
POLLARD AND VETERAN TREE MANAGEMENT

Proceedings of the meeting hosted by the
Corporation of London at Burnham Beeches, Bucks.,
on 6th March 1991.

Edited by Helen J. Read

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Back in the 1870s before it was fashionable to be 'green', the Corporation of London began an innovative policy of acquiring open spaces for the recreation and enjoyment of the public. Today we own, fund and maintain over 3,600 hectares of open space within 40km of the City of London, including Epping Forest, Hampstead Heath and Burnham Beeches.

Burnham Beeches is an area of national importance, not only because of its status as a Site of Special

Scientific Interest, but also because of the pioneering pollarding work being carried out on its ancient trees. This work has generated great national interest and has encouraged many people to consider treating ancient trees as less of a liability and more as an endangered ecological resource.

The attendance at the meeting held in March 1991, indicates the depth of feeling in Britain and the level of interest this subject is generating. It is hoped that this publication will stimulate more people to look upon pollards as a future asset and not a forgotten legacy.

The Corporation is proud to be at the forefront of the re-pollarding movement which will contribute to the protection of our heritage.

Mr. D. Balls
Chairman of the Epping Forest
and Open Spaces Committee

Foreword

Pollarding was the ancient practice of lopping the top off a tree 2.5 to 4.0m above ground level. At the point of cutting, or below, new shoots grew. This new wood, and the associated foliage, could be used for fuel, small scale timber and fodder. The advantage of pollarding over coppicing (cutting at ground level) was that the land under the trees could be used as pasture for animals such as cattle, sheep and pigs without the danger of the stock eating the young shoots. This type of land management seems to have been quite widespread in Britain in the past but today is almost non-existent. Pollarding was repeated at regular intervals and the process seems to act in a rejuvenating fashion. Many trees reach a considerable age, usually much older than maidens of the same species. Because of this great age, pollards occurring within blocks of woodland, as opposed to those forming field boundaries or isolated specimens in towns etc. are valuable habitats for epiphytic plants and wood living invertebrates.

In recent years, increased awareness of ecological and conservation concerns has resulted in a surge of interest

in the old pollard systems. Because many of the trees are of such a great age they provide links with the indigenous wild wood. More importantly they harbour a plethora of invertebrates and lower plants which depend upon ancient trees and decaying wood for their very existence. Many species are now confined to a tiny number of trees which provide the precise conditions they require e.g. rot holes in the tops of the bolting (trunk) or decaying heart wood. Speight (1989) stresses the importance of the over mature tree as a habitat and Harding (1978) lists many of the associated Coleoptera (a dominant group in this habitat). Harding & Rose (1978) have discussed the importance of pollards in pasture woodland situations. Britain has some of the foremost sites for pasture woodland, and its associated fauna and flora, in north west Europe (Harding & Rose 1978). The New Forest and Epping Forest are perhaps the most well known, both being former Royal Forests for hunting. Many of the ancient pollards have not been pollarded for a considerable number of years, this has led to increasing problems when contemplating restarting the pollard cycle.

People are increasingly considering re-pollarding these old trees or creating new pollards, but a major problem has arisen. Few written documents are available giving any information on how to pollard trees, thus knowledge of the practice is scant. Many attempts at re-pollarding have failed dismally, leading to the sense of untouchability that people feel about these ancient trees. It has taken some brave foresters with much determination to succeed in order to encourage the more tentative to start to experiment.



This meeting, held on March 6th 1991, was the first step in bringing together those who have had some experience in dealing with old trees. Oliver Rackham set the scene by placing the British pollards in perspective and outlining their history. Three case studies then follow: Burnham Beeches (Helen Read *et al.*), which deals principally with beech, a notoriously difficult species; Kingston Lacy (David Smith) where ancient documentation is available about oak pollards and Hatfield Forest (Lawrence Sisitka) which is notable for having eight different tree species which have been pollarded.

The case studies are followed by papers concerned with specific groups of organisms which are directly affected by ancient trees, fungi (Ted Green), epiphytes (Francis Rose) and invertebrates (Peter Hammond and Paul Harding). In addition to the formal papers the extended discussions have been included as some important points were brought up therein. The final section of the proceedings is a series of short notes contributed by participants concerning their own experience on pollarding. This includes some aspects not fully covered in the formal articles, for example the pollarding of holly and the physiology of the process.

Already a meeting subsequent to the one at Burnham has taken place, this time at Hatfield Forest. A small group of people representing the Forestry Commission, English Nature and Burnham Beeches, among others, were shown the Hatfield pollarding work by Lawrence Sisitka. It is hoped that there will be many more such meetings countrywide where information and ideas can be discussed and the interest and enthusiasm for pollarding maintained.

Helen J. Read



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Introduction to pollards

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The word 'pollard' comes from *poll* in the sense of 'head'. Like its French equivalent *têtard* it means a 'headed' tree. The equivalent in Old English is *copped*, which comes in the mention of a *coppedan āc* in the charter-boundary of St. Mary Bourne (Hants) in 901, and in the place name Copdock; both of these mean 'headed oak' and are the earliest allusion to pollarding in English (Rackham 1986). However, like many other forms of land management, pollarding goes back far beyond the earliest written allusion: I have seen remains of a small pollard ash, and of a pollard-like practice with hazel, in the Neolithic trackways of the Somerset Levels of c. 2800 BC (Rackham 1977).

for feeding animals are a product for which there is archaeological evidence and some early documentation; but since the invention of the scythe they have been less important in England than in other countries, because here it is easier to make hay (Rackham 1986, 1988).

Pollarding is rarely associated with specialized underwood trades. However, the late Mr. Albert Jaggard, head porter of Corpus Christi College, told me that his family, in the woodless area north of Cambridge, had been makers of wattlework hurdles from pollard willows.



Plate 1. Ancient pollard oaks in the medieval Staverton Park, Suffolk. May 1982.

A widespread variant in other countries is *shredding*, repeatedly cropping the side branches of a tree leaving a tuft at the top. Shredding is often mentioned in English documents down to the seventeenth century, but I know of no surviving examples.

Pollarding and shredding are done to produce crops of either wood or leaves; the boughs are seldom straight or substantial enough to be timber. Leaves

Pollarding is not normally done in woodland. It is a feature of *wood-pasture* practices combining trees with grassland or heath (Plate 1), and of *non-woodland trees* in hedges or standing in fields. Many wood-pastures, including Burnham Beeches, have now become woodland, but this is the result of neglect. In their traditional state, the pasturage was at least as important as the trees; they should be thought of as tree'd grassland, not as pastured woodland.

The reason for not pollarding woodland trees is probably that pollarding is much more laborious than coppicing for the amount of wood cut. Pollarding is mainly to prevent browsing animals from eating the young shoots. In a wood it is better to forego the pasturage (which would be of little value because of the shade), to fence livestock out of the whole wood, and to coppice the trees. As the experiments in Burnham Beeches show, pollarding works best where the trees are not so close as to compete with each other.

Woods do, however, have *boundary pollards* of distinctive shape, standing on the woodbank round the edge of the wood, and also marking any internal boundaries. (Woods also contain ancient trees in the form of coppice stools.)

History of pollards, and the special importance of England

Pollard trees are well documented in England throughout the historic period. In hedges and fields, and on wood-pasture commons, they go back at least to Anglo-Saxon times. With the spread of deer-farming in Norman times, they came into the new land-uses of parks and wooded Forests. Pollard willows along watercourses go back at least to the middle ages. At times there have been vast numbers of pollards; with beech this was probably the chief management practice (Rackham 1986). Essex is particularly rich in documentation of pollards in all these types of site. For example there are many references to the cutting of beech pollards (*capita fagorum*, 'heads of beeches') in Writtle Forest between 1396 and 1426 (Rackham 1980). Writtle evidently had pollard beeches much as Epping Forest has now.

England appears to be richer in pollards and ancient trees than any other country in Europe except Greece. Two factors permitted them to outlive periods of being out of fashion and of official disapproval: the strong English common-rights, which preserve old-fashioned land-uses; and the English tradition of loving, honouring and celebrating ancient trees. A medieval park was a status symbol, and a new landscape park preserved existing trees to give it an air of respectable antiquity from the start (Rackham 1990, 1991; for an example see Phibbs 1980). The idea was expressly set out by Humphrey Repton, the eighteenth-century landscape designer, but examples can be found as far back as the parks around Henry VIII's palace of Nonsuch, and the practice probably began in the middle ages. Many, if not most, ancient trees in England owe their survival to being incorporated into a 'pseudo-

medieval' park. For example, the ancient oaks of Windsor Forest are preserved in Windsor Great Park. Hatfield Forest - probably the supreme place in England for its diversity of pollards - survived the nineteenth-century by being made an annexe to Hallingbury Park (Rackham 1989). The ancient oaks of Ickworth and Sotterley (Suffolk), originally farmland trees, are preserved in two great eighteenth-century parks. The pollards of Burnham Beeches survive in a nineteenth-century public park.

Pollards in other countries

Pollarding is probably to be found throughout Europe except Iceland, although in Sweden and Scotland pollards are now very rare. There are many styles of pollarding and intermediates between pollarding and shredding. Often there are several pollarding heads on a tree, instead of only one as is the commonest style in England.



Plate 2. Shredding: a Turkey-oak shredded for the first time. Varese, Liguria. September 1984.

In Norway, elm, ash, lime and birch are shredded and pollarded on a short rotation for foliage, which is dried and stored for feeding cattle (Austad 1988). Pollarding and shredding, especially of ash and oak,

are to be seen in parts of France and the Alps; in Italy new shredded trees are still being started (Plate 2). (I understand that the chief stronghold of shredding for fodder is Nepal.)



Plate 3. Corsican Pine (or a very close relative) in an unfamiliar form. Pollard *Pinus nigra*, Mount Taygetos, south Greece. August 1984.

Probably the most extensive pollarding in Europe is on the east slopes of the Pindus Mountains near Grevenà in N.W. Greece. Wood-pastures, with scattered oaks in grassland, extend for forty miles or more. The oaks are of at least six deciduous species; they are pollarded and shredded in various styles, partly for feeding cattle, sheep and goats, and partly for wood. Some of them are 600 years old, and their annual rings demonstrate pollarding cycles going back to the middle ages. (There are also pine wood-pastures, oak coppices - many with a former wood-pasture history - and dwarf oaks browsed directly as if they were heather.)

Greece and Crete are supremely rich in pollards and ancient trees (Plate 3). The few limes in Greece, lurking on north facing cliffs, are usually pollarded. In the mountains of Crete there are 'goat-pollards' of the evergreen oak *Quercus coccifera*: the tree forms a flat, topiary-like crown into which a goat climbs to nibble the dense prickly foliage (Plate 4). Crete also has pollard deciduous oaks, pollard holm-oaks (*Q. ilex*), pollard maples (*Acer orientale*), pollard phillyreas, gigantic pollard planes, pollard willows (used for basketry) and even pollard pines and cypresses. Among cultivated trees, I have seen pollarded carobs, pollard chestnuts up to 700 years old, and pollard olives up to 2,300 years old. The white mulberry is pollarded on a one-year cycle to produce leaves for feeding animals and useful rods.

Pollarding is rare in North America. The practice was becoming unfashionable in England at the time the colonies were founded, and in America, with its abundant trees and scarce labour, tree-management took the form of coppicing. I have, however, seen what appear to be ancient shredded birches (*Betula alleghaniensis*) in the southern Appalachians which would probably have been worked by Cherokee Indians.

How pollarding works

Artificial pollarding makes use of a natural property of trees. As the great storm of 1987 demonstrated, to have brittle branches, and to regenerate them when shed, is a survival mechanism, especially in oaks and poplars. In American wildwoods I have found a few trees, such as tulip, which pollard themselves. (Lombardy poplar - an artificially invented tree - is also self-pollarding.)



Plate 4. Prickly-oak cut and browsed in the 'goat-pollard' style. Katharo Plain, Crete. September 1986.

Pollarding, whether natural or artificial, prolongs the life of a tree. It enables an individual tree to escape from the imbalance between the amount of leafage, which is finite, and the necessity each year of making the material to lay down a new annual ring over an inexorably increasing area of twigs, branches, trunk and roots.

Not all trees respond to pollarding: for example white poplar does, but aspen, its close relative, refuses. There are three mechanisms. Beech and some elms form a callus at the cut surface at the junction of bark and wood; this organises itself into new shoots. With ash and oak, existing buds, lying dormant for many years, are activated and bore their way out through the bark; this may take months, occasionally more than a year. Alternatively, any existing small branches remaining on the tree, develop the power to grow upright and to become leading shoots; this happens with conifers and any tree that does not pollard readily.

Sprouting from a callus is likely to be helped if the pollarding wound is large and ragged; the arboriculturists' preference for small, tidy wounds is counter-productive. (This was well demonstrated by beeches at Toys Hill (Westerham, Kent) broken in the 1987 storm.) Sprouting from existing buds is genetically determined: individuals that run to epicormic shoots pollard better than those with the 'clean' stems at present fashionable among tree planters. As the Burnham Beeches experiments show, retaining small branches greatly increases the chances of success among trees left long unpollarded or that do not easily form new sprouts. The earliest writer to give advice on pollarding, Thomas Tusser (1573), says 'One bough stay unlopped [for two years] to cherish the sap' - advice which it would be well to follow with difficult trees.

Decay

Decay in a tree used to be thought of as one of the misfortunes of 'old age'. A big tree, as I was taught, consists of a core of dead heartwood surrounded by a shell of living tissues. Any large breach in this shell admits wood-rotting fungi to the heartwood, which they progressively consume until, sooner or later, the tree falls down. On this basis it was supposed to be possible to identify 'dangerous' trees which should be felled lest they fall on people's heads. This theory has been the ending of many ancient trees. Although I had long suspected, from the effects of previous storms, that trees do not generally behave in this way, it was the great storm of October 1987 that decisively failed to uphold the theory.

In that storm the majority of trees broken or uprooted were perfectly sound, while many apparently 'dangerous' trees remained unscathed. Those most affected were big young trees which had recently reached full size. Ancient trees were the least scathed of all. For example, the greatest devastation anywhere was to the big, 60 year-old Corsican and Scots pines of Rendlesham Forest (Suffolk), which were almost all broken or uprooted; in the middle of square miles of catastrophe, the medieval pollard oaks of Staverton Park withstood the storm. The ancient hornbeams of Mersham-Hatch Park (Kent) survived not only the storm but also having a poplar plantation collapse on top of them. The only exception to this rule was where young trees had grown up between the ancient trees and had resulted in crowding, the main cause of windblow (as at Toys Hill); although even here the old trees fared rather less badly than the young ones.

The reality is that trees, although they cannot heal wounds as animals can, have a damage-limitation mechanism which walls off decay and confines it to parts of the wood where it does least harm (Shigo 1983). As soon as a wound is made, barriers are set up, defining an internal surface up to which rot then progresses. Heartwood remains alive to the extent of being able to form barriers within itself. Decay is not a misfortune, but a means of removing wood that is superfluous to the new structure of the tree, and of recycling the minerals in it. A pollard rots into a hollow cylinder - a strong shape - confined by a barrier extending all round the internal surface, which may remain stable for centuries.

Most of the work on compartmentation has been done in America in the context of arboriculture. Pollards, however, follow the same principles, although their complexities have yet to be explored. Rot is inevitable; its extent will be determined by the shape and position of the wound, but not by treating the surface in the hope of preventing rot. Care should be taken not to damage the stability of barriers set up after previous pollardings. Boughs should not be cut very close to the previous cut. It is unwise to cut into existing living compartments. The internal surface of hollow trees should be treated with the same respect as if it were covered with bark. The partial death of pollards in the years after cutting, as with the hornbeams described by Mr Sisitka in this volume, is evidently due to aggressive parasitic fungi somehow being enabled to breach the compartment barriers.

The future

We in England share with the Greeks an international responsibility for ancient trees. The stock of those that already exist, even if we learn to maintain them, is bound to diminish gradually, more through accident than through anything that can be identified as old age. After the conservation of existing trees, the second priority is to set up replacements to be the ancient trees of the future.

Planting trees will not achieve this. The countryside is by no means lacking in young trees; to add more will not increase the tiny chance that any one of them goes on to be an old tree. The critical stage, at which that chance greatly increases, is the first pollarding. It is very important to start new pollards.

When choosing trees to make new pollards, one should take note of the genetic factors that are likely to make a long run of successful pollardings for the future. Trees to be pollarded should have plenty of buds and epicormic twigs. They should not conform to Common Market regulations regarding the genetics of oak and other species to be grown for timber. They should not, therefore, be bought trees. Preferably they should be descendants of existing ancient pollards.

Acknowledgments

I have drawn on field experience gathered through the comradeship and collaboration of Professor John Birks (Norway), Dr Susan Bratton (U.S.), Dr Jennifer Moody (Crete and Greece), Dr Diego Moreno (Italy) and Professor Nancy Wilkie (Greece).

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Pollarding in Burnham Beeches, Bucks.: a historical review and notes on recent work

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Introduction

Burnham Beeches is an ancient woodland which has been owned and maintained as a public open space by the Corporation of London since 1880. The area consists of lowland acid heath, valley bog and pollard trees. It is now mostly deciduous woodland but is most notable for the 540 or so remaining ancient beech and oak pollards. These formed the major component of a pasture-woodland system of management (see Rackham 1986) originally covering an area of approximately 80 hectares.

The old pollards are greatly overgrown with encroaching secondary woodland. The trees themselves are of varied condition, mainly being in a state of decline. Management practices at Burnham Beeches have the aim of restoring certain areas to pasture-woodland. This policy involves the reinstatement of grazing, probably by cattle and/or sheep. Complete reversion to the traditional system would not be possible as originally any wood on the ground would have been collected for fuel and dead wood on the trees would probably have been removed. These old practices are not desirable at Burnham Beeches where as much dead wood as possible is left because it is essential for many invertebrates and fungi. This current practice embraces both fallen and standing dead wood. The continuity of the habitat has been broken as there are no young pollards, thus an essential part of the present management is the creation of new pollards. There is considerable biological interest in retaining the ancient trees for as long as possible until new habitats are available for the epiphytes and specialist wood species. Besides this, the gnarled trees are full of character and an integral part of the history of Burnham Beeches.

The problem with pollarding these woodland trees at the moment is two-fold. First, the information on pollarding new trees and the subsequent lopping regime is poor. Secondly, many of the old pollards have not been cut for 200 years or so (see Plate 1 for an example). This has resulted in large branches, the size of trees in their own right, growing from the top of the bolling several metres up in the air. These top

heavy trees become increasingly unstable, especially in the high winds of recent winters and have been described variously as over-mature and moribund. Foresters and woodland managers are often reluctant to touch these elderly trees. In previous years they have been felled (in the New Forest and Epping) as they have been considered unsightly, dangerous and a good source of fire wood. Many people considered that the day of the pollard was over e.g. Edlin (1971, *Goodbye to the Pollards*) writing about oak pollards said, 'we shall never grow their like again.' Harding & Rose (1986) considered that pollarding was obsolete, however a report produced by Mitchell (1989) entitled 'Re-pollarding large neglected pollards' assessed the problem. Whilst providing some constructive comments the report indicated that effort should be put into the creation of new pollards rather than prolonging the lives of the existing ones. More recently attempts have been made to re-pollard some trees (e.g. Hatfield Forest, Essex, Sisitka this volume).



*Plate 1. Ancient pollard not cut for 200 years.
This tree has already lost some of its heavy branches.
Photographed 1991.*

Both of the problems have been addressed at Burnham Beeches where the principal tree is beech, a notoriously difficult species to deal with and one Mitchell (1989) recommended avoiding. To date the results are promising and are documented below.

Historical review of pollarding

General

Wood pasture is considered by Harding & Rose (1986) to date from the Norman Conquest in 1066. Wood pasture does not necessarily imply that pollards were present, it can be described as any grazed land on which there is some tree cover. The beginning of the practice of pollarding is not so easy to date. Tubbs (1986) has estimated that the pollards in the New Forest date from 1616-1660, Le Sueur (1931) considers those in Burnham Beeches to have started around 1530. In some areas it has been considered that the pollards seen today result from a single lopping (Townley 1916, cited in Le Sueur 1931) but in other places a long history is determinable.

Pollarding seems to have been repeated on a rotational basis similar to coppicing, but the length of time between cuts is rather variable. Edlin (1971) thought 25 years to be the normal rotation and that lopping was done in a planned way, not haphazardly. Mitchell (1989) considered pollarding to have been rather more irregular. Le Sueur (1931), by counting rings on some trees in Burnham Beeches and looking for a check in growth, estimated a first cut at 25-35 years of age. Then for the next 50 years cuts were made at approximately 12 year intervals; the time span between cuts became progressively longer, to up to 15 years or more. The size of the wood cut reflected the type and efficiency of the tools of the day. The usual rotation in Bucks. was given as 7 years (Le Sueur 1931). Loudon (1838) stated that beech must be cut more frequently than almost any other tree, which may account for the short cycles recorded by Le Sueur.

