Adventurer's MK

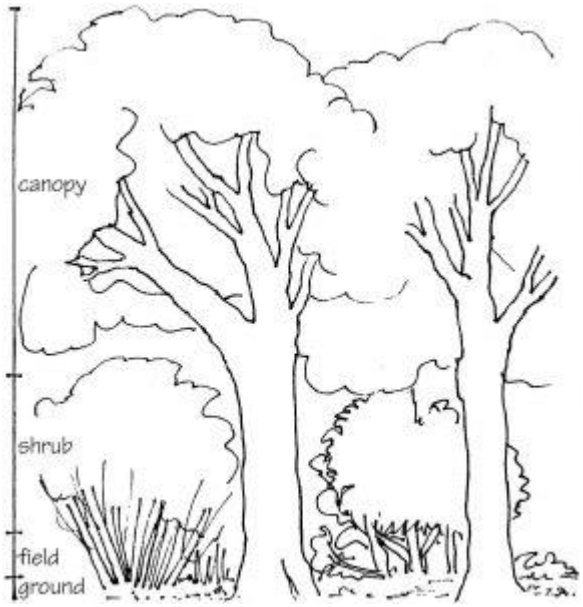
FOREST MANAGEMENT

The woodland ecosystem

Structure

The complex structure of semi-natural broadleaved woodland offers a great diversity of habitats in which plants and animals can live. Like other aspects of the woodland environment, structural features change over time. One of the main aims of woodland management for conservation is to create, maintain or restore structural diversity where it has been lost or where, without management, it would decline.

Four layers are recognised in the woodland structure: the tree canopy, shrub layer, field layer and ground layer. The importance of the underground layer should not be forgotten.



Further layering may develop where the dominant canopy trees are overtopped by occasional emergent trees, or where they grow in the company of somewhat lower understorey trees. The field layer may develop two sub-divisions: a layer of tall herbs and undershrubs, and a layer of low herbs. Trees of the canopy and shrub layer may consist of plants of a single species, but of different ages and sizes, or they may be of different species which reach varying heights when mature. In a mixed wood, typical emergent species may include elm or beech, with oak or ash as dominants and crab apple, wild cherry, holly, rowan or field maple forming the understorey. This shrub layer may include hazel, hawthorn or blackthorn. Bracken. rose-bay willow-herb and bramble may form a tall herb layer with bluebells dog's mercury, ramsons and smaller ferns among the low herbs. The ground layer consists of mosses and liverworts, plus the seedlings of the plants of the taller layers. Where the woods are coppiced, the lower layers are likely to include coppiced shoots of the canopy species.

Not all woods have all these layers, and none would be likely to have them throughout. Some canopy species, such as ash, let in quite a lot of light so that full layering can develop. Others, such as beech, cast a heavy shade so that the shrub and field layers are largely absent except where there

are breaks in the canopy. Plantations usually show little diversity within stands. A well-stocked oak plantation is unlikely to contain much besides sparse brambles and a ground layer of mosses. Conifer plantations are dense and dark and most have little other than fungi from the time the canopy closes over until the first heavy thinning. Wood pastures usually lack the shrub layer and higher field layer, due to grazing, while in scrublands the shrub layer forms a canopy in the absence of taller woodland trees.

Woodland plants are adapted to the structural conditions. For example, yew and holly are typical trees of the understorey, as being evergreen, they are able to compensate for the dense shade of summer by growing at other times of year. Dark leaves, such as holly and ivy, also contain a relatively large amount of chlorophyll, so they are able to use low light levels efficiently. Holly and yew are amongst the few trees which can regenerate in dense shade. Many of the species in the tree and shrub layers produce flowers before they come into leaf, as being wind-dispersed, the seeds need to ripen before the unfolding leaves shelter them from the wind. The plants of the field layer have to grow and flower early, before the canopy closes over them. Annual plants, that must germinate and complete their cycle within one growing season are at a disadvantage, and hence are poorly represented in woodlands. Most of the field layer plants are perennials, with bulbs, corms, tubers or rhizomes to give a rapid early start in spring.

Lateral structure is also important for diversity. Where woods are allowed to develop unhindered, some canopy trees eventually die and create gaps, where seedlings of canopy, shrub or field layer can spring up. Coppiced woods are often especially diverse because at any given time they are likely to contain some coupes which have recently been cut over, some where the coppice has created a dense shrub layer, and others where the coppice has matured into an understorey with standards as canopy dominants.

For some forms of wildlife, these relatively short-lived openings in the canopy are less important than longer-lasting glades, margins, lawns and rides. Such sheltered, humid but well-lit areas are much richer in species of epiphytes and invertebrates than either shaded woodland or open-ground habitats. It seems likely that they occurred frequently in the primaeval woodland, maintained under natural conditions by heavy grazing and browsing. In this respect, relatively open wood pastures may retain more similarity to the original forests than do dense plantations, or ungrazed, unmanaged woods.

However, the maintenance of shelter within a woodland is of great importance, providing a microclimate that is moist, sheltered and shaded, with smaller temperature fluctuations than those that occur outside the wood. Many woodland species, including flowering plants, mosses, ferns, liverworts and invertebrates have limited ability to disperse, and can be lost by changes in the woodland cover that are too drastic.

Within a woodland, various associated features provide many additional habitats, especially for fungi and invertebrate animals which are often restricted to these situations. The most important of these from a management viewpoint include large and old trees, decaying wood, streams and ponds, and climbing plants.

One of the most important parts of the woodland structure is the part you can’t see. Beneath the soil surface is a complex ecosystem of roots, fungi and soil micro-organisms. Tree roots are often surprisingly shallow, with the most important feeding roots occurring in the top 30cm (1ft) or so of soil. The roots may spread out beyond the outer edge of the canopy, so damage at some distance from a tree may have adverse effects.

Amongst the most important organisms in the soil are a type of fungi called mycorrhiza, which forms a symbiotic relationship with roots of trees, shrubs and other flowering plants. Mycorrhiza occur in nearly all plant communities, and it's estimated that 90% of the world's plant species depend on a mycorrhizal association. Mycorrhiza fungi form highly branched, interconnected networks that invade the roots of plants in order to obtain a supply of carbohydrate. In return, the mycorrhiza converts organic nitrogen to inorganic nitrogen, supplies phosphate to the host plant, and may also confer some degree of pest, disease or drought resistance. For many plants the nutrient and water uptake is mainly by way of mycorrhiza, and not directly through the roots. It's estimated that the fungal network extends the volume of soils that plant roots can exploit for water and nutrients by a factor of 12 to 15. Mycorrhizal threads are more efficient than plant roots at nutrient uptake, as they are finer and more active.

In woodlands, the ability of mycorrhiza to make nutrients available to the trees, shrubs and other woodland plants is vital for the self-renewing fertility of the wood. Mycorrhizal associations are partly the reason why natural regenerated tree seedlings in soils with mycorrhiza already present tend to thrive. A seedling transplanted into a cultivated soil or disturbed soil, where there is little mycorrhizal activity, will struggle.

Some species of mycorrhiza will only associate with particular plant species. Others will associate with various plant species, though possibly with little benefit to the host. 'Easy to grow', tolerant plant species such as ash, cherry, alder, willow and sycamore can form associations with a range of species. At the other end of the spectrum, many orchids are totally dependent on a particular mycorrhizal association, without which the seed cannot even germinate. This accounts for the rarity of orchids, their ability to thrive in particular places and not in others, and why transplanting leads to failure. With other plants, a particular mix of mycorrhiza may be needed.

Mycorrhiza are very fragile, and are easily damaged by cultivation. Being symbiotic, they need their host plants to survive, so the removal of woodland above is also the destruction of all the mycorrhizal associations below. This is why it is so difficult to create a woodland ecosystem simply by planting or seeding, and why it is so important to protect remaining areas of woodland and woodland soils.

Communities

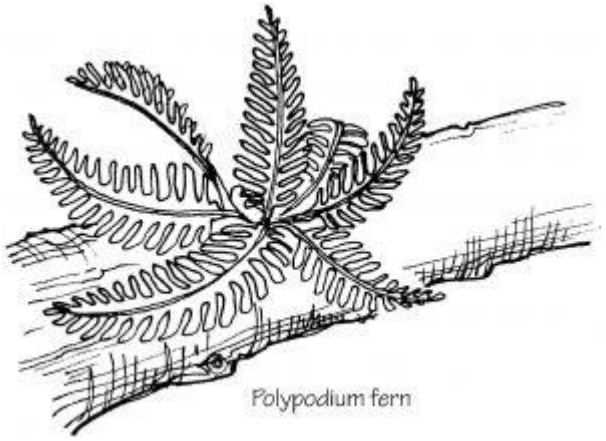
Woodlands, wood pastures and other wooded areas support a huge range of organisms, with their distinctive mixtures of trees and shrubs, and associated flora of flowering plants, ferns, mosses, liverworts and lichens.

Semi-natural broadleaved woods may contain many of the 60 or so native species of trees and shrubs, as well as a wide variety of flowering plants and ferns, with even small woods containing 20 or more species, and large diverse woods supporting over 200 species. A diversity of plant species in turn supports a variety of insects, birds and other fauna. Some tree species, notably oak, willow, birch and hawthorn are outstanding in the fauna they support, with blackthorn, aspen, elm, hazel, beech and Scots pine also being important.

The bark of trees also provides a habitat for epiphytes, which are non-parasitic plants that grow on other plants. Epiphytes are normally only found on trees within woodland, where the shady, humid atmosphere allows sufficient moisture for them to survive. Mosses, liverworts, algae and lichens may all be found growing as epiphytes, with one higher plant, the fern also occurring in Britain.

Epiphytic growth tends to be much more lush in the moist and mild westerly areas. Lichens only survive in unpolluted air. Lichens and other ephiphytes grow slowly, with the richest communities

found on the oldest trees of stable, undisturbed woodland, making an assemblage of great conservation interest.



Succession

Woodlands, like all communities of living things, are dynamic. Sometimes they change so slowly that little seems to happen in a human lifetime. At other times, as when a felled wood is left to regenerate or a grassy area is allowed to grow up to scrub, the changes are noticeable within a few years. It is important to take account of this dynamic aspect of woodland ecology when managing woodlands, since to ignore it may make management difficult, frustrating and ultimately unsuccessful. Where woodland succession is understood, it can be accounted for, and if necessary, manipulated.

'Natural succession' is the process by which one community of organisms gives way to another, in a series from coloniser to climax. To give an idealised example, bare land is first colonised by annual 'weeds', then by grasses and mixed herbaceous meadow species, followed by shrubs and finally by trees, which grow up through the shrubs and largely suppress them. The weeds are the pioneer species, while the forest trees form a 'climax' community which tends to persist indefinitely.

In reality, succession seldom takes place uninterrupted by natural or man-induced agencies such as fire, grazing, felling or drainage. It is also usually much more complex that the picture given above. Certain trees and shrubs may come in immediately, depending on the proximity of parent or 'donor' plants, and on the feeding patterns of birds, which distribute the seeds of many of these species.

Tree species vary in their tolerance of shade and other conditions, and in their ability to regenerate within the woodland. Even without interference by man, woods may change in their species composition with time. 'Tolerant' species are those that can survive and regenerate under the canopy. They tend to be species that live longer, and flower later and more irregularly. They can persist in the understorey as suppressed seedlings, and then quickly take advantage of any increase in light due to canopy loss, for example when mature trees are blown down. Tolerant species are poorly adapted to long distance dispersal, so are not found early in the woodland succession, but tend to be part of the climax community. Species include hornbeam, lime, elm and beech.

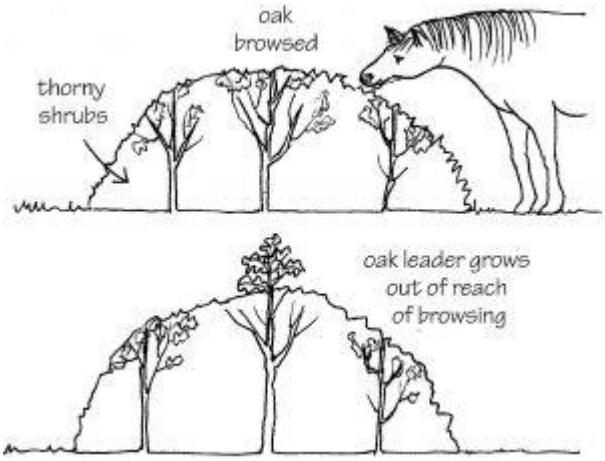
'Intolerant' species are those which cannot tolerate shade, and tend to be succeeded by tolerant species. Intolerant species are fast-growing, quick-maturing, short-lived species which produce seed regularly and in quantity. They are pioneers in two ways. Firstly they are opportunistic, and can quickly occupy sites which come available, and secondly, they can persist and reproduce in infertile or difficult sites. Species include alder, willow, pine and birch.

Some species have characteristics of both tolerance and intolerance. Oak is intolerant of shade, but is very long- lived. Holly and yew are tolerant of shade, but are widely dispersed by birds. In some of these woods, pine also seems to alternate with birch in a relatively stable long-term cycle, depending on which species is better able to regenerate in a given area at a given time.

Oak is a pioneer species and is often present very early in the succession of grassland to scrub, and is not a stable climax woodland species as is often imagined. Oak cannot regenerate under its own canopy or under the canopy of other trees, as there is not sufficient light. Acorns may germinate and seedlings appear, but unless an opening appears in the canopy due to windblow or felling, the seedlings wither away, or are defoliated by tortrix moth caterpillars which fall down from the parent tree above. Oak is dependent on being spread, mainly by jays, which select ripe and fertile acorns in autumn and bury them for food stores. The jays choose sites in long grass and under thorny bushes at the edges of woodland, in bare or waste ground, and in loose soil which is easy to penetrate. The acorns are buried singly. During late winter and through the following spring and summer the jay will return and retrieve some of the acorns, in the later part of the season by tugging at the seedling tree and removing the acorn, but normally without damaging the tree.

Oak is also adapted to withstand browsing and competition from grasses, herbaceous plants and thorns. Its large seed produces a deep taproot which sustains the seedling, and if browsed it can normally regrow.

A young oak tree can remain browsed and small for many years, and then take advantage of any break in browsing to put on a spurt of growth. Oak frequently grows up in the shelter of thorny shrubs including holly, hawthorn, blackthorn and gorse, where it is protected from grazing.



Oak, and other species which cannot regenerate in closed woodland, may therefore be dependent on grazing animals maintaining open areas in which regeneration can take place. In natural conditions, oak would have colonised grazed areas. In managed landscapes, it can colonise cleared ground, waste ground, roadsides and railway embankments. If left unmanaged, oaks eventually get overtaken and suppressed by species such as lime, hornbeam, elm, sycamore or beech, except on poor soils or exposed sites. In western coastal areas oak is the climax vegetation of rocky dells and slopes which have little soil, where other trees cannot survive.

Woodlands with fairly closely spaced oaks are nearly always plantations. Old oaks in woodland with wide spreading branches low on the trunk show by their shape that they grew originally in open ground, and the woodland by which they are now surrounded has grown up since.

Other tree species take advantage of holly and other thorny shrubs for protection from browsing. Trees have to become established in holly in the first 20 years or so after the holly starts to grow, or the shade is too dense. The next opportunity does not arise until the holly degenerates, after 2-300 years.

There are many situations where natural woodland succession needs to be managed to benefit wildlife diversity. Trees encroaching on rare and valuable habitats such as heathland, downland, wet grassland, marshes or dunes may need to be kept in check. Another situation where intervention is necessary is where succession favours one species over others which are considered more valuable. Introduced species, notably rhododendron and sycamore, are the most common culprits.

Field and ground flora

The field layer of woodlands consists of plants which are adapted to the conditions of shade, shelter and high humidity. The flowering plants have to seize the opportunity in early spring when rising temperatures allow insect pollination to take place, but before the canopy is in full leaf. Primroses, wood sorrel and wood anemones are amongst the earliest to flower. As the canopy begins to close, there is a second burst of flowering of the more shade tolerant species, with dog's mercury, bluebell, bugle and ground ivy typical of southern lowland oakwoods. In damp northern woods on limestone soils, ramsoms, bellflower and yellow archangel are found. Less common and easily overlooked are several species which are now more associated with gardens, including violets, yellow star-of-Bethlehem, lily-of-the-valley, columbine and monk's hood. Orchids and helleborines are amongst the rarest woodland flowers. Many woodland plants grow from bulbs or rhizomes, storing food during the long periods of shade, and allowing a rapid burst of growth in spring. The woodland field flora of ancient woodlands is very specialised, and cannot be replicated.

The variable conditions of woodland edges, rides and glades allow a much greater range of generally more common plants to flourish. Woodland edge habitats vary from sunny, dry banks to shady, damp ditches, and are affected by grazing, mowing and other management. Plants vary from those that are able to take advantage of recent clearance, to those that are adapted to stable, undisturbed conditions. Large grassy glades and clearings may have a flora more typical of old meadow or pasture, depending on how the clearing is managed.

Ferns are adapted to the damp, shady conditions of the deciduous woodland floor. They die back in winter, the dead fronds protecting the crown, and then in late spring the new fronds uncurl. Typical species include hart's-tongue, male, soft shield and broad buckler fern. The size and appearance of the fronds can vary considerably between different individuals of the same species, and many different varieties of most species have been identified. Some species of ferns can grow in the humus that accumulates on the spreading branches of mature trees, particularly oak, giving an almost tropical appearance to some ancient deciduous woods in the damp mild parts of Britain. Bracken is the most adaptable fern, and can grow not only in woodlands but in pastures and other open areas, where it can become an invasive weed.

Mosses are a primitive type of plant, many species of which are adapted to growing in woodland. They have no true leaves, stems or roots, but instead absorb water and nutrients over their entire surface, and so every moss cell must be within reach of the growing surface to obtain its water supply. Some of the most spectacular mosses are found in very damp places, near springs and upland streams, where the water is rich in oxygen and minerals. Mosses are sensitive to soil acidity and alkalinity, to light and shade, and to moisture conditions. They grow actively when it's cool and damp, and are at their most luxuriant in late winter. In spring they produce their spore capsules, and then gradually wither and die as summer progresses.

Mosses also grow on tree trunks, especially on the shady, lee side of leaning trunks where moisture can accumulate. The water-trapping ability of mosses enables them to grow on rocks and other exposed places, where they can play a significant role in succession, by providing a suitable substrate for seeds of other plants to germinate. Tree trunks are also host to other epiphytic plants, including lichens and liverworts, which absorb their nutrients from the air around them. Lichens are either crustose and pressed to the branch, or foliose, forming festoons of branching, trailing growth. They are particularly abundant in damp, western areas as they require moisture-laden air and are sensitive to pollution. Epiphytes grow most abundantly on fissured bark of old trees, which grows only slowly.

Where wood is decaying there is often a distinctive epiphyte flora due to the nitrogen being exuded from the tree.

Fungi that appear on living trees, decaying branches and on the woodland floor are the visible signs of the complex breakdown process which is an essential part of the woodland ecosystem. The visible toadstool, mushroom or other fruiting body is only a short-lived part of the intricate thread-like mycelium which penetrates wood, leaf litter and soil. Fungi lack the ability to make food, but instead break down living and dead plants into simple substances on which they can feed and grow. There are many hundred species of fungi in Britain that require wood for their survival, and most are host-specific, living on only one species or group of species. Standing trees can become infected by spores which settle on them and develop in damp conditions. Fallen trees and branches are infected by the mycelium that is abundant but invisible in the leaf litter on the woodland floor.

Woodland fauna

'Take care of the habitats and the animals will look after themselves'. This is the best rule where the aim is general wildlife protection. The creation and maintenance of floristic diversity is usually the key to animal conservation, since all animal food webs are based on plants, and because the greater the variety of plant life the better the chance of providing the necessary conditions for most animals.

Invertebrates

Diversity of habitats is the main requirement for invertebrates, as their complex life cycles require a range of conditions. Leaf litter contains vast populations of mites, as well as spiders, ground beetles, woodlice, springtails and other organisms which help initiate the decay of leaves and plant debris. Woodland edges, glades, rides and dead or dying trees are particularly important for many invertebrates.

Trees and shrubs vary widely in their importance for invertebrates, with native plants much more valuable on the whole than introduced species. Many adult insects depend on trees and shrubs for food in the form of nectar and pollen. Early flowering species such as willow, and late flowering species such as ivy are especially useful at a time when other food is scarce. Some invertebrates have very restricted distributions, specialised habitat requirements or poor rates of dispersal.

Reptiles and amphibians

Of Britain's six native species of reptile, three are at home in wood margins and hedgerows, as well as heathlands and commons. These are the common lizard, the adder and the grass snake. The common lizard and adder are widespread, while the grass snake is limited to southern and central England and Wales, where it is found mainly in woods and hedgerows near water at low elevations. Woodland management for reptiles consists mostly of habitat protection and freedom from disturbance. The most important measure is to allow hedgerows, rides, glades and other edge habitats to develop a border of coarse grasses and low shrubs. Where rides and glades are mown, it is worth leaving rough patches or sections for reptiles to bask. On sites where wood and hedge-

banks are overgrown, it may be worth cutting them back in places on the south or west sides to let sun reach the ground. Hibernacula can be constructed on suitable sites.

One of the few benefits of rhododendron is that it provides hibernation cover for adders and other reptiles, especially on sandy soils and heathland sites. This should be borne in mind during winter clearance operations, and any known hibernation sites should be left untouched.

The creation of marshy areas and ponds can improve the conditions for grass snakes. Piles of leaves, log stacks or other material which provides undisturbed conditions will provide overwintering sites for reptiles. Loose piles of branches or brash are not particularly valuable for reptiles, because they do not provide the advantage of constant temperature conditions that closer piles do.

Undisturbed and uncleared woodland ponds, with plenty of weed growth and varying depths of water are important for amphibians, especially the great crested newt.

Birds

The management of woodland and scrub for birds concentrates on providing suitable breeding habitat, mainly through the management of the woodland edges, glades and open spaces within the woodland. At the same time, it's important to recognise that large blocks of woodland usually contain more species, though at a lower population density, than smaller woodland areas.

Management work should be timed to avoid disturbance during the nesting season, which is April to July inclusive for most species. Other measures include providing nest boxes or bunches of branches tied to tree trunks, where existing nest sites for hole and shrub-nesting species are in short supply

Trees such as oak, which support a large and diverse insect population, supply the most food for insect-eating birds such as tits and tree-creepers. Dense, thorny shrubs are good for nest sites, as are old or dying trees which have holes and loose bark. Ash is particularly good because although fairly short-lived, the dead tree remains standing a long time. Shelter is most important for fledglings and overwintering birds. Clumps or belts of evergreen trees and shrubs can significantly improve the value of broadleaved woods for birds in winter. Ivy, when in its mature, bushy stage, is very valuable for birds and other types of wildlife. Loose piles of brash, especially where overgrown with bramble or other scrambling plants, can provide useful roosts for birds.

Unchecked increases in deer may lead to shifts in the species composition of woodland bird communities, due to the loss of the understorey habitat. Moderate levels of grazing and browsing are thought to be associated with the highest diversities of birds in woodland. Many species of woodland birds have adapted well to the habitat of wooded suburbs, with their gardens and parks, as a replacement for the old wood-pasture habitats.

Mammals

In the past in Britain, there was a much more diverse range of mammals in the woodland ecosystem. Aurochs (wild cattle), elk, red deer and roe deer were the main grazers and browsers, with populations kept in check by bears and wolves. The actions of beaver and wild swine affected woodland structure and succession. Grey squirrel, rabbit, and sika, fallow and muntjac deer were not yet introduced. As well as the direct effect of man's activities on woodlands, the losses and gains in the mammalian fauna have had, and still have, a very significant effect on woodlands and trees in Britain.

Deer are probably now more numerous than at any time in history, due to the lack of predators, the recent growth in woodland cover and the lack of culling. Winter cereals, an important food source,

and recent mild winters have reduced losses. In Scotland, red deer are a major influence in preventing the regeneration and spread of native woodland. In many parts of England and Wales, natural regeneration of woodland is impossible without protection against deer. Parts of Wales and the Midlands, the extremities of Kent and Cornwall, and the Isle of Man and the Isle of Wight are the only areas to remain relatively free. In some areas deer numbers are as high as 40 per sq km. Muntjac have spread rapidly in recent years, and have an effect on the woodland field layer plants as well as young trees. For details of fencing and tree protection.

