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ADVANCED GCE

GEOGRAPHY B

2692/RB

Issues in Sustainable Development

RESOURCE BOOKLET

JUNE 2010

This booklet is available for use by teachers and candidates not earlier than six working weeks before the examination.
It can be taken into the examination but must not be annotated in any way.

OCE/15249

INSTRUCTIONS TO CANDIDATES

You are reminded that this synoptic unit requires you to draw upon your knowledge and understanding of the relevant physical and human processes you have studied and the connections between different aspects of geography represented in your course. You will also be required to show a knowledge and understanding of the content of Module 2692 (Issues in Sustainable Development).

The Issue:

Destruction of the Forests

CONTENTS

This booklet is divided into five sections as listed below. It provides a range of information relevant to the selected issue that shows how the destruction of forest cover has led to environmental, social and economic problems at scales from local to global. It uses case studies to illustrate these problems and then examines the ecology and traces the history of British forests as a reminder that much of what is happening to forests today worldwide has happened in Britain as well.

INFORMATION FOR CANDIDATES

- This document consists of **40** pages. Any blank pages are indicated.

A guide to using the resource booklet during the study period

You have several weeks in which to study the chosen issue, but you will probably already have undertaken some work on it in class. You will spend some of the study time working on your own, but it would be best if some of the activities listed below could be done as part of group discussions. There is no reason why the group should not share the search for other sources.

Remember as you use these resources that many are not taken from textbooks. They come from original sources and are written in language suitable for a particular purpose – you might like to discuss that purpose to see if any bias is evident.

Suggestions for studying:

- To begin with, pick out the different sections of the booklet and skim read them to check that you have a good idea of what each is about. Start with Section A.

- Now read each section more carefully. Try to summarise in as few words as possible the key points in the text, tables or figures.

- List all the technical and geographical terms used. Make sure you understand the meaning of any ones new to you.

- Look out especially for those parts concerned with location, spatial patterns and people/ environment interactions – the geography.

- Now try out some of these questions on the different parts of the booklet;

  – How are human activities affecting the physical environment?

  – What are the interactions between physical and human processes?

  – To what extent are the situations described sustainable/unsustainable? What solutions to the issue are proposed?

  – What solutions, or mix of management strategies would best meet the criteria for sustainable development?

- Look at previous question papers, noting how the questions are phrased to encourage you to draw upon your whole understanding of geography and to use the resources selectively to illustrate your answers.
  Use the page numbers to refer to the resources.

- Think about how your studies in other parts of your A level course, as well as in the Issues in Sustainable Development module, might contribute to your understanding of this issue.

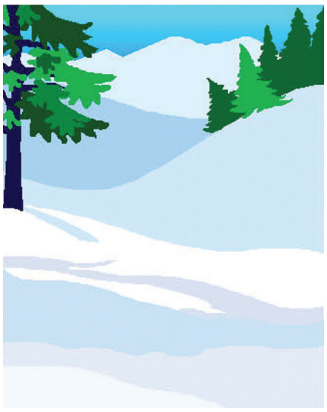
- Extend your knowledge of this issue by finding out what is happening in your home area or different contexts from that presented in the resource. You could also search for other sources. These may include texts, articles, websites and official reports.

References to published resources used in this booklet:

Author	Publication	Resource pages
Bellamy, David 2001	**In my opinion**. *Geographical, Vol. 73 No 5 May 2001*	5
Flint, David 1999	**Managing Resources.** *Hodder and Stoughton, London ISBN 0-340-730889*	22, 23, 24
Kidd, Adrian 1999	**Managing Ecosystems**. *Hodder and Stoughton, London ISBN 0-340-72495-1*	10, 11, 12, 17, 18, 19
Myers, Norman (Ed.) 1985	**The Gaia Atlas of Planet Management**. *Pan Books, ISBN 0-330-28491-6*	6, 7, 8, 9, 35, 36, 37, 38
Rackham, Oliver 1997	**The Illustrated History of the Countryside**. *Phoenix Illustrated London ISBN 1-85799-953-3*	31, 32, 33
Rae, Alison 1996	**Some managed environments in Britain**. *Geofile No 288*	25, 26
Wood, David 1996	**The fuelwood crisis in Africa.** *GeoActive No 137*	20, 21
Woodfield, Judith (Ed.) 1994	**Ecosystems and Human Activity**. *RSPB and Collins Educational ISBN 0-00-326644-3*	14, 15, 16, 28, 29, 30

Section A: Identify the Issues

- Why forests are important
- Harvesting the forests
- The implications of this harvest



David Bellamy lets off steam about the importance of restoring Earth's natural forests in an attempt to reduce the threat of global warming

In 1997, the Third Conference of Parties (COP) to the UN Framework Convention on Climate Change met in Kyoto, Japan. The results of the COP was the Kyoto Protocol, in which several articles recognised that forests are a source of atmospheric CO_2 as well as providing opportunities to reduce emissions or increase removals of CO_2 from the atmosphere (often referred to as 'sinks').

If the argument against using forests to absorb or reduce CO_2 emissions were accepted and forestry were excluded from the Kyoto Protocol, a tremendous opportunity would be missed – the opportunity to reduce the threat of global warming while restoring some of the natural forest cover we have lost over the last decades, with the accompanying benefits of enhanced biodiversity, habitat, water quality and local climate.

It is suggested that increasing carbon stored in forests will not halt global warming, but rather the burning of fossil fuels must be slowed. Much of the opposition to using forests as carbon sinks stems from the ideological beliefs that the climate treaty should only be concerned with CO_2 emissions from the combustion of fossil fuel. This ignores the fact that an estimated 20–25 per cent of human-induced greenhouse gas emissions result from tropical deforestation and forest degradation, and that if these practices could be averted considerable amounts of emissions would be avoided. These beliefs also ignore the fact that replanting degraded land with forests removes CO_2 from the atmosphere. Yes, reducing the combustion of fossil fuels is essential, but it does not make sense to eliminate other environmentally and economically beneficial options.

The argument that 'using forests to sequester carbon is technically complex' does not hold water.

"Given the potential rewards, we must not let pass this unique opportunity to restore our planet's forests"

Scientists have been measuring forests for decades and have developed reliable methods for accurately and precisely measuring carbon stored in live and dead forest biomass, including sampling, direct measurement and extrapolation. There are techniques for estimating carbon gains in all components of a forest in ways that ensure carbon credits are not over-estimated. Many pilot projects have demonstrated that reliable measurements can be made. These include efforts of companies such as Winrock International and SGS for projects with sponsors including The Nature Conservancy, Pro-Natura and the Government of Costa Rica.

Perhaps the most frequently used argument against using forests as carbon credits is that it would allow nations, especially the USA, to shirk their responsibilities. Yet President Bush has said that he wants to "reforest the tropics". He should be given a chance to do so. With a tough international agreement defining which sorts of forestry activities qualify and laying out environmentally rigorous accounting rules, rich countries' emission-reduction targets could mitigate greenhouse gas emissions and bring financial and environmental benefits to the developing world. And it really doesn't matter where the reductions take place – climate change is a global problem.

An estimated cumulative 86 per cent of past CO_2 emissions related to fossil fuel have come from developed countries. Currently 45 per cent of total emissions are estimated to come from developing countries, when deforestation is included. The important thing is to get all countries involved in all aspects of the solution to this serious problem.

Plantations of exotic species, which can indeed be bad news for the poor and the environment, come in for special criticism. However, Kyoto Protocol rules can be fashioned so that such plantations would not receive credits. The government of any country in which a reforestation project is located can refuse to allow carbon credits for a project if it does not meet sustainable development criteria.

Those of us who have seen the global destruction of tropical rainforests know that, where there is any residue of natural forest, recovery is possible. There has been a lot of successful research into ways of propagating tropical hardwood trees. Natural or assisted regeneration of forests on degraded lands, with long-term conservation, should be the most common type of carbon sink project. Preventing deforestation to avoid carbon emissions should earn credits as well.

The poor in these areas could have their poverty alleviated without incurring debt. Any successful carbon sink project in these areas will include a component that provides economic benefit from the forest for the local population. This is necessary for the success and longevity of these projects.

Turn over

Harvesting the Forest

Forest products represent one of our most valuable categories of cash crops. As such, they are widely traded around the world, albeit with unequal patterns between the developed and developing worlds. This trade is likely to expand, especially in so far as two of the main consuming regions, Japan and Western Europe (outside Scandinavia), intend to continue to import huge volumes, even though they could grow more wood at home. (Britain, for example, which imports nine-tenths of its wood needs, could reduce its demand by planting more trees on under-utilised land in Scotland.)

Demand for paper alone in the developed world rose by a factor of 2.75 during the period 1975–2000, while developing nations, with their expanding populations, increased their consumption three-fold. Worldwide demand for paper is likely to double again by the year 2050. The average Northerner consumes more than 150 kg of paper a year, compared with the Southerner's consumption of 5 kg.

Product demand in the North…

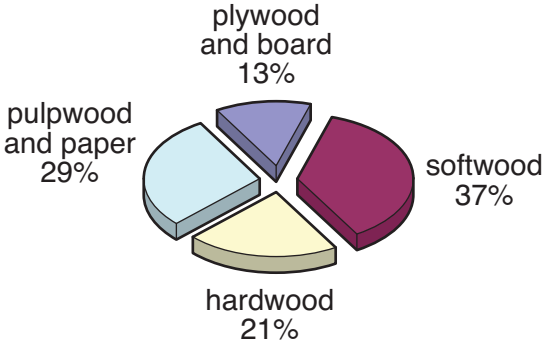
Northerners use huge amounts of wood for constructing houses, office buildings, railway sleepers, pit props, and the like. They also consume a great deal of paper products (notably packaging materials), as well as luxury hardwood items.

... and South

Southerners likewise consume much wood, but mostly for fuel. Almost all houses in the Third World use wood, but not as high-grade construction material, rather as simple building poles. As for paper products, the average Southerner consumes all too little – to the detriment of education and communications.

Trade in forest products

Unprocessed hard and softwoods account for just over half of world trade. Pulp and paper make up about a third.



The forest cash crop

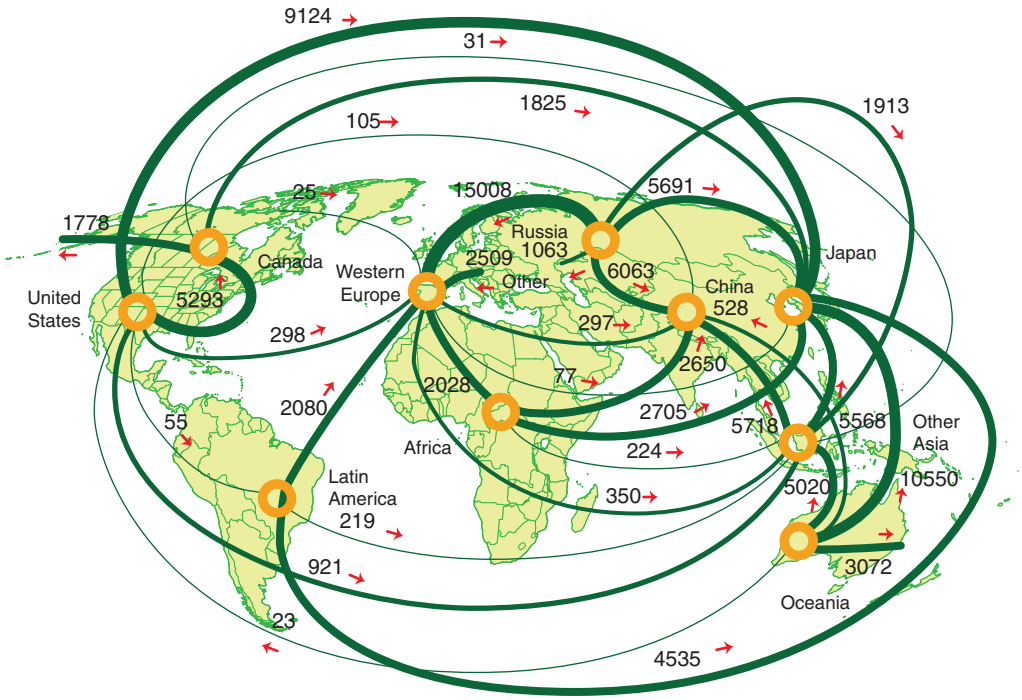
More people everywhere want more wood. We presently consume about four billion tonnes per year, more than half of it is as fuel and it could easily soar to six billion before the middle of the 21st century.