Pollarding probably declined from the beginning of the eighteenth-century due to the increase in other fuels. In 1698 the practice of starting new pollards was made illegal in the Royal Forests as straight timber was required for ships. Tubbs (1986) recorded that the ban was surprisingly successful in the New Forest. Declines occurred in other areas, but in Burnham Beeches pollarding persisted on a small scale until about 1820, probably still as a source of fire wood. In later years cutting was primarily carried out on smaller trees near roads and paths

(Le Sueur 1931). More recently the decline in rabbits, due to myxomatosis, and lapsing of grazing rights has led to many of the old pasture woodlands becoming grown-over with secondary growth thus shading out the pollards (despite beech being a shade tolerant species). There are, however, a few places where pollarding has been carried out up to the present day e.g. Mersham/Hatch Park in Kent where the tree species are predominantly hornbeam and oak. It is interesting here that areas regularly cut on a 25 year rotation show very low failure rates, however one third of the pollards were lost in one area where lopping was re-started after a long gap (Garnett 1987).

Pollarding in Burnham Beeches

Le Sueur (1934) recorded Burnham Beeches as one of the finest examples of lopped beech trees. At the peak there were probably just under 3,000 pollarded trees and every available tree was pollarded (old maps show 'the maiden tree' which was almost certainly the only one in the area). Burnham Beeches covers an area of some 220 ha but not all of this originally bore pollards. Part was open heathland or bog and part was managed as coppice (beech, oak and hazel). In 1931 Le Sueur listed 1,795 pollards on an area of 80 ha. He considered that there was an average of 5 per acre on gravelly soils which was fairly representative of the area as a whole. In a limited area this increased to 13 per acre (although on the evidence of trees still standing today this seems to be an under-estimate). In the 50 years previous to 1931 it was estimated that around 300 pollards were lost. In 1956 there were 1,300 (Nicholson 1956). Today there are around 537 pollards remaining of which by far the majority are beech (the remainder, approximately 15%, being oak).

Exact dating of the trees is difficult as the majority are hollow. By various methods Le Sueur (1934) estimated the age of some of the pollards. He considered his estimate to be accurate to within 10 years and pointed out that, due to the state of the trees, such a study would not be possible in the future. Allowing for the intervening years, Le Sueur's estimates give a current age range of 327-417 years, with a mean of 377.

Le Sueur (1934) points out that at Burnham Beeches the complete crown was not removed during cutting i.e. some branches were always left. On any particular tree a mixture of ages of branches can be seen which suggests that cutting was done as and when a particular size of branch was needed i.e. not in a strict rotation. This method was apparently widespread amongst gardeners in the past and is still continued at Westonbirt on a variety of species (J. White pers. comm.).

Previous ways of dealing with elderly trees

In the past various methods have been employed to ensure that old pollards are safe. These mostly involved strapping up existing branches with wire. The problem with this being that in adverse conditions the tree may fall completely rather than just losing a branch. Other methods included the use of wire netting, or even concrete, to block holes thus preventing vandalism and attempting to halt heart rot. The legacies of these methods can still be seen in trees today. Whilst perhaps prolonging the tree's existence over the short-term, they do not solve the long-term problems.

Re-pollarding at Burnham Beeches

In 1954 the Superintendent at the time, A.D.C. Le Sueur, employed the services of a tree surgery company from London. In one area of Burnham Beeches they re-pollarded over 100 trees. The cuts were quite severe and almost all the crown was removed. (Without leaves the tree cannot make any new wood which must be spread over the entire surface of the living tree. If there is not enough produced the part of the tree lacking new wood will die.) Nearly all the trees cut in the early 1950s died; today a few of the stumps are still identifiable.

In the later 1950s the Corporation of London employed their own staff to deal specifically with tree work, two of these men continue to work in Burnham Beeches today. Up until approximately 1963 two main areas of pollards were worked on, plus various other isolated specimens in different parts of the woods.

Around 1958 about 30 trees were tackled in an area off Myers Drive. Lopping was carried out in the winter, primarily November to January. By late February the wood was considered too brittle and in danger of breaking in undesirable places. The cuts were made using hand saws and where necessary a double handed cross cut saw. Trees were cut a considerable distance up the branches and quite level, forming a flat top to the tree. The stubs left were long, sometimes in excess of 4m, and lower branches were retained complete. The trees have subsequently grown from below the cuts forming, in effect, pollards on top of pollards. The men worked as a team, around four operating on a tree at a time, with one on the ground to direct the procedure. The cut surfaces were treated with creosote and the wood removed was all cut for firewood. This area has recently been cleared of young birch, up to 15 years old, which were competing with the trees. When

pollarded the trees benefited from maximum light. The survival rate of these trees was high, probably around 90%, with some forming fine specimens, e.g. see Plate 2.



Plate 2. Pollard cut in the 1950s. Photographed 1991.

Around 1961 work began on an area off Dimsdale Drive. This north-west corner is the highest point of Burnham Beeches and the soil is more shallow and very gravelly. The area of pollards is situated adjacent to, and in amongst, a block of sessile oak which is quite stunted in appearance and has a lower canopy than the rest of Burnham Beeches. Initially re-pollarding here followed the same procedure as on those trees cut along Myers Drive described above, and a similar number of trees were cut. However, towards the end of the work there was a change of Superintendent with A. Quist taking over in 1962. Quist attempted to re-pollard by wrenching off the branches so that the breaks were more like natural breaks, but it was far less easy to control the amount of timber removed. For whatever reason, the re-pollarding in this area was less successful than the earlier work. Approximately 60% of the trees are still alive today but many do not look as healthy as those along Myers Drive and have fewer branches left. One interesting point is that there were several oak pollards in this area and all of those lopped have since died. These may well be sessile oak whereas those in other parts of the Beeches are pedunculate. Perhaps the difference of species is

important. The stubs as seen today on the dead stumps look much shorter - possibly too much crown was removed. The poor soil quality in this area has probably had an effect on the survival of the pollards but this is impossible to prove at the present time. It was noticed here that beech trees which died did grow for a couple of years after re-pollarding and in their final year produced huge leaves.



Plate 3. New pollard cut between 1983 and 1987. The lower branches were removed in February 1991. Photographed 1991.

Very little was done in the subsequent two decades with regard to the pollards until the present Superintendent, I. Turney, took over in 1984.

Creation of new pollards

In 1983 the first recent attempts were made to create new pollards at Burnham Beeches. The plot used was an area of beech and larch which was planted in the early 1930s. Thinning of the larch nursery crop was carried out in 1963, leaving the beech to mature. The regeneration of the beech in this area, as in most of the Beeches, is good. Some of the original beech trees were experimentally pollarded at a height of approximately 3.0m. Initially lopping was done more or less indiscriminately. Some trees produced new shoots but a high proportion died, some of these produced a flush of adventitious shoots for 1-2 years before dying. The plot was further thinned and in the following three winters to 1987 more lopping was done. Some of

the young generation (15 years old) were cut as well as the older ones (50 years old). On the older trees care was taken to leave at least one lower branch. This, coupled with the increased light, resulted in a success rate of nearly 100%. Plate 3 shows the results as seen in 1991. Regrowth occurs in these trees as shoots down the trunk and along the branches as well as extensions of the remaining branches left after cutting, the latter produce vertical shoots.

Old pollards

Having achieved successful results on the young trees, attention was turned to the elderly pollards. The first candidate was tackled in the winter of 1985/86. The largest limbs cut were 197 years old (as counted from the tree rings). This tree is growing well and has produced vigorous new growth.

In June, September and October 1989 work started on the area of Seven Ways Plain. The trees were cut with chain saws, making use of an access platform which enabled easier penetration into the canopy and a more stable surface to work from. The work can be done by two men, one up on the platform and one on the ground. Branches were cut leaving long stubs, though not as long as those left in the early 1950s. In contrast, selected large limbs were cut whilst other smaller ones were not touched (Plate 4). Extensive clearing was done round the trees and any suitable



Plate 4. Ancient pollard cut in 1989 by selectively thinning the heavy branches. Photographed 1991.

young beeches were pollarded for the first time. As more trees are cut the procedure is being modified, the amount of canopy removed is gradually reducing so that it is predominantly the large limbs which are cut back thus reducing the weight of the crown. The success rate for these trees so far has been 100%, however many of them have had only one growing season so far. Some of the wood is removed from the site and some is left 'in situ' to rot down. When managed traditionally all such material was probably removed, but retaining wood in place provides valuable habitats for the saproxylic organisms.

Growth on the existing branches of the old trees has been quite strong despite the summer drought experienced. Some have also shown lammas growth. Measuring between terminal bud scars on these trees has shown that the growth since pollarding has been similar to the majority of previous increments and in one tree substantially more. Measurements on the new pollards in the same area (cut for the first time at approximately 30-60 years), give a mean growth of 144mm after cutting in comparison with 72 and 75mm for the two years prior to cutting (5 branches measured on 5 trees).

Growth subsequent to cutting on the new trees has arisen from the bases of the old branches and in some cases from below the cut surface. It is unusual, on any old or young tree, to see growth directly from round the cut surface, although it does occur occasionally.

Discussion

Results of the work at Burnham Beeches suggests that creation of new young beech pollards and treatment of elderly ones is subject to similar criteria. So far the results are encouraging and suggest that we should not give up hope. One important thing to remember is that a few pollards always did die; Rackham attributes the robora of Henry III's time to dead bollings (Mitchell 1989).

The only available description of how to pollard is by Fitzherbert in 'Art of Husbandry' (1523) (quoted by Le Sueur 1931). This gives important information and provides a base line for discussion.

"Let hymme beginne at the nethermost bough fyrste and with a light axe for an (one) hande to cut the bough on both sydes a foote or two foote from the bodye of the tree. And specially cut it more on the nether syde than on the over (upper) side so that the bough fall not streight down but turn on the side and it shall not flawe (strip) nor breake no

barke. And every bough shall have a new head and beare moche more woode. And by thy wyll without thou must needs do it, head him not when the wynde standeth in the north or in the easte, and beware that thou croppe him not in sappe tyme."

Factors affecting the success of pollards (predominantly beech)

Height/position of cut

When pruning, branches are generally (but should not be) cut flush with the trunk. However, with pollarding it appears that it is better to leave a length of branch in place. Loudon (1838) points out that beech, when cut close to the trunk, does not send out shoots. Leaving long stubs has been advocated by Mitchell (1989) and is also carried out at Mersham Park, Kent. In both cases up to 30cm of the branch is retained. At Burnham Beeches at least 30cm is left but the actual amount varies according to the individual situation. Where very tall branches, only, occur on a pollard, much longer stubs have been left. It is hoped that after shoots have been produced along the length of the stubs more can be cut off leaving some of the young shoots. This is being done at Westonbirt and at Markshall, Essex (J. White pers. comm.). Mitchell (1989) is obviously concerned with producing new shoots from the bolling and not from any remaining branches. However, as the dormant buds on beech are relatively short lived and would have to penetrate a very thick layer of bark to arise from the bolling, it is considered that the chances of such regrowth are very slim on most trees. There is no reason why side shoots from the base of younger branches should be regarded as inferior and/or undesirable.

Amount of canopy removed

Mitchell (1989) quotes Cole (1894) for details of pollarding beech in Epping Forest, stating that one leading branch was retained when lopping beech to act as a sap lifter. Coupled with the information that a similar practice is carried out in France on oak, it seems surprising that both Mitchell and apparently Rackham appear to think that the practice was not widespread. Mitchell recommends that if any branches are left it should be a single one left for a year (or two if growth is slow) and preferably a central leader. Hodgetts (1989) suggested removing some limbs in order to stabilise trees which are in danger of falling.

The old pollards at Burnham Beeches all support crowns with a mixed age structure. This implies that removal of the total crown was not carried out. Even on young trees being pollarded now for the first time,

total decapitation nearly always results in death. Present cutting of the elderly trees at Burnham has operated with a policy of retaining a variable amount of existing crown depending upon the tree concerned. A strong central branch is not usually retained if it is very large and there are enough additional smaller branches arising from the sides of the bolting. Cutting at Burnham Beeches aims to reduce the weight of the crown, maintain or increase its stability and encourage new growth from cut surfaces or young branches, thus increasing vigour. It is essential that each tree is regarded as an individual; no single prescription can be applied to them all. As increasing numbers of pollards are selectively thinned, an increasingly higher percentage of canopy is being left. It is important to get the old trees back to a cutting regime and it is increasingly the feeling that it is better to be very selective in the thinning, and to cut again after a short period if the results are encouraging.

Age of tree

The age of the initial cut commencing the pollarding regime seems to have been done originally when the tree was around 25 years old. This is presumably the first point at which they would be able to survive the pressures from grazing animals after cutting. It is undoubtedly true that the older the tree, the more difficult it is to persuade the tree to re-shoot. First cuts at Burnham Beeches have been successfully made on trees up to approximately 150 years old. Again, as long as some growth is left on the tree, roughly in proportion to its age, regrowth can be expected. Indeed it is now essential to start pollarding on older maiden trees to help bridge the generation gap. There are even trees at Burnham which have been cut in clearance work only a few feet above the ground, which have produced abundant side shoots but this is relatively unusual in older trees.

Aspect/shading

The aspect of the tree seems to have little effect on the success of the pollards, however the degree of shade is very important. Mitchell (1989) also considers shading to be deleterious for the first few years. In contrast he quotes work in Epping where shading was found to be an important restricting factor for oak but not for beech. Early experimentation on new pollards where surrounding trees were not cleared was far less successful, thus clearing secondary vegetation from round both new and old pollards is carried out routinely at Burnham Beeches. Clearing may lead to problems of frost damage or sun scorching, the latter being observed in the summer of 1990 on the beeches. At present in Burnham Beeches, the benefits from the increased light probably outweigh the damage from exposure.

Soil type may be a factor introducing variation. Loudon (1838) records that in Germany beech coppices produce better shoots in poor ground. Certainly at Burnham the beech coppices are situated on very poor shallow ground. (These areas are proposed for re-coppicing trials in the near future). The soil requirements of beech pollards are unknown except that Le Sueur (1931) recorded that the largest pollards, in terms of diameter, occur where the soil is richest and the lopping done in the 1950s was less successful on the site with poorer soil.

Time of year to cut

The time of the year to make the cuts is one of the most contentious issues. In general most authors seem to consider that lopping should be done in the winter; Fitzherbert (in Le Sueur 1931) indicates not to cut in sap time. At Mersham Park (Kent) January and February are considered the best months. Mitchell (1989) quotes a survival rate of 2/3 obtained by cutting in January and February, a lower rate (1/3) was obtained when cutting was done in November and December (here the complete canopy was cut and the species was not beech). In Kent (Mitchell 1989) most pollarding is done early in the year and stops when the sap starts to rise. Mitchell concludes by recommending lopping after Christmas not before. In contrast he also points out that cutting for foliage must have taken place in the summer. Loudon (1838) states that the French note that the English felled beech in the beginning of the summer when the sap was in motion and that in Germany, beech coppicing on rich soil was also cut then. Edlin (1971) thought that lopping of the beech in the New Forest was done in the spring when the leaves were most palatable. Le Sueur (1934) sums up the existing confusion on the matter by recommending not cutting between April and June to avoid bleeding, but then stated that beech wounds heal up quicker whilst the tree is bleeding heavily. It seems likely that wood and foliage was cut when it was needed, thus some branches were cut in the winter for fuel and some in the summer for fodder. If, as we believe, cutting at Burnham Beeches did not involve total decapitation, branches were probably just selected for whatever purpose was required. Thus they were probably cut at various different times of the year. This would fit with the fact that the wood and foliage was put to different uses throughout the year.

At Burnham Beeches lopping has been done mainly during the winter, primarily because this fits in with the work schedule. Some trees have been done at other times of the year and no significant differences have been noted yet.

Type of bark

Mitchell (1989) recommends cutting trees with burry bark as these shoot more easily. This may well be true, however at Burnham Beeches trees have been re-pollarded as a matter of course and distinctions have not been made between burry trees and those with smooth bark. Those with many side shoots obviously re-shoot more easily but this is no reason to avoid those with smooth trunks if the branch structure of the latter is suitable.

Type of cut

Of the few wind damaged trees in Burnham Beeches, regrowth seems to be quite good as long as a few branches remain on the stump. This has led to speculation that chain-saw cuts are detrimental due to the heat, oil and vibration produced. Hand saws have been promoted and axes even more so. However, all the recent pollarding at Burnham Beeches has been done with chain-saws due basically to the practicalities and time limitations. Work done in the 1950s here using hand tools produced good results in one area and less successful results in the other. Mitchell (1989) noted that a clean cut through the bark is essential but that the condition of that through the wood is unimportant and that edge tools such as axes are better. Certainly in the past the trees were not cut with chain-saws, but in general such cuts do not inhibit growth and are far more practical today. It is probably important not to leave a very rough or damaged surface as this encourages water penetration and rotting. Mitchell (1989) also suggests cutting branches with a slant to increase water run off and the length of perimeter for shoots to arise. This is generally followed in Burnham Beeches although the shoots usually arise from below the cut surface. Le Sueur (1934) considers protecting the cuts, as after pruning, but it seems better to let them heal themselves. Some bird damage to the young buds has been noted at Burnham Beeches, thus some form of protection may be advantageous.

Grazing

At the height of the pollarding system, the land under the trees was grazed. Grazing stock would, no doubt, have eaten new shoots growing from the trees creating the browse line characteristic of park land trees. The absence of stock has had a profound influence at Burnham Beeches in allowing secondary woodland to become established between the pollards, but there are other consequences too. The elderly pollards may well benefit initially from lack of grazing, as existing branches can grow without being eaten which would reduce the crown. The young pollards however, have a tendency to become bushy down the main trunk, stock would keep this

in check thus encouraging the upper most new shoots to grow on. Many grazed park land type sites in Britain show very little or no regeneration of the pollard species, which is obviously a disadvantage from the forester's point of view. In the long-term it is going to be essential to have a low stocking rate and to graze over areas which are large enough to maintain a mosaic of diversity, including some areas where seedlings can become established. Animals do add another important component into the system and that is dung which acts as a fertiliser.

Pollarding other tree species

At Burnham Beeches most of the work has been on beech. It is proposed to treat the elderly oak pollards in the same manner, i.e. selectively thinning the crown, which has worked so far on the few trees attempted. Le Sueur (1934) also comments that complete lopping of oak is risky unless the trees are young. A young hornbeam has been pollarded, some lower branches were left on and it is growing well. Other species which may be considered for pollarding are holly and hawthorn. There are limited other species to try on the site. It is likely that if leaving branches successfully encourages beech to grow the practice is almost certain to work on most other native broadleaves.

Conclusions

In the past many people have been very pessimistic about the survival of ancient pollarded trees and foresters have not considered them desirable. In 1931 Le Sueur recorded that repairs would be very expensive and an absolute waste of money. D. Patch in 1985 (pers. comm. to I.S. Turney) said there was "no possibility of re-pollarding the mature trees". The work so far at Burnham Beeches suggests a little more optimism is in order. Even though complete lopping of the crown is not done, the action does act in a rejuvenating manner and there is a high probability that this is the way in which many trees were originally cut. Selective branch thinning of the ancient trees is the only way to increase stability, giving a better chance of survival in high winds and snow. Light cutting back, taking the process slowly over several years, will hopefully lead the trees back to a system of regular cutting. It seems that a system of very light cutting little and often, is the ideal solution. Without cutting, the trees may decline more quickly as they are becoming increasingly top heavy and prone to having the canopy broken off in strong winds, despite having apparently healthy root systems as seen in the trees which have blown right over. The surviving trees have lived for several

hundred years, there seems no reason why a regularly cut tree could not live for a long time yet.

It cannot be stressed too much that each tree is an individual and some can be remarkably difficult to tackle. Notable amongst these are trees where the foliage is high up on long branches, as is widely the case in beech at Epping Forest. Recent experimentation at Burnham Beeches has involved the use of grafting and plant growth hormones to try to encourage shoots lower down on these branches, thus enabling lopping higher up at a later date. Grafting may not be a long-term solution but it may enable certain trees to survive until younger pollards reach the age at which the specialist epiphytes can colonise. So far the results are not encouraging, however trials are continuing.