Foxes have adapted well to woodland loss, and are now numerous in suburban and urban areas. Badgers, now protected against killing, injury or disturbance, have maintained active populations in most areas. Favoured places for setts are sloping copses and woods adjoining pasture, where the badgers can forage for earthworms. Well-established setts may be hundreds of years old, and are easy to recognise, with mounds of earth near the many entrance holes, which are at least 25cm (10”) wide. Signs of use are usually obvious in spring, with discarded bedding of hay or bracken outside the entrances, fresh soil and evidence of footprints. All setts are protected by law where they show signs of current use.

Among the smaller woodland mammals, a number of bat species are of management interest because they roost in hollow trees during at least part of the year. The best way to maintain roost sites is to preserve these trees, and where appropriate, to pollard new trees to provide habitats in the future. Provision of bat boxes can provide suitable roosting and nesting sites.
Dormice favour middle-aged to mature coppice or coppice with standards. Young or senescent coppices are not suitable habitats, as they lack the variety of food sources and nesting sites. A 15-20 year cycle is most favourable, with adjacent coupes cut at different times so there is always some suitable habitat. Some mature growth should be left to provide ‘bridges’ across rides and tracks. Dormice occur in the south of England and in parts of Cumbria. They thrive in warm summers, but numbers can be reduced during mild winters interrupted by cold spells. Botanical diversity is important to provide a succession of food sources through the seasons. In May, oak flowers and various types of pollen may be eaten, followed by caterpillars and aphids in June, ash keys in July, and nuts and berries through the late summer and autumn.

Dormice nest in tree holes up to 10m high in the canopy, and amongst honeysuckle and bramble, with individuals often having more than one nest. They normally breed early in July and again in August. In suitable habitats, nest boxes can be very successful, with perhaps 60-70% of boxes being used. Boxes similar to tit boxes can be used, but with the hole facing the trunk. The only predators are human, so boxes should be put out of easy reach. Dormice may still be present on the margins of otherwise unsuitable woods, so it may be worth putting up nest boxes along woodland edges.

Wood mice are one of the most widespread mammals in Britain, but highest densities are found in mixed woodland. The mice prefer areas with low vegetation, fallen branches and logs through which they will make their runways. Wood mice are seed-eaters, gathering the seeds of oak, beech, ash, hawthorn and sycamore for storage over winter. Seeds of other woodland plants, small invertebrates and fungi are also eaten. Wood mice are prey to various species, notably tawny owl and weasel. Numbers fluctuate in an annual cycle, being highest in autumn and winter, during which survival is determined by the size of the autumn seed crop. The rarer yellow-necked mouse is larger than the wood mouse, and spends part of its time in the woodland canopy. Although not aggressive to the wood mouse, the two species are rarely found together.

Woodland adjacent to river margins are important habitats for otters, and where they are thought to be present, disturbance should be avoided.

Conservation

The most important law regarding conservation in England and Wales is the Wildlife and Countryside Act (WCA) 1981, which includes protection of birds, other animals and plants, as well as other legislation regarding the countryside. Some of the WCA legislation and other laws which affect woodland plants and animals are outlined below.

Plants

General protection

Under the Wildlife and Countryside Act 1981, it is an offence for any person to uproot any wild plant without permission from the landowner or occupier. Uproot is defined as to 'dig up or otherwise remove the plant from the land on which it is growing', and includes plants without roots. Lichens, fungi, mosses, liverworts and vascular plants are thus covered under the Act. Similar protection is given in Scotland and Northern Ireland.

Under the Theft Act 1968, it is an offence to dig up and take for commercial purposes any plant, tree, shrub, soil, peat, gravel etc without permission from the landowner or occupier.
Under common law it is not normally an offence to pick fruit, foliage, fungi or flowers, which are growing wild, if they are for personal use and not for resale, and providing that none are specifically protected. Thus seasonal gathering of blackberries, mushrooms or holly is normally permissible, provided this is from a right of way or other public place, and that there are no bylaws prohibiting it.

Endangered plants

The Wildlife and Countryside Act contains a list of endangered plants (Schedule 8), which are protected against intentional picking, uprooting, destruction and sale. Schedule 8 is revised every five years. In addition, bluebells (Britain) and primroses (Northern Ireland) are listed for protection only against sale.

There are exceptions to the General and Schedule 8 protection if the person has a specific or general licence issued by a relevant authority, or if it can be shown that the action was an incidental result of a lawful activity and could not reasonably be avoided.

Protected areas

In SSSIs or ASSIs (Northern Ireland), owners and occupiers may be prosecuted if they destroy plants growing in these sites or remove plant material, unless they have first consulted the statutory nature conservation agency. In other areas bylaws may forbid the picking, uprooting or removal of plants.

Mosses

It is illegal to gather moss without the landowner's permission. There are 28 moss species listed under Schedule 8 for which collection is illegal, whether or not the landowner's permission has been obtained. In some areas Forest Enterprise issues licences for the collection of moss from forestry plantations, from where collection is not damaging, for use in floristry.

International protection

Under the Conservation (Natural Habitats) Regulation 1994, updated by The Conservation of Habitats and Species Regulations 2010, certain internationally rare plants are listed as European Protected Species. This makes it an offence to deliberately pick, collect, uproot or destroy one of these plants, and includes similar protection for their seeds and spores.

Animals

The Wildlife and Countryside Act applies to wild animals, which are defined as those that are living wild or were living wild before being captured or killed. All wild birds, excluding game birds, are

protected, and those animals listed under Schedule 5. This includes bats, many reptiles and amphibians, wild cat, pine marten, dormouse, some moths, butterflies and other invertebrates.

Badgers

Badgers are protected under the Protection of Badgers Act 1992. Under the Act, it is an offence to wilfully kill, injure or take a badger; to interfere with a sett by damaging or obstructing it or by disturbing a badger when it is occupying a badger sett, with intent or recklessly. The Act also contains provisions to permit, under licence, certain activities which would otherwise be prohibited by the Act. These activities may include construction of forest roads, quarrying, protection works for ancient monuments near badger setts and some types of recreational activities. The licensing authorities are the agriculture departments or nature conservation agencies, depending on the type of activity.
The law protects all setts which show signs of current use, including seasonal or occasional use. Badgers live in groups of about 5-12 animals, and usually have more than one sett in their territory. The main breeding sett is normally used continuously, and signs of use are fairly easy to find. Outlying setts up to 150m away from the main sett may only be used occasionally. Tunnels are often only 600mm (2') or so below the surface, and can be disturbed by heavy machinery. Where management work is taking place, a protection zone should be established so that no work takes place within 20m of any entrance to a sett believed to be in current use.

Bats

All bats are protected under the Wildlife and Countryside Act (Schedule 5). They are also included in Schedule 2 of the Conservation Regulations 1994. These make it illegal to:
Intentionally or deliberately kill, injure or capture bats.
Deliberately disturb bats, whether in a roost or not.
Damage, destroy or obstruct access to bat roosts.
A bat roost is any structure or place which is used for shelter or protection, whether or not the bats are present at the time.

General principles

Take time to get to know a woodland before making decisions about changes. Visit the woodland frequently over a year and make notes of plant and animal species, gaps in the canopy and any signs of regeneration. The form of individual trees, the woodland structure and landforms in the woodland are easiest to see in the winter, but conditions of light and shade are easiest to see in summer, along with the herbaceous flora of the wood.

The natural distribution of native woodland species has been extensively studied through the National Vegetation Classification (NVC). With knowledge of the location, soil type, soil wetness and aspect of any site, a clear picture can be given of the type of woodland which the site would naturally have supported. This information includes species of trees, shrubs, flowering plants and mosses, and can be used in restoring woodlands which have been altered by planting, and in creating new native woodlands.

There should be no replanting in ancient semi-natural woodlands, which should only be managed using systems which allow natural regeneration. Other semi-natural woodlands and long-established planted woods should also be managed primarily by encouraging natural regeneration of the native species which they contain.

Allow nature time to recover before intervening. The elm disease and drought of the 1970s, and the storms in southern England in 1987 and 1990 were not the disasters for woodlands and trees that they were thought at the time. Replanting has not always been successful. Elm is recovering in many

areas and the regrowth from suckers has long overtaken many trees which were planted to replace them. In many cases clearance and replanting of storm damaged woodland has been detrimental, whereas those left mainly untouched are regrowing and recovering. Working with the natural growth is likely to be far more successful than replanting. Even semi-natural woods damaged by replanting with conifers are recovering in many places, as the native growth returns and suppresses the conifers.

Exotic species and cultivars of native species have no place in semi-natural woodlands, and should only be planted in arboreta, gardens and urban parks. Some exotic species may be needed to establish woodland cover on polluted or otherwise damaged sites.

Don't make changes which can't be sustained. Lapsed coppicing regimes should only be restarted if they can be sustained, and if damage by deer can be controlled. Glades should only be created if they can be maintained by mowing or grazing.

Not all woodlands or all areas of woodlands need management. Non-intervention may be appropriate.

Woodland ecosystems are kept in balance by a degree of browsing and grazing by wild animals. Total and permanent exclusion by fencing can sometimes lead to excessive natural regeneration of woody species.

Successful methods of establishing new native woodland are well proven. The NVC gives clear guidance on the appropriate species for any particular area. All planted trees need weeding for at least three years, and those planted on disused agricultural land need particular attention. With correct choice of species, close spacing, rigorous weeding and early thinning, it is quite possible to establish self-sustaining woodland cover within about 10 years. If weeding and other early maintenance cannot be given, it's better not to plant at all.

Advice on the principles and practices of woodland management is given in a series of eight Forestry Practice Guides: The Management of Semi-Natural Woodlands, available from the Forestry Commission.

General procedures

Description

Name and location, with the OS map grid reference for the entrance to the wood. The 1:2500 scale map is suitable for small woodlands, and the 1:10000 for large woodlands. Standard methods of marking maps are used by the Forestry Commission, with details given in grant applications.

- Statutory designations.
- Areas, with sub-divisions if these clarify management proposals.
- Aspect, soils, drainage.
- Historical aspects, including past management.
- Trees and shrub species, dominant trees and abundant underwood shrubs.
- Age class distribution of trees: stocking; composition and condition of any natural regeneration.
- Ground flora; dominant species and any unusual species.
- Fauna, especially any rare or notable species.
- Conspicuousness in the landscape.
- Archaeological features.
- Existing public access and planned future access.
- Surrounding land use and other nearby woodland.

Evaluation

Any special values such as rare species, veteran trees, natural features, timber potential or prominence in the landscape should be noted. The site's importance in contributing to a local Biodiversity Action Plan, Habitat Action Plan or Species Action Plan should be noted.

- Management objectives
- These may include any of the following:
- Maintaining and creating new wildlife habitats
- Producing wood and marketable timber
- Regenerating woodland
- Enhancing the landscape
- Restoring or improving industrial or derelict land
- Providing public recreation
- Providing employment
- Providing sporting use
- Providing shelter for crops, animals or buildings
- Involving the local community
- Screening unattractive views, reducing traffic noise

Management proposals

This should include the long term strategy and a five year summary work plan. The long term strategy may include any of the following operations. The five year summary plan will specify the areas to be worked and the main operations to be done in the next five years:

- New planting or replanting
- Site preparation
- Species to be planted
- Mixtures and planting patterns
- Spacing
- Protection against deer, rabbits, domestic stock, people
- Weed control
- Beating up (replacement of losses)
- Natural regeneration
- Species
- Site preparation
- Felling of parent trees, stand opening
- Respacing, protection and weeding
- Felling and thinning

Monitoring

Monitoring must be included, so that the results of any management work are measured and evaluated. Lessons from monitoring can then be included in a review of the management plan, which should normally be made every five years. Monitoring involves recording the state of the woodland at the start of the period, the work done and how the wood responded. There are many aspects of management which may be monitored, including the following:

- Response of the woodland to coppicing, thinning, felling, fencing or other operations.
- Changes in woodland structure or species composition.
- Amount and type of natural regeneration.
- Success rates of tree planting.
- Success rates of woodland flora planting or sowing.
- Control of woody weeds such as rhododendron.

Fixed point photography is a simple and useful method of recording changes in the woodland.

Timber measurement

Age

The age of a tree can be roughly estimated from measuring the diameter of the trunk, and observing the conditions in which it is growing. In its early life, a tree tends to grow fast, increasing in height, spread and circumference of the trunk. As the tree ages, growth slows, and height and spread increase may stop, but the trunk continues to grow slowly in girth. The mean growth in girth of most native broadleaved trees, grown in open ground and with a full crown, is 2.5cm (1") per year

Therefore an open-grown tree 2.4m (8') in girth is usually about 100 years old. Yew tends to conform to the 2.5cm rule for the first 100 years, but then slows to less than half this rate over the next 4-500 years.

Trees put on girth more slowly when in competition with other trees, so that a tree growing in a woodland will show a mean growth in girth of 1.5cm (1/2") per year or less. Species also vary in their speed of growth. The table on page 44 is based on Forestry Commission estimates for trees grown in closed woodland.

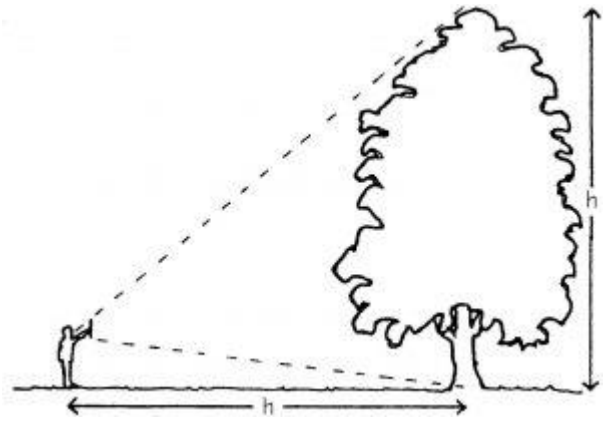
An accurate age can be obtained from counting the annual rings of a felled tree. An increment borer, available from forestry suppliers, can be used to take a core of wood from a living tree, from which the annual rings can be counted.

Length and height

All lengths should be measured in metres, rounded down to the nearest tenth of a metre for lengths up to 10m, and to the nearest whole metre for lengths greater than 10m. The length of a piece of timber should be measured with a tape following the curvature of the log.

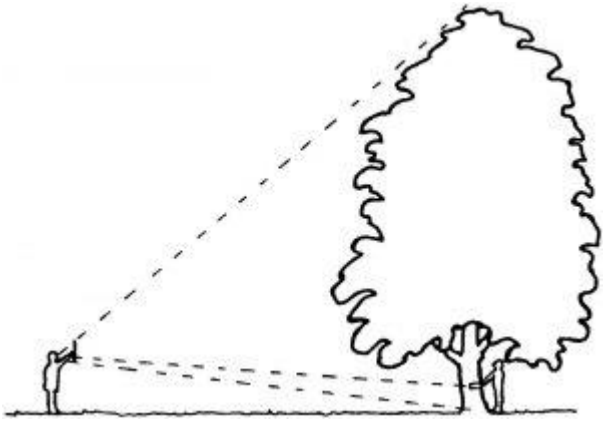
The total height of a standing tree is the vertical distance from the base to the uppermost point (tip).
The total height of a felled tree is the straight line distance from the base to the tip.
The timber height (or timber length) of a tree is the distance from the base of the tree to the lowest point on the main stem where the diameter is 7cm overbark. In hardwoods, and occasionally in conifers, this may be the lowest point at which no main stem is distinguishable.

Two alternative methods of estimating height, using simple equipment, are as follows.
Cut a cane or suitable piece of wood to the exact distance measured from your eyeball to the farthest stretch of your grasping finger and thumb. Stand at a distance from the tree to be measured, holding the cane vertically at this same outstretched reach. Then walk back or forth until the tip and base of the tree are exactly in line with the upper and lower end of the cane. Mark the ground directly below the cane. The height of the tree is equivalent to the distance from this mark to the base of the tree.



This method requires two people, and a 30cm ruler, clearly marked at the 3cm point. One person holds the ruler vertically at arm's length, and moves back or forth until the tree is aligned vertically with the ruler.

The second person holds an easily visible marker against the tree, and moves it up or down, guided by the calls of the first person, until the marker aligns with the 3cm mark on the ruler. This point is marked on the tree and is then measured from the ground, and this measurement is one tenth of the total height of the tree.



Note that it is only in spire-topped trees that the apparent top shoot is the true tip of the tree. On wide-spreading trees, the shoots on the nearest branches will appear higher than the actual tip. Where possible, walk around the tree and study it from several angles before choosing the point which appears to be the top centre.

Diameter

Tree diameter should be measured in centimetres, rounded down to the nearest centimetre for individual trees. Mean diameters are recorded to the nearest whole centimetre. Diameters are usually measured with a special girth tape, available from forestry equipment suppliers, which is placed around the trunk 1.3m above the ground, and from which the diameter can be read. This measurement is called the diameter at breast height (dbh). Alternatively, use a standard tape measure, and divide the measured circumference by 3.142 to obtain the diameter.

Path clearance

This chapter is mainly concerned with paths through woodlands, copses and scrub, and paths enclosed by hedges through agricultural and residential land. Conditions vary greatly from one part of the country to another, and sheltered south and western areas will have much lusher growth than exposed or upland areas.

Reasons for doing clearance work may include:
Making the path easy to follow and pleasant to use. Increased use will keep the path open and reduce the need for future work.
Keeping a right of way in use. By clearing a path and walking it, one is decreasing the likelihood of there being a successful order (England and Wales) to close it.
Improving the quality of the path and its edges. Clearing overgrowth allows wind and sun to dry muddy paths, and if done with care can be of benefit both visually and ecologically. Woodland and scrub edges with a gradation of vegetation are valuable habitats.
Channelling use onto a particular route, and diverting use away from ecologically sensitive areas.

Planning the work

Unless clearance of all paths in a particular area is being undertaken, it is best if volunteer energies are directed at paths that will be used and so kept open. This is more likely on paths that make a circular route, a link, or lead to a viewpoint or feature of interest.

Clearance is often only part of a scheme which may include stile construction, waymarking or publicity, and normally any work would be done after consultation with the highway authority and the landowner. The Parish Paths Partnerships between highway authorities, parish councils and landowners are active in promoting this type of work.

Make sure all parties agree about the exact line of the path. If possible walk it with the landowner or occupier, but bear in mind they may be misinformed, or may deliberately mislead. Any discrepancy should be referred back to the highway authority. Removal of vegetation not directly in the line of the right of way could constitute an act of trespass for which damages could be claimed by the landowner.

There is no general right to go into a field adjoining a path to do clearance or to burn debris. If debris cannot be disposed of along the line of the path, come to an arrangement with the landowner about its disposal.

Try to establish what will be done once the initial clearance is finished. It is very discouraging for volunteers to return to a cleared path only to find it overgrown again.

Time of year

Ideally, lush non-woody growth should be cut back twice each year, the first cut being in May or June, and the second in August or September. In practice, most paths will be lucky to receive an annual cut, which is probably best done in June.

Woody growth, scrub, hedgerows and brambles should not be cleared during the bird nesting season from the beginning of April until the end of August. October and November are often the best months for major clearance jobs as working conditions should still be pleasant with the ground not yet at its wettest.

How much clearance?

An appropriate working minimum is 2m wide x 2m high for a footpath, and 3m x 3m for a bridleway. However, advice from experienced clearance workers is always to cut back as much as possible, usually to the boundaries of the path. A path cut back to 3m width will stay open for twice as long as a 2m wide path. Some shrubs such as blackthorn and bramble will regrow, unless dug out or treated, even in the presence of quite heavy trampling. As detailed below, a wide path should develop a ground cover of turf, which is easier to manage than a shaded and often muddy path.
Before starting clearance consider the following:

What sort of use will the path receive? Will it be by groups or individuals, one-way or two-way use? A newly opened path in a country park may attract a high level of use and will need to be at least 3m wide.

By making a bridleway wider than 3m you may attract illegal vehicular use. Likewise, by clearing a footpath wider and higher than is necessary you may attract horse riders. Bridle gates and barriers can be erected, but often the resources are not available. A fortuitous fallen tree which stops horses but not walkers may be useful to deter unwanted use. A tunnel of scrub 2m high will also discourage riders.

If time is limited, try to gauge the work so that the clearance is completed in one project or session. It may be better to clear right through to a narrow width and widen it later if there is time. A 'no through road' will only cause confusion and trespass.

Vegetation and shade

The width of a path through woodland or scrub obviously affects the amount of shade that is cast, which in turn determines the type of vegetation that will grow.

A path completely enclosed by scrub or low trees will have virtually no ground flora at all. Unless there is good natural drainage the path is likely to be often muddy as sun and wind cannot dry it out. Once cleared of branches which block it, the path is likely to stay clear for some time as non- woody growth will not flourish in the dense shade.

Ground under tall or open canopy will have a woodland flora of plants such as dog's mercury, bluebell, red campion and ground ivy, which are not resistant to trampling. (Beech woods are an exception in having very little ground flora due to the deep leaf litter, and the early emergence of the leaves in spring which shade out other plants.) The woodland flora can rapidly grow to obscure or block a path in the absence of trampling.

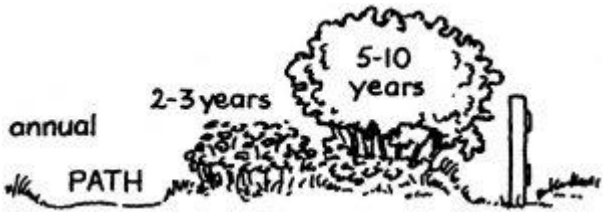
A path not enclosed by a canopy and receiving plenty of light will develop a flora mainly of grasses, especially in the presence of trampling or grazing. The width at which such a flora develops depends on the height of the trees and the alignment of the path. A path running on a north-south axis will receive more light than one on an east-west axis.

If it is feasible to clear to a width of about 4m, an attractive and relatively hard-wearing path can be made which is easy to maintain by machine. The initial clearance is likely to produce a flush of growth of weedy species such as thistle, rose-bay willow herb and nettle, but these will decline with regular cutting, grazing or trampling to produce a grassy turf.

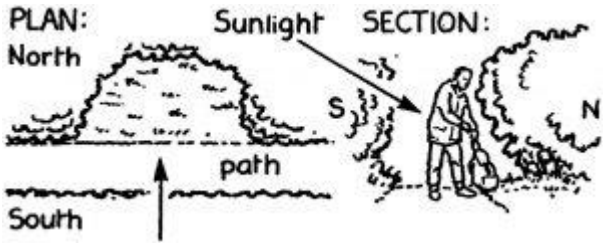
Landscaping the path

Often clearance will simply be a matter of cutting back growth to the original edges of a path, enclosed by banks or walls. On other paths there may be opportunity to vary the amount of clearance to increase visual and ecological interest.

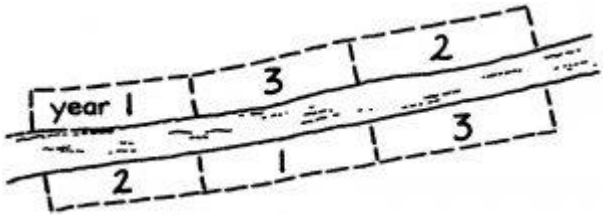
Grade the edges by cutting at different heights or frequencies to create a diversity of habitats.



Clear glades at intervals along the paths especially on the northern side of the path where they will get maximum sunshine. These glades will attract certain types of butterflies. They will also provide pleasant places for walkers to rest.



Cut sections in rotation each year to maintain a succession of habitat development.



Vary the width to give visual interest, for example retain a narrow section to emphasise the drama of a viewpoint ahead.

Narrow or winding sections can be created when clearing along old railway lines, to add variety to the path.

Views can be opened up by clearing scrub or trees, but consider first any unwelcome effects these may have. Views of nearby features such as a pond or stream may attract trespass by walkers on the path. Clearance of vegetation on a slope to open a view may expose the slope to erosion by rainfall, and encourage people onto the slope which will further hasten damage.

