17 Rural land use

'Nor rural sights alone, but rural sounds, exhilarate the spirit.'

William Cowper

'I see the rural virtues leave the land.'

Oliver Goldsmith

The term **rural** refers to those less densely populated parts of a country which are recognised by their visual 'countryside' components. Areas defined by this perception will depend upon whether attention is directed to economic criteria (a high dependence upon agriculture for income), social and demographic factors (the 'rural way of life' and low population density) or spatial criteria (remoteness from urban centres). Usually it is impossible to give a single, clear definition of rural areas as, in reality, they often merge into urban centres (the rural–urban fringe) and differ between countries. Although generalisations may lead to over-simplifications (Framework 11, page 347), it is useful to identify three main types of rural area.

1 Where there is relatively little demand for land, certain rural activities can be carried out on an extensive scale, e.g. arable farming in the Canadian Prairies and forestry on the Canadian Shield.
2 In many areas, especially in economically developing countries, there is considerable pressure upon the land which results in its intensive use. Where human competition for land use becomes too great to sustain everyone, the area is said to be overpopulated (page 376). This often leads to rural depopulation, e.g. the movement to urban centres in Latin American countries (page 366).
3 In many economically developed countries, competition for land is greater in urban than in rural areas. The resultant high land values and declining quality of life are leading to a repopulation of the countryside (urban depopulation), e.g. migration out of New York and London (page 365).

The urban–rural continuum

It is now unusual to find a clear distinction between where urban settlements and land use end and rural settlements and land use begin. Instead, there is usually a gradual gradation showing a decrease in urban characteristics with increasing distance from the city centre Figure 17.1). This is known as the **urban–rural continuum** (page 393).

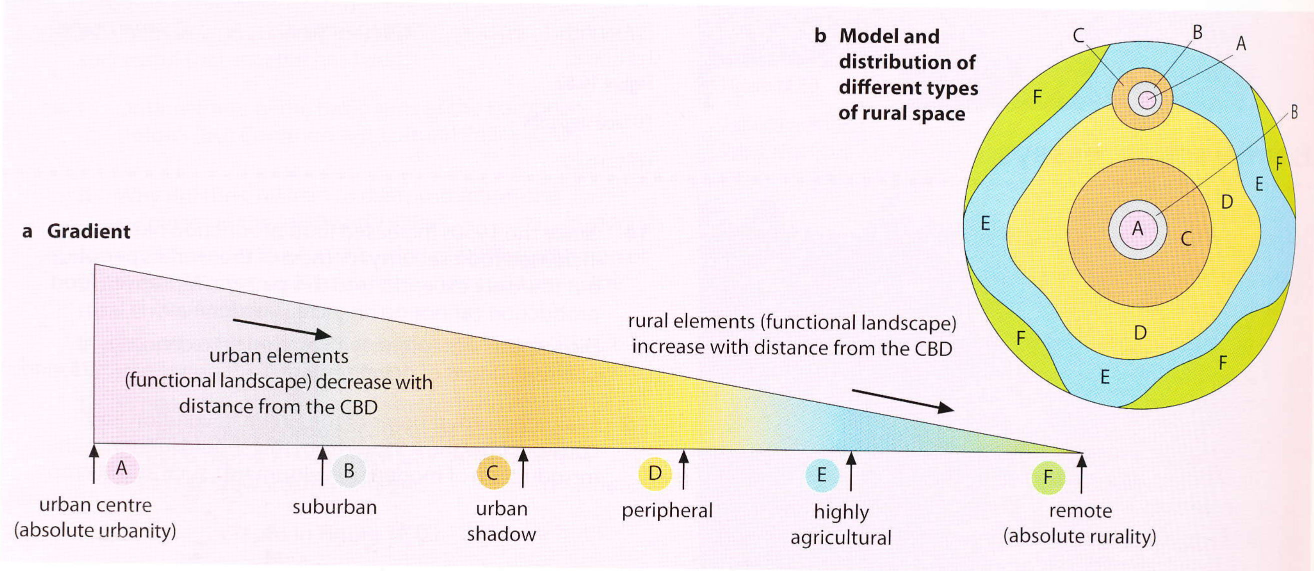


Figure 17.1
The urban–rural continuum

The urban–rural continuum includes the rate at which rural settlements expand or decrease as people move out of or into nearby cities; changes in the socio-economic base as services and other functions are transferred to the countryside; and changes in land use resulting from increased pressure exerted on rural areas by nearby urban areas.

Figure 17.3

Rurality in England and Wales

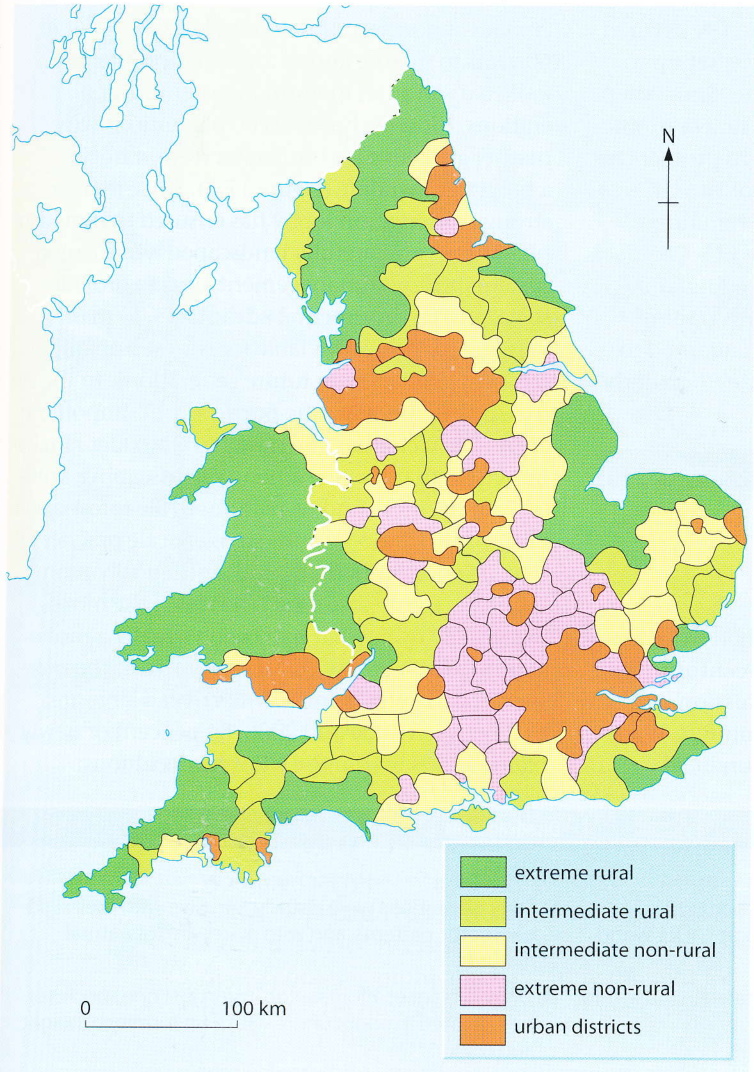


Figure 17.2

An index of rurality for England and Wales (*after* Cloke, 1977)

Indices	Characteristics in rural areas
Population per ha	Low
% change in population	Decrease
% total population: over 65 years	High
% total population: male 15–45 years	Low
% total population: female 15–45 years	Low
Occupancy rate: % population at 1.5 per room	Low
Households per dwelling	Low
% households with exclusive use of (a) hot water (b) fixed bath (c) inside WC	High
% in socio-economic groups: 13/14 farmers	High
% in socio-economic group: 15 farmworkers	High
% residents in employment working outside the rural district	Low
% population resident < 5 years	Low
% population moved out in last year	Low
% in-/out-migrants	Low
Distance from nearest urban centre of 50 000	High
Distance from nearest urban centre of 100 000	High
Distance from nearest urban centre of 200 000	High

There are a number of measures of the intensity of change over distance, of which the best known is Cloke's **index of rurality** (Figure 17.2). The index is obtained by combining a range of socio-economic measures or variables, with absolute urbanity at one extreme and absolute rurality at the other. Using his index of rurality, Cloke then produced a map with a five-fold classification to show rurality in England and Wales (Figure 17.3).

