Sustainable forest

This article presents a case study of sustainable forest management at Thirlmere Reservoir in the Lake District. The interaction between forest and water resources, and the value of the surrounding landscape, makes Thirlmere an excellent location for demonstrating modern approaches in sustainable forestry. Today, forests are managed for a variety of purposes: environmental, economic and social. This case study shows that such management requires a range of geographical understanding, and illustrates the synoptic approach required at A2.

Forests occupy about one third of the land area of our planet. They include some of the most diverse and vital of ecosystems and have environmental, social and economic values. Their loss or degradation has impacts on soil and slope stability, biodiversity, local and regional climates, renewable resources and people. In the UK we have one of the least forested landscapes in Europe, with only 12% forest cover, so we rely on imports for over 80% of our timber-based requirements. Policies that encourage sustainable forest management are in place so that woodlands continue to meet the needs of current and future generations.

If forestry was simply about the harvesting of timber it might cause a loss of critical habitats, damage to forest soils and reductions in water quality that would lead to permanent degradation of the forested landscape. In fact, many forests are managed for other purposes: environmental, ecological or social. Although some activities in the forest are compatible with more than one forest purpose (or 'value'), other situations require sensitivity. Foresters must have a detailed knowledge of each value and must plan beyond the timescale it takes to grow a crop of trees. The day-to-day work of forestry requires thinking that is global, but action that is very local.

The criteria for forest sustainability are described in the UK Forest Standard and interpreted to meet the needs of England, Scotland and Wales in respective forestry strategies. The forest at Thirlmere Reservoir has a complex and sometimes conflicting set of management objectives, making it an excellent case study for modern approaches to sustainable forest management.

View of Thirlmere showing woodland around the lower slopes of the valley. The mountain on the far side is Helvellyn

management

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Thirlmere Reservoir

Thirlmere Reservoir is owned and operated by United Utilities and has been the major source of water for the City of Manchester since around 1900. The reservoir is in the northern Lake District, 6 km south of Keswick, and was formed by damming a valley that originally contained two small lakes. The valley forms the major north–south transport corridor through the National Park and the eastern slopes lead up to the summit of Helvellyn, England's third highest mountain. At the time of the reservoir's creation the landscape was largely barren, except for a few small patches of broadleaved woodland, and a programme of tree planting was undertaken on the steep slopes of the surrounding hills. Fast-growing conifers were preferred, to quickly cover the ground and stabilise the soils.

These trees have matured into a forest of magnificent Douglas fir, larch and spruce, with areas of **ancient semi-natural woodland (ASNW)**. The forest plays several important roles:

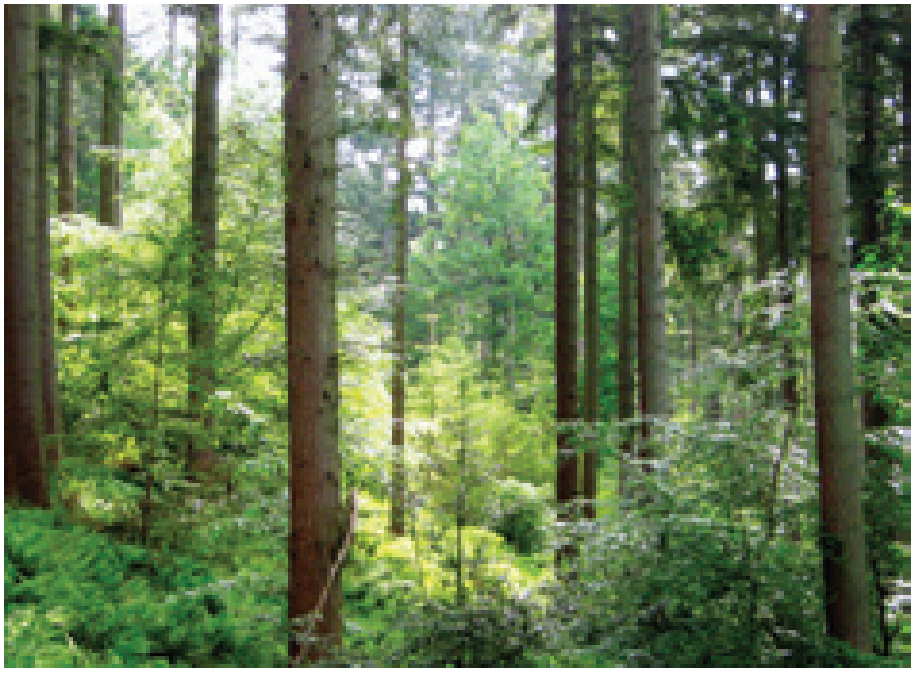
- the conservation of water quality
- a prominent landscape feature within the Lake District National Park
- a destination for low-impact recreation activities
- a habitat for wildlife such as red squirrel and otters
- a source of renewable natural resources including high-quality timber