In the developed world, a large amount of wood is used for paper: almost 200 million tonnes of pulp a year, compared with the developing nations' consumption of around 25 million. Developing nations have powerful incentives to develop their own sources of pulp, as they import virtually all their supplies at a cost that nearly wipes out their earnings from hardwood exports. As literacy increases in the developing world, so the demand for paper there increases too.

As for industrial timber Northerners increasingly seek specialist hardwoods, notably those from the tropics, for constructional and semi-luxury purposes. By contrast, timber in the South is used mostly for essential purposes. At least one billion Southerners can be described as living in the Wood Age. Yet because prices for wood are determined internationally, and thus tend to be set by consumption in the North, Southerners find themselves squeezed out of the market place. When Northerners have to pay a little more for stylish veneer or a newspaper, there may be complaints about inflation, but the upshot does not generally affect living standards. For a person in the South an increase in price often means doing without.

These imbalances are aggravated by the forestry policies of several developed nations. Japan, for example, fears for its economic security in world wood markets. Hence it adopts a 'siege strategy' by building up its own forest stocks and growing more wood than it cuts, while depending heavily on foreign sources of timber. Within the context of Japan's own needs, this approach makes sense. But within a global setting, it illustrates the 'tragedy of the commons' and will ultimately paint Japan itself into an ever-tighter corner.

Main net flows ('000 $m^{3)}$ of wood raw materials in 2000

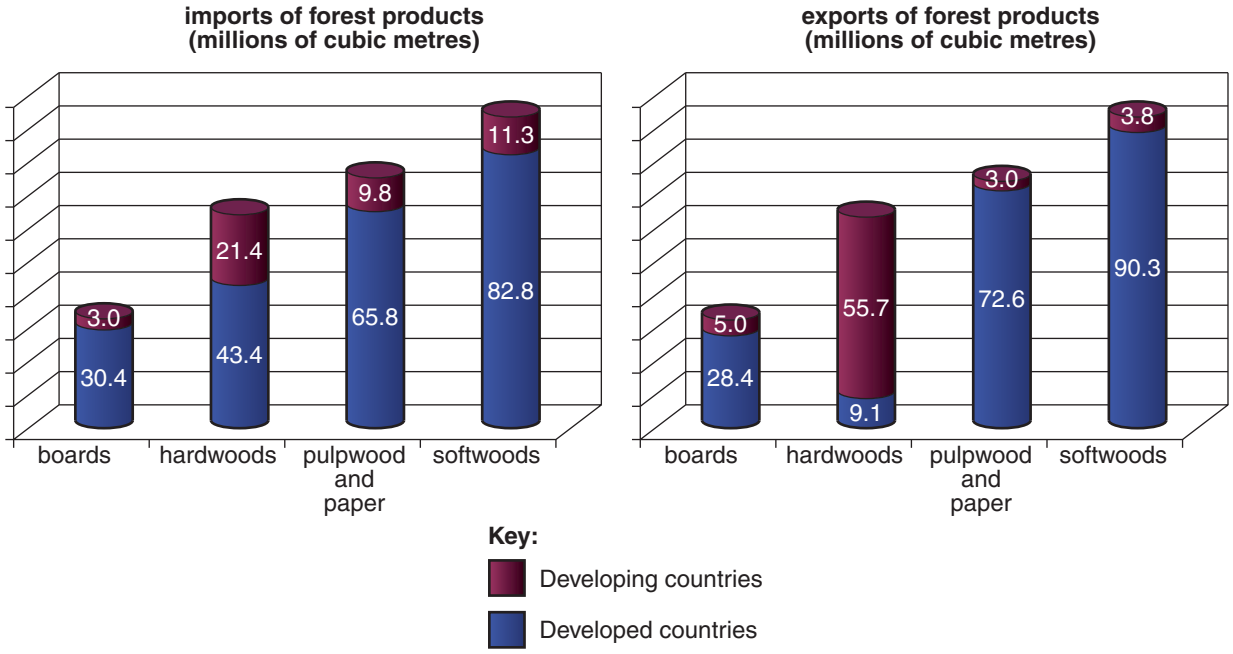


World trade

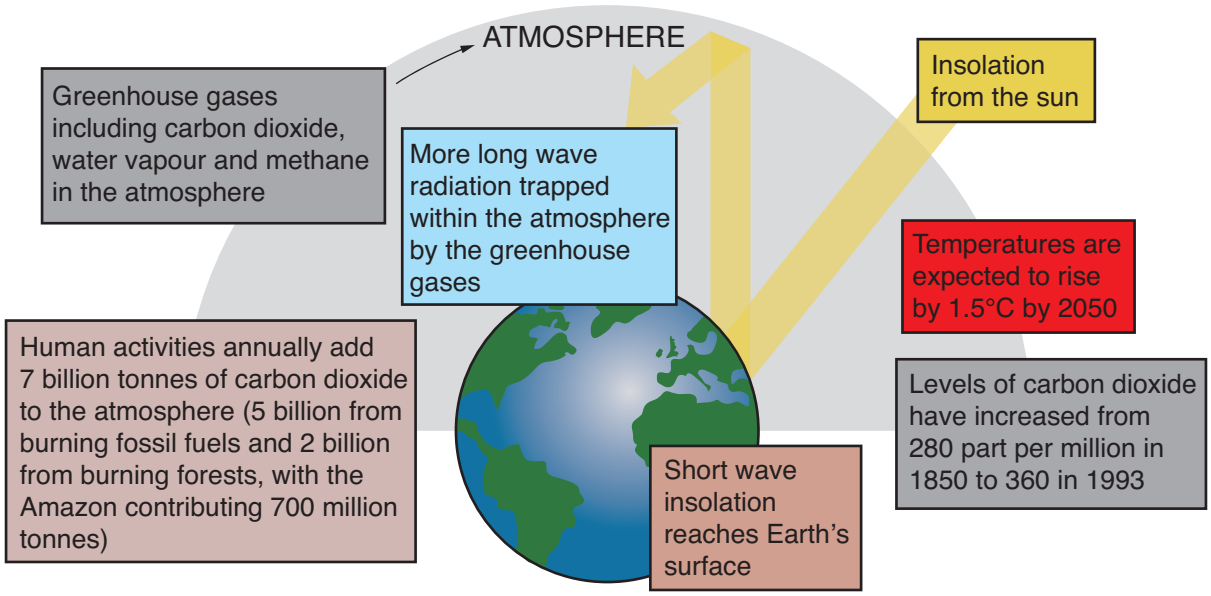
What patterns of trade are suggested by the map? Most of the hardwood products are sourced from developing countries, while softwoods are produced by Northern countries. How and why have markets changed and grown? China, with its rapid industrialisation, has rapidly increased its consumption of wood products. What effect is the move towards sustainable forestry having? Why is timber an important commodity in world trade?

A source of revenue

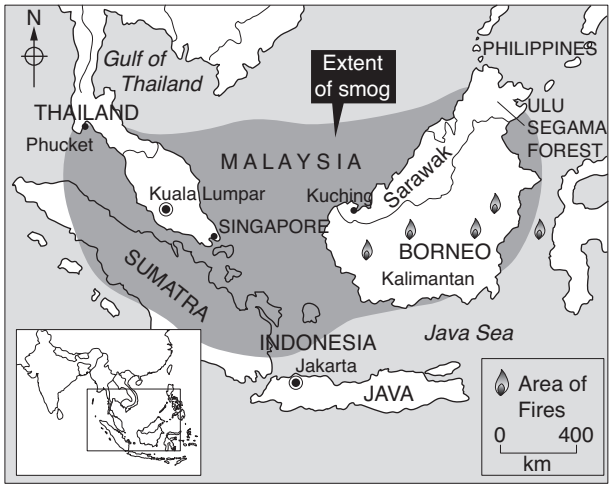
When large numbers of huge logs are taken from a Southeast Asia forest (photo, top right), at least half of the remaining trees are injured beyond recovery. Yet the logger does not care, as long as there is enough forest to last for the next few years. Governments could be much tougher in enforcing less harmful harvesting techniques, but the need for hard cash often means that they fail to see their forests as sources of future revenue. Fortunately a partial breakthrough is on the way, in the form of increased wood processing: the veneer sheet (photo, bottom right) earns several times more foreign exchange than a raw log, thus relieving pressure to exploit every forest tract.


imports of forest products
(millions of cubic metres)
3.0
30.4
21.4
43.4
9.8
65.8
11.3
82.8
boards
hardwoods
pulpwood and paper
softwoods
exports of forest products
(millions of cubic metres)
5.0
28.4
55.7
9.1
3.0
72.6
3.8
90.3
boards
hardwoods
pulpwood and paper
softwoods
Key:
Developing countries
Developed countries

The implications of the forest harvest



The felling and burning of the forests is believed to be having a major impact on the climate of the world by increasing levels of carbon dioxide in the atmosphere. In September 1997, the issue of tropical rainforest destruction was brought to the attention of the world's media, when it was combined with two other environmental concerns. A major pollution incident covering large areas of south east Asia, and centred on Indonesia and Malaysia, occurred due to the burning of large areas of rainforest in Indonesia. The burning became uncontrollable, as the area was already being affected by a drought, thought to be the result of the El Niño effect in the Pacific Ocean.



The high smoke levels trapped gases, including carbon monoxide, nitrous oxide, sulphur dioxide and ozone, especially in urban areas such as Kuching and Kuala Lumpur, producing a dangerous photochemical smog.

In 2001, the problem recurred.

South-east Asia choked by smog from jungle fires

By Richard Lloyd Parry, Asia Correspondent
***From* The Independent 13 July 2001**

Choking smog from fires in Indonesia is once again threatening tourism, transport and health across south-east Asia.

In recent days, dangerous levels of smoke have been recorded in Indonesia, Malaysia, Singapore, Brunei and Thailand, raising fears of a repeat of the 1997 crisis when thousands of people became ill, and billions of pounds were lost in tourist cancellations, disruption to transport, sickness and absence from work.

In Pontianak, in the west of Indonesian Borneo, visibility is down to 50 metres and people have been urged to wear masks or stay indoors after midday. Flights have been delayed because of smog.

Earlier this week, poor visibility forced southern Thai fishermen to stay in port for fear of colliding with shipping. Malaysian schools have closed and those working outside such as street sweepers, wear masks.

The Malaysian government suppresses news of the air pollution index (API), to avoid discouraging tourists, and insists the smog is easing. But eye irritation and dense smoke are reported across the country, including in the tourist city of Penang. A spokeswoman for Malaysia's environmental department said this week: "We have been monitoring the readings and find that the API is quite stable and should come down in a day or two as we don't see any increasing trend. We don't want to confuse the public with numbers."

This week, however, Malaysia banned open fires, a mandatory step if the API rises above 100. Meenakshi Raman, of the environmental group Sahabat Alam, said: " The people who are monitoring the situation are not telling us what the haze situation is like. We can only guess how bad it is."