Viewpoints through tall trees are best opened up by cutting back the lower branches so that the canopy remains to protect the slope and to shade out growth beneath. View points made by lopping trees or clearing scrub will only be temporary features, unless they are maintained frequently.

Rights of way, although private property, attract public interest. There may be conflict, for example, between naturalists, who would rather see overgrowth left undisturbed, and walkers and riders who want clear and easily passable paths.

Adjacent landowners not responsible for the path may complain if vegetation is thought to be spreading weed seeds onto their land, or harbouring pests. Landscaping the path and being sensitive to these interests should help reduce conflict.

Marking the route

The route should be marked with stakes painted a bright colour, or by strips of fertiliser bag tied to branches. Shrubs, saplings or trees which you wish to retain can be tagged at the same time. Be consistent in the way you place the markers so that they mark either the centre or the edge of the path. It is usually better to put the markers to the edge so they can be left in place during clearance operations, and collected at the end of the task for re-use.

Hand clearance

This will depend on the type of vegetation and the number of volunteers. Space to work is usually very restricted, so if there are more than five volunteers, split them into groups with each taking a section, either 'leap frogging', or by dividing the total length by the number of groups. In very dense vegetation it may be difficult to work other than from one end of the path, but it should be possible for volunteers to follow the route taken by the person who marked the path. It is not unknown for one hardy volunteer to have to wriggle into the undergrowth and clear a space until there is room for another to follow!

With all clearance work, the main problem is in getting rid of the cut material. Sometimes it is possible to get rid of the debris off the edge of the path by dumping it in clearings, pushing it under overhanging scrub and filling holes in the ground. All non-woody material will rapidly bulk down and decompose. In this type of vegetation each person can cut and dispose of material. In clearance of thickets and woody growth there will have to be a division of labour between people cutting and people carrying and disposing of debris.

A possible division of labour is as follows. One person 'breaks the trail' using a slasher or billhook on brambles and light scrub. Material is then pulled back from behind them by one or two people using pitchforks or rakes, and carried to the point where it is to be dumped or burnt. They are followed by a person with a bow saw to fell any small trees or lop overhanging branches, and a fifth person to remove or treat stumps, and to do a final tidy-up with a pitchfork or rake.

Avoid having a bonfire if there is any other satisfactory way of getting rid of the material. Bonfires are enjoyable, especially in cold weather, but are environmentally undesirable, and can take up to half the volunteer effort because of the time involved in carrying material to the fire and in tending it.

On a path requiring only light clearance it is usually possible for each person or two sharing to have a set of tools such as a slasher, loppers and bowsaw, and to work on their own section of path.

Non-woody growth

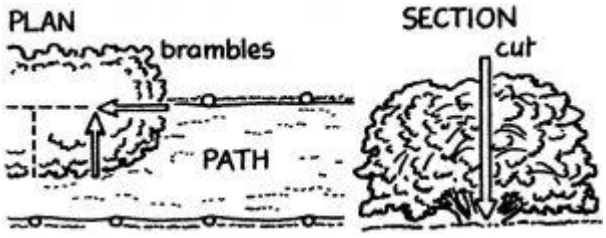
Cut back overhanging growth with a grass hook. Use a crooked stick to hold the vegetation for cutting with a hook.

Grasses and herbaceous plants can also be cut with a scythe or scythette. Scythes require some practice to handle effectively but are useful on wide paths or for cutting glades. Scythettes are easy to use, but are slower and less robust.

Brambles

Brambles need to be attacked in orderly fashion from 'inside-out', as the outer growth is springy and rather resistant to cutting.

Using a slasher or grass hook, make two vertical cuts as shown, and one underneath to cut through any rooting stolons. The mass of bramble can then be pulled away. Bramble frequently grows along fence lines, and if agreed by the landowner, remove the bramble from both sides of the fence or it will quickly regrow.



Alternatively, for those not adept at using slashers, it is possible but slower to cut your way with loppers to the root of the plant, and then to pull the growth away from the root end. You should then have a big bundle of growth which you can easily drag away. If you start cutting from the outside of the plant you will end up with lots of small pieces of prickly growth which are difficult to handle.

Bramble spreads by stolons, which are stems that bend down and root at the perimeter of the plant. Sometimes a long stolon can be pulled away which is rooting at several points along its length. Always try to remove as many roots as possible, or else the plant will quickly sprout new growth.

Nettles

The stinging nettle (*Urtica dioica*), is a perennial plant with a very tough and dense root system which is difficult to remove from a path by digging. The plant is easily cut or trampled but rapidly grows again, and in the south, has a very long growing season. Cutting must be frequent if no other method of control is used. Scythes are better than grass hooks for cutting tall nettles as they allow one to keep a comfortable distance from the plant. Repeated cutting and trampling will weaken the plant.

Bracken

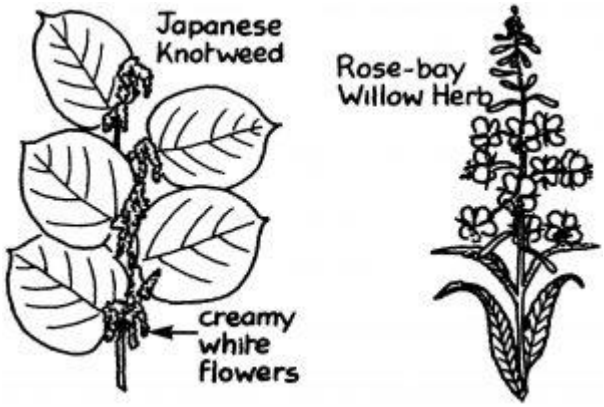
Bracken (*Pteridium aquilinum*) is a fern, being flowerless and reproducing by spores instead of seeds. It spreads mainly by tough underground stems called rhizomes.

When cutting bracken, especially in late July, an ori-nasal mask should be worn to prevent inhalation of spores. Bracken also harbours sheep ticks during the summer months, and it is advisable to wear long-sleeved clothing with tight cuffs, and trousers tucked into socks, to decrease the chance of infestation.

Bracken is easily trampled or cut in spring and early summer, but can present a formidable barrier by August, especially on rich moist soils in the south. If cutting is to be the only treatment, timing is very important as it should be done when the food store in the rhizomes is at its weakest. The best method is to cut in mid June, and then again at the end of July to remove any secondary growth which will have further depleted the food store. If only one cut is possible, do it at the end of July. By August it is getting too late, as sugars produced in the fronds are by then moving down into the rhizome. Cutting tends to increase the frond density, but fronds are short and weak and the path will be easy to see and follow.
Bracken is not destroyed by trampling until the level of trampling is such that other plants are destroyed.

Other plants

Japanese knotweed (*Polygonum cuspidatum*) is an introduced plant with extremely vigorous growth and extensive underground stems. It has heart shaped leaves and a cane-like stem that grows up to 2m tall and hardens by mid-summer. The stems remain over winter. It has some wildlife value for birds and invertebrates, and mature stands may develop a woodland type ground flora, but on most sites it should be eradicated. Herbicide treatment is the only effective method of control. Warn, and enlist the assistance of adjacent landowners as it spreads rapidly.



Various species of thistle are common on paths in agricultural areas. Cut plants down in mid summer before they seed. Rose-bay willow herb (*Epilobium angustifolium*) is a rapid coloniser of disturbed ground and it may be wise to cut it in flower to prevent it seeding. Foxglove (*Digitalis purpurea*) and red campion (*Silene dioica*) may flourish where a woodland canopy has been recently removed, but decline in the following years.

All the native plants mentioned above have their own value in the British flora, as well as being food plants or egg- laying sites for invertebrates. Do not cut more than is necessary to keep the path clear, unless edges or glades are being managed as described above.

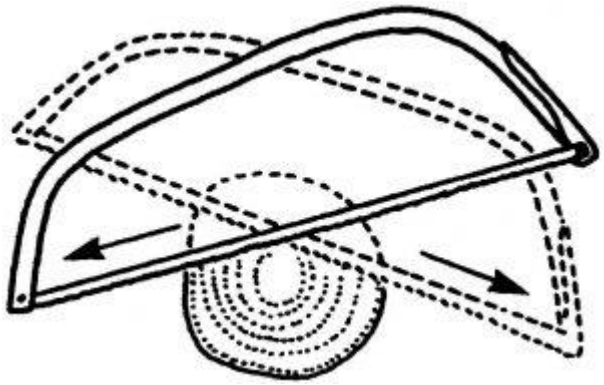
Scrub

This term covers shrubs and small trees such as blackthorn (*Prunus spinosa*}, hawthorn (*Crataegus* spp), elder (*Sambucus nigra*), holly (*Ilex aquifolium*} , rhododendron (*Rhododendron ponticum*) and hazel (*Corylus avellana*).

The bowsaw is the safest and most efficient tool for felling, with the billhook and pruners useful for trimming and snedding. Beware of blackthorn, as wounds caused by the thorns can go septic.
On bushy or overhanging growth such as blackthorn or holly you will probably need to cut away the lower branches with loppers to gain access to the main stem or trunk. Give yourself plenty of room, or you will restrict the length of saw stroke you can make.

If the stump is to be chemically treated, cut it as low to the ground as possible. If it is going to be dug or winched out, leave about lm of stem for leverage.

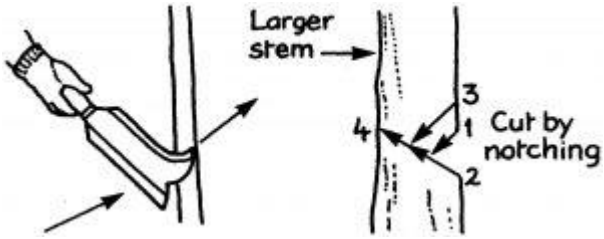
Cut level or at a slight angle in the direction of fall, using the full length of the blade. A slight rocking motion, as shown below, gives greatest speed. Use both hands on a D-shaped saw until it is necessary to steady the tree. The triangular saw can be used one-handed. Use equal force on push and pull strokes to prevent the blade twisting.



Steady the trunk as it starts to settle or move, and saw quickly through the last bit to prevent the stem splitting.

Billhooks are useful on multi-stemmed or coppiced shrubs such as hazel.
Cut away with loppers or secateurs any young or springy shoots which the billhook may catch on. Use a small billhook one handed, and keep the other hand as high up the stem as possible, for safety.

Cut small stems with a single, slightly upward-sweeping stroke. Larger stems can be cut by notching.



Stump removal

Removing the stumps of scrub has the following advantages:
For most species there will be no re-growth. Poplar can re-grow from roots left in the soil.
Any hazard to walkers is removed.

However, there are disadvantages:
Removal disrupts the surface and foundation of the path, and may hasten erosion on slopes.
Removal can be difficult and time consuming, especially in rocky or compacted ground.
Stumps can be treated chemically to prevent or discourage re-growth, but does not solve the problem of the hazard to walkers. The following guidelines are suggested:
Remove all stumps from the line of a path which is going to be surfaced for intensive use. In this case a certain amount of ground disturbance will happen anyway.
Remove all stumps of species that have a low susceptibility to chemical treatment. This mainly applies to rhododendron, hawthorn and sycamore.
Remove all stumps from paths or edges that are to be maintained wlth grass-cutting machines or hand tools, to prevent damage to them.
If time is short or the path is in a remote location which only well-shod walkers should reach, treat all stumps chemically.

To remove stumps by hand:
Dig with a spade or mattock around the base of the stumps to expose as many roots as possible. Chop through the roots with a grubbing mattock. Do not use an axe or you will blunt it on any earth or stones around the roots. Lever under cut roots with the other end of the mattock to loosen them. Try and loosen the roots by levering on the stump. Chop under the stump with a sharp mattock or spade, and lever out using a crowbar or Tirfor winch.

Fill the hole, using material dug from off the path if necessary, and tread well down to leave an even surface. Finish to match the existing surfacing. If possible, repair a grass path with turves.
The following method is used for clearance of scrub, mainly blackthorn and hawthorn, by the National Trust at Badbury Rings, Dorset. This may not be suitable for clearing along the line of the path as stumps are left in place for several months. However, it is a very useful method of scrub control for restoring grassland and opening up areas for access, as it uses no chemicals.

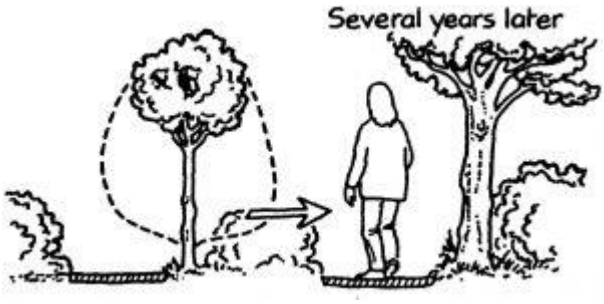
The scrub is cut and removed in winter, leaving stumps about 200-300mm high. The re-growth is then flailed in late spring/early summer with a tractor-mounted flail. This causes the stumps to weep sap and then rot. Flailing is repeated up to twice more as necessary.

Ecological value

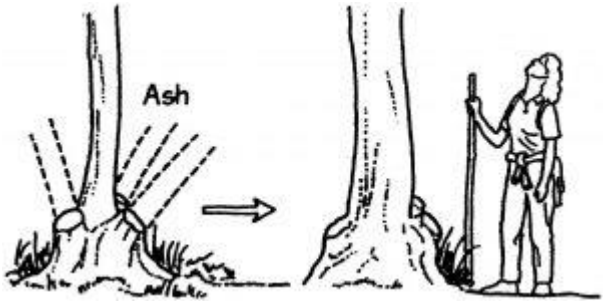
The value of any particular plant depends on the balance of species in the habitat. Try to conserve any that are uncommon but typical of the habitat. If a lot of clearance has to be done, conserve a representative sample of the range of species in the habitat. Try and visit the path that has to be cleared in the summer before clearance takes place, when it is easier to identify and evaluate the species. Note down and mark any that you wish to save.

Some species can be treated in such a way as to retain some ecological value, while making them more amenable as path-side plants.

Trim holly bushes of their lower branches to make a standard 'tree'. This will look very unbalanced at first, but should grow into a reasonably shaped tree.



Ash, birch and other species can be encouraged to grow as single trees. From each stool, cut all stems but one, retaining the strongest and straightest. Growth will then concentrate into the single stem.

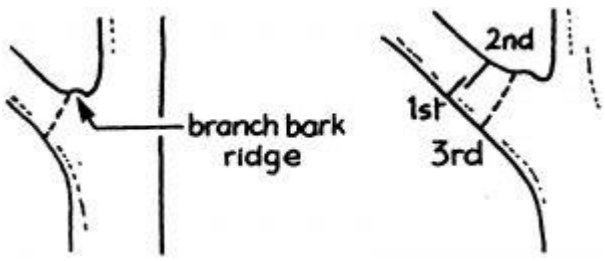


Although infected, elm appears to be not susceptible to the attack of the ambrosia beetle (responsible for Dutch Elm Disease) until it is about 3m high. As elm suckers rapidly it is possible to try and keep the plant healthy by continually cutting to restrict growth to this height. This maintains some scrub habitat for cover, and in particular conserves the habitat of the white-letter hairstreak butterfly, which is dependent on elm.

Trees

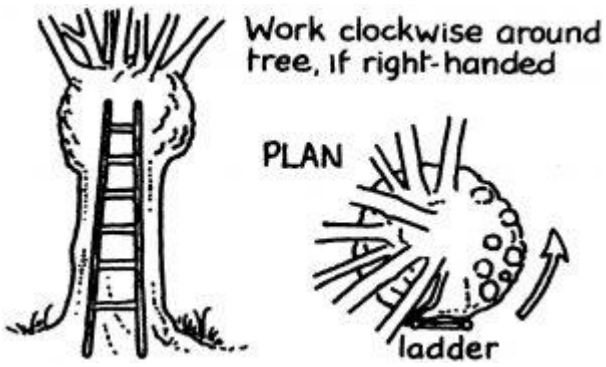
Unless a wide path is to be cleared through dense woodlands, the felling of mature trees is not usually required for footpath clearance. Felling of trees is described in Woodlands.
If side branches must be removed, use a pruning or bowsaw, with an extension to reach high branches. Always make the cut on the outer side of the branch bark ridge. A cut on the inner side will expose the trunk to fungal infection. Make the cut slanting slightly outwards.

If the branch is thicker than 30mm, it is likely to tear if only one cut is made. Make three cuts as shown.



Pollards

Pollarded trees are valuable habitats, as well as being traditional features of hedge banks and boundaries that footpaths often follow. Pollarding is a traditional method of producing roundwood for firewood and other uses, by growing the stems out of reach of livestock. Managed pollards are cut at intervals of between ten and twenty-five years, and are relatively simple to maintain. Ancient pollarded trees that have not been pollarded for generations should only be dealt with by specialists.



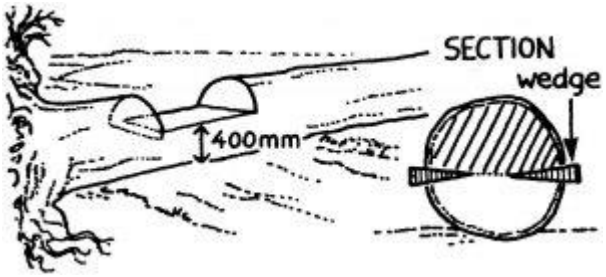
Safety precautions must be observed when using ladders for pollarding. The ladder should be long enough, extending 1m beyond the highest rung being used. The top of the ladder should be secured if possible, and if not, the bottom. Whilst the top is being secured, a second person should stand on the bottom rung. If neither top nor bottom can be secured, a second person should stand on the bottom rung at all times when the ladder is in use. Use a bowsaw or pruning saw on stems up to 100mm diameter, taking care that the ends fall clear away from you.

It is also possible to pollard existing trees, which may provide a useful compromise if the landowner wishes to clear trees to allow more light onto the path or adjacent field. Species suitable for pollarding include willow, lime, ash, field maple, holly, hornbeam, oak and beech. A new pollard is best made when the trunk is 100mm-l50mm diameter, at a height of 2m-3m, choosing a point with at least some branches below the desired cut. Ideally, leave a whorl of branches which can grow on for the next two growing seasons, before being cut away as desired. Cut above the height which any browsing stock can reach, taking care not to split the trunk or infection may result. Follow standard tree felling practices for this and for maintaining old pollards which have stems over 100mm diameter.

Fallen trees

Large trees that have fallen across the path should be cut at either side, using a chain saw. Roll the freed section off the path, or cut it up for use.

Alternatively, if the fallen tree is not a hindrance to legitimate use, or is on a path already inaccessible to wheelchairs, the trunk may be useful as a barrier against horses or motorbikes. If necessary a step can be cut, by making two vertical cuts with the saw, slightly below the finished height of the step. The step should be not higher than 400mm, to be easily negotiable by walkers. Cut the step away using either the chain saw, or by knocking wedges in on each side. Knock them in by equal stages on either side so that a horizontal cut is made.



Smaller trees only need one cut, and then the top can be dragged off the path. Cutting up and disposal of fallen trees depends on the habitat and the situation. You may be able to use the timber elsewhere along the path for steps or barriers, but if not, leave it in place as rotting timber provides a good habitat.

Saplings

By way of balancing the destructive element of path clearance work, a positive contribution to the landscape can be made by tagging saplings. This involves attaching tags to saplings which are to be left to grow into mature trees. Use tags of a bright colour which are easily visible to machine operators. Tagging must be done in agreement with the landowner if the system is to be respected. Choose straight, healthy saplings, leaving at least 10m between each.

Disposal

Try and do as little carrying and burning as possible, while leaving the path completely clear of debris, and its edges attractive.

Non-woody growth rapidly rots down and should cause little problem. Brambles and scrub are more awkward as they are bulky and difficult to 'lose'. Consider using branches and scrub for blocking off short cuts and gaps in hedges, or for covering bare areas to stop trampling and allow vegetation recovery. Piles of brushwood in odd corners are useful habitats for over-wintering and nesting wildlife.

Chipping

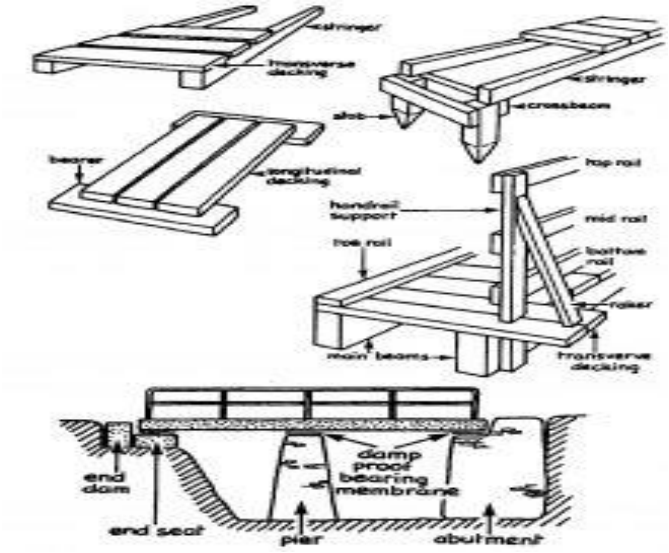
Scrub, branches and other timber can be put through a wood-chipping machine to produce a useful material for path surfacing and mulching. Machines vary from petrol- driven garden shredders which can shred prunings and branches up to 75mm, up to large chipping machines which can deal with timber from 150mm diameter up to whole trees. Garden shredders can be hired. Many local authorities use chipping machines and may be able to offer assistance. Chippers and shredders should only be operated by trained persons. Groups responsible for managing paths and other areas in woodland may find it worth purchasing a machine and training operators from within their group, as the chippings are useful for path surfacing and mulching within the woodland, and can be sold or distributed for garden and other use.

Snedding

Most scrub will have to be snedded either for stacking, chipping or burning. Before snedding, drag the tree or shrub to the point where it will be stacked or chipped, as this is easier than carrying bundles of cut material. Using a snedding axe, billhook or loppers, remove all side branches, starting at the base of the stem. If using an axe or billhook, stand on the opposite side to the branch you are cutting, to protect your legs.

Boardwalks and bridges

The following terms are used to describe the parts of boardwalks and bridges.



Materials and fixings

Local materials

In some situations it may be possible to use local materials, which will save on purchase and transport costs. Local timber supplies should be assessed carefully to decide whether this saving justifies a probable shorter useful working life, compared to purchased and pressure treated timber.

Uses of local materials

Timber: Bearers, main beams, stringers, decking

Stone Boulders: Bearers, abutments, piers, scour protection

Aggregate: Boardwalk approaches, concreting

Water: Concreting

Do not use sea sand or shingle for concreting, as the salt reduces the setting ability.

Timber

Timbers and preservatives lists different types of timber, with suggested uses and preservative treatments. In general, pressure treatment with creosote is more durable than pressure treatment with water-borne preservatives such as Tanalith.

Heavy-duty rubber gloves should be worn when handling preserved timber. Creosoted timber can stain and taint clothes, so protective or old clothing is recommended to be worn. Beware of burning any off-cuts of creosoted timber, as it will burn fiercely. Both Tanalised and creosoted timber give off noxious fumes. Save any extra or off-cuts for re-use elsewhere, or dispose of them at a refuse site. Preservatives from pressure treated timber can leach out and damage surrounding vegetation.

Creosote tends to 'weep' in warm weather, especially when newly applied. Order several months in advance if possible, and store outside where excess creosote can leach out harmlessly. There is evidence that the salts in Tanalised timber can leach in very acid conditions, such as peat bogs (Yorkshire Dales National Park, 1993). Scottish Natural Heritage (CCS, revised 1989) advise using larch rather than preserved timber for boardwalks on special sites. However, preserved timber has been used on many nature conservation sites for many years with no problems of vegetation damage.

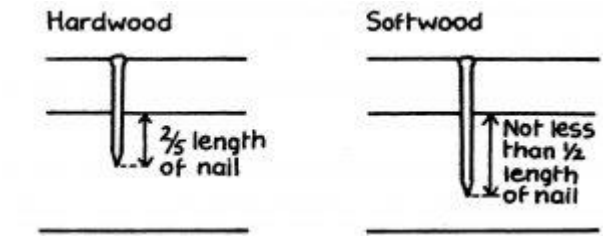
For bridges, use Tanalised rather than creosoted timber for handrails and handrail posts, to avoid staining of hands.