Sustainable forest management principles

Forest planning takes place at both strategic and local levels. Strategic planning involves high-level decisions about the most important attributes of a forest and the purpose of forest management. At the level of individual forests, management plans detail all the actions to take place over a designated period. Typically, management plans are produced and reviewed every 5 years with a minimum planning horizon of 20 years. They can be revised to take account of changing policies, new scientific discoveries, natural disturbance events and priorities of the forest users (stakeholders).

Foresters usually divide the forest into 'working circles' or zones with a specific primary management objective. Working circles range from areas of intensive timber production to areas where there is minimum management intervention. In the timber production areas a wide range of operations take place, including large-scale harvesting of timber, tree planting and road construction. Areas of minimum intervention might be designated to protect certain species or landscape features, while intermediate working circles might be designated for more mixed-use activities.

For the first 5-year period of the plan, detailed information about each activity is



Continuous cover forests include trees of many species and sizes. There are many environmental benefits of this approach but detailed knowledge of the ecological requirements, especially shade tolerance, for each species is required for effective management

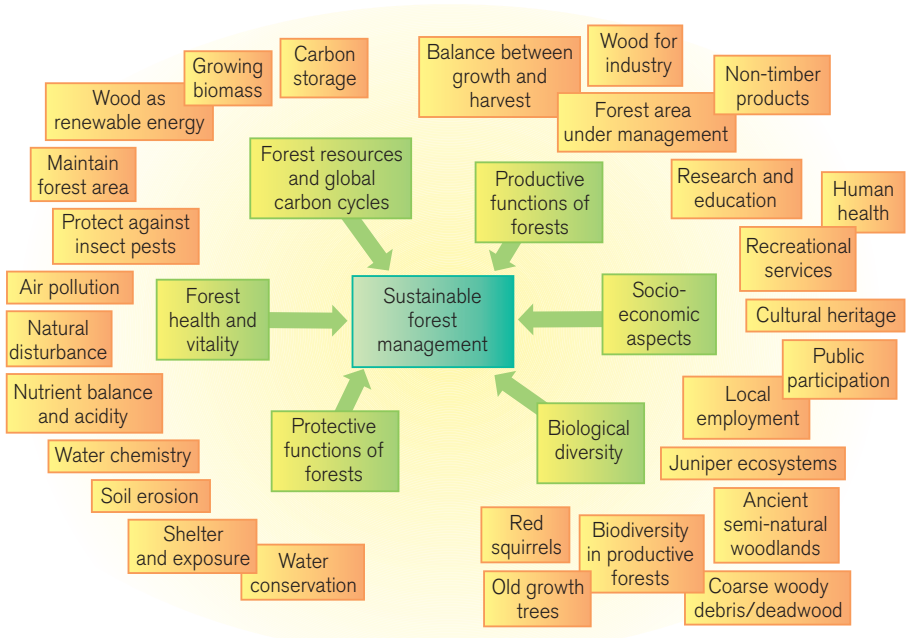


Figure 1 *Diagram of sustainable forestry values at Thirlmere forest*

laid out, including the volume of timber to be harvested, projected costs and revenues, staffing allocations, habitat conservation measures, and road construction or repairs. Effective planning requires an accurate inventory of the forest (soils, flora, fauna and cultural features), **ecological site classification (ESC)** and mapping of areas where activities are scheduled. An important principle is that the volume of timber harvested in any one period is no greater than the volume of forest growth. The remaining 15 years of a plan has less detail but helps ensure the forest is being managed on a sustainable basis.

Management planning usually involves a multidisciplinary team of experts in ecology, animal conservation, biochemistry, geographic information systems, sociology, economics, harvesting technology and engineering, in addition to the key role of the forester. Increasingly, management plans are certified by third party organisations to ensure that they are sustainable. In Britain the UK Woodland Assurance Scheme (UKWAS) carries out this role.

Stakeholder organisations are invited to contribute ideas or comment on draft copies of the plan. This is vital for species groups such as birds, insects and plants (including lichens and mosses) where specialist knowledge is often required. Consultation with local communities is also vital.

