets.
Source: UNEP/GRID–Sioux Falls

Credit: Xintian Pan/UNEP/Topfoto

in the specific agro-ecological context. The characterization of land resources includes components of climate, soils and landform, which are basic for the supply of water, energy, nutrients and physical support to plants (FAO 2000).

Worldwide, the effect people are having on the Earth is substantial and growing. Satellite images reveal in startling detail the signs of human impact on the landscape. From the herringbone patterns of deforestation etched into once-undisturbed rain forests (Figure 2.8) to the patchwork patterns of agricultural fields and concrete splotches of urban sprawl, the evidence that people have become a powerful force capable of reshaping the Earth's environment is everywhere.

Scientists estimate that between one-third and one-half of the Earth's land surface has been transformed by human activities (Figure 2.9) (Herring n.d.). The activity that has had the greatest impact on the global landscape is agriculture. Twelve per cent of the world's land surface—an area equivalent to that of the South American continent—is under permanent cultivation (Ramankutty and Foley 1999; Devitt 2001).

Over the next 30 years, the annual rate of growth in global crop production is expected to decrease. However, the Food and Agriculture Organization of the United Nations predicts that production will still exceed demand, despite the world's growing population. By 2030, 75 per cent of the projected global crop production will occur in developing countries, compared to 50 per cent in the early 1960s. Increases in production will be achieved by improving plant yields and through more intensive land-use activities, including multi-cropping or high-cropping intensities (UCS 2004). In light of these projections, continued support of agricultural research and policies in developing countries is vital.

Nearly one-third of the world's cropland—1 500 million hectares—has been abandoned during the past 40 years because erosion has made it unproductive (Pimentel et al. 1995). Restoring soil lost by erosion is a slow process; it takes roughly 500 years for a mere 2.5 cm (1 inch) of soil to form under agricultural

Global Soil Degradation Map

Source: http://www.isric.nl/

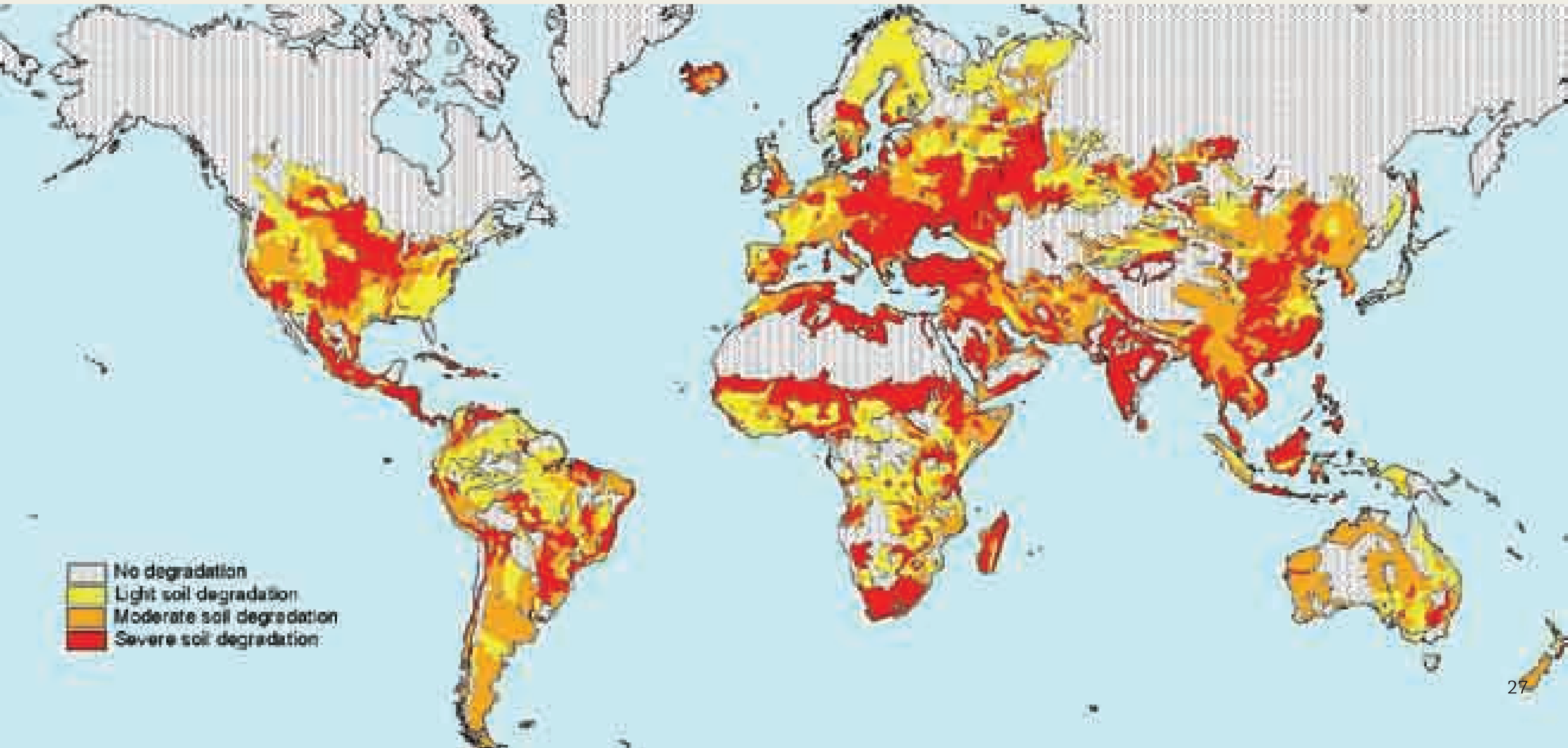
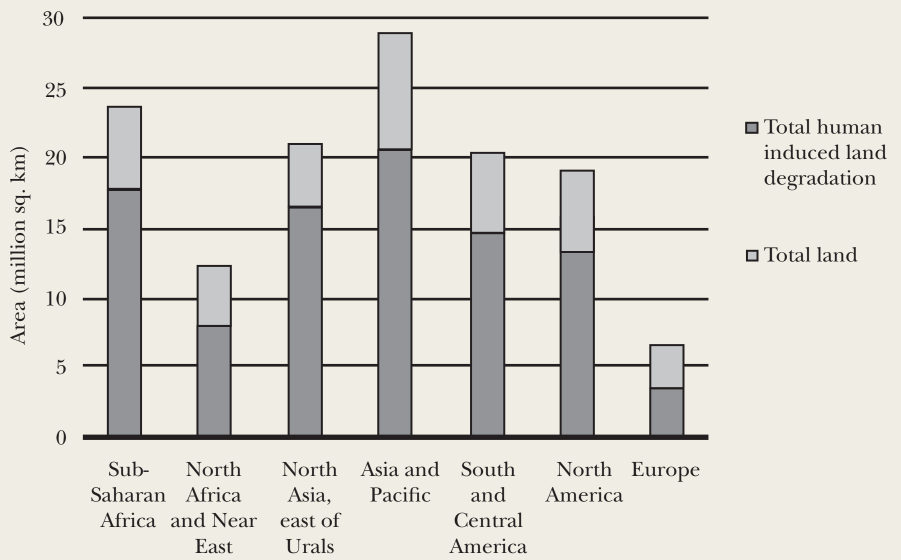


Figure 2.9: Human-induced land degradation (severe and very severe) as percentage of total land area



Source: World Atlas of Desertification (UNEP 1992)

conditions (Pimentel et al. 1996). Thus the approach to replacing eroded agricultural lands typically has been to clear more and more areas of grassland or forest and convert them to cropland. The ever-growing need for agricultural land accounts for 60 to 80 per cent of the world's deforestation (Figure 2.9).

Despite such "replacement" strategies, the amount of available cropland worldwide has declined to 0.27 hectare (0.67 acres) per person (Pimentel et al. 1996). It is possible to feed one adult on a plant diet grown on about 0.2 hectares (0.5 acres) of land (Knee 2003)—and this land-per-person minimum is roughly what will be available when world population reaches 8 000 million—but only if crop yields now being achieved in developed countries are achieved worldwide. To do so requires that most countries' inputs of fertilizer, and probably pesticides, rise to match those of North America and Europe. Furthermore, any mechanization of crop production will entail additional energy consumption. Increased mechanization is likely given the mass migration from rural areas to cities currently underway on all continents. While agriculture accounts for only about two per cent of energy consumption in North America and Europe, it accounts for roughly ten per cent of energy consumption in the rest of the world (Knee 2003).

The shortage of cropland, together with falling productivity, is a significant factor contributing to global food shortages and associated human malnutrition. Political unrest, economic insecurity, and unequal food distribution patterns also contribute to food shortages worldwide (Pimentel et al. 1996).

In addition to agriculture, the global trend toward urbanization is another key factor bringing change to the landscape. Historically, forests and grasslands have been converted to cropland. Increasingly, cropland is being converted to urban areas (Ramankutty and Foley 1999; Devitt 2001). Millions of hectares of cropland in the industrial world have been paved to create roads and parking lots. The average car requires 0.07 hectares (0.17 acres) of paved land for roads and parking space (Brown 2001).

If farmers worldwide fail to meet the challenge of increasing yields on existing cropland, or they cannot access the tools necessary to achieve increased yields, the only alternative will be to clear the world's remaining forests and grasslands (Green 2001). Yet indications are that the world does not have enough forests to fulfill all the current and future demands being placed on them (Nilsson 1996).

As natural forests are exhausted or come under protection, the demand for wood and wood products will be increasingly satisfied by tree farms. Between 1980 and 1995, forest plantations in developed countries increased from 45-60 million hectares (111-147 million acres)to 80-100 million hectares (198-247 million acres).

Credit: Choosak Khemtai/UNEP/Topfoto

Credit: Paiboon Patta/UNEP/Topfoto

In the developing world, the area in forest plantations doubled from roughly 40 million to about 81 million hectares (99-200 million acres) over the same period. More than 80 per cent of forest plantations in the developing world are found in Asia, where demand for paper and other wood products continues to grow rapidly. Forest plantations now cover more than 187 million hectares (462 million acres) worldwide. That accounts for less than five per cent of the Earth's total forested area, but 20 per cent of current global wood production (Larsen 2003).

Land Degradation and Desertification

By the beginning of the twenty-first century, unprecedented global environmental changes had reached sufficient proportions to impinge upon human health—simultaneously and often interactively. These changes include the processes of land degradation and desertification (Menne and Berollini 2000).

Land degradation is the decline in the potential of land resources to meet human economic, social, and environmental functions needs (Africa Mountain Forum n.d.). Desertification is soil degradation in arid regions, often to such an extent that it is impossible to make the soil productive again (Table 2.9). Desertification is the result of complex interactions between unpredictable climatic variations and unsustainable land use practices by communities who, in their struggle to survive, overexploit agricultural, forest, and water resources (CIDA 2001).

Over 3 600 million hectares (8 896 million acres)—25 per cent of the Earth's land area—are affected by land degradation. Desertification occurs to some extent on 30 per cent of irrigated lands, 47 per cent of rain-fed agricultural lands, and 73 per cent of rangelands (Figure 2.10). Annually, an estimated 1.5 to 2.5 million hectares (3.7 to 6 million acres) of irrigated land, 3.5 to 4.0 million hectares (8.6 to 9 million acres) of rain-fed agricultural land, and about 35 million hectares (86 million acres) of rangeland lose all or part of their productivity due to land degradation processes (Watson et al. 1998).

Desertification and drought are problems of global dimension that directly affect more than 900 million people in 100 countries, some of which are among the least developed nations in the world (Watson et al. 1998). The consequences of desertification include (UNEP 2002a):

- reduction of the land's natural resilience to recover from climatic disturbances;
- reduction of soil productivity;
- damaged vegetation cover, such that edible plants are easily replaced by non-edible ones;
- increased downstream flooding, reduced water quality, sedimentation in rivers and lakes, and siltation of reservoirs and navigation channels;
- aggravated health problems due to wind-blown dust, including eye infections, respiratory illnesses, allergies, and mental stress;
- undermined food production; and
- loss of livelihoods forcing affected people to migrate.

Desertification results from mismanagement of land and thus deals with two interlocking, complex systems: the natural

Table 2.9 – Degree of soil degradation by subcontinental regions (per cent of total area)

	None	Light	Moderate	Strong	Extreme
Africa	83	6	6	4	0.2
Asia	82	7	5	3	<0.1
Australiasia	88	11	0.5	0.2	<0.1
Europe	77	6	15	1	0.3
North America	93	1	5	1	0
South America	86	6	6	1	0
World:					
Per centage	85	6	7	2	<0.1
Area ('000 km^2)	110 483	7 490	9 106	2 956	92

Source: World Atlas of Desertification (UNEP 1992)

Credit: Rick Collins/UNEP/Topfoto

ecosystem and the human social system (Eswaran et al. 1998). While much desertification is attributed to poor land-use practices, hotter and drier conditions brought about by potential global warming would extend the area prone to desertification northwards to encompass areas currently not at risk. In addition, the rate of desertification would increase due to increases in erosion, salinization, fire hazard, and reductions in soil quality. As a result, the process of desertification is likely to become irreversible (Karas n.d.).

Worldwide, an estimated 6 to 27 million hectares (15 to 67 million acres) of land are lost each year to desertification. Seventy per cent of the world's dry land is degraded enough to be vulnerable to desertification (Anon 2002). The amount of land susceptible to desertification (areas known as tension zones) also is increasing. Currently, 7.1 million km^2 (2.7 million square miles) of land face low risk of human-induced desertification, 8.6 million km^2 (3.4 million square miles) are at moderate risk, 15.6 million km^2 (6.2 million square miles) are at high risk, and 11.9 million km^2 (4.6 million square miles)are at very high risk. Tension zones result from:

- excessive and continuous soil erosion resulting from overuse and improper use of lands, especially marginal and sloping lands;
- nutrient depletion and/or soil acidification due to inadequate replenishment of nutrients or soil pollution from excessive use of organic and inorganic agrichemicals;
- reduced water-holding capacity of soils due to reduced soil volume and reduced organic matter content, both of which are a consequence of erosion and reduced infiltration due to crusting and compaction;
- salinization and water-logging from over-irrigation without adequate drainage; and
- unavailability of water stemming from decreased supply of aquifers and drainage bodies.

The following negative effects are highest in the tension zones (Eswaran et al. 1998):

- systematic reduction in crop performance, leading to failure in rain-fed and irrigated systems;
- reduction in land cover and biomass production in rangelands, with an accompanying reduction in quality of feed for livestock;
- reduction of available woody plants for fuel and increased distances to harvest them;

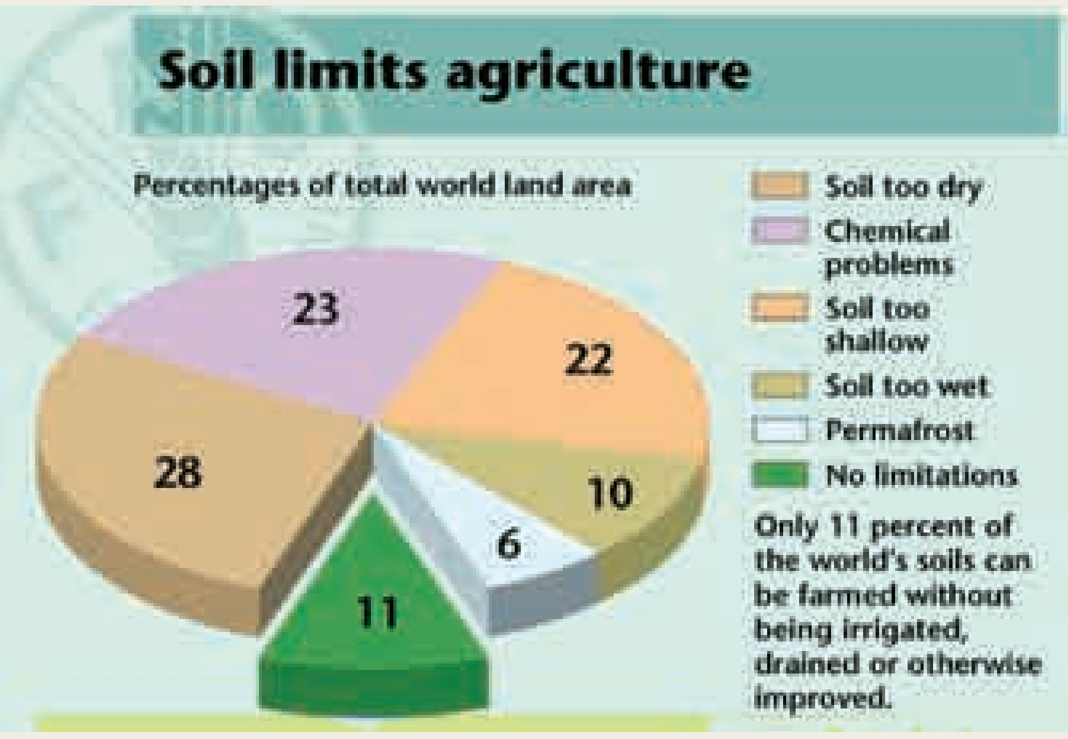
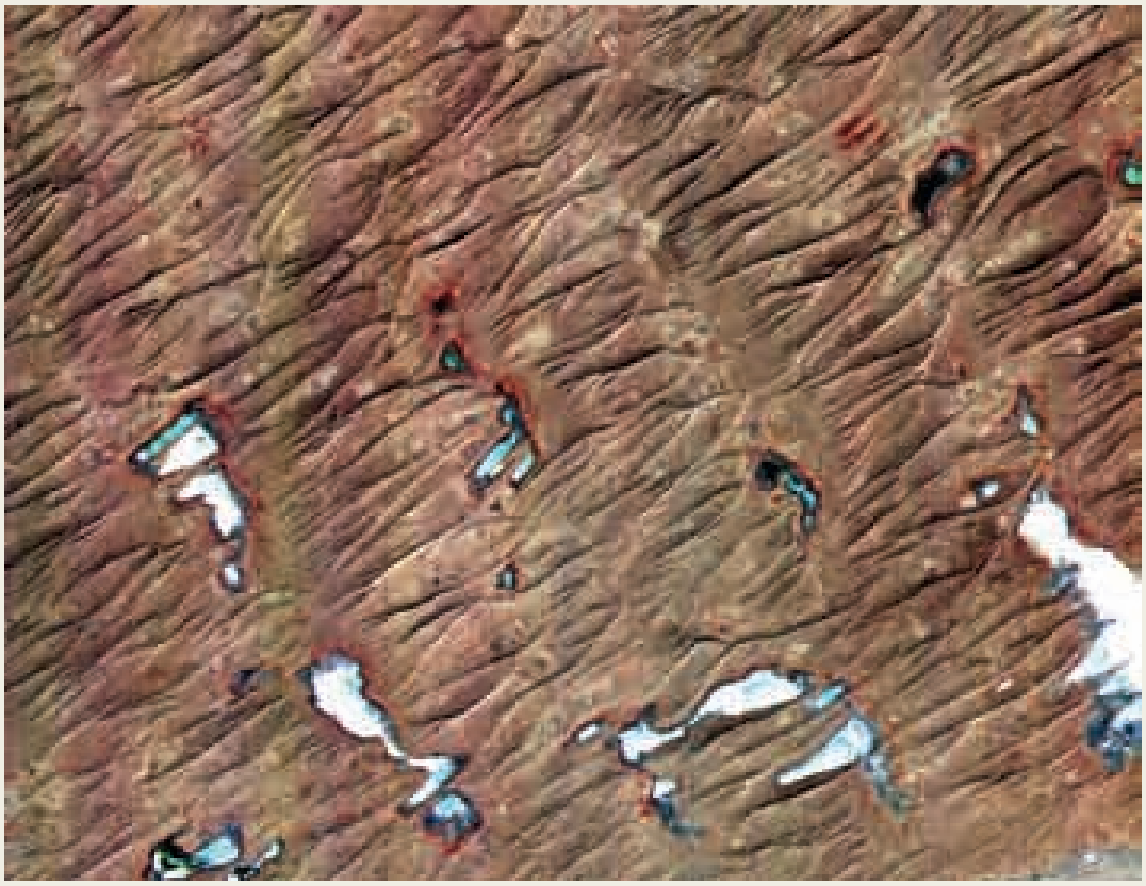


