

TREE ECOLOGY

THE ROLE OF TREES IN THE ECOSYSTEM

Trees are not a single habitat but dozens of habitats inhabited by thousands of different species. Many of our rarest species are associated with ancient trees and only occur where there has been a continuous cover of old trees back through time on the site.

Trees are keystone species in the British landscape because they are essential to the survival of so many other organisms. Below is a list of some organisms dependent on trees:

- **Birds**

One third of all woodland birds nest in holes or cavities in dead trees, and large, hollowing trees provide ideal roosting sites for species such as the great spotted woodpecker and various owls. Some birds also rely on the invertebrates in dead wood as a food source. Raptors (birds of prey) will frequently use snags as lookouts and food handling points. Trees provide birds with a rich harvest of seeds, berries, and invertebrates as well as places to hide and nest and of course the all-important song posts.

- **Small Mammals**

At least ten of our fifteen bat species use tree holes for summer and winter roosts. Dormice are a protected species in the UK, overgrown hedgerows and deciduous woodland are the favoured habitat.

- **Spiders and Pseudoscorpions**

A huge variety of spiders are found on trees. Branches and hollows are ideal structures to situate webs. All orb weaving spiders make suspended, sticky, wheel-shaped orb webs. Webs are placed in openings between trees, hollows and branches where insects are likely to fly.

Huntsman Spiders are found living under loose bark on trees, in crevices on rock walls and in logs, under rocks and slabs of bark on the ground, and on foliage. Dozens of the social huntsman species can be seen under bark on dead trees and stumps but they can also be found on the ground under bark slabs.

Pseudoscorpions are very tiny indeed, the biggest is less than one centimetre long but most of them are only 2 millimetres long. They resemble actual scorpions very much except that they lack the poisonous tail. Just like scorpions and crabs they have front legs in form of scissors which are poisonous. All species are predators; they feed on very small insects. Many can be found by turning leaves in woodland leaf litter or under the bark of trees. These species are mainly dark brown with reddish brown pincers.

- **Beetles**

Many species are directly dependent on trees, feeding on foliage, bark, wood, roots, buds, flowers or seeds.



This is a female stag beetle on a veteran oak. Stag beetles are a protected species in the UK and Europe.

- **Squirrels**

Grey Squirrels are doing very well under current conditions in Britain, so well that they are considered a pest by many. Of course squirrels rely absolutely on trees for shelter and for food.

- **Flies**

There are some 120,000 species of fly known, many more species still fly about undiscovered, and some experts believe that there may be well over 1 million species. Flies can often be seen around all parts of a tree.

- **Slugs & Snails**

This may come as a surprise to some but slugs and snails can commonly be found at the tops of trees. They graze the algae growing on tree bark and they even eat leaves!

- **Butterflies and Moths**

Adult butterflies and moths frequently use stubs from snapped branches or bark fissures as egg laying sites. Larvae usually eat the leaves of trees, but flowers, dead vegetable matter and live timber or internal parts of woody plants are all utilized.

- **Bees and Wasps**

Bees, wasps and ants are close relatives, for they all belong to the Hymenoptera. In this group most of the insects living socially can be found. These animals live in large or small colonies. These colonies are built around a central animal, called the queen. In many cases her task is limited to laying eggs. Bees and wasps often site their nests in tree hollows. Many types of wasp induce trees to form galls in which their young can develop in a sheltered environment.



A spangle gall on the underside of an oak leaf.



A knopper gall on an acorn. This gall is formed by the wasp *Andricus quercusalicis*. *A. quercusalicis* was first recorded in the UK in 1956. Like many other invading gall wasps *A. quercusalicis* has two generations a year that induce different galls on two different host oak trees (*Quercus robur* - English Oak, and *Q. cerris* Turkey oak). While English oak is native to the UK, Turkey oak is an introduced tree species that is native to the Balkan regions and the near East. The wasp can reach very high densities and the induction of a gall on the acorns of English oak (knopper galls) tends to destroy the acorn.



A marble gall on the twig of an oak tree.



An oak apple found on oak leaves and twigs. In this picture the wasp is visible.