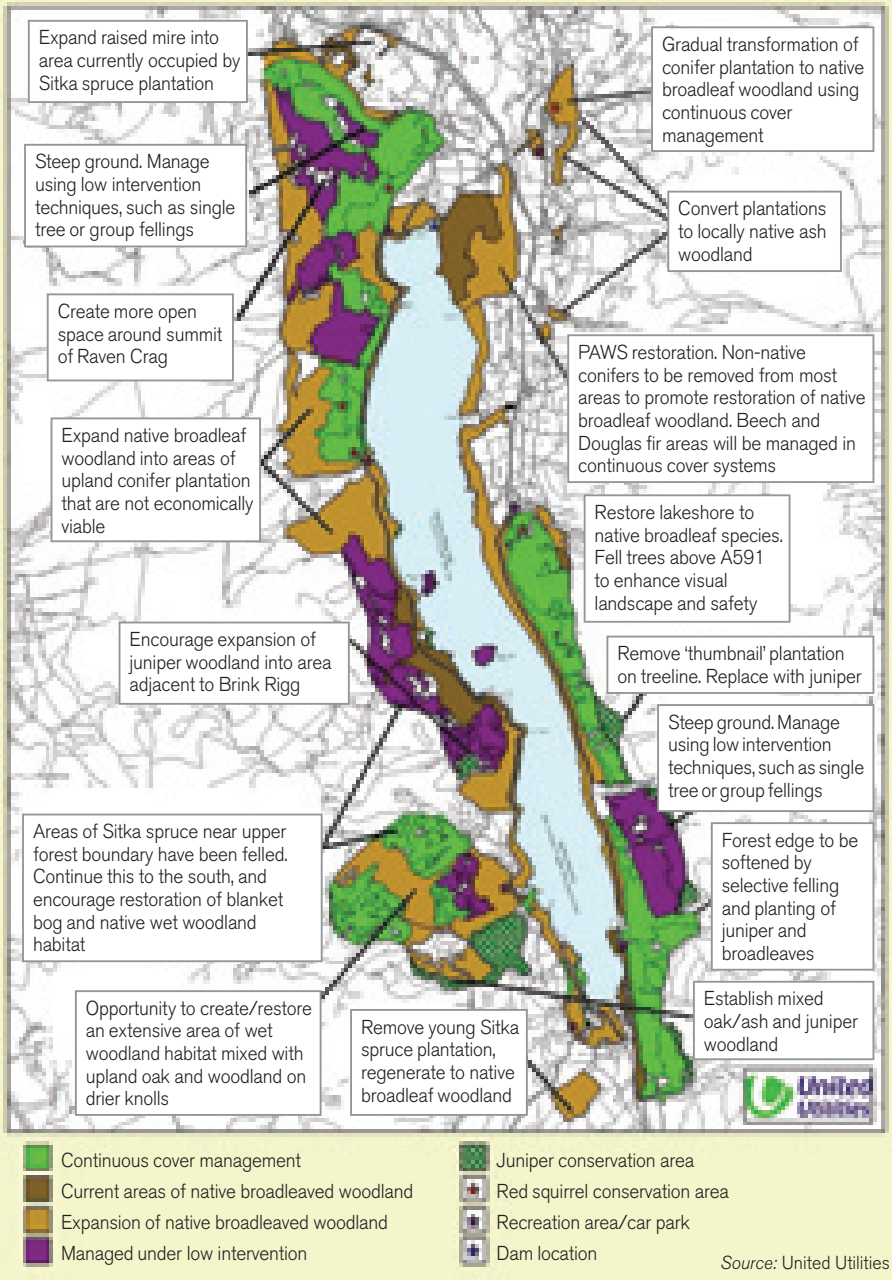


Figure 2 *Land-use map of Thirlmere showing the major forest types and management considerations for future development of the forest*

Silviculture

A core skill of every forester is **silviculture** — controlling the regeneration, growth, composition, health and quality of forests. Stands of trees can be even-aged (all trees in the stand are roughly the same age) or uneven-aged (trees in the stand vary from young seedlings through to large, mature trees) (Table 2), single species (monoculture) or mixed species. There is therefore a spectrum in terms of structural complexity from even-aged monocultures to uneven-aged stands of many tree species. Each silvicultural approach has its own benefits and drawbacks.

Thirlmere: a case study

Although only 800 ha in size, the forest at Thirlmere demonstrates how modern sustainable forestry in Britain is able to integrate a wide range of management objectives. Figure 1 shows how forest values (green) relate to the main management priorities at Thirlmere (orange). Zonation of activities within working circles makes it possible to integrate a range of objectives and priorities across the forest (Figure 2).