Figure 2.10: Soils are classified according to the proportions of different sized particles they contain. As seen in this figure, the largest percentage of world land area unsuitable for agriculture is land that is too dry. *Source: FAO 2000, http://www.fao.org/desertification/default.asp?lang=en*

This sub-scene of an ASTER satellite image shows sand dunes covering an area roughly 12 km x 15 km (8 x 9 miles) in the Thar Desert of northwestern India and eastern Pakistan. The dunes here shift constantly, taking on new shapes. Approximately 800 km (497 miles) long and 490 km (305 miles) wide, the Thar Desert is bounded on the south by a salt marsh known as the Rann of Kutch, and on the west by the Indus River plain. The desert's terrain is primarily rolling sand hills, with scattered outcroppings of shrub and rock. *Source: NASA 2004, http://asterweb.jpl.nasa.gov/gallery/gallery.htm?name=Thar*

- significant reduction in water from overland flows or aquifers and a concomitant reduction in water quality;
- encroachment of sand and crop damage by sand-blasting and wind erosion; and
- increased gully and sheet erosion by torrential rain.

Ultimately, desertification processes impact about 2 600 million people, or 44 per cent of the world's population (Eswaran et al. 1998).



Credit: NASA/GSFC/METI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team.

Case Study: Mt. Kenya–Diversity in Ecosystems

Christian Lambrechts

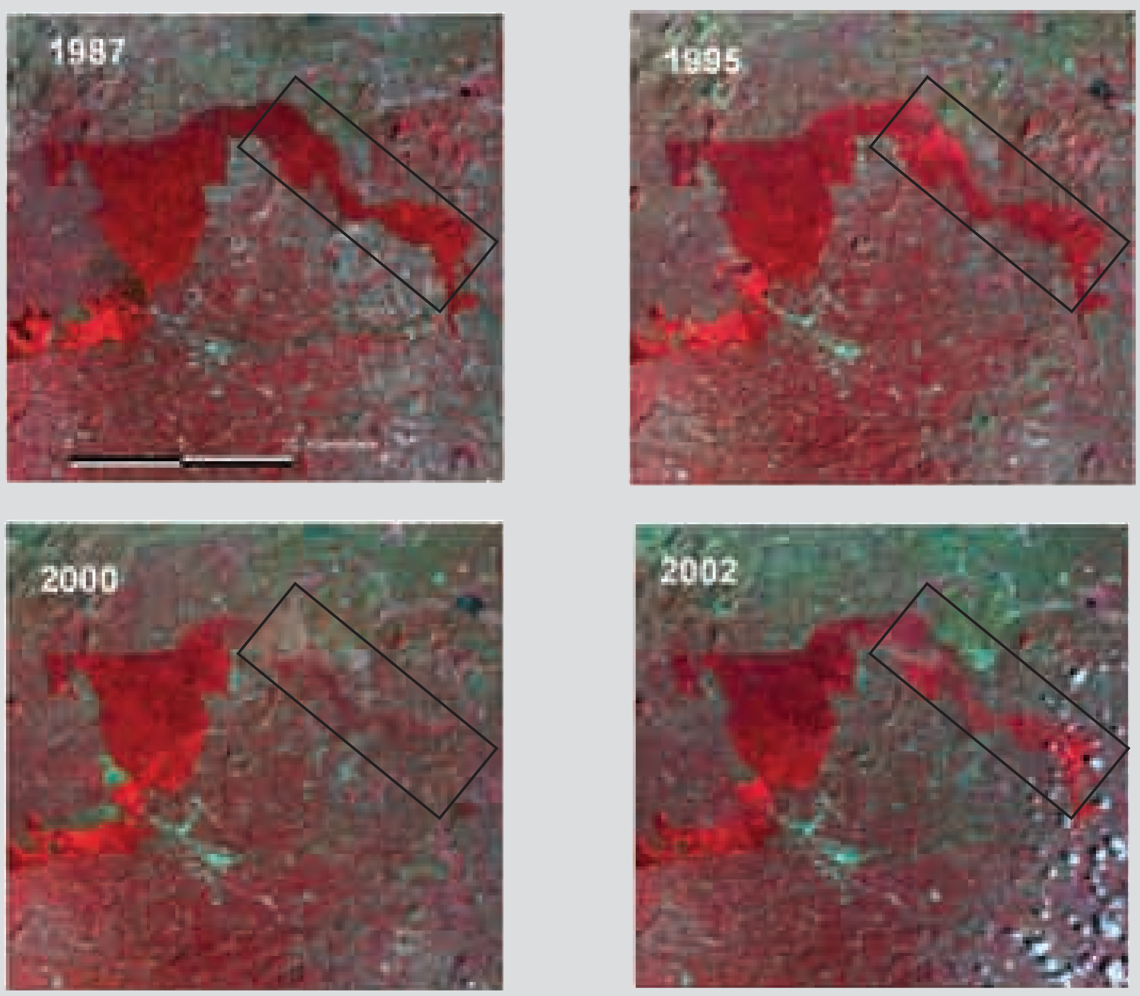
Mount Kenya is located on the equator 180 kilometres north of Nairobi. It is a solitary mountain of volcanic origin with the base diameter of about 120 km (75 miles). Its broad cone shape reaches an altitude of 5 199 m (17 057 ft) with deeply incised U-shaped valleys in the upper parts. Forest vegetation covers the major part of the mountain, with a total area around 220 000 hectares (548 574 acres). The forests are critical and invaluable national assets that must be protected.

High diversity in ecosystems and species

The wide range in altitude clines—from 1 200 to 3 400 m (3 900 to 11 000 ft)—and rainfall clines from—from 900 mm/year (35 in/year) in the north to 2 300 mm/year (91 in/year) in the south-eastern slopes—contributes to the highly diverse mosaic patterns of Mount Kenya forests. Mount Kenya adds value to the nation by providing tourism potential and local cultural and economic benefits. It also provides important environmental services to the nation such as a water catchment area of the Tana River where 50 per cent of Kenya's total electricity output is generated.

Forest conservation initiative

Following a 1999 aerial survey, the entire forest belt of Mount Kenya was gazetted as National Reserve and placed under the management of Kenya Wildlife Services in the year 2000. In 2002, a study was carried out to assess the effectiveness of the new management practices put in place in 2000. The study revealed significant improvement in the state of conservation of the forests.



Forest is shown in red on these images. Note the changes in forest cover in the boxes.
Source: UNEP/GRID–Nairobi

2.4 Ecoregions and Ecosystems

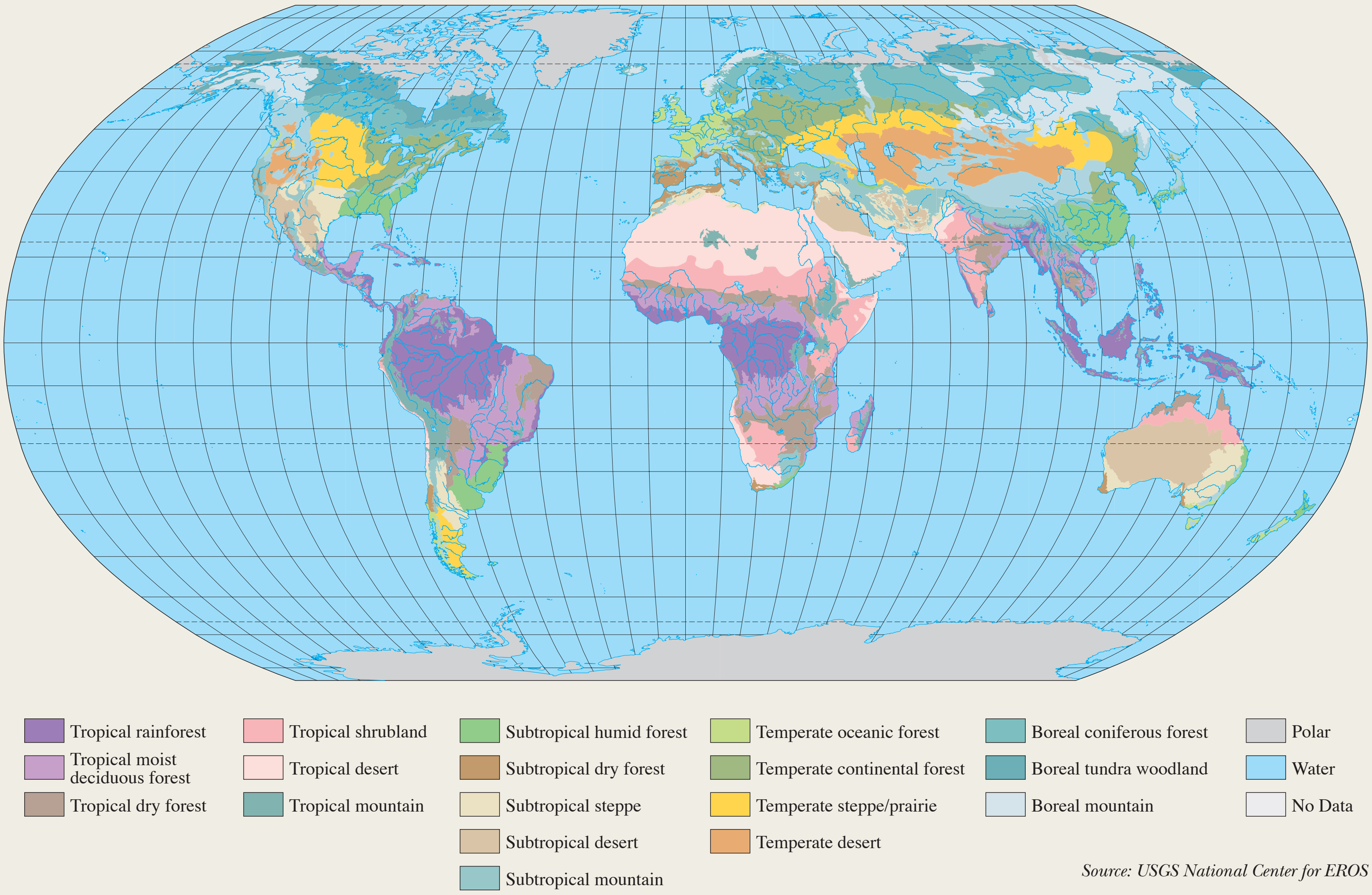
An ecosystem is an organic community of plants and animals viewed within its physical environment (habitat); the ecosystem results from the interaction between soil and climate. It is a dynamic complex of plant, animal, and microorganism communities and their non-living environment interacting as a functional unit (UNEP-WCMC 2003).

An ecoregion is a cartographical delineation of a relatively large unit of land or water containing a geographically distinct assemblage of species, natural communities, and environmental conditions. An ecoregion is often defined by similarity of climate, landform, soil, surface form, potential natural vegetation, hydrology, and other ecologically relevant variables. Ecoregions contain multiple landscapes with different spatial patterns of ecosystems.

The ecoregion concept is one of the most important in landscape ecology, both for management and understanding (Hargrove and Hoffman 1999). Ecoregion classifications are based on particular environmental conditions and designed for specific purposes, and no single set of ecoregions would be appropriate for all potential uses (Wikipedia n.d.).

The environment of an ecoregion in terms of climate, resource endowments, and socioeconomic

Credit: John R Jones/UNEP/Topfoto



Source: USGS National Center for EROS

Credit: Philip De Mancz/UNEP/Topfoto

conditions is homogeneous. Specific advantages of using an ecoregion approach for planning and decision-making include:

- easier identification of production capabilities and constraints;
- better targeting of prospective technologies;
- improved assessment of responses to new technologies; and
- wider adoption and larger impact of research outputs (Saxena et al. 2001).

Table 2.10 – Loss of biodiversity from 2000 to 2003—expressed as changes in species numbers—in animals and plants classified as critically endangered, endangered, and vulnerable

Group	Critically Endangered 2000	Critically Endangered 2002	Critically Endangered 2003	Endangered 2000	Endangered 2002	Endangered 2003	Vulnerable 2000	Vulnerable 2002	Vulnerable 2003
Mammals	180	181	184	340	339	337	610	617	609
Birds	182	182	182	321	326	331	680	684	681
Reptiles	56	55	57	74	79	78	161	159	158
Amphibians	25	30	30	38	37	37	83	90	90
Fishes	156	157	162	144	143	144	452	442	444
Insects	45	46	46	118	118	118	392	393	389
Mollusks	222	222	250	237	236	243	479	481	474
Plants	1 014	1 046	1 276	1 266	1 291	1 634	3 311	3 377	3 864

Source: http://www.redlist.org/info/tables/table2.html

Trends

An increase in average global temperature has the potential to bring about dramatic change in ecosystems. Some species may be forced out of their habitats (possibly to extinction) because of changing conditions. Other species may flourish and spread. Few, if any, terrestrial ecoregions on the Earth are expected to remain unaffected by significant global warming.

Since 1970, there has been a 30 per cent decline in the world's living things and the downward trend is continuing at one per cent or more per year (Collins 2000; UNEP 1997). Table 2.10 shows an increase in the number of endangered and vulnerable species between the years 2000–2003. Modification of landscapes, loss of native species, introduction of exotic species, monoculture-focused agriculture, soil enhancement, irrigation, and land degradation have all tended to "simplify" ecosystems, leading to a reduction in biodiversity. In aquatic environments, eutrophication and habitat destruction have had a similar effect (Tilman et al. 2001). As ecosystems become simpler, so do ecoregions.

Ecoregion and ecosystem fragmentation also contributes to a decline in biodiversity and threatens many species. Globally, over half of the temperate broadleaf and mixed forests and nearly one quarter of the tropical rain forests have been fragmented or removed (Wade et al. 2003).

Impacts

Simplification of ecosystems and ecoregions results in species extinctions and a loss of natural resources (Tilman et al. 2001). Climate change and the way in which ecological communities respond to it have enormous conservation implications. These include developing awareness of the transience of native ranges and plant associations and the significance of population declines and increases, as well as the need to develop targets and references for restoration, and strategies for dealing with global warming (Millar 2003). For example, changes in the potential distribution of tree and shrub taxa in North America in response to projected climate change are expected to be far-reaching and complex; growing ranges for various species will shift not only northward and upward in elevation but in all directions (Shafer et al. 2001). Some models predict that more than 80 per cent of the world's ecoregions will suffer extinctions as a result of global warming (Malcolm et al. 2002). Ecoregions expected to be most dramatically altered by climate change include the boreal forests of the Northern Hemisphere, the fynbos of Southern Africa, and the Terai-Duar savanna and grasslands of northeastern India (Malcolm et al. 2002).

Credit: Ron Levy/UNEP/Topfoto

Credit: Gary Wilson/UNEP/NRCS

2.5 Biodiversity, Invasive Species, and Protected Areas

Biological diversity, or "biodiversity," refers to the variety of life on the Earth in all its forms. There are three levels of biodiversity: biodiversity of a landscape or ecosystem, species biodiversity, and genetic biodiversity (IUCN, UNEP, and WWF 1991). These three levels are intimately connected. For example, genetic diversity is often the key to survival for a species, equipping it with the necessary resources to adapt to changing environmental conditions. Species diversity, in turn, is typically a measure of ecosystem health (Rosenzweig 1999).