In addition to care and rejuvenation of the old trees it is essential to continually create new young pollards. The age class distribution is already very wide and efforts should be made to keep it as narrow as possible. At Burnham, we have a policy of trying to start as many new pollards within the original areas as possible, the minimum being one for every old pollard. Again, some trees lend themselves to pollarding more than others and they should be treated on an individual basis.

At Burnham Beeches the general feeling is that the art of pollarding is not dead and there is a definite future in the reinstatement of pasture woodland.

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Pollarding experiences in Hatfield Forest, Essex

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Introduction

In the past few years awareness of the existence of pollards has grown. Perhaps this is at least partly due to the work of Oliver Rackham (e.g. 1986, 1989) who has opened our eyes to these strange looking trees. Suddenly we realise we all have pollards.

Hatfield Forest is an area of 1,000 acres in north west Essex owned by the National Trust. It is rather different to Burnham Beeches in that the pollards are in wood pasture with the trees very much in the open. Shading is not a problem but exposure may be. The site is unusual in having eight tree species represented as pollards. The whole area is grazed with cattle all year round, we estimate that the optimum rate would be 200-250 animals (4-5 per acre) although the numbers tend to be lower at approximately 150. The site is open to the public, receiving a large number of visitors.

Re-pollarding the old trees

Approximately 15 years ago a brave decision was made to start re-pollarding the large old pollards at the entrance to the Forest. These were primarily hornbeam plus a small number of 200-300 year old oaks. Cutting was undertaken on a dramatic scale, large numbers of trees were cut in the first few years with the removal of the entire crown. The trees are not shaded at all and are in full sunlight. Of the nine oak cut only two survived. Success was higher with the hornbeam, initially around 80%. However, now many of these trees are starting to look rather sad and have been attacked by the fungus *Bjerkandera adusta*. The problem may have been exacerbated since the trees have been weakened by drought and compaction due to cars parking under them. The fungus has had a devastating effect in causing the bark to peel off, it is only where the cambium is intact that regrowth occurs.

In the course of the pollarding operation some interest has been shown in the timing. Unlike the situation in the middle ages when trees were cut as and when required, there are different constraints on cutting. Mid-summer is not a suitable time as there is

a strong presumption against cutting at a time when disturbance would be caused to nesting birds and there is much other life associated with the trees, so cuts have been restricted to the winter. The first recent re-pollarding was done early in the winter, during the months of November and December, but this did not seem particularly successful. Subsequently cutting was done in February and March. This was the period recommended to Mitchel for his report (Mitchel 1989). There is much disagreement on this subject but, based on experience at Hatfield, late winter appears a suitable time. One explanation for this is that adventitious buds which respond and come to the surface, even if not breaking through the bark, may be frosted by late cold spells leading to loss of the first buds. Cutting at the end of the winter appears to reduce this risk although there is no scientific evidence for this.

The second critical factor in pollarding is the length of stub left. Experience at Hatfield shows that regrowth takes place from a considerable distance behind the cut. Initial cuts were done aesthetically, making a clean, close cut, close to the original stump. This does not appear to be the best way to approach the problem as results are more successful when a reasonable stub length is left. There is greater die back from larger diameter stubs. Thus it appears logical to leave longer stubs on a larger diameter tree. Possibly there is a correlation between the diameter of the stub and the distance back from it that regrowth occurs. Perhaps this could provide a suitable subject for a research paper!

Time of year of cutting and length of stub left appear to be the two main errors in re-pollarding old trees.

Wind damaged trees often seem to respond well to this form of 'natural' pollarding. For example one young maiden oak at Hatfield was damaged in October 1987, the top was blown off tearing a strip of bark down the side. Regrowth has occurred from the sides of this jagged tear. This is not something we would want to emulate but shows that clean cuts are not necessarily what is required.

Pollarding young trees (maidens)

As a result of this work on the ancient pollards it has been decided to leave the rest of the old trees intact and only to work on them as a rescue operation. If the trees are dangerous and about to fall apart, they need to be surveyed in detail to see what work needs doing. If rescuing is feasible then they will be re-pollarded or partially pollarded.

It is essential for the lichens and invertebrates to establish the next generation of pollards and this is the area which is being concentrated on now at Hatfield. The amount of scrub in the Forest has increased over the century as grazing pressures have lessened. Naturally regenerated trees occurring in these areas represent a good range of species, including most of those required for pollard replacements. It is possible in the scrub area to achieve two aims in one. First to move back the scrub to relieve wood pasture and possibly over a long period of time to increase the area of ancient grassland. Secondly, within this area, trees can be selected for pollarding. In the last three years oak, hornbeam, ash, field maple, elm, hawthorn and beech have been pollarded from the scrub areas. The success rate has been almost 100% with the exception of one ash, one beech and the only elm so far attempted.

Ash seems to be very late in breaking bud. The first maiden to be cut had not broken by the end of June. Very powerful buds appeared under the bark which swelled but did not break until mid July. The second maiden, cut last year, has not broken at all. The break points on ash are usually a long way down the stems. This indicates that ash, when pollarded, should be cut too high rather than too low, particularly if grazing animals are present. One ash broke at only 1.5m and the cattle removed all the lower buds. In future the height of the first cut will probably be increased from 2-3m to over 3m allowing plenty of room for the new buds to break through without risk of browse damage.

Field maple is extraordinarily good, and there is little which will stop this species from breaking bud, the species coppices well and pollards equally well. Again, as with ash, shoots appear from fairly far down the cut, and again, pollarding should probably be done higher than the recommended 2-3m. A 3m high pollard looks rather ridiculous and does not appear to correspond to the browse height of the animals but 3m seems to be almost a minimum height for some tree species.

Scrub clearance exposed some elm just beginning to show some signs of Dutch elm disease. It was decided to pollard the trees to see if cutting could act as a rescue operation or if the disease already had too strong a hold. Unfortunately it appears that the latter was true. Elm gives a tremendous response and is well worth trying. If the tree is healthy, pollarding will obviously produce a greater quantity of small branches which are less susceptible to colonisation by the beetle and the action may actually save the tree. At Hatfield there is, in addition, a precedent of elm being pollarded.

Hawthorn is also no problem, regrowth occurs if the trees are just snapped off. Many of the old, mistletoe carrying, hawthorns at Hatfield have fallen apart and layered themselves forming a circle, resembling a group of hawthorns, which is actually based on a single old tree. There is potential for pollarding one of these end regrowths, which may stem from a 400 year old tree, at the risk of only a small part of the whole. These hawthorns are not now obvious pollards, it is necessary to visually reconstruct the tree to realise their former shape. There may be other such pollards on other properties around the country. Hawthorn was widely pollarded, primarily as a browse species. Traditionally it was almost certainly cut in the summer when it still carried foliage. This is no longer the practice owing to the constraints previously mentioned.

Beech behaves quite differently. There are very few beech on the property and only one has been pollarded. Again this was where one old pollard dropped a branch around 15-20 years ago. Unusually for beech the branch layered and sent up three young trees along its length. One of these has been pollarded leaving a single branch. The tree is still alive but there are no signs of regrowth as yet.

Conclusions

Cutting of the old trees at Hatfield has been a major problem. As yet, pollarding leaving some branches on has not been tried, but in the future partial pollarding would probably be practiced when necessary.

With regard to young trees, it does not seem to make a tremendous difference what the original diameter is. The younger the tree the better in many ways, but oak has been cut up to 30cm in diameter with complete success resulting. Only when the trees are over approximately 100 years old may problems occur.

With regard to species differences, beech is probably the most difficult to deal with, followed by oak. Hornbeam is a close third because of the secondary decay which sets in resulting in die back after a period of years. It shoots well in the first couple of years on both old and young trees. Ash is extremely successful at self-pollarding. Field maple and hawthorn are very successful. Elm is potentially good if disease free. The eighth species present at Hatfield is crab apple. Three large pollards occur in the area but unfortunately there is little scope for creating any new ones as there are few suitable young trees available.

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The management of the oaks at Kingston Lacy Estate, Wimborne, Dorset

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Description

Part of the 16,000 acre Kingston Lacy and Corfe Castle Estate is the wood called The Oaks, formerly known as Starley Bushes. It is an ancient woodland of 5.6 hectares first mentioned in estate records in 1308 when Henry de Lacy, 3rd Earl of Lincoln, was Lord of the Manor. For the most part it is a pure oak forest with some coppiced hazel. Records show that the wood has been used as cover for deer and cattle and managed by pollarding and coppicing, with game rearing since the late eighteenth-century. The meaning of the original name of the wood was "the low trees where animals were kept" reflecting a period when woodland grazing took place. The National Trust has owned the estate since 1982.

The dominant tree species are oak, with smaller numbers of large leaved lime, horse chestnut, ash, sycamore, wych elm, elder, Douglas fir and hazel. A rich herb layer has been recorded, along with many species of fungi. The most important feature of the wood is the large number (82) of old pollarded oaks with trunk diameters of one to three metres. These are scattered throughout the wood and indicate a sustained interest in woodland management over a long period of time. Many of these old pollards are surrounded by younger vegetation with which they are now competing.

The comprehensive estate records have provided details of woodland acreages, pollarding months, techniques, wage rates and timber usages, from Domesday, through to the thirteenth, fourteenth, fifteenth and sixteenth-centuries especially. The foresters not only cut trees in the winter, but also in the summer the boughs being left on the ground until the early winter for cattle and deer to browse. Evidence for this practice includes the following references:

"Alsoe that the oak trees are cutt in every bough when it growes to necessarye as it shalle bee done when the leaves are fully borne and left for cattel and deere" (Crown Survey 1552).

"No timber should be cut under a licence from the steward, unless marked by the bailiffe of the manor, as unless they are standing so close as to injure one another, none but ripe trees ought to be cut; and the bailiffe should discountenance, by every means in his

power, the too prevalent habit of lopping trees, especially elm trees, to an unreasonable height and at the wrong time of year, which not only chills the wood and contracts its growth, but renders the timber, when cut, hard, crooked and knotty" (Alfred Caswall 1830).

After consultation with the National Trust advisory staff from Cirencester, as well as foresters from other properties and organisations, a management plan for the wood was agreed and work was begun to re-pollard the ancient oaks. Each tree was treated in several stages rather than in one go to try to reduce the shock to the tree and increase its likely survival. The following plan has been adopted:

Stage 1. Cut ivy from the tree and reduce any surrounding vegetation to allow light and air to encourage new growth points from lower on the trunk. Some older trees are very slow to react. Estimated time allowance 2-3 years.

Stage 2. Reduce tree crown by half or as fit. Estimated time allowance 1-2 years.

Stages 3/4. If tree has reacted with good new growth, reduce further in yearly stages until cuts are close to trunk or at desired height. If tree has not reacted, either further reduction of all surrounding vegetation, or leave for monitoring. Estimated time allowance 2-6 years.

Since the work was started, a large number of trees have been cleared of ivy and much surrounding vegetation. Ten trees have been fully pollarded and six others successfully reduced. Monitoring continues on all trees in the wood and every tree has been measured, recorded, plotted and photographed. It is the intention, after periodic review, to continue this staged pollarding process until the whole wood is once again under this form of management and hopefully to re-introduce woodland grazing. This, it is hoped, will ensure that the unique character of this particular Dorset wood will continue for many hundreds of years to come.

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Discussion

M. Burleton (Royal Horticultural Society, Wisley): Would Oliver please say what species the birch was in America?

O. Rackham: Yellow birch, I can't remember for certain but that was probably what it was.

T. Green (Windsor): Just to state the obvious, we are talking about two sorts of pollarding, pollarding young trees and the possible renovation of old trees. I think that is something which has not come out yet. The problem seems to lie more with the renovation of old trees which isn't necessarily real pollarding in the sense when we look into history.

David Lonsdale (Forestry Commission): I have been working on a related problem for quite a number of years now, in fact we have had a project in this area, pruning and pruning of fruit trees for over 15 years now. It strikes me that some of these interesting ideas which have emerged over a number of years are not really being appreciated by the non-arboricultural circles. There were a number of telling comments after O. Rackham mentioned compartmentalisation, a well known idea in arboricultural circles. Some of the points in the last talk typically highlighted the fundamental ideas of how nutrients and moisture move in wood and in wounds. Some of these ideas are already well established, others are very conjectural but I think if there was a bit more discussion between the arboricultural circle and those people in the process of pollarding, as I am myself, we would find we move forward in some areas. I don't want to get into technical details but I would predict some of the effects we've seen on the ground.

J. Thompson (Nature Conservation): I was wondering, in relation to the renovation of ancient pollards, whether anybody has tried bonding or grafting, if not, why not?

I. Turney: Perhaps I can offer a comment on that. In the 1990 storm we lost a very ancient beech pollard called Mendelssohn's pollard on Mendelssohn's slope. In view of our experience that beech, if it loses all of its head is likely to fold up its toes and die on us, we were very anxious to see if we could save this feature tree and we took two steps. I consulted with D. Patch at the Forestry Commission at Alice Holt and we came up with two possible ways forward.

One was to graft and the second one was to give hormonal treatment to wounds that we created on the edge of the tree. The grafting took place last year and we were assisted by East Malling Research Station. The buds did not break last year but we were advised that they may remain dormant through the summer. We also unfortunately suffered some vandalism on the grafting work which took place but we will watch with some degree of interest to see what happens this spring. In addition to this we scarred the two beech trees and also cut cubes of bark out, gave hormonal treatment to the newly exposed cambium and replaced the bark cubes to see if we could encourage dormant buds to break. As we mentioned this morning, on these older pollards the thickness of bark is quite considerable and it may be almost impossible for a dormant bud to break through this thickness of bark if it is not given some sort of assistance. So again we will not know the results of that action until this year. At this stage we can say that Mendelssohn's pollard is in fact still green and still appears to be pushing up sap to the breaks so there is still a life force within the tree. We will just have to wait to see if our actions have in fact saved it. One of the things suggested by Kew was, where these feature trees were, to create an oxo cube in the ground of natural bone meal fertiliser. When Kew Gardens undertook this work, after the 1987 storm when they dug into these oxo cubes on the ground (60cm square blocks of natural fertiliser), they found a mass of root fibre which had penetrated into the natural bone meal. This would not have happened if it had been artificial fertiliser which can in fact turn toxic. So we have taken some artificial steps, but steps none the less, to see if the tree will respond. We are waiting for the results this summer if they work at all.

T. Wall (NCC): I just wanted to offer a little bit of experience on pollarding another species which is holly. I have the responsibility for a place called 'The Hollies' in Shropshire which is part of the Stiperstones and Hollies SSSI. It is an area of holly park land which has within it the biggest stand of old holly anywhere in the country. The actual age of the trees is not known but for the most part is in excess of 250 years. A lot of holly was pollarded in the past and the branches used for feeding livestock in winter. We do not know for sure that this happened in Shropshire but it is more than likely

that it was so. We were keen to ensure longevity of these trees and provide holly with the best method of doing this and some twelve months ago we did some pollarding of some ancient trees. The initial results are successful, we have had regrowth on all cut trees. We are a little worried about possible frost damage. There was minor frost damage in February this year but the shoots still appear to be alive and vigorous. We do intend to do further pollarding in the future. On the advice which we received we left a branch on each tree. The other thing I would like to mention on the practical side is that holly is susceptible to frost damage, so we did delay pollarding until late April, early May and June. I would be interested if anyone has experience of pollarding holly.

R. Woods (NCC): I am no physiologist whatsoever, but recently I have re-read one of Professor Wareing's papers. He worked on sycamore and it is rather interesting that he proposed a theory that bud dormancy was induced by hormones which are largely produced from roots in the late summer. So, if you chopped the branches off in the beginning of the Autumn you tend to get an accumulation of dormancy activated substances whilst the dormancy breakers then produce from the buds in the early part of the spring, so hence this might account for the fact that you get a better response if you take the tops off later in the year because you have already got some of these chemicals and they are starting to induce bud break. I wonder if any of the speakers have in fact spoken to physiologists to try to get some ideas or explanations as to the requirements.

L. Sisitka: No!

M. Game (London Ecology Unit): On a similar theme about the practice, particularly on nut trees, of breaking bud dormancy by taking buds at about four feet. They have a system of nicking, where you cut above the bud, but you do not actually cut the branch off. The idea is that that bud will break dormancy and the following year the old branch will be taken off. I do not know anything about the arboricultural methods. I do not know if this would work for old trees whether you could try to break dormancy before you actually did pollarding.

I. Turney: I think that is a point we can record, and some of these points we can always follow up on afterwards. Certainly the hormonal and bud breaking ideas are things we need to talk to the arboriculturalists about and see if there is any further progress we can make in this field.

J. Boyd (Merrist Wood): Surely the thing is also the fruit growers. We should also be talking to fruit growers because the action we have just had described is a direct orchard practice.

I. Turney: That is why we went to East Malling Research Station for the grafting exercise because the thought crossed my mind a long time ago when we began to start with this work whether there is some justification in putting a tourniquet on a tree. If you could go to that amount of effort to sort of strangulate it, to force it into thinking it was dying and create certain responses from within the tree itself, before you went to the second stage of decapitating it. We never actually practised that, I can see from your smiles you probably think it is a bit extreme but it was just a thought because in orchards that is quite a common way of getting the tree to bud and create fruit. It is a case of creating some stress on the tree.

J. Boyd: I think from fruit trees as well they also transplant bark. A lot of people have been talking about these big thick layers of bark and possibly transplanting smaller pieces of bark from further up the tree.

N. Sanderson (Ecological Planning & Research): More about holly. We have done a fair bit in the New Forest with a slightly different emphasis. But the problem here is that the holly is killing everything else and having a significant effect. We have done a bit of pollarding last year and in the course of this work we have been able to see if we can stop it spreading. You do not even have to leave a branch, just cut it off and it grows again.

I. Turney: Can I ask a question to the floor. One of the delegates, I do not know if he is here, phoned me up a few weeks back to ask a question about lime pollards. He was having problems, having done some lime pollarding, with the branches breaking out and I wondered if any one in the audience has got any experience of dealing with lime and lime pollards and the viability of the exercise?

D. Smith: Yes, we have done some lime pollarding and we find that as soon as you pollard you get a tremendous amount of growth from right down, almost on ground level, and it far out reaches any growth further up. In fact so much effort seems to be put into the lower growth that it takes it completely away from the top. So we have actually gone round and trimmed away growth on the bottom levels and that has had a dramatic effect.

O. Rackham: What sort of lime is this?

D. Smith: This is mainly *Tillia cordata* but also *T. pentaphyllus* the red twigged lime as well.

O. Rackham: I suspect that this may be a genetic trait.

D. Smith: Yes I think so but it has put on such extraordinary amounts that it is in detriment to everything above ground.

O. Rackham: But nevertheless one sees, up and down the country, small leaved lime pollards just like any other sort.

D. Smith: And also last year, after the storm, where so many of our lime trees actually blew over, we have actually stood 32 back up and pollarded them at about 6' high and they have taken on remarkably well. So it is fingers crossed and maybe it will continue.

I. Turney: The point of standing trees back up - if we had had time today we would have taken you past a very ancient beech pollard, probably the best part of 350 years old which blew over in the 1990 storm. We took the weight back off that and in fact re-dug the root plate out because obviously a lot of the root soil fell off the tree. We stood the tree back up and grafted on it, but it also was able to retain some of its lower branches. Now this was shortly after January as we worked quite quickly on it. So, shortly after March this tree was back in the ground plugged in. It was in a semi-dapple shade environment and quite moist ground conditions and, in fact, to our surprise the tree continued to grow throughout the summer. It put on growth and new buds broke so whether that is a long term thing which is going to last we do not know but it was purely an experiment really on our part, a sort of suck it and see. We just took this one and stood it up. It had a wonderful root plate on it, very fibrous and had the dimensions of at least 10-12' across. We put this thing back in, we put wire rope on it just to hold it for the time being and took the weight off so obviously it is not top heavy but just to see whether it would survive. It had a very healthy root system, and again, like a lot of this work it is a question of watch this space and we will see what comes of it. But, that tree did go all through last summer despite the drought. So it did not die as we had expected it to.

M. Ellison (Cheshire Woodlands): I am a self-employed tree surgeon working mainly on lime and it was my query which prompted the comments by I. Turney earlier. The major problem as far as I am concerned is that, due to excessive regrowth, the

trees are very top heavy. The lime tree concerned is one of an avenue of trees. About 13 years ago someone lit a fire in the top of the pollard causing some damage, although the tree survived. The tree was re-pollarded and grew well but about two months ago, without any warning at all, all one side of the tree collapsed. The area which collapsed showed 11 years of xylem growth and that *Ganoderma* had taken hold in the base of the old pollard 11 years ago.

O. Rackham: Perhaps I can comment on that, I think perhaps the unusual feature is the *Ganoderma* which has the reputation of being a very fast spreading and aggressive agent of carrying.