Protective functions of the forest

United Utilities is a major utilities company and its most important objective at Thirlmere is to sustain and enhance the quality of drinking water. Water quality has an important impact on human health and breaching the legal water quality standards can result in large fines. The main function of the forests at Thirlmere is to act as the primary raw water filter to ensure the supply of clean water. This filtration has the advantage of reducing operational costs and

Table 1 *A classification of the main tree species used in British forestry according to their seedling light requirements*

Shade tolerance rating		
Light demanding	**Intermediate**	**Shade-tolerant**
Birch	Sessile and English oak	Sycamore
Poplar	Ash	Beech
Lodgepole pine	Cherry	Silver fir
Scots pine	Lime	Western hemlock
European larch	Rowan	Norway spruce
Japanese larch	Sweet chestnut	Grand fir
	Whitebeam	Western red cedar
	Douglas fir	Yew
	Sitka spruce	Hornbeam
	Noble fir	Field maple

The more shade-tolerant species are better suited to continuous cover silvicultural systems, including shelterwoods and selection systems

amounts of chemical used when the water reaches the treatment works.

In the hydrological cycle (Figure 3), forests increase transpiration and evaporation, reducing water yield. The litter layer of forest soils can act like a sponge, reducing overland flow and the peak flows that can cause flooding. Forests can also have beneficial effects on water quality — the roots of the trees bind the soil, reducing erosion and hence sedimentation in the reservoir. Trees can help change the chemical characteristics of the water, for example, water can become more acidic as it moves through soils in coniferous forest.

Since 2005, much of the forest at Thirlmere has been managed under **continuous cover forestry (CCF)**. This aims to reduce the risk of erosion by maintaining a permanent tree canopy, often using uneven-aged **forest stands**. Although conifers dominate the forest there are also large areas of mixed and broadleaved woodland, ensuring that the throughflow is not too acidic and minimising the release of soil nitrate. Maintaining forest rather than grazing in the catchment has other positive effects on water quality. A case of *Cryptosporidium* contamination of the water in 2000 was traced to sheep droppings in the catchment. Greater emphasis is now placed on fencing along river corridors so that areas of new woodland can be established to filter the water and keep grazing stock away from river banks.