Figure 17.4 shows some of the major competitors for land in a rural area. In many parts of the world, farming takes up the majority of the land and, especially in developing countries, employs most of the population.

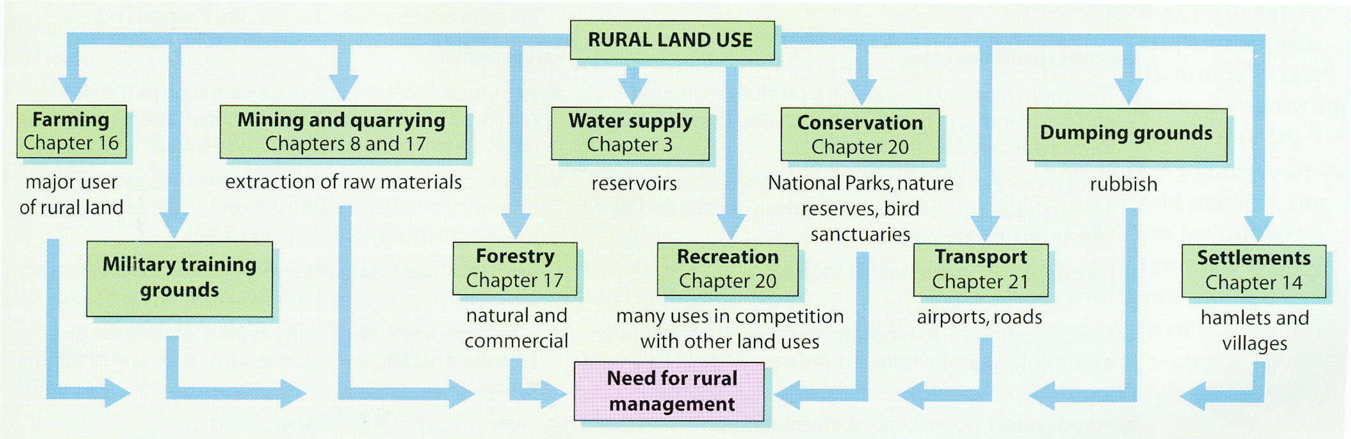


Figure 17.4

Competition for rural land use and the need for management

Forestry

In Britain

Neolithic farmers began the clearance of Britain's primeval forests about 3000 years ago. Aided by the development of axes, some clearances may have been on a scale not dissimilar to that in parts of the tropical rainforests of today. In 1919, with less than 4 per cent of the UK covered in trees, the Forestry Commission was set up to begin a controlled replanting scheme. Since then the policy has been to look towards an economic profit over the long term and to try to protect the environment. By 2008, 11 per cent of the UK was classified as woodland, but this still remained one of the lowest proportions in the EU.

Deciduous trees are more suited to England where the relief is lower and the location more southerly, whereas conifers are better adapted to Scotland with its higher relief and more northerly latitude.

	Coniferous	Deciduous
England	32%	68%
Scotland	78%	22%
UK	58%	42%

Much of Britain's surviving, established woodland is deciduous while most of the 20th-century forest planted by the Forestry Commission was coniferous. This is mainly because conifers, being softwoods, have a much greater commercial value than deciduous trees. This is partly due to their greater range of use, ranging from paper to furniture, and partly because, regardless of whether they are grown naturally or have been replanted, as there are fewer species within a given area than in a deciduous woodland, selection and felling of trees is made easier.

Softwoods growing in the poor soils and harsh climate of northern Britain take between 40 and 60 years to mature and so afforestation was always looked upon as an investment for future generations. Most of the pre-1980 plantations were neither attractive for human recreation nor as a habitat for wildlife (Figure 17.5). Since then, a strong conservation lobby has ensured that modern plantations are carefully landscaped while a more sustainable forest management aims to provide social and environmental advantages, to maintain an economically viable forestry sector and to protect woodlands for future generations. In the last two or three decades, the previously all-important economic factor has given way to a broader range of objectives that include amenity landscaping, wildlife management and recreation, while forest operations have moved towards smaller-scale practices that are environmentally and aesthetically more sensitive (Figure 17.6). Such has been the movement away from what had been virtually a monoculture, with perhaps only one, or two at the most, species of conifer being planted over a large area, that between 2004 and 2008, 84 per cent of newly planted trees within the UK were deciduous.

Figure 17.5

The case for and against forestry in Britain (*after* Warren, *Geography Review*, March 1998)

Advantages	Disadvantages
Socio-economic	**Landscape**
■ National timber needs – the UK supplies only 13% of its own timber and has a large annual import bill for wood products.	■ Early plantations were visually intrusive with their rigid geometric patterns, and with no regard for natural features.
■ Provides employment, especially as located in those rural areas where jobs are in short supply.	■ Often a 'blanket afforestation', using just one species of tree, created a monoculture with a uniformity of height and colour.
■ A positive method of using set-aside land.	■ They transformed the landscape and obliterated views. Concern over the speed and scale of replanting.
Non-market/environmental	**Environmental**
■ Trees are a renewable resource if carefully managed and, by planting in the UK, reduces pressures on tropical forests (sustainable development).	■ Introduction of non-native species, such as the North American Sitka spruce and lodgepole pine, as they were faster-growing than indigenous species.
■ Trees replace oxygen in the atmosphere and so help counterbalance the increase of carbon dioxide and its effects on global warming.	■ Destruction of valued environments such as the Flow Country wetlands of Caithness and Sutherland, and moorlands elsewhere in upland Britain.
■ Forests reduce water runoff (page 63).	■ Adverse impacts on flora and fauna, e.g. moorland birds and plants.
■ Forests contribute to biodiversity, providing habitats for a range of fauna and flora, e.g. red deer and red squirrels.	■ Concerns over water quality as afforestation led to increased acidification of lakes and rivers, and disrupted runoff.
■ Forests offer opportunities for recreation, and trees make an aesthetic contribution to the countryside.	
■ Some people argue that forests are part of Britain's traditional landscape.	

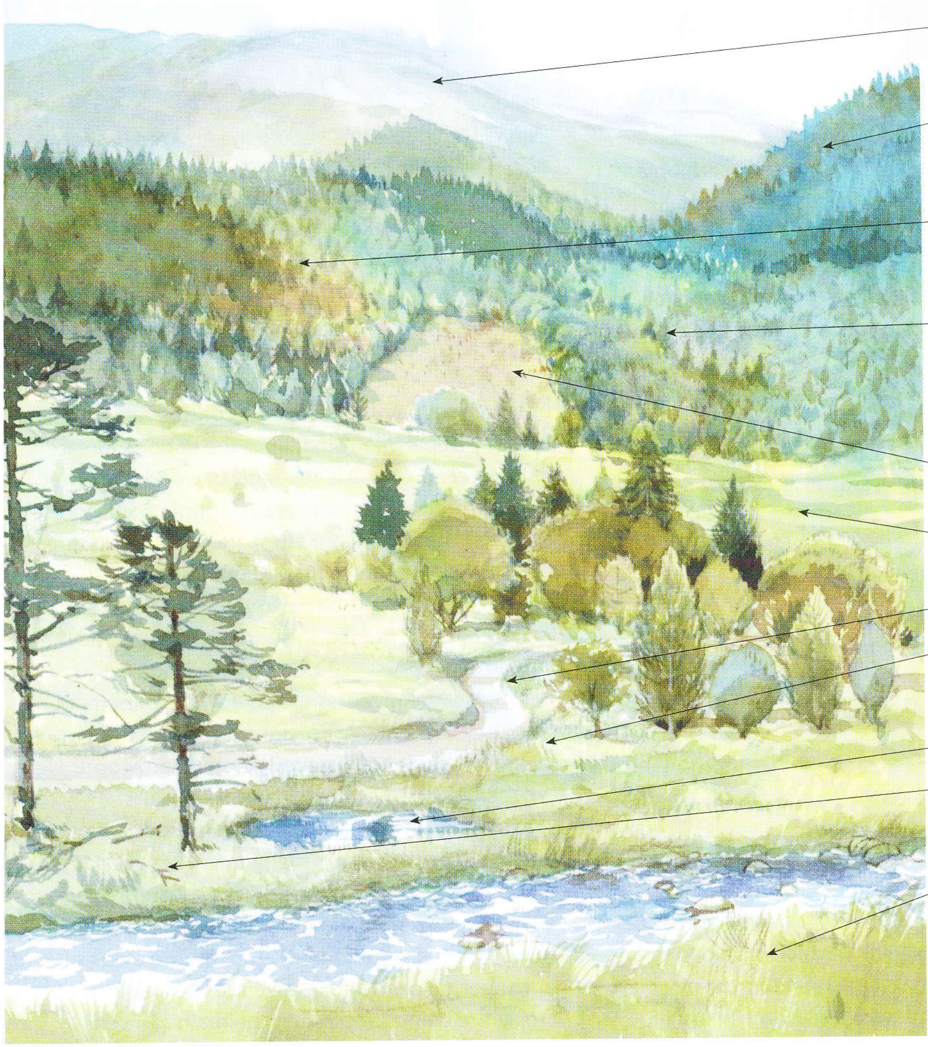


Figure 17.6

Managing an upland British forest (Kielder)