We have just begun to identify and fully understand the diverse living things that currently inhabit the Earth. Scientists have discovered and described roughly 1.75 million species to date. That number is expected to increase substantially when all marine organisms, arthropods, bacteria, and viruses are eventually added to the list. Tragically, however, humans are destroying this great diversity at an alarming rate. Rates of human-induced species extinction are estimated to be 50 to 100 times the natural background rate; this could

Credit: Gyde Lund/UNEP

Credit: William M. Ciesla/UNEP/Invasive.org

increase to 1 000 to 10 000 times the natural rate in the next 25 years (Lund et al. 2003; Pellew 1996).

Why are so many species becoming extinct? Human activities over the last three centuries have significantly transformed the Earth's environment, primarily through the conversion of natural ecosystems to agriculture (Ramankutty and Foley 1999). It is estimated that cropland expanded from 3-4 million km^2 (1.2-1.5 million square miles) in 1700 to 15-18 million km^2 (5.8-6.9 million square miles) in 1990, primarily at the expense of forests. At the same time, grazing lands expanded from 5 million km^2 (1.9 million square miles) in 1700 to 31 million km^2 (12 million square miles) in 1990, largely via the conversion of native grasslands (Goldewijk and Ramankutty 2001). In addition to agriculture-driven landscape transformations, the move to monoculture-based forms of agriculture has contributed to declining biodiversity.

Wild plants and animals are a major source of food. Billions of people still harvest wild or "bush" food around the world. Between one-fifth and one-half of all food consumed by poor people in developing countries is gathered rather than cultivated. On a global scale, ocean fish caught in the wild account for 16 per cent of the human diet (Harrison and Pearce 2001).

Wild plants are also a major source of medicine, and the loss of biological diversity has serious implications in terms of human health. Of the 150 most frequently prescribed drugs, more than half are derived from or patterned after chemical compounds found in plants (Brehm 2003). Moreover, plants are an important source of fuel. Nearly 15 per cent of the world's energy is derived from the burning of plant materials (De Leo and Levin 1997).

Worldwide, people eat only a small fraction of the 70 000 plants known to be edible or to have edible parts (Wilson 1989). But retaining biodiversity is still vital for the food supply, since most food crops constantly require an infusion of "wild" genes to maintain their resistance to ever-evolving pests (Harrison and Pearce 2001).

Photos left to right: A family of elephants in Africa (Credit : Gyde Lund/UNEP). A clear-cut section of forest (Credit: Steven Poe/UNEP/Topfoto). Yellowstone National Park (Credit: Gyde Lund/UNEP). People often peel the loose bark off birches for souvenirs. Danforth, ME USA (Credit: Randy Cyr/UNEP/Forestryimages.org).

Despite our dependence on biodiversity, it has been estimated that 27 000 species are lost every year—roughly three per hour. Other estimates put the number much higher. The greatest loss of biodiversity is currently taking place in wet tropical regions where rain forest ecosystems are being altered dramatically. But loss of biodiversity is also evident in drier regions, due to desertification. Major contributors to species extinctions and loss of biodiversity worldwide include:

- human population growth;
- unsustainable patterns of consumption such as over-harvesting of plant and animal resources;
- poor agricultural practices;
- increased production of wastes and pollutants;
- urban development; and
- international conflict (UNEP 2002b).

Loss of biodiversity occurs hand-in-hand with habitat loss, and habitat loss is generally greatest where human population density is highest (Harrison 1997). One type of habitat loss is fragmentation. Fragmentation occurs where a once-continuous ecosystem is broken up into many small, poorly connected patches of land, which happens when blocks of trees are removed from a forest. A change in land cover typically accompanies fragmentation. Six categories of fragmentation have been identified (interior, perforated, edge, transitional, patch, and undetermined) depending on how a given area of land is broken up (Riitters et al. 2000). Fragmentation may be human-induced or due to natural causes such as fire, floods, or wind. Fragmentation may create more diverse landscapes than were originally present, and while it may destroy habitats of some species, it can also create habitats for others.

Left to right: Junipers near near Paulina, Oregon. Without natural fi res to control their spread, junipers can become invasive in rangelands (Credit: Gyde Lund/UNEP). Women herding goats (Credit: Unknown/UNEP/Topfoto). Cattle grazing in a bog (Credit: Rubai Wang/UNEP/Topfoto). Kudzu taking over the land and trees in the southeastern United States (Credit: Gyde Lund/UNEP).

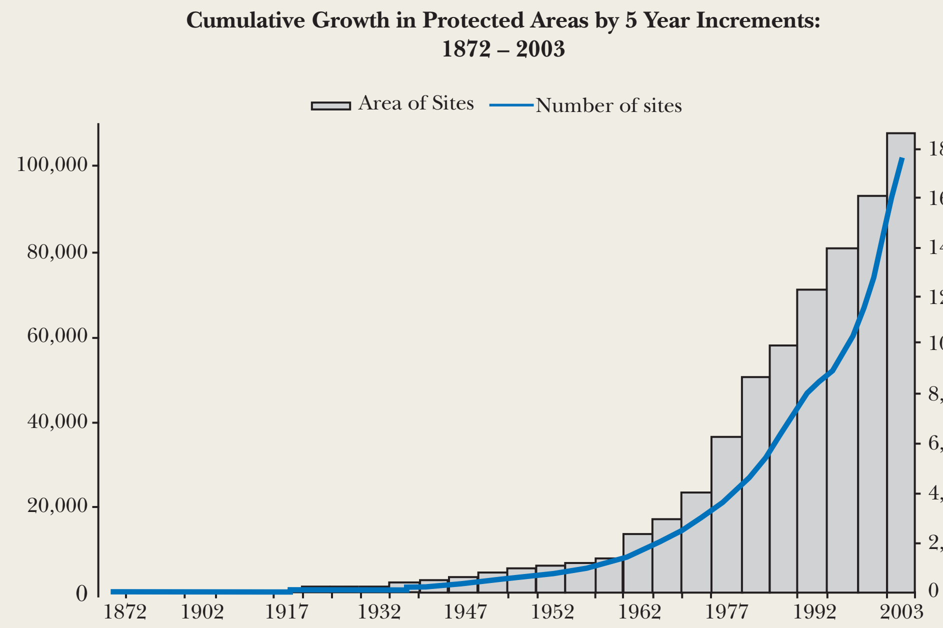


Figure 2.11: The number and extent of the world's protected lands increased significantly during the period from 1872 to 2003. The greatest increase has occurred over the past few decades. In 2003, the total number of protected sites surpassed 100 000, while total area increased to more than 18 million km^2 (7 million square miles). *Source: Chape et al. 2003*

Invasive Species

Most plants and animals exist in places in which they did not originate. They moved or were introduced into new areas over time. While rooted plants cannot themselves move from place to place, the dispersion of their seeds by wind, water, and animals has enabled them to spread into many new habitats.

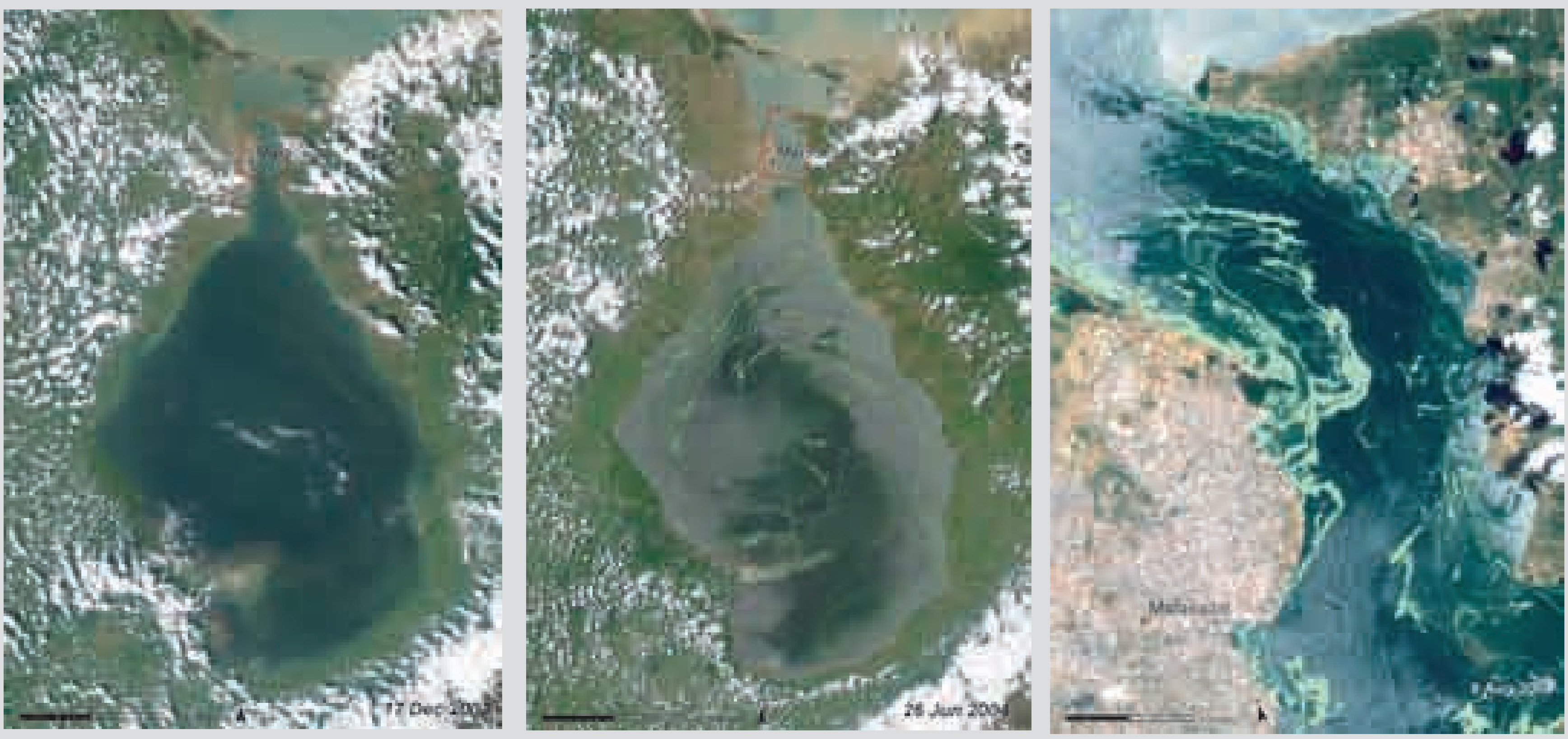
An introduced species is one whose existence in a given region is due to some type of human activity. That activity may enable the species to cross natural geographic barriers or it may transform conditions in an area as to be in some way favorable to the species' growth and spread. Introduced species are also called alien, or exotic, species.

Many introduced species have been actively transported by people to new areas for specific purposes and have played important and beneficial roles in human history. Most modern agricultural crops were introduced into the regions they now inhabit. For instance, corn (maize) is thought to have originated in Mexico some 7 000 years ago. Today it is found worldwide. Wheat probably originated in the Middle East. Currently, wheat is grown on more land area worldwide than any other crop and is a close third to rice and corn in total world production.

Many modern domesticated animals were also new species introductions at some point in their history. Modern domestic cattle evolved from a single early ancestor, the auroch. Cattle were domesticated between 10 000 and 15 000 years ago near the boundary of Europe and Asia or Southwest Asia. Cattle are now widely distributed throughout the world. The total world cattle population in the late

Case Study: Lake Maracaibo, Venezuela

Lake Maracaibo in northwestern Venezuela is the largest natural lake in South America at 13 330 km^2 (5 146 square miles). At its widest point, it is more than 125 km (78 miles) wide. The lake itself lies in the Maracaibo basin, which is semi-arid in the north, but averages over 1 200 mm (47 in) of annual rainfall in the south. It has been suffering from a serious problem of invasive duckweed, a tiny aquatic plant that grows in freshwater. This first image (left), taken by the Aqua MODIS satellite on 17 December 2003, shows the lake during the winter months, when duckweed is absent from the lake's waters, and the silvery sunglint is absent. In summer the weed blooms. The true-colour image from 26 June 2004 (middle) shows strands of duckweed curling through the lake, floating at the surface, or slightly submerged in the brackish water. A closer look in August 2004 (right) reveals the stranglehold the duckweed has on port areas, especially along the important oil shipping routes in the neck of Lake Maracaibo. Fish and the fishing industry suffer as thick green mats block photosynthesis and alter fish habitats. The weed also adheres to boats, affects cooling systems, and obstructs travel. In September 2004, Venezuela's Ministry of Environment and Natural Resources reported that it had reduced the duckweed area by 75 per cent, using duckweed harvesting machines from the United States. The ministry is investigating using the harvested weed as animal fodder.



Credit: (Left, right images) NASA; (middle) LPDAAC – USGS National Center for EROS

Table 2.11 – Growth of protected areas of the world in 1994 and 2004 (in per cent)

Ratio	1994	2004
World	7.8	9.5
Developed Countries	11.3	14.1
Commonwealth Independent States (CIS)	2.8	3.0
CIS-ASIA	3.6	3.8
CIS-Europe	2.6	2.8
Developing	7.6	9.1
Northern Africa	3.5	3.9
Sub-Saharan Africa	8.1	8.3
Latin America & the Caribbean	8.0	9.9
Eastern Asia	8.2	14.2
Southern Asia	4.5	5.1
South-eastern Asia	4.8	5.9
Western Asia	21.4	22.0
Oceania	1.0	1.1
Least Developed Countries (LDCs)	7.7	7.9
Landlocked Developing Countries (LLDCs)	8.4	9.6
Small Island Developing States (SIDs)	1.6	2.8

There is considerable variation in the total area protected between regions, ranging from 1.1 per cent in the developing countries of Oceania to 22.0 per cent in Western Asia. The percentage coverage in both Western and Eastern Asia (14.2 per cent) exceeds the coverage of all developed countries (14.1 per cent) representing a significant commitment by these regions to conservation. However, the constraints imposed upon the data by the criterion for a date of establishment within the Millennium Development Goals (MDG) reporting period suggest that all figures should be treated cautiously.

Source: UNEP-WCMC 2005

1980s was estimated to be nearly 1.3 billion. Chickens—the world's most abundant domesticated bird—are generally believed to have descended from jungle fowl in Southeast Asia. They were subsequently introduced into almost every country and region of the world.

In stark contrast to such positive species introductions are those where introduced exotic species have become invasive. Scientifically speaking, invasive species are those organisms that are unwanted and have a tendency to spread. Invasive species harm, or have the potential to harm, a given ecosystem or peoples' health or economic well-being (Clinton 1999). Historically, some invasive exotic species have been intentionally introduced into new settings; the introduction of the common starling into the United States and the rabbit into Australia are two classic examples. Introductions of other invasive species have occurred by accident, such as that of zebra mussels into the American Great Lakes as a result of shipping activities.

Native or indigenous species are those that occur naturally in an area or habitat. Invasive species often out-compete and displace native species because the invaders have no natural enemies and can spread easily and quickly. Both managed and natural ecosystems throughout the world are under siege from increasing numbers of harmful invasive species. These include disease organisms, agricultural weeds, and destructive insects and small mammals that threaten economic productivity, ecological stability, and biodiversity. On a local scale, such invasions decrease diversity of native flora and fauna. Globally, they contribute to making the biosphere more homogeneous and less resilient.

Natural biodiversity helps to maintain ecological resilience in the face of varying environmental conditions (Holling et al. 1995). Invasion by exotic species lessens ecological resilience and can transform ecosystems in unpredictable ways that may have negative consequences for people. This problem is growing in severity and geographic extent as global trade and international travel expand, as markets are liberalized and deregulated, as ecosystems are further altered and fragmented, and as global climate continues to change (Brandt 2003; Dalmazzone 2000).

Invasions by alien species are set to worsen in the next few decades if the world continues to warm as most scientists predict it will. Longer growing seasons spawned by global warming may give invasive weedy plants time to flower and set seeds where previously they could only spread asexually. This new-found ability could allow the weeds to adapt to new environments more quickly, and better resist attack by insects. Higher levels of carbon dioxide in the atmosphere may also favor plants that can utilize extra carbon dioxide and grow faster. One such example is cheatgrass, an introduced species that now dominates vast areas of the American West (Holmes 1998). In other parts of the world, invasive exotic plant species make up 4 to 44 per cent of the total number of species in ecosystems (Lövei 1997).