With increasing management of local woodlands, good use can be made of local durable timber such as oak and chestnut, to make simple bridges and boardwalks.

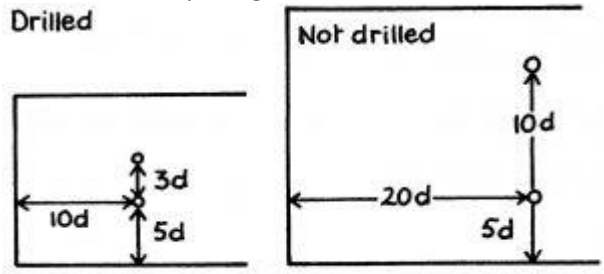
Fixings

Nails

Use galvanised, sherardised or zinc or cadmium plated nails. To reduce the chance of splitting, preferably pre-drill for nails in hardwood and larch. Always pre-drill for nails 100mm or longer. Pre-drilled holes should be 0. 8 x diameter of the nail. Nails should be of the lengths shown below.

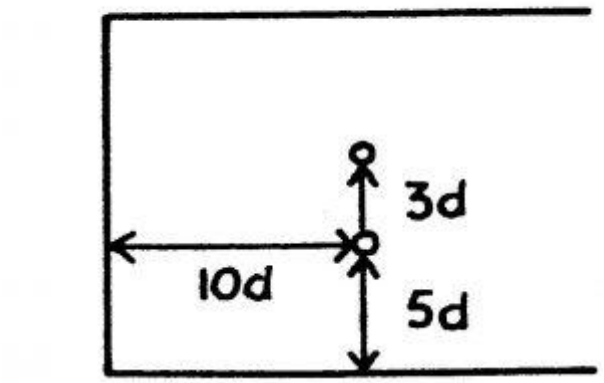


The minimum spacing of nails should be as shown below.

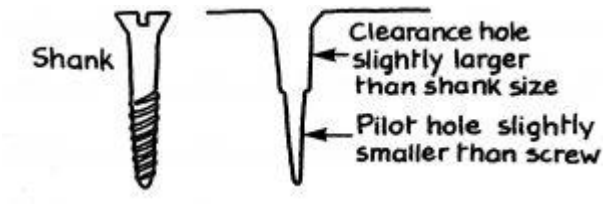


Screws

Use sheradised or galvanised screws. Minimum spacing should be as shown below.



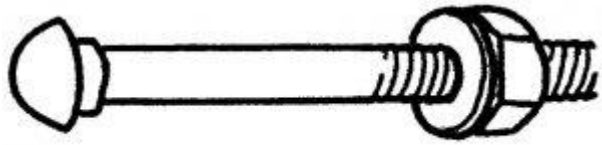
The pilot hole should be half the screw length if fixing to softwood, and slightly deeper for hardwood. Make the pilot hole a smaller diameter in softwoods than in hardwoods. Dip screws in linseed oil or Vaseline before use.



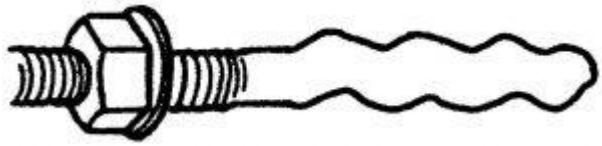
Bolts

Electro-plated bolts are the best quality.

Coach bolt. Square collar locks in wood as nut is tightened. Up to 500mm long, 5 – 19mm diameter.



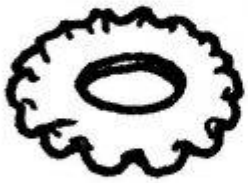
Rag bolt. Ragged end holds in concrete. 30 – 200mm long, 4 – 60mm diameter.

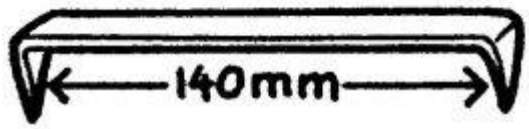


Length of bolt must equal the thickness of timbers, two washers and nut plus 5mm.

Washers

Use galvanised or sherardised washers.



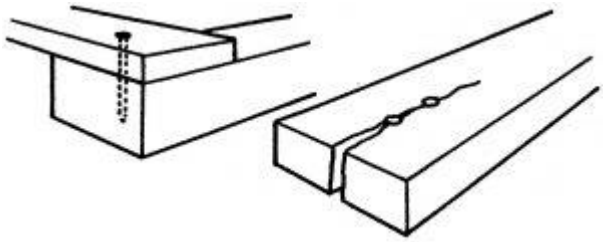


Internal diameter should be slightly larger than bolt.

Timber connectors, used to strengthen grip between softwoods.

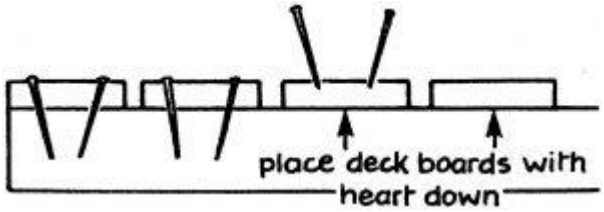
Dog clip, for joining adjacent timbers.

Timber joints
Cut the joints accurately. Gaps will weaken the joint and collect water which hastens rot.
Always nail lighter timber to heavy. Avoid nailing twice into the same grain line.

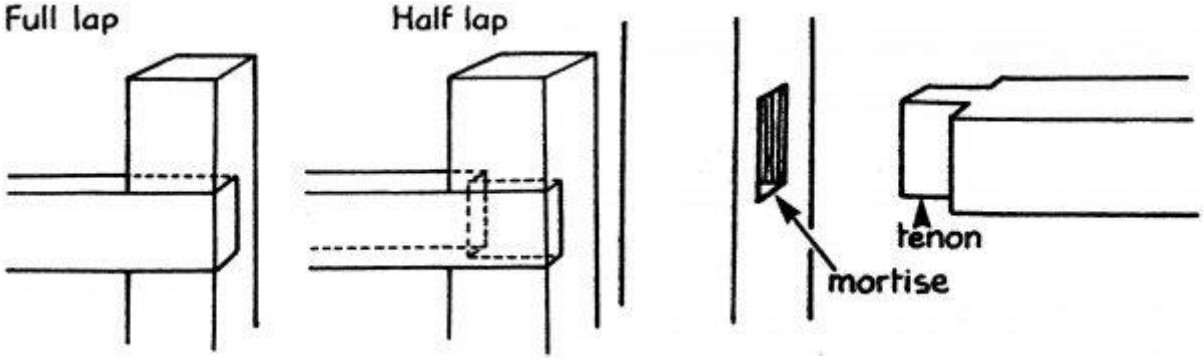


Pre-drill for nails in hardwood or larch.
Soak all joints with preservative before assembly.

T joint
Used for bridge and boardwalk decking. Nail obliquely, preferably with the deckboard overlapping the beam.

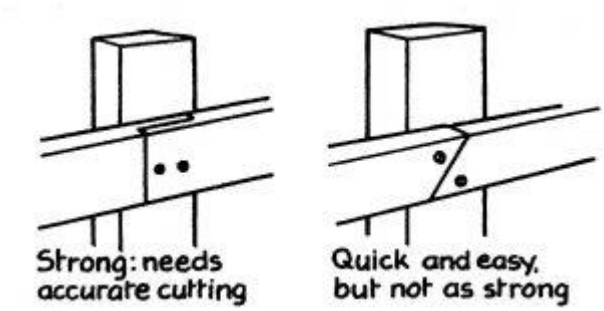


Lap joints
The full lap joint can be used in boardwalks to fix stringer to stob. Either joint is suitable for stile rails.



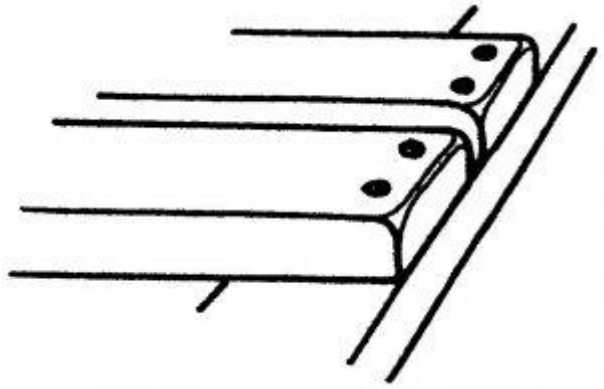
Mortise and tenon
The thickness of the tenon should not exceed one third the thickness of the rail. This is a strong joint, used for handrails on bridges and bars on stiles. It is however, difficult to mend if the rail is broken or vandalised. For extra strength, the joint can be dowelled.

Lengthening joints
These are used for handrails. If there is more than one rail, position the lengthening joints so there is only one on any handrail support.

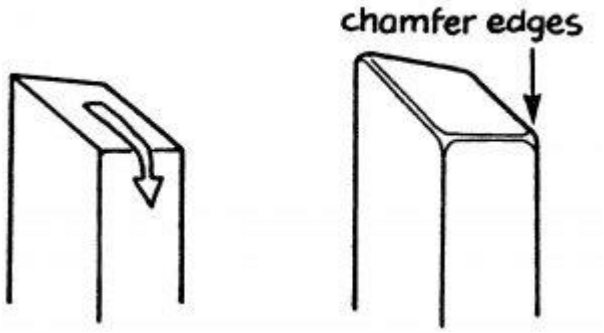


Three-way joints
These are used for boardwalk corners and steps.

Finishing
To give a neat finish, chamfer the ends of the deck boards with a Surform.



Weather the tops of uprights to allow water to run off, and chamfer edges and corners to give a smooth and attractive top.



Steps
Building steps is one of the most difficult parts of footpath construction, and often fails due to wrong choice of line, insecure construction, or lack of drainage. Only build steps if there is no other way around the problem. The following are guidelines for considering whether or not to build steps.
On existing routes, is the slope so badly gullied or eroded that steps are required to prevent further damage?

Is there danger to path users because of an eroded or slippery slope? Danger may be acceptable in some locations, such as on mountain-sides, whereas a path in a country park should cater for the less agile walker.

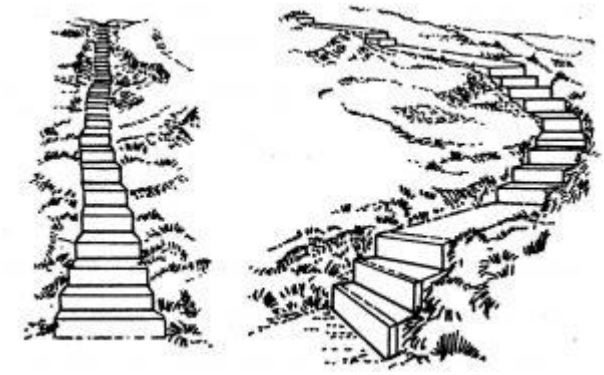
Consider whether there is any provision for maintenance. Well-built stone steps should be maintenance-free, but steps with wooden risers require frequent attention and it may be better not to build if such provision for maintenance cannot be made.

On slopes below about 20 degrees, would a more durable solution be to stone pitch the entire path, rather than putting in steps?
Are there alternative ways which visitors can use to get up and down the slope? What are the chances of walkers keeping to the steps ?
Try to anticipate where steps will be needed on new paths, instead of waiting to see where erosion occurs. It is easier to get steps into use if they are part of the original design. Putting them in when the need arises will involve the extra work of repairing damage and changing patterns of use.

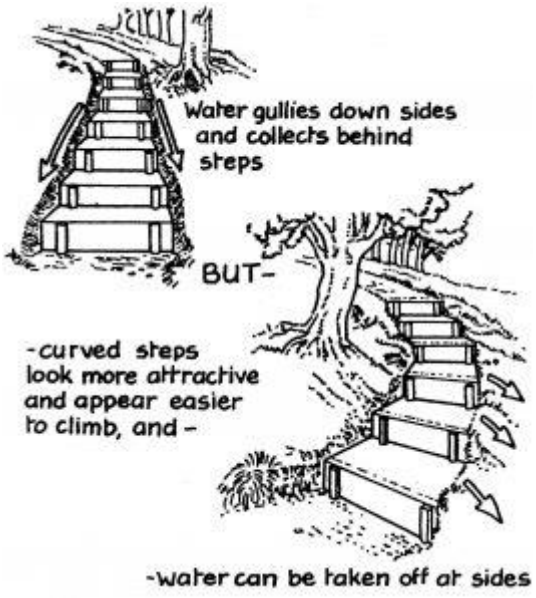
Designing and estimating

Line and location

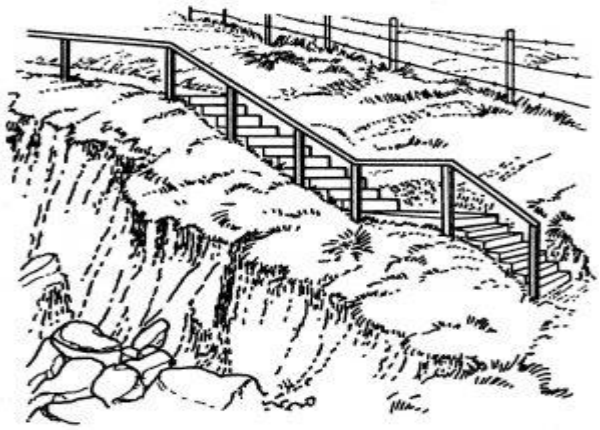
Avoid straight lines. Long straight flights of steps are an intimidating prospect for the walker, and look out of place in rural settings. Break up long flights with bends and ramps.



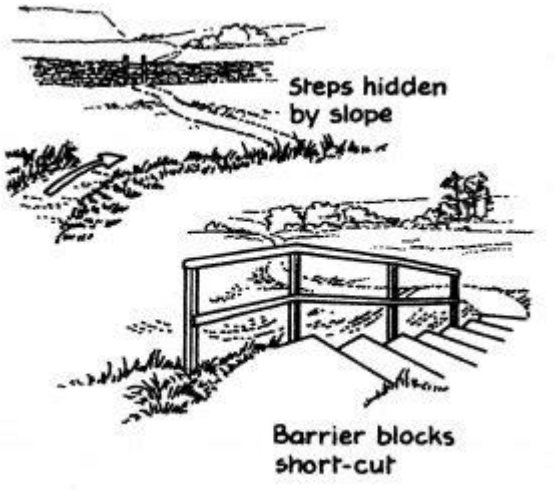
Straight steps are also more difficult to drain effectively, as water tends to collect behind each riser, or run down the sides of the steps, causing erosion.



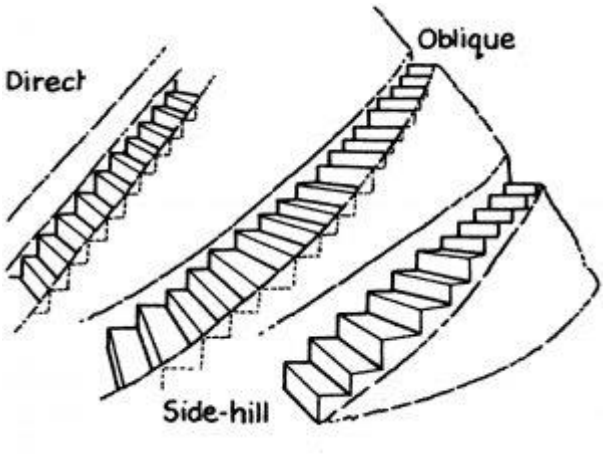
Cliff-top paths may well have no alternative to the direct line. In this case, the steps should be built as close as possible to a staircase, with even width and gradient, landings where possible, and a handrail.



When choosing the line of the steps, look at the site from both above and below. Walkers going down are more likely to take short cuts, and it is this that causes most of the damage to slopes. Make sure that the line can be clearly seen from above, and that any possible short cuts are blocked or disguised.

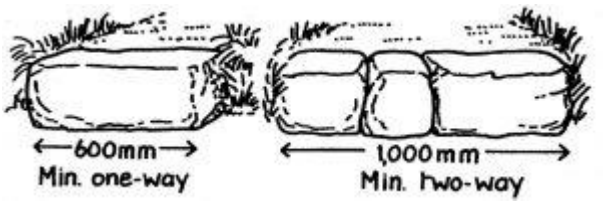


Avoid building sidehill steps, especially across unstable slopes. They are difficult to construct, and need abutments above and below. The treads tend to drain too quickly, causing erosion on the lower side. If possible, build on a steep oblique line, which is easier to drain.

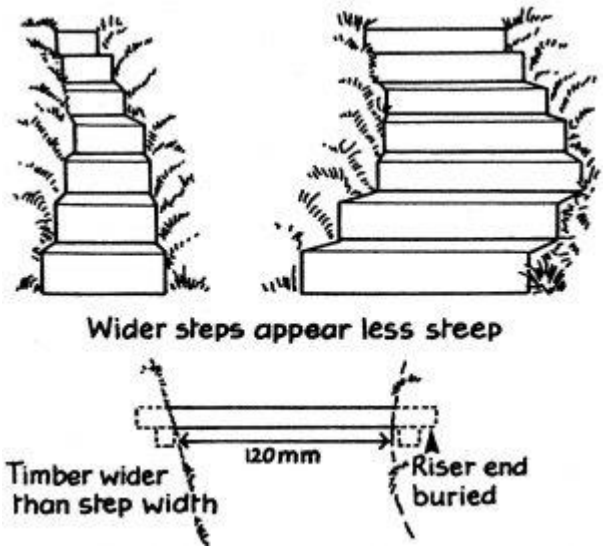


Dimensions

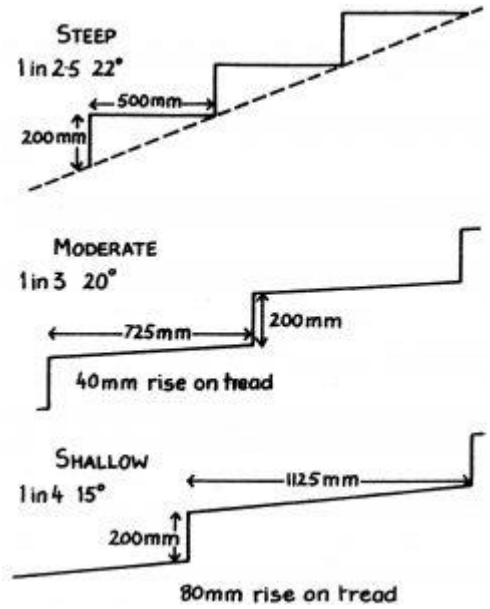
The dimensions of stone steps will be dictated by the stone available, but must be at least 600mm wide, which only allows single-width use. Steps for two-way use can be built of several large stones, to make a step at least 1000mm wide. The rise formed by the stone should be between 150mm and 200mm.



Wooden steps should be 1200mm wide to allow comfortable two-way use, and with a rise of 150 or 200mm. Wide steps look more attractive and less steep than narrow steps. Both for these reasons, and because they give more room for traffic flow, wide steps are likely to be followed by walkers. The timbers themselves may be wider than the finished step width, depending on the method of construction.



The depth of the tread depends on the gradient of the slope.



500mm is the minimum depth of tread and should only be used on 'staircase' type flights, and should be broken where possible with a landing. Most slopes have a changing gradient which can be climbed with flights of one or two pace steps, divided by ramps. It is not possible to maintain a constant depth and tread on a variable slope, but try to keep the same depth of tread in any one flight. As shown, treads should always be built with a rise from front to back. This is not only very important for drainage (see below), but saves on the total number of steps needed, and forms steps that are comfortable to walk up and down as they do not break the rhythm of walking.

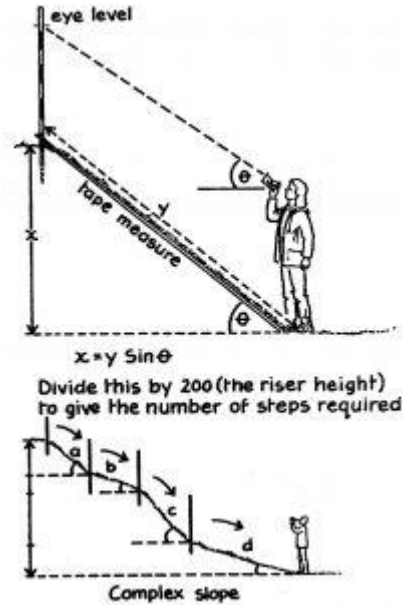
In general, wooden steps look better, and are safer to use, if built to a regular width, height and depth on any one flight, with stobs aligned neatly. Stone steps, built of natural, rough stone in an upland setting will blend better in the landscape if they are of varying dimension, to avoid a formal staircase effect.

Estimating materials

It is important to survey the slope in some way in order to design the flights and landings or ramps, and estimate the amount of materials needed. If surveying equipment and expertise is not available, either of the following methods can be used. Both can be done by one person on their own.

Clinometer

To measure a simple slope of even gradient:
Put a ranging pole or cane, with an easily visible mark on it at your eye height, in the ground at the top of the slope. Attach the end of a tape to the bottom of the pole.
Walk down the slope, unreeling the tape as you go.
Note the measurement at the bottom of the slope, and read off the angle of slope with an Abney level or clinometer using the mark on the ranging pole.
Complex slopes can be measured by repeating this process at each change in the angle of slope.



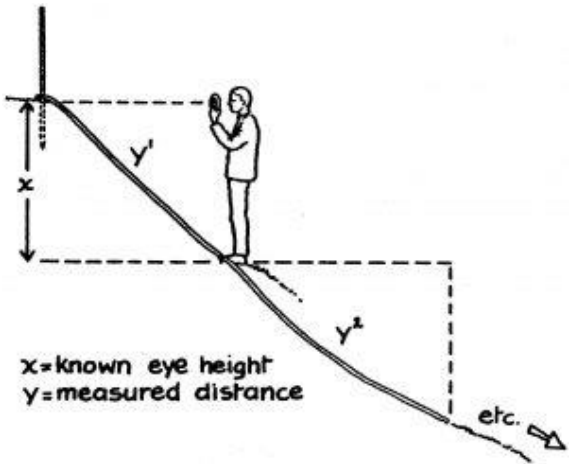
Level

This is a similar technique, but measures the height instead of the angle. Use a sextant or a home-made level.

Put a ranging pole or cane in the ground at the top of the slope, with a tape attached to the bottom of the pole.