M. Ellison: You can see from the tree that there is one *Ganoderma* down one side of it and another down the other side.

T. Green: You are probably talking about two different *Ganodermas*.

M. Ellison: No, no I really don't think so, what is happening is that the tree is unable to recover. Trees have no real defence mechanism to fight off this *Ganoderma*.

T. Green: *Ganoderma* is usually just heartwood rotting fungi, at some stage they can become the actual killer, if you like. The tree has gone under stress and the *Ganoderma* which is already in the tree has now taken over the killing of the rest of the tree. The tree is under stress.

M. Ellison: You are sure it is the same species?

T. Green: Yes. I will come on to that in my lecture but normally I find with *Ganodermas* they are no problem at all until, and only, in very old age.

M. Ellison: This has caused related problems.

T. Green: But it is after stress.

M. Ellison: It is a very individual problem and a very individual site.

O. Rackham: What I would say is that decay in itself, we should not think of as objectionable.

T. Green: It is beneficial.

O. Rackham: It is a means by which a tree disposes of superfluous wood and recycles the minerals in that wood. Now the mechanisms do not always work, but that is not to say that they do not exist.

Simply fungi

by E. E. Green

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Introduction

Fungi are the forgotten components in forest ecosystems. There is a lot of literature around on ancient woodland and forests, especially on conservation. In most of these there is a small paragraph tucked at the bottom mentioning lichens and fungi. In other words they skip over them. A more correct representation would be to have five chapters of a book devoted to woodland history etc., two chapters on the fungi and one paragraph on the birds and bees and flowers. We have not taken on the importance of fungi in the environment. How I can do it in this small space I do not know, not in ten minutes, perhaps in ten hours.

Recently I visited Switzerland and was shown round by a forester. He proudly took me 80 miles to see some old oak trees he had. I was afraid to tell him that by British standards they were not particularly old and in addition there were not very many of them and here he was showing me the finest old trees in Switzerland. So here in Britain we certainly have some of the finest old trees in Europe and certainly most of the old trees in Europe, excepting the olive and plane trees in the Mediterranean. Ecologically these trees are incredibly important for invertebrates, fungi, bacteria etc. and we have not really started to explore the importance of them yet.

Hollow trees

I have travelled a lot over Europe recently looking for old trees, mainly because I wanted to expand a survey. I have worked extensively in Windsor Park which is one of the three most important sites in north west Europe for dead wood and old trees. Windsor has a substantial number of old, predominantly oak, trees and pollards up to 800 years old. It has also been well researched entomologically. In my survey I wanted to find out why all the old trees were hollow. To approach the problem from a different point from foresters and most conservationists I asked the questions: Why are they hollow? Is it a benefit to be hollow? and What are the reasons for it?

I devised a simple technique of going round looking at trees on which fungi were growing, basically heartwood fungi, and scoring their condition. Having done around 700, I have basically come to the conclusion

that most trees with this sort of fungi are basically very healthy. In other words it is probably very healthy not to have heartwood. The 400 year old hollow beeches at Burnham probably had the fungi growing on them 150 years ago. Today the fungi have gone and the tree still remains. From an engineer's point of view a hollow cylinder is far stronger than a solid pillar. In some of the trees at Burnham Beeches there is now sufficient heartwood which is being formed again behind the cambial layer for the fungi to come back. The heartwood rotting fungi were present 150 years ago and the next generation are present now. In the gale of 1987 very few hollow trees blew down. They do tend to shatter at the point where the rotting has stopped but they do not blow down.

Fungal action within the trees

The centre of old trees, where the heartwood has rotted down, consists of a gunge. It is this that the aerial roots like, they can recycle the nutrients from the rotten heartwood in an incredible way. If a tree is felled at this point, the soft decaying material in the centre of the stump can be seen to have a dark ring round it, between the heartwood and the cambium. This is Shigo's barrier. Such barriers are considered to compartmentalise parts of the tree separating damaged areas from healthy ones. As far as I am concerned such barriers could be fungal. I like to think there are fungi living in the living wood which actually interact with fungi which are living in the heartwood. Shigo's barrier can be quite hard and seasoned as can be seen by looking inside hollow trees, for example at Burnham Beeches.

Recent research has shown that heartwood rotting fungi could actually be beneficial in many ways in combating attacks from other pathogenic fungal species. A good example of fungal barriers can be seen in leaves containing fungi which retards senescence, this leads to the appearance of a blotchy leaf.

Many of the big limbs which came down in the storm of 1987 were very quickly colonised by fungi. This gave me a problem because the fungi were fruiting straight away. How have the spores got onto the limb? There is a school of thought that a lot of these wood rotting fungi actually live within the tree. As

long as the outer layer of living wood is healthy, these fungi live quite happily. Immediately the limb comes off and is dead, the fungi immediately start to decompose the wood. So when the tree is alive what are the fungi doing? I wouldn't mind betting that the majority of them, although primarily wood rotting fungi, are actually beneficial to the tree while living. *Bulgaria inquinans* is well known to appear on wood within days of it falling down. I wouldn't be surprised if it will be proved to be a very beneficial fungus to the living tree.

Some examples of beneficial fungi

Ganoderma

Ganoderma is a genus of bracket fungi found on old trees. Each fruiting body produces millions of spores. Unfortunately there are not many trees left in Europe for these spores to colonise but there are a few in Britain.

Fistulina hepatica (Beef steak)

As far as I am concerned beef steak is very beneficial to a tree because, as with the next species, it appears to be the other major heartwood rotting fungus on oak. Despite its name I think it is revolting to eat.

Laetiporus sulphureus (Sulphur polypore)

This is also beneficial to the trees. It is nice to eat and many beetles make it their home. Normally we do not see the heart rot fungi because they carry on inside until the heartwood is exposed to day light. This can be for example in a lightning strike or when the tree falls or is cut.

Pholiota sp.

Another heartwood rotter. I have seen these species growing on a felled beech 200-250 years old which had not started to rot. The fungal fruiting bodies grew out from the cut surface, where it had been exposed to light, but only from the centre of the trunk where the heartwood was.

Phaeolus schweinitzii

This species has always been considered a killer. Again it occurs in heartwood and only fruits when exposed to the air. On mature trees it just rots out, here *P. schweinitzii* is not a killer but a heartwood rotter of conifers.

Pleurotus ostreatus (Oyster fungus)

This is another species which only appears when the wood starts to die. It may well be beneficial whilst the tree is healthy.

Detrimental species

Bjerkania adusta

This is not a heart rot species. The fungi attack living wood causing it to discolour and die. These fungi may already be in the tree and do not touch the heartwood but attack the tissue and the bark. Because of the last two years of drought this has become quite a problem particularly on the very old pollards which have been re-pollarded. Although the tree is alive there is not much in the way of limbs on it to draw up the sap or keep the living wood moist. The tree is stressed and *Bjerkandera*, which is probably living in the tree, assumes the tree is dying and attacks it. This has been a problem with old pollards, particularly the large hornbeams at Hatfield. All due to stress.

The importance of dead wood

I have tried to build up some of the many causes for keeping dead wood in woodlands. If you imagine that before man started to manage woodland for his own purposes everything that fell down or grew was recycled. For thousands of years we have removed everything from woodlands and this has led to the unbalanced system we have now.

A lot of fungi, bacteria and insects are now missing from many of these woodlands and we don't know exactly what we have done. When we start talking about *Armillaria mellea* (honey fungus) and other organisms rampaging through forests, the chances are that over the years or centuries we have removed the fungi or other biological control agents that would have naturally controlled these species. At Windsor we do not suffer from *A. mellea* because there has always been a continuity of woodland on these soils. The forest soils are very healthy but it is essential that leaf litter and wood debris is left lying on the woodland floor. In a natural ecosystem, leaf litter and other organic material rots down so there is no need for bonfires - so no bonfires please.

Conclusions

Fungi rotting out the heartwood of a tree can be beneficial in providing resources for the aerial roots to feed on. We still do not understand fungi in forests. We talk about killer fungi, of which there are maybe three or four major species, but there are perhaps 10,000 species and the majority will be beneficial (and they were there before us anyway). It is gratifying to see so many people are interested in looking after old trees, hopefully we can encourage this even more.

The importance of old trees, including pollards, for lichen and bryophyte epiphytes

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Old trees, particularly those associated with relics of ancient woodland, are of extreme importance for the rarer and more local lichen and bryophyte epiphytes. This appears to be because such trees provide some continuity over time with relics of the Wildwood. It has been calculated from various lines of field evidence that the Wildwood of southern and western lowland Britain is likely to have had as many as 150 to 220 species of lichen epiphytes per square kilometre.

Even in areas of significant (but not overwhelming) pollution levels, like Burnham Beeches, some species of epiphytes have apparently been able to survive (mostly lower down on the trees in more sheltered situations) on ancient trees dating from long before there was any appreciable air pollution. Such species cannot be found in woodland without ancient trees today except in very "clean" areas, as in western Scotland, or in a few places in south-west England and west Wales.

Ancient coppice woodlands usually lack the old standard trees; even where they occur they tend to have been heavily shaded in the later part of the coppice cycle, and to have become abruptly dried out after coppicing has occurred. Presumably for these reasons, such famous ancient coppices as the Bradfield Woods in Suffolk, although outstanding for their ground flora of vascular plants and for their diverse underwood species, are extremely poor in epiphytes even on the (very few) older trees that survive. Bradfield Woods has only 15 recorded epiphytic lichens in approximately 1 km², after careful survey. Some ancient Forests and Park lands with many ancient trees have still, in southern England, 150-200 epiphytic lichens per square kilometre.

The presence of old pollards is particularly valuable because pollarding not only prolongs greatly the life of trees, but provides various microhabitats, such as rain tracks, crevices, sheltered underhangs, and root rugosities, which provide a diversity of niches where different epiphyte species have been able to survive. Even at the moderately polluted site of Burnham Beeches, some 89 lichen epiphytes have been recorded over the last 20 years or so.

It should be emphasised that, in "cleaner" areas, these species are less confined to old pollards. This

implies that, with pollution levels greatly fallen in many parts of southern England, some of these relict species may be able to re-colonise both new pollards and mature maiden trees. One can see this happening today in such places as the New Forest.

Oak, ash and beech are the most important pollard species for interesting epiphytes, followed (in those more limited areas where they occur) by field maple and hornbeam. Old sweet chestnut is always poor in Britain; its bark appears to be more acidic, less buffered and of low water - and base - retaining capacity with us, but strangely, in southern Europe (e.g. Provencal and Tuscan hills) it is one of the richest trees of all.

Besides the presence of old pollards, the open structure of old pasture-woodland is important for epiphytes. Centuries of grazing pressure in old wooded commons, deer parks and Forests have produced open glades and lawns with low ground cover and plenty of light reaching the tree boles, while at the same time humidity within the trunk space remains high. Hence it is important to maintain this open structure. Areas of closed, ungrazed, high forest, even with some mature or ancient trees present are often extremely poor in epiphytes, often it seems because of the heavy shade of under-shrubs and excessive numbers of smaller trees. Ideally, rich pasture woodlands should be grazed (or re-grazed if this has ceased). If this is impossible, then the management should be directed to producing or maintaining the characteristic structure of ancient pasture woodland.

Besides overall quantitative richness in numbers of epiphytic species, old pasture woodlands with ancient pollards are qualitatively different in that there is a considerable number of epiphytic species confined (or nearly so) to such habitats. Many of these species have been used by me to construct Indices of Ecological Continuity for woodlands. The Revised Index of Ecological Continuity (RIEC) (Rose 1976) contains 30 species of this type. When a figure of the number of such species is obtained for a wood, this is converted to a percentage on the basis of 100% indicating the presence of 20 out of the 30 species on the list (this is to allow for geographical variations in distribution and the unlikelihood of all 30 species

being present in one area). The New Index of Ecological Continuity (Rose in prep.) uses a larger number of species (70) and expresses the total as a fraction.

Characteristic lichens of ancient woodlands used in these indices include such large foliose species as the lungwort lichens (*Lobaria pulmonaria*, *L. virens*, *L. amplissima*) and also crustose lichens such as *Thelotrema lepadinum*, *Pachyphiale cornea*, *Thelopsis rubella* and *Catillaria atropurpurea*. The crustose species often survive today in ancient woodlands that have suffered slight pollution or limited disturbance even when the larger, foliose species have gone, so they are useful indicators of continuity in many areas of south England.

Bryophyte epiphytes in the category of ancient woodland indicators are few, but they do include *Zygodon baumgartneri*, *Pterogonium gracile*, *Neckera pumila* and *Frullania tamarisci* in southern England.

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Saproxylic invertebrate assemblages in British woodlands: their conservation significance and its evaluation

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Introduction

Woodlands provide habitat for a high proportion of the animal species known to occur in the British Isles. In addition to the many generalists found both in woodlands and elsewhere, a number of species are effectively limited to woodland habitats. For example, Hammond (1974) noted that approximately 650 British beetle species (i.e. ca. 18% of the British Isles total) are woodland specialists. Using a slightly less rigorous definition of the term (specialist) about one quarter of the more than 20,000 British species of insects may be regarded as woodland specialists, while at least a further quarter are of regular occurrence in woodlands. Not surprisingly, considering the extensive removal of natural forest from the British landscape over the past few thousand years (see Rackham 1980, 1986), populations of such woodland species tend to be fragmented and vulnerable (Hammond 1974). Some indication of this is provided by the list of beetle species contained in the British Red Data Book for insects (Shirt 1986), 40% of which are woodland specialists.

A high proportion of woodland species, but by no means all, are directly associated with trees and it is widely appreciated that, in Britain, the native species of trees provide habitat for a greater range of invertebrates than any other plants (see for example Kennedy & Southwood 1984, although these authors considered only those species deemed to be phytophagous). Not all tree-associated species, of course, may be regarded, even in the loosest sense, as woodland specialists.

The habitat assemblages and trophic guild structure of the invertebrate fauna of the British woodlands have not been adequately described (see Mattson 1977 and discussion below). However, the importance of the **woody** part of trees to woodland invertebrates, especially once the processes of decay have begun, is clear. Elton (1966) observed that "Dying and dead wood provides one of the two or three greatest resources of animal species in a natural forest".

Studies of one of the major groups in British woodlands - the Coleoptera - indicate that around 30% of species are dependent on wood and its directly associated fauna and flora, while further species use the woody parts of trees for shelter or as pathways. In Richmond Park, Surrey, 25.5% of the 1056 recorded beetle species (Hammond 1983, Hammond & Owen, unpublished) are wood dependent, and the proportion of such species would be substantially greater if those (ca. 20% of the total) exclusively associated with the open areas of this deer park were omitted from consideration. There is every indication that forests in other parts of the world, including the tropics, contain equally high proportions of species that are dependent on the woody parts of trees. For example, in describing the beetle fauna (amounting to more than 6,000 species) of a 500 hectare tract of moist lowland forest in Sulawesi (Indonesia), Hammond (1990) concluded that over 32% of species were primarily associated with and dependent on wood in some form. Although living-wood associates (some 7.5% of species) are included in this total, it excludes any species (8.2% of total) associated with large fungus fruiting bodies, many of which are themselves associated with wood decay.

The rich assemblages of invertebrates associated with wood, and more particularly with dead or dying wood, include many very fastidious species, a number of which, in Britain, may be regarded as true members of a relic forest fauna. Some such species may have been lost from the British fauna already (see Hammond 1974, Speight 1989) while the long-term survival in the country of many others must be in some doubt (see Shirt 1986 for a list of insect species of this type now regarded as threatened or vulnerable). In the survival of old forest species, pollards (see below) have a potentially important part to play.

Saproxylic invertebrates

Saproxylic invertebrates are those which are dependent, during some part of their life cycle, upon dead

or dying wood of over-mature, damaged or dead trees (standing or fallen), upon wood-inhabiting fungi, or upon other species associated with this habitat. Most orders of insects have some species which are regarded as being saproxylic. Other invertebrate groups, such as spiders, pseudo-scorpions, millipedes, woodlice and molluscs, also include species of this type. However, two insect Orders, the Diptera (flies) and Coleoptera (beetles), contain not only the greatest numbers of saproxylics but also the most characteristic and striking British examples.

Specialised habitats and life styles

The life styles of saproxylic invertebrates are extremely varied, as are the situations in which they are found and the resources which they exploit. Fidelity to very precise conditions and to a very limited range of food is common.

In a review of saproxylic invertebrates and their conservation in Europe, Speight (1989) noted that to the saproxylic fauna, a moribund, over-mature tree represents not only a single habitat but a multiplicity of habitats, a true "arboreal megalopolis". The major classes of habitat for saproxylics in this megalopolis were listed by Speight (*loc. cit.*):

1. Loose bark and the bark/wood interface.
2. Dead wood.
3. Partly decomposed wood resulting from the actions of other saproxylics (including saproxylic fungi).
4. Rot-holes.
5. Saproxylic fungi.
6. The workings (i.e. burrows and cavities) of other saproxylics.
7. Tree humus.

Encompassed within and parallel to this very useful general scheme is a great range of microhabitat specialism. For example, some saproxylic species are restricted to a particular species or genus of tree. As well as its stage of decay, the dimensions of a piece of timber and its position, e.g. exposed to rain or not, still attached to the tree or fallen, greatly influence whether or not it is likely to harbour a particular saproxylic species. The bark and wood of a single decaying tree branch represent truly complex mosaics, amongst which only one or a few small patches may contain the resources essential to a particular inhabitant. The form of a rot hole may be critical in determining which invertebrates take up residence within (see Dajoz 1966, Speight 1989 *etc.*) and in any one species of tree such holes may be classified into up to five general types; these in turn are capable of subdivision, for example according to

the position of the hole on the tree or, for water-filled holes, whether they are bark-lined or not.

Knowledge of the precise habitat requirements of saproxylic invertebrates in Britain is generally poor, although there is a large body of anecdotal and unpublished information. Most of the more useful general works, many of them dealing only with one or both of the major insect groups involved (Coleoptera and Diptera) are by continental entomologists, e.g. Dajoz (1966, 1980; Iablokoff 1943, Leseigneur 1972, Palm 1959 *etc.*). The emphasis in most studies is on the requirements of the immature stages, with relatively little attention paid to the adults which, in many instances, leave the saproxylic community on emergence to feed, often on pollen or nectar, and mate elsewhere.

The role of pollards

Over-mature trees and decaying wood in living trees occur only infrequently in the twentieth-century landscape and have no place in deciduous woodlands managed for commercial purposes. Also, the majority of traditionally managed coppiced woodlands would have contained little habitat for saproxylic species, except in poor quality standard trees, infrequent boundary pollards and in long neglected coppices.

Consequently, the habitats required by most saproxylic invertebrates very rarely occur in managed woodlands. Sites where large assemblages of these mostly highly specialised invertebrates occur in Britain tend to be characterised by the following features:

1. Historical continuity of land use, for example as a deer park or as part of a wooded Royal Forest.
2. The presence of old and over-mature trees, often in the form of pollards.
3. The trees are long-lived native species, especially oak, beech, ash and elm.

Harding & Rose (1986) listed several such sites where numbers of rare and threatened saproxylic invertebrates are known to occur. Subsequent surveys at other sites, including Burnham Beeches (Purvis & Hammond 1990), have shown them to be rich in saproxylic species also. At almost all the most important sites, the presence of pollards is a feature. Pollards are long lived trees and as such provide continuity of habitat, with the amount of dead wood accumulating as the tree ages, both in the bole and in the crown. This continuity (of the individual tree, as well as the site) seems to be an important factor in the survival of some of our rarest and threatened saproxylics. Some saproxylic insect species are rather

rarely encountered except in pollards, generally of beech or oak. Examples include the elaterid *Ampedus cardinalis* and the dermestid *Trinodes hirtus* in red-rotten oak and the Tree Ant *Lasius brunneus* - and its commensals in both beech and oak. In some instances pollards may be chosen because they are the only available trees with substantial amounts of dead wood in and around the bole. Some pollard-favouring species, however, are particularly associated with a hollow crown containing tree humus and accumulations of wood and leaf litter, a relatively rare feature of standard trees; one example of this type among the Coleoptera is *Scydmaenus godarti*.