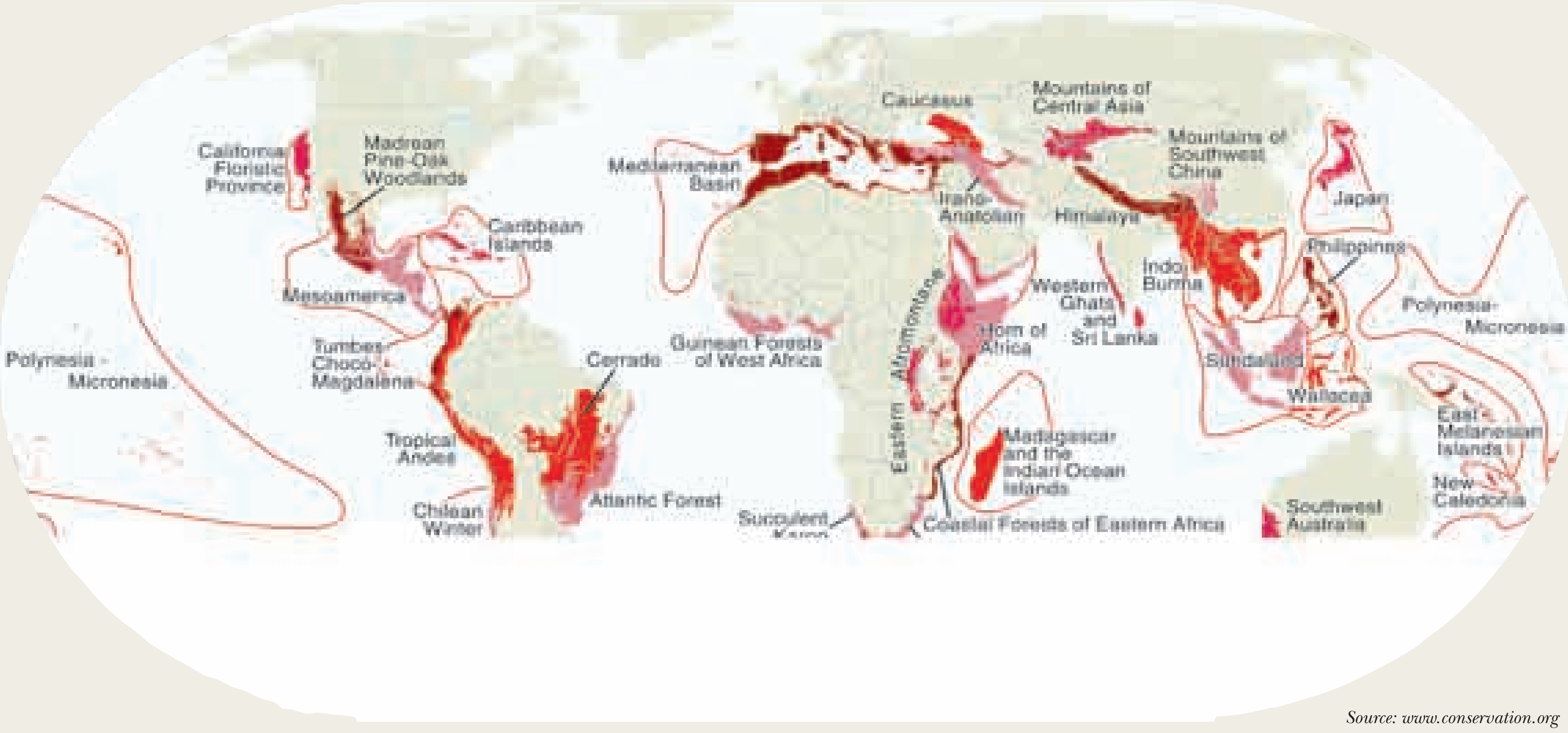
Invasive exotic species are one of the most significant drivers of environmental change worldwide. They also contribute to social instability and economic hardship, and place constraints on sustainable development, economic growth, and environmental conservation. Worldwide, the annual economic impact of invasive species on agriculture, biodiversity, fisheries, forests, and industry is enormous. The World Conservation Union (IUCN) estimates that the global economic costs of invasive exotic species are about US$400 billion annually (UNEP 2002a). Alien invaders cost 140 billion dollars a year in the USA alone (McGrath 2005). Less easily measured costs also include unemployment, impacts on infrastructure, shortages of food and water, environmental degradation, increases in the rate and severity of natural disasters, and human illness and death. Invasive exotic species represent a growing problem, and one that is here to stay—at least for the foreseeable future (Brandt 2003).

Protected and Wilderness Areas

Wilderness areas are those areas of land that are relatively untouched by human activities. To qualify as wilderness, an area must have 70 per cent or more of its original vegetation intact, cover at least 10 000 km^2 (3 861 square miles), and be inhabited by fewer than five people per km^2 (12 people per square mile).

Wilderness areas are major storehouses of biodiversity. They also provide critical ecosystem services to the planet, including watershed maintenance, pollination, and carbon sequestration. Wilderness areas currently cover nearly half the Earth's terrestrial surface (Mittermeier et al. 2003). While that represents a significant amount of land area, however, most wilderness areas are not protected, and are therefore at risk.

World Environmental Hotspots as identified by Conservation International.



Source: www.conservation.org

One of the most effective means for conserving wilderness is through the development of protected areas. A protected area is an area of land (or water) especially dedicated to the protection and maintenance of biological diversity, along with natural and associated cultural resources, that is managed through legal or other effective means (IUCN 1994). Protected areas are managed for a wide variety of purposes, including:

- scientific research;
- wilderness protection and preservation of species and ecosystems;
- maintenance of environmental services;
- protection of specific natural and cultural features;
- tourism and recreation;
- education;
- sustainable use of resources from natural ecosystems; and
- maintenance of cultural and traditional attributes (Green and Paine 1997).

The 2003 United Nations List of Protected Areas—compiled by UNEP and the IUCN and released during the Fifth World Parks Congress in Durban, South Africa—reveals that there are now 102 102 protected areas, together representing a total land area roughly equivalent to China and Canada combined, or more than 12 per cent of the Earth's surface (Chape et al. 2003). That total exceeds the ten per cent called for in the Caracas Action Plan formulated at the Fourth World Parks Congress held in 1992 in Caracas, Venezuela. Between 10 and 30 per cent of some of the planet's vital natural features, such as Amazonian rain forests and tropical savannah grasslands, are classified as protected areas. However, ecoregional and habitat representation remains uneven.

Currently, almost half of the world's protected areas are found in regions where agriculture and logging are primary land-use strategies. All indications are that food

and timber production will need to increase in coming decades to keep up with population growth and increasing demand for wood and wood products. Thus, establishing additional protected areas, while helping to preserve biological diversity, will take land out of production and put more stress on lands elsewhere (Sohngen et al. 1999). Balancing the need to protect wild species and conserve habitat while at the same time increasing agricultural and timber production represents a tremendous challenge (McNeely and Scherr 2001).

Of the world's protected areas, the vast majority—91.3 per cent—are found in terrestrial ecosystems. Fewer than ten per cent of the world's lakes and less than 0.5 per cent of the world's seas and oceans lie within protected areas (SBSTTA 2003). Recognizing that the world's marine environment remains largely unprotected, the Fifth World Parks Congress put forth the Durban Action Plan. The Plan calls for the establishment of at least 20-30 per cent marine protected areas worldwide by 2012. The Plan also calls for the conservation of all globally threatened or endangered species by 2010.

In the coming years, further development of global networks of protected areas will need to focus on four areas (Green and Paine 1997):

- consolidating existing networks by addressing major gaps;
- physically linking protected areas to one another so they function more effectively as networks;

Credit: Harriett O'Mahony/UNEP/Topfoto

- expanding networks by forming or strengthening links with other sectors, notably the private sector;
- and improving the effectiveness with which protected areas are managed.

Protected areas are often considered a kind of sacrifice, a financial burden rather than an asset. Yet establishing, maintaining, and expanding protected areas is a fundamental approach to safe-guarding the environment and conserving biological diversity.

Protected areas are also important in other respects, such as helping to maintain freshwater resources. Protected areas may also hold the cures to some of the world's most devastating diseases in the form of unique chemical compounds and as-yet-undiscovered genetic material.

A recent analysis published by Conservation International identified nine additional sites as areas of extraordinarily high biological diversity, popularly known as hotspots, taking the count of hotspots to 34. These 34 regions worldwide are where 75 per cent of the planet's most threatened mammals, birds, and amphibians survive. In these 34 hotspots, estimated 50 per cent of all vascular plants and 42 per cent of terrestrial vertebrates exist. Therefore it is critical to protect and preserve these areas (Conservation International 2005).

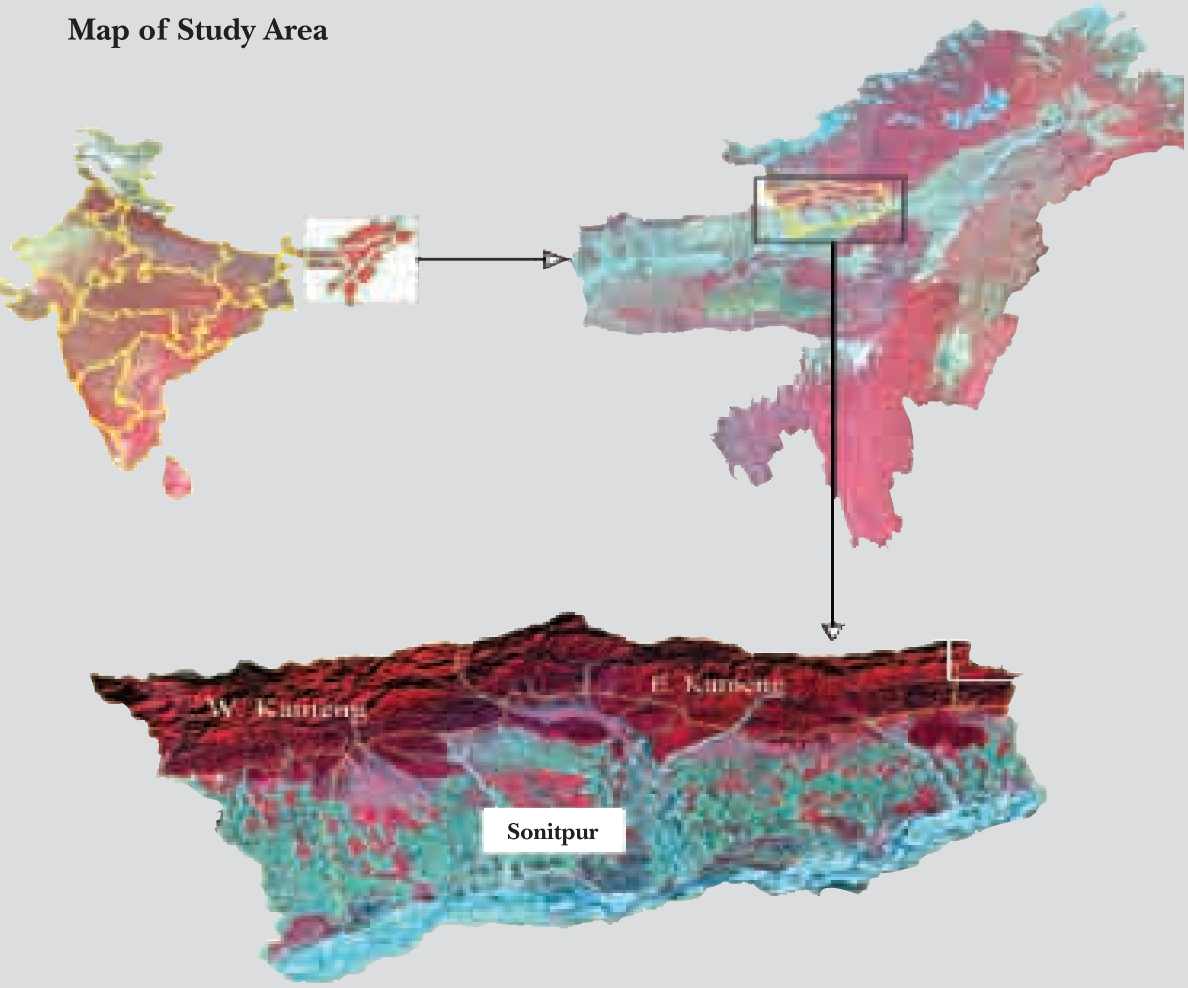
Credit: Christian Lambrechts/UNEP

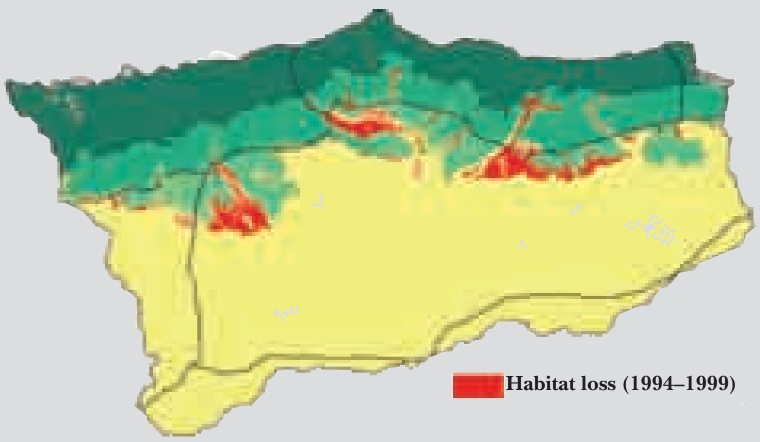
Case Study: Kameng and Sonitpur Elephant Reserves, Arunachal Pradesh, India

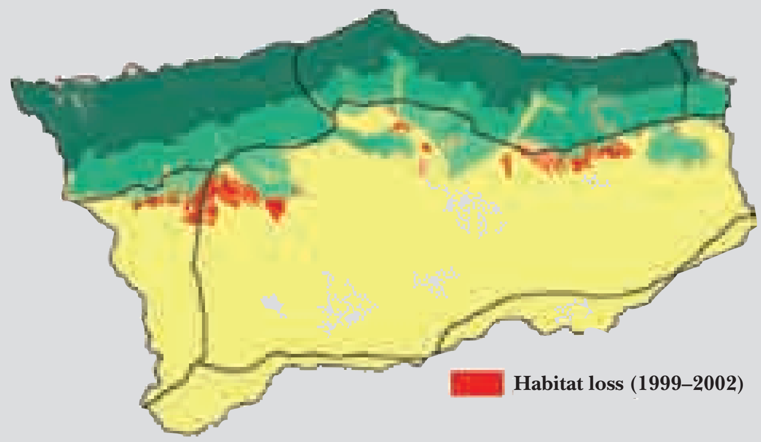
S. P. S. Kushwaha and Rabul Hazarika

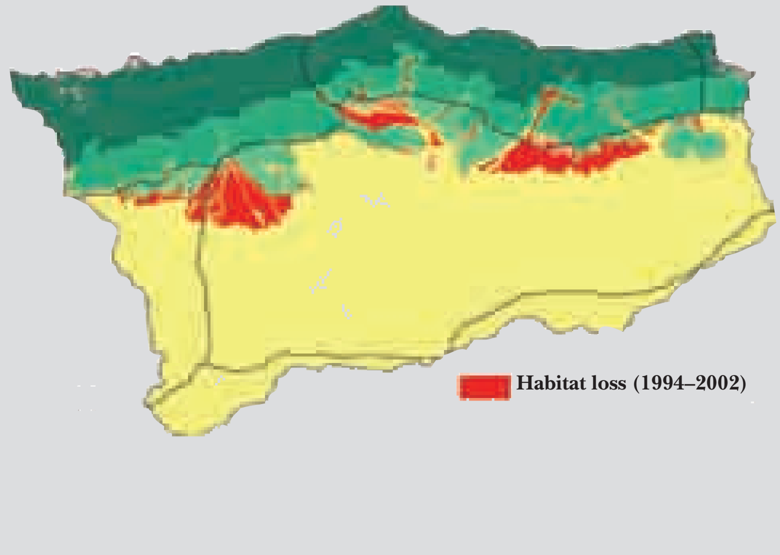
The Kameng and Sonitpur Elephant Reserves in northeastern India are comprised of transborder subtropical evergreen to tropical moist deciduous forests of Arunachal Pradesh andAssam. The reserves are facing deforestation and habitat loss in recent years. This study attempts to investigate the loss of habitat in these reserves using temporal satellite imagery of periods 1994, 1999 and 2002. The on-screen visual interpretation of the three-period imagery revealed alarming and continuous habitat loss from 1994 to 2002. The overall habitat loss was found to be 344 km^2 (133 square miles) between 1994 and 2002. The average annual rate of deforestation worked out to be 1.38 per cent, which is much bigger than the national average. The rate of deforestation was highest between 1999 and 2002. The study indicated that at this rate much of the forests in the study area would be depleted within the next few years. It also showed that moist deciduous forests, which possess the highest biodiversity in Assam, are facing maximum deforestation. High deforestation has resulted in high man-elephant conflicts.

Map of Study Area









Credit: Dr. Bibhab Talukdar

2.6 Energy Consumption and Resource Extraction

Energy is measured by its capacity to do work (potential energy) or the conversion of this capacity to motion (kinetic energy). Most of the world's convertible energy comes from fossil fuels that are burned to produce heat that is then converted to mechanical energy or other means in order to accomplish tasks (EIA 2004a).

Energy is essential for the fulfillment of many basic human needs, such as generating electricity, heating and cooling living spaces, cooking food, forging steel, and powering engines for many forms of transportation (Harrison and Pearce 2001). Energy use is closely tied to human health and well-being. Worldwide, roughly 2 000 million people do not have access to electricity. Countries in which energy use is low tend to have high infant mortality rates, low literacy rates, and low life expectancies. It is through the utilization of convertible energy sources that the modern world has transcended its agrarian roots and fostered the energy-driven societies that characterize it today. Generating the power to sustain these societies has entailed extracting massive amounts of natural resources from the planet. Extraction is the process of obtain-

Credit: Darren Defner/UNEP/Topfoto

Nightlight Map of the World

Credit: NOAA/UNEP/NASA

Credit: Jon P Bonetti /UNEP/Topfoto

Global Natural Resources

Affluent countries consume vast quantities of global natural resources, but contribute proportionately less to the extraction of many raw materials. This imbalance is due, in part, to domestic attitudes and policies intended to protect the environment. Ironically, developed nations are often better equipped to extract resources in an environmentally prudent manner than the major suppliers. Thus, although citizens of affluent countries may imagine that preservationist domestic policies are conserving resources and protecting nature, heavy consumption rates necessitate resource extraction elsewhere and oftentimes with weak environmental oversight. A major consequence of this "illusion of natural resource preservation" is greater global environmental degradation than would arise if consumption were reduced and a larger portion of production was shared by affluent countries. Clearly, environmental policy needs to consider the global distribution and consequences of natural resource extraction (Berlik et al. 2002).

ing a useful substance from a raw material (NCR&LB 2003). Such raw materials may include fossil fuels, metals, minerals, water, and biomass, including animals and raw materials from plants and crops (EEA 2001).