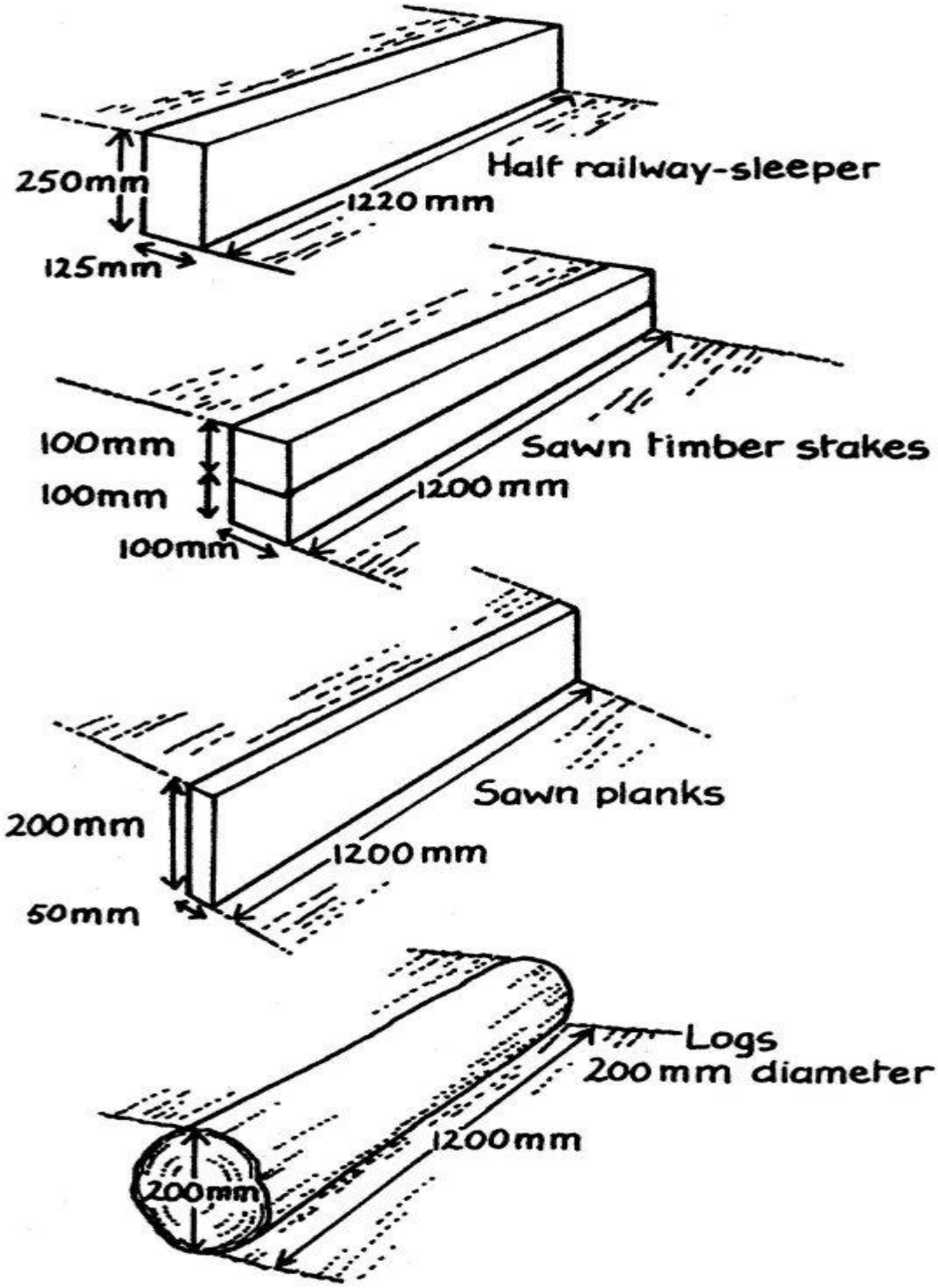
Back down the slope until the level indicates that your eye height is level with the bottom of the pole, unreeling the tape as you go. Note the tape measurement to your feet, and put down a temporary mark (eg the level or your notebook) at that spot.

Retrieve the ranging pole, stick it in the ground at the marked spot, and repeat the process.



This information can be drawn directly onto graph paper. At a suitable scale, draw in the vertical line x. Place the ruler through point A, and swing it until y meets the line CB.

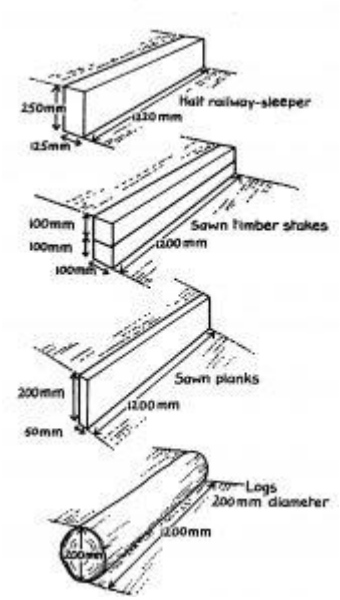
Timber steps



Timber steps are best used in woodland and lowland locations, and on sites where maintenance can be done as necessary. Timber is not appropriate in upland areas where stone is available. Timber steps are also insufficiently durable for some coastal locations, where heavy use combined with severe conditions of slope and weather may result in failure of the timber.

Use pressure-treated sawn timber and stakes. Where home-grown supplies are available, untreated logs can be used for risers, and split oak or chestnut for stobs.

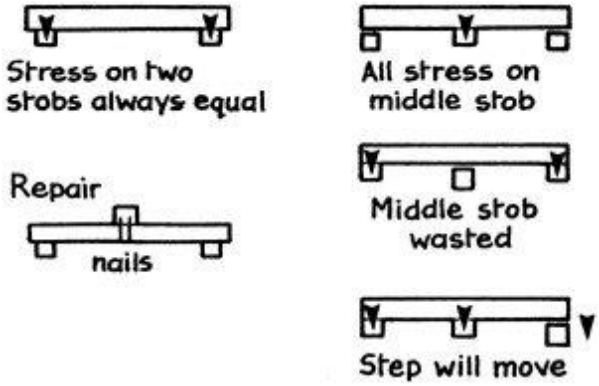
Timber steps must be built with care, to give a strong construction and good appearance. Always measure to ensure stobs are equidistant from the ends of the risers, use a spirit level for the riser, and finish the tops of the stobs neatly.



Stobs

These secure the riser to the ground, and can be square or round timber stakes, metal pins or angle iron. Avoid using more than two stobs for each riser, and always choose to use two longer rather than three shorter stobs. It is difficult to knock the third stob in exactly in line so that the stress is placed equally on all three stobs.

If two stobs are not sufficient to hold the riser without it bending, then the riser is not strong enough. If unsuitable timber has been supplied, or if a repair job is being done, put the middle stob on the inside and nail.

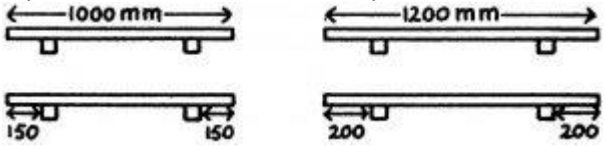


The stability of the stob in the ground is the most important factor in keeping the step secure. A stronger construction is made by nailing the riser to the stob, but this is not essential, as it can cause problems with the stob splitting. There is also the problem that there is not always space to nail from the inside of the step, and nailing from the outside requires using 125mm nails, which are difficult to use without splitting the stob. If nailing is done, always get someone else to support the other side of the riser with a crowbar, so that the action of nailing does not loosen the stob. Nailing may be essential in areas of high vandalism, to prevent the timber being removed.

General procedure

Normally steps will be built from the bottom upwards, but where access for materials is easier at the top, construction can proceed from the top downwards.

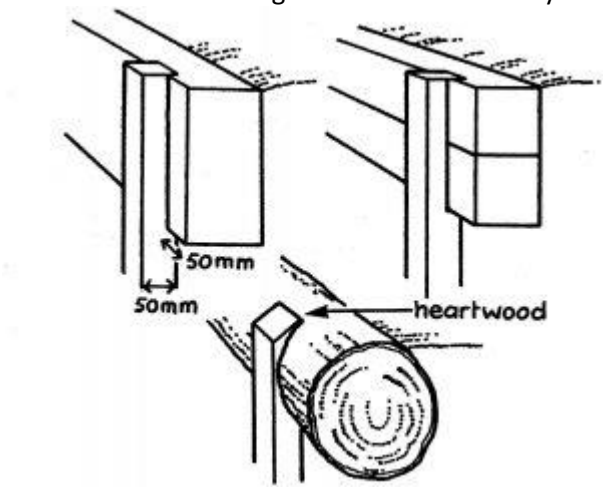
Place the riser temporarily in position, and measure the positions for the stobs so they are equidistant from the ends. Keep to this measurement for the entire flight.



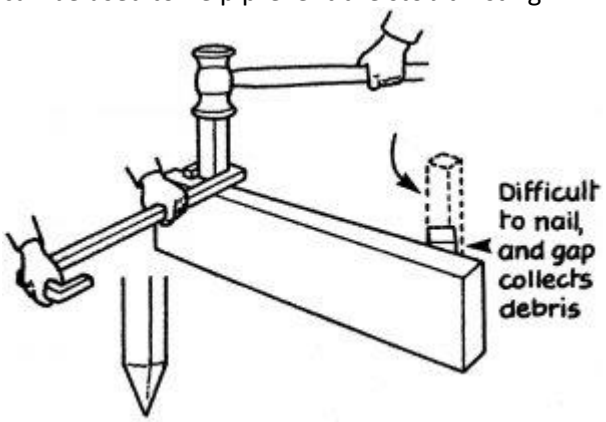
Start the hole for the stob with a crowbar, to make it easier to get the stob vertical.
Place the riser, using a spirit level to check that it is level, or that it has the correct cross-fall as required. Knock wooden stobs into position with a mell, or use a sledgehammer for angle iron or steel bar stobs.
Cut off the tops of wooden stobs using a carpenter 's saw, and treat cut ends with preservative.
Backfill steps and tidy site (see below).

Square stobs

Use 50mm x 50mm timber. The length will depend on the type of ground, but will normally be about 450mm. In ground where stakes can be knocked in easily, the step can be made stronger by cutting a 15mm notch, as shown. Weather the top of the stob. Do not cut notches for stakes in stony ground, as it will be difficult to get the stakes in exactly in line with the notches.



Always place the stake with the heartwood against the riser, as shown, as it is more durable than the sapwood.
The main disadvantage of square stakes is that it is difficult to knock them 'squarely' into stony ground. Often they twist slightly as they go in, leaving a gap which prevents a strong, close joint being made, and which looks untidy. Try starting the hole by working a crowbar across the 'diagonals' of the hole. Rounding the point of the stob reduces the tendency to twist. A stob holder can be used to help prevent the stob twisting.

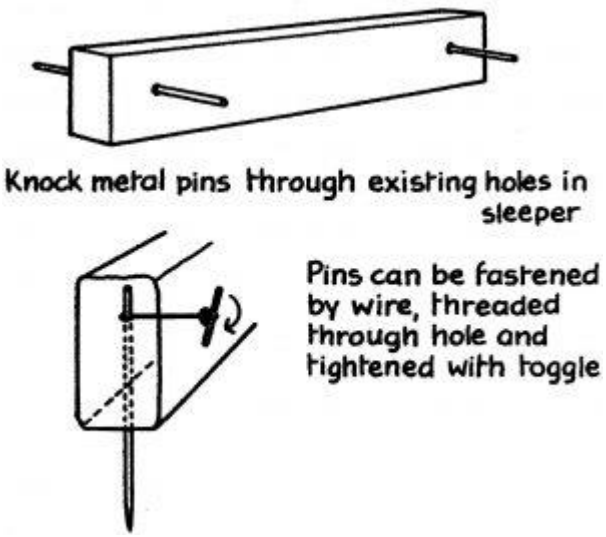


Round stakes

These are easier to knock in than square stobs, as the alignment is not so critical. Use stakes of about 75mm top diameter, or larger diameter half-round stakes. Split oak or chestnut can also be used.

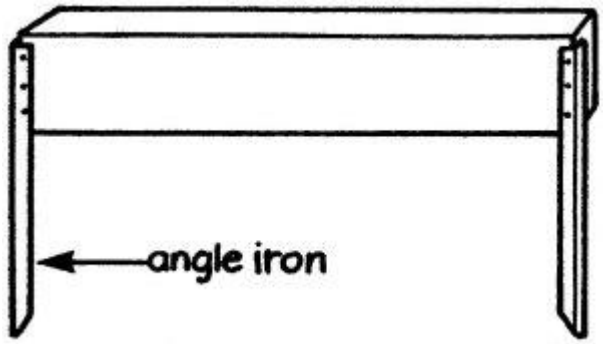
Steel stobs

Steel bar of 16mm diameter, reinforcing rod or other suitable material can be used, from steel stockholders or scrap merchants. Steel rods can more easily be knocked into stony ground that wooden stobs. For a neat finish, the risers can be routed in the workshop to accept the rods. Alternatively, the rods can be fastened as shown below. When used with railway sleepers, rods can double as carrying handles, pushed through existing holes, to ease the task of getting materials onto site.



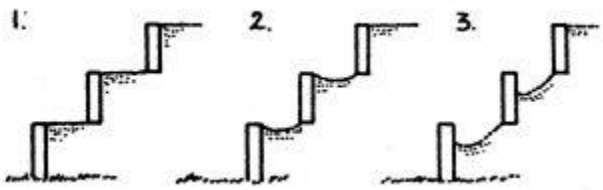
Angle iron

This makes neat and inconspicuous stobs for sleepers or sawn timber risers, and in most situations will become hidden as vegetation covers the sides of the steps. Nail with galvanised nails. In stony ground, it may be difficult to accurately position the angle iron at the corner of the riser, as shown. If so, position as for other stobs, about 100mm in from each end, with the angle outwards. Do not nail.



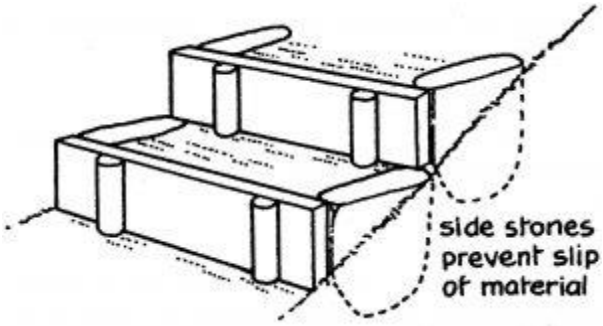
Drainage and surfacing

A common problem with wooden steps is that the tread compacts with use and water collects behind the riser. Trampling turns the surface to mud, which is carried away on boots or washed away by rain. The steps are abandoned as they become uncomfortable to use, and a path forms alongside.

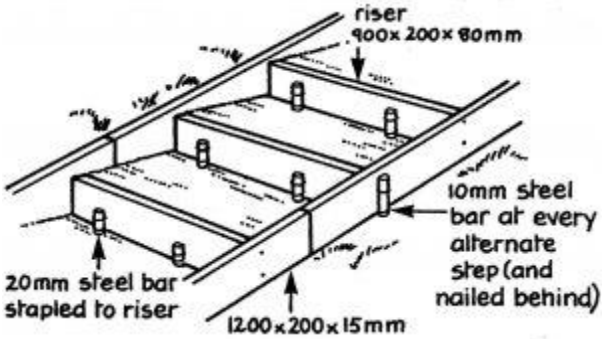


This problem can be lessened by proper surfacing and drainage:

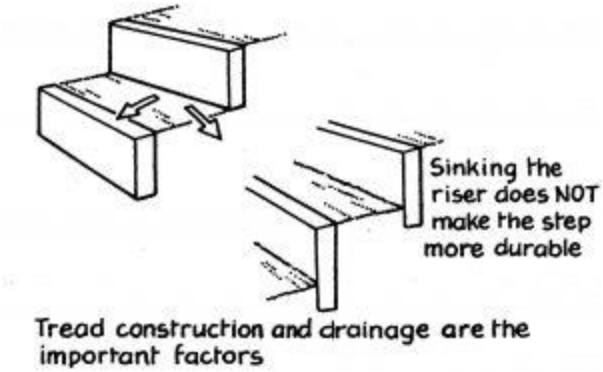
The tread should be formed of free-draining material which will not be carried away on boots. Do not use clay or organic soil.
Prevent 'waterfall' flows down the steps by constructing a cross-fall or camber to shed water off to the side. On steep slopes and impermeable ground, install a French drain down the side.
Alternatively, lead the water off every five or so steps into a short open drain leading away from the steps.
The sides of the tread can be protected with suitable stone where available, bedded onto a solid foundation to prevent subsidence, and with the top set level with the top of the riser.



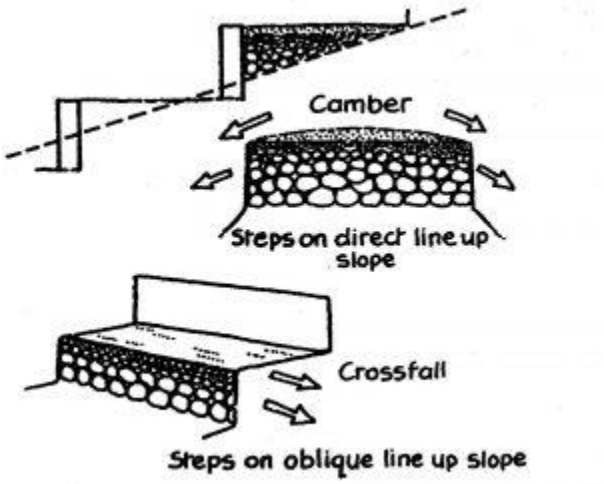
Alternatively, timber can be used, nailed to the risers and secured with stobs.



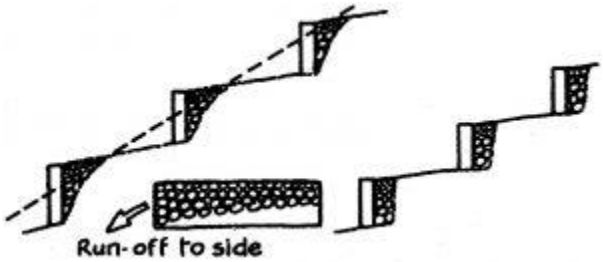
Treads should always <u>slope from back to front</u> to allow water to drain off. Do not sink the bottom of a riser below the top of the previous riser in an attempt to prevent the tread eroding, as this only worsens the effect illustrated above. To reduce the waterfall effect down the face of the steps, the tread should have a cross-fall or camber to shed water to the side. A camber will not be as durable as a cross- fall , but should be used on steps taking a direct line up a slope.



On steps where the tread mainly comprises 'fill' material, the tread can be built up in a similar way to a <u>surfaced path</u>. Local material from borrow pits, scree or stream beds should be suitable. Grade the material as shown, and put in a cross-fall or camber to direct the water away from the step.



Steps where the tread is partly comprised of fill can have a ‘toe’ or French drain of free draining material to take water from the tread.

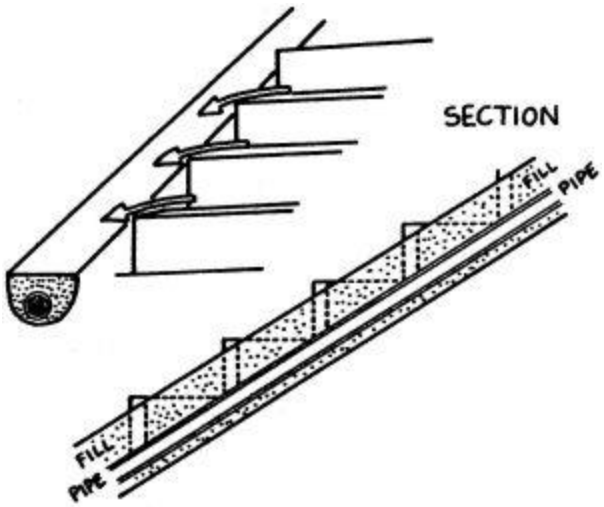


Steps cut into steep slopes of clay need a surface dressing to prevent the treads becoming muddy and eroded. Crushed stone of about 20mm to dust, well trodden down, is suitable. This will need renewing periodically.

However carefully treads are constructed, maintenance will still be necessary. On some sites it may be decided, probably after much agonizing, to use concrete for the treads. This weathers to an unobtrusive colour, which on chalk or limestone may be not so different from the natural material, but will give a much more durable surface.

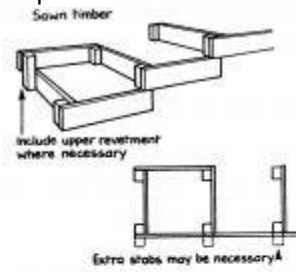
Drains

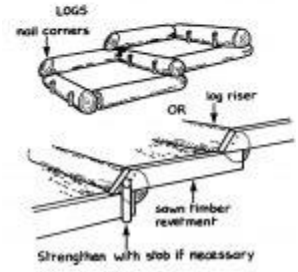
On moderate clay or peat slopes, an open ditch can be dug. Water must be able to flow freely into the ditch, with no possibility of it being diverted back onto the flight of steps. Make the gradient of the ditch as smooth as possible, and where available, line it with stones. On steep slopes or those likely to slump, a French drain with a perforated plastic pipe can be constructed, running parallel to the flight of steps. Run it into a ditch or soakaway, so the water does not merely collect at the bottom.



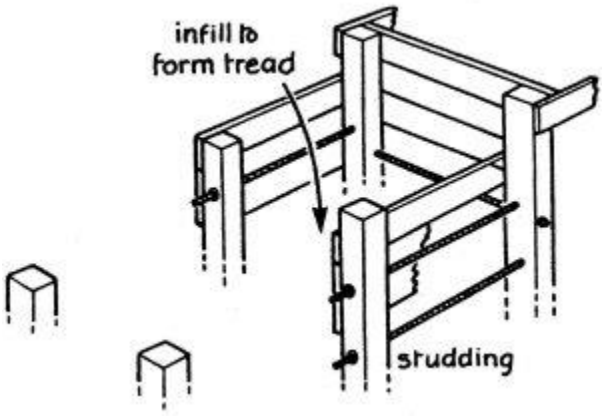
Revetted steps

Where steps take an oblique line up a slope it may be necessary to build simple revetments to protect the sides of the step. Revetments will be essential where steps have to climb an unstable slope.





Where space is very restricted, for example on steps down to beaches, more complex structures may be needed. Stobs are replaced by 100 x 100mm uprights, braced with steel studding. Oak should be used for durability, drilled on site with a battery-powered electric drill. This type of structure is difficult to specify in advance, and detailed design must be decided as work proceeds.

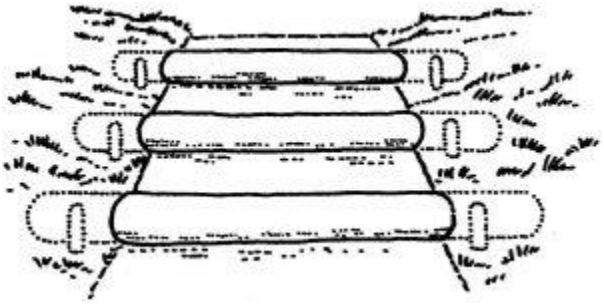


Revetted steps should only be built where no better line is available, as they require a lot of timber and can look very obtrusive. See also Chapter 11 – Erosion control and vegetation restoration for other types of revetments which can be built in association with steps.

Sunken steps

On gentle slopes of free-draining soils extra long risers can be used, and the ends buried in the spoil dug from the tread. This discourages walkers from going around the side, and looks attractive as the stobs are hidden and the steps appear moulded into the hillside. Any turf cut from the line of the steps can be used to protect the shoulder of the slope. This is not recommended on steep

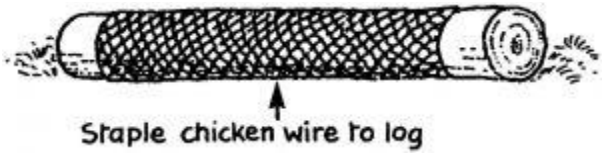
impervious slopes, or where run-off is high, as the unconsolidated material will be simply washed away as the line of the steps acts as a watercourse.



Non-slip treatments

Log steps can get very slippery, especially in woodlands where humid conditions favour algal growth. Although the bark may seem to improve the grip, it should always be removed before the step is built, as it can itself become slippery and speeds the decay of the timber. Creosoting helps to reduce algal growth, and can be repeated at intervals as necessary.

The simplest method of improving the grip is to roughen the top of the step using a billhook. Alternatively, a recess can be cut in the top of the log using an axe or chainsaw. Do this after the step has been fitted, but before it is backfilled or surfaced. The method shown below has successfully withstood several years' heavy use at the Birks of Aberfeldy, Tayside. It is not too obtrusive, as the wire soon loses its silvery appearance.



Erosion control and vegetation restoration

Erosion is a serious problem on many popular paths and areas where the public have unrestricted access. Excessive trampling destroys the vegetation, so exposing the soil to rain splash and overland flow, and causing a great increase in the rate of erosion. The steeper the slope, the greater is the problem. Damaged landscapes range from mountain tops to peat moorlands, chalk downs, lowland heaths and coastlands.

There are various ways of tackling the problem:

Reducing the total volume of use. This can only be done indirectly, by restricting the availability of car parking at road access points, or by reducing publicity for certain routes. In the past, serious damage has been caused by mass walks, particularly on upland areas of peat bog. The effects can be especially long-lasting if a sponsored walk, training exercise or other event coincides with a period of wet weather. The damage caused by a single event may be seen for many years. These events are now actively discouraged in most vulnerable areas. Some types of use, particularly by off-road vehicles and mountain bikes, are very damaging. Where the legal situation is clear, barriers can be erected to illegal use, although this may be physically difficult and almost impossible to enforce in some areas. On other routes, the legal status is still being clarified.