The role of saproxylic invertebrates in woodland quality assessment

Invertebrates may be used in the assessment of the quality of British woodlands in a variety of ways (see papers in works edited by Ratcliffe (1977), Usher (1986) and Luff (1987) for general discussion). As noted by Erzinçlioğlu (1990) the cost of using invertebrates to evaluate sites of potential conservation interest is low and the returns are quick, even though considerable rigour may be involved. Concerns common to all approaches, whether presence of many species, presence of rare species, "typicalness" or "naturalness" forms the basis of the assessment, are how to gather appropriate "hard" data (see Disney *et al.* (1982), Disney (1986a, 1987), etc.) and how to quantify results (see Usher 1986, Eyre & Rushton (1989) etc.). Various components of the woodland invertebrate fauna have attracted the attention of investigators. For example, the carabid beetles of the ground and litter layers have been employed both to assess uniqueness of woodland sites (see Eyre & Rushton 1989) and in attempts to estimate "naturalness" or age (Terrell-Nield 1990). However, the greatest focus of attention has been the saproxylic insects associated with wood decay. The particular attention paid to Coleoptera derives in part from the number and variety of beetle species in saproxylic assemblages and partly from the state of knowledge of the group. The representatives of more than 60 beetle families that may be regarded as members of the British saproxylic "community" exploit between them almost the full range of resources to be found in the "arboreal megalopolis". The distribution of at least the larger and more conspicuous of these species, through both space and recent time, is relatively well documented.

A series of studies of the invertebrate fauna of the mature timber habitat in British woodlands in the 1970s culminated in the compilation by Harding (1978) of a graded list of beetle species regarded as 'indicators of ecological continuity'. In contrast to the approach by Speight (1986, 1989) in compiling a provi-

sional Europe-wide list of saproxylic indicator species, Harding (1978) attempted coverage of all beetle groups, and included a number of small, reclusive and "taxonomically difficult" species. His primarily national list, with species allocated to 3 groups according to the strength of their ties with ancient woodland, was incorporated in Hyman's (1978) review of British Coleoptera, and was followed by one attempt (Garland 1983) to produce a regional (northern England) list. In the light of new data and contributions from several other entomologists, the 1978 list of indicator species was revised and the resulting list of 196 species published by Harding & Rose (1986). Ancient woodland indicator species identified in Ball's review (1986) of the status of British terrestrial and freshwater invertebrates include members, although relatively few, of several other invertebrate groups (mainly Diptera), as well as Coleoptera (categorised according to Harding's (1978) earlier list). These lists of indicator species, notably of Coleoptera, have now been used to compare or evaluate a number of woodland sites. Although less well documented than lichens in terms of distribution and precise habitat requirements, saproxylic invertebrates evidently have considerable potential as indicators of ecological continuity. Indeed, their lack of any marked sensitivity to atmospheric pollutants gives them one clear advantage over lichens in this respect. Regionally or even locally varying levels of air pollution, as well as the effects of differing climate, remain seriously complicating factors in interpreting the lichen index of ecological continuity (see Rose, this volume).

To help in evaluation, a simple system (a score of 3 for a group 1 species, 2 for a group 2 species and 1 for a group 3 species) has been proposed by Keith Alexander (1988) so that a total saproxylic beetle indicator score or index may be calculated for individual sites. The system has already been used to compare some woodland sites (K. Alexander (unpublished), Purvis & Hammond (1990) etc.) and more sophisticated scoring systems that give greater weight to the most fastidious species (e.g. see Eyre & Rushton 1989) are in the process of being developed.

Other developments under consideration include an increase in the number of saproxylic Groups to 4 or 5 so that finer distinctions of rarity can be incorporated, the construction of separate lists for various categories of rare non-saproxylic woodland Coleoptera, and the production of regional lists, at least for saproxylic species. Such developments may seem to imply departure from Harding's original aim of using saproxylic invertebrates (as indicators) to detect habitat continuity rather than attempt to achieve overall assessments (via species richness or presence of rare species) of woodland conservation value. However, in practice, the two approaches may

go hand in hand if Groups 1 and 2 in the saproxylic list remain restricted to species considered to be characteristic of and largely confined to ancient woodlands.

Whether or not it is adapted for regional or other uses, some revision of the existing list of saproxylic beetle indicator species (Harding & Rose 1986) is now desirable, and further re-appraisal of its composition will be possible as new information on saproxylic species becomes available. Among species that might usefully be excluded from the list are those of exotic origin (e.g. *Pentarthrum huttoni*) and those that favour man-made habitats (e.g. *Dienerella separanda*). If separate lists of non-saproxylic indicator species are also compiled, species not associated with wood decay (e.g. *Calosoma inquisitor* and *Cryptocephala querceti*) might also be omitted. Other candidates for exclusion are species such as *Enicmus brevicornis* (a feeder on spores of the fungal pathogen causing sycamore sooty bark disease), that have exhibited recent and dramatic extensions of range. The inclusion of Tree Ant associated species (e.g. *Euryusa* spp.) may also require reconsideration as the ant in question *Lasius brunneus* continues to expand its range. The position of a few other species apparently in an "expansive phase"

(e.g. *Agrilus pannonicus*, *Tomoxia bucephala* and *Uleiota planata*) also needs review. Down-grading or, in a few instances, exclusion from the list of certain species (e.g. *Bibloporus minutus*, *Ctesias serra*, *Enicmus rugosus*, *Quedius maurus*) that new data reveal to be less restricted in occurrence than had been thought may well prove advisable. Re-

appraisal of species that appear to be good colonists of secondary woodland (e.g. *Eledona agricola*, *Prionychus ater*, *Stenagostus villosus*) is desirable also.

The other side of the coin is the evaluation of additional saproxylic species that are new candidates for inclusion in the list. In the light of new information some 50 or so of these already suggest themselves. Many of them are small, not easily detected (at least using traditional collection methods), and among the less readily and/or reliably identifiable species. Indeed, a number of such species have been excluded from the list so far only because of uncertainties as to the reliability of available data on their occurrence. Species only recently detected in Britain and so far known only from one or a few ancient forest sites,

such as *Cicones undatus* and *Dorcatoma ambjourni* are also clearly strong candidates for inclusion.

Evidence particularly useful in identifying potential indicator species may be obtained from studies of the distribution of beetle species across areas of varied landscape that include some ancient woodland and some woodland of other types. An example is provided by data from one county (Essex) that has been relatively well surveyed for Coleoptera (Hammond unpublished). A relatively high proportion (106 out of 196) of the saproxylic indicator species on the current list have been found within the county at one time or another (see Table 1). Essex is relatively poorly wooded (compared to nearby counties such as Kent or Surrey) with few areas of ancient woodland outside the old Forest of Essex, represented today by Epping Forest and outliers such as Thorndon Park and Weald Park. While the beetle fauna of Epping Forest (Hammond 1979 & unpublished) is well documented, that of Hatfield Forest, a smaller but historically significant pasture woodland (Rackham 1990 etc.) remains relatively poorly known.

Table 1. Occurrence of ancient woodland indicator species of Coleoptera (*sensu* Harding & Rose, 1986) in Essex.

Recorded from	Grade 1	Grade 2	Grade 3	Total	"Score"
Epping Forest (<i>s.l.</i>) only	12	10	22	44	78
Epping F. + 1 other site	3	4	10	17	27
Epping F. + 2 other sites	1	4	10	15	21
Epping F. + 3 or more other sites	—	1	19	20	21
Other sites only	1	1	8	10	13
Essex total	17	20	69	106	160

As expected, the Essex (and Epping Forest) data (summarised in Table 1) largely support the indicator species categorisation, especially those of Group 1 and 2, given by Harding and Rose (1986). Note, however, that 20 of the indicator species have been reported from three or more Essex sites outside of Epping Forest *sensu lato*, and a further 10 indicator species from other Essex sites but **not** Epping Forest. Scrutiny of the data on the occurrence of these 30 species reveals that some are found sufficiently regularly in secondary woodland or non-woodland habitats for their value as ancient woodland indicators to be placed in some doubt. Examples are *Bitoma crenata*, *Dienerella separanda*, *Phymatodes testaceus*, *Prionychus ater*, *Pseudotriphyllus suturalis* and *Tetratoma fungorum*. More significantly, the Essex data are of assistance in

identifying additional candidates for inclusion in the indicator species list. Of the just over 2,000 species of Coleoptera recorded from Essex, 195 have so far been recorded exclusively from Epping Forest. Ninety-eight of these are saproxylics. The majority of them, however, are not at present listed as ancient woodland indicators. These species, 54 in all, and a few additional ones reported also from such sites as Thorndon Park (but not elsewhere in Essex), deserve a closer look. Several of them, e.g. *Cartodere constricta*, *Cis vestitus*, *Dexiogyia corticina*, *Henoticus serratus*, *Phloeocharis subtilissima*, *Phloeostiba plana*, *Ptinella aptera*, *Sphindus dubius*, *Taphrorychus bicolor* and *Trypophloeus asperatus*, are likely to prove strong candidates for inclusion in the list of saproxylic species.

"Threshold scores"

In as much as saproxylic beetle species such as those in Groups 1 and 2 of Harding & Rose (1986) are truly **indicative** of continuity of dead wood habitats in ancient woodlands, knowledge of the occurrence of any such species at a site may prove of use in assessing its conservation value. However, bearing in mind the tentative nature of such "indicator species" lists, the recorded occurrence of just one or a very few of the listed species, especially those in Group 3 (see Harding & Rose 1986), will not, in practice, provide a reliable indication of the site's history and conservation value. With this in mind, it may prove appropriate to designate a threshold number of indicator species or threshold "score" (varying with region and perhaps also with area of the site in question) above which the ancient woodland character of a site is regarded as more or less definitely established. For poorly known sites, "further investigation warranted" status might be awarded on the basis of a considerably lower threshold score, one of around 10 on the "Alexander scale".

Sampling saproxylic invertebrates

For many purposes although not necessarily all (see Disney 1987) site assessment for conservation involves direct comparison between sites with a view to ranking them. Our relatively full knowledge of the composition of the saproxylic invertebrate assemblages (especially beetles) found at a few especially well-known sites (e.g. Windsor Forest, New Forest) already makes it possible to rank such sites (in terms of the saproxylics) in a reasonably meaningful way. Although haphazardly gathered, the data available for well-studied sites provide us with approximations to complete listings of relevant indicator species; that we are, nevertheless, dealing with approximations is well demonstrated by the continuing discovery of "new" but undoubtedly indigenous ancient woodland species at the very best known sites. Complete or almost complete

lists of saproxylics, however, are difficult and expensive to compile. Intensive and expert collecting, using an array of techniques, in all seasons (and preferably over several years) are virtual prerequisites. Less costly but reliable approaches are needed if the saproxylic beetle assemblages of many sites are to be compared.



Plate 1. Large area flight interception trap in operation in a Thailand forest. The vertical wall of the trap, made of fine-meshed black nylon, is approximately 2.5m in length. (Photograph: Martin Brendell.)

The alternative to attempting a complete inventory of the saproxylic indicator species occurring at a site is to obtain data by sampling that reliably reflect differences between sites in indicator species richness. Sampling methods and protocols employed must furnish **enough data** (i.e. samples taken must include a sufficient number of the indicator species present) and the data must be **reliable** (i.e. must reveal real differences between sites). In addition, it is advantageous for procedures to be cheap, not too time-consuming, not destructive of habitats sampled and robust (i.e. can be used by the relatively inexpert in a consistent manner, are not readily compromised or disrupted by bad weather or vandalism, etc.).



Plate 2. Funnel-shaped collecting trays in position beneath an oak tree (in Richmond Park, England) that has just been fogged. The smooth-sided trays - each with a surface area of 1m² - are suspended at about waist height from ropes attached to suitable trees and saplings. Insects and other arthropods fall to the bottom of the trays and into the preservative in half-pint pots positioned beneath. (Photograph: Jon Martin.)

Table 2. Collecting methods by which ancient woodland indicator species of Coleoptera (*sensu* Harding & Rose, 1986) were obtained during an intensive survey of Richmond Park, England. All data relate to samples taken post-1980. The insecticide fogging data concern some 60 trees, mostly but not exclusively oak, fogged at 3 different sites within the Park, April-October, 1983/84. The flight interception trap data derive from 2 traps, both operated in Sidmouth Wood, for a total of 70 trap weeks, 1985/86. Samples taken of other types, including direct sampling from dead and dying wood and lignicolous fungi (listed under 'Wood etc.' below) were very numerous, cover all parts of the Park and every month, 1981/86. Bracketed figures in the table are the number of species taken exclusively by a particular sampling method.

Sampling method	Grade 1	Grade 2	Grade 3	Total	"Score"
Insecticide fogging	5 (2)	7 (2)	17 (7)	29 (11)	46 (17)
Flight interception traps	3 (—)	6 (1)	11 (2)	20 (3)	32 (4)
Fogging + FITs	6 (2)	9 (3)	23 (11)	38 (16)	59 (23)
Wood etc.	13 (9)	10 (2)	31 (17)	54 (28)	90 (48)
Other	2 (—)	2 (1)	7 (2)	11 (3)	17 (4)
Richmond Park total	15	13	45	73	116

Table 3. List of ancient woodland indicator species of Coleoptera (Grades 1 & 2 only) present in British Malaise trap, flight intercept trap and fogging samples. Red Data Book (Shirt, 1986) and ancient woodland indicator (Harding & Rose, 1986) grades are indicated in columns 1 (RDB) and 2 (AWI). A double-plus in columns 3 to 5 indicates frequent and/or abundant occurrence.

	RDB	AWI	Malaise	FIT	Fog
<i>Agilus pannonicus</i>	2	2	—	—	+
<i>Atomaria lohsei</i>	3	1	+	+	—
<i>Bibloporus minutus</i>	3	2	—	++	+
<i>Cicones variegatus</i>	—	2	—	+	—
<i>Colydium elongatum</i>	3	1	+	+	—
<i>Corticaria alleni</i>	—	1	—	+	+
<i>Cryptophagus micaceus</i>	3	1	—	—	+
<i>Dienerella separanda</i>	—	2	—	+	—
<i>Diplocoelus fagi</i>	—	2	+	+	—
<i>Dorcatoma chrysomelina</i>	—	2	—	+	+
<i>Enicus brevicornis</i>	—	2	+	++	+
<i>Enicus rugosus</i>	2	2	+	++	+
<i>Lathridius consimilis</i>	—	1	—	++	—
<i>Lymexylon navale</i>	2	1	—	+	+
<i>Mesosa nebulosa</i>	3	2	+	—	—
<i>Micridium halidaii</i>	1	1	—	+	—
<i>Microscydmus minimus</i>	2	1	—	++	—
<i>Notolaemus unifasciatus</i>	3	2	—	—	++
<i>Phloiotrya vaudoueri</i>	—	2	—	+	+
<i>Plegaderus dissectus</i>	—	2	—	++	—
<i>Prionocyphon serricornis</i>	3	2	++	++	+
<i>Ptinus subpilosus</i>	—	2	+	—	—
<i>Pyropterus nigroruber</i>	3	2	+	—	—
<i>Scaptia testacea</i>	—	1	—	—	+
<i>Toxomia bucephala</i>	3	1	—	—	+



Plate 3. Insecticide fog rising into the canopy of a beech tree at Burnham Beeches, England, after release from the Activax access platform of a Multicar, at dawn when the air is particularly still. (Photograph: Nigel Stork.)

Of traditional collecting methods, the direct examination of dead or dying wood (and its epiphytes) remains the most effective way of finding rare saproxylic species (see Table 2). However, collecting from wood tends to be destructive of habitat, and it is difficult to standardise procedures used so that they may be applied in a comparable fashion at different sites and by different personnel. Fortunately, methods more suited to quantitative sampling of saproxylic invertebrates are available, and some show particular promise. These methods - flight intercept trapping (see Plate 1), canopy fogging (see Plates 2 & 3) and Malaise trapping - have been used extensively by Natural History Museum entomologists; their varying advantages and limitations as means of gathering reliable quantitative data, in a tropical setting, have been discussed by Hammond (1990). A body of data arising from the use of these methods in British woodlands (but so far little referred to in print) has also been assembled over recent years, enabling

further evaluation of the methods to be made and provisional protocols established for their use here. Although some calibration of these methods has already been done at Richmond Park and elsewhere (e.g. Burnham Beeches) in Britain, further tests are needed at sites where the saproxylic fauna has been fully inventoried, including 'good' secondary woodland with mature trees. Results obtained to date suggest that valid comparisons between British woodland sites using data on saproxylic beetles are feasible on the basis of just a few samples of one type, if taken at the optimal time of year. However, as the three methods mentioned above are in many ways complimentary (see Tables 2 & 3), the use of a sampling 'package' involving more than one of them is to be recommended.

Managing sites for saproxylic invertebrates

A common feature of almost all the most important sites for saproxylics which contain pollards is a large gap in the generations of trees. Most have very old trees; any pollards are very ancient and probably have not been pollarded for two centuries or more; there is no rising generation of pollards which could replace the veterans in future decades; often there are no young trees which could be used to establish a new generation of pollards. This generation gap is a major problem in conserving the rich saproxylic fauna at many sites and in perpetuating the survival of what may be very isolated populations.

The site manager contemplating the management of veteran trees or old pollards at a site known for its saproxylic fauna is faced with a number of dilemmas:

1. Should trees be re-pollarded and thereby lose dead wood habitat in the crown, and even risk killing the tree?
2. Should trees not be re-pollarded and thereby risk the tree collapsing due to the weight of the crown and/or the effects of high winds or drought?
3. Should younger trees be pollarded to create a new generation of senescent trees with the potential to provide habitat for saproxylics?

At many of the most important park land sites in Britain these dilemmas are with us now. Practical experience with pollarding is a scarce commodity and most available information on the subject is anecdotal. For these reasons, the pioneering work on pollarding being undertaken at Burnham Beeches has a special significance.

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Discussion

K. Kirby (NCC): It really was not fair to ask four specialists in their fields to try to cram everything in to such a short time. Nevertheless we attempted it. They can come back to answer any questions you might have. You might also like to draw the discussion out because one thing which I think came out this morning, in passing, was that quite possibly there may be conflicts in the management of old park land and veteran trees for different groups. That we might want some areas kept shaded, other areas opened out to the light perhaps more for the lichens. So either general questions or specific ones for the speakers.

R. Key (NCC): I am very interested to hear Francis Rose commenting on pollarding in the creation of a diversity of niches for the lichens. You find exact parallels with the invertebrates. The state of knowledge is not quite as dire as Paul Harding has led us to believe; we do know what some of them do, and again you do need this continuity effect by keeping the tree alive for much longer and you also need this diversification which you get with a pollarded crown.

F. Rose: Yes, I think it is particularly important for beech because beech, when grown as a maiden tree is relatively short lived among our forest trees. I mean at 200 years it has usually pretty well had it but it can go on quite a bit longer, if pollarded, so you get the greater continuity. For oak it is perhaps less important. Pollard oaks are very important for lichens and bryophytes but a good ancient maiden oak, such as you find in places like the New Forest and some of our parks are almost equally good. But it is this diversification of niches too which is very important. If you look at those trees we saw today you can see the potential sites for plants to grow and similarly a range of potential sites for invertebrates.

J. Boyd (Merrist Wood College): To all three speakers really. There is much pressure upon woodlands to keep the continuity by actually getting timber out of the wood still. Do you think that you can still manage to balance the two together, that you will still get fungi, insects and epiphytes and still take timber out of a woodland?

T. Green: From the point of view of fungi I think it is very important to let some trees grow on. I think this will probably apply also to insects and lichens. Where possible now leave trees and maybe even have non-intervention areas. Certainly after the great gale of 1987 there were great moves to get people to leave areas and let them go just to see what happened and hopefully this will become more and more the policy. Let us see what happens, let us go back to nature and find out what a really healthy woodland looks like.

P. Harding: I think that the problem with dead wood fauna is that by taking out trees when they are reaching maturity you are taking out the potential dead wood even before it is dead wood. So that perhaps immediately is a problem. I think that there is a way of overcoming part of this problem in that some trees will just never make decent timber therefore they might just as well be left for wildlife. Tidy mindedness is not a good thing in woodland of any sort, just clearing up every last scrap of dead wood and burning it or taking it off to the pulp mills is not the best policy.

O. Rackham (Corpus Christi, Cambridge): I think also, is there not the consideration that in general the good saproxylic woodlands do not produce good timber and never have done? This is why they have a good decay system.

F. Rose: Yes, I think there are several points here. Very quickly, selective removal of trees has obviously gone on in sites, such as the New Forest, in the past for timber. Those parts of the forest where the selective removal of timber was on a very small scale - the more remote areas - seem to be those which are now richest in epiphyte populations today. In general I think one would say, as has already been said, these are not really timber producing sites. The number of sites which are so rich are really a minute proportion of our total woodland and one feels that they, if possible, should not be regarded primarily for timber production. This does not mean to say that there are not certain trees in these woodlands that might quite happily be removed and felled, but, owing to the sheer scarcity factor in terms of total numbers of trees and areas involved, one feels that it

is difficult to reconcile these two things in the prime sites. There are lots of other second rate sites where a certain amount of timber removal could go on without any great harm, as it obviously has in the past. But there are so many adverse factors working against the populations of scarce organisms that I think we have to handle each site on its merits with great care.