In developing countries

Commercial forestry is a relatively new venture in the tropics. It is usually controlled by transnationals based overseas which look for an immediate economic profit and have little thought for the long-term future or the environment. The UN suggests that over half of the world's forests were cleared during the last millennium and that the present rate of clearance is 102 000 km^2 annually. Of this, 94 000 km^2 is in developing countries located in the tropical areas of Africa, Latin America and South-east Asia where rates of replanting are often minimal.

The underlying causes of deforestation in developing countries are varied. Key issues, according to the World Wide Fund for Nature, include unsustainable levels of consumption; the effects of national debt; pressure for increased trade and development; poverty; patterns of land ownership; and growing populations and social relationships. It is also usual to blame forest destruction on the poor farmers of these countries rather than on the resource-consuming developed countries.

During commercial operations the forest is totally cleared by chainsaw, bulldozer and fire: there is no selection of trees to be felled. The secondary succession (page 318) is of poorer-quality trees, as little restocking is undertaken. Where afforestation of hardwoods does take place, there is often insufficient money for fertiliser and pesticide. The hope for the future may lie in **agroforestry**, where trees and food crops are grown alongside each other. Forest soils, normally rated unsuitable for crops, can be improved by growing leguminous tree species. Commercial forestry is more difficult to operate in developing countries as they are distant from world markets, the demand for hardwood is less than for softwood, and although there are several hundred species in a small area only a few are of economic value.

The threat of the destruction of the rainforests has become a major global concern. Some of the consequences of deforestation are described in Places 76 and Case Study 11.

Places 76 Ethiopia, Amazonia and Malaysia: forestry in developing countries

Ethiopia

Early in the 20th century, 40 per cent of Ethiopia was forested. Today the figure is 11 per cent. In 1901, a traveller described part of Ethiopia as being 'most fertile and in the heights of commercial prosperity with the whole of the valleys and lower slopes of the mountains one vast grain field. The neighbouring mountains are still well-wooded. The numerous springs and small rivers give ample water for domestic and irrigation purposes, and the water meadows produce an inexhaustible supply of good grass the whole year.' A century later, the same area was described as 'a vast barren plain with eddies of spiralling dust that was once topsoil. The mountains were bare of vegetation and the river courses dry.' As the trees and bushes were cleared, less rainfall was intercepted and surface runoff increased, resulting in less water for the soil, animals and plants. There has been little attempt to treat the forest as a *sustainable* resource.

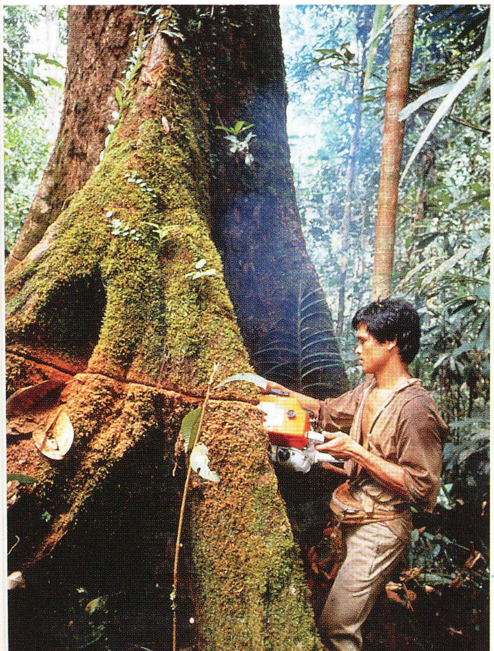
Amazonia

The clearance of the rainforests means a loss of habitat to many Indian tribes, birds, insects, reptiles and animals. Over half of our drugs, including one from a species of periwinkle which is used to treat leukaemia in children, come from this region. It is possible that we are clearing away a possible cure for AIDS and other as yet incurable diseases. (Despite the rainforests being the world's richest repository of medical plants, only 2 per cent have so far been studied for potential health properties.)

Without tree cover, the fragile soils are rapidly leached of their minerals, making them useless for crops and vulnerable to erosion (Figure 12.8). The Amazon forest supplies one-third of the world's oxygen and stores one-quarter of the world's fresh water – both would be lost if the region was totally deforested. The burning of the forest not only reduces the amount of oxygen given off, but increases the release of carbon dioxide (a contributory cause of global warming). It has also been suggested that the decrease in evapotranspiration, and subsequently rainfall, caused by deforestation could also have serious climatic repercussions – could the Amazon Basin become another Ethiopia? There is a much greater need for *sustainable* logging.

Figure 17.7

Logging operations in Malaysia



Malaysia: a model for the future?

Malaysia has several thousand species of tree, mainly hardwoods, with timber and logs being the country's third-largest export. However, the government has imposed strict controls, and the Forestry Department 'manages the nation's forest areas to ensure sufficient supply of wood and other forest produce and manages and implements forest activities that would help to sustain and increase the productivity of the forest' (*Malaysia Official Year Book*, 2007). The Department insists that trees reach a specific height, age and girth before they can be felled (Figures 17.7 and 17.8). Logging companies are given contracts only on agreement that they will replant the same number of trees as they remove. Many newly planted hardwoods are ready for harvesting within 20–25 years due to the favourable local growing conditions. Further experiments are being made with acacias and rattan, both of which grow even faster. Consequently, half of Malaysia is still forested and as most of the remaining third is under tree crops such as rubber, oil palm and coca (Places 68, page 483) stocks are being successfully maintained. Even so, Malaysia's rapid industrialisation (Places 91, page 578) is causing increased deforestation, especially around the capital of Kuala Lumpur. Attempts have been made to make logging *sustainable*.

Figure 17.8

Timber lorry in the Malaysian rainforest

Places 77 South-east Asia: forest fires

From September 1997 to June 1998, much of South-east Asia was blanketed by a thick smoke haze, in reality smog, caused by thousands of uncontrolled forest fires, mainly in Sumatra and Borneo (Figure 17.9). At its peak the smoke haze covered an area the size of western Europe and caused visibility to be reduced to 50 m. Its effects were various:

- **Human** The Air Pollution Index on Sarawak reached 851 (300 is considered 'hazardous' for human life), children and high-risk groups already suffering from respiratory or cardio-vascular diseases (Places 99, page 621) were prone to major health problems, and schools on Sumatra were closed.
- **Economic** Airports throughout the region were closed (an airline crash in Sumatra and a ship collision in the Strait of Malacca were both attributed to the haze), logging operations were suspended and farm crops destroyed.
- **Environmental** An estimated 90 per cent of canopy trees were lost in Sumatra and Borneo, and the rate of secondary succession would be slow; soils were seriously degraded; and wildlife habitats were lost (including those for such endangered species as the orang-utan, Sumatran rhinoceros and Sumatran tiger, and an irreparable loss in biodiversity).