The last bad outbreak of 'haze', as it is euphemistically known, led to losses estimated at $9.3 bn (£6.6 bn). Smoke spread from fires in Indonesia's territories of Borneo and Sumatra, many started by plantation companies to clear jungle. But this time many fires appear to be underground, in the peat soil of the rainforest. These fires do not register on satellite images and are nearly impossible to put out. They can smoulder for years under the peat, generating no flames but a lot of smoke.

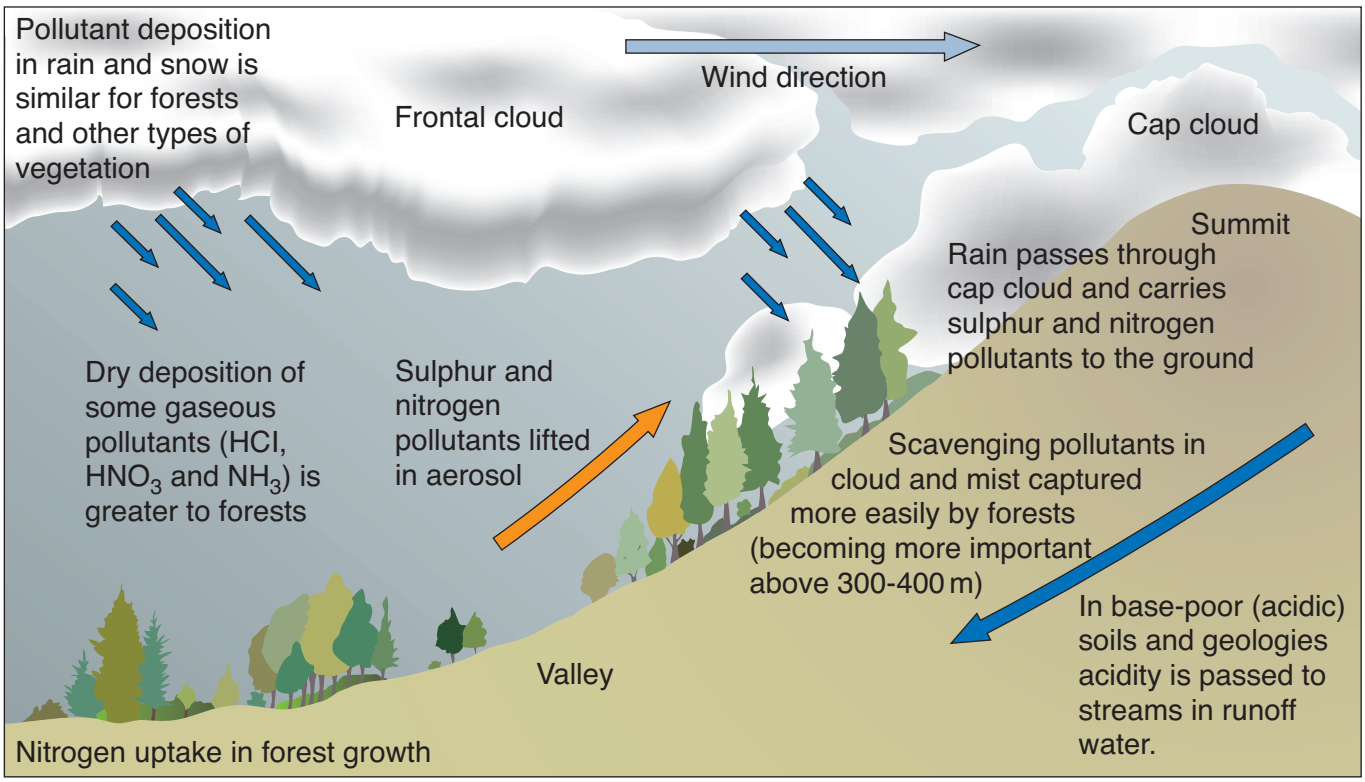
Appeals by other countries for Indonesia to act had little effect. "So far, we don't have a clear blueprint of how to cope with the problem," Marzuki Usman, Indonesia's forestry minister, said this week. "We will start to prepare it."

A summary of some of the impacts of rainforest destruction

Impact on the water cycle	• Bare soil increases surface runoff
	• Increased downstream flood risks
	• Rainfall reduced
Impact on soils and landforms	• Increased soil erosion as a result of sheetwash, gullying and aeolian processes
	• Increased risk of landslides
	• Increased sediment load in rivers
	• Loss of soil nutrients
	• Reduction in soil fertility
	• Formation of lateritic crusts
Impact on plants and animals	• Original primary forest destroyed or replaced by inferior secondary forest
	• Diversity of plant and animal species reduced
	• Transpiration reduced
Impact on the climate	• Bare soil increases albedo rate
	• Burning of trees increases CO_2 levels in the atmosphere contributing to global warming
	• Diurnal range of temperature increases
	• Rainfall decreases
	• Less CO_2 absorbed and less oxygen produced
Impact on native populations	• Loss of traditional way of life
	• Loss of land
	• Introduction of new diseases

Section B: Five Case Studies

- Acid rain
- Effects on wildlife
- Amazon Basin and dry tropical forests
- Russia
- Ashdown Forest



Acid rainfall in coniferous forests

Afforestation and stream acidity

It is widely accepted that some rivers and lakes have become increasingly acid in the 20th century because atmospheric pollutants, especially sulphur dioxide, are deposited as acid rain. This has been noted particularly in Scandinavia, North America and Great Britain.

In Great Britain the acidification has been linked with the planting of conifer forests of non-native species. Some ecologists think that afforestation may have the following effects:

- The tree crowns can trap acid pollutants and salts easily because of their shape
- Forests give off more water vapour than moorland, so acid pollutants become concentrated
- Chemical processes take place in the tree crown, particularly the uptake of ammonium and release of hydrogen
- Planting trees causes the soil to dry out. This causes greater oxidation of sulphur and nitrogen compounds in the soil
- The drying of soil causes cracks in the peat. The cracks and forest drains (which are dug when planting takes place) mean that water moves in an unnatural way through the forest
- Acidic humus produced by pine needles encourages increased soil acidity. Water moving through the soil will cause leaching. Both of these processes combine to increase soil acidification

Effect of afforestation on streams in Scotland, 1987

Waterway	Mean summer pH	Areas afforested (%)
Big Water of Fleet (A)	5.7	90
Big Water of Fleet (B)	6.6	30
Dalwhat Water	7.2	20
Garpel Burn	7.0	5
Garrouch Burn	7.1	5
Little Water of Fleet (A)	5.5	100
Little Water of Fleet (B)	6.1	40
Moneypool Burn	7.0	5
New Abbey Pow	6.7	10
Palnure Burn	6.7	80
Penkiln Burn	6.3	65
River Girvan	7.5	10
Scaur Water	7.5	10
Shinnel Water	7.5	35
Skyre Burn	8.1	0
Southwick Burn	7.1	10
Water of Cree	5.7	55
Water of Minnoch	6.3	85

Stream Acidity and Ecosystems

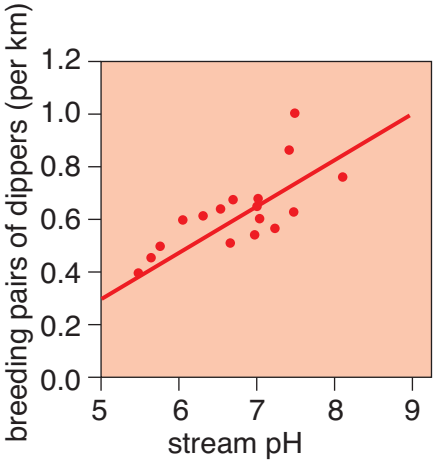
The effect of stream acidity on dippers

Dippers are birds that are closely associated with fast-flowing streams. They nest under bridges and in cavities in stonework. They feed on stream invertebrates by swimming under water to catch their prey.

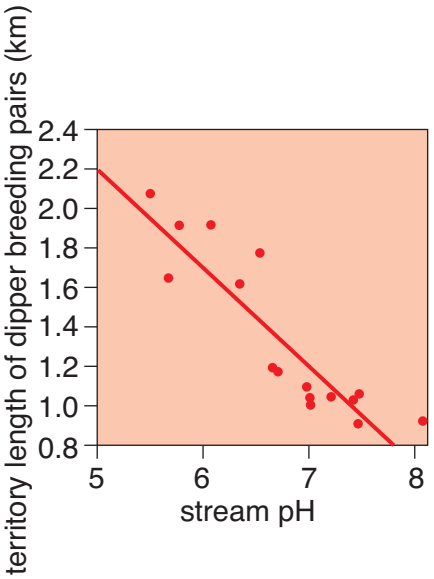
The breeding areas of dippers have been greatly changed by afforestation. Data have been collected to investigate the various factors affecting dippers.

Seventy-four streams in mid-Wales were surveyed. They were divided into those with dippers present and those without.

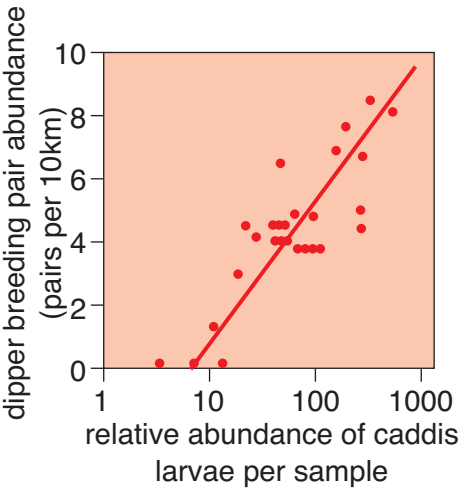
We can compare the difference between the streams with and without dippers and assess the statistical significance of the various factors. In this case a *t*-test is used. The results show that the probability of the differences in forest cover between streams with and without dippers being purely due to chance is very small indeed.



The relationship between stream pH and breeding density of dippers.



The relationship between stream pH and territory length of breeding pairs of dippers.



The relationship between the abundance of caddis larvae and the abundance of breeding pairs of dippers

Results of a dipper survey in mid-Wales

	Streams with dippers *X* (mean)	Streams without dippers *X* (mean)
Area of water catchment afforested (%)	8.4	96.3
Mean pH	6.4	6.0
Caddis larvae abundance index	12.5	4.8
Number of sites	*N* = 21	*N* = 53

Developments in the Brazilian Amazon

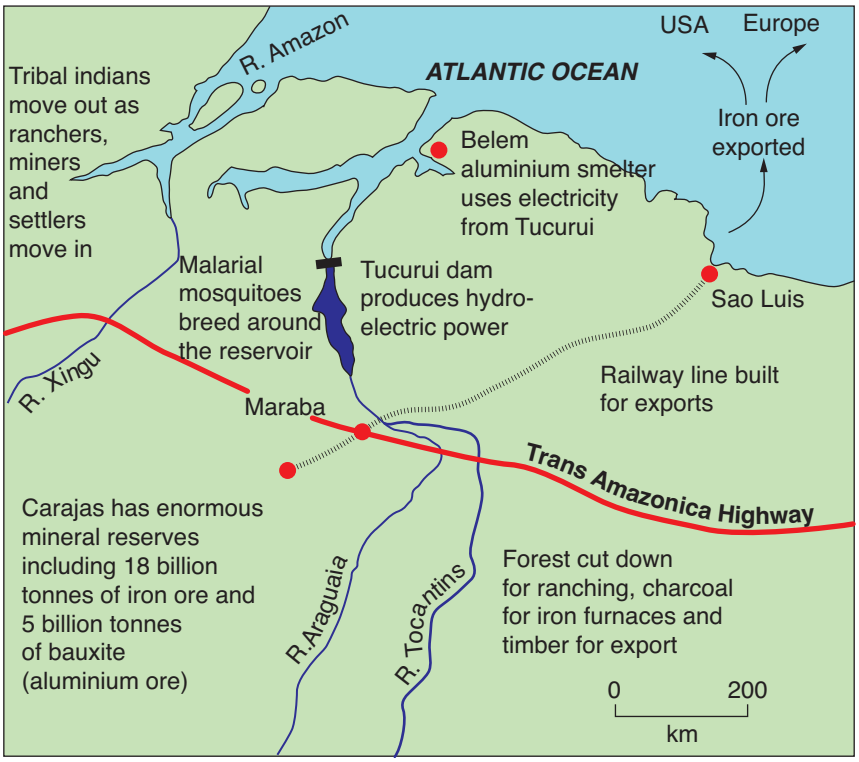
Brazilian Amazônia covers an area of over 5 million square kilometres, or 57 per cent of Brazil's land area. It contains only 4 per cent of the country's population, and generates only 2 per cent of the total Gross Domestic Product. Brazil is the world's eighth largest economy, and some of its population and economic details are shown below.