- **Ants**

Eight out of ten animals walking on this world are believed to be ants and so it is unsurprising to find them on trees. The best known ant in all Britain probably is the Black Garden Ant. The name is slightly misleading, for many individuals are dark brown rather than black. It is an omnivorous animal. It will attack and kill other small insects, but will also take small cadavers (dead bodies), parts of plants, fungi or seeds into the nest. Columns of ants can often be seen during summer months filing up tree trunks into the crown and back down again. Ants eat the honeydew produced by tree aphids and will even actively milk the aphids to get more. As a reward they will protect the aphids from small natural enemies, such as lady birds.

There are two ant species which form their nests in the decaying heartwood of trees in Britain: brown tree ant and jet ant. Wood is macerated by their jaws and hardened by secretions from the mandibular glands to create the nest itself and intricate passageways are developed through the heartwood to access points in the outer trunk from whence the workers forage over the leaf canopy for food.

- **Woodlice and Centipedes**

Woodlice feed on decaying wood and plants. They are easily found in damp crevices and under loose bark.

Centipedes are commonly associated with decomposing logs, in leaf litter and under logs and tree bark. Some centipedes are vegetarians, although this species eats other small insects. They are also equipped with a poison claw on each side of the head. Although these are not dangerous to humans, they are used to catch and kill their prey.

- **Epiphytes**

A wide range of mosses, liverworts, lichens and algae can be found on trees and decaying wood. The establishment and persistence of these organisms depends on suitable local light levels, humidity, pH, and shelter. The need for good lighting means that it is the large old open-grown trees which support the richest epiphyte communities, rather than trees in closed canopy woodland.

- **Micro-organisms**

Soil microbial communities depend heavily on the rhizosphere (The soil zone that surrounds and is influenced by the roots of plants). The microbial biomass accounts for only 1–3% of soil organic Carbon, but it is the eye of the needle through which all organic material that enters the soil must pass. Through the microbial community's activities, organic matter can be: incorporated into new microbial biomass; transformed to produce compounds which stabilise soil aggregate structures; provide long-term nutrient reserves (and therefore buffers to supply); or respired to rejoin the pool of carbon dioxide in the atmosphere.

- **Fungi**

Fungi are one of the few organisms able to break down cellulose and lignin, which are the principle components of wood. As a result fungi are closely associated with trees. Different fungi live on different types of tree, and on different parts of a tree; some will colonise the roots, some are only found on branches and some live on the leaves. There is a whole succession of fungi that can be found living on a piece of wood that has begun to decay. Each fungus breaks down the wood structure until it has decomposed and the organic components are released into the soil. Most invertebrates rely on fungi and/or micro-organisms to convert these compounds into more digestible materials.

Tree fungi themselves offer an important suite of habitats. For example Dryads Saddle has 246 known beetle associates!

A mycorrhiza is a symbiotic association between plant and fungus localized in a root or a root like structure in which energy moves primarily from plant to fungus and inorganic resources from fungus to plant. Enhanced nutrient uptake is the principal potential benefit that a tree obtains from being mycorrhizal. The familiar red-and-white spotted 'Toadstool' (Fly Agaric) is a mycorrhizal fungus which (usually) forms partnerships with Birch and Pine trees.

Many mycorrhizal fungi have very low host specificity so that their hyphae can link several root systems. Mycorrhizas can enhance the ability of plants to tolerate stresses other than nutrient deficiencies. One is the potential for hyphae to transfer water. The growth of external fungal hyphae may improve contact between the soil and roots. Some mycorrhizae increase resistance or tolerance of the plants to root pathogens that include bacteria, fungi and nematodes. 10-40% of the total energy produced by trees through photosynthesis is 'paid' to their mycorrhizae for the services that they provide.

WOODLAND ECOSYSTEMS

Succession is a long-term change in the composition of communities. Unlike the action of seasons and natural disasters, succession is brought about by the activities of living organisms themselves who inhabit the environment. Over a period of time the environment is modified by these organisms so it becomes suitable for colonisation by another species and less suitable for those already there. These original species cannot compete with the new species better equipped to exploit the improved conditions so these organisms are 'out competed' and disappear. Most land in Britain will develop into woodland if succession is allowed to proceed without disturbance. The climate, temperature, wind, soil type, subsoil type, the chemical nature of the soil and the degree of exposure, to a large extent limits which organisms can survive in any particular system. A woodland ecosystem is a climax community engaged with the abiotic environment in which it is set. The ecosystem is sustained by species that function as primary producers, decomposers and detritivores, herbivores, carnivores and parasites, plus the water, soil and air that provides living conditions and acts both as a source and a sink for energy and matter.