Many Indonesians, accustomed to the humid climate and with little experience of dry weather, still adhere to fire-using traditions. Fire has long been used as a quick and cheap method of land clearance by farmers, and by plantation and forestry-concession owners. In 1997 the monsoon rains failed and the resultant prolonged drought, believed to have been triggered by the El Niño event (Case Study 9A), together with the prevailing land use and land management conditions, proved ideal conditions for the spread of forest fires on an unprecedented scale. The remoteness of the fires and the lack of resources, organisation and expertise combined to make fire-control impossible. Satellite imagery suggested that, although the blame for most of the fires was apportioned to the many small farmers, 80 per cent of the fires were due to large companies. By the time the rains did come, in May 1998, 10 million ha of forest had been burnt. Lessons were not learned, however, and fires and the resultant smoke haze kept returning each year until, in 2006, the consequences were almost as bad as in 1997–98. As in 1997, the fires followed a summer drought associated with an El Niño event (Case Study 9A). Most of the out-of-control fires were, as in previous years, on the Indonesian islands of Sumatra and Kalimantan (Indonesian Borneo). Government officials accused the many small farmers who clear their land annually by fire, whereas environmentalists claimed 80 per cent of the fires were begun by large companies clearing land on big plantations, timber estates and protected areas. By July over 100 fires were spotted by satellite, by which time many people were already experiencing breathing difficulties. During the first week of October, visibility in Pontianak (Kalimantan) was reduced to less than 50 m for several days, and many flights from the town's airport were either delayed or cancelled. Air pollution was said to be at a 'dangerous' level and people were advised to wear protective face masks if they went out of doors. Schools remained closed. A thick haze, blown by a strong wind from Sumatra, prompted Singapore to warn people against vigorous outside activities, while in adjacent Malaysia, Kuala Lumpur recorded 'unhealthy air quality'. The event lasted several months.

In 2007, the Indonesian government pledged to reduce forest fires while admitting to its neighbours that it might be incapable of totally eradicating them. With Malaysian co-operation, personnel were being trained in fire prevention, fire control and public education.

Figure 17.9

Maximum extent of smoke haze in 1997 and 2006

Mining and quarrying

Even since the Neolithic (when flint was excavated from chalk pits), Bronze and Iron Ages, quarrying and mining have been an integral part of civilisation. It was through the extraction and processing of minerals that many of today's 'developed' countries first became industrialised, while to some 'developing' countries the export of their mineral wealth provides the only hope of raising their standard of living. The modern world depends upon 80 major minerals, of which 18 are in relatively short supply, including lead, sulphur, tin, tungsten and zinc.

Minerals are a finite, non-renewable resource which means that, although no essential mineral is expected to run out in the immediate future, their reserves are continually in decline. **Resources** are the total amount of a mineral in the Earth's crust. The quantity and quality are determined by geology. **Reserves** are the amount of a mineral that can be economically recovered.

Although many items in our daily lives originated as minerals extracted from the ground, no mineral can be quarried or mined without some cost to local communities and the environment. Extractive industries provide local jobs and create national wealth, but they also cause inconvenience, landscape scars, waste tips, loss of natural habitats, and various forms and levels of pollution.

The most convenient methods of mining are **open-cast** and **quarrying**. In open-cast mining, all the vegetation and topsoil are removed, thus destroying wildlife habitats and preventing other types of economic activity such as farming (Places 79). Sand and gravel are extracted from depressions which, although shallow, often reach down to the water table, as in the Lea valley in north-east London. Coal and iron ore are often obtained from deeper depressions using drag-line excavators which are capable of removing 1500 tonnes per hour (Figure 17.10). Often, the worst scars (eyesores) result from quarrying into hillsides to extract 'hard rocks' such as limestone and slate (Figure 17.11 and Places 78). There is usually greater economic and political pressure for open-cast coalmining than to quarry any other resource: it is the cheapest method of obtaining a strategic energy resource, but none generates greater social and environmental opposition. The increased demand for aggregates for road building and cement manufacture has led to the go-ahead being given for superquarries to be opened up in many different parts of the world, including that at Dehra Dun in northern India (Case Study 8).

Mining involves the construction of either horizontal **adit mines**, where the mineral is exposed on valley sides, or vertical **shaft mines**, where seams or veins are deeper.

Deep mining still affects local communities and the environment either by the piling up of rock waste to form tips – of coal in South Wales valleys (Aberfan, Case Study 2B) and china clay in Cornwall, for example – or by causing surface subsidence – as in some Cheshire saltworkings. Waste can also be carried into rivers where it can cause flooding by blocking channels and, when it contains poisonous substances, can kill fish and plants and contaminatse drinking water supplies. This was highlighted in early 1992 when floodwaters from Cornwall's last working tin mine, Wheal Jane, flowed into rivers and to the coast, carrying with them arsenic and cadmium.

Figure 17.10

Opencast mining for coal, West Virginia, USA

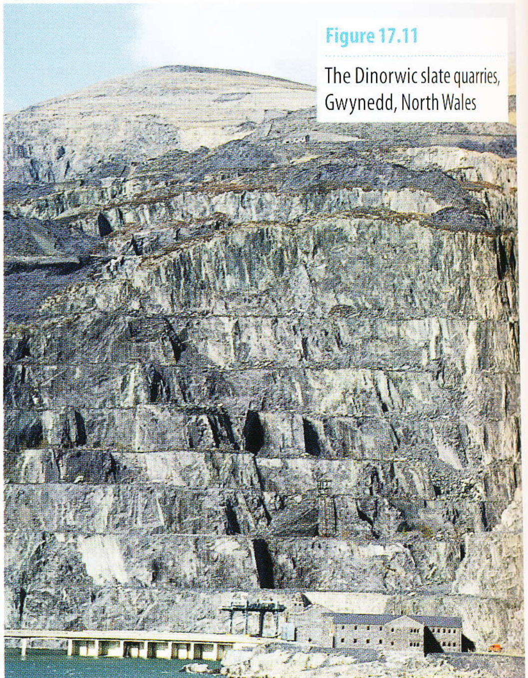


Figure 17.11

The Dinorwic slate quarries, Gwynedd, North Wales

Mining and quarrying

Even since the Neolithic (when flint was excavated from chalk pits), Bronze and Iron Ages, quarrying and mining have been an integral part of civilisation. It was through the extraction and processing of minerals that many of today's 'developed' countries first became industrialised, while to some 'developing' countries the export of their mineral wealth provides the only hope of raising their standard of living. The modern world depends upon 80 major minerals, of which 18 are in relatively short supply, including lead, sulphur, tin, tungsten and zinc.

Minerals are a finite, non-renewable resource which means that, although no essential mineral is expected to run out in the immediate future, their reserves are continually in decline. **Resources** are the total amount of a mineral in the Earth's crust. The quantity and quality are determined by geology. **Reserves** are the amount of a mineral that can be economically recovered.

Although many items in our daily lives originated as minerals extracted from the ground, no mineral can be quarried or mined without some cost to local communities and the environment. Extractive industries provide local jobs and create national wealth, but they also cause inconvenience, landscape scars, waste tips, loss of natural habitats, and various forms and levels of pollution.

The most convenient methods of mining are **open-cast** and **quarrying**. In open-cast mining, all the vegetation and topsoil are removed, thus destroying wildlife habitats and preventing other types of economic activity such as farming (Places 79). Sand and gravel are extracted from depressions which, although shallow, often reach down to the water table, as in the Lea valley in north-east London. Coal and iron ore are often obtained from deeper depressions using drag-line excavators which are capable of removing 1500 tonnes per hour (Figure 17.10). Often, the worst scars (eyesores) result from quarrying into hillsides to extract 'hard rocks' such as limestone and slate (Figure 17.11 and Places 78). There is usually greater economic and political pressure for open-cast coalmining than to quarry any other resource: it is the cheapest method of obtaining a strategic energy resource, but none generates greater social and environmental opposition. The increased demand for aggregates for road building and cement manufacture has led to the go-ahead being given for superquarries to be opened up in many different parts of the world, including that at Dehra Dun in northern India (Case Study 8).

Mining involves the construction of either horizontal **adit mines**, where the mineral is exposed on valley sides, or vertical **shaft mines**, where seams or veins are deeper.

Deep mining still affects local communities and the environment either by the piling up of rock waste to form tips – of coal in South Wales valleys (Aberfan, Case Study 2B) and china clay in Cornwall, for example – or by causing surface subsidence – as in some Cheshire saltworkings. Waste can also be carried into rivers where it can cause flooding by blocking channels and, when it contains poisonous substances, can kill fish and plants and contaminatse drinking water supplies. This was highlighted in early 1992 when floodwaters from Cornwall's last working tin mine, Wheal Jane, flowed into rivers and to the coast, carrying with them arsenic and cadmium.