Resources can be divided into those that are renewable, such as plant and animal material, and those that are not, including coal, oil, and minerals. The Earth has a finite supply of non-renewable resources. Even renewable resources, however, are exhaustible if they are used faster than they can be replenished.

Total world energy consumption has risen almost 70 per cent since 1971 (WRI 1998). It is expected to increase by 58 per cent between 2001 and 2025, from 404 quadrillion British thermal units (Btu) in 2001 to 640 quadrillion Btu in 2025 (EIA 2003; EIA 2004b). While a slow, steady increase in energy consumption is expected in industrialized nations, where most energy use currently takes place, a meteoric increase in consumption is anticipated in the developing world during that period (Tilford 2000).

The tempo at which energy resources are being used to fuel modern societies is rapidly depleting supplies of non-renewable resources and far exceeding the rate at which renewable resources can be naturally renewed (Ernst 2002). In many least–developed countries, for instance, burning biomass in the form of wood (largely a non-renewable resource) generates 70 to 90 per cent of the energy needed and disregard for the fate of non-renewable resources is prevalent. In the United States, for example, 72 per cent of the country's electricity is generated using non-renewable resources. Only about 10 per cent comes from renewable resources, with nuclear power providing the rest.

Currently, 85 per cent of world energy consumption comes from the burning of fossil fuels—oil, coal, and natural gas (BP 2003). Although no immediate shortages of these non-renewable energy resources exist, supplies are finite and will not last forever. What took millions of years to

Case Study: Blackout in United States and Canada 14 August 2003

On 14 August 2003, parts of the northeastern United States and southeastern Canada experienced widespread power blackouts. Among the major urban agglomerations affected by the electrical power outage were the cities of New York City, Albany, and Buffalo in New York, Cleveland and Columbus in Ohio, Detroit in Michigan, and Ottawa and Toronto in Ontario, Canada. Other U.S. states, including New Jersey, Vermont, Pennsylvania, Connecticut, and Massachusetts, were also affected. The blackout resulted in the shutting down of nuclear power plants in New York and Ohio, and air traffic was slowed as flights into affected airports were halted. Approximately 50 million people were affected by the outage. The change in the nighttime city lights is apparent in this pair of Defense Meteorological Satellite Program (DMSP) satellite images. The top image was acquired on 14 August, about 20 hours before the blackout, and the bottom image shows the same area on 15 August, roughly seven hours after the blackout. In the bottom scene, notice how the lights in Detroit, Cleveland, Columbus, Toronto, and Ottowa are either missing or visibly reduced. Previous major blackouts include the 9 November 1965 outage caused by a faulty relay at a power plant in Ontario, which affected a large swath of land stretching from Toronto to New York. Another one followed on 14 July 1977, the result of a lightning strike, affecting New York City. The power supply in nine western states was also affected in August 1996 as a result of a high demand for electricity, a heat wave, and sagging electrical power lines.

Source: NASA 2002, http://earthobservatory.nasa.gov/NaturalHazards/natural_hazards_v2.php3?img_id=11628; GlobalSecurity.org 2003, http://www.globalsecurity.org/eye/blackout_2003.htm

14 August 2003 before power failure

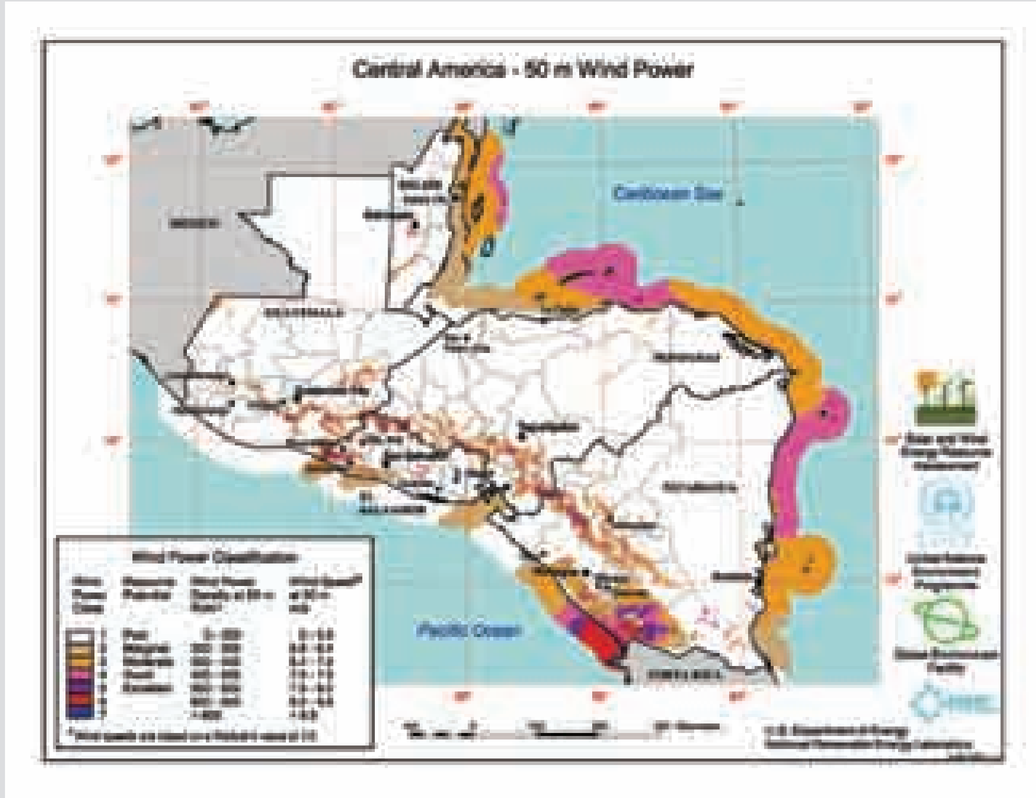
15 August 2003 after power failure

Credit Image courtesy Chris Elvidge, U.S. Air Force http://earthobservatory.nasa.gov/NaturalHazards/Archive/Aug2003/NE_US_OLS2003227_lrg.jpg

Case Study: SWERA, the Solar and Wind Energy Resource Assessment

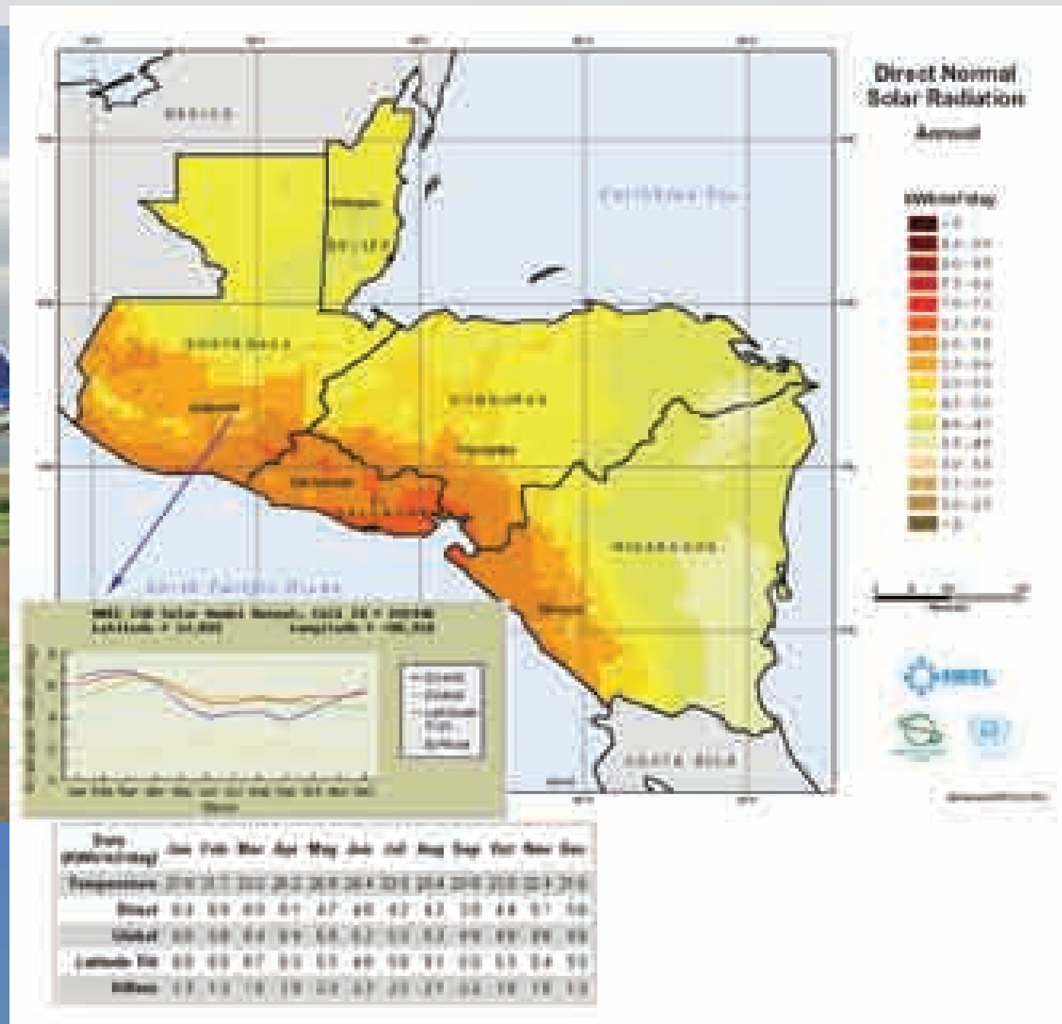
The Solar and Wind Energy Resource Assessment (SWERA)—co-financed by the Global Environment Facility (GEF)—is a project to assist 13 developing countries identify optimal locations for potential solar and wind energy production. SWERA assists by creating a global archive of information gathered through a network of international and national agencies. These agencies collect and analyse data on solar and wind energy resources, energy demand, and electrification. Using inputs derived from satellite and surface observations, SWERA partners model wind and solar energy resource potential and produce maps of wind power density and monthly average and daily total solar radiation of a given area. This information can then be used to facilitate investments and create policies in the participating countries for developing solar and wind energy.

Source: UNEP/GRID–Sioux Falls



Credit: NREL

Credit: NCAT/UNEP/NREL



Credit: Energy Northwest/UNEP/NREL

produce will be consumed in the time frame of a century or two (Hawken 1994; Tilford 2000).

This rapid, large-scale consumption of a fuel source that took millennia to produce has generated unforeseen complications, several with global implications. Burning fossil fuels produces atmospheric pollutants such as oxides of sulfur and nitrogen and unburned hydrocarbons. Fossil fuel combustion also adds one of the most prevalent greenhouse gases—carbon dioxide—to the atmosphere. As a result, world energy use has emerged at the center of the climate change debate. World carbon dioxide emissions are projected to rise from 23 900 million metric tonnes in 2001 to 27 700 million metric tonnes in 2010 and 37 100 million metric tonnes in 2025 (EIA 2004b). The Earth's atmosphere and biosphere will not remain unchanged by the combustion of such enormous amounts of these fuels. The relatively sudden release of massive amounts of carbon has the potential not only to disrupt the Earth's heat balance and climate, but other parts of the global carbon cycle as well, and in unpredictable ways.

The Earth cannot sustain existing levels of resource consumption. Furthermore, resource extraction methods are often environmentally destructive. The impact of environmental degradation hits those who are poorest the hardest. Many of the world's energy sources and other natural resources come from developing countries. Extracting and harvesting these resources can result in air, soil, and water pollution. It also generates waste; the amount of waste associated with extracting minerals, for instance, can be enormous. Disposing of wastes in environmentally friendly ways is a daunting, if not impossible, task in many developing nations.

A major challenge for the 21st century is to develop methods of generating and using energy that meet the needs of the population while protecting the planet (Harrison and Pearce 2001). Yet most of the world is still without energy policies that direct or restrict consumption patterns.

Only through conservation and resource recovery strategies can we hope to reach a sustainable balance between available resources and their consumption. The utiliza-

Sources of Energy

Coal

Coal is the world's largest source of fuel for electricity production. The byproducts of coal combustion are also a major source of environmental damage.

Credit: Unknown/UNEP/Freefoto.com

Oil

Although used primarily in the production of transportation fuels, oil is also used for generating electricity, for heating, and in the production of chemical compounds and synthetic materials.

Credit: Unknown/UNEP/Freefoto.com

Natural Gas

Compared to coal and oil, natural gas is a relatively clean-burning fossil fuel. It is used primarily for heating and for powering many industrial processes. Increasingly, natural gas is burned to drive turbines used in the production of electricity.

Credit: Unknown/UNEP/Freefoto.com

Biomass

Plant and animal material, or biomass, is a rich source of carbon compounds. When burned to release energy, biomass does not add additional carbon to the natural carbon cycle as do fossil fuels. Fast-growing plants, such as switchgrass, willow, and poplar can be harvested and used as "energy crops." Biomass wastes, including forest residues, lumber and paper mill waste, crop wastes, garbage, and landfill and sewage gas, can be used for heating, as transportation fuels, and to produce electricity, while at the same time reducing environmental burdens. According to the World Bank, 50 to 60 per cent of the energy used in developing countries in Asia, and 70 to 90 per cent used in developing countries in Africa, comes from wood or other biomass; half the world cooks with wood.

Credit: Volker Quaschning/UNEP

Sources:
www.freefoto.com, http://www.topfoto.co.uk/, Prof. Dr.-Ing. habil. Volker Quaschning http://www.volker-quaschning.de

tion of non-renewable resources is theoretically not sustainable. But if used wisely, some non-renewable resources can be conserved and recycled for a very long time. To recycle means to make new products from old ones. Recycling materials such as paper, aluminum, and glass saves energy, reduces pollution, and conserves natural resources (EPA 2003). Every nation must assume responsibility for recycling its own wastes. Some industrialized Western countries "dispose" of their electronic wastes by shipping them to Asia—an increasingly common practice (FOEE 2004).

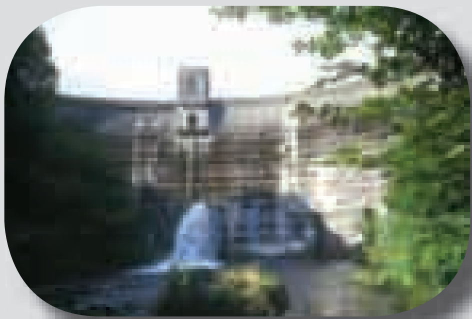
To insure that renewable resources can be replenished at a sustainable rate, people must switch to more environmentally friendly energy sources and employ new technologies that can help make such sustainability a reality (Ernst 2002). Indeed, new technologies—coupled with effective and efficient use of existing technologies—are essential to increasing the capabilities of countries to achieve sustainable development on many fronts, as well as sustaining the world's economy, protecting the environment, and alleviating poverty and human suffering (Hay and Noonan 2000).

Most changes in the Earth, including changes brought about by increasing energy consumption, can be observed through such tools as remote sensing. Remote sensing is the collection of information about an object without being in physical contact with the object. Aircraft and satellites are the common platforms from which remote sensing observations are made. Satellite imagery, a crucial component of this publication, is especially useful for studying changes in our Earth's environment. Most satellite imagery is collected using multispectral scanners, which record light intensities in different wavelengths in the spectrum from infrared through visible light through ultraviolet light. Satellite imagery is useful because of its stable nature (same resolution, same time, same data characteristics). Aided by the global positioning system (GPS), these satellites know their orbital position precisely. Thus, satellite imagery is ideally suited for applications requiring large-area coverage, such as agricultural monitoring, regional mapping, environmental assessment, and infrastructure planning (Krouse et al. 2000).

Credit: Unknown/UNEP/Freefoto.com

Nuclear

Nuclear power harnesses the heat of radioactive materials to produce steam for electricity generation. The use of nuclear power is expected to decline as aging plants are taken out of operation.



Credit: Volker Quaschning/UNEP

Hydroelectric

Hydroelectric power uses the force of moving water to produce electricity. A large part of the world's electricity is produced in hydroelectric plants. Many of these plants, however, are associated with large dams that disrupt habitats and displace people. Smaller "run of the river" hydroelectric plants have less environmental impact.

Credit: Lupidi/UNEP/Topfoto

Geothermal

Geothermal energy is energy contained in intense heat that continually flows outward from deep within the Earth. Geothermal energy is typically used to heat water, which is then used to heat buildings directly or to drive turbines to produce electricity.

Credit: Anthony Karbowski/UNEP/Topfoto

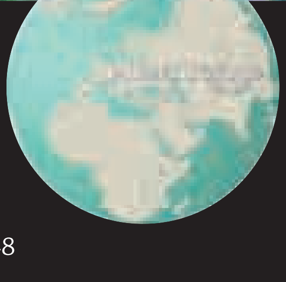
Solar

Solar energy—power from the sun—is readily available and inexhaustible. Humans have used sunlight for heating and drying for thousands of years. Converting the power of sunlight into usable energy forms, such as electricity, is not without cost, but the sunlight itself is free. Solar cells, or photovoltaics, are devices used to transform sunlight into electric current.