P. Harding: I think there is a further problem, riding on Oliver Rackham's point. Most of these sites are threatened by other forms of management, for instance intensive grazing and attempts to get a good grass yield from part of a site therefore (leading to eutrophication of the bank) removal of dead wood once it falls and at some sites, such heavy stocking rates that the ammonia may well be causing problems.

F. Rose: Fertiliser drift coming in from outside is very serious for epiphytes. I do not know if it is quite so bad for invertebrates is it? But this is where opening up the periphery of a wood may be serious. It is often very important to keep, round a wood or park or whatever it may be, a sort of protected filter zone to prevent noxious substances from outside getting in. This includes of course air pollution, though that of southern England has dropped so much that it is not really the problem it has been in the past.

M. King (BBONT): Going on from what T. Green was saying about the non-intervention areas, I would like to ask the panel generally: our nature reserves which have been under coppice (we do not have any wood pasture unfortunately) surely the biota, fungi and lichens we have been talking about have gone from these areas. The heartwood rotting fungi that you were talking about will have become extinct probably thousands of years ago, should we be talking about re-introducing those? If we are going to have non-intervention areas haven't we got to get the species back in there to do the jobs that they were originally doing? Also, following on from that, how big? Or rather how small should the non-intervention areas be? Because I feel that they have got to be pretty damn large if you want to get back to the natural state.

F. Rose: I feel very strongly about this idea of non-intervention because it needs defining. If someone says to me, we should manage this woodland on a non-intervention basis, M. King is right. You need at least 10,000 ha, you need an electric fence all round, you need to reintroduce wolves, bison, wild boar etc. etc., then you can start talking about non-intervention. Whereas if you try to practice non-intervention in a modern wood you have got a mess which is the

result of moronic activities of one sort or another by human beings over a long period of time. Just to say stop, halt, don't do anything else, well you have got a mess which presumably in a few centuries might resolve itself. It would probably end up as a sycamore wood full of wood pigeons.

T. Green: I think nature is far more resilient. If you look at woodlands where there has been non-intervention, something is happening. I think we always look at woodlands in too much of a short term. Woodlands probably evolved over centuries. If oak is dominant now, who is to say that lime was not, three or four hundred years ago. We look at it in too much of a short term. I know we haven't much time left and we are talking about pocket handkerchief nature reserves but even if we are talking about a square yard of non-intervention there is a question mark over it. Why not try it? Why not ship in a piece of dead wood? Why not take in some soil? Why not? You are all here, you all made the effort to come today, why not make the effort to do something about a bit of non-intervention?

P. Harding: Don't dismiss your coppice woods as being a dead loss for saproxylic species because it would appear from the records we have, that most sites have at least some species. Take the case of Monks wood, a large nature reserve near where I work in Cambridgeshire. This has been quite intensively surveyed for beetles for quite a long time, 20 or 30 years, by one or two people regularly and by visitors. They have come up with very small numbers, usually, of a good selection of saproxylic species. So Monks Wood is a typical coppice with standards wood, much of it was almost totally clear felled in the first world war. So your coppice site is likely to have something, especially if it has got the odd boundary pollard hanging on, especially if it has the odd scrubby tree which has been left because it is no good for anything else. Especially if it is near a water course where there are some willow pollards or poplar pollards, I mean we have not talked about riparian pollards at all, it's a completely different topic I think which needs to be aired at some point. So, don't assume that there is nothing there, there is something there and it will be favoured if you try and create more dead wood type habitat and keep some older trees.

O. Rackham: I was going to comment that ancient woods in my sense and what some of our ancestors call ancient woods do indeed contain ancient trees in the form of coppice stools and boundary pollards. The coppice stools are probably too low for the light and the boundary pollards are too near the edge. But as far as the special invertebrates are concerned, we

do not know to what extent those two particular habitats are sufficient (ancient coppice stools and boundary pollards).

P. Harding: I think ancient coppice stools are not likely to harbour many species, a few maybe. The boundary pollards - I think very few have actually been looked at. Keith Alexander and Roger Key, have you looked at boundary pollards in woodland?

R. Key: I have found looking at boundary pollards for *Dendrochernes*, the false scorpion found in dead trees, successful.

P. Harding: In Peterborough?

R. Key: Yes.

P. Harding: That is one example.

F. Rose: If I may come on to this. I don't want to give the impression that coppice woodlands are totally boring. A lot of them are quite interesting if they are coppice with standards. It is true, as Oliver Rackham has long shown, that in the past most standards and coppice were cut to a small size in fairly small patches but there are many coppice woodlands with very impressive standards. Not only just boundary pollards but even internal pollards along the rides or just trees which have got away. There are quite a number of woods I know which are intermediate between a coppice structure and possible former pasture woodland structure. I think there has been a change over in some woods, particularly in the southern counties, Hampshire and Sussex. I know a number of cases where you have a rich ground flora of coppice, the wood is no longer grazed and yet you have got quite a lot of large old trees, whatever their origin, which are quite rich in epiphytes. I can think of a number of examples of that kind of thing.

S. Ball (NCC): I would like to disagree with what Ted Green said. I think we have got plenty of sites where we know there are good epiphytes or invertebrates, where there is an awful lot to be done. Paul Harding mentioned the problems with age structure. We have heard today about the problems with re-habilitating old pollards. There is an enormous amount to be done. There is no need to be putting effort into trying to create new sites. There are plenty of sites there to keep us occupied. At the moment we simply do not know enough about the ecology and distribution of these species and willy nilly moving them round the countryside unrecorded and adhoc muddies the waters and makes it more difficult. I would strongly suggest, don't do it.

Dave Pape: (Hants. C. C.): Formerly I worked for the London Ecology Unit where, on behalf of the London borough of Redbridge, I studied an experiment in Hainault Forest on Hornbeam. This was looking at the potential success of re-introducing pollarding to these trees. Gerry Coop is now continuing to develop that piece of work and she has recently informed me of a situation that really mimics what Lawrence Sisitka has said about hornbeam in Hatfield, this relates to this fungus *Bjerkania adusta*. Gerry tells me that out of 90 hornbeam trees that were cut, only 16 failed to sprout and there was quite a good success rate over the first few years. Now, the majority of them seem to be succumbing in some way to the die back and bark peel caused by this fungus. So, just a few questions to direct to Ted Green. You mentioned possibly weather conditions and drought, but to what extent though do you think the fungal attack on these trees can be attributed to the method of pollarding? Also, is it confined to this species or can it occur on other species? And are there any methods of control?

T. Green: If I take it the long way round. I don't think there are any methods of control other than possibly shading that side of the tree. I will return to shading in a minute. I actually did look at these trees by the way. Is it a threat to other trees? - no. And the methods - don't cut so far back. I mean most of the Hainalt pollards were all cut back to look like willow pollards. One of the things I noted in France when I went was that on all of the successful oaks, they left at least one big limb, I think this also came out today at Burnham where we saw that probably the pollards were not all pollarded on the same day. This is a thing for efficiency, we go to pollard that tree, we go in and take everything off. I think in the past the old boys went in, you wanted a lintel for a house so they went and found a limb and took it down. They may not go back to that pollard for another 10 years. We are talking about renovating old trees aren't we?

O. Rackham: On that point, you remember that pollarding was to mainly produce woodland timber. Tusser in the sixteenth-century actually refers to the practice of leaving one limb on a tree.

T. Green: And many of the ones in Burnham have different ages. When they have been cut, people have counted the rings and, there have been a different ages on the limbs that have come down. Anyway to go back to this shade business. Remember we have had two years of drought, very hard drought, and a lot of sunshine. So if you were to select a limb on that tree to leave or may be two or three limbs,

then my suggestion, if you don't like the cow dung theory because of the lichenologists, is to leave the limbs on the side of the tree so they shade that edge of the bark. So in other words leave them on the south-west and west sides so they do not get the full strength of the sun.

S. Searle (Crown Estates): One thing which has not been mentioned today is the cost of all this. I think I have now got 'why to pollard' - to prolong the life of the tree. In order to do this we are going to have to incur certain costs. Now, the Crown Estates has the will to do this and anyway we have other income coming in so we can probably afford to do it. I would like to know what the general feeling is about how you are going to encourage small estates that have no other income to lay out costs for tree surgery work, protecting growing buds (as has been mentioned earlier) and also to take the land out of economic production. Okay, we know why we want these trees for insects, fungi etc. but it has got to be paid for in some way. If it is the management's will to sit back and say, that area was traditionally worked like that, we will keep it and carry on the procedure. I say this is money on this land, we are not all like the Council here, prepared to put that kind of money into it. I would like to know what sort of grant schemes you think, who is going to fund all this work? One thing I will mention, after consultation with the NCC, we are prepared to put aside five

oak trees per hectare per rotation to go on, to carry on the ancient dead wood cycle in Windsor Estate. Do we have to pollard them? Because we tried to work it out, if we leave trees of 120 years old which will be there for the entire rotation length, at least five per hectare after two rotations you will have five trees at 250 years and five at 120 years and you still keep taking the crop off all the time. Does that fit in or am I being told that insects and fungi cannot survive on maidens?

T. Green: Why not give it a go? There are places in Europe with old trees therefore old wood is important.

P. Harding: I agree with Ted Green.

K. Kirby: With regard to funding, the situation is changing. There are general grants but within two years more may be available e.g. the woodland management grants from the Forestry Commission (available shortly) which include supplements for conservation work.

We could regard areas with pollards as spaced out hedges, therefore why not apply for hedging grants!

C. Smith (FWAG): The Countryside Commission in Bucks. is already giving grants for pollarding.

Pollarding at Epping Forest

by Peter Burman

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There is evidence that Epping Forest has been managed as wood-pasture, with the pollarding of trees at about 2.0m, for more than 1,500 years. This system of management continued until about the middle of the nineteenth-century. Pollarding was then neglected or abandoned until the late 1940s and early 1950s when some small areas of the Forest were re-pollarded on an experimental basis. Further small scale experimental pollarding has been carried out intermittently in the 1980s. More recently, in the winter of 1990/1991, some larger scale experiments have commenced.

Traditionally, oak, beech and hornbeam have been pollarded in fairly equal measure in the Forest. Beech tends to be dominant on the drier knolls and freer draining soils with oak and hornbeam most commonly found on the heavier clays. It is believed that the pollarding rotation was about 13 years although this may not have been a regular cycle. Commoners were allowed to commence pollarding at midnight on the night preceding St. Martin's Day (November 11th). Their pollarding season finished on St. George's day (April 23rd).

The 1940s and 1950s pollarding was almost entirely composed of hornbeams and records indicate only that it was carried out in the winter months. All of the 'branch wood' was removed and cuts appear to have been made as close as practicably possible to the bolling. The area involved on each occasion was approximately 0.8 hectares, and maiden oaks in the plots were left as an over-storey. These were relatively low in number and irregularly distributed. Success appears to have been at least 90% with little or no evidence of the death of bollings, although some bark death seems to have occurred. However, even where this was apparently quite extensive, in the 40 or so years since then, much of this has been overgrown with new wood and the crowns appear to be quite healthy.

Pollardings in the 1980s involved all three species. Plots were generally small, involving only a few trees or narrow and linear along Forest Slades. (The topography of Slades will be best appreciated if the initial S is substituted by a G, translating the word to Glades). The soils of Epping Forest are generally

notoriously heavy. Ground conditions therefore frequently become too wet in winter for vehicular access. Slades are particularly prone to this condition. For this reason, most of the 1980s pollarding was carried out in the growing season, June to September, when the ground was dry. These experiments met with mixed success, with the death of up to half the trees pollarded on some occasions. However, all the evidence suggests that shade from adjacent, un-pollarded trees was the principal cause of failure. There is no evidence that the time of year was a significant factor. Virtually all trees commenced regrowth the first season after pollarding with deaths occurring in the most shady areas between 2 and 5 years after pollarding.

The storms of October 1987 and January 1990 caused widespread damage to pollards throughout the Forest. In 1987 many old pollarded beeches lost all or part of their crowns, or, where underlying impervious clays were too close to the surface, were completely toppled. Crowns of oak were damaged but few were wind thrown; hornbeam suffered intermediately. In 1990 hornbeams were more extensively toppled and, although less severely affected, more beech were damaged on the margins of previously formed gaps. In taking action to deal with the damage caused it was noted that many windblown hornbeam continued to come into leaf. Wherever possible therefore, these were pollarded whilst prostrate and subsequently the bollings were uprighted. Even where the rootball became almost or completely detached from the surrounding soil most uprighted bollings have produced good regrowth after upto two seasons. It will be difficult to distinguish the effects of shade, on these generally isolated trees, from other influences but monitoring will continue.

Larger scale experiments in the 1990/1991 season involved pollarding more or less on a monthly basis to monitor the effect of season on success. The experiments took place at three locations involving mostly hornbeam with some oak. The first was done in August and September the second site in October, November, February and March and the third in December and January. Complete crowns were removed in every case and where younger, naturally

regenerated trees occurred in a plot these were also pollarded. Photographic records were taken at each stage and a sample of individual pollards is being numbered and tagged and regular periodic monitoring will be undertaken. The first plot, August/September consisted of a strip some 30 to 40m wide which effectively opened up an existing, overgrown ride which was some 300m long. The second and third plots were both of approximately one hectare. The December/January plot had as much as practicable of the dense holly undergrowth retained. In the other plot all the undergrowth was removed. The purpose of this part of the experiment is to find the effect of increased light levels on the holly undergrowth retained. In the other plot all the undergrowth was removed.

Many parts of Epping Forest have, in the last 50 years or so developed a very dense, almost impenetrable, under-storey of holly. In many instances this appears to be most dense where the canopy of pollards is least open, particularly in the oak/hornbeam areas. Where gaps have appeared in the canopy as a result of storms there is evidence of a

marked diminution of the vigour in the holly that has been thus exposed. There had been fears that holly would benefit from increased light due to pollarding. Hopefully this experiment will confirm the casual observation that this may not be the case.

Questions to be answered during all these experiments, on hornbeam, oak and beech, include:

1. What time of year to pollard?
2. How close to the bolling to cut?
3. How small, or how large to make the wound?
4. At what age can trees be successfully pollarded?
5. How much crown can be removed?
6. How large or small an area should be pollarded at one time?
7. What will be the effect on the shrub and herb layers?

Centuries of accumulated wisdom has been lost by the temporary abandonment, throughout the country, in the first half of the nineteenth-century, of the practice and art of pollarding. There is much to be learned in the next decade.

Hainault Forest Country Park

by Geri Coop

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Hainault Forest Country Park has approximately 90 hectares of ancient hornbeam pollard and oak standard woodland which is a remnant of the Forest of Essex left after the final Enclosure Acts in 1853. The hornbeam pollards have not been cut for at least a hundred years and many are supporting heavy crowns on decaying boles. This makes the trees very vulnerable to high winds which can cause extensive crown damage and complete windblow. When windblow occurs large gaps are opened in the canopy and this creates problems for regeneration. As the pollards die the character and ecology of the woodland is gradually changing and the unique habitat is being lost. It was therefore decided to investigate the possible success of re-pollarding.

The woodland is densely stocked with pollards at about 160/ha and many maidens of 15-25cm dbh (diameter at breast height). The soil is acid clay with typical vegetation, mainly holly, bramble and bracken with little variation except in flushes or stream banks.

Experimental re-pollarding trials

In 1986 research was undertaken into the feasibility of re-pollarding, and experimental trials were set up under the guidance of the London Ecology Unit.

The experiment uses 25x25m plots selected within the forest to sample a variety of aspects, pollard ages and under-storey types. Most plots contain 10-12 pollards. The trees within the plots were mapped, their size, type and vigour recorded and photographed. Particular note was taken of the presence of previous callusing, twiggyiness and burriness, basal shoots, fungal infection, bole condition, limb size and number.

Maiden trees (not previously pollarded) within the plots were included in the records and cutting to assess response to initial pollarding. This information will provide the basis for a programme to create new pollards and so conserve the nature of the woodland.

The vegetation of each plot as a whole was recorded in terms of species present, area covered by species and height of shrub and ground layers. Five 2x2m quadrats were established within each plot for

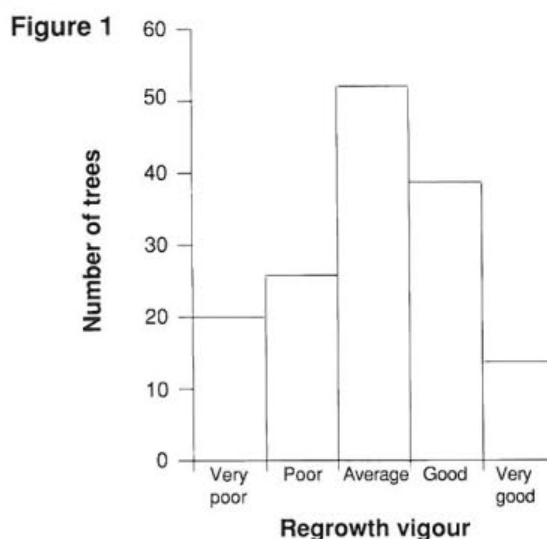
detailed records to monitor the effect of re-pollarding on the under-storey vegetation. These included species and area covered, height of shrub cover, and tree seedling counts.

Each plot as a whole was photographed to record vegetation and trees. Repeat records and photographs of the pollard trees and plot vegetation are to be made every season after cutting to assess effects and regrowth. Cutting took place between January and March leaving 300mm stubs and slightly slanted cuts to shed water (to reduce decay).

Ninety trees over seven plots were re-pollarded in 1989 in this way. Eighty trees were pollarded in eight plots in 1990. The second group of plots were selected in one of the worst areas of storm damage after the January 1990 gales to assess the success of re-pollarding as a remedial treatment for wind damage. Many of these trees were completely windblown and were winched back up after pollarding.

Results 1990

In November 1990 an assessment was done of the survival and condition of regrowth. The vigour of the regrowth was graded as very poor (very few shoots), poor, average, good or very good (dense well-grown shoots from stubs and bole). Although this is subjective it has value when done by the same person. A photographic record was also made. A graph of the regrowth is shown in Figure 1.



Regrowth varies considerably between trees and for most it is not possible to relate regrowth to site factors or original tree conditions. Trees with particular burriness definitely have more vigorous regrowth and pollards with rotten boles, fungal infection or poor condition before pollarding have given poor regrowth.

Recovery of the wind blown trees re-pollarded in 1990 is generally even poorer, although some are exceedingly vigorous against all odds! It is doubtful whether they will be able to produce a root system which will hold them stable in the future.

Regrowth of maidens has been poor unless they are less than 15 cm dbh or particularly burry.

Previous re-pollarding in the forest

Seventy-nine trees were re-pollarded by the Greater London Council in 1983. No record exists of the condition of these trees prior to pollarding but they were obviously cut close to the knuckle. A survey of these trees in 1988 shows that 52 trees had regrowth and 27 showed no regrowth or regrowth that had died. Re-assessment in 1990 shows 18 dead, 29 with very poor vigour and 32 with average vigour. All of the surviving trees are infected to varying degrees by the fungi *Bjerkandera adusta* and *Armillaria gallica* (a honey fungus species).

Fungal infection

Initially, the survival rate and condition of growth in the trials appears encouraging but at least 94% of the 1989 trees are infected by *B. adusta*. On some the only evidence is a line of pustules running down the bark from the wound but many have mature fruit bodies on the cut surface and on others this extends well down the stub and even the bole.

B. adusta is best known as a secondary infection of beech suffering from beech bark disease. In beech it tends to cause pipe rot and eventual snapping of the stem. It attacks tissue which is already wounded or diseased but it will then move into healthy tissue and can kill the whole tree. If the tree is particularly stressed or weakened this can happen quickly.

Shoots initiated after cutting may escape direct invasion by the fungus due to barrier zone formation but they can be isolated by the decay of tissue below their point of attachment. Growth of the shoot is then restricted and a strong bond cannot form at its base so that it will break away when it becomes too heavy. The results of infection by *B. adusta* can be seen clearly on the 1983 re-pollards. Regrowth has been very slow and often parts easily from the bole or stub. These trees also show advanced infection by *A. gallica*. *A. gallica* attacks through a stressed root system and will then move up the tree into healthy tissue.

On some trees a line can be seen where the two fungi, *A. gallica* and *B. adusta*, meet. Obvious evidence of infection by *A. gallica* above the surface cannot be seen for some years but it is very possible that the recently re-pollarded trees are infected by it and the trees are therefore being attacked from both crown and root. Rhizomorphs are present in the soil around the roots of trees where the bark is alive and healthy.