Population and economic data for Brazil						
Year	**Population (000)**	**Birth rate per 1000**	**Death rate per 1000**	**Natural increase %**	**Urban %**	**GNP per capita US$**
1997	169 872	27.0	7.0	2.0	76	3640
2007/8 (estimated)	198 739	18.0	6.4	1.2	86	10100

Brazil admits increase in burning of rainforest

Destruction of the Amazonian rainforest nearly tripled between the 1990–91 and 1994–95 burning seasons, according to information issued by the Brazilian government.

The figures show that 11196 square miles of Amazon rainforest were destroyed in the 1994–95 burning season, an area about the size of Belgium. In contrast, on the eve of the 1992 Earth Summit in Rio, deforestation had dipped to 4247 square miles. The figures issued on Monday show that 6950 square miles of the Amazon were destroyed from 1995 to 1996. Earlier this month a separate study issued by a congressional commission said 22393 square miles of the Amazon were being destroyed each year through deforestation.



The Carajas Project

New Development in Amazônia

The Greater Carajas Project is one of the 15 economic growth poles created in Amazônia by the POLAMAZONIA scheme. The Project is financed by a $2 000 000 000 loan from the World Bank and the European Union, and some of its features are shown below. The Project also involves the clearance of forest for extensive cattle ranching, but the poor nutrient status of the soil, following clearance, means that stocking levels are very low with 1500 cattle requiring 3000 hectares of grazing.

Developments such as the Greater Carajas Project have led to conflict between several organisations. The UDR, the cattle ranchers' organisation is generally in favour of the government's proposals, but FUNAI, the National Indian Foundation, supported by ecologists from Europe and the United States are campaigning for a more sustainable approach to development.

In August 1997 the Brazilian Government, in response to an upturn in the economy, announced seven new schemes for Amazônia, costing $3 bn and due for completion by 1999. It also proposes to build an additional 10 hydroelectric power stations.

In 1998, the Brazilian Government announced the creation of a 640 km long conservation corridor along the River Amazon, 400 kilometres west of Manaus. The designation of the Amara Sustainable Development Reserve (SDR) links the existing Mamiraua SDR to the west, and the Jau National Park to the east. The 'sustainable' designation of the Amara SDR will allow its 2000 inhabitants to remain in their homes, and be actively involved in the management of the reserve, which contains many endangered species including Amazonian manatees, black caimans, river dolphins, jaguars, black uakari monkeys, and harpy eagles.

The Impact of Rainforest Destruction

At a variety of scales, from local to international, the destruction of the rainforest has an impact on both environmental and human systems. Locally, in the past, the indigenous native populations, for example the Kayapo in Amazônia, and the Dayaks of Malaysia have used the forest for shifting cultivation, in a largely sustainable form, by clearing and burning the forest, and then using it for several years before moving to new locations.

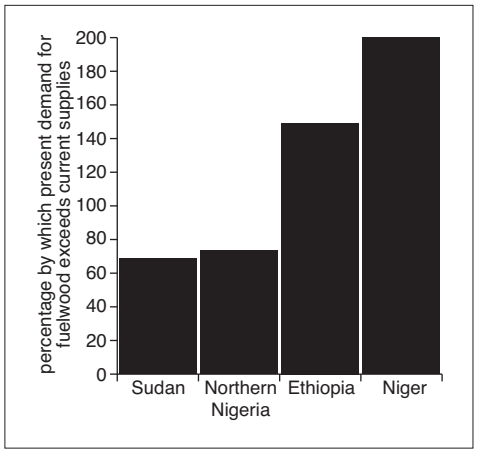
The increased light levels following the clearance allow the growth of a secondary type of forest, lower in height and with a reduced range of species. Increasing population trends, and a desire by many governments to see such peoples settled and integrated into the main economy, have seen the development of a form of subsistence agriculture, which has a much greater impact on the forest. This may result in the total destruction of the forest and its replacement by areas under permanent cultivation.

Proposed Scheme	*Potential Impact*
Paving the BR 174 and 364 roads between Brazil, Peru and Venezuela	The BR 174 runs through or near the lands of 16 000 Indians and several ecological reserves. The BR 364 runs through forest suitable for logging, and could also be used as a new cocaine drug route
Dredging the Amazon River to improve navigation	Will pollute the water supplies of local communities
Dredging the Madeira River to improve navigation	Will pollute the water supplies used by five indigenous communities
Building a 2000 mile waterway network joining the Tocantins and Araguala Rivers, to allow grain to be shipped from Belem	Involves draining numerous wetlands, including the Bananal Island National Park which has a unique biodiversity and is home to 6000 Indians.
The building of the Ferronorte, a 3000 mile railway between Mato Grosso and Para States	Involves the loss of forest. Will open up 800 000 square miles for farming, particularly for export crops such as soya bean leading to large scale pesticide pollution
The building of a 1000 mile electricity transmission line between the Tucurui dam and various towns in Para State	Involves the loss of forest
Building a natural gas pipeline between the Urucu field and Manaus	Involves the loss of forest

The problem in the Sahel

When people think of tropical forests they usually think of wet, humid rainforests. Yet rainforests account for just over half of tropical forests. The rest are the tropical dry forests. Worldwide, such forests cover an area larger than China.

Tropical dry forests are found over large sections of Africa's Sudano Sahel zone, which stretches for over 4200 kilometres from Sudan and Ethiopia in the east to Mauritania and Senegal in the west. Together, these areas of forest account for half the world's tropical dry forests.



This zone of widely spaced scrubby trees, thorn bushes and grasses was often thought by visiting Europeans to be no more than an area of 'useless scrub'. Yet today 60 million people rely on the dry Sahelian forest to provide fodder for their animals, poles for building and other uses, welcome shade from the fierce tropical sun, an annual harvest of gum arabic and fruits, many useful herbal medicines and, most valuable of all, fuelwood.

Unfortunately, this vital natural resource is currently being used up faster than it is being replaced in many parts of the region, and the dryland forests are in crisis. Cutting for fuelwood is often the major culprit, although in some areas it is also due to the fact that the dry forest lands are being cleared to create more cropland – 3-400 000 hectares in Mali alone in the last 25 years, for example.

Rapidly growing populations (3% a year in Mali) pressurise people into farming less fertile areas, or marginal land. In the last 20 years, droughts have also been more frequent, adding to the general crisis.

In Ethiopia, the dry forest, which in the early twentieth century covered 40% of the country's total land area is now reduced to just 4% of the total land area.

Tackling the fuelwood crisis

Few experts nowadays see the solution to the fuelwood crisis as simply a case of planting more trees. The old idea of Western aid agencies 'going into Africa' and planting trees is now recognised as being unworkable.

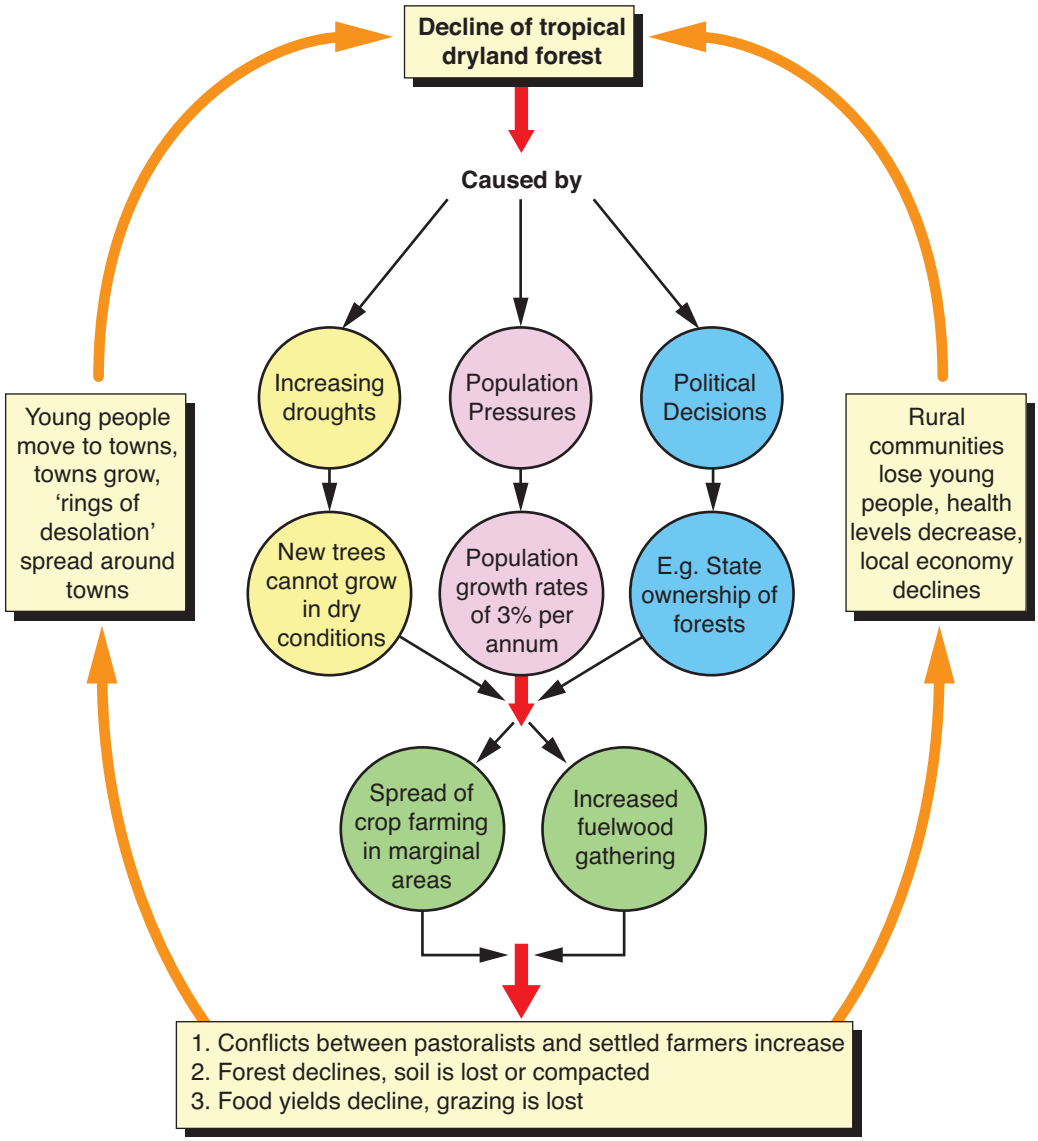
Any solutions to the problem must be sustainable. This means that solutions and improvements must be carried out by local people who feel they are doing what is best for their own future, without constant interference from outsiders.

SOS Sahel

SOS Sahel is a good example of one UK-based agency that advises and assists local communities in the Sahel region to develop sustainable solutions to long-term problems such as fuelwood shortage. Before setting up an aid project in an area, SOS Sahel always checks first on:

- who owns the local trees;
- who owns the land they are planted on;
- who will be responsible for taking care of any new plantings in the long term;
- which are the most appropriate trees to plant, both to suit local needs and local conditions;
- who will eventually profit from the scheme.