Credit: Sanjay Singh/UNEP/Topfoto

Wind

Wind power is an ancient energy source that has moved into the modern era. Aerodynamically designed wind turbines can produce electricity more cheaply than coal-burning power plants.



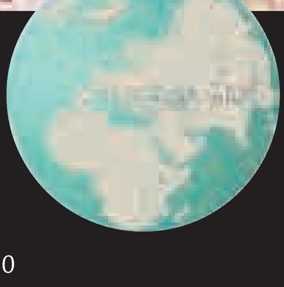
Mining
The Black Triangle, Europe

The so-called Black Triangle is an area bordered by Germany, Poland, and the Czech Republic and is the site of extensive surface coal mining operations. In the 1975 satellite image above, the gray areas are surface mines located primarily in the Czech Republic. Air-borne pollutants from coal extraction activities tended to become trapped by the mountainous terrain to the northeast and were concentrated in the area around the mines,

eventually causing severe deforestation along the border between the Czech Republic and Germany. In the 2000 image, this deforestation is very obvious, appearing as large brownish patches. Interestingly, the 2000 image also reveals somewhat improved vegetation cover—a slight "greening" of the landscape—as compared to conditions in 1975. Some of this improvement may be attributable to actions taken by the three countries bordering the Black Triangle to reduce pollutants produced by the mining operations. The implementation of anti-pollution technologies, including circulating fluidized-bed boilers, clean coal technology, and nitrous oxide emission burners, appears to have reversed some, albeit not all, of the environmental damage experienced by the region as a result of the mines.

In one year up to 67 000 tonnes of sulfur dioxide, 500 tonnes of lead, 400 tonnes of zinc and 4 tonnes of cadmium can be released by the city's two active smelters. The affected area is huge: in excess of 180 000 hectares (445 000 acres) of land are affected by air pollution and 150 000 hectares (371 000 acres) of agricultural land are untenable. 31 000 hectares (77 000 acres) of forest are also unacceptably polluted.

Credit: Lorant Czaran/UNEP



Mining

Copşa Micâ, Romania

Copşa Micâ is a large industrial city located in the very center of Romania and is classified as an "environmental disaster area." The environmentally damaged area covers hundreds of square kilometres of land. The main industries in Copşa Micâ are non-ferrous metalworking and chemical processing plants, and their effect on the environment has been devastating. Air pollution by heavy metals is 600 times

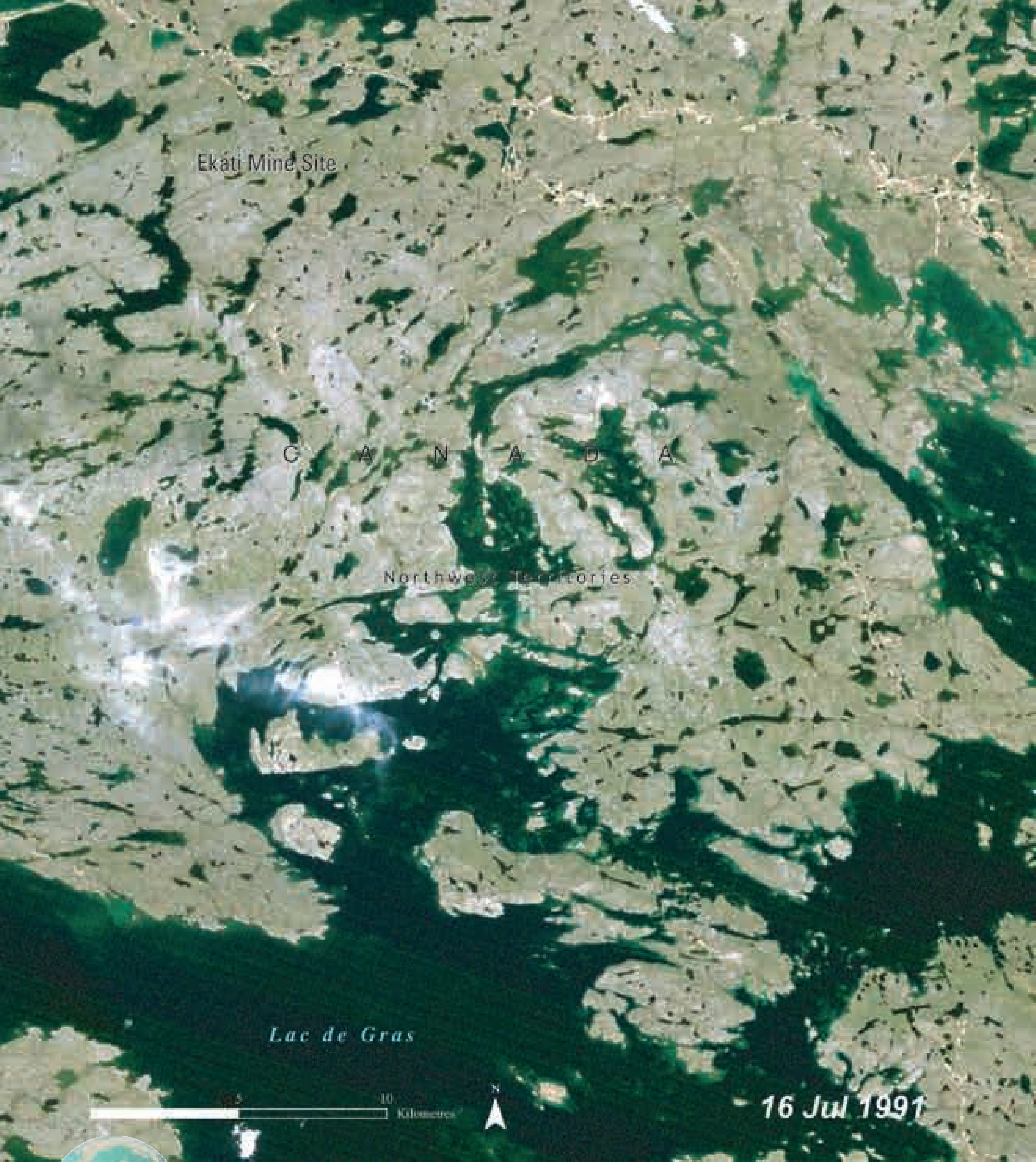
the allowed levels. To make matters worse, a lead-smelting facility emitted fumes containing sulfur dioxide, lead, cadmium, and zinc on the town and surrounding area for 50 km^2 (19 square miles). The entire town and much of the surrounding area were covered with a blanket of black soot daily until the facilities were forced to close in 1993.

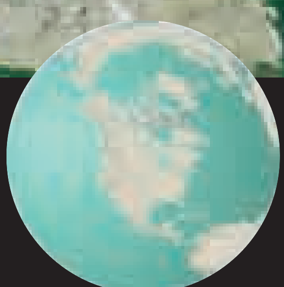
In 1989 Copșa Micâ was exposed as one of the most polluted places in Europe. It has the highest infant mortality rate in Europe, 30.2 per cent of children suffer reduced "lung function" and 10 per cent of the total population of 20 000 suffer "neurobehavioral problems." The soil and the local food chain probably will remain contaminated for at least another three decades.

Mining
Escondida, Chile

Located at an elevation of 3 050 m (10 006 ft), Chile's Escondida Mine is an open-pit copper, gold, and silver mine and also the largest copper mine in the world. Isolated in the barren, arid Atacama Desert in the country's far north, the Escondida Mine relies heavily on external well fields for the water used in its mining operations. Unlike similar mining operations, however, Escondida has a redeveloped tailings

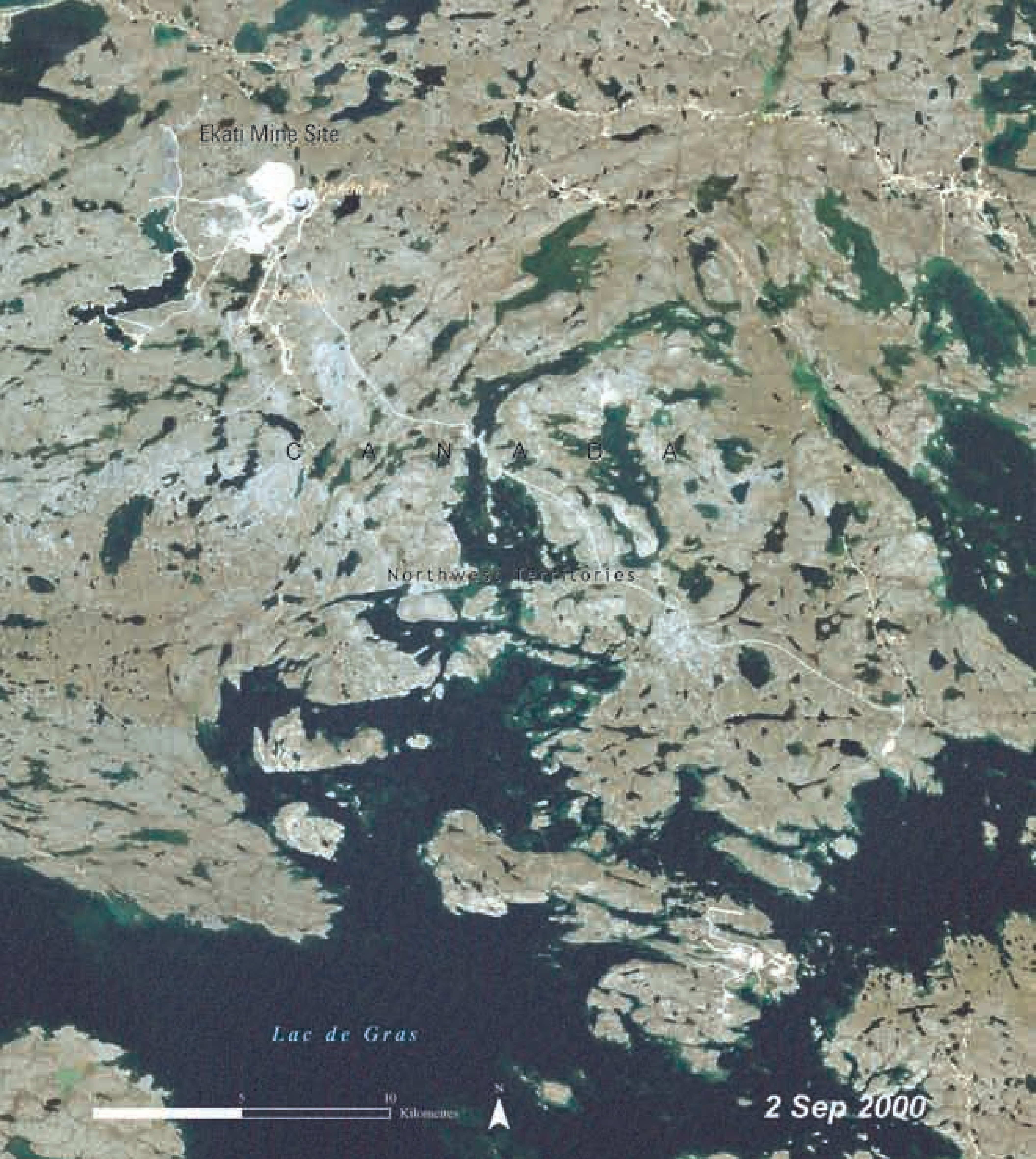
impoundment, which appears on the 1989 image as a white patch in the lower left corner. Impoundments of this type help reduce water consumption and enhance water conservation, two areas where mining activities typically fall short. The Escondida Mine also minimizes the impact of its operation on the environment by means of a 170-km-long (106 miles) underground pipeline that carries copper concentrate slurry from the mine to the port of Coloso. This underground scheme is efficient and ecologically sound, as the copper travels downhill without disrupting the environment. The 2003 image shows how the Escondida Mine has grown and expanded while at the same time continues to minimize negative impacts from its mining operations on the environment.





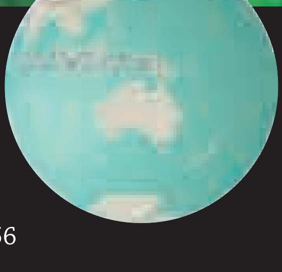
Mining
Ekati, Canada

As of 2001, the Ekati Mine was North America's only operating diamond mine. Located in the north central Northwestern Territories (NWT) of Canada, the mine yields raw diamonds from a sparsely inhabited sub-arctic region. Air transport connects mine personnel and supplies year-round, while a single winter ice road provides the only vehicular access just ten weeks per year.



Expanded mining exploration in the 1990s began a new era for this otherwise undeveloped region. Wildlife officials have collared and tracked caribou, in a herd ranging from 350 000 to half a million, to monitor their movement and behavior in proximity to the mines. Historical information about the herds comes from Dogrib and Inuit knowledge obtained from elder natives who still inhabit the NWT, and who have depended on the caribou for centuries.

These two images compare the same area, pre-mining and after mine operations have commenced. The white patch in the northwest portion of the 2000 image represents the mine and the associated infrastructure.



MINING

OK TEDI MINE, PAPUA NEW GUINEA

The controversial Ok Tedi copper mine is located at the headwaters of the Ok Tedi River, a tributary of the Fly River, in extremely rough terrain in the rainforest-covered Star Mountains of Papua New Guinea's western province. Prior to the opening of the mine in 1984, this area was very isolated, sparsely inhabited, and ecologically pristine. This

pair of satellite images reveals the tremendous environmental impact the mine has had in 20 years. The uncontrolled discharge of 70 million tonnes of waste rock and mine tailings annually has spread more than 1 000 km (621 miles) down the Ok Tedi and Fly rivers, raising river beds and causing flooding, sediment deposition, forest damage, and a serious decline in the area's biodiversity. In the 1990 image, both the mine and the township of Tabubil—developed east of the river in support of the mine—are clearly visible. Lighter patches of green show disturbance of the original forest cover from subsistence agriculture, road clearing, and other infrastructure development.

Mining

Powder River Basin, United States

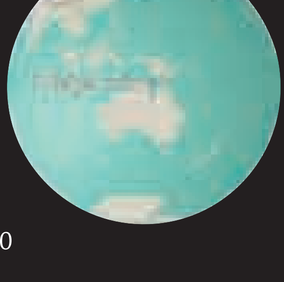
The Powder River basin, located in northeast Wyoming and southeast Montana, is a core area of coal and natural gas production in the United States. Coal mining activities in the basin date back to 1975.

In recent years surface mining in Wyoming has mushroomed, making it the leading coal producer in America

at almost 300 000 tonnes per year. Similarly, coal bed methane gas development in this region is unrivaled in the U.S.

The images show areas under coal exploitation. Notable is the remarkable increase in mining operations in the 2001 image. Reasons for the expansion include improvements in the area's rail network, the high grade of the coal deposits, and the depletion of high-grade deposits in other major coal mining areas such as West Virginia and Kentucky.

The open cast coal mines appear as white-purplish while the reddish brown areas are bare ground. Vegetated areas are green.



Mining

Weipa Bauxite Mine, Australia

Mining of bauxite (aluminum ore) began at Weipa, on the Cape York Pennisula in Queensland, Australia, in 1963. The mine produces 8.5 metric tonnes of ore annually, making it one of the world's largest open-cut bauxite mines.

Under current mining practices, vegetation is cleared and the topsoil is removed and either stockpiled for later use or immediately

The total lease covers an area of approximately 2 590 km^2 (1 000 square miles) of which 68 km^2 (26 square miles) have been mined. Approximately four km^2 (1.5 square miles) of the mined land is revegetated each year, and over 50 km^2 (19 square miles) of land has been revegetated to date.

replaced on previous mined areas. After topsoil removal, the bauxite is removed, resulting in a lowering of the entire landscape to a depth equivalent to the thickness of the orebody, often several meters. If the topsoil can be returned to a mined-out area after only a short time, it still contains most of the original soil fungi, bacteria and micro fauna. In addition, the seeds from the original plant community are likely to be viable. On slopes, rigorous soil conservation measures are implemented, and the area is then normally planted with suitable native species so that it gradually reverts to bushland. Some of the profits generated by the mining operation are being placed in a trust for cultural protection, development and long-term investments to compensate for the disruption of local Aboriginal inhabitants and their environment.

References

Africa Mountain Forum (n.d.). Definitions of terms used. Land Use Change and Intensification. Introduction. http://anmf.web1000.com/publications/ LUCIdocuments%5CLUCIintroduction.html on 2 April 2004.

Anon. (2002). Desertification. Nature Gallery – Global Trends. Pacific Island-Travel. http://www.pacificislandtravel.com/nature_gallery/desertification.html on 1 April 2004.

Ashford, L. (2004). World Population Highlights, BRIDGE, Population Reference Bureau. http://www.prb.org/Template.cfm?Section=PRB&template=/ContentManagement/ContentDisplay.cfm&ContentID=11267 23 September 2004.

Berka, C., McCallum, D., Wernick, B. (1995). Land use impacts on water quality: case studies in three watersheds. Presented at The Lower Fraser Basin in Transition: A Symposium and Workshop, May 4, 1995. http://www.ire.ubc.ca/ecoresearch/publica3.html on 1 May 2004.

Berlik, M. M., Kittredge, D. B., Foster, D. R. (2002). The illusion of preservation - a global environmental argument for the local production of natural resources. Harvard Forest Paper No. 26. Harvard University, Harvard Forest, Petersham, Massachusetts, USA, 23. http://harvardforest.fas.harvard.edu/publications/pdfs/illusion.pdf on 8 November 2004.