Pustules of *B. adusta* are visible on several of the 1990 re-pollards. Other hornbeams in the woodland, wind damaged or in poor health are infected by both these fungi. Some cordwood left on pollard plots is infected by saprophytic *B. adusta*.

Present situation

In January 1991, after assessment of the regrowth and the fungus survey, it was decided to have a moratorium of five years in the re-pollarding trials to allow a longer term assessment of the prognosis before continuing.

It is possible that, although initial regrowth is good, it may be supported solely from the reserves of the tree and when these are exhausted the tree will die as it has been unable to regenerate sufficiently to support the root system and annual wood commitments.

The vigorous presence of *A. gallica* and *B. adusta* in the woodland makes long term success doubtful if the deaths of the re-pollards are attributed to infection by these fungi.

Suggestions for re-pollarding oaks at Markshall, Essex

by J. White

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The following figures (1A-E) illustrate some recommendations given for re-pollarding some oaks at Markshall.

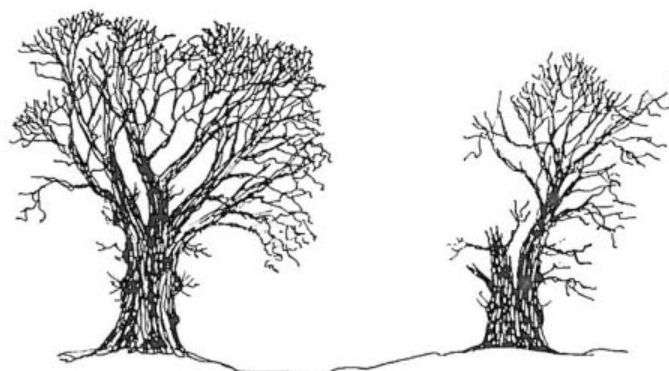
Many of the ancient trees are clearly boundary pollards. They have not been pollarded for at least 150 years and are suffering as a result. To avoid total collapse progressive pollarding is suggested. At Hatfield trees have been killed by drastic action after such a long period of neglect so cutting away half the

crown first would seem a good idea. When the tree responds by sending out new growth a further shortening can take place. A large specimen may require three cuts. A trunk with active epicormic shoots or one that has lost major limbs recently could be treated in one go.

Two oaks have been pollarded at Markshall during spring 1991 and are now shooting well (R. Tattershall pers. comm.).

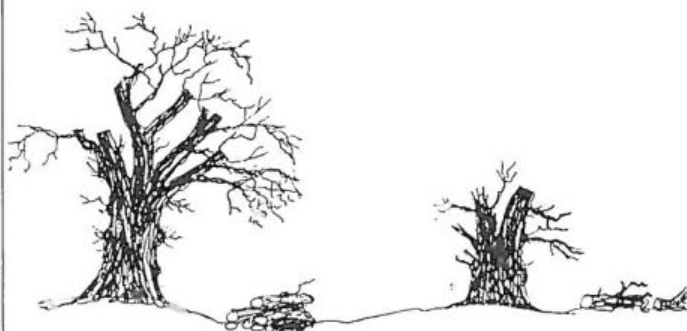
Figure 1. Oak re-pollarding at Markshall (J. White)

A.



Trees having been left for at least 100 years since last pollarding.

B.



Tree with full crown is reduced but the total canopy is not removed. Tree with small canopy is cut back further.

C.



After approximately five years the regrowth should have increased the canopy.

D.



At this point the half cut tree can be cut right back. The other tree can be left.

E.



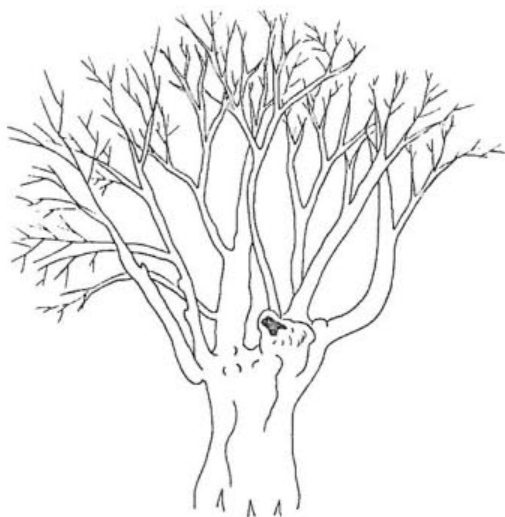
The trees after a further five years.

The sequence of figures 1A-E contrasts with the methods of re-pollarding recently undertaken at Burnham

Beeches although the reasoning behind it is the same. Figures 2A-F show treatment in the 1950s and the 1990s.

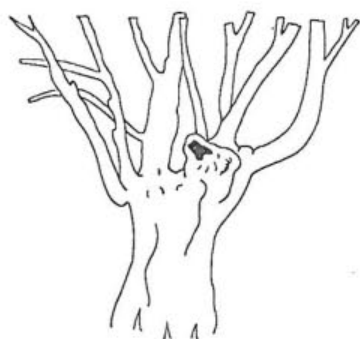
Figure 2. Beech re-pollarding at Burnham Beeches (H. Read)

A.



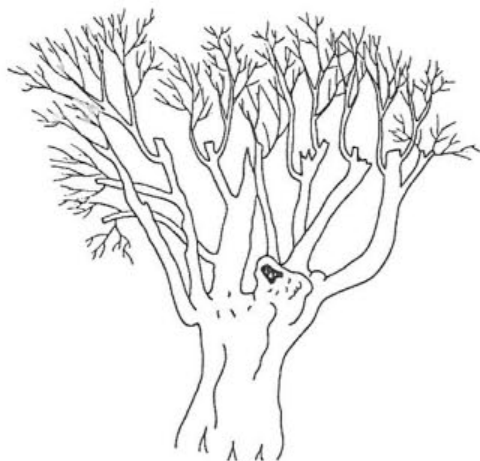
Trees approximately 200 years since last pollarding.

B.



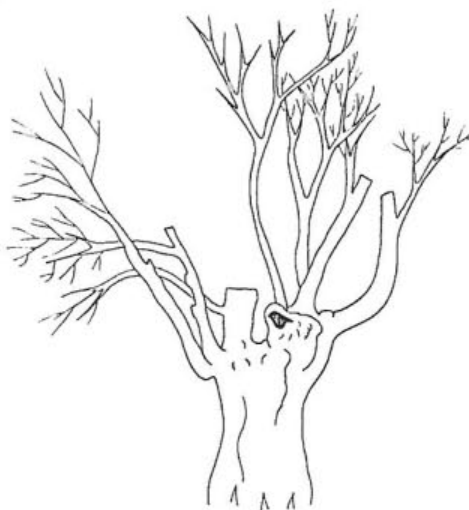
Tree re-pollarded in the 1950s style with a level cut some distance above the original pollarding level.

C.



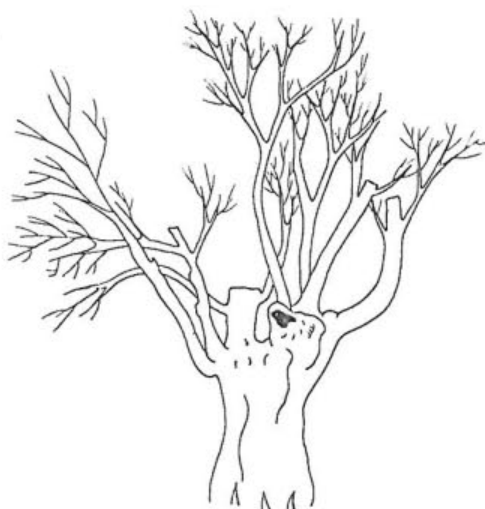
Tree cut in the 1950s as seen in the 1990s.

D.



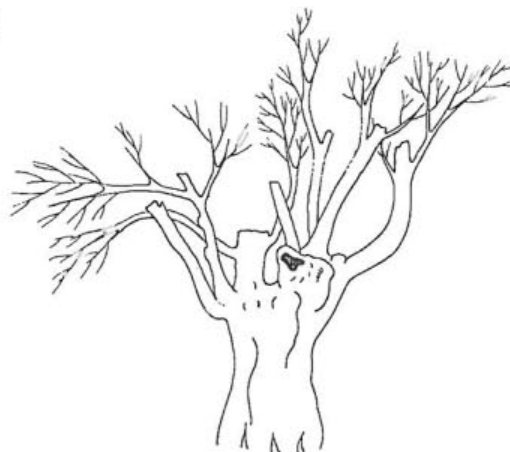
Tree pollarded in the 1980s and 1990s style. Selected heavy limbs are removed.

E.



Tree pollarded in the 1980s as anticipated 30 years on.

F.



Tree in E. re-pollarded again 15-20 years after the last cut.

Dealing with pollards and veteran trees in Savernake Forest

by R.C. Budden & T. Buchanan

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Following the October 1987 and January 1990 storms at Savernake, the Forestry Commission was concerned that the important resource of old growth beech and oak was seriously reduced. The pre-storm numbers had been estimated at about 2,500 beech and 900 oak. Over one-third of the beech were blown and in addition a high percentage of the remainder were damaged to varying degrees.

We have defined old growth to mean beech of 200 years or more and oak over 150 years. The current situation is that about 1,700 beech and 800 oak in these categories remain, with little else until the Forestry Commission plantings dating from the 1940s. The oak, some of which go back to medieval times have been less affected by the storms but still present us with the problem of bridging the generation gap.

The oldest Forestry Commission plantations of oak and beech will need at least another 50 to 100 years' growth before they are in a condition for any significant transfer of lichens, bryophytes and saproxylic invertebrates.

With this age gap in mind, we have decided to institute some experimental pollarding in an endeavour to prolong the life of the old beech, and also, by pollarding young trees regularly, introduce the decay process which is so important for the transfer of dead wood invertebrates.

Outlined below are the categories we intend to treat in the next few years within our budget provisions.

1. Re-pollard some existing healthy beech of about 220 years old which we think were last pollarded around 1820. This work was carried out in January this year on three selected trees.
2. Old beech damaged but still standing and perceived to be a public hazard. This category is treated by tree surgery in varying degrees to render them safe, some effectively being pollarded. This work, currently funded by the NCC, and carried out in January, will be an annual operation following normal winter storms.
3. It is proposed to pollard an area of 30 year old beech adjacent to some old growth, and with regular pollarding carried out at 30 year intervals, it is hoped that suitable conditions will be created for transference.
4. Single and small groups identified for pollarding in the 10-20 year old age range, which are again in close proximity to old growth beech. This category is situated along the avenues, and this gives us the opportunity to inform the public using interpretive signs.

Notes on re-pollarding hornbeam at Gernon Bushes Nature Reserve

by Neil Coombs

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Gernon Bushes Nature Reserve is a 32 hectare reserve owned by the Essex Wildlife Trust. It is sited on the north east edge of Epping Forest and is included within the Epping Forest Site of Special Scientific Interest. Most of the wood consists of closely spaced pollarded hornbeam together with a fairly high density of oak standards. In places there is a dense under-storey of holly. There is also considerable birch as an invasive species.

Historical records for the reserve have proved hard to come by although the site was until recently part of a large estate which employed its own woodman. It would seem that very little woodland management has been done in the last 30-40 years.

The trust purchased the woodland three years ago with the aim of re-establishing a pollarding cycle. Following the guidelines set out by Mitchell (1989) and after discussions with Lawrence Sisitka at Hatfield Forest a small area was selected and some 20 hornbeam pollarded. Following successful regrowth this area has been extended and a further site added.

So far at least 95% of the pollards have sent out new growth. In some instances this new growth has been sparse and there is considerable decay to the bolting making it uncertain that these trees will survive.

The re-pollarding is largely done by the Warden using a chain-saw. Usually it is possible to use standard felling cuts working from the crown. However, due to the confined work space and the growth habit

of hornbeam accurate cutting of hornbeam is difficult. Some of the re-pollarding has been done by volunteers from conservation groups but because of the nature of the work experienced volunteers should be used. Generally pollarding is now offered as an optional task to other woodland work for those who particularly want to try it. Trust staff are always available to supervise and deal with any problems. At present stems are often too thick to cut with a bowsaw. It may well be that once the pollard cycle is re-established volunteers will find it easier and more rewarding to maintain the cycle.

A system of monitoring has been established with all trees pollarded being numbered and the date of pollarding recorded. Further details such as girth, height to crown, number of stems cut and the method e.g. chainsaw or bowsaw, are also recorded. Although the monitoring system is time consuming, it is felt that at present it is better to record as much data as possible. With experience it should be possible to refine the system to detail only relevant information. Colour slides have also been taken of many of the pollards although photographing each tree every year is time consuming and no doubt refinements could be made without losing important data.

Reference

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Pollarding experiences of the Woodland Trust

by Kim Wisdom

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Introduction

Our experience of pollarding, under the direction of regional staff throughout the country, has been confined to three main areas so far:

- a) Re-pollarding of existing pollards;
- b) Pollarding in response to storm damage;
- c) Creation of new pollards in appropriate locations.

Pollarding techniques have followed the advice given in NCC-CSD reports and the research findings at Epping Forest and Burnham Beeches. Encouragingly there have been few failures to date.

Some specific examples of our experience in each category follow:

a) Re-pollarding of existing pollards

Dolebury Warren, Avon (ST 454 595)

Small leaved lime, an ancient pollard, last pollarded 30-40 years ago, shaded and surrounded by conifers on a north facing slope.

Prescription: Conifers cleared for 3.0-4.5m around. Tree pollarded with bowsaw in January 1989. Each stem cut leaving 0.3m stubs and young bark exposed. Regenerated prolifically.

Wildacre Wood, Avon (ST 588 867)

Field maple, aged 100-120 years, with large canopy, last pollarded 30-40 years ago. Located on wood/field edge facing N/NW.

Prescription: Pollarded with bowsaw in January 1988 and January 1990, leaving 15cm stubs. No clearance behind tree. Successful.

A mature ash in Wiltshire

Aged 200-250 years, last pollarded 60-70 years ago. Located on a field boundary and completely hollow.

Prescription: Cut with a bowsaw in January. No buds evident until June and no regrowth till July. 15cm growth in first year and still thriving.

b) Pollarding in response to storm damage

Kingsettle, Shaftesbury, Dorset (ST 865 255)

Maiden oak aged 60 years, 60cm dbh (diameter at breast height). Located within conifer stand on ride edge. Ride had been widened to 7.6m, equivalent to height of conifer canopy. West facing.

Prescription: Decision made to pollard rather than fell in an effort to preserve the tree. Chain-saw cut after Christmas. Buds emerged mid June. Bark was very thick (not burred nor epicormic). Regrew well following pollarding in 1987/1988.

c) Creation of new pollards in appropriate locations

Binswood, Alton, Hants. (SU 746 370) SSSI

This is one of the few wood pasture commons actively managed in a traditional manner in Britain today. The site contained pollards, mostly oak with a few beech, the majority of which were felled by a previous owner. There are now very few old pollards remaining which were last cut approximately 100 years ago. The Woodland Trust is now pollarding as a means of bringing Binswood back into active management.

Prescription: Limited pollarding has taken place in both the open pasture area and the central woodland core.

Maiden oaks (20-25cm dbh) pollarded in the open have responded with mixed success.

Similar oaks, pollarded within the woodland core, to mark the dead-hedged boundaries of coppice-with-standards coupes, have pollarded successfully and helped to reduce shade in the coppice coupe.

Although actively grazed, browsing by cattle and deer has not occurred on the new pollards.

Pollarding will continue next year, with modifications, drawn from our experience on the site so far and the recommendations of others in analogous situations.

Managing veteran holly trees - A preliminary note

by Tom Wall

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Introduction

'The Hollies' is a circa 20 hectare area of holly park land forming part of The Stiperstones & The Hollies SSSI, Shropshire. It is privately owned.

The trees form what Peterken (1967) described as 'one of the oldest stands of holly in Britain'. Peterken and Lloyd (1967) expressed the view that many of the trees might be considerably older than the 254 years recorded for a tree from the New Forest which was the oldest specimen known to them.

The trees at 'The Hollies' are mostly pollards and it is assumed that their foliage was used as winter feed for livestock as described for other sites by Radley (1961) and Spray (1981), but pollarding ceased long ago.

longevity of the existing trees. Accordingly, between 29 April and 3 May 1990 an initial batch of 8 trees was pollarded, including 5 trees which were old pollards (these old pollards had trunk diameters in the range 34-58cm, average 45cm).

Initial results

Shoots did not appear for 2 months, but subsequently growth has been good and shoots of up to 45cm in length were produced in the first season; none of the trees has failed to produce new growth. Damage to the young shoots by hard frosts in early February 1991 appears to have been relatively slight. Nevertheless, it would be unwise to claim success until growth has been sustained over a number of years.



Plate 1. An old holly pollard. Photographed 1991.

Re-pollarding methods

In each case a branch was left, as suggested by Mitchell (1989). It is intended that these should be removed in spring 1991. Because some of the bollings are no more than 1.5m above ground level cattle have, for the time being, been excluded from the group of freshly pollarded trees. In view of the opinion expressed by Brooks (1980) and others, that holly is susceptible to damage if cut at a time of frost, pollarding was done in the spring.

Policies

The area is heavily grazed by sheep and cattle, giving no opportunity for seedlings to get established, so in 1982 the Nature Conservancy Council erected a number of livestock exclosures which, it was hoped, would help the natural establishment of a new generation of hollies, in what is otherwise a stand of predominantly veteran trees. Results are slow and, as yet, patchy and inconclusive.

It was also felt important to reintroduce pollarding in the hope that this would help to increase the

As success did not seem certain, no tree was cut back really hard, right to the old bolling. This made the estimation of the date of the last pollarding difficult. However, a maximum ring count on severed material was 140 years.

Trees have been numbered, records kept and photographs taken detailing the state of the trees prior to re-pollarding.

Provided the initial apparent success is confirmed it is intended that further trees will be re-pollarded in the future.



Plate 2. Ancient pollards cut in spring 1990. Photographed 1991.

Acknowledgments

NCC is most grateful for the co-operation of the Dudlestone family in enabling this work to be carried out.

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Notes on holly cutting in the New Forest

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Background

The New Forest is renowned for its extensive grazed pasture woodland and heathland, which are an exceptional survival of the medieval landscape, complete with an outstandingly rich associated flora and fauna. The woodland is rich in ancient trees most of which have been pollarded. Surviving pollards include beech, pedunculate oak, sessile oak, ash and holly. One maple pollard and a single collapsed sallow pollard have been found but hawthorn, crab apple, whitebeam and rowan pollards are apparently absent although present in the woodland as maidens. The history and ecology of these woods are summarised by Tubbs (1986).

Pollarding of most trees ceased about 150 years ago. Rough ring counts of wind blown trees indicate canopy ages of 150 to 200 years which is much younger than the 300 years quoted for the cessation of pollarding in most texts. This latter conclusion is probably based on a 1698 Act of Parliament which attempted to ban pollarding. This may have prevented the cutting of new pollards but certainly did not prevent the re-cutting of existing pollards, and it is the 1851 Deer Removal Act which actually stopped tree pollarding by removing the keepers' duty to feed deer. Cutting of holly for fodder must also have been greatly reduced by this Act, but has in fact continued to the present day in a small way - particularly during hard winters.

Holly has been exploited both by coppicing and pollarding, with some bushes having been both coppiced and then pollarded. When coppiced, holly shows a remarkable ability to gradually grow back, even when heavily browsed and such young thickets of holly were probably very important in protecting regenerating trees. The holly pollards were mostly cut at a much lower height than other tree species, often as low as 1.75m, suggesting that ease of cutting was a more important consideration than full protection from browsing.

Holly in the Forest

Holly may have been increasing in the Forest since medieval times, partly at the expense of hazel,

(Flower and Tubbs, 1982) although at least 50% of the New Forest woodlands are on soils now too acid to support hazel. Browsing is generally stated to be responsible for this switch but the field evidence suggests that the process is more complex than this; the surviving hazels show little sign of browsing damage and appear to be near immortal, being capable of self-coppicing, with new shoots either being protected by the old stems or by the tangle of collapsed bushes. However a combination of coppicing and browsing may eliminate hazel but be harmless to holly. Given the greater value of holly over hazel as a winter fodder crop and the abundance of ungrazed hazel coppices elsewhere in south Hampshire this switch may have been encouraged. The dense under-scrub now typical of many New Forest woods may be a recent feature dating from the reduction in deer grazing after the 1851 Deer Removal Act. Pollen diagrams show the rise in holly to have been synchronous with the rise in beech (Flower 1977).