Reducing grazing. Grazing by sheep, deer, goats and rabbits on upland and moorland areas can have a very great effect on the species content and vigour of the vegetation cover. The reduction or exclusion of grazing may be the most important single factor in vegetation restoration. During the 1980s, dramatic changes were made to the flanks of Kinder Scout in the Peak District, by banning all sheep from the moor, and rounding up all trespassing sheep (over 25,000 sheep removed in 10 years). There has been a great reduction in the amount of bare ground, and an increase in the amount of heather, bilberry and other desirable species (The National Trust, 1993). Once such areas have regenerated and stabilised, grazing may be allowed again at the rate of about one sheep to 1.5 ha, in order to help maintain the moorland vegetation.

Spreading use over a wider area to lessen the impact on one particular path or location. On the large scale, this may be part of a management scheme for an extensive area of countryside, such as a National Park. On the small scale, this may require simply the removal of fences enclosing a path to allow use to spread. On chalk downland and ancient monuments particularly, the aim is often to encourage an even use all over the site by removing 'targets' and desire lines, or in other words, allowing access without the development of paths. Draining and improving the path, or altering its line, to allow natural regeneration of the hillside.

Restoring damaged areas by constructing revetments and erosion barriers, filling, grading, reseeding and transplanting. These techniques are considered below. Successful restoration requires keeping people off the area being restored, and is a complementary process to improving the path.

Over the years, many techniques have been tried, mainly on an experimental basis, to re-establish vegetation. The overall picture that emerges is that where trampling is confined to the path, and grazing is excluded, vegetation has a great capacity to recover, either from the seed bank contained in the substrate, or by the artificial spreading of seed. On eroding slopes, the most important procedures are to create drains, improve the path to confine trampling and remove grazing if possible. Then vegetation can recover. Within this general picture, there are of course great variations, according to the site, location, local climate, use and so on. Amongst the most difficult areas are acid peat, where the seed bank is low, and acidity, worsened by acid rain, and low nutrient levels, resulting in little or no vegetation growth.

The other general point that emerges is that although products such as geotextiles and gabions may help in certain situations, there is no 'quick fix'. The simplest techniques are often the best. Careful use of natural materials on site, together with long term management planning for the whole area gives the best results.

The moment to act

In many places the moment for a 'stitch in time' passed by many years ago, and damage is extensive. However, most areas have developed the techniques and the expertise to deal with nearly all situations, and given time and resources managers are confident that they have the problem solved. Hopefully, many areas will never again suffer the extent of damage that was occurring in the 1970s and 80s. However, there is still much work to be done.

Vegetation restoration

Vegetation is the perfect control agent against erosion. It works in three ways; breaking the impact of raindrops, trapping sediment and stabilising the upper layers of soil or substrate.
There are three basic methods of vegetation restoration, as listed below. Often a mixture of these methods will be used on any one site, either at the same time, or according to season. The most noticeable attribute of natural vegetation is its lack of uniformity. Avariety of methods, and 'patchy' results, will give the most natural effect.

Allowing vegetation to return naturally, by seed spread or vegetative spread from surrounding vegetation. In grazed areas, the removal of grazing will allow plants to flower and set seed, thus greatly increasing the rate of natural seed spread. The reduction or removal of grazing and trampling will also greatly increase the rate of seedling success, and is nearly always the most important factor in vegetation recovery. Recovery can also be aided by boosting any remnant vegetation with fertiliser, and lime on acid sites.

Sowing seed, either purchased or collected locally, of grasses and other plants.

Transplanting turves or clumps of vegetation dug from elsewhere. This may include nursery-grown trees and shrubs.

The success of any of these techniques depends on reducing or removing grazing or trampling pressure. Success will also vary considerably with the soil, altitude, aspect, prevailing weather and other natural factors. Results on apparently similar sites only a short distance apart may vary considerably due to differences in soil, water availability or micro-climate.

Natural recolonisation

In all but the most extreme locations of high salinity, toxicity, acidity or on moving scree, vegetation should eventually return if trampling is removed or lessened. The plants will only be those occurring locally, and so a 'natural' plant community should result. However, in areas where erosion is severe, this natural recolonisation may be too slow to prevent further erosion, and where topsoils are gone, nutrient levels are too low to support much growth. In lowland areas recovery may be rapid, but it can take some years to achieve a balance, as in the first few years the plant community will be dominated by pioneer or weedy (aggressive) species, usually those which are fast growing and can survive in extreme situations. For example, it is likely that thistles, docks and willow herb will arrive before the more desirable slower growing grasses and herbs. After a few years, if the recovering patch is managed in the same way as the rest of the area, the weedy species will decline until the patch blends in unnoticed.

This natural pattern of recovery may be unsuitable for the following reasons:

The rapid or even instant restoration of a scar or closed- off path may be a vital part of the scheme to persuade walkers to keep to the newly designated path. Walkers are more likely to respect the scheme if they can see that positive measures are being made to restore the eroded area.

Growth may not be quick or thick enough to prevent renewed erosion of the area, particularly on steep slopes.

The appearance of the pioneer plant community.

The addition of fertiliser and other treatments such as lime has been tried on several sites, to boost the surviving vegetation. Trials done on trampled areas during the Three Peaks Project in the Yorkshire Dales were inconclusive, but seemed to suggest that the removal or lessening of trampling was a much more important factor than fertiliser treatment.

On the large scale, where trampling is not the only factor in vegetation loss, fertiliser and lime treatments have been very successful on acid peat. In the Kinder Scout area of the Peak District, the National Trust have applied fertiliser and lime by helicopter to stimulate natural regeneration and self-seeding of remnant moor land vegetation. The lime temporarily reduces the acidity of the peat, and the fertiliser provides the extra nutrients to boost growth. A light application, of about 1 tonne of lime dust and 0.3-0.5 tonnes of fertiliser per hectare, is enough to have a significant effect on plant growth, flowering and seed-set of the remnant sward.

Seeding

Seeding requires careful analysis and preparation if it is to be a success. This will include surveying the local flora, and analysing the soil or substrate to determine if any chemical treatments are necessary. Care must be taken that invasive species are not introduced which may upset the balance of species in surrounding plant communities. Seek advice if necessary from the local office of English Nature, or equivalent nature conservation agency for Wales, Scotland or N. Ireland.

The seed mix should usually be of native species and should include a fast growing 'nurse' species, and slow growing long lived species for permanent cover. As well as grasses, seeds of other herbaceous perennials, shrubs and trees can be sown. After seeding the area must be fenced to exclude walkers, preferably for at least a year.

Turfing and transplanting

Like seeding, turfing will only be successful if the original reason for vegetation loss has been removed; usually by the provision of a more resistant path. Turfing has the obvious advantage that its effect is immediate, and it can transform the edges and surrounds to a new path so there is no question in the walker ’s mind of following any route other than the path. If turfing is done with care, and the site is meticulously cleared up afterwards, it should be almost impossible to detect any signs of the work that has been done. This cosmetic effect can be vital in successfully altering visitors’ patterns of use. Turfing is slow and sometimes heavy work, and the source of turves may be a limiting factor. Permission to cut turves must always be obtained from the landowner. Under the Conservation of Wild Creatures and Wild Plants Act 1975 it is illegal to dig up any wild plant without the landowner ’s permission.

Sources of seed

Local seed

Seed can be gathered locally from grasses and other flowering plants. This is slow and painstaking work, but it does mean that the seeds are of the same genotypes of the species that occur on that particular source. It is also a free source. Even if only a small quantity is gathered, the seed can be mixed with commercial supplies to improve the ecological value of the restored area.
Most seeds should be gathered during July, August and September, but timing will vary with species and locality. Grass seed can be collected by cutting the heads as they ripen, and leaving them spread on trays or paper in a dry place. The seeds can be shaken off when dry. Other plants may be more difficult, as the seeds on each head may not ripen simultaneously. The best method is to hold a plastic tray or container under the plant and gently shake the stem, or rub the seed head between the finger and thumb. This ensures that only ripe seed is collected, and there should then be no danger of depleting the natural stock. Always consult the statutory nature conservation agency or the local wildlife trust if there is any doubt over the wisdom of collecting any species which may be locally uncommon.

Leguminous seeds should be gathered just before maturity as the pods of some species explode and scatter the seeds. Gather the pods, and cover loosely to prevent the seeds being lost when the pods explode. Store seed in paper bags or cardboard boxes, but not in polythene bags.

Local groups or site managers may find it worth establishing stock plants of native species, in the same way that commercial seed companies operate. These stock plants are grown in a nursery in optimum conditions, and so can produce far higher yields than if competing in the wild. For example, one cowslip plant can produce 4,000 seeds (4.54g) in a season.

Live mulch

This involves raking existing turf, heath, scrub or woodland floor to gather a mulch of topsoil, plant litter, moss and plant fragments. This is then spread on the area needing revegetating at the rate of 1-3 litres per m2, and lightly raked into the surface (Bayfield and Aitken, 1992). The mulch will contain seed and plant fragments capable of rooting, as well as providing topsoil, organic matter and micro-organisms which aid establishment. The most successful use so far has been to combine live mulch with sown grasses to provide quick cover. Live mulch is unlikely to be successful in drought conditions. Little damage is done to the source area, though a light application of compound fertiliser can be given as required to speed recovery.

Hay and sweepings

Hay bales will contain suitable seed if cut from the type of sward you wish to reproduce. The seed can be extracted either by beating or trampling the hay over a sheet or clean floor, or the hay can be spread directly onto the site.

Sweepings from hay barns also contain seed, but should not be used on ecologically sensitive sites as they could contain undesirable agricultural strains. Seed merchants may give away sweepings but the species composition will be variable.

Heather

Fire-breaks are cut on many heather moorlands. If this is done in autumn, the cut material with its fruiting shoots can be gathered up and stored over the winter, and then spread over bare areas the following spring (Tallis and Yalden, 1983). Heather plants are slow-growing and in the first two years or so are very vulnerable to grazing,trampling or being buried or uprooted in unstable peat. The best method of establishment may be to sow a nurse crop of grasses, supported by fertiliser and lime, and then to spread the heather cuttings over this the following year. The heather grows up within the protection of the grasses, which decline as nutrient levels drop.

Soil seed banks

Most soils contain viable seeds, and some, at semi-natural recreation sites have been found to contain over 500,000 seeds per square metre. Seed banks tend to decline with altitude and trampling. In two different studies of a range of habitats in Scotland and the Yorkshire Dales, seed banks have been found to be dominated by rushes (Bayfield and Aitken, 1992). Bare peat usually contains no viable seed.

Trials suggest that the germination of seed and survival of the young plants can be encouraged by an application of fertiliser. Lime is also needed on acidic sites such as peat. However, trials have not been conclusive, and with infinite site variations, weather and other factors, outcomes are difficult to predict. For most small scale areas the best approach would seem to be to use a seed mix, with fertiliser and lime as necessary, rather than relying on the natural seed bank. The extra cost of seed on small sites is not significant compared to other costs. The normal priority is to get something growing to stabilise the site. However, on sites of special scientific interest, and other areas, there may be overriding reasons for not introducing any seed to the site. The example of Badbury Rings, shows how the simple method of collecting mole-hill soil provides a viable seed bank.

Soil stabilisation

Brashings

A simple, effective method to encourage the success of natural recolonisation or artificial seeding is to lay cut brashings of woody material over the eroded area. These stabilise the soil, trap wind-blown soil and seed, and provide shelter as seedlings grow up. The branches are also a deterrent to trampling and grazing. Any material can be used, but branches with a flat form of growth, such as larch, are more effective. On slopes and exposed sites, secure the brashings with pegs cut from suitable woody material.

Geotextiles

There is a huge range of materials, known as geotextiles, which are used for stabilising bare slopes, encouraging vegetation, and reinforcing existing vegetation against trampling. They are widely used in civil engineering for slope stabilisation, and especially on steep slopes at the sides of roads, railways and urban areas, and at water margins.

Their use for stabilising slopes on recreation sites, where trampling pressure is removed, have been mainly successful, and many types have been tried. Their main disadvantage is their cost, and the

fact that they are easiest to use and disguise on regular slope profiles, which are common in civil engineering, but not on natural sites. Where the geotextile does not closely fit the slope, unsightly suspended sections of geotextile are likely to result.

Geotextiles suitable for erosion control and slope stabilisation on amenity sites are of two basic types; either a woven net, or a three-dimensional mat.

Woven net is available in jute, coir or synthetic materials such as polypropylene or wire. Jute and coir have the advantage of being natural, biodegradable, and drape closely over irregular slopes. Jute is able to absorb up to five times its own weight in water, which lessens initial run-off, and provides a moisture reserve for plant growth. Jute mesh typically covers 35-40% of the soil surface, providing shade, insulation against temperature extremes, and maintenance of humidity, whilst not inhibiting plant growth. The cellulose fibres become incorporated into the soil as the material decomposes, improving long-term resistance to erosion. The mesh is secured with wire staples that rust away within five years or so. Seed can be sown before or after the mesh is laid on the slope, and shrubs or trees can be planted through it. Jute is biodegradable within two to five years in lowland areas, giving sufficient time for vegetation to stabilise. However, in the uplands and mountains jute only lasts about one year, which is not long enough for vegetation to establish, and the site is likely to be further disfigured by tatters of fabric blowing in the wind. The pale colour is also much more noticeable from a distance than dark or black materials. Brands of jute mesh include Soil Saver (Hy-Tex Ltd.) and Geojute (Ardon International). They weigh about 500g per square metre. The UK market leader jute mesh, Soil Saver, costs about 65p per square metre, including the fixing pins (1995 price).

Coir (coconut fibre) geotextiles last between four to ten years, which is double the life of jute. They have a greater tensile strength, and are heavier for the same mesh size. Coir is suitable for steep or severe sites, or where plant establishment is expected to be slow. Coir geotextiles are available in a range of mesh sizes, from the suppliers given above for jute.

Polypropylene and wire mesh geotextiles are described here. Some types have been used successfully for laying over existing grass or into new grass paths to provide surface reinforcement against trampling. Once established, the geotextile is hidden within the root matrix and the area can be grazed or mown as necessary. They are not recommended for general slope stabilisation for amenity sites because they are non-degradable and do not ‘drape’ well over uneven ground. However, Pathcraft Ltd. have successfully used polypropylene ‘Netlon’ on sites in Scotland, and have found its durability necessary for mountain conditions. Its black colour makes it virtually invisible, even when viewed close by. Pieces are cut to manageable size for transport and ‘drapability’, and then pegged in position for several seasons. If done with care, the net can be lifted for reuse without damaging the restored vegetation.

Three-dimensional geotextile matting is available in a variety of materials including jute and coir. They are also available pre-seeded, with the client’s choice of seed mix, and then are simply unrolled down the slope and pegged. Brands include Greenfix (Phi Group) and GrassMat (Hy-Tex Ltd.). Three-dimensional polypropylene matting such as Enkamat or Tensar Mat (Netlon) is a more durable product designed to be laid on a slope and then backfilled with soil and seed, to provide surface and sub-surface reinforcement. It is available in various specifications, including pre-seeded or with growing turf, and may have uses in particular locations where its durability is useful.

The general verdict amongst recreation managers seems to be that jute and coir geotextiles have uses for particular small, steep areas that are difficult to revegetate, and where trampling can be excluded. On steep slopes, over 25degrees, they appear to be more effective than hydroseeding (see

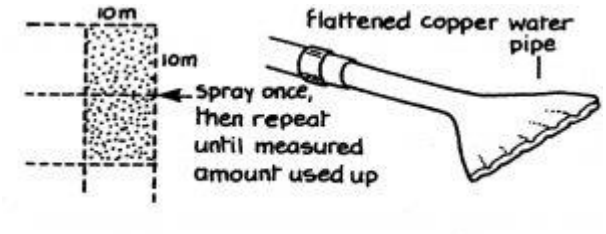
below), but are more expensive. Partly due to cost, no large areas on recreation sites have yet been treated with geotextile, although upland pipeline routes have been restored using jute geotextiles. There is also the strong preference amongst managers of upland areas, where such eroded areas exist, against the use of 'synthetic' solutions. Geotextiles can only succeed if the other factors of trampling, grazing and drainage are also dealt with. Some open weave textiles have been found to discourage grazing, as sheep are wary of getting their feet entangled. Children, on the other hand, may see it as a novel slide or a net to climb up. All geotextiles tend to attract small mammal populations beneath them, where the animals flourish in the sheltered micro-climate and protection from predators, to the detriment of vegetation establishment!

Soil stabilisers

These are a range of products, also known as 'tackifiers' or surface glues, which are sprayed onto the ground to hold seed, fertiliser and substrate in place during the establishment phase. Soil stabilisers can be of bitumen, latex, or resin. They can be applied by specialist hydraulic seeding (hydroseeding) equipment, by tractor-mounted sprayers or hand sprayers.

From a large number of products on the market, those tested for upland sites were all found to perform adequately on a trial basis. Choice is likely to be determined by cost, and ease of mixing, powders being easier to apply on small areas than emulsions (Bayfield and Aitken, 1992). Hydroseeding was carried out on a trial basis by a specialist contractor on various sites in the Yorkshire Dales, with varying degrees of success (Yorkshire Dales National Park, 1993). Hydroseeding involves the application of a 'slurry' containing seed, fertiliser, moisture retainer and soil stabiliser, sprayed at high pressure from a lorry-mounted sprayer. The high pressure spray has the advantage that it reaches over some distance, thus minimising ground disturbance, but the disadvantage on slopes that the force of the spray can cause run-off.

More recently a sloping area of about one hectare on Pen- y-Ghent was seeded and stabilised using hand-held equipment. Apath was first delineated through the eroded area by using simple rope edging. Larger stones were moved to the side to make a comfortable walking surface, and the area was left for a week to settle. NPK fertiliser (10.15.10) was spread, followed a week later by the seed mixture, and the area was sprayed by hand using an 8% mixture of stabiliser M166 (Houghton Vaughan) diluted in water. The usual recommendation of 4% was found insufficiently sticky, the material washing down as it was sprayed. The problem with spraying slopes is to get sufficient product onto the slope to stabilise it, but without run-off. In this project the stabiliser was carefully applied in two thin coats up to the recommended rate of 3 litres/m2. An area of 10 x 20m was treated at a time, to allow the first coat to dry before the second coat was applied.



The problem of supplying sufficient water for the job was solved by lining existing small hollows with waterproof building membrane, to trap rainwater and stream seepage. This was done several weeks in advance of the spraying operation, with the pits fenced against livestock. The pits were pumped out using a small petrol pump, and mixing was done in large plastic tanks, hired from a building hire centre. The spraying operation took three people about five days.

All soil stabilisers tend to block spraying equipment, and large-hole sprayers are needed, with frequent washing out to keep them working properly. For this project, flattened water pipe was

used, attached to alkathene pipe. As with all chemicals or hazardous substances, manufacturer ’s instructions must be followed, and care taken with wearing of protective clothing, disposal of containers and other procedures.

Unfortunately, a few weeks after completion of the project, exceptionally heavy rain caused large areas of the newly germinated sward to wash down the slope. However, it was felt that the technique was basically sound and would be used again on a similar site, with hopefully better weather.

Depending on dilution rates, a reasonable guide price for soil stabilisers is about 65p per square metre, which is comparable with the cost of jute geotextile (1995 price). For sloping sites, a choice between geotextiles and soilstabilisers is likely to be made taking into account factors of labour, costs of other equipment needed, water supply to the site, aesthetic considerations and personal choice.

Requirements of seed mix

The choice of seed mix will depend on the physical nature of the site, and the use to which it will be put after restoration. The mixture is determined by the percentage of different species and strains. On the same site, trample- resistant mixes can be used for path surfaces, and other mixes for non-trampled areas. In practice, on many sites there is much to be said for using a standard amenity mix (see below), suitable for the general habitat, which is readily available for staff to use as necessary on eroded patches, and for restoration as soon as other path work is completed. Where possible, this ‘stitch in time’ approach is more likely to be successful than large-scale reseeding, and to result in a natural mosaic of vegetation. Specialist advice will be needed for large areas, and on which a variety of mixes and treatments may be advisable to create a natural-looking pattern of vegetation. Any revegetation work on Sites of Special Scientific Interest can only be done after consultation with the relevant statutory nature conservation agency.

Acultivar is a named strain of a species, which is maintained in cultivation. It may be very different from other cultivars of the same species. Specialist seed advisers or seed suppliers will advise whether particular cultivars are suitable for particular locations and uses. Cultivars are distinguished by a name or letter and number after the species name.

Seeds from native British grasses tend to be much more expensive than foreign cultivars, and for this reason the latter are used on some amenity sites.

Nurse species

The mix should include a species which grows rapidly to protect the soil and other seed from being washed away, and provides a suitable micro-climates for the germination and growth of other species. This is usually perennial rye grass (*Lolium perenne*) which establishes quickly, especially if fertiliser is applied, but declines as fertility decreases. It can be used in both acid and alkaline situations, and cultivars are available which germinate at low temperatures and are thus suitable for high altitudes. On many amenity sites, especially in upland situations, it will not persist without management intervention, and can thus be allowed to decline as local species take over.

The speed with which other species take over depends on many factors, including the vigour of the nurse crop, the natural spread of seed from nearby, and the speed of establishment of these local species.The exclusion of grazing is an important factor in allowing existing native plants to flower and set seed into adjacent newly sown areas.

Resistance to trampling

It is unlikely that re-seeded areas will be kept entirely free of trampling, whether by animals or humans. Some trampling will be desirable if the aim is to maintain a grass sward and prevent it being invaded by scrub. Species resistant to trampling may therefore be selected, and will include those with tough leaves, often in a rosette, a growing point well below the soil surface, and an ability to propagate by stems as well as by seed.

Footpaths tend to develop this type of species composition, as non resistant species are destroyed by trampling and resistant ones take their place. These differences can be seen quite clearly where path vegetation shows as a different colour, or resistant species such daisy (*Bellisperennis*) are in flower along the line of a path.

Level of productivity

The mix should be productive enough to give a cover that will prevent soil erosion, but not so thick that local species are unable to recolonise. Very productive strains of agricultural and sports turf grasses should normally be avoided. Fertilising the ground can also slow the return of native species because their growth rates cannot usually compete with those of sown species while soil fertility is high. Fertiliser treatment is usually needed for initial establishment, and may be needed in following years until a satisfactory sward is established.

Colour

'Improved'grassland, containing agricultural grass species, is a brighter green than unimproved semi-natural grassland. Restored areas may be visible for some years as a bright green 'scar ' if certain strains are used.

Procedure

In areas of erosion and low fertility, fertiliser applications may be have to be repeated over several years. The initial application would be of a quick release fertiliser applied at a high rate, followed by reducing rates of slow release fertiliser for up to five years.

Timing

The optimum time for sowing seed mixes varies with the locality. In general, in the south and southwest, seed can be sown from March to May, and September to November. Slightly shorter periods of April and May, or August and September are possible in the midlands and parts of the north. In the drier eastern regions, spring sowing is more risky due to summer droughts. In the

upland areas of the north west and Scotland, spring sowing is more reliable than autumn sowing, which may fail in cold and wet seasons. Within this general pattern there is much room for variation according to weather patterns and particular localities.

Methods of sowing

For small areas, simple broadcast sowing by hand from a bucket or bag is the best method. For larger areas, a seed fiddle can be used. It is preferable, but often not possible in the uplands, to sow on a dry, still day. If it is windy, walk up and down in the direction of the wind, so that any blown seed falls in the required area.

For mechanical sowing, seed drilling by tractor and drill directly into the ground is not usually possible because of ground conditions. Seeding from a spreader may be possible but often windy conditions cause problems. The ideal for many upland areas would be low-level seeding attachments for quads or All Terrain Vehicles, which are being developed.