BP (2003). BP statistical review of world energy. London: British Petroleum, 44. http://www.bp.com/liveassets/bp_internet/globalbp/STAGING/global_assets/downloads/B/BP_statistical_review_of_world_energy_2003_print_version.pdf on 18 April 2004.

Brandt, K. (2003). Invasive alien species and the Global Invasive Species Programme. The Phycological Society of Southern Africa – Newsletter #54, December 2003: 7-10. http://www.botany.uwc.ac.za/pssa/articles/features/no54.htm on 22 March 2004.

Brehm, D. (2003). Nobelists sound alarm on global environmental trends. MIT News March 7, 2003. http://web.mit.edu/newsoffice/nr/2003/nobels.html on 22 March 2003.

Brown, L. R. (2001). Paving the Planet: Cars and Crops Competing for Land. Earth Policy Institute Alert 12: 14 February 2001. http://www.earth-policy.org/Alerts/Alert12_printable.htm on 2 May 2004.

Chape, S., Blyth, S., Fish, L., Fox, P., Spalding, M. (compilers) (2003). 2003 United Nations List of Protected Areas. IUCN, Gland, Switzerland and

Cambridge, UK and UNEP-WCMC, Cambridge, UK. ix, 44. http://www.iucn.org/themes/wcpa/wpc2003/pdfs/unlistpa2003.pdf on 20 March 2004.

Chew, S. C. (2001). World Ecological Degradation: Accumulation, Urbanization, and Deforestation 3000 B.C. – A.D. 2000. Rowman & Littlefield. 216.

CIDA (2001). Canadian International Development Agency: Canada combats-desertification. http://www.acdi-cida.gc.ca/cida_ind.nsf/vall/ 05633A876C55D09C852569A60080FA70?OpenDocument on 2 April 2004.

CIESIN (2000). Center for International Earth Science Information Network, Gridded Population of the World (GPW), Version 3.0 beta., Columbia University, Palisades, New York, USA. http://beta.sedac.ciesin.columbia.edu/gpw/global.jsp on 5 April 2005.

Clinton, W. J. (1999). Invasive species. Presidential Documents, Executive Order 13112 of 3 February 1999. Federal Register 64(25): 6183-6186, Monday, 8 February 1999. http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=1999_register&docid=fr08fe99-168.pdf on 21 March 2004.

Collins, M. (2000). Globalizing solutions. Biological diversity. http://www.ourplanet.com/imgversn/105/collins.html on 15 May 2004.

Conservation International (2005). Hotspots Revisited: Nine new biodiversity hotspots are added to list of high priority conservation targets by John Tidwell. www.conservation.org on 14 February 2005.

Costanza, R., d'Arge, R., de Groot, R., Farberk, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R. V., Paruelo, J., Raskin, R. G., Suttonkk, P. van. den., Belt, M. (1997). The value of the world's ecosystem services and natural capital. Nature, 387:253-259. http://www.esd.ornl.gov/benefits_conference/nature_paper.pdf on 16 July 2004.

Dalmazzone, S. (2000). Chapter 2 - Economic factors affecting vulnerability to biological invasions. In: Perrings C., Williamson M. and Dalmazzone S. (eds.) The Economics of Biological Invasions. Cheltenham, Elgar, 17-30. http://www.soc.uoc.gr/calendar/2000EAERE/papers/PDF/D6-Dalmazzone. pdf on 21 March 2004.

De Leo, G. A. and Levin, S. (1997). The multifaceted aspects of ecosystem integrity. Conservation Ecology 1(1): 3. http://www.consecol.org/vol1/iss1/art3 on 21 March 2004.

Devitt, T. (2001). World land database charts troubling course. NEWS@UWMADISON, University of Wisconsin, Madison, Wisconsin, USA. http://www.news.wisc.edu/story.php?get=6315 on 2 May 2004.

EEA (2001). Total material requirement of the European Union. Technical report No 55. European Environment Agency, Copenhagen, Denmark. http://reports.eea.eu.int/Technical_report_No_55/en/ on 8 November 2004.

EIA (2003). International Energy Outlook 2003. World Energy Consumption. U.S. Department of Energy, Energy Information Administration, Washington, DC, USA. http://www.eia.doe.gov/oiaf/archive/ieo03/world.html on 19 April 2004.

EIA (2004a). Energy glossary. U.S. Department of Energy, Energy Information-Administration, Washington, DC, USA. http://www.eia.doe.gov/glossary/glossary_e.htm on 18 April 2004.

EIA (2004b) International Energy Outlook 2004. U.S. Department of Energy, Energy Information Administration, Washington, DC, USA. http://www.eia.doe.gov/oiaf/ieo/highlights.html on 19 April 2004.

EPA (2003). Glossary. U.S. Environmental Protection Agency, Office of Solid Waste, Terminology Reference System, Washington, DC, USA. http://oaspub. epa.gov/trs/trs_proc_qry.navigate_term?p_term_id=8880&p_term_cd=TERM on 9 November 2004.

Ernst, W. G. (2002). Global equity, sustained resource consumption through efficient extraction-conservation-recycling, and development of cheap, inexhaustible energy. The Geographic Society of America Annual Meeting, 27-30 October 2002, Denver, Colorado, USA. http://gsa.confex.com/gsa/2002AM/finalprogram/abstract_37598.htm on 8 November 2004.

ESA (2003). World Population Prospects: The 2002 Revision. Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat. http://esa.un.org/unpp/index.asp?Panel=1 on 25 April 2004; http://esa.un.org/unpp/index.asp?panel=2 on 25 April 2004.

Eswaran, H., Reich, P., Beinroth, F. (1998). Global desertification tension zones. Proc. Of International Soil Conservation Organization Conference,Purdue University, Indiana, USA. http://www.nrcs.usda.gov/technical/worldsoils/papers/tensionzone-paper.html on 2 April 2002.

FAO (2000). Global Agro-Ecological Zones (Global-AEZ). http://www.fao.org/ag/agl/agll/gaez/index.htm on 8 August 2004.

FAO (2001). Forest Resources Assessment 2000. Main Report FAO Forestry Paper 140, Rome, Italy. http://www.fao.org/forestry/foris/webview/forestry2/index.jsp?siteId=101&langId=1 on 25 February 2004.

FAO (2002). Land resources information systems in the Near East. Regional-Workshop Cairo, 3-7 September 2001. Food and Agriculture Organization-of the United Nations, Rome, Italy. http://www.fao.org/DOCREP/005/Y4357E/y4357e20.htm on 1 May 2004; http://www.fao.org/desertification/default.asp?lang=en on 1 May 2004.

FOEE (2004). Reducing resource use. Friends of the Earth Europe's response to the European Commission communication towards a Thematic Strategy on the Sustainable Use of Natural Resources, 10. http://www.foeeurope.org/publications/reducing_resource_use_feb2004.pdf on 9 November 2004.

Forestry Images: Forest Health, Natural Resources & Silviculture Images. http://www.forestryimages.org on 24 November 2004.

Forney, W., Richards, L., Adams, K. D., Minor, T. B., Rowe, T. G., Smith, J. L., Raumann, C. G. (2001). Land Use Change and Effects on Water Qualityand Ecosystem Health in the Lake Tahoe Basin, Nevada and California.Open-File Report 01-418, 29. U.S. Geological Survey, Menlo Park, California, USA. http://pubs.usgs.gov/of/of01-418/of01-418.pdf on 18 November 2004.

Gary, J. and Rubino, C. (2001). Facts about the world's languages. H. W. Wilson Co., Bronx, New York, USA, 896. http://www.hwwilson.com/print/factslangs_introduction.htm on 25 April 2004.

Global Population Profile 2002 (2004). International Population Report. U.S. Agency for International Development and U.S. Department of Commerce Publication. http://www.census.gov/ipc/prod/wp02/wp-02.pdf on 27 October 2004.

Global Security.org (2003). Great Northeast Power Blackout of 2003. http://www.globalsecurity.org/eye/blackout_2003.htm on 22 February 2005

Goldewijk, K.K. and Ramankutty, N. (2001). Land cover change over the lastthree centuries due to human activities: the availability of new global datasets. Submitted to Geojournal in November 2001. http://www.sage.wisc.edu/pubs/Abstracts/goldewijkGEOJ.html on 20 March 2004.

Green, M. J.B. and Paine, J. (1997). State of the world's protected areas at the end of the Twentieth Century. Paper presented at IUCN World Commission on Protected Areas Symposium on "Protected Areas in the 21st Century: From Islands to Networks" Albany, Australia, 24-29th November 1997, 35. http://www.unep-wcmc.org/protected_areas/albany.pdf on 20 March 2004.

Green, R. (2001). Production agriculture is only hope for world's remaining forests. Perspicacity & Paradigms Online. http://www.perspicacityonline.com/101/environment10101.htm on 1 May 2004.

Hargrove, W. W. and Hoffman, F. M. (1999). Locating and characterizing the borders between ecoregions using multivariate geographic clustering. http://research.esd.ornl.gov/~hnw/borders/ on 16 May 2004.

Harrison, P. (1997). Population and sustainable development: five years afterRio. United Nations Population Fund (UNFPA), New York City, New Yorkii, 38. http://www.ncseonline.org/PopPlanet/ePopulationReports/rest/abstracts/134981.pdf on 20 March 2004.

Harrison, P. and Pearce, F. (2001). AAAS Atlas of Population and Environment. American Association for the Advancement of Science, Washington, D.C., USA 215. http://atlas.aaas.org/ on 2 March 2004.

Hawken, P. (1994). The Ecology of Commerce: A Declaration of Sustainability. New York: Harper Business, 250.

Hay, J. E., Noonan, M. (2000). Anticipating the Environmental Effects of Technology -A manual for decision-makers, planners and other technology stakeholders. United Nations Environment Programme, Division of Technology, Industry and Economics, Consumption and Production Unit, Paris, France. http://www.unep.or.jp/ietc/Publications/Integrative/EnTA/AEET/index.asp on 9 November 2004.

Heilig, G. K. (1996). World Population Prospects: Analyzing the 1996 UN Population Projections. IIASA Electronic Working Paper WP-96-146. International Institute for Applied Systems Analysis (IIASA), IIASA LUCProject, Laxenburg, Austria. http://www.iiasa.ac.at/Research/LUC/Papers/gkh1/chap1.htm on 10 November 2004.

Herring, D. (n.d.). Changing Global Land Surface. TERRA –The EOS Flagship. http://terra.nasa.gov/FactSheets/LandSurface/ on 2 May 2004.

Heywood, V.H. (ed.) (1995). Global Biodiversity Assessment. United Nations Environment Programme, Cambridge University Press, Cambridge, UK, 1140.

Holling C. S., Schindler, D. W., Walker, B. W., Roughgarden, J. (1995). Biodiversity in the functioning of ecosystems: an ecological primer and synthesis. In: Perrings C. A., K.- G. Maler, C. Folke, C. S. Holling, and B.- 0. Jansson (eds.), Biodiversity Loss: Ecological and Economic Issues, Cambridge University Press, Cambridge, UK, 44-83.

Holmes, B. (1998). The coming plagues – non-native species on the move due to global warming. New Scientist (weekly), London, UK, 18 April 1998. http://www.sare.org/htdocs/hypermail/html-home/29-html/0117.html on 23 March 2004.

Howenstine, E. (2004). Northeastern Illinois University, Department of Geography, USA. http://www.neiu.edu/~ejhowens/104/6/cultur.gif on 26 June 2004.

Hunter, L. M. (2001). The environmental implications of population dynamics, RAND Publications, Santa Monica, California, USA, 98. http://www.rand.org/publications/MR/MR1191/ on 25 April 2004.

ISRIC (2004). International Soil and Reference Information Centre: Global Assessment of Human-induced Soil Degradation, Soil Degradation Status Assessment, AR Wageningen, The Netherlands. http://www.isric.nl/ on 26 June 2004.

IPCC (2001). Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change [Houghton, J.T.,Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 881.

Isaac Newton School Geography Department, Internet Geography, UK. http://www.geography.learnontheinternet.co.uk/topics/popn1.html#growth on 14 October 2004.

IUCN (1994). Guidelines for protected areas management categories. IUCN: Publication CNPPA with assistance of WCMC. Gland, Switzerland andCambridge, UK, 261. http://www.unep-wcmc.org/protected_areas/categories/eng/ on 20 March 2004.

IUCN, UNEP and WWF (1991). Caring for the Earth. A strategy for sustainable-living. Gland, Switzerland, 228.

Karas, J. (n.d.). Climate change and the Mediterranean Region. Desertification. Greenpeace.org, 34. http://archive.greenpeace.org/climate/climatecountdown/documents/desert.pdf on 1 April 2004.

Klein G. K., 2001: Estimating global land use change over the past 300 years: The HYDE Database. Global Biogeochemical Cycles, 15, 417-433. http://www.gsfc.nasa.gov/topstory/20020926landcover.html on 2 May 2004.

Knee, M. (2003). Domestic and Global Trends. Studies in Quality, Ethics, and the Global Environment, Ohio State University, Ohio,USA. http://hcs.osu.edu/hcs600/sm1067.htm on 1 May 2004; http://hcs.osu.edu:16080/hcs600/sm1011.htm on 1 May 2004.

Krouse, A. J., Ferry, M. M., Crowsey, R. C. (2000). Satellite imagery: the space odyssey arrives in the courtroom. The Defense 42(6):18-23. http://www.crowsey.com/spacearticle.htm on January 20, 2005.

Kushwaha, S. P. S., Hazarika, Rubul (2004). Assessment of habitat loss in Kameng and Sonitpur Elephant Reserves. Current Science, Volume 87, No. 10, 25 November 2004.

Larsen, J. (2003). Shrinking forests. Peopleandplanet.net. People and forests. http://www.peopleandplanet.net/doc.php?id=1481 on 1 May 2004.

Lebel, L. and Steffen, W. (eds.) (1998). Global Environmental Change and Sustainable Development in Southeast Asia: Science Plan for a SARCS

Integrated Study. Chiang Mai, Thailand: Southeast Asian Regional Committee for START (SARCS). http://www.sarcs.org/issp/isspindx.htm on 1 May 2004.

Lotfi, S. (2001). Remote Sensing for Urban Growth in Northern Iran, Department of Urban Planning, University of Mazandaran, Babolsar, Iran, 9 November 2001.

Lõvei, G. L. (1997). Global change through invasion. Nature 388: 627-628. http://www.nature.com/cgi-taf/DynaPage.taf?file=/nature/journal/v388/n6643/index.html on 22 March 2004.

Lund, H. G., Dallmeier, F., Alonso, A. (2004). Biodiversity: Biodiversity in forests.MS 146, 33-40. In: Encyclopedia of Forest Sciences. J. Burley, J. Evansand J.A. Youngquist (eds.). Elsevier/Academic Press. ISBN 0-12-145160-7.

Malcolm, J.R., Liu, C., Miller, L.B., Allnutt, T., Hansen, L. (2002). Habitats at risk: Global warming and species loss in globally significant terrestrial ecosystems, WWF, 2002. http://www.undp.org.vn/mlist/envirovlc/022002/post54.htm on 16 May 2004.

McGrath, S. (2005). Attack of the alien invaders. National Geographic 207(3): 92-117. McGraw-Hill Higher Education: http://highered.mcgraw-hill.com/sites/dl/free/007248179x/35299/map12.pdf on 10 August 2004; http://highered.mcgraw-hill.com/sites/dl/free/007248179x/35299/map11.pdf on 10 August 2004.

McNeely, J. A., Scherr, S. J. (2001). Common ground - common future: how ecoagriculture can help feed the world and save wild biodiversity. IUCN Publication, Gland, Switzerland, 23. http://www.futureharvest.org/pdf/biodiversity_report.pdf on 20 March 2004.

McNeill, J.R. (2001). Something new under the sun - An environmental history of the twentieth-century world. New York: W.W. Norton & Company, 421.

Menne, B. and Bertollini, R. (2000). The health impacts of desertification anddrought. Down to Earth: Newsletter of the UNCCD, No. 14, 4-7. http://www.unccd.int/publicinfo/newsletter/no14/news14eng.pdf.

Middleton, N. et al. eds. (1997). World Atlas of Desertification. Second Edition. United Nations Environment Program 0340691662, 192.

Millar, C. I. (2003). Climate change as an ecosystem architect: Implications torare plant ecology, conservation, and restoration, 37. http://www.fs.fed.us/psw/programs/snrc/staff/millar/MillarCNPS.pdf on 15 May 2004.

Mittermeier, R. A., Mittermeier, C. G., Gil, P. R., Pilgrim, J., Fonseca, G., Brooks,T., Konstant, W. R. (2003). Wilderness: Earth's Last Wild Places. University of Chicago Press. Distributed for the Conservation International, 576. http://www.mindfully.org/Heritage/Earth-Half-Wilderness4dec0.htm on 21 March 2004.

NASA (2002). Landcover Changes May Rival Greenhouse Gases As Cause Of Climate Change, NASA-GSFC News Release, 1October 2002. http://www.gsfc.nasa.gov/topstory/20020926landcover.html on 13 July 2004.

NASA (2003). Blackout in US and Canada. http://earthobservatory.nasa.gov/NaturalHazards/natural_hazards_v2.php3?img_id=11628 on 18 July 2004.

NASA (2004). Thar Desert. NASA/GSFC/METI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team. http://asterweb.jpl.nasa.gov/gallery/gallery.htm?name=Thar on 25 August 2004.

NCR&LB (2003). Construction Terms. National Contractor Referrals and License Bureau. http://www.contractorreferral.com/glossary/ on 8 November 2004.

New Internationalist Magazine (n.d). http://www.newint.org/issue309/Images/population.gif on 16 July 2004.