SOS Sahel believes that local people have a right to their local woodlands and that, given some thought, the woodlands can be used without being eventually destroyed - provided they are managed properly with the agreement of everyone in the community.



Russia's needle leaf forests

Russians tend to think of their forests as almost limitless because there are 810 million hectares (ha) of such forests! However, forest ecosystems are extremely sensitive to human interference. Tree felling and other economic activities have caused irreversible damage by converting forests into bogs and causing the ground to freeze more deeply. What seemed like unlimited resources are now seen to be disappearing at an alarming rate. The dangers of over exploitation can be seen in Siberia and they are similar to the effects in the Amazon rainforest where human exploitation has laid waste trees essential to the maintenance of the Earth's atmosphere. For example the timber operations near the new Siberian town of UstIlinsk require annually an area of forest three times the size of Luxembourg to be felled. Such operations are not environmentally friendly. The Russian timber industry has treated the forest resource as a type of 'mining' operation in which trees are cut down and then the loggers move on to new stands of trees even further from the central regions. As a result forests in the western regions of Russia, close to the centres of population and industry have been overcut. The trend since the 1990s is for timber operations to push into more remote eastern areas of Russia such as Siberia. There is awareness in Russia of the practical value of a sustained forest yield in which the amount cut corresponds to the annual growth. However the problem is that the forest industries have never had enough investment to allow them to meet both production and environmental targets. As a result production has triumphed over environmental awareness. For example each year Russia cuts between 3.5 and 4.0 million ha of forests, yet replanting amounts to less than 1 million ha.

Even worse is the fact that Russian foresters derive much less industrial product from each tree than their counterparts in Scandinavia or North America. Hence much Russian wood is wasted in the production process because equipment is inefficient and outdated.

Environmental impact of Russian forest industries

The forest industries have a negative environmental impact in three main ways. Firstly, the forest industries are direct sources of environmental damage by deforestation, which contributes to soil erosion and the pollution of water resources. Pulp and paper mills also discharge their untreated effluent into Siberian rivers and lakes so adding to the pollution problem. Only 19 per cent of all the waste water of the Russian pulp and paper industry receives any anti-pollution treatment. Worse still, much timber (47 million tonnes in 1994) is still moved by water. Some logs sink and as these submerged logs decay they pollute the ecosystems of rivers and lakes. Similarly large hydroelectric dams on rivers like the Angara have been built to power new pulp and paper mills.

Behind such dams millions of hectares of forest have been flooded and here too, decaying trees pollute the water. Secondly, Russian forest industries make poor use of wood by-products. Over 50 million cubic metres of leftover wood is produced in Russia each year during industrial processing but only half of this is used to make composition boards or contributes to the wood chemical industries. For example 20 per cent of all wood that is cut is used directly to make packaging material yet much of this could come from wood by-products.

Thirdly, Russian forest industries have a low level of capital investment. The industries should be investing in newer and cleaner technologies to make better use of trees and improve productivity levels. However, such technology is expensive and investment levels in forest industries have not risen in real terms since the 1950s. So older, less efficient and more polluting technologies continue to flourish.

Forests and food, recreation and replanting

Russian forests have always served as a source of food for people often linked to local recreation such as berry or mushroom picking. Over 5 million tonnes of edible products are derived each year from the forests. Wild nuts and fruits are gathered such as walnuts, chestnuts, beechnuts, apples, pears and apricots. In addition 600 types of forest plants are harvested for the pharmaceutical industry.

Forests are also important for recreation. All large Russian cities have nearby recreational forests often with facilities for hunting, hiking and tourism. For example there are 6000 hunting clubs with access to 291 million ha of forest for sport, hunting and fishing. Greenbelts around cities feature many forests that contribute to the health of the urban population through water conservation and microclimate improvements.

Over 3 million ha of shelter belts have been planted around roads, farms or water bodies in Russia. Trees along roads absorb car emissions. For example, one hectare of 20 year old pine forest can daily absorb 9.4 tonnes of carbonic gases and give out 7.3 tonnes of oxygen. So trees have been planted in cities to reduce air pollution. Similarly 100 metres of forest reduces noise levels by 20 decibels so trees have been planted round airports and factories to reduce noise pollution.

Causes of Russian forest destruction

The main causes of forest destruction are:

- logging which not only cuts more wood than is being replanted but poor logging practices add to the environmental damage;

- forest fires, which exacerbate deforestation. Although natural fires play a positive role in the forest regeneration 75 per cent of fires are started by people. Worse still forest fires are becoming larger and more difficult to extinguish;

- natural predators such as the Large Black Fir Beetle and Fir Bark Beetle cause severe losses; and

- acid deposition from burning fossil fuels and driving motor vehicles causes acidification of soils and tree damage. Needles become yellow and fall off, whilst the tops of trees thin out, trunks are deformed and even roots are damaged. Russia is the world's number one producer of sulphur dioxide generating 25 million tonnes each year. However 32 per cent of the acid deposition comes from sources outside Russia mostly in eastern or northern Europe.

One result of forest destruction has been the eastward shift of timber operations into Siberia. This increases the long distance transport necessary to move the logs to the processing industries located close to demand centres like Moscow in western Russia. This in turn raises the cost of logging, decreases profitability and adds to pollution. It also serves as a disincentive to make better use of the remaining forests in the western regions of Russia.

What future for Russia's forests?

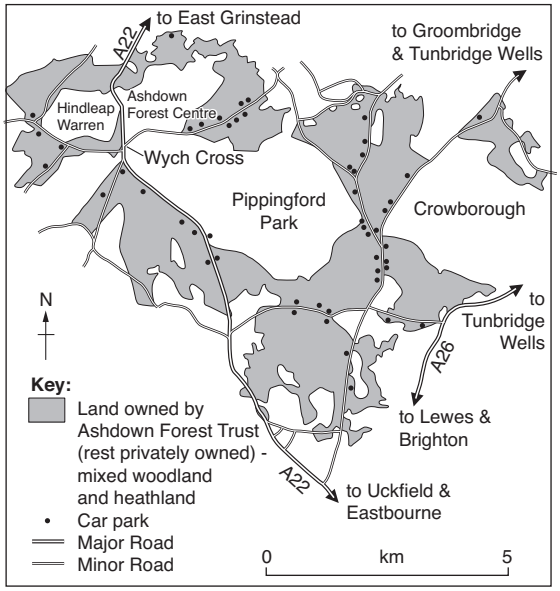
Despite the problems there is a growing environmental awareness amongst the Russian people that has led to demands for forest preservation. Forest experts are gaining more technical expertise with help from other countries and there is already in existence a system for conserving forests. Future forest ventures may be taken jointly with Japan or a European country that will provide inputs of modern technology. Conservation in the end may boil down to an issue of economics, namely how much are Russians prepared to pay for the preservation of their forest ecosystems? Whilst one can accurately calculate the value of a log delivered to a saw mill it is much harder for society to measure the value of an uncut tree that absorbs pollution, and serves an important function in the ecological cycle.

Woodland and heathland management – Ashdown Forest

Ashdown Forest is located in the High Weald area of East Sussex. Consisting of 25 km^2 of open heathland and woodland, the 'forest' part of its name seems something of a misnomer. In fact this comes from the Latin word *foris*, meaning outside. In its past it has been a Stone Age hunting area, a medieval royal hunting forest, and part of the industrial heartland of England when charcoal and iron ore resources were much in demand. As such, its vegetation is not natural, but rather the result of human economic activity and management extending over thousands of years. Ashdown Forest, is an environment created by man, which has then become valued for its appearance as well as for the mix of plants and animals dependent on it. Now both need active management techniques for their continued existence.

'If we let it, Ashdown Forest would gradually return to natural woodland and we should lose the valuable heathland habitat.'

The importance of heathland for wildlife means that its management and conservation are the top priority.



Management is in the hands of a body of people known as Conservators, and their responsibilities are laid down in the Ashdown Forest Act of 1974. Section 16 states:

It shall be the duty of the Conservators to regulate and manage the Forest as an amenity and place of resort subject to the existing rights of common...and to protect such rights and the Forest from encroachments and to conserve it as a quiet and natural area of outstanding beauty:

The physical work this entails is primarily carried out by Forest Rangers, assisted by conservation groups and other volunteers. Estate workers, scientists and the Forest Commoners (730 people with ancient rights including the cutting of birch, alder and willow as domestic fuel) also cooperate. The Society of Friends of Ashdown Forest, a registered charity formed in 1961, assists the Conservators by raising funds. These have paid for:

- the clearing of burnt areas after the 1984 fires, and of dead gorse after the severe winter of 1986
- radios for the rangers, important in the day-to-day management and vital in an emergency
- a mechanical digger for draining the rides and repairing the car parks
- a tractor, trailer and forage harvester for cutting old heather to encourage new growth.

Heathland management traditionally involved methods including grazing, cutting wood for fuel, and the removal of litter for animal bedding. Modern substitutes now replace these; combined use of a tractor-driven mower, mechanical digger, chain saw and chemicals (e.g. herbicide to prevent the re-sprouting of birch stumps) are examples. Deliberate burning of heathland to produce a new flush of grass and kill livestock parasites such as ticks is no longer undertaken, because this encourages bracken to dominate. Bracken's resilience comes from the fact that its rhizomes spread underground, and are protected from fire. Bracken dominates other plants, often excluding them from the ecosystem altogether. The modern method of coping with bracken is to mow in June and again in July, eventually weakening the rhizomes. Sixty hectares of the Forest is managed in this way. Additional benefits are the avoidance of unpleasant burnt landscapes and of damage to insects and other invertebrates.

Current management policy includes mowing heather on a 15–year cycle to encourage a mosaic of old and new patches. This practice also helps prevent invasion of the heathland by trees. Studies have, however, shown that enclosed grazing is a more effective way of

Turn over

achieving these two goals. Fencing necessary for such a system could limit public access and damage the landscape appearance. A 40 hectare pilot scheme in 1994 proved successful, and the intention is to fence a further 445 hectares. The result, as well as saving the heathland and its wildlife, will be the partial recreation of a traditional pastoral landscape, quite a rare sight in Britain today.

Woodland areas of Ashdown Forest are also managed using traditional techniques. Coppicing involves cutting down trees and shrubs to ground level and allowing the remaining stumps to re-sprout. The new growth can then be harvested on a regular cycle. This practice, dating back several centuries, has long been both economically and ecologically important. It is also common in other managed woodlands such as Epping Forest in Essex and Wilderness Wood in East Sussex. Timber from coppicing is now used to make woodland products, an important source of income which can be ploughed back into management costs. Examples include:

- hazel – hurdle fencing
- sweet chestnut – post and rail fencing
- Scots pine – Christmas trees.

Thinning scrub and low quality trees encourages growth of straight-trunked high quality oaks for sale. Rhododendron, an invasive foreign species spread from gardens, also has to be cleared. Wardens undertake several other tasks, for example surveying wildlife, putting out fires (especially in very dry summers such as that of 1995), and dealing with deer casualties on the roads.

Education of the public in how to use the Forest is an integral plan of its management.

A code for visitors has been formulated and is displayed at the Forest Centre and major car parks. It states:

- do not pick wild flowers – seeds are needed for next season
- take care not to trample plants
- never dig up roots
- do not disturb birds, touch nests or remove eggs
- do not damage trees or remove saplings
- keep dogs away from sheep or horses
- do not disturb free-grazing sheep
- you may picnic anywhere in the Forest, but stoves are allowed only in car parks and only between 1 July and 31 December
- take all litter home
- no camping or overnight parking.