Figure 17.10

Opencast mining for coal, West Virginia, USA

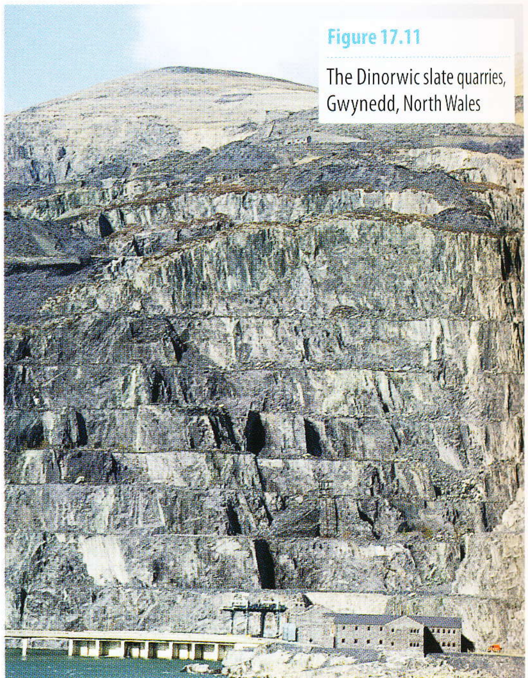


Figure 17.11

The Dinorwic slate quarries, Gwynedd, North Wales

Places 78 North Wales: slate quarrying

The Oakley slate quarries were first worked in 1818. By the 1840s, the most easily obtained slate had been won and mining began. The introduction of steam power and the building of the Ffestiniog railway led to the export of 52 million slates from Porthmadog in 1873. At the quarry's peak productivity, 2000 men and boys were employed on seven different levels. Each level was steeply inclined into the hillsides and was worked to a depth of 500 m. Apart from farming, the slate mines were the sole providers of employment, and Blaenau Ffestiniog's population peaked at 12 000. Working in candlelight in damp and dusty conditions for up to 12 hours a day, and with rock falls common (pressure release, page 41) the life expectancy of miners was short. By the turn of the century, the manufacture of clay roof tiles heralded the beginning of the industry's decline and in 1971 the mine at Blaenau closed. A decade later, renamed Gloddfa Ganol, the underground galleries were re-opened to tourists, some of whom arrive via the narrow-gauge Ffestiniog railway.

Figure 17.12

Spoil heaps above Blaenau Ffestiniog, Gwynedd

As the mines closed, people became either unemployed or were forced to move to seek work – the present population of Blaenau is under 500. Today the slate mines are a tourist attraction and have again become the town's largest employer. Above the rows of the former miners' cottages tower the large and unsightly spoil heaps (Figure 17.12) as for every tonne of usable slate, ten tonnes of waste was created – though these spoil heaps seem more stable than the coal tips which affected Aberfan (Case Study 2B). Some of the old buildings have been restored as tourist attractions and there is little evidence of subsidence as in other mining areas.

Places 79 Malaysia: tin mining

Malaysia (2008) is the world's seventh major producer of tin ore but whereas it was the world leader until 1993 and in 1970 was producing 40 per cent of the world's output, now its contribution is only 1 per cent. Early tin mining was typical of the colonial trade period (page 624). British settlers brought in the capital, machinery and technology; supervised the mining; and organised the export of tin for refining. Malaya, as it was then known, received few advantages. Most tin was obtained by opencast methods and the use of hydraulic jets.

After independence, when the mines were nationalised and operated under the Malaysian government, tin played a major role in the country's economic development and its emergence as one of the 'Asian tigers' (page 578). However, since then the total output and the number of workers have fallen rapidly due to the depletion of reserves (especially those of the highest-quality), the low market prices and the rising costs of extraction. Many of the former mines have been left as land either covered in mining spoil (Figure 17.13) and polluted lakes or with abandoned overhead 'railways', machinery and buildings. There is talk of re-opening some of the mines in Perak in the north-west of the country due to a resurgence in world prices.

One of the largest abandoned mines lies 15 km south of Kuala Lumpur in an area of rapidly growing housing and high-tech industry. It has been converted into a theme park with the world's longest aerial ropeway, together with water slides and various water sports (Figure 17.14) .

Figure 17.13

Disused tin mine, Malaysia

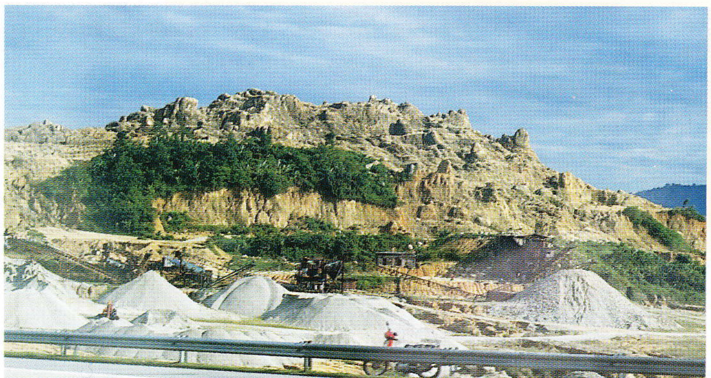


Figure 17.14

Sunway Lagoon Theme Park, near Kuala Lumpur, Malaysia

Framework 17 Standard error calculations

Having completed any sampling exercise (Framework 6, page 159), it is important to remember that patterns exhibited may not necessarily reflect the parent population. In other words, the results may have been obtained purely by chance. Having determined the mean of the sample size, it is possible to calculate the difference between it and the mean of the parent population by assuming that the parent population will conform to the normal distribution curve (Figure 6.37). However, while the sample mean must be liable to some error as it was based on a sample, it is possible to estimate this error by using a formula which calculates the **standard error of the mean** (SE).

$$SE\bar{x} = \frac{\sigma}{\sqrt{n}}$$

where: $\bar{x}$ = mean of the parent population
σ = standard deviation of parent population
$\sqrt{n}$ = square root of number of samples

We can then state the reliability of the relationship between the sample mean and the parent mean within the three confidence levels of 68, 95 and 99 per cent (Framework 6). Unfortunately, when sampling, the standard deviation of the parent population is not available and so to get the standard error we have to use the standard deviation of the sample, i.e. using *s* rather than σ. Although this introduces a margin of error, it will be small if *n* is large (*n* should be at least 30).

For example: a sample of 50 pebbles was taken from a spit off the coast of eastern England. The mean pebble diameter was found to be 2.7 cm and the standard deviation 0.4 cm. What would be the mean diameter of the total population (all the pebbles) at that point on the spit?

$$SE = \frac{0.4}{\sqrt{50}} = \frac{0.4}{7.07} = 0.06 \text{ (to two decimal places)}$$

This means we can say:

1 with 68 per cent confidence, that the mean diameter will lie between 2.7 cm ± 0.06 cm, i.e. 2.64 to 2.76 cm
2 with 95 per cent confidence, that the mean diameter will lie between 2.7 cm ± 2 x *SE* (2 x 0.06 = 0.12 cm), i.e. 2.58 to 2.82 cm
3 with 99 per cent confidence, that the mean diameter will lie between 2.7 cm ± 3 x *SE* (3 x 0.06 = 0.18 cm), i.e. 2.52 to 2.88 cm.

If we wanted to be more accurate, or to reduce the range of error, then we would need to take a larger sample. Had we taken 100 values in the above example, we would have had:

$$SE = \frac{0.4}{\sqrt{100}} = \frac{0.4}{10.00} = 0.04 \text{ (to two decimal places)}$$

which means we can now say with 68 per cent confidence that the mean diameter size will lie between 2.7 cm ± 0.04 cm (i.e. 2.66 to 2.74 cm). Of course, this also means there is a 32 per cent chance that the mean of the parent population is *not* within these values. This is why most statistical techniques in geography require answers at the 95 per cent confidence level.

This standard error formula is applicable only when sampling actual values (**interval** or **measured data**). If we wish to make a count to discover the frequency of occurrence where the data are **binomial** (i.e. they could be placed into one of two categories), we have to use the **binomial standard error**. For example, we may wish to determine how much of an area of sand dune is covered in vegetation and how much is *not* covered in vegetation. When using binary data, the sample population estimates are given as percentages, not actual quantities – i.e. *x* per cent of points on the sand dune *were* covered by vegetation; *x* per cent of points on the sand dune *were not* covered by vegetation.

The formula for calculating standard error using binomial data is:

$$SE = \sqrt{\frac{p \times q}{n}}$$

where: *p* = the percentage of occurrence of points in one category
q = the percentage of points not in that category
n = the number of points in the sample.