Nilsson, S. (1996). Do We Have Enough Forests? IUFRO Occasional Paper No. 5, International Union of Forestry Research Organizations, Vienna, Austria. http://www.actionbioscience.org/environment/nilsson.html on 2 May 2004. http://iufro.boku.ac.at/iufro/publications/dowehave.htm on 2 May 2004.

O'Neil, D. (2004). An introduction to the processes and consequences of culture change. Tutorial. Palomar College, Behavioral Sciences Department, San Marcos, California, USA. http://anthro.palomar.edu/change/change_1.htm on 15 July 2004; http://anthro.palomar.edu/language/language_1.htm on 15 July 2004.

Pellew, R. (1996). The Global Biodiversity Assessment. Our Planet 7.5. http://www.ourplanet.com/imgversn/75/pellew.html on 22 March 2004.

Pimentel, D., Harvey, C., Resosudarmo, P., Sinclair, K., Kurz, D., McNair, M., Crist, S., Sphpritz, L., Fitton, L., Saffouri, R., Blair, R. (1995). Environmental and economic costs of soil erosion and conservation benefits. Science 267: 1117-1123.

Pimentel, D., Huang, X., Cordova, A., Pimentel, M. (1996). Impact of population growth on food supplies and environment. Presented at AAAS Annual Meeting, Baltimore, Maryland, USA, 9 February 1996. http://dieoff.org/page57.htm on 2 May 2004.

Pimentel, D., B., O., Mullaney, K.E., Calabrese, J., Nelson, W.F., Yao, X. (1999). Will Limits of the Earth's Resources Control Human Numbers? Cornell University, New York, USA. http://www.dieoff.com/page174.pdf on 17 November 2004.

Planning Department (2001). Chapter 12 Glossary. Raleigh Comprehensive-Plan, City of Raleigh Planning Department, Raleigh, North Carolina, USA. http://www.raleigh-nc.org/planning/CP/Text/Chapter_12/Glossary.pdf on 1 May 2004.

Population Division (2000). Charting the Progress of Populations. Department of Economic and Social Affairs, United Nations, New York, USA, 95. http://www.un.org/esa/population/pubsarchive/chart/contents.htm on 10 November 2004.

Population Fact Sheet (2000). People in the Balance: Population and NaturalResources at the Turn of the Millennium, Engelman, R. with Cincotta, R. P., Dye, B., Gardner- Outlaw, T. and Wisnewski, J.: Population Action International, Washington, DC, USA. www.populationaction.org on 14 October 2004.

Ramankutty, N. and Foley, J. A. (1999). Global Potential Vegetation Data. Climate, People, and Environment Program, University of Wisconsin, Madison, Wisconsin, U.S.A. http://cpep.meteor.wisc.edu/pages/available.html on 2 March 2004.

Ramankutty, N., Foley, J. A., Olejniczak N. J. (2002). People on the Land: Changes in Global Population and Croplands during the 20th Century, Ambio Vol. 31 No. 3, May 2002, Royal Swedish Academy of Sciences 2002, 251-257. http://www.bioone.org/pdfserv/i0044-7447-031-03-0251.pdf on 16 August 2004.

Rau, J. L. (2003). Atlas of Urban Geology: Environmental and urban geology of selected cities in Central, Southwest and South Asia, United Nations Economic and Social Commission for Asia and the Pacific.

Riitters, K., Wickham, J., O'Neill, R., Jones, B., Smith, E. (2000). Global-scale patterns of forest fragmentation. Conservation Ecology 4(2): 3. http://www.consecol.org/vol4/iss2/art3 on 21 September 2004.

Rosenzweig, M.L. (1999). Heeding the basic warning in biodiversity's basic law. Science 284:276-277. http://www.sciencemag.org/cgi/content/full/284/5412/276 on 21 March 2004.

Saxena, R., Pal, S., Joshi, P.K. (2001). Delineation and characterization of agro-ecoregions, 3. National Centre for Agricultural Economics and Policy Research, New Delhi, India. http://www.icar.org.in/ncap/publications/pmenotes/pmenotes6.pdf on 15 May 2004.

SBSTTA (2003). Status and trends of, and threats to, protected areas. UNEP/CBD/SBSTTA/9/5/Rev.1. Ninth meeting of the Convention on BiologicalDiversity, Subsidiary Body on Scientific, Technical and Technological Advice. Montreal, 10-14 November 2003 Item 4.1, 19. www.biodiv.org/doc/meetings/sbstta/sbstta-09/official/sbstta-09-05-rev1-en.doc on 5 May 2004.

Shafer, S. L., Bartlein, P. J., Thompson, R. S. (2001). Potential changes in the distributions of Western North America tree and shrub taxa under future climate scenarios. Ecosystems 4: 200–215. http://www.usgcrp.gov/usgcrp/Library/nationalassessment/forests/Ecosystems4%20Shafer.pdf on 16 May 2004.

Sohngen, B., Mendelsohn, R., Sedjo, R. (1999). Forest management, conservation, and global timber markets. American Journal of Agricultural Economics, 81(1): Abstract 1-10. http://www.acs.ohio-state.edu/units/research/archive/timber.htm on 24 February 2004.

Southern Oregon University, Geography Department, Oregon, USA. http://www.sou.edu/Geography/JONES/GEOG111.112/atlas/Map14.GIF on 14October 2004.

Sutherland, W.J. (2003). Parallel extinction risk and global distribution of languages and species. Nature 423: 276-279. http://www.nature.com/cgi-taf/DynaPage.taf?file=/nature/journal/v423/n6937/abs/nature01607_fs.html on 25 April 2004.

Taylor, E.J., Martin, P.L. (2002). Human Capital: Migration and Rural Population Change (Chapter for Handbook of Agricultural Economics, Bruce L. Gardner and Gordan C. Rausser, eds.), Elsevier Science, New York, USA. http://www.iga.ucdavis.edu/human.pdf on 14 October 2004.

Terralingua, UNESCO, and WWF (2003). From the poster 'The World's Biocultural Diversity: People, Languages, and Ecosystems', a companion to the booklet 'Sharing a World of Difference: The Earth's Linguistic, Cultural, and Biological Diversity', produced by Terralingua in collaboration with UNESCO and WWF and published by UNESCO Publishing, Paris. The World Almanac and Book of Facts (2003).

Tilford, D. (2000). Why Consumption Matters. Center for a New American Dream. http://www.newdream.org/core/whyconsumptionmatters9.html#_edn177 on 18 April 2004.

Tilman, D., Fargione, J., Wolff, B., D'Antonio, C., Dobson, A., Howarth, R., Schindler, D., Schlesinger, W. H., Simberloff, D., Swackhamer, D. (2001). Forecasting agriculturally driven global environmental change. Science 292: 281-284. http://pangea.stanford.edu/courses/GES56Q/Tilman2001-Agriculture%20and%20Env%20Change.pdf on 5 May 2004.

UCS (2003). Clean Energy: The Sources of Energy, Union of Concerned Scientists, Cambridge, Massachusetts, USA. http://www.ucsusa.org/clean_energy/renewable_energy/page.cfm?pageID=77 on 19 April 2004.

UCS (2004). FAO Report: Enough food in the future–without genetically engineered crops. Food and Environment. Backgrounder. Union of Concerned Scientists, Cambridge, Massachusetts, USA. http://www.ucsusa.org/food_and_environment/biotechnology/page.cfm?pageID=331 on 3 May 2004.

UN (2000). Dialogue among Civilizations and Cultures: Resolution adopted without a vote by the 103rd Inter-Parliamentary Conference, Amman, Jordan, 5 May 2000. http://www.dialoguecentre.org/PDF/culture.pdf on 20 July 2005.

UNEP (1992). The World Atlas of Desertification, First Edition.

UNEP (1997). Global Environment Outlook 2000. United Nations Environment Programme. Oxford University Press. http://www.grida.no/geo1/ on 15 May 2004.

UNEP (1999). Taking Action – An Environmental Guide for you and your Community. http://www.nyo.unep.org/action/default.htm on 24 November 2004.

UNEP (2000). In cooperation with UNHCS and UNHCR, Environmental impact of refugees in Guinea, March 2000, Morten R. (2001). Aid and safety for Guinea's refugees, The Lancet, London, 7 April 2001, Volume 357, Issue 9262, 1123; Anonymous (2002). Surveillance of mortality during a refugee crisis—Guinea, January-May 2001, JAMA, 9 January 92002, Volume 287, Issue 2, Chicago, 182. http://www.grid.unep.ch/guinea/ on 8 August 2004; www.ids.ac.uk/ids/env/GuineaBiodiversity.pdf on 8 August 2004.

UNEP (2001). Globalization: Threat to World's Cultural, Linguistic and Biological Diversity, 8 February 2001. http://www.unep.org/GC/GC21/NR%20_18.doc on 20 July 2005.

UNEP (2002a). Global Environment Outlook 3 (GEO3) – Past, present and future perspectives. London: Earthscan, 446. http://www.unep.org/geo/geo3/ on 4 March 2004.

UNEP (2002b). Children of the New Millennium: environmental impact on health. Nairobi, United Nations Environment Programme. http://www.unep.org/ceh/ch04.html Accessed on 1 April 2004.

UNEP-WCMC (2003). A Survey of Global and Regional Marine Environmental-Assessments and Related Scientific Activities. United Nations EnvironmentProgramme and World Conservation Monitoring Centre, Cambridge, UK.Miscellaneous Pagination. http://www.unep-wcmc.org/marine/GMA/ on 15 May 2004.

UNEP-WCMC (2005). Millennium Development Goals: Goal 7, Target 9 - Indicator 26: Ratio of area protected to maintain biological diversity to surface area.

UNESCO (2003). Dialogue among Civilizations: The International Ministerial-Conference on Dialogue among Civilizations: Quest for New Perspectives, New Delhi, India, 9-10 July 2003. http://unesdoc.unesco.org/images/0013/001343/134394e.pdf on 20 July 2005.

UNESCO (n.d.): What is Cultural Diversity? http://portal.unesco.org/culture/en/ev.php-URL_ID=13031&URL_DO=DO_TOPIC&URL_SECTION=201.html on 20 July 2005.

UNFPA (2001). The State of World Population 2001 - Footprints and Milestones: Population and Environmental Change. The United NationsPopulation Fund. http://www.unfpa.org/swp/2001/english/contents.html on 1 August 2004.

US Census Bureau (2004). World Vital Events. http://www.census.gov/cgi-bin/ipc/pcwe on 14 October 2004. van Lynden, G., Schwilch, G., Liniger, H. (n.d.). A standardised method for assessment of soil degradation and soil conservation: the WOCAT mapping methodology, 7. http://www.wocat.org/ftp/ISCOmap.pdf on 1 May 2004.

Volker Quaschning. Personal Communication. http://www.volker-quaschning.de/fotos/re-spanien/index_e.html on 14 October 2004.

Wade, T. G., Riitters, K. H., Wickham, J. D., Jones, K. B. (2003). Distribution and causes of global forest fragmentation. Conservation Ecology 7(2): 7. http://www.consecol.org/vol7/iss2/art7 on 15 May 2004.

Watson, R. T., Dixon, J. A. Hamburg, S. P., Janetos, A. C., Moss, R. H. (1998). Protecting our planet - securing our future -linkages among global environmental issues and human needs, MEA Resources: Fact Sheets, Desertification and Land Degradation. http://www.gdrc.org/uem/mea/factsheets/fs5.html on 1 April 2004.

Wilk, R. (2000). Globalization, consumer culture, and the environment. Course Outline ER290-6 Spring 2000 cc#26251. Bloomington, Indiana University, Indiana, USA. http://www.indiana.edu/~wanthro/290-00.htm on 15 July 2004.

Wilson, E. O. (1989). Threats to biodiversity. Scientific American 261, September 1989, 108–112.

WRI (1998). 1998-99 World Resources: A Guide to the Global Environment. The World Resources Institute, The United Nations Environment Programme, The United Nations Development Programme, The World Bank. New York: Oxford University Press, 384. http://www.wri.org/wri/wr-98-99/on 18 April 2004.

WRI (2000). World Resources 2000-2001: People and ecosystems: The fraying web of life. World Resources Institute in cooperation with United Nations, Washington, DC, USA.

Wurm, S. A. (1970). Atlas of the world's languages in danger of disappearing.UNESCO Publishing, 90. http://portal.unesco.org/culture/en/ev.php@URL_ID=2229&URL_DO=DO_TOPIC&URL_SECTION=201.html on 25 April 2004.

Site References

Black Triangle

Common Report on Air Quality in the Black Triangle Region (2000). Reportprepared by the JAMS Working Group and published with the assistance of the PHARE Black Triangle Project. http://www.env.cz/envdn.nsf/0/1f9cf50ae801b07fc1256b5a00309f85/$FILE/Trojuhel.pdf on 14 December 2004.

NASA's Earth Observatory, Changes in Biochemical Cycles. www.eos-ids.sr.unh.edu/ids-cycles.html on 15 December 2004. Czech Power Company CEZ, a.s. http://www.cez.cz/eng/ on 14 December 2004.

Ardö, J., Lambert, N. J., Henzlik, V. and Rock, B. N. (1997). Satellite Based Estimations of Coniferous Forest Cover Changes, Krusne Hory, Czech Republic, 1972-1989. Ambio, Volume 26, No. 3., 158-166.

Strub-Aeschbacher, N. (2002). Presentation - Black Triangle. UNEP/DEWA/GRID-Geneva.

Cape York Bauxite Mining

State of the Environment Queensland (1999). Underlying Pressures Weather and Climate. http://www.env.qld.gov.au/environment/science/environment/soe3_pre.pdf on 14 December 2004.

Australian Academy of Technological Sciences and Engineering (2000). Aluminum Technology in Australia 1788-1988. Australian Science and Technology Heritage Centre. http://www.austehc.unimelb.edu.au/tia/873.html on 31 December 2002.

Tomago Aluminum (2002). The Aluminum Industry in Australia. Tomago Aluminum. http://www.tomago.com.au/alum/industry.html on 31 December 2002.

Hick, P. and Ong, C. (2001). Remote-sensing for the assessment and management of the Comalco Andoom Bauxite Mine. CSIRO Australia. http://www.per.dem.csiro.au/research/EGG/weipa/index.html on 31 December 2002.

Industry Science Resources (2002). Developing Opportunities for Aboriginal People. Backing Australia's Ability. http://www.innovation.gov.au/resources/indigenouspartnerships/ on 31 December 2002.

Comalco (2002). Queensland, Australia. CaseStudies/RioTinto/index.html on 31 December 2002. http://www.comalco.com.au/05_operations/02_weipa. htm on 31 December 2002.

Copsa Mica_Romania

Thompson, J. (1991). East Europe's Dark Dawn, The Iron Curtain Rises to Reveal a Land tarnished by Pollution. National Geographic Magazine, 36-69 Volume 179, No. 6 June 1991.

Czaran, L. (2004). Personal Communication.

Escondida Mine, Chile

SPG Media Limited. (2004). http://www.mining-technology.com/ on 3 March 2005.

NASA's Earth Observatory. http://earthobservatory.nasa.gov/Newsroom/NewImages/images.php3?img_id=4492 on 3 March 2005.

NASA/GSFC/METI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team. http://asterweb.jpl.nasa.gov/gallery/gallery.htm?name=Escondida on 3 March 2005.

Etaki Mine, Canada

The Canada Centre for Remote Sensing, Natural Resources Canada. Tour-Canada from Space. http://www.ccrs.nrcan.gc.ca/ccrs/learn/tour/43/43nwt_e.html on 3 March 2005.

Gunn, A., Dragon J., Boulanger, J. (2001). Seasonal movements of satellite-collared caribou from the Bathurst herd. Wildlife and Fisheries Division, Resources, Wildlife and Economic Development, Government of the-Northwest Territories, Yellowknife, Canada.

BHP Billiton (2003). Ekati Diamond Mine Facts. BHP Billiton Diamonds Inc. Issue 6. www.bhpbilliton.com on 3 March 2005.

Ok Tedi Mine, Papua New Guinea

Claassen, D. (2004). Personal Communication. October 2004. About the Environment (2001). Ok Tedi Mining Limited. http://www.oktedi.com/resources/pages/aboutEnvironment.php on 3 March 2005.

Powder River Basin, Wyoming

Wyoming Oil and Gas Conservation Commission (n.d.). Map of coal-bed distribution, http://wogcc.state.wy.us/CoalBedTwpRge.htm?RequestTimeout=3500 on 3 March 2005; Statistics. http://wogcc.state.wy.us/coalbedchart.cfm?RequestTimeout=3500 on 3 March 2005.

BLM White Paper on the San Juan Basin. http://oil-gas.state.co.us/blm_sjb.htm on 3 March 2005.

Powder River Basin Resource Council. http://www.powderriverbasin.org/ on 3 March 2005.

Conserving Wyoming Heritage. http://www.wyomingoutdoorcouncil.org/programs/cbm/Conserving_WY_heritage.pdf on 3 March 2005.

Powder River CBM Information Council. http://www.cbmwyo.org/ on 3 March 2005.

USGS Central Energy Resources Team Report. http://greenwood.cr.usgs.gov/energy/CBmethane/OF00-372/index.html on 3 March 2005.

Northern Plains Research Council, Coal Bed Methane – comprehensive list of impacts, includes white paper on proposed wastewater reinjection. http://www.nprcmt.org/Issues/CBM/CBM%20index.asp on 3 March 2005; http://www.nprcmt.org/media/2001/op-ed-TomSchneider-CBM.asp on 3 March 2005; http://www.escribe.com/culture/native_news/m664 on 3 March 2005.