None of these requirements can really be classed as restrictive. Members of the public may walk where they like, although riding is by permit only and within restricted areas. Forest management requires more than just physical work and implementing the code. Long-term planning is essential. Ashdown Forest is located in the crowded South East, with all the pressures on land this entails. Threats from local policies and politics need to be recognised and countered.

Of all managed environments, Ashdown Forest is probably one of the best protected. Not only is it supported by an Act of Parliament, but also by its status as a Site of Special Scientific Interest, and as part of the High Weald Area of Outstanding Natural Beauty. Moreover, European legislation currently in the pipeline may add further protection. As other examples have shown, not all areas in need of high levels of management are so fortunate.

Section C: The ecology and history of deciduous temperate woodlands in Britain

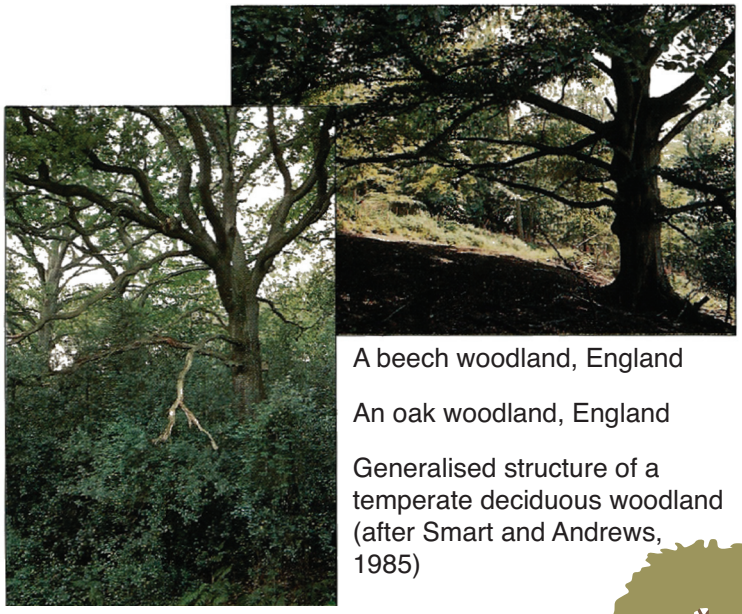
- Ecology
- History of British Woodlands

Temperate Deciduous Woodland: The nature of the ecosystem

Energy (in biomass equivalent) transferred between trophic levels in temperate deciduous woodland

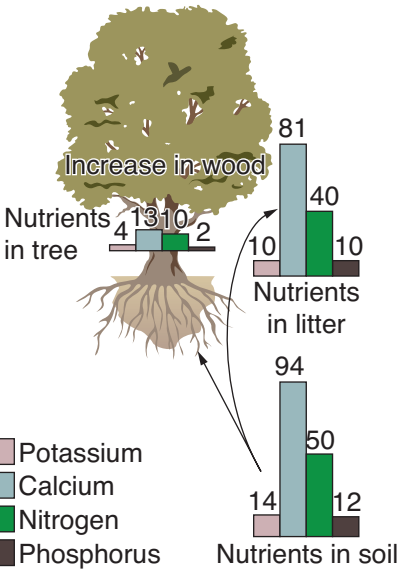
Level	Average productivity g/m^2/year
1 (Producers)	1200
2 (Primary consumers)	20
3 (Secondary consumers)	5
4 (Tertiary consumers)	1.25

Nutrients
Nutrient cycling slows down during colder months. Lower temperatures limit the activities of **decomposers**. During these months trees take up nutrients in smaller quantities, since they lose their leaves.



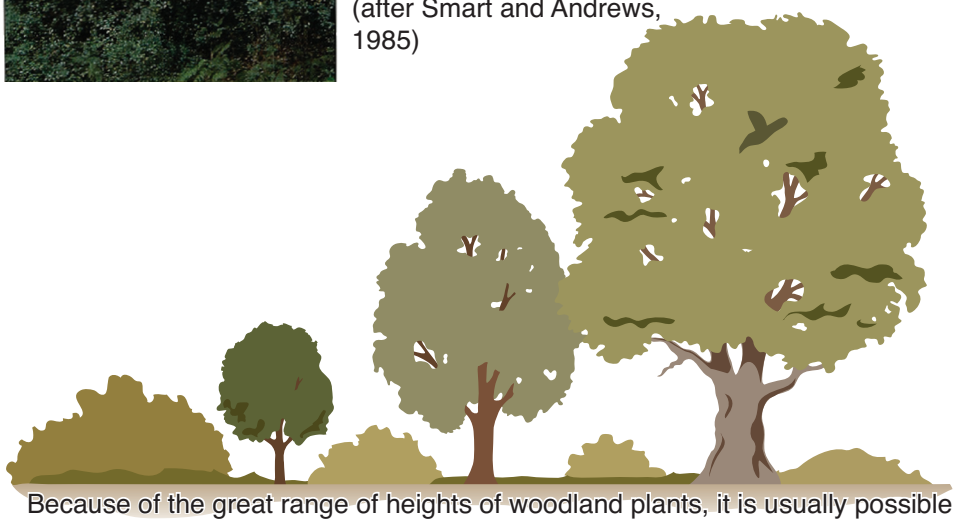
A beech woodland, England

An oak woodland, England



Cycling of four nutrients in a temperate deciduous forest in kilograms per hectare per year (after Duvigneaud and Denaeyer De Smet, 1970 in O' Hare, 1988)

Generalised structure of a temperate deciduous woodland (after Smart and Andrews, 1985)



Canopy
The uppermost layer - the branches, twigs and leaves of larger trees.

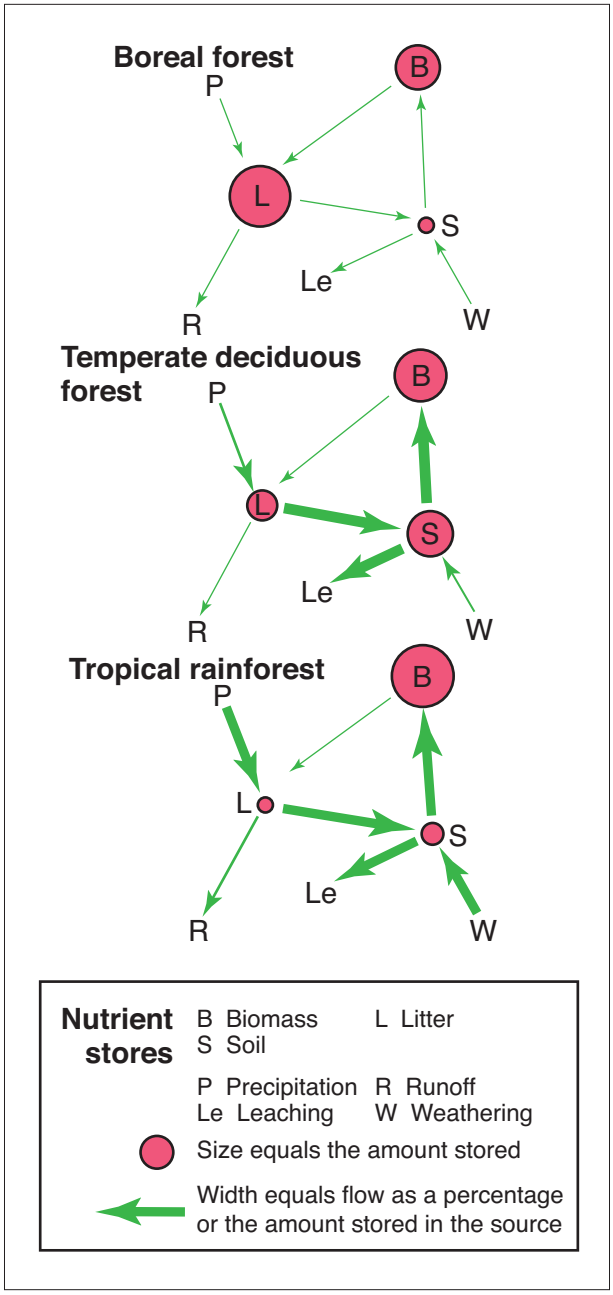
Shrub Layer
Beneath the canopy - smaller trees, shrubs and some of the climbers.

Field or herb layer
The taller non-woody plants, including flowering plants and herbs.

Ground Layer
Mosses and other small or creeping plants growing on or close to the ground.

Because of the great range of heights of woodland plants, it is usually possible to pick out vertical layers in its structure.

Nutrient circulation in three forest ecosystems



Woodland History

Before the Ice Age

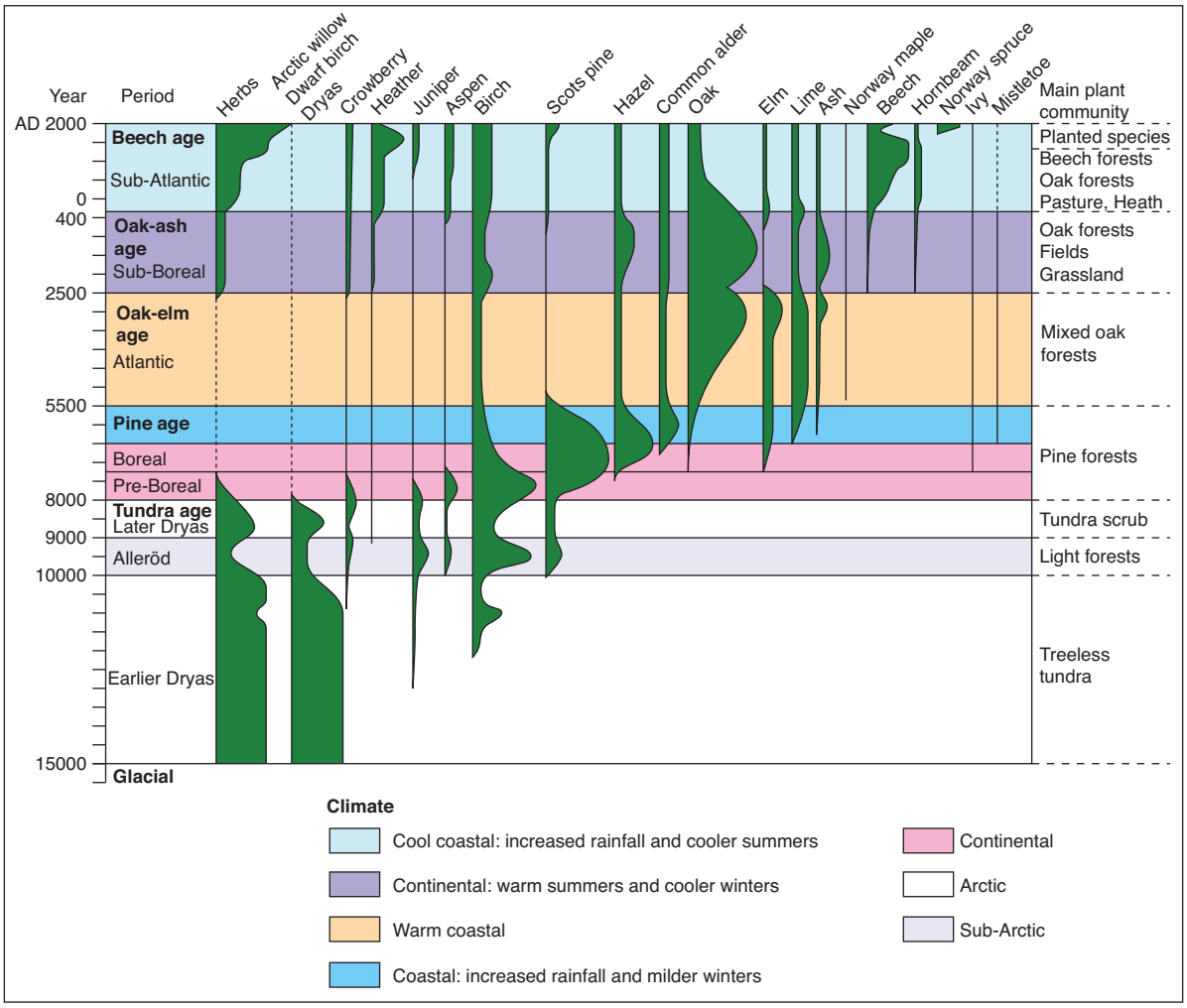
Fifty million years ago, what is now Europe had a tropical climate and was covered by evergreen forests. These contained trees similar to those that grow today in tropical Asia, Australia, Africa and South and Central America. Plate tectonics explains that land that later became Europe moved further away from the Equator and into cooler climatic zones. By about 2 million years ago, plant communities similar to present day climatic climax communities grew where Great Britain is today.