A random sample of 50 points was taken over an area of sand dunes similar to those found at Morfa Harlech (Figure 6.33). Of the 50 points, 32 lay on vegetation and 18 on non-vegetation (sand) which, expressed as a percentage, was 64 per cent and 36 per cent respectively. How confident can we be about the accuracy of the sample?

$$SE = \sqrt{\frac{64 \times 36}{50}} = \sqrt{46.08} = 6.79$$

As the sample found 64 per cent of the sand dunes to be covered in vegetation and knowing the standard error to be ± 6.79, we can say:

1 with 68 per cent confidence, that the vegetated area will lie between 64 per cent ± 6.79, i.e. between 57.21 and 70.79 per cent
2 with 95 per cent confidence, that it will lie between 64 per cent ± 2 x *SE* (2 x 6.79 = 13.58), i.e. between 50.42 and 77.58 per cent will be vegetated
3 with 99 per cent confidence, that it will lie between 64 per cent ± 3 x *SE* (3 x 6.79 = 20.37), i.e. between 43.63 and 84.37 per cent.

Minimum sample size

It seems obvious that the larger the size of the sample, the greater is the probability that it accurately reflects the distribution of the parent population. It is equally obvious that the larger the sample, the more costly and time-consuming it is likely to be to obtain. There is, however, a method to determine the minimum sample size needed to get a satisfactory degree of accuracy for a specific task, e.g. to find the mean diameter of pebbles on a spit, or the amount of vegetation cover on sand dunes. This is achieved by reversing the two standard error calculations.

For measured data: Imagine you wish to know the mean diameter of pebbles at a given point on a spit to within ± 0.1 cm at the 99 per cent confidence level.

The 99 per cent confidence level is 3 x *SE.*

$$3\,SE = \frac{3s}{\sqrt{n}}$$

$$\text{i.e. } 3s = 0.1\sqrt{n}$$

$$\text{i.e. } \frac{3s}{0.1} = \sqrt{n}$$

We determined earlier that *s* (standard deviation of the sample) for the pebble size was 0.4, and so by substitution we get:

$$\frac{1.2}{0.1} = \sqrt{n}$$

$$\text{i.e. } 12 = \sqrt{n}$$

$$n = 12^2$$

$$n = 144$$

We would need, therefore, to measure the diameter of 144 pebbles to get an estimate of the parent population at the 99 per cent confidence level.

For binomial data: How many sample values are needed to estimate the area of sand dunes which is vegetated, with an accuracy which would be within 5 per cent of the actual area (i.e. at the 95 per cent confidence level)?

$$n = \frac{p \times q}{(SE)^2}$$

Again by substitution we get:

$$n = \frac{64 \times 36}{(5)^2}$$

$$n = 92.16$$

We would therefore have to take a sample of 93 values to achieve results within 5 per cent of the parent population.

The need for rural management

As was shown on Figure 17.4, there is often considerable competition for land in most rural areas and, therefore, there is a need, in most people's opinion, for careful management. In Britain, this management may be the task of national, local or voluntary organisations such as the Department of the Environment, the various National Parks Planning Boards (Places 92, page 592) and the Council for the Protection of Rural England (CPRE). Pressures on rural areas increase towards large urban areas where there is a greater demand for housing, shopping, business parks and recreational facilities (Figure 14.20 and pages 433 and 567). Pressure on the land may be even greater in economically less developed countries where the need to improve people's basic standard of living is likely to take preference over management schemes.

One attempted management scheme in a developing country is described in Places 80. It draws together several topics discussed in this book, i.e. an island (Chapter 6) with interrelated ecosystems (Chapter 11) offering alternative, rural land use possibilities (Chapter 17), where the population is increasing (Chapter 13) and wishing to improve its standard of living (Chapter 21), thus putting pressure on natural resources (Chapter 17).

Places 80 Mafia Island, Tanzania: rural management

Over two-thirds of Tanzania's 900 km long coastline consists of three fragile ecosystems – a fringing coral reef, separated from mangrove swamps on the mainland by a lagoon. Mafia Island, where the coral reaches above sea-level, is a national marine park.

An island management plan was put forward in the 1990s to try to maintain economic development, to conserve resources for future generations and to avoid conflict between different land uses and users. Some of the various economic activities threatening the fragile island ecosystems include the following:

- **Coral mining** The removal of live coral for the tourist and curio trade, and of fossilised coral rock for building purposes (Places 37, page 302). For lime, the rock is burnt over fires made from locally collected wood.
- **Fisheries** At all scales from subsistence to commercial, taking fin-fish, octopus, crayfish and edible shellfish.
- **Dynamite fishing** The illegal use of dynamite to stun and kill fish. This destroys the physical structure of the reef and kills virtually every organism within 15 m of the blast.
- **Seaweed farming** Important as a means of diversifying income but suffers from the problems associated with cash crops and could lead to biodiversity loss through the creation of monoculture (page 501).
- **Salt production** By evaporation: hyper-saline seawater is boiled using local mangrove wood for fuel, a crude process that can cause the denudation of large areas of mature trees.
- **Tourism** A rapidly growing industry and one that the government is keen to promote. Coastal tourism includes game-fishing, 'sea-safaris', diving, snorkelling and beach activities. Tourists, per capita, are major consumers of resources (drinking water, fuel and foods), can damage the natural environment (new hotels, destruction of the reef) and can cause cultural conflicts (dress code in a Muslim country).
- **Off-shore gas extraction** From the small Songo-Songo gasfield.
- **Farming** Pesticides entering the lagoon behind the roof are killing coral.

A new management approach

This aims to satisfy economic, social and environmental objectives in order to ensure:

- the maximum sustainable economic benefit from the long-term use of natural resources
- the maintenance of the conditions and productivity of the natural environment
- the allocation of resources between competing uses and users.

These aims are often seen as contradictory, and the main problem is how to cope with the diverse requirements of the different user-groups, especially those who utilise finite resources.

Developing a management model

To achieve an understanding of the nature and conditions of the resources in a proposed management area, the following considerations should be explored:

- **Political factors** What is the scale and structure of the area? Is it stable? Who will pay? Can it provide finance or secure funding? Who will advise? Are there powerful interest groups either for or against?
- **Physical factors** What are the main physical features? Are these stable? Are there any natural hazards?
- **Biological factors** What biological communities exist? In what condition are they? Are there records of change or overuse over a period of time? Are there species of endangered, cultural or commercial importance?
- **Socio-economic** What are the current uses of the area? Who uses it? Are they traditional or local uses? Have they a commercial interest? How are the resources exploited? Are these practices sustainable or destructive?

Once an area has been chosen, four stages can lead to a practical plan for its creation as a multi-user management scheme:

1. The definition of management goals – normally including conservation, sustainable resource use and economic development (Framework 16, page 499).
2. The establishment of an administrative authority – the process of human representation.
3. The formulation of a management strategy and objectives – an assessment of the physical and human characteristics of the whole area and, within it, sub-zones.
4. The development of legislation – to achieve the objectives.

But remember – no plan should be considered as final – it is simply an improvement on what was done before.

Rural conflicts in south-western USA

Case Study 17

Figure 17.15

National Parks and Recreation Areas in south-western USA

The scenery of the mountain states of western USA is spectacular and varied. It includes some of the country's highest peaks, as well as extensive desert and wild river scenery. Yellowstone was set up in 1872, and is arguably the world's best known National Park with its variety of mountain and volcanic scenery, geysers, hot springs, canyons, lava flows and wild-life including bear, elk and buffalo (bison). Tourists from all over the world now flock to the region to visit the large number of designated National Parks, Monuments and Recreation Areas. Figure 17.15 indicates the accessibility of the most popular attractions for visitors from major cities and international airports. Over 30 million people live within 500 km of the major National Parks and Recreation Areas.

The National Parks were set up to preserve and protect the environment for future generations. Visitors are encouraged to stay, but apart from workers associated with the National Park there are no permanent residents within the parks. (This is a major difference from National Parks in the UK where farmers and other residents live on the land throughout the year.) Lodges, hotels, tourist villages and regulated camping grounds are provided, together with well-made roads and tracks to the different scenic attractions. This contributes to visitor pressure on 'honeypot' sites such as Old Faithful in Yellowstone where people wait for the geyser to blow once every 85 minutes (Figure 17.16). There are traffic jams as cars stop to watch animals such as bison grazing or herds of elk close to the road (Figure 17.17). Roads are closed by rangers if pressure is considered too great.