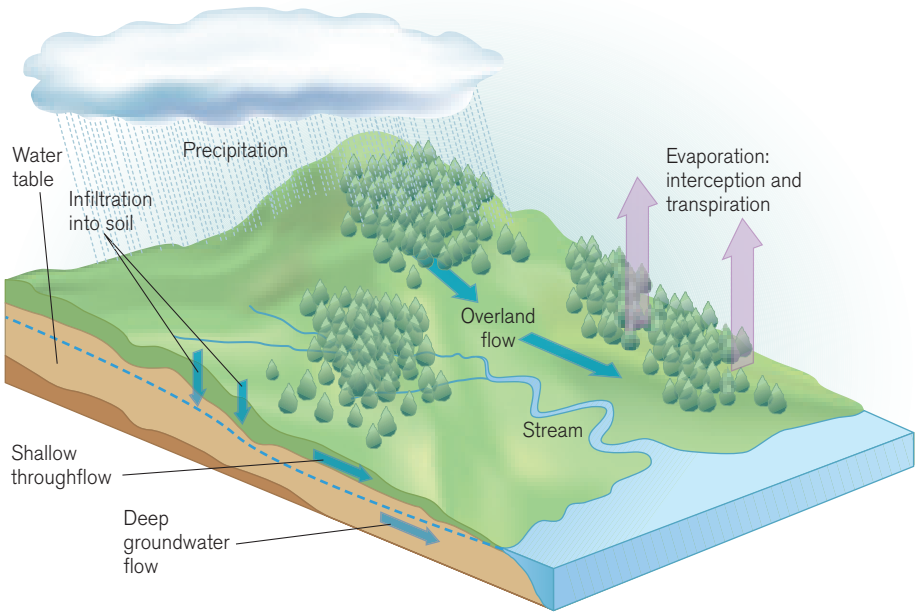


Figure 3 *Hydrological pathways in forested watersheds*

Table 2 *Comparison of even-aged and uneven-aged forest stand types*

Even-aged stands	Uneven-aged stands
Generally suited to light-demanding pioneer tree species. These often regenerate naturally through large-scale disturbances, such as fire and wind	Generally suited to shade-bearing climax tree species. These often regenerate naturally through local disturbances, such as gaps caused by single or groups of trees falling
Simple structure: one main forest canopy, with uniform crown architecture	Multilayered canopy, with trees of different crown architecture, which provides a complex structure and a wider range of habitats
All trees are of the same size and (usually) one dominant species, which simplifies harvesting and marketing the timber	Trees of varying sizes and species which can make marketing more complex
Often all trees are felled at the same time through clear-felling, which makes harvesting operations simpler and cheaper	Trees are felled singly or in small groups, which maintains a continuous forest canopy, providing constant woodland conditions and reducing impact of rainfall. Harvesting is more complicated
Models have been developed to predict the yield of wood from even-aged stands, making management simpler	Complex models are required to predict production of wood. These are not yet available to forest managers
Stands are visually less interesting, as the trees are of one size and usually only one or two species	Stands are varied visually with trees of different size, shape, colour and texture
Planting, thinning and harvesting take place at different stages in development of the stand	Regeneration, thinning and harvesting take place simultaneously at regular intervals
Suited to wide range of sites including windy uplands	Suited to sheltered sites and deeper soils
Increased risk of sediment and nutrient runoff following clear-felling, especially on steep slopes	Conservation of fine soil particles and mineral nutrients due to continuous cover of vegetation
Increased likelihood of release of soil carbon following harvesting operations due to increased solar radiation on the exposed forest floor	Conservation of soil carbon, considered beneficial in helping minimise carbon dioxide release to the atmosphere

Socioeconomic aspects

The area around the reservoir attracts an estimated 100,000 visitors per year. Car parks, toilet facilities and paths are provided as part of an open public access policy. The car park at Swirls, for example, is a major access point for Helvellyn, low-level walks through the woods and a path down to the lakeshore. Car parking charges are an important source of revenue for the catchment team, enabling them to offer facilities such as toilets and nature interpretation. The reservoir acts as a **honeypot**, attracting visitors into the area and benefiting local businesses. Managing the woodlands provides income for local forestry workers and contractors.

Biological diversity

There are some important habitats in the Thirlmere catchment, including small areas of ASNW — mainly oak-birch woodland. Here the stable environment maintained by a woodland canopy over hundreds of years, and the low levels of air pollution, allow populations of sensitive woodland species, such as rare mosses, to develop. Standing dead trees and woody debris provide habitats for cavity nesting birds and many insects, especially beetles. Forest management in the ASNW is largely non-intervention, with the main focus being removal of hazard trees and branches near to public areas for safety.

The main objective in UK forestry for much of the twentieth century was to expand the productive forest resource. This involved planting upland sites with conifers such as Sitka spruce. ASNW was sometimes felled and replaced with conifers, which damaged ancient woodland ecology. These sites are now being restored. United Utilities has identified sites with potential for restoration or conversion to native

woodland and is gradually removing the conifer overstorey through thinning and **clear-felling**, which allows native broadleaves to establish through either direct planting or natural regeneration.

Management of the forest is also focused on conservation of certain species, including otters and the endangered native red squirrel. The Lake District is a refuge for the red squirrel, which has been displaced in England by the North American grey squirrel. Red squirrels thrive in forests of conifers or small-seeded broadleaves, such as birch. Continuous cover forestry with conifers means there are older trees of seed-bearing age in most forest stands, and these provide food supply and habitat. Other measures include the removal of any invading grey squirrels, red squirrel monitoring and close engagement with the local community and the Save our Squirrel Project.

A mature stand of Douglas fir being transformed to continuous cover management. The best trees are retained at each thinning, allowing them to develop. The mix of open and dense areas creates greater biodiversity

Production functions of the forest

Wood is a renewable, low-energy source of material suitable for buildings, furniture, fuel and other uses. Production of wood is less important than some of the other objectives at Thirlmere, but it contributes approximately 40% of total estate income, and helps to offset forest management costs. In the UK conifers generally grow faster than broadleaved trees and offer a better economic return. The continuous cover system makes it possible to grow large, high value Douglas fir timber while fulfilling soil and species conservation objectives. At the same time it minimises leaching of nitrate and other soil compounds that degrade water quality.

Glossary

Ancient semi-natural woodland (ASNW) Woodland composed of native species that have not obviously been planted, and are known to have existed since 1600 in England and Wales or 1750 in Scotland. Such woods have many ancient trees and are important for biodiversity conservation.

Clear-felling A silvicultural system where all trees in a stand are felled at one time. In the UK, a new stand is then established by planting. It is grown for a time and then felled. The resulting stand is even-aged.