Holly occurs in two very different situations: it occurs in varying degrees of abundance with oak and beech in ancient primary woodlands, or as the dominant in low scrubby woodlands known locally as 'hats' with whitebeam, rowan, crab apple, yew and young oak as typical associates. These holly hats are mostly secondary woodland, relatively poor in epiphytic lichens, and lack a woodland ground flora.

Holly is an important part of the character of the Forest. Scattered trees provide a substrate to a nationally rare epiphytic lichen community (a species-rich variant of the *Graphidietum scriptae*), its flowers provide one of the few nectar sources for many woodland insects, and the browsing mammals of the forest are highly dependent on it as winter forage. *En mass*, however, the dense shade cast by the post-1851 holly thickets greatly reduces the ground flora and the epiphytic lichen flora. For the latter this increasing shade represents a more immediate threat than air pollution and several rare species are thought to have been lost from individual woods since the 1970s due to increased shade, such as *Pannaria conoplea* in Shave wood and *Catinaria grossa* in South Ocknell Wood. More may be lost if action is not taken soon. Existing good lichen trees may be shaded out by growing holly while many

trees otherwise suitable for colonisation by rare lichens will not be available because they are already in deep shade.

There is a growing consensus among lichenologists that active intervention is required if the internationally important lichen flora of the New Forest is not to suffer serious damage. This to some extent contradicts the conclusions of Flower & Tubbs (1982) that the New Forest pasture woodlands are 'near natural' and that a policy of non-intervention should be generally applied. Therefore some trials of holly cutting were initiated to investigate the problem.

Trial holly cutting

In the late 1980s the Forestry Commission re-cut a scatter of holly pollards and some maidens with very successful results in terms of regrowth. More extensive areas were cut during the winter of 1990/91 to provide browse for the commoner's ponies and help to conserve rare epiphytic lichen communities. The following criteria were observed during these trials:

1. The sites were chosen to represent a range of structural types of woodland as well as simply being areas where increasing shade was threatening rich lichen communities. The aims of both feeding ponies and opening up species-rich areas of woodland dictated the choice of sheltered low-lying sites.
2. All old pollards were re-cut, all maidens over about 10cm diameter were pollarded as high as was practicable, all hollies smaller than this were to be coppiced and finally all hollies within about 1m of mature trees were coppiced as a lichen conservation measure.
3. All hollies within the block were cut, to allow enough light in to the trunks of the old pollards. The area to be cut, however, was chosen so as not to be too large so as to avoid drastic drying out of the area treated. An area of about 30 x 30m was thought to be a reasonable size to start off with, while the maximum area which should be cut is probably 50 x 50m, the minimum area recommended for normal coppicing.
4. The cut material was simply left where it was felled as browse wood.

Using these criteria, five blocks were cut by the Forestry Commission on 23 February 1991:

1. The Knowles GR SU 26 08. An area of open beech wood with dense clusters of holly around the beeches. The holly was free of the tree canopy. The site contained a regressing *Lobaria pulmonaria* colony.
2. Woosens Hill GR SU 25 07. Only a small area around a rather shaded *Lobaria virens* colony on a beech was cut.
3. Anses Wood GR SU 22 12. An area under a closed oak-beech canopy by a glade was cut. The holly layer not very dense and was free of the canopy. Trees with base rich bark were present but had a low lichen cover although some poorly grown *Porina hibernica* (a RDB species) was present.
4. Bramble Hill GR SU 25 15. An area of old oaks with a low canopy into which a dense understorey of holly had grown. *Lobaria virens* was recorded in the vicinity in the past but no lichen species of interest were noted in the area cut.
5. Coalmeer Gutter GR SU 26 12. An area of beech wood with a completely closed canopy with dense understorey of holly next to a very lichen rich area but the species of interest were only found high up on the beeches above the holly within the block cut. The local old forest species *Phyllospora rosei* was found on a beech.

As well as the above sites several small areas of holly which were shading rare lichens were cut by hand.

Observations on the success of cutting

No systematic monitoring of the cut areas was carried out but notes were taken on their progress over the last year. The following observations are drawn from these notes:

1. The five sites cut by the Forestry Commission took two men one day to do. Predictably, sites with dense holly growing into the tree canopy are rather hard work with tall, free standing, less dense holly easiest.
2. Small quantities of holly branches hand cut in October remained uneaten, but also unshrivelled, until January when they were then rapidly consumed. The larger blocks cut by the Forestry Commission in February attracted ponies immediately; at one site a herd started browsing before the pollarding was finished. The cut material lasted about three weeks with over 20 ponies seen

browsing on another site at one time. Between 75% to 100% of the leaves and large quantities of bark were eaten. When freshly cut the brash looks a total mess but after the ponies have finished with it the remains more or less merge into the general litter of branches on the forest floor.

3. On pollards where one or more green branches were left, the green branches started growing in late April/early May at the same time as uncut bushes. Fully cut pollards showed no growth until mid to late June when epicormic buds break beside small 'knobs' on the bark. By the end of the summer well over 90% of the pollards supported new growth at all the sites. There is no obvious factor uniting all the failed pollards except all were youngish maidens before cutting. They were found in all types of light from fully open to deeply shaded. Nearly all of them, however, were not dead but had new shoots coppicing from the base and a lack of epicormic buds may be responsible for their failure to respond to pollarding. All chain-saw cut pollards were cut at about 2.1m above the browsing of ponies but some hand cut pollards were cut as low as 1.5m. These are regrowing as only the soft tips of the last season's shoots are eaten in the following winter.

4. The lichen response is most easily observed on the large foliose (leafy) lichens such as *Lobaria* species. At several sites (including site 1) *Lobaria pulmonaria* which had been showing signs of serious regression (no young growth and high levels of slug damage), recovered rapidly with between 5 to 10mm of new growth in the first year. At one site *Lobaria virens* has grown fruit initials since the colony was opened up. Crustose species also showed some visible response, with species such as *Thelopsis rubella*, *Pronia hibernica* and *Ramonia chrysophaea* appearing more vigorous. Also noticeable was extensive die back of the common liverwort *Mertzgeria furcata* which is a serious competitor with lichens in shaded situations.

Conclusions

The trial cutting of groups of holly confirmed that holly readily and vigorously responds to pollarding.

The failure to respond of a small number of pollards is of little concern in situations such as the New Forest where holly is abundant but suggests that leaving some green branches when cutting may be advisable where old holly pollards are a scarce resource.

The cutting of whole stands of holly proved to be much more effective for both providing pony browse and conserving species-rich lichen communities than the previous limited re-pollardings. The encouraging results of the trials suggest that the techniques used in these trials should be applied more widely in the New Forest. To be effective the holly cutting would have to be widespread. Areas of holly would be cut each winter in every unenclosed wood on the New Forest. In hard winters three of so areas would need to be cut in succession in large woodlands to maintain the food supply to which the ponies would have been accustomed. The result of this would be rather similar to the existing heather burning programme, which maintains a rotation of varied conditions both in terms of grazing quality and habitat diversity. Obviously a major obstacle to starting a fully blown holly cutting programme on the New Forest is the cost of the work. A balance between the resources available and the grazing and conservation benefits of an extended holly cutting programme will need to be found.

The views expressed in this note are those of the author and should not be attributed to any organisation.

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Some thoughts on the physiology of pollarding

by D. Patch

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When a tree grows it produces externally visible buds and dormant buds, both of which have their origin in the pith. The externally visible buds may flush while the dormant buds develop only so that they remain in the outer tissues of the wood. Control of these dormant buds is likely to be by auxins produced by the externally visible buds. Removal of this source of auxin by pollarding could stimulate the dormant buds into activity.

Repeated pollarding will remove these new shoots and stimulate more dormant buds into activity the growth from which would eventually be removed.

As there are a finite number of dormant buds in the trunk of a tree it is possible that repeated pruning will exhaust this type of meristematic tissue. At that time the tree will have to produce adventitious buds which have their origin in the cambium. This will inevitably take time and draw on the energy resources of the tree which in beech may be exhausted before new shoots appear.

A tree such as oak is likely to have a considerable number of dormant buds in the trunk whilst beech is less well endowed. As a result the two species are likely to respond differently to repeated pollarding.

The technique practised at Burnham Beeches of renewing pollards, but taking care to retain young tissue of the latest regrowth shoots, will ensure that there is a supply of dormant buds. As such regrowth should be "easier" for the tree and the delay in the renewal of the energy supply should be minimal.

If this hypothesis is correct the same will be true of repeatedly pollarded London planes for example. A number of comments have been made by arboriculturalists suggesting that London planes in some of the London Boroughs are going into decline. This appears to be where the trees are being heavily pollarded back to the bolting on a frequency of two to three years.



Plate 1. Beech at Loughton Camp, Epping Forest.

Pollarding success or failure; some principles to consider

Based on a letter from David Lonsdale,
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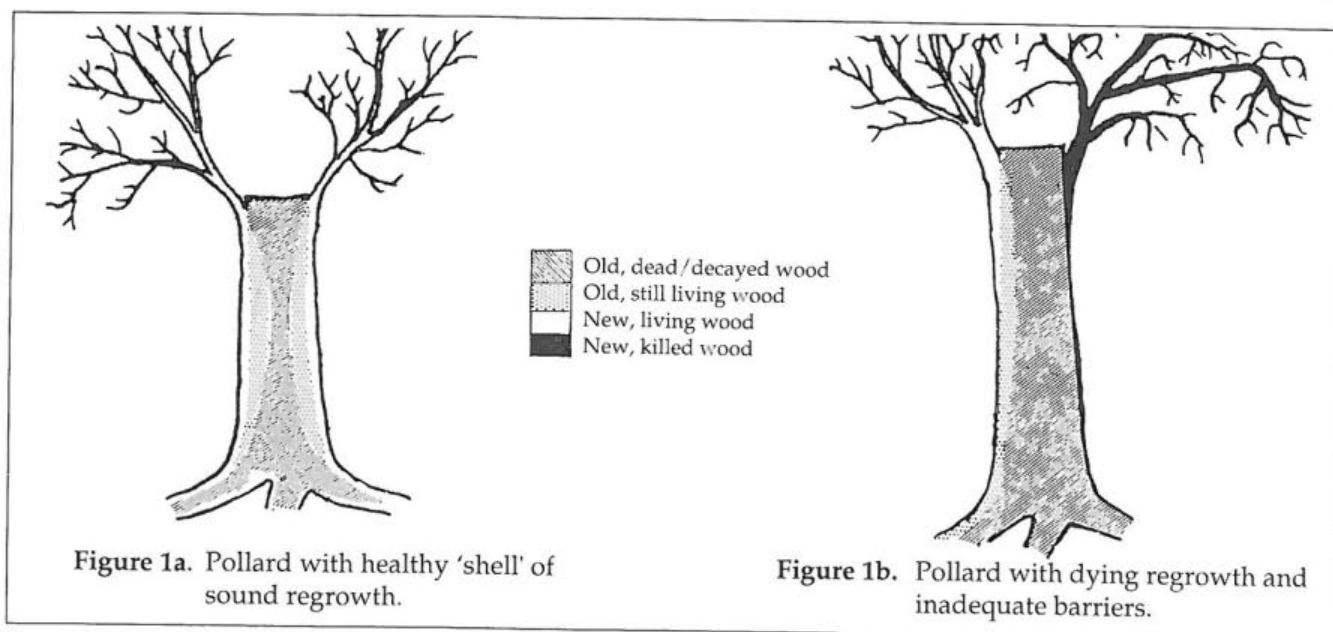
When a branch or a main stem is severed from a tree, several important things happen. These can be put into the following three main categories:

1. The exposure of wood, cambium and inner bark to infection by micro-organisms.
2. The alteration of the moisture and gas regime in the tissues which formerly lay within the transpirational flow of the part of the tree now severed.
3. A reduction in the supply of photosynthetic products and hormones which were previously produced by the severed part.

In different but inter-related ways, all three processes can lead to the death of all or part of the tree. First, exposure of tissues to microbial infection can initiate the development of disease or decay. Then, the growth of the disease or decay-causing micro-organisms may be encouraged by the alteration of the moisture content and aeration within those tissues now that they have lost their transpirational connections and have become exposed to the atmosphere. These tissues are, furthermore, deprived of the photosynthetic products which are needed to sustain life and to fuel the tree's active defences against microbial attack, a problem which is compounded by the disturbance of hormonal regulation previously exerted by the severed parts.

In general, the more severe a wound, the greater will be these deleterious effects, so that a treatment as drastic as pollarding can be extremely damaging. This may seem paradoxical in view of the undoubted ability of pollarded trees to survive to a greater age than normal for the species concerned. However, it is important to realise that, although the tissues present at the time of pollarding may be severely damaged, a tree can use its remaining resources of starch, mineral nutrients and water to initiate the growth of new tissues. These will later become photosynthetically independent and, being structurally separated from the tissues being invaded and occupied by the decay organisms, they can survive and grow to become, in effect, a new tree surrounding a dead or decaying centre (Figure 1a).

The relative immunity of new tissues to microbial invasion originating from an earlier trauma illustrates a very important principle, namely that the highly ordered structure of a tree directs and controls patterns of microbial invasion. Micro-organisms invade the tree most easily along lines of least resistance, e.g. the long and wide xylem vessels of broadleaved species. Penetration across cell walls is generally more difficult, and it is yet more difficult to cross the lines of demarcation between different types of tissue or between zones of incremental growth. Thus a tree contains many barriers, separating axial units such as twigs and their parent branches, as well as discrete units within the woody



cylinder such as adjacent annual rings. Except in dead tissues like heartwood and outermost bark, these barriers can be reinforced by defensive reactions which the living cells can mount against the invasion. As successive barriers give way to disease or decay, or to stress-related dieback, the damage develops in a series of steps, until either a 'permanent' barrier is reached, or the tree dies (Figure 1b).

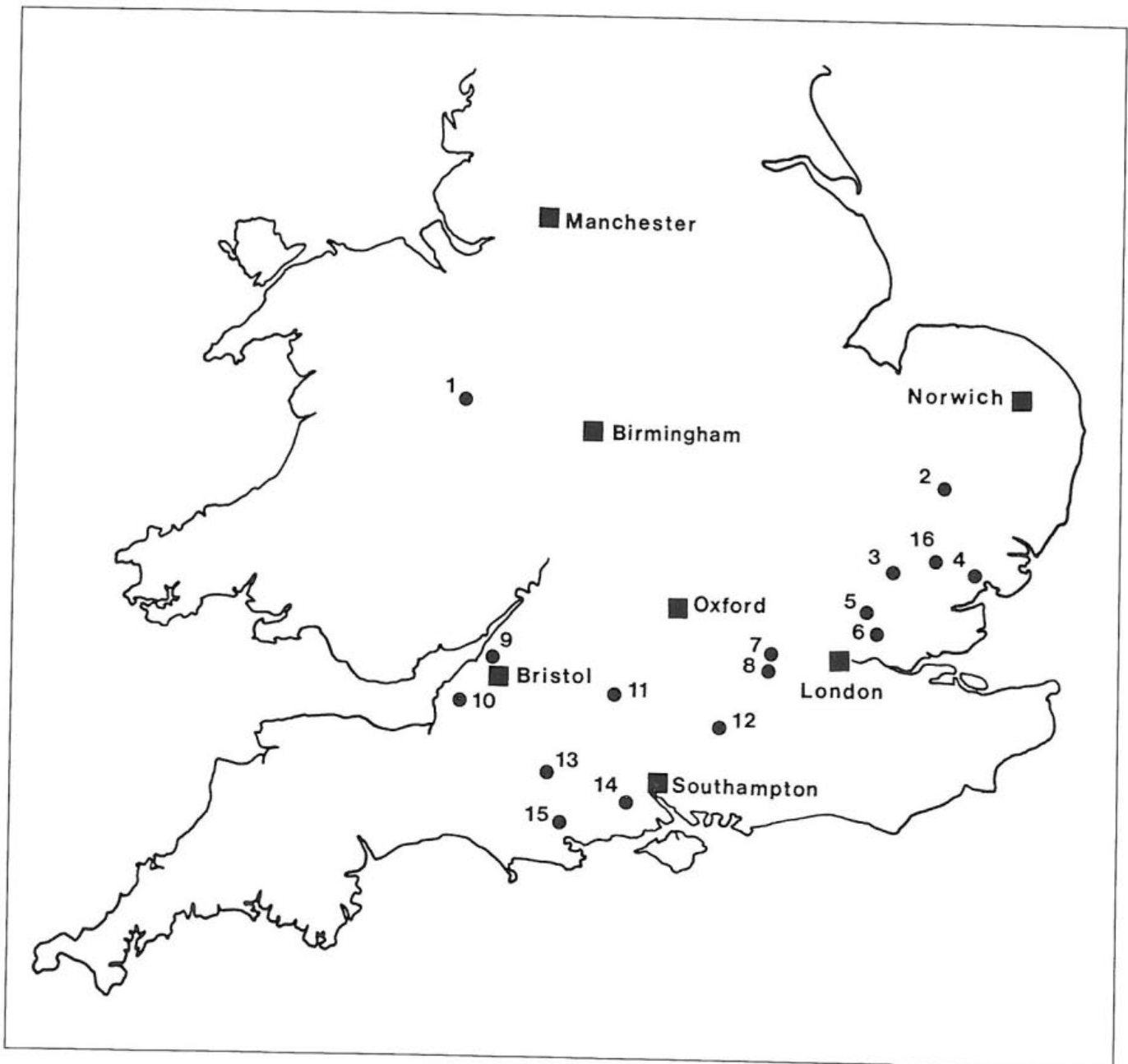
When a tree is pollarded or re-pollarded at the main stem (or very close to it), there is little chance for barriers within the existing tissue to function, and so the life of the tree depends very largely on its ability to form new growth, as I have explained. Also, the new growth needs to become independent of the existing tissues before these undergo inevitable dieback and microbial attack. Once the new aerial growth is producing enough photosynthetic product to support both root regeneration and the production of new wood in the main stem of the pollard, the survival of the 'new tree' is usually assured, and it may develop a structural complexity which can provide more barriers against disease and decay than would have been present in the non-pollarded tree. As for the decayed core, this becomes an ecological asset until eventually the new growth becomes heavy enough to pull the tree apart. These considerations can be translated into the following suggested guidelines, which are by no means tried and tested, nor exhaustive.

1. Where possible, leave some substantial living shoots on the tree when pollarding or re-pollarding, preferably leaving no major part of the circumference of the main stem without an obvious 'pipeline' to such shoots. This will help to sustain living channels within the existing sapwood and bark, and to supply the products of photosynthesis to the root system while new growth is developing.
2. In re-pollarding, do not cut below or very close to the previous pollard level. The cuts should preferably be made above side-branches of the re-growth, thus retaining living shoots or 'pipelines' - see guideline (1) above.
3. When cutting above a side-branch, make the angle of cut a 'mirror image' of that of the branch bark ridge, as explained in the arboricultural literature (e.g. "Urban Forestry Practice", Forestry Commission Handbook No. 5).
4. Avoid pollarding between the time of bud-burst and midsummer and during autumn and early winter. In the first period, starch reserves are depleted due to flushing, while in the second, the condition of the wood and cambium is at its most vulnerable to microbial attack.
5. Avoid pollarding during a drought year or in the following year, since the tree's starch reserves may be insufficient to sustain re-growth. Also drying of wood may cause rapid fungal invasion.
6. Be aware of the differing tolerance of tree species to pollarding. Species like beech, which do not form a true heartwood, are more likely to die back than those such as oak in which there is a decay-resistant heartwood, plus a substantial outer shell of living sapwood. Take especial care to follow Guidelines 1 and 2 when pollarding species which do not readily form adventitious buds.
7. Re-pollard trees before the re-growth becomes too heavy to be supported by the partly decayed parent stem.

Appendix 1

Map to show the location of sites mentioned in the text.

- | | |
|--|----------------------------------|
| 1. The Hollies - Shropshire | 9. Wildacre Wood - Avon |
| 2. Bradfield Woods - Suffolk (Coppice) | 10. Dolebury Warren - Avon |
| 3. Hatfield Forest - Essex | 11. Savernake Forest - Wiltshire |
| 4. Gernon Bushes - Essex | 12. Bins Wood - Hampshire |
| 5. Epping Forest - Essex | 13. Kingsettle - Dorset |
| 6. Hainault Forest - Essex | 14. The New Forest - Hampshire |
| 7. Burnham Beeches - Buckinghamshire | 15. Kingston Lacy - Dorset |
| 8. Windsor Forest - Berkshire | 16. Markshall - Essex |



Appendix 2

Map of Burnham Beeches to show areas visited during the meeting.

- A. Experimental area of young trees pollarded 1983-1990.
- B. Area of trees pollarded in the 1950s.
- C. Recently cleared area with trees pollarded in 1989-1990.