During the ice age

In Europe this pattern of vegetation was severely disrupted by a series of glaciations. The most recent, the Devensian, ended approximately 17 000 years ago. Each glaciation removed much of the cover on land, destroying many plant species. As the ice advanced and retreated, so did zones of plants and their associated fauna.

After the ice age

Relict communities were gradually re-colonised; species also colonised new areas. Evidence of climatic change and its effects on vegetation since the last glaciation has been preserved in the layers of ancient peat bogs and lake muds. Core samples from these deposits have been radiocarbon dated. An analysis of the pollen grains found in these layers shows the kinds of woodland that grew in the surrounding areas.



Wildwood

Woodland history begins for practical purposes about 12 000 BC, when the last glaciation ended. The story is known chiefly from pollen analysis. The trees which had retreated to southern latitudes during the preceding glacial phase slowly migrated north again. Birch, aspen and willow were followed by pine and hazel; then alder and oak; next lime and elm; then holly, ash, beech, hornbeam and maple. Birch, aspen and willow are relatively arctic trees. Late-comers were either trees of warmer climates (hornbeam, maple) or bad colonisers (lime).

After the changes of the first millennia there came a long period of apparently stable climate, about 7000 to 5000 BC. Tree species fought one another by natural processes of succession to form a series of 'climax' woodland types. They covered all the British Isles except for small areas of moorland and grassland on high mountains and in the far north, and for coastal dunes and salt-marshes. Such was the natural wildwood before the beginning of large-scale human activity.

Wildwood was far from being the monotonous 'mixed oak forest' which earlier pollen analysts supposed. There were many local variants, which can be grouped into five 'provinces' where many different types of woodland could be found. These 'provinces' have some expression in ancient woodland today.

A Mesolithic inhabitant, returning to the British Isles after 7000 years, would find that we have got rid of 99 per cent of the original woodland, and even the remaining 1 per cent is no longer wildwood; for instance, its management history has deprived it of old trees. But that 1 per cent would not be utterly unfamiliar. There are still eastern Scottish pinewoods and western Scottish birchwoods. Oakwoods are still a speciality of the north and west, even though 6000 years of human intention and default have favoured oak relative to other trees.

Some woods are believed to be derived from the original wildwood; others (*secondary woods*) have arisen on land that has at some time not been woodland. Let a field be abandoned, and within a year it will be invaded by oaks springing up from acorns dropped by passing jays, or birches from wind-blown seed. In 30 years it will have 'tumbled down to woodland'. The same happens to chalk downs, heaths, fens and some moorland whenever grazing and burning cease.

How Was Wildwood Destroyed?

To convert millions of acres of wildwood into farmland was the greatest achievement of our ancestors.

It belongs to an age far beyond record or memory. We know nothing of how it was organised, how many man-hours it took to clear an acre, or what people lived on while doing it. Experiments on 'clearing' woodland with prehistoric tools should not be hastily extrapolated to prehistoric Britain. Most British trees are difficult to kill; they survive felling or ringbarking, though their regrowth is eaten by cattle and sheep. In the twentieth century, Amazon wildwood is easier to destroy (acre for acre) than ordinary English coppice.

A persistent myth claims that prehistoric people 'cleared wildwood by fire'. This is not possible in Britain or Ireland, where woodlands (except pine) burn like wet asbestos. As Dr James Dickson tells me, the frivolous youth of Glasgow try every year to burn down the oakwoods around the city, and have never succeeded. To burn trees, one has to cut them down, cut them up, and stack the pieces, a far more laborious task than merely felling them. A log of more than 10 inches diameter is almost fireproof and is a most uncooperative object. There are the bigger problems still of digging up or ploughing round the stumps and preventing regrowth. Cattle, sheep and goats probably helped by browsing regrowth and killing the stumps. This has been done in historic times, but it takes a great deal of grazing to go on consuming all the saplings year by year for centuries. How often was there enough livestock to do this in prehistory?

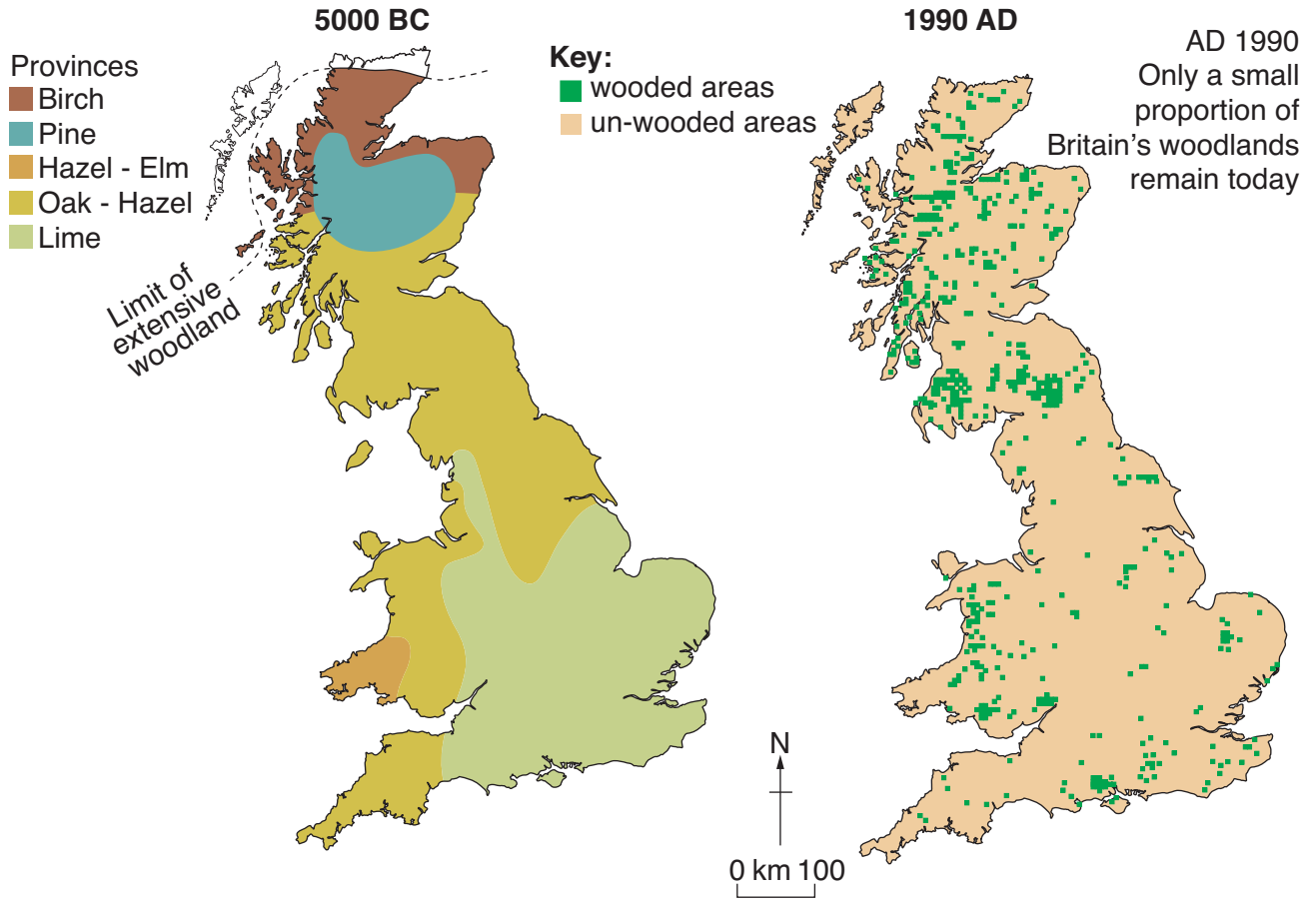
Secondary woods may be of any age from prehistory onwards. They are composed of those pioneer trees – oak, birch, hawthorn, ash – which easily invade vacant ground. They also lack many of the herbaceous plants of ancient woodland.

Secondary woodland is familiar on railway land and old quarries; its spread threatens the conservation of heath and old grassland. In the eastern United States, an area much greater than the whole British Isles has tumbled down to woodland since 1800. Once the subject of many scientific studies, secondary woodland is now unfashionable: recent writers call for expensive tree-planting as if it were the only way to create new woodland. Like all gradual changes which cost nothing, succession to woodland often goes unnoticed.

Mesolithic men, who were great eaters of nuts, may somehow be responsible for the great abundance of hazel in prehistory.

There is no doubt about the 'Neolithic revolution'. Farmers – whether actual settlers, or people who had acquired the crops, domestic animals and weeds, and had learnt how to use them - arrived about 4500 BC. They set about converting Britain and Ireland to an imitation of the dry open steppes of the Near East in which agriculture had begun. They attacked elms and caused a sudden drop in elm pollen production, perhaps by letting loose Elm Disease. This 'Elm Decline' is associated with early pottery and Neolithic tools, with an increase in plants of non-wooded country, and with crops such as emmer wheat and weeds such as plantains. Within 3000 years large tracts were converted to farmland or heath. Wildwood vanished from terrain as diverse as the chalklands, the Somerset Levels, and the coastal Lake District.

During the Bronze Age (2400–750 BC) most wildwood disappeared from high altitudes and river valleys. Inroads were made on some of the heavy soils. I shall hazard the guess that half of England had ceased to be wildwood by the early Iron Age (500 BC); some archaeologists would put it earlier.



Wildwood Regions in 5000BC

In the Lime Province the commonest tree was small leaved lime, but there was much local variation; as well as limewoods, there were areas of hazelwood, elmwood, ashwood and probably oakwood. In the Oak Province the commonest tree was oak, followed by hazel; there were areas of oakwood and hazelwood, with patches of elmwood, pinewood and limewood. The Hazel-Elm Province included hazelwoods, elmwoods, and areas of oakwood. The Pine Province included pine – woods with areas of birch, oak and elm. The Birch Province was mainly birchwood with patches of pine and oak to the west. In the extreme north there was tundra, with woods confined to sheltered ravines.

Multi-purpose use of temperate deciduous woodlands

In Great Britain, natural climatic climax temperate deciduous forest is rare. The majority of forests are affected by the activities of past or present human populations. In Europe only Bialowieza Forest in north-eastern Poland remains as a genuine **primary woodland.**

The text below was written about Penkelly Wood (in Dyfed) by George Owen in 1594. The use of Penkelly Wood allowed people to integrate timber production, grazing and at the same time provided a rich wildlife **habitat** and opportunities for game (hunting and fishing).

Historically the **management** of woodland for wood production was an important part of the rural economy. We have the remnants of that managed woodland, and conservationists aim to recreate sustainable management of it.

To manage for several objectives it is important to understand how woodland can be managed for each use and how compatible they are with each other. This is known as multiple-use management.