Trees are obviously a vital component of a woodland ecosystem. Their size and framework is responsible for the diverse physical structures found within woodlands. This diversity of structures helps to create a range of microclimates that support a wide variety of life forms. In addition, logs are a valuable physical feature for other vertebrates, and are used for cover, feeding, lookouts, resting, sunning, drumming and hibernating. Woodland fungi also play a key role in a number of ecosystem processes, such as the decomposition of cellulose and lignin, mediation of soil processes and the enhancement of tree growth through the development of mycorrhizal associations. Fungi also enhance habitat quality for other species. For example wood boring insects require wood infected by fungi before they can digest the lignin, and many other insect groups depend on fungi as a food source.

A further feature of woodland that adds to their value for other species is their physical structure. A person walks *on* grassland but *in* a woodland. In addition to the field layer there is an understorey and a canopy. The niches of some woodland bird species are partitioned by the part of the canopy that they use. We don't fully understand the structure, function or resilience of life in forest canopies because of the difficulties of gaining access to the forest canopy and study. Now some of the most exciting scientific research into the life of woodlands now takes place at the tops of trees!

A vast community of invertebrates is associated with the non-tree components of woodland habitats, preying or parasitizing primary feeders, or utilising the understorey flora and fauna in a shaded or semi-shaded and frequently damp ecosystem.

A distinct community of flowering plants has evolved to live in woodland conditions. Field and ground layer vegetation is key components of biodiversity in forests. There is also an array of mosses and ferns that are characteristic of woodland habitats.

Forests and woodlands hold more biodiversity than any other land-based habitat. Ancient and semi-natural woodlands have the greatest value for nature conservation of woodland species in the UK.

THE ECOLOGICAL VALUE OF NON-WOODLAND TREES

The requirement for trees in woodland ecosystems is easy to understand. However trees also play an important role in non-woodland ecosystems. Open grown trees have a different crown framework to trees in woodlands; they often have wider crowns that extend lower than those found in woodlands. They are also often exposed to stronger winds and so branch loss is common. These factors add to the range of habitats that trees provide. Certain trees or groups of trees may have especially high ecological value because of their location, size, species, and/or condition. For example, a given tree may be an important roost, nesting site, or food source for certain wildlife species; it may be situated in a site where it provides shade needed by other plant or animal species; it may be an important genetic resource for a local tree population or the species as a whole. Trees in the wider landscape may function as corridors or stepping stones between woodland habitats that dependent organisms may rely upon for dispersal. The sheer size of trees makes them a significant contribution to the biomass of any ecosystem. The physical structure that they provide is crucial to the survival of vast amounts of life, and as such they are an important part of the natural environment.

Soil benefits from trees, as their far-reaching roots hold the soil in place, preventing erosion. Trees improve soil quality as their leaf litter makes perfect compost. Natural mulch consists of dead leaves, twigs, fallen branches and other plant debris which accumulate on the earth's surface. Bacteria, fungi and other living organisms use these raw organic materials for food, a process we know as decay. In the natural scheme of things, decay is Nature's way of returning to the earth the raw materials borrowed by previous generations of plants. All soil life needs energy; these organisms cannot collect energy directly as green plants do, but feed on energy released from decaying mulch which is their preferred food source. As microbes digest organic materials they give off a sticky substance that glues soil particles into a crumb-like structure. Crumb-like or crumbly soil structure also allows water to soak in better. Water that soaks in is held on the humus for future plant use.

In soil or compost, high species richness diversity promotes numerous interspecies relationships and interpopulation interactions. Species richness diversity is important because it allows for a more varied and flexible response to environmental fluctuations and stress. For instance, those communities with more diverse microbial populations will be more likely to cope with disturbances and stress than those communities with low diversities. Good soil has the ability to buffer thus preventing leaching and providing nutrients.

Channels and fissures, including biopores formed by earthworms and decayed roots, offer pathways for unimpeded root growth. These biopores are reservoirs of oxygen and carbon dioxide which are vital to the living components of the soil. In this way a living soil creates conditions favourable for plant roots near the soil surface where air content and nutrient levels are conducive to good plant growth.