Continuous cover forestry Any silvicultural system that creates and maintains an uneven-aged woodland structure. Regeneration, thinning and harvesting of trees take place simultaneously on the same site. CCF is often considered for sensitive sites, to protect soils and landscape and where the woodland is managed for multiple objectives.

Ecological site classification (ESC) A tool used by foresters to provide an ecological basis for sustainable forest management decisions. ESC uses a combination of soils, moisture regime, environmental and climate information to determine the limitations and opportunities for forest growth.

Exotic species Species introduced to the UK by human activity since approximately 7500 BP. More than 1,500 species of trees have been introduced, mainly since the 1600s. Sitka spruce, Douglas fir, Norway spruce and a small number of other conifers have been planted in large areas for commercial forestry.

Forest stand Community of trees that are similar enough in composition, age, arrangement, or condition to be distinguishable from adjoining areas and form a distinct management entity.

Native species Indigenous species to the UK that were present or colonised by natural means after the last Ice Age and before isolation from the European mainland by rising sea levels. There are approximately 30 broadleaf and 3 conifer species recognised as native to the UK.

Selection system A method of forest regeneration and maintaining an uneven-aged structure by removing some trees in all size classes either as single trees or in small groups or strips. Regeneration is usually by natural means.

Shade tolerance The capacity of a species to become established and persist under the shade of canopy trees. This is an important ecological feature of a species that influences the choice of silvicultural system.

Shelterwood Any silvicultural system designed to encourage regeneration under the protection of the existing canopy, and where the resulting stand will be more or less even-aged.

Silvicultural system An approach to coordinating regeneration, tending and harvesting of trees within a stand.

Forest resources and global carbon cycles

In recent years, rising fossil-fuel prices and awareness of climate change have spurred interest in the use of wood as a source of 'green energy'. If there is a balance between the carbon fixed in the trees' tissues through photosynthesis and that released by combustion, producing energy from the forest is carbon-neutral. The only additional inputs are fertilisers, pesticides, and the fossil fuel required for mechanised operations and transport.

United Utilities is exploring a project with the local community to supply wood fuel to a combined heat and power installation in the Thirlmere valley. This will supply affordable heating to local households and company offices, create secure local employment, and provide a local market for small-diameter and low value timber.

Forest health and vitality

The greatest threat to the health of forests worldwide, including those at Thirlmere, is climate change. Predictions for Britain over the course of this century include significant increases in mean monthly temperatures, changes in the pattern of rainfall and an increase in the number and severity of storm events. Stands of mixed species with uneven-aged structures are potentially more resilient than monocultures to natural disturbances. For example, only a small proportion of trees in a mixed stand will be blown over by high winds while in monoculture large patches may be lost. Multi-species stands are less likely to suffer serious pest damage as most pests favour one or a small number of host species. Transforming most of the forest to continuous cover, with stands of mixed species and

age, should make it more able to withstand changes in our climate. In addition, such forests are effective in the long-term storage of carbon, in both the vegetation and the soil.

Landscape and 'sense of place'

Thirlmere is an important cultural landscape in the Lake District National Park. Care must be taken to ensure that new tree planting and harvesting operations do not have a negative impact. At the landscape level, popular or significant views on roads and at major access points must be preserved. More locally, buildings, drystone walls and other artefacts that contribute to the identity of the area must be conserved. United Utilities also recognises the importance of archaeological and culturally significant sites, which are protected from disturbance during forestry operations.

Conclusion

Thirlmere is an excellent example of modern approaches to sustainable forest management in the UK. The most important priority in the valley is the conservation of water quality and supply for the people of the northwest, but the forest fulfils many other functions. Integrated land use and resource management requires complex field assessments, zonation of land use and planning. The great benefit of a modern approach is that we are more able than at any time in the past to meet current needs as well as considering those of future generations. The vision of foresters, engineers and geographers who created the Thirlmere estate is a magnificent legacy for future generations, and a demonstration of how sustainability can be achieved in the heart of England's Lake District.

Key points

- The UK is one of the least forested countries in Europe and woodlands must usually be managed to fulfil multiple objectives.
- Strict international standards for sustainability and criteria for the conservation of biodiversity are employed in UK forestry.
- Forests are complex ecosystems that serve a wide number of environmental, economic and social purposes at the local, regional and global scales.
- Forests play a major role in the landscape and in environmental processes, including the hydrological cycle.
- Forests are important for the conservation of water resources at Thirlmere. They protect the slopes, filter and regulate water flow through the soil, exclude stock and influence water chemistry.

References and further reading

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