Visitor numbers to the Parks and Recreation Areas in the mountain states have continued to increase. Many come in private cars, camper vans and buses. Park authorities are working to provide better traffic management, which includes vehicle

Figure 17.16

Old Faithful, Yellowstone National Park

restriction. The most popular 'round tour' of parks includes those located in Utah and neighbouring Arizona. Of these, by far the most popular are the Grand Canyon National Park with 4.4 million visitors in 2007 (Figure 7.19) and the Glen Canyon National Recreation Area with 1.9 million visitors (Figures 17.22 and 17.23). Both of these areas stretch along the sides of the Colorado River but their access and uses are very different, as most visitors to the Grand Canyon travel to the North or South Rim to look down at the river flowing 1.6 km below them, whereas at Glen Canyon people have access to Lake Powell which was created by damming the river.

At present most visitors to the Grand Canyon go to the South Rim, mainly because it has easier access, more facilities and better panoramic vistas although the North Rim, which is closed by snow in winter, is becoming increasingly popular. The Canyon itself continues to attract rafting and canoeing enthusiasts but their number is strictly limited to protect the natural habitat along the river banks. At the western (downriver) end of the National Park is the Lake Mead National Recreation Area which has taken advantage of the lake created by the construction of the Hoover Dam (Figure 17.18). This dam, known as the Boulder Dam when it was built in the 1930s, has created a lake which has a shoreline of over 1100 km and whose water is used for irrigation, to provide hydro-electricity for the local area and recreation opportunities for lake cruising, boating and swimming. The dam is only half an hour away from the 'bright-lights' of Las Vegas.

The numbers visiting Utah's five National Parks of Arches (Figure 17.19), Bryce Canyon, Canyonlands, Capitol Reef and Zion doubled between 1982 and 2007. These parks, together with smaller protected areas such as Goosenecks State Park (Figure 17.20) and, straddling the border with Arizona, Monument Valley Navajo Tribal Park (Figure 7.25), offer some of the world's most spectacular desert and river-eroded (canyon) scenery. Visitors using motor caravans, 4x4s or tourist buses can manage to visit all of these attractions in a week, but for those who are more energetic, twice that time is preferable. At places like St George, near to Zion National Park, and Moab, close to Arches National Park, many holiday lodges and small hotels have been built, together with housing for 'retirees' wishing to move away from large urban areas.

Figure 17.17

Yellowstone National Park: bison grazing on the verge; the vegetation is recovering from a brush fire

Figure 17.18

The Hoover Dam and Lake Mead

Rainfall is low in the Basin and Range province lying between the Sierra Nevada, which forms the border with California to the west, and the Rocky Mountains in the east. Although the states in this region now rely upon tourism as their major source of employment, the rural economy also depends on ranching, irrigation and mining.

In an area that is naturally short of water, and where the problem has been accentuated by recent droughts, it is not surprising that there should be conflicts over its use. In the last three or four decades there has been rapid in-migration to the region, particularly to the larger urban areas of Salt Lake City, Phoenix and Las Vegas. These, and other smaller towns, are growing as more people decide to move here partly for the climate and partly as they choose to work from home using computers and other electronic equipment.

Increasing amounts of expensive water are taken by canal and pipeline to fill the swimming pools of new houses and to work the fountains of Las Vegas. This extra water means there is less for agriculture, yet farming itself needs more as the extra fruit and vegetables demanded by both new residents and tourists can only be grown

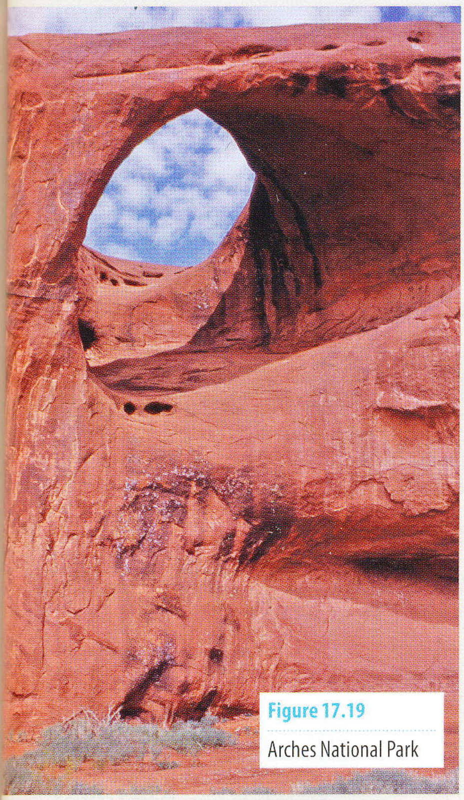


Figure 17.19
Arches National Park

Figure 17.20
Gooseneck State Park, Utah

Figure 17.21
Irrigation on rangelands near Salt Lake City

under irrigation. Irrigation is also necessary close to cities where good-quality pasture land is needed if dairy cows are to be reared for their milk, butter and cheese, as well as in more remote areas where it helps produce the silage for beef cattle (Figure 17.21). There are also water disputes between individual states.

Traditionally, several of the south-western states were important mineral producers, especially of copper, silver and gold. Much of the easily obtained and higher-quality ores have already been used, while falling world prices and rising extraction costs have forced the closure of all but the most profitable of mines, leaving scars on the landscape.

Glen Canyon National Recreation Area

This Recreation Area is based on Lake Powell (named after Major Powell who led the first expedition down 1600 km of rapids in the Colorado River), which is the country's second largest artificial reservoir. Despite a hard fight by conservationists, the Glen Canyon Dam was begun in 1956, completed in 1963 and the reservoir had filled by 1972. When full the lake – which accounts for only 13 per cent of the total Recreation Area – is 300 km long and has a shoreline of 3000 km due to its zigzagging through 96 major canyons. High water, reached in the mid-1980s when the lake was over 125 m deep, is marked by a white ring etched into the red canyon walls. Since then the onset of numerous drought years has resulted in a drop in the lake level, by 2005 of over 30 m, and its volume has decreased by one-third. The fall in level revealed petroglyphs (indian carvings, compare Figure 7.7) and enabled visitors to walk (rather than visiting by boat) into some of the tributary canyons. It also meant the exposure of huge areas of mud at the head of the drawn-down reservoir and the closure of marinas, as at Hite. Since that time the wet winter of 2005 and record snowfalls in 2008 have seen the levels of Lake Powell rise by 15 m – equal to half its previous fall.

The lake is ideal for water sports such as canoeing, water boarding, water-skiing, wind-surfing, scuba diving and fishing. Most tourists hire houseboats whose lengths range from 15 to 25 m and which can cost up to $14 000 a week to hire. The latest houseboats, which can sleep 8 to 12, come with a hot tub, a wet bar and a 120cm flat-screen TV. Around the shores of Lake Powell are six marinas (Figures 17.22 and 17.23) with the names of Bullfrog, Hite, Wahweap, Hall's Crossing, Dangling Rope and (the latest) Antelope Point. On land there are wilderness trails and back-country roads which can only be used by four-wheel-drive vehicles, but which give access to isolated geological, historical and archaeological sites, such as the Rainbow Arch Monument Park.

Environmental damage is evident along the busiest stretches of shoreline. 'Adopt-a-Canyon' has become a slogan, encouraging visitors to take out everything they take in. Water quality is constantly tested and water-skiers are designated to specific areas. Summers can be extremely hot – up to 43°C – while winters, when fishing is almost the sole recreational activity, are very cold.

A survey of visitors in 2007 showed that 48 per cent were aged in the 41–65 age group; 78 per cent had visited before; people came from 48 states and 21 countries; and most came for either the scenery or for motorised boating. Over 85 per cent found the quality of services, facilities and recreational opportunities as 'very good' or 'good'.