ECOSYSTEM SERVICES PROVIDED BY TREES

It is trivial to ask what the value of the biosphere to humankind is, or similarly the value of rocks and soil. Their value is infinite in total, when damaged they take many times longer than a human lifespan to recover (under favourable conditions), and once lost they are irreplaceable. However, it is possible to ask how the quantity and quality of natural features and ecosystem services have an impact on human welfare. Such changes include both small changes at large scales and large changes at small scales. The chains of effects from ecosystems to human welfare can range from extremely simple to exceedingly complex. Tree covered areas provide timber, but also hold soils and moisture, and create microclimates, all of which contribute to human welfare in complex, and generally non-marketed ways. There is very little relation between the value of services and observable current spending in many cases. This is because a large part of the contributions to human welfare are of a purely public goods nature. They accrue directly to humans without passing through the economy at all. In many cases people are not even aware of them. Examples include clean air and water, soil formation, climate regulation, waste treatment, aesthetic values, and good health.

Box 1: The ecosystem services that trees provide.

- ▶ *Water storage and retention* – Forests catch, hold and recycle rainwater, moderating water flows. Plants absorb rain water and then release it back into the air.
- ▶ *Erosion control* – Retention of soil within an ecosystem.
- ▶ *Carbon and oxygen cycles* – Plants absorb carbon dioxide and release oxygen back into the air, creating a breathable atmosphere.
- ▶ *Nitrogen Cycle* – Nitrogen is essential for plant growth. Bacteria living on some tree roots convert nitrogen from the atmosphere into a form that the tree can use. Creatures feeding on these trees release nitrogen in their waste products. When the waste is broken down it is released back into the atmosphere.
- ▶ *Harbouring pollinators* – This can be vital to the success of some of our food crops.
- ▶ *Biological control* – Many predators of crop pests survive on alternative prey in hedgerows ready to disperse once pests appear.
- ▶ *Refugia* – Hedgerow trees act as nurseries and habitats for migratory species. Hedgerows are refugia for woodland species in the farmed landscape.
- ▶ *Food production* – Nuts and berries can be collected from hedgerow trees.
- ▶ *Transforming energy from the sun into stored chemical energy* – This is the foundation for virtually all food webs.
- ▶ *Genetic resource* – Some tree species exist as sub-populations of locally adapted species for example elm and black poplar.
- ▶ *Carbon sequestration* – Although only minor in relation to the scale of carbon emissions in Britain, any form of sequestration is of value.
- ▶ *Provision of sites for particulate deposition* – Small particulates in the air can influence respiratory health. Tree can reduce the effects of such pollution by intercepting them on their leaves and thus having a filtering effect on the air.
- ▶ *Cultural* – Trees are large and conspicuous features that make an obvious contribution to the character of the British landscape. In this way they contribute to tourism income in some areas. They can also screen negative attractors.
- ▶ *Disturbance regulation* – The presence of trees in the landscape provides capacitance, damping, and integrity of ecosystem response to environmental fluctuations. For example, widespread atmospheric pollution, together with greenhouse gases, appears to be leading to climate change. If a change in climate becomes significant, a high proportion of woodland reserves will be at risk because they are ecologically isolated. Any species that cannot tolerate the change will be eliminated from reserves marginal to its range, and poor colonizing species may be lost where they exist in isolated populations.

THE NEED FOR CONSERVATION OF TREE-RELATED HABITATS

At present, Britain is one of the least wooded countries in the temperate regions of the world. In some ways the situation is improving, currently 12% of Britain has woodland cover, compared with just 5% in 1924. But there remains room for improvement as currently Europe has an average of 46% woodland and yet England has only 8% woodland cover. It must also be remembered that Rainforests are being destroyed at the rate of at least 60,000 square kilometres per year! And half the Earth's woodland cover has disappeared since 1950! This situation has resulted from a long history of human settlement, high numbers of domesticated grazing animals, and past climatic changes. The loss of woodland over the past millennia has been associated with substantial losses of woodland biodiversity. Fragmentation of woodland habitats has long been a problem and continues to worsen in many areas. The main management practices causing habitat loss and degradation are: the development of land for housing or commercial purposes, inadequate protection of veteran trees; replanting with inappropriate tree species; inappropriate grazing, and overgrazing.