Tilth

On flat ground or gentle slopes, preparing a seed bed is is worthwhile even where the site looks beyond redemption. Soils on trampled areas will be very compacted, and should be broken up with a fork or pick. Ideally this should then be left to be broken further by weathering, but normally this will have to be done straightaway, by knocking the lumps apart with the fork or rake. Rake to produce as fine a tilth as possible. Any remaining soil on slopes should be raked to break the surface crust, but do not loosen more than this, or you may encourage further erosion.

Topsoil brought from elsewhere should be roughly spread with a rake, and then trodden to firm it. Rake the surface again to produce the final tilth. Slopes should be raked from the bottom upwards. If any mulch such as sewage sludge or composted bark is being used on stony slopes, it must be well raked in so that the mulch and substrate are mixed to at least 100mm. Otherwise the plants will merely root into the surface mulch, which will slide away like a carpet after heavy rain or snow.

Eroding stony slopes may be too unstable for any raking or other preparation, and seeding may have to be done in stages over several years. The method used by the National Trust Carneddau Footpath Team is as follows. The area is first fertilised with Vitax Q4 at the rate of a golf ball-size handful per square metre. About a week later, an upland amenity mix (see below) is sown, at the rate of one tennis- ball size handful per square metre. This is normally done in May. Later that year, or the following spring, the area is picked over to remove large stones. This cannot be done initially before any seedling establishment, as the slope is too vulnerable to erosion. Bare patches where stones were removed are seeded, and any failed patches are reseeded. Eroding material covering newly-established grass is also carefully removed so that it doesn't smother growth. This is repeated again as necessary until the slope has stabilised.

Seed mixes

For special sites and large areas, seed mixes are likely to be chosen with expert advice from the statutory nature conservation agency, wildlife trusts or specialist seed advisers. However, for many amenity sites, the important properties for a seed mix are that it establishes quickly, is moderately productive and trample resistant, reasonably priced and commercially available in sufficient quantity. Many seed mixes for such sites are based on a mixture of perennial rye grass (*Lolium perenne*), smooth meadow grass (*Poa pratensis*), common bent (*Agrostis tenuis*) and fescues (*Festuca* sp.). Of the fescues, sheep, red and Chewing's may be used. All the above species are available in various cultivars, on which seed suppliers will give advice.

How to plant

The roots of bare-root plants must be kept covered at all times, to prevent them drying out. Even a few minutes' exposure to air can dry the delicate root hairs, reducing the plant's ability to establish quickly. Keep small bare-root plants completely within a polythene sack until the moment of planting, and keep the roots of larger plants similarly covered.

Don't soak or dip bare-root plants in water before you plant. Roots are not able to absorb water this way, and the water may damage the delicate root hairs by washing off the protective soil covering. If plants are delivered with dry roots they should be returned to the supplier. An exception to this rule is when using a root dip, which coats the root hairs with a fine gel that aids establishment.
Preferably plant on mild, damp days. Avoid days with frost or strong, drying winds.

Don't dig planting pits or notches until the day of planting, as they are liable to fill with water. The easiest and most efficient method is to make the pit or notch and plant the tree in one operation.
On variable ground choose each planting position with care. Keeping to rigid spacing patterns is less important than maximising tree survival. Avoid hollows or dips which may become waterlogged, or patches of ground which are prone to drying out. Don't plant too close to existing stumps or rocks. On exposed sites, plant in the lee of any mounds or ridges.
The planting notches or pits must be big enough to take the roots, without having to bend or break any to fit. The main roots stay in the position in which they are put at planting, so take time to ensure they are spread evenly.

A bare-root tree should be planted to the same depth or slightly deeper as it was growing previously, as shown by the soil mark on the stem. Cell-grown plants are planted slightly lower than previously grown.

After planting, tread carefully around the stem, taking care not to scrape the bark with your boot. Don't stamp hard, as this may displace the tree and spoil the soil structure. In clay soils, don't make a depression around the stem, as this may gather water and result in stem rot.
Check for firmness by pulling gently on the stem, which should not move. Check again at least once during the four weeks after planting, and firm back in any plants that have worked loose from wind or frost action.

If at all possible, water the tree immediately after planting, using a bucketful of water per tree, tipped slowly around the stem of the tree so it trickles down into the rooting zone. Such watering aids establishment, and it is worth putting effort into providing a supply of water on the planting day.

Stakes should not be necessary when planting small transplants within woodlands or on other fairly sheltered sites. Some movement in the wind helps develop a strong base to the stem and a good root system. However transplants in very exposed situations may need staking for a year or two, until their root systems are established. Tree shelters and most other tree guards include stakes, which are needed to hold the shelter in position, and so help protect the tree from wind damage. Transplanted standard trees will require staking.

Ground preparation

Tree species should be chosen to suit the location, site and soil, rather than trying to alter site conditions to suit particular species. Planting within or near existing woodlands should follow the local woodland type, which will be adapted to local soil conditions.

Areas available for new woodland planting may be on highly disturbed soils within urban areas, old industrial workings or derelict land, which tend to have poor soil structure and moisture holding

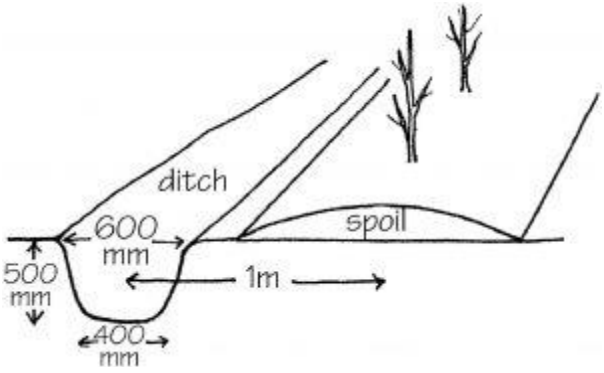
capacity. Amenity grassland areas often have soils which are badly compacted from frequent trampling. These sites are often dry in summer, but waterlogged in winter, creating anaerobic conditions which kill tree roots. Pre-planting site preparation to provide at least 500mm of uncompacted, freely draining soil greatly improves tree establishment and long-term stability. On the large scale, this will require ripping or subsoiling using specialist machinery, which can break up the ground beneath grassland without disturbing the turf. For further details see Hodge, Simon J (1985) or Kerr, Gary and Williams, Hugh V (1999). On the small scale, double digging may be needed, as for garden cultivation.

Clay soils

Trees can be difficult to establish on clay soils, which become waterlogged in winter and dry out in summer. Tree roots of most species require air in the soil, and die in waterlogged, anaerobic conditions. Clay soils, although containing plenty of moisture, hold it by strong suction in the minute gaps between the clay particles, making it unavailable to tree roots. Loamy soils, with bigger gaps between the particles, make water more easily available to plants. Where trees establish in a free draining layer over clay soils, they can be very unstable because of the shallow roots. In summer, when the top layer of soil dries out, the tree may suffer from drought because it has no roots into the waterlogged area below. Small cell-grown or notch planted trees tend to dry out in summer as the topsoil dries and cracks. Pit planting is not the answer, as the pit will normally become waterlogged. The only exception are soils which have a ploughpan or impermeable zone in the subsoil, which can be broken up to allow water to drain through. Addition of organic matter may improve the appearance of a clay soil at planting time, but is not necessarily helpful to tree growth

For large-scale tree planting schemes on clay soils, mechanical cultivation of the whole site will be necessary. For small schemes the following approaches should be considered:
Reconsider. It may be better not to try planting trees on the site. If the site is damp grassland, it may have ecological value as it is.
Fence the site against grazing animals, and then natural regeneration of shrubs and trees that are tolerant of the site conditions may eventually appear.
If planting is still required, consider the following options:
Plant only trees or shrubs that are tolerant of wet sites.

To increase the range of species which can be grown, improve drainage by digging drainage ditches. The ditches should be aligned to take water slowly off the site. Dig approximately to the dimensions shown, and mound the material in a flattened ridge, starting about 100mm back from the edge of the ditch, so material doesn't slide back in. The tree should be planted at least one metre from the centre of the ditch.



Soil ameliorants

Research has found that the incorporation of organic amendments into planting pits is rarely beneficial and can be harmful (Hodge, Simon J, 1995). Compost and other organic matter can make

the planting pit soil more coarsely textured than the surrounding soil, which can result in waterlogging in the winter and increased drought stress in the summer. Soil ameliorants with high levels of nutrients can damage or 'scorch' the roots, when water moves out of the roots under osmotic pressure.

Water retentive gels can be added at planting time. These can absorb many times their own weight in water, which is then available to the plant as needed during dry periods. However if there is a prolonged drought, irrigation will be needed to 'recharge' the gel.

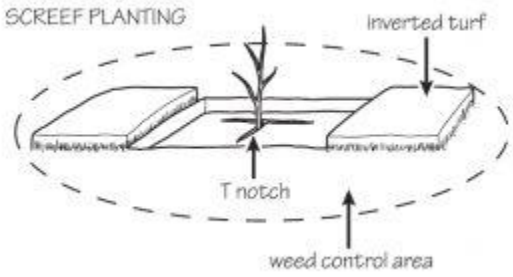
Mycorrhiza

Mycorrhiza provide a beneficial association between certain soil fungi and the roots of trees and other plants, through which the fungus supplies dissolved nutrients and water to the tree. Mycorrhizal associations are vital to woodland ecosystems. Mycorrhizal activity can be encouraged at planting by the use of root dips or powders which contain mycorrhizal spores. Alternatively, the introduction of rotted leaf mould from around an existing nearby tree of the same species is thought to help initiate mycorrhizal associations. Rake away the top 25cm (1") layer of leaf litter from an area of about two square metres, and then carefully scrape away the top centimetre or so of organic material, taking care not to damage any surface roots. Add about half a spade of this material into the planting notch or hole.

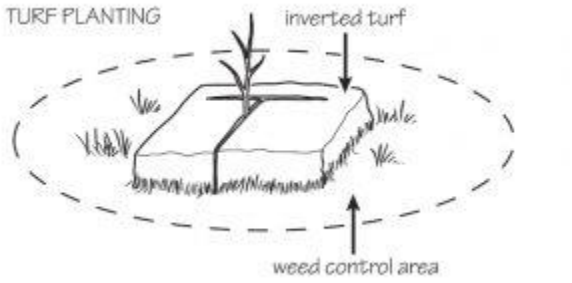
Planting in grass

When planting in a grass sward, for example planting a new woodland on a former pasture, it's best to leave the grass sward undisturbed, and then use mulches or herbicide after planting to create a grass-free zone around each tree. If the whole sward is ploughed or treated with herbicide before planting, there is likely to be strong growth of weeds. These are much more difficult to manage than the grass they replaced.

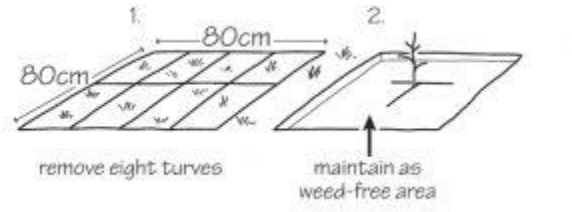
Planting notches or pits are relatively easy to make in short turf thathas been regularly grazed or mown, but more difficult through a thick thatch of long grass. Consider mowing the planting area a few times in the months prior to planting, as this will make it easier to dig notches or pits, and herbicides or plastic sheet mulches are also more effective on newly-grown short grass.
If making a notch through grass is too difficult, you may need to remove a few turves first and then plant into the bare ground. Removing a few turves will also be necessary if you want to make a planting pit. The turves can either be broken up and discarded, or turned over around the planted tree.



In damp ground, cut a thick turf, preferably about 230mm (9") thick, and turn it over to create a better drained planting position. Make a slit through the turf and plant the tree. Inverted turves are not effective in controlling weeds, and herbicides or mulches will be needed.



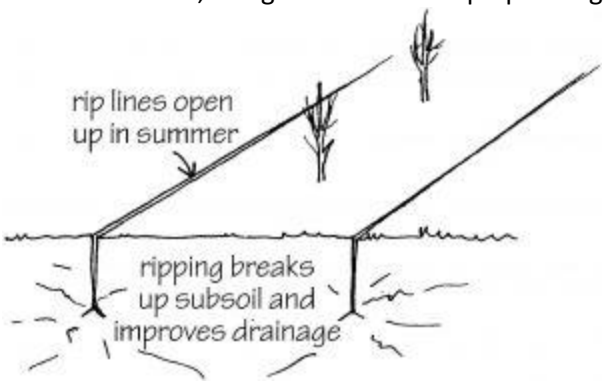
If you don't plan to use either a herbicide or a plastic mulch to control weeds, you will need to start with a generous weed-free area, and maintain it by hand weeding or hoeing. An area with sides equivalent to four spades' width is not too big, though it will seem so when you plant. You must weed regularly, or by mid-summer the planting square will be grown over with weeds, adversely affecting tree growth. This method of weed control is labour intensive, and it is easy to damage the tree stem or roots with a hoe or fork.



Ploughed or ripped ground

Where soils have been ploughed to reduce compaction, ridges will be formed. Planting along the ridges will be beneficial in providing a better drained planting position, as shown above. On exposed sites, plant on the leeward side of the ridge, to give some shelter.

Where compacted ground has been loosened by ripping or subsoiling, it's not advisable to plant along the rip line, as this will tend to open up in dry weather, exposing the tree roots. Plant between the lines instead, using either notch or pit planting.



Planting in existing woodlands

Ground preparation will not normally be needed for planting within existing woodlands, as soils will be suitable for tree growth. Planting may be needed because of lack of natural regeneration, or to improve age or species diversity. However note the following:

Following tree felling, either for clearance or harvesting purposes, soils tend to become wet because of damage to the soil structure during extraction, and because of the sudden loss of transpiration due to tree loss. Temporary drainage ditches may be needed to take water off the site. Plant on mounds or any dry patches within the cleared area.

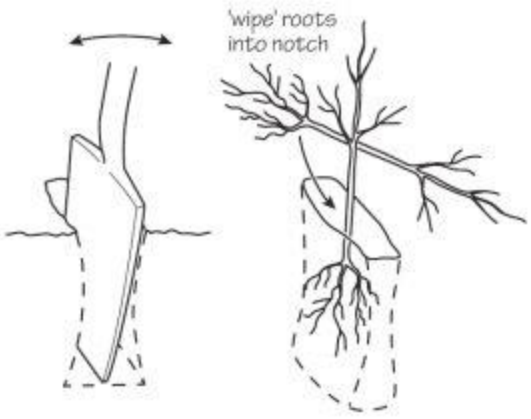
The absence of trees at a particular place within a woodland may indicate that the soils are unsuitable, and it may be best to leave the site unplanted.

When replanting a recently cleared area, plant in the gaps between the stumps, rather than close to them. If the stumps are being left to regrow, they will soon outgrow any tree planted nearby. Planting close to rotting conifer stumps or treated broadleaved stumps may increase the risk of fungal damage.

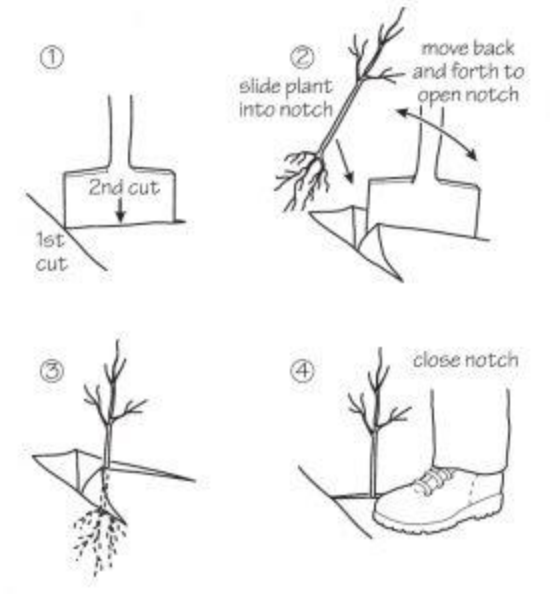
Notch planting

Notch planting is generally the best method of planting young bare-root trees, which are in turn the best size of plant for rapid establishment. Roots of vigorous young trees are very strong and will have no difficulty penetrating normal soils, provided they are not competing with grass for water and nutrients. Notch planting reduces the effects of windblow because the transplant is held firmly in the notch, which is made with minimal ground disturbance. This lessens the requirement for staking. However if notch planting is badly done, with roots crammed into too small a space, or notches not properly closed, losses will result. Young trees with spreading roots will need to be pit planted, and trees should not be notch planted direct into clay soils without previous soil preparation. Trees notch planted into recently cultivated ground should be planted so that the soil mark on the root collar is about 2-3 cm below ground level, to allow for soil settlement. Similarly plants on newly made mounds should be planted a little deeper than normal. This is to avoid the possibility of plant roots becoming exposed through soil settlement or erosion.

Use a heavy, straight-bladed spade or specialist planting spade to make the notch, which should be just deep enough to take the roots. Push the blade into the ground, and then move it backwards and forwards to open up a notch. With a sideways, wiping motion, slide the plant into the notch and pull it upwards to spread the roots. Tread carefully but firmly around the stem to close the notch and prevent any movement in the wind.



For plants with larger root systems, make two cuts in a ‘T’shape as shown, to open up a larger notch to take the roots.



Cell-grown stock

Note the following:
Cell-grown plants can be planted with an ordinary spade or trowel, but a special tool called a 'spear' makes planting easier and quicker.

The top of the cell or plug must be at least 12mm (half an inch) below the soil surface, and covered with soil. It left exposed, the compost in the cell dries out and does not easily re-wet.
In heavy clays, cell-grown plants should not be planted without earlier ground preparation.
Plant boxes and carriers are available from suppliers of cell-grown plants, for use during planting operations.

Pit planting

Pit planting involves digging out a pit, large enough to take the roots, and piling up the soil temporarily at the edge of the pit. The tree is then planted and the hole backfilled. Pit planting is required in the following cases.

For transplants or other young trees which have roots that are too bushy and spreading to fit in a notch.

For container-grown plants other than cell-grown plants. These might include holly or other evergreens which do not survive bare-root transplanting, and are grown for two years or more in containers.

On sites with disturbed soils that have not been prepared by machine cultivation. On steep slopes, stony ground or other difficult sites young trees will normally benefit from pit planting. However pit planting should not be used instead of whole site preparation on clay soils or those prone to waterlogging (see below).

For standard trees which have large root-balls or are grown in large containers. Standard trees have a poor success rate, and are not recommended for planting, other than for orchards or gardens.
Pit planting has the advantage over notch planting in that it makes it easier to plant the tree without damaging the roots, and breaks up the soil to allow the roots to spread. The main disadvantage is that it takes longer. For small transplants planted into cultivated ground, there is no evidence that

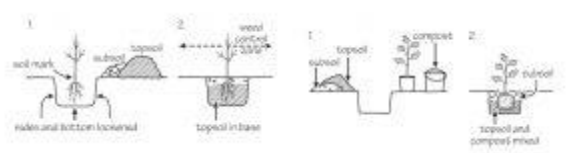
pit planting improves establishment, and notch planting is the standard method used for large-scale woodland planting.

Some people find that a 'hybrid' method works well, combining the advantages of digging a pit with the speed of notch planting. This is also a good system for pair working. One person cuts through the turf and digs out a sod of earth which is kept on the spade, resting on the ground by the hole. The other person places the tree in position and spreads the roots, and then the first crumbles the soil back into the hole. With experience, one person can do this on their own, by tipping the soil gently off the spade whilst holding the tree with the other hand.

Procedure

To pit plant a tree:
When planting in grass, first remove some turves. If herbicide or mulch is going to be used for weed-control, you need only remove sufficient turves to dig the hole. To create a clear metre square for hand-weeding, remove eight turves. The turves can be inverted around the pit, chopped up in the bottom of the pit, or inverted around the tree.

Dig a pit large enough to take the roots or root-ball, and put the soil to one side. If there is a difference in the top and lower layer of soil, pile up separately. Dig the hole square rather than round, as round holes encourage roots to spiral.



In cohesive soils, loosen the soil in the sides and bottom of the pit with a spade or fork.
Place the tree centrally in the pit, checking that the soil collar is at the correct height, and spread the roots. If working as a pair, one person can hold the tree while the other backfills carefully around the roots, using the friable top soil first. Shake the tree gently so that soil trickles down between the roots. Backfill with the rest of the soil, finishing with the subsoil.

Tread gently around the tree to firm the soil, taking care not to scrape the bark of the tree with your foot.

Water the tree if possible.

Container-grown stock

Nearly all native trees for woodland planting are supplied bare-root or cell-grown, but holly and a few introduced species such as holm oak are supplied container-grown, in peat, coir or other light, friable composts. This is because they are slow-growing evergreens, and are too small to plant out as one-year-old cell-grown seedlings, and do not transplant well bare-root. After planting, the roots may not easily make the transition into the surrounding soil, especially if there is any spiralling of roots within the rootball. Adding compost, leaf mould or other organic material when backfilling the planting pit should encourage the roots to grow out of the rootball and into the surrounding soil. Before planting, make sure that the compost in the container is moist throughout, as if planted dry, it will tend to stay dry. If a rootball of peat compost has been allowed to dry out before planting, re-wet it with a solution of about 5ml of washing-up liquid in 5 litres of water.

Follow the general procedure given above for pit planting, but mixing in the compost and soil when backfilling. Plant so that the surface of the compost can be covered with a thin layer of soil. If the compost is exposed at the surface, the water tends to evaporate more quickly from the compost, leaving the rootball drier than the surrounding soil.

Staking

Small transplants (eg 40-60cm) do not require staking to prevent displacement by the wind, as correct notch-planting techniques should hold them firmly in the ground. Tree shelters and other tree protection products are widely used with transplants, and protect against wind damage as well as browsing. More details on tree protection are given below.

Stakes may be needed for taller transplants (90-120cm) in exposed positions, or where it is considered that stakes may help prevent accidental damage or vandalism. The Conservation Volunteers can supply square stakes in a range of sizes from 75 cm to 1.5m height, and 50-75mm diameter round stakes 1.65m height.

Procedure

It is easier and safer to knock in the stake after you have planted the tree, to avoid the chance of the stake causing injury to the face when you bend down to plant. The stake should normally be put in on the south-west side of the tree, so that the prevailing wind blows the tree away from the stake. When planting, avoid placing any spreading roots at this point, or they will be damaged when the stake is knocked in.

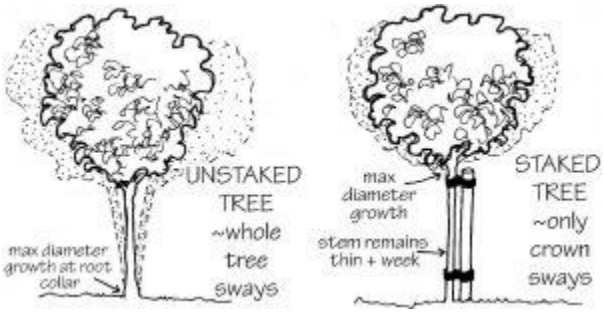
Plant the tree by notch planting or using the 'hybrid' method described above. Place the stake on the south-west side of the tree, and knock it in until it is completely firm in the ground, and no higher than one-third of the tree height. As explained below, it is important that the upper part of the tree sways in the wind, to encourage strong roots and lower stem diameter. Any excess height should be sawn off, as the stem may chafe against it. Attach a tree tie at the one-third height.

Where stakes are functioning mainly as markers to make trees easy to locate in nettles, bracken or other tall vegetation, it is much cheaper to use bamboo canes. Proper weed control measures should ensure that trees are not lost in vegetation.

Sturdy round diameter tree stakes have the useful incidental function of protecting tree trunks from mower damage, which is a frequent cause of damage to young trees near mown grass. It's worth 'staking' any vulnerable young trees alongside mown paths or on the outer edge of any tree planting area surrounded by mown grass. In this case ignore advice about prevailing wind, and instead put the stake where it will protect against prevailing mower damage! Retain stakes in this position for as long as mower damage remains a possibility.

Pit planted trees

Larger, pit planted trees, for which tree shelters are not appropriate, will normally require staking. This will include pit-planted young trees over about 1.5m (5') tall, or 1.2m (4') tall if planted in exposed positions. The function of the stake is to hold the base of the stem firmly and allow the roots to establish, but not to prevent wind sway. Research has shown that it is the swaying of the tree in the wind which stimulates the growth of the stem diameter. If the tree is staked and tied just below the crown, the stem cannot sway, and little increase in stem diameter occurs from base to crown. In extreme cases the stem may become thicker above the tie than below it. Wind sway also stimulates the growth of roots at the root collar.