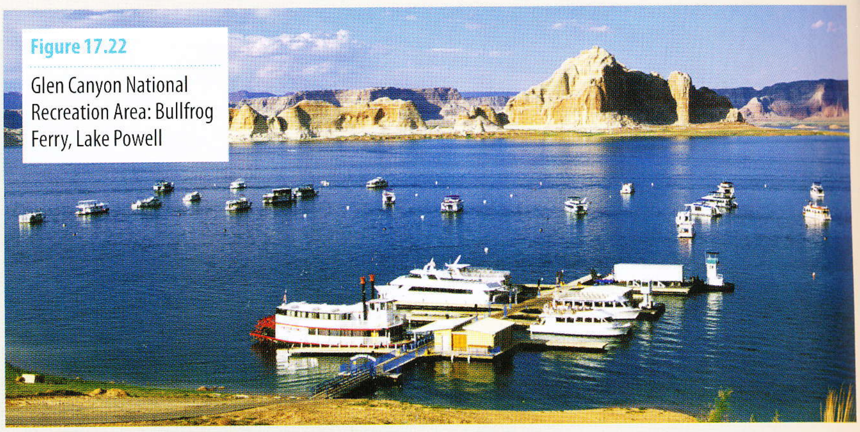


Figure 17.22
Glen Canyon National Recreation Area: Bullfrog Ferry, Lake Powell

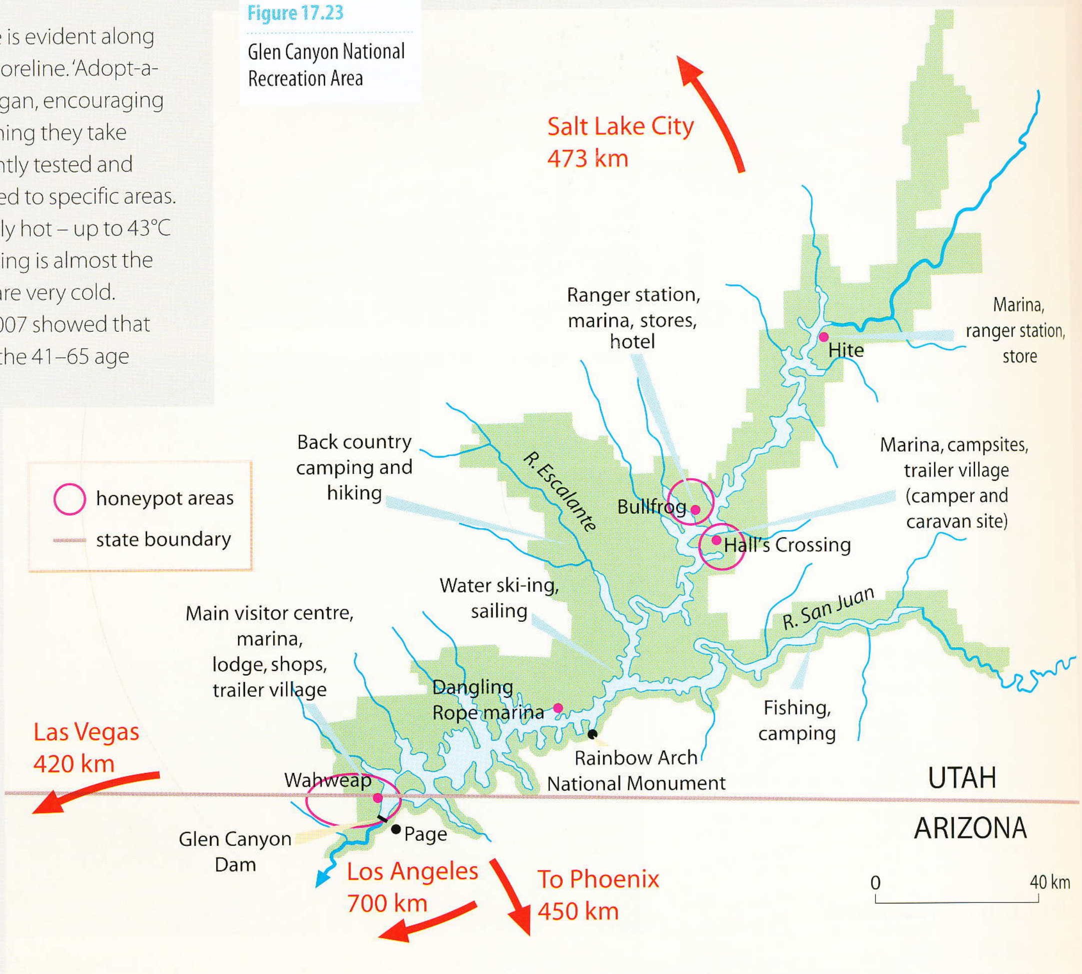


Figure 17.23
Glen Canyon National Recreation Area

Further reference

Pickering, K.T. and Owen, L.A. (1997) *An Introduction to Global Environmental Issues*, Routledge.

Wilson, J. (1984) *Statistics in Geography for A Level Students*, Schofield & Sims.

Council for the Protection of Rural England:
www.cpre.org.uk

Finnish Forest Association:
www.metla.fi/forestfin/intro/eng.index.htm

Forestry Commission of Great Britain:
www.forestry.gov.uk/

ForestWorld:
http://forestworld.com/

Natural England:
www.naturalengland.org.uk

UN Food and Agriculture Organisation Forestry:
www.fao.org/forestry/home/en/

Questions & Activities

Activity

1 a 'Forestry is not usually economically viable in developed countries unless supported by the state with subsidies.'

Explain the advantages of forestry in rural areas of the United Kingdom, giving:

i two socio-economic advantages *(4 marks)*

ii two environmental advantages. *(4 marks)*

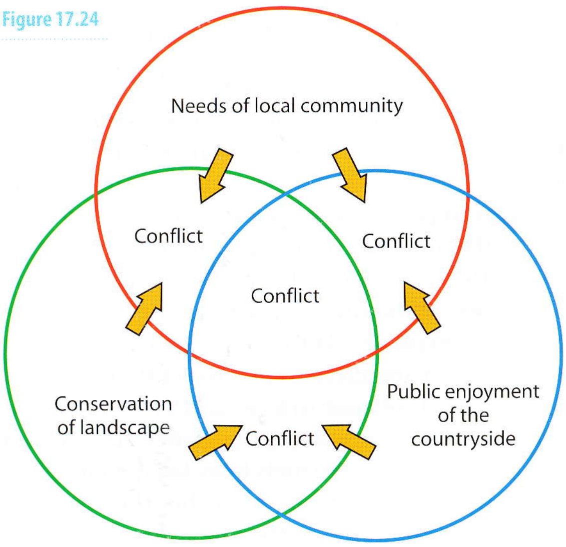
b i Explain why some people think that commercial forestry plantations have caused environmental damage in some parts of the United Kingdom. *(4 marks)*

ii 'In the last decade ... forest operations have been transformed, with a shift towards smaller-scale practices which are more environmentally and aesthetically sensitive.' Explain how the changes in forest management referred to above have improved the rural environment in parts of the United Kingdom. *(5 marks)*

c With reference to a named tropical country, explain how commercial forestry in the rainforest can be a form of sustainable development. *(8 marks)*

Exam practice: basic structured question

Figure 17.24



2 Study Figure 17.24. It shows how conflicts may arise in a rural area where recreation and tourism are important.

a Name a rural area in a more economically developed country where recreation and tourism are important, and where their development has caused conflicts with local people and conservationists. Describe conflicts in that area between:

i tourists and the local community

ii tourists and conservation

iii the local community and conservation. *(8 marks)*

b Explain how management of the area is attempting to reduce the conflicts described in **a** above. *(7 marks)*

c Can tourism ever lead to sustainable development in rural areas in less economically developed countries? Illustrate your answer with reference to one or more case studies. *(10 marks)*

Exam practice: structured question

3 a 'In the last decade ... forest operations have been transformed, with a shift towards smaller-scale practices which are more environmentally and aesthetically sensitive.'

With reference to a named area of forestry in the United Kingdom, explain how the changes referred to above have altered forest management practices. Explain how this has benefited the environment. *(10 marks)*

b i How has commercial forestry caused environmental damage in tropical regions? *(7 marks)*

ii Suggest how commercial forestry in tropical regions can be managed so that it is a sustainable form of development. *(8 marks)*

Exam practice: essay

4 Study Figure 17.24.

'The development of the tourist industry can bring both benefits and problems for communities and the environment of rural areas.'

Discuss this statement with reference to examples from more economically developed and less economically developed countries. *(25 marks)*