As population and other pressures built up in the middle and later Saxon period (Circa 800-1066AD), people switched from living in dispersed hamlets and farmsteads to a more communal system which facilitated the expansion of arable at the expense of wood pasture and waste ground. With the advent of intensive agriculture in the 21st Century trees have been lost from the wider landscape at an alarming rate. Roughly half of the hedgerows of Britain – some 160,000 kilometres – were ripped out between 1950 and 1995, creating open prairies in place of the traditional landscape of small fields and copses. The decline in hedgerow length has now halted, largely due to grant incentives to encourage the creation and restoration of hedges, the Ancient and/or species rich Habitat Action Plan (HAP), and the Hedgerow regulations which came into force in 1997. However, newly created or restored hedges count in the studies for hedgerow length, which masks the fact that we are losing the larger trees that are of the most value in the landscape. Consequently, even if the length of hedges is not declining, the ecological value of these hedges continues to decline primarily due to the loss of tree habitats.

The numbers of trees in hedgerows is steadily declining as trees are removed to allow greater access for farm vehicles, through regular flailing that prevents the development of young trees, or through soil and root damage caused by the huge farm machines that have become common in recent years.



Ploughing too close to trees damages tree roots and causes trees to decline.

Urban sprawl and the construction of roads has also caused the loss of significant numbers of trees in recent times. A further mechanism causing the loss of trees in the urban environment is the fear of subsidence caused by the extraction of water by trees from clay soils under the foundations of nearby buildings. In reality it is often unclear if adjacent trees are the cause of building subsidence. Insurance companies often ask for the removal of trees near buildings before insuring a property or granting a mortgage and a detailed investigation is rarely specified. It is commonly seen as the simplest and cheapest option to remove the tree in such circumstances. Insurance companies behaving in this way has undoubtedly caused a significant loss of trees from the urban environment in the UK and unfortunately these situations are becoming more frequent.

Advice from a qualified arboriculturist should be sought before trees are removed on the basis of subsidence avoidance. In many situations there may be ways of retaining the tree with no harm occurring to the property.

Numerous studies have shown that the lack of nest sites can limit breeding numbers of birds; data collected by the British Trust for Ornithology shows that numbers of the lesser-spotted woodpecker have reduced by 75% since 1970, and farmland bird numbers remain at 60% of the 1970 level. It seems reasonable to expect that organisms that depend on other specialised tree habitats also become scarce as trees in the landscape become more infrequent. As numbers of these species reduce, their contribution to the ecosystem that they have co-evolved with also reduces. In the case of food webs, if a few filaments of the web are lost the web will continue to function; as more filaments are lost the web ceases to function effectively and relies more and more on the remaining threads, with a corresponding increase in the risk of total failure.

Box 2 shows that the number of non-woodland trees has declined by 57% since 1980. **The loss of these non-woodland trees has largely gone unnoticed** and to date there has been little action to reverse the trend.

Box 2: Forestry Commission data on the loss of non-woodland trees.

Feature type	1980 Census	1998 Inventory	Change (%)
Boundary tree	8 014	5 048	-37
Middle tree	10 063	2 670	-73
Total Individual Trees	18 077	7 717	-57
Groups	32 644	19 665	-40
Linear Features	37 213	40 542	9
Total	87 934	67 924	-23

From the Forestry Commission National Inventory of woodland and trees 2003.

- **Group**

A group containing two or more trees with an area less than 0.1 ha.

- **Individual Tree**

A tree with a crown that has no contact with any other tree crown, and which is at least 2m tall. Two types of Individual Tree are recognised:

- Boundary Tree (an Individual Tree on a boundary).
- Middle Tree (an Individual Tree not on a boundary).

- **Linear Feature**

A feature with a length of 25 m or more, and one which is at least four times as long as it is broad. It can be up to 50 m wide or as narrow as a single line of trees. Two types of Linear Feature are recognised:

- Narrow Linear Features (with a width of 16 m or less).
- Wide Linear Features (with a width greater than 16 m).

Fungi and invertebrate species richness is strongly correlated with the volume of dead wood on the forest floor. For many years the value of standing dead wood and fallen timber has not been recognised. Therefore dependent species are now facing a crisis as so little of their habitat remains. It is now crucial that we take active steps to conserve dead wood in gardens, parks and woodlands.

Those who would like to contribute to the conservation of woodland are encouraged to join the Woodland Trust www.woodland-trust.org.uk.

This document has tried to illustrate that trees are slowly being lost from the landscape. Obviously planting trees is a valuable and sensible thing to do. Consider where you may be able to plant a tree, perhaps in your garden or at your place of work. Always take care when selecting which species to plant; think about how big the tree is likely to grow and if any structures or activities may be disturbed by this.

Ben Rose

November 2005