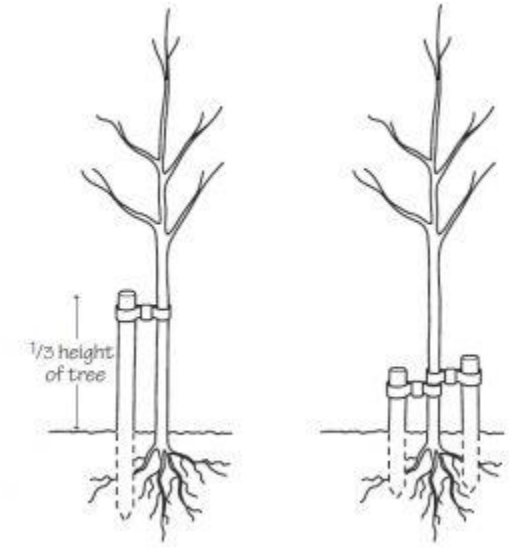


Stakes and ties cost money and need maintenance to check they are not rubbing or restricting stem diameter growth. It is much better to avoid the need for them altogether by planting younger, smaller trees.

Remedial staking

Sometimes young trees become displaced by exceptionally strong winds, or where temporary flooding has caused root damage. A short stake or stakes should be used to secure the tree until root growth has recovered. Knock the stake in on the windward side of the tree, and attach the tie at a point no higher than one-third the height of the tree. Use a proprietary tree tie, which has a spacer between the tree and stake or is tied in a figure of eight, to prevent chafing. Most ties will need nailing to the stake to stop them slipping. On buckle ties, the buckle should be at the stake, not the tree stem. Double stakes can be used as shown.

A stake should only be required for two growing seasons, by which time the tree should have put on sufficient root growth to hold it firmly. If it hasn't, improved weed control measures should be used to encourage the tree into growth.



Tree protectors and guards

There is a large range of products made from plastic mesh of various gauges, available as pre-formed tubes, in rolls or pre-cut in various heights and diameters. All give protection against rabbits, and those over 1.2m height protect against deer (see Table 6d, above). Unlike shelters they do not increase temperature or humidity, but give protection from wind damage, whilst allowing more natural 'unforced' growth. Fine mesh guards are claimed to give some microclimatic benefits, without the problems of high humidity and moisture build-up associated with solid wall shelters. As guards offer less wind resistance, they are also less likely than shelters to get blown over. Mesh

guards do not give protection for foliage against herbicide spray drift, but conversely can be useful for hand-applied herbicide which can be used through the mesh to kill grass within the guard.

Guards are less of a danger to small birds than are shelters, as any birds that fall in can clamber up by gripping on the mesh. Birds play a useful role in eating aphids, caterpillars and other damaging insects within the guard.

Pre-formed tree protectors and guards are fitted in a similar way to treeshelters. Rolls or pre-cut lengths, supplied flat, must be formed into a roll, attached with ratchet or similar ties and then stapled to the stake. Further details are available from suppliers.

Spirals

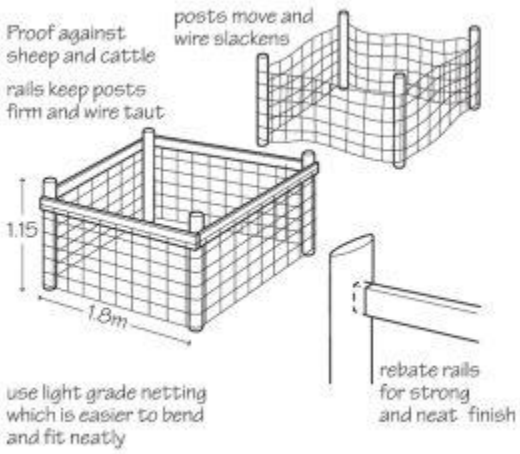
Transparent spiral guards, supported by a cane, are a cheap method of protecting small hedging plants or other small transplants against rabbits, hares and voles. The outer end of the spiral should always be at the base, as shown, so that it is free to expand as the stem expands. If fitted the wrong way up, the bottom end gets trapped, and constricts the growth of the stem. To fit to small transplants, plant first, slip the spiral over without unwinding, and then insert the cane through the spiral.

Spirals can also be wrapped around the stems of larger, clear stemmed stock. To fit, hold the spiral the correct way up, and then wrap it around the stem starting at the bottom. Then hold the bottom and the top, give the top a sharp tug, and the spiral should spring into its correct form with the bottom end to the outside.

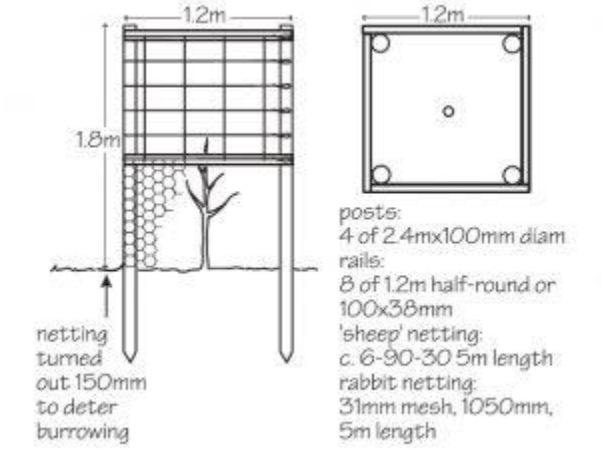
Other methods of tree protection

Standard fencing materials can be used to construct tree guards. These may be useful for protecting individual trees against damage from grazing domestic stock or deer, for which tree shelters and plastic mesh guards are not sufficiently robust. Applications include individual trees in fields, pastures, grazed commons and wood-pastures, and individual trees in woodlands with a high deer population. Such guards are mostly expensive in materials and time-consuming to build.

Against domestic stock, four posts and rails will be needed for each tree. To be proof against deer and rabbits, the 1.8m height guard, with 8 rails, will be necessary. Leave one end of the upper netting detachable, to give access to the tree for aftercare.



A less robust guard is sufficient to protect plantings or natural regeneration in woodlands, where cattle and sheep are excluded. Use a 3.6m (12') length of wire deer netting, joined back on itself to form a ring, and secured to the ground with 1.8m (6') stakes. Where rabbit protection is necessary, use a plastic mesh or spiral guard around the stem of the tree.



Various products are available to protect individual trees in parklands and orchards:
Plastic mesh tree guards (Netlon) for sheep protection in orchards.
Heavy grade fine plastic mesh for protection against deer and other animals.
Weldmesh guards in a variety of height and diameters.

Fencing

Fencing will be needed to protect new planting or natural regeneration in the following circumstances:

To keep out cattle, horses, sheep or other domestic stock.
To prevent people from accidentally or purposely damaging young trees. Damage may be caused by trampling, vandalism or by mowing machinery.

As an alternative to individual protection, to protect against damage by rabbits and deer. No fences are proof against voles, for which vole guards are necessary.

Careful costings will be needed to choose the most cost-effective solution for each planting site. Sometimes a combination of fencing and individual protection may be used, for example a stock

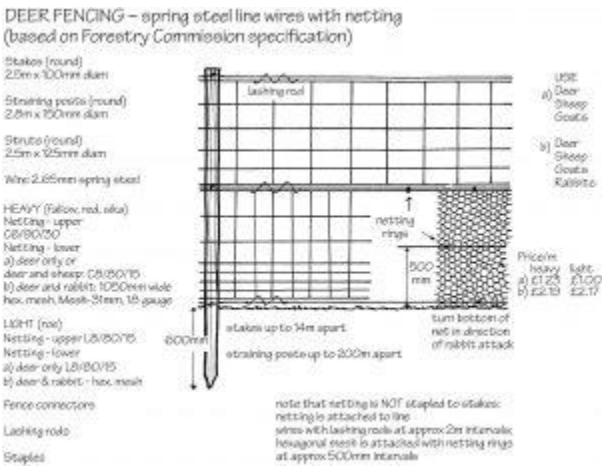
fence against cattle, and spiral guards around each tree against rabbits There are disadvantages to fencing new woodlands, blocks within existing woodlands or to encourage natural regeneration: Fencing can hinder the natural movements of non-target species, including badgers, foxes and game birds. In coniferous woodlands in Scotland, fencing can have damaging effects on capercaillie and black grouse populations.

Browsing and grazing has value in keeping woodland glades and rides open, and in controlling undergrowth. If all deer and rabbits are fenced out, it may be necessary to increase mowing and hand clearance to keep areas open, and to control undergrowth. A balanced woodland ecosystem requires some grazing, and is an argument for the need to bring deer populations into a sustainable balance with the woodland habitat.

Unwanted species can be fenced in, as well as fenced out. It is essential that rabbits are eliminated before any area is fenced. Fenced areas must include a gate to give access for woodland management, as well as to allow out any deer or stock which get into the area. Alternatively site the fence near a bank or rocky outcrop, or build a ramp, so that deer or sheep which get in can leap out. Once the woodland is established, the fence can be used to enclose a sustainable population of grazing animals.
Fences require regular maintenance, and if breached repair is essential, or the protection for the whole area is lost. Redundant fences are an eyesore and a danger, and can take as long to remove as they did to erect.

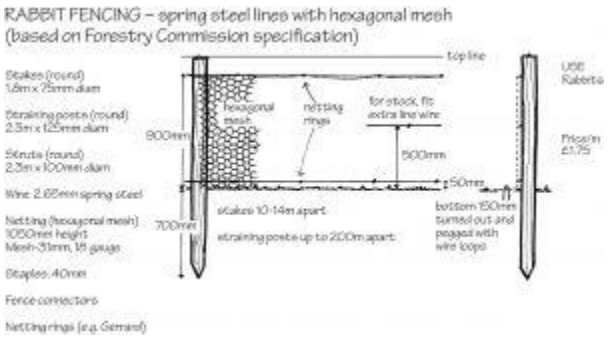
Deer fencing

This is the highest specification fence for protecting tree planting, and is also proof against domestic stock and people. Against rabbits, hexagonal mesh should be fitted to the lower section, and turned out at the base in the direction of rabbit attack. Badgers are strong enough to push their way through which then gives access to rabbits, hares and small deer. Fit badger gates on established runs, to allow badgers but no other animals through.



Rabbit fencing

This is proof against rabbits and sheep. For cattle and horses, extra line wires should be fitted mid way and at the top. Where there is heavy pressure from domestic stock, an electric line wire to keep stock away from the fence may also be advisable. This fence is not proof against deer, although muntjac and roe may be discouraged from jumping it. Where areas of tree planting are below about one hectare, most species of deer will tend to go around the fence rather than jump it, unless the fence crosses a path which the deer have traditionally used.



Temporary fencing

Temporary fencing may be appropriate to give protection for a minimum of three years, which is long enough for fast-growing newly planted species to grow beyond the reach of deer. Physical damage by cattle, sheep and horses is likely to be a problem for up to 10 years or more after planting, so temporary fencing is not normally suitable against stock. Light grazing by sheep may be possible.

Temporary fencing is appropriate for protecting newly-cut coppice coupes from deer. Lightweight plastic netting, dead hedging or electric fencing may be suitable.

Protecting natural regeneration

Areas within or on the edges of woodland can be fenced against deer and rabbits, to protect any natural regeneration of trees from being browsed.

In many woodlands there is ample regeneration, but all apart from the unpalatable species are browsed away within a few months of the seedlings emerging. However, in spite of its name, natural regeneration may not happen without intervention in managed woodlands, as there may be insufficient seed trees, not enough light or other reasons. Woodland succession may mean that the species mix changes as the woodland ages.

Natural regeneration ensures the survival of local genotypes of tree, and saves the cost of purchase and planting. Natural seedlings usually establish more quickly than transplants due to the lack of root disturbance, and because they are adapted to local conditions.

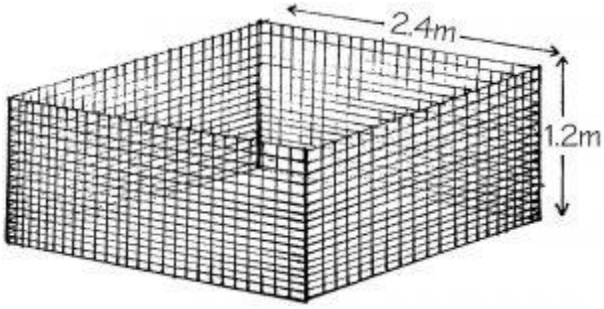
Some species such as ash, sycamore, birch, rowan and aspen produce seed virtually every year. Others, notably beech and oak, only produce seed in 'mast' years, which may occur at intervals from 3-5 years for oak, and 5-15 years for beech. Most species of trees will require ground that is free of other growth, although oak germinates through a grass sward. Oak, hazel and other species do not regenerate under a closed canopy, because it is too shady. The seedlings germinate, but wither away after a few years unless the canopy is opened up. Oak is spread by jays to woodland edge and grassy habitats, where it's thought that seedlings which grow up in the protection of thorny bushes are the main method of spread in grazed semi-natural habitats. Germination and survival is normally best on soil which is well-drained at the surface, with plenty of leaf mould to suppress other growth and provide the mycorrhizal associations which most species of tree require.

There are two approaches to protecting natural regeneration. You can either fence an area and wait for regeneration to occur, or you can protect regeneration after it has occurred. Because protection has to be put in place quickly after a successful season for regeneration, it's not normally feasible to fence a large area. One method is to use portable 'cages' (for example Gengards) or build tree guards from standard fencing materials to protect small patches of regeneration. Cages can be erected very quickly in response to regeneration, and have few of the disadvantages of large fenced

areas listed above. Costs of later thinning are greatly reduced, as it's only necessary to thin the protected regeneration. Gengards are 2.4m x 2.4m x 1.2m. For suppliers, see here.

The progress of regeneration should be checked at intervals during the first year, as later-germinating tree species may appear through the season. A typical pattern of emergence in a mixed broadleaved woodland is firstly sycamore, followed by beech, ash, oak and lastly sweet chestnut. Weed out any unwanted species. Seedlings can also be removed and relocated as desired.

It is estimated that 5 Gengards or similar per hectare are sufficient to ensure establishment of regeneration for a single tree selection system. The Gengards can be repositioned after about five years. For group felling, 16 are needed per 0.25 hectare. Provided the guards are not damaged, making re-use possible, they represent the best-value method of ensuring natural regeneration. See Enact Vol. 8 No. 4 for full details.

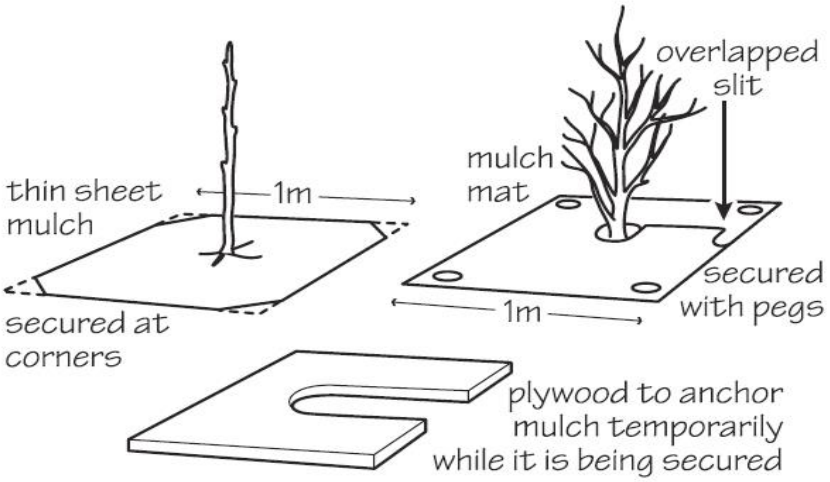


Allternatively, a ring of deer netting as described here can be used. Rabbit netting (1050mm height, 31mm mesh, 18 gauge) can be fitted around the lower half, and lapped outwards 150mm. Secure with two stakes. Re-use is possible with careful handling.

Another method is to use coppice poles or other untreated wood of suitable size, and build a guard of the type shown here. Leave one top section of fence temporarily fastened, so it can be rolled back to give access for weeding and thinning. It should be possible to detach and re-use the netting if done with care, and attach to fresh poles in a new position.

Individual seedlings can also be protected with shelters or guards.
As can be seen on abandoned railway lines, undisturbed gravel heaps and other barren areas, tree seedlings can thrive on apparently inhospitable ground where they are free of competition from grasses and other plants. In places where there is a seed source nearby, the simple procedure of applying herbicide to an area of grass, and then protecting it against trampling, grazing and mowing as necessary, can result in a crop of tree seedlings. These are most likely to be pioneer species such as birch, sycamore, ash or oak, or suckers of nearby trees such as elm, aspen, cherry or blackthorn. Similar regeneration can occur along fencelines, in 'dead hedges' or piles of brash, or other places where weeds, browsing, grazing or mowing are absent.

Oak regeneration, through dispersal by jays, tends to occur in rough grass at woodland edges, roadsides, along hedgerows and in grassy areas. Where such regeneration is desirable, protect the seedlings in early summer from browsing or mowing, and use mulch or herbicide to reduce competition from weeds. Seedlings can be transplanted in the late autumn as required.



Weed control

Mulches

Mulches are materials which are put down on the ground to suppress weeds and retain soil moisture by reducing evaporation. Mulches can be either sheet material, such as polythene, bitumen or various textiles, or loose materials such as bark, chipped wood or gravel. Most sheet mulch materials also increase soil temperature, which encourages early root growth in spring. Mulches, either sheet or loose, are not recommended for use on damp ground, as by preventing evaporation they increase the tendency of the ground to become waterlogged and anaerobic, which kills tree roots.

Proprietary sheet mulches

Sheet mulches are available either in a roll, for hedge or shelter-belt planting, or in pre-cut squares or mats to fit around individual trees. Sheet mulches need to be substantial enough to last at least two years, thick enough to resist wind or animal damage, and large enough to be effective. The sheet mulch tends to invigorate the growth of grasses around its edge, so a mat smaller than 500mm square will be ineffective. The larger size mats, usually 840mm, 900mm or 1m square, are recommended.

The cheapest mats are made of black, single-sheet polythene, but are not sufficiently durable. The 'Thermat' is a multi-layered anti-tear polyethylene mat which is durable for at least two years, and is effective in raising soil temperature. It degrades after about three years, so no clearing up is necessary. Other mats are available made of mixtures of wool, jute and hair, or flax and hemp. Some mats are supplied with a cross-shaped slit in the centre, and others have a slit from the edge to the centre, making them easier to fit to multi-stemmed shrubs. Depending on type and quantity ordered, expect to pay between £1 and £2 per mat.

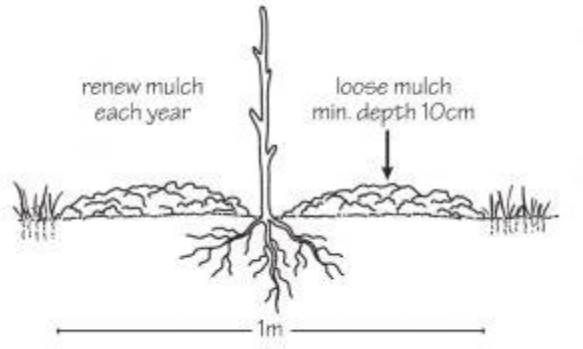
Mulch mats can be fitted directly over short mown grass, into which trees have been notch planted. Otherwise, fit the mat onto bare soil. Do not try and fit the mat over long, tufty grass. The mats are normally fitted after planting, by carefully threading the growing tip of the plant through the slit, and then anchoring the mat. The mats should be fastened at the corners by pushing down into a slit in the soil, or by pegs available from the supplier. Suppliers will recommend the best method for particular products. Non-biodegradable mats can be further anchored by stones, gravel, upturned turves or a small amount of soil, to weight down the mulch and discourage animals from disturbing it. Don't use too thick a layer of soil, or weeds will establish in it. Biodegradable mats should be anchored by pegs or stones, and not by covering with soil, as this makes the material degrade more quickly.

Mulch mats need checking at least once during the growing season. Weeds can grow up through the gap around the stem. Mats may be disturbed by vandals, or torn by the wind, and may need replacing during the initial three year establishment period. Voles may use the shelter provided by the mulch and then damage the tree stem, and foxes may tear the mulch to get at the voles! Some fibrous mats may be damaged by large birds seeking nesting material.

Loose mulch materials

Loose mulch materials such as composted woodchips or bark can be used for mulching, although they are not as effective as herbicides or sheet mulches in controlling weeds. As the material breaks down it is incorporated into the soil, which has the benefit of adding to the organic matter content and improving soil structure, and may introduce beneficial mycorrhiza. However, a layer at least 100mm (4") thick is needed, and the mulch will need replacing every year, as it becomes incorporated into the soil. Additional hand weeding will be needed at least once during the growing season. Mulches can be used in combination with herbicides, for example in early spring after a winter application of residual herbicide. This reduces herbicide use during the summer, and gives the soil benefits of mulching. The mulch also looks more attractive than bare, 'weed killed' ground. If the whole tree planting area can be mulched, this will speed tree establishment and the formation of a woodland-type ecosystem.

The mulch should cover an area at least 1m diameter. Keep it away from the stem, or rot may result. Mulch can be laid at the time of planting, or in very early spring, before growth starts again. Replace annually in winter. Continue until the canopy starts to close over and the trees produce their own mulch of fallen leaves.



Loose mulch materials are only worth using for tree planting schemes if they can be acquired cheaply in bulk, or home-produced from woodchipping. Woodchips, bark, leaves and other organic material should be composted for about six months before use, or the young trees may be deprived of available nitrogen as the material decomposes. See page 88 for information on woodchippings. Leaf mould is a useful and beneficial material. Leaves swept from roads and parks may be available for free from local councils.

Hand weeding

Hand weeding is labour intensive, and only suitable for small planting schemes. As in a garden situation, weeding will be needed regularly throughout the growing season. Avoid using any tools near the stem of a tree, but hand-pull weeds instead. Where grasses have taken hold, it's generally best to use a contact herbicide to destroy the sward, and then try to keep the area weed free by mulching or hoeing.

Weak herbaceous growth such as nettles, creeping thistles and many tall annuals and biennials can be hand pulled, but make sure this doesn't then allow the growth of grasses, which will be much

more damaging. Pulled material that hasn't gone to seed can be spread around the trees to act as a mulch. Larger areas of nettles, thistles or bracken can be trampled which suppresses rather than stimulates growth, but may need to be repeated a few times through the season. Cutting with a grass hook must only be done with extreme care, because it is so easy to damage the young trees. Bracken can be 'whipped' with a stick as the fronds open, to weaken the growth, but beware of damaging the trees.

Bracken can be a problem in old pasture woodlands and parks. One of the best control methods is to trample or roll the growth in July, which flattens and bruises the stems, but does not sever them. This encourages water loss from the plant, and prevents re-supply of nutrients to next year's dormant buds. A deep accumulation of bracken litter can be a serious fire risk on tree planting sites, and should be raked away before planting is carried out.

Inter-row vegetation

The 1m radius circle around each tree must be kept free of weeds. At 2m tree spacing, this weed-free area amounts to about one sixth of the total area. The remaining area between the trees can be left to grow up, or can be mown.

Leaving the inter-row vegetation to grow up unmanaged is useful for hiding the trees from vandals, and for discouraging unofficial access across the site. On exposed sites, it may help shelter the young trees from wind. However, you need to check that growth does not get so tall that when it collapses in late summer, it crushes the young trees. This can be a problem if there is a wet spell in late summer. Voles are more likely to be a problem in long grass, so vole guards may be needed. Tall vegetation can provide useful habitat for ground nesting birds, and may include plants which add to the wildlife value of the site.

Long-handled scythes are not recommended for use near trees, and short-handled grass hooks should only be used with extreme care. Shelters and guards make it easier to see the trees, but are not robust enough to protect trees from a sharp tool.