... the forest of Penkelly... contyneth of the usual measure of that contrey about 500 acres of woodds and is enclosed with quicksett and pale rownde about the under locke... it is all growne about with greate okes of 200 yeres growth and more and some younge wodde of 50 yeres growth and most of it well growen with underwooddes, the herbage whereof... will somer 300 breeding mareas and winter 300 sheepe and 200 cattell well sufficiently, beside swyne which may be kept there. Allso there is... great storc of woodcockes taken yearly...

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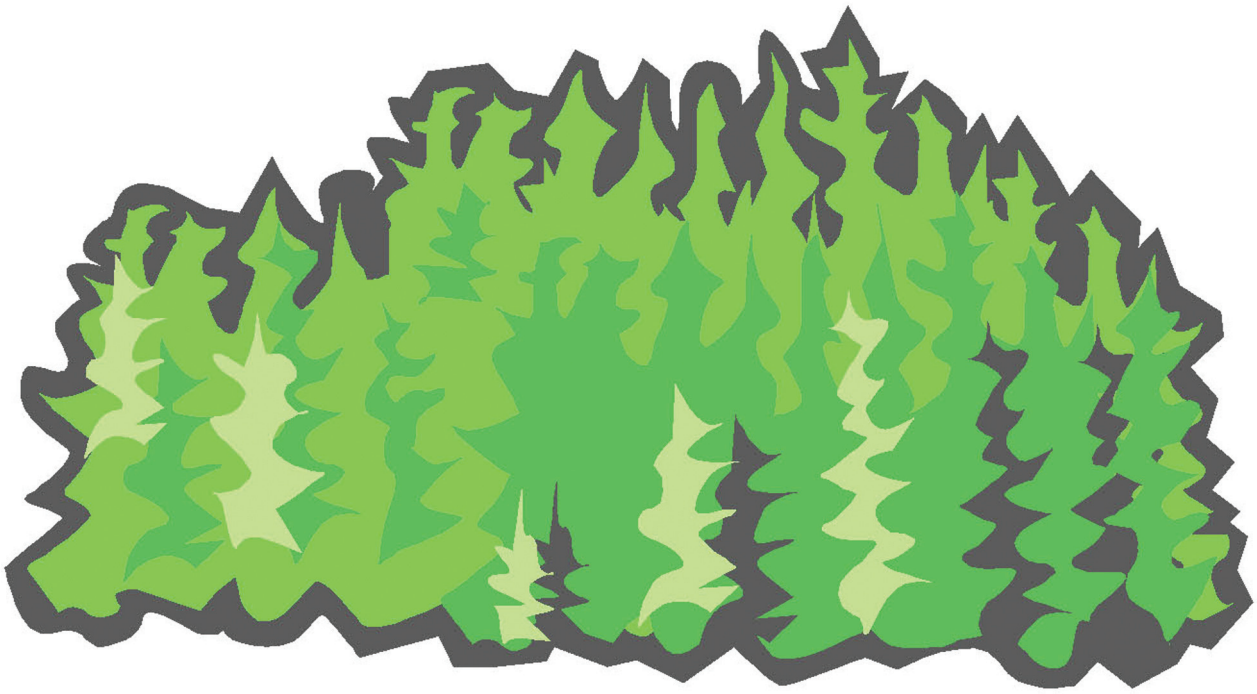
Section D: Forests of the Future



Forests of the future

What can we do to improve the global wood situation? Plenty. But we need to act as a community of nations for the benefit of all humankind. Adequate funding should be provided for the establishment of commercial fuelwood plantations in the tropics, where the year round steamy warm climates are ideal for generating timber – thus increasing wood stocks and relieving pressure on virgin forest. In addition, developed nations should review their own forestry policies, with a view to producing more homegrown wood (including hardwood) and encouraging greater recycling of paper. There is no doubt about the Earth's capacity to supply us with sufficient wood: the question lies with our commitment.

Planting tomorrow's trees

In the North, we can safely say that we know a good deal about how to manage forests. In the forests of the South, by contrast, we have scarcely made a start. Ironically, much of the problem lies with the streamlined techniques developed in the North. Many mechanised logging operations in the tropics are wasteful and destructive: often 75% of the surrounding canopy is damaged during one operation to extract a few commercially valuable species. Unlike temperate forests, tropical forests are unable to withstand such disruption because of their ecological complexity. In fact, tropical and temperate forests are so dissimilar that it would probably be better if we did not use the same word 'forest' to describe them.

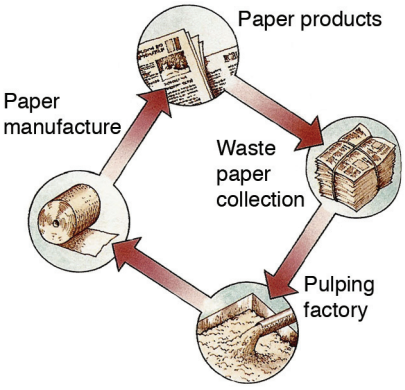
The main advance in the North in recent years has been in genetic engineering. Trees grown from tissue culture can quickly reforest large areas of denuded land. Also, geneticists are learning how to isolate the genes that make a tree species grow straight and tall, or produce wood with high tensile strength whereupon they can replicate such prize characteristics in identical trees in large numbers.

But in the South, because of the critical role played by tropical forests, it is better to establish 'tree farms' on lands already deforested than to harvest the natural forest. A plantation of eucalyptus or pine can generate ten times as much sustainable harvest as can a patch of virgin forest. But a plantation costs at least $1000 per hectare to establish, let alone maintain, and the present rate of tree planting is not even one-tenth of the rate at which natural forests are being logged and degraded.

Fuelwood plantations are also urgently required to relieve pressure on natural forests. We need more trees around farms and in village woodlands, at least five times as many in the Third World as a whole right now, and between 20 and 50 times as many in certain African states. The difficulties, however, are not financial. Community forestry relies on the involvement of local people. If everybody's views are sought from the start, hopefully everybody will plant trees and tend them, and everybody will ensure the harvesting system produces a regular supply of fuelwood.

Similar community efforts are needed to rehabilitate denuded watersheds in the South. In China, South Korea, and parts of India, there has been much success, due to the close coordination of planners and villagers.

Tropical and temperate forests are so different in their biological make up that they need two fundamentally different approaches to their management. Temperate forests are actually expanding slightly, due to reforestation in the North. Densely settled zones such as southern Germany are one-quarter covered with forests. Much land, however, is still under-utilised: Scotland, for example, could accommodate much more tree cover.



Recycling paper

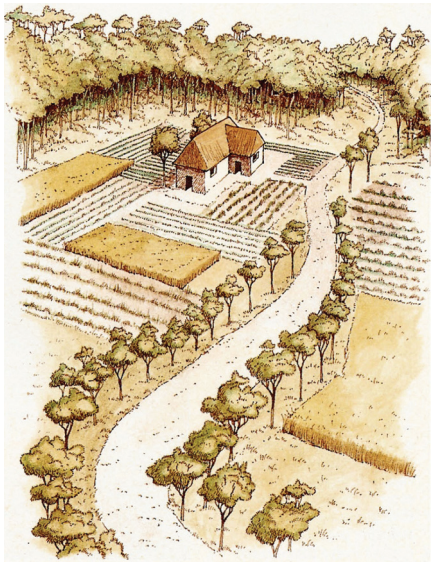
Developed countries could reduce their demand for paper pulp by at least one quarter, simply through greater recycling. During World War II, most Northern countries recovered as much as half of their paper.

Forest management in the South

In most developing countries, forestry departments are understaffed and underfunded. Foresters see their main duty as keeping people out of forests, rather than helping them to establish woodlots, fuelwood plantations, and other village forestry projects. Fortunately, international agencies such as the World Bank are now taking the preservation of tropical forests seriously, and are promoting forestry as an important aspect of rural development. Although the Bank has no effective system for ensuring that ecological considerations are introduced at the outset of all projects, it can choose to withdraw aid if the project proves to be environmentally unsound. Recently, the Bank withdrew support for a Colombian cattle-ranching project after surveys showed the forest soils to be incapable of supporting large-scale development.

Replanting catchments

Nations are realising the value of restoring tree cover on upland catchments – a measure that benefits virtually everyone in the community. Although implemented on far too limited a scale as yet, this is an encouraging step forward.



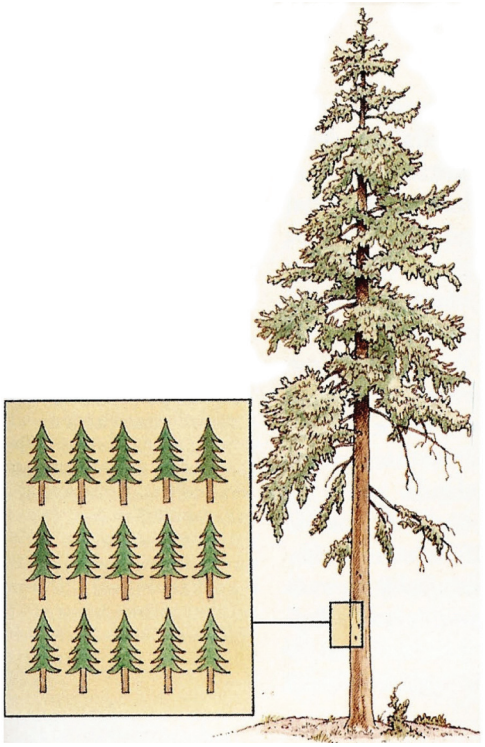
Community forestry

Supported by international development agencies, many countries are encouraging their people to become actively involved in establishing fuelwood plantations. In Gujarat, India, schoolchildren may soon be raising as many tree seedlings as the government.

Cloning trees

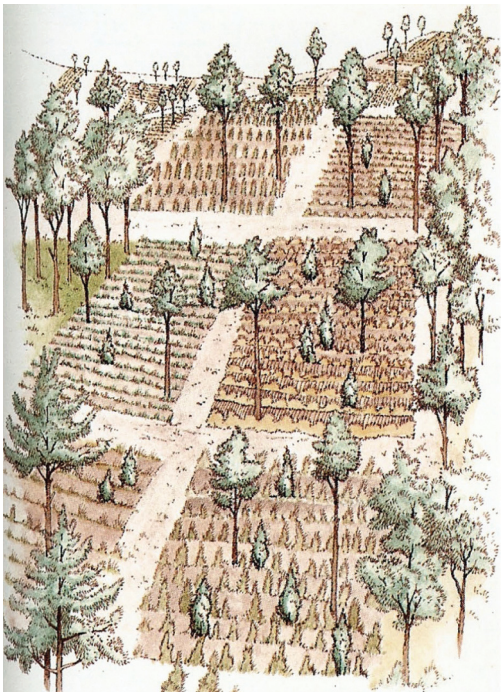
Douglas Firs, American sycamores and several other species are sprouting like mushrooms thanks to recent advances in genetic engineering. They will grow straighter and produce denser wood. Modern forestry has progressed rapidly since the 1980s – but the results will not be usable for many more years.

The forests of Germany – Covering a third of the country, these forests occupy an important part in the national psyche. According to previous Chancellor Kohl, they are "of inestimable importance for the water cycle, for our climate, for our health, for our recreation, and for the identity of the German landscape".



A sustainable land use system

A strategy with much potential is agro-forestry (shown bottom right) in which trees and food crops are grown alongside each other. Forest land and marginal land, normally rated unsuitable for crops, can be utilised for the production of food. Certain tree species, notably the leguminous ones, fix atmospheric nitrogen in the soil, thereby helping to rehabilitate degraded forestlands.



The Chipko movement

In 1974, the women of Reni in northern India (see below) took simple but effective action to stop tree felling. They threatened to hug the trees if the lumberjacks attempted to fell them. The women's protest, known as the Chipko movement, saved 12 000 km^2 of sensitive catchment forest.

Section E

A simple model of how resources have been or may be developed