Ancients of the Future

Managing veteran trees and dead wood for species

BACK FROM THE BRINK

Ancients of the Future

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The importance of ANCIENT TREES

Trees—including old trees—are vital for us, our landscape and wildlife. This document is intended to demonstrate this. Drawing on a huge breadth of information, and aiming at a wide audience, it presents the issues involved in looking after ancient and veteran trees, in particular. It offers an accessible introduction in how best to manage trees for all species and in the best possible way.

PETE HUGHES

1. PREFACE: THE IMPORTANCE OF ANCIENT TREES

This document is about old trees, the wildlife they support, why they are important, and how to look after them. It is intended to address a wide audience and to reach new ones that are not necessarily aware of all the issues involved but want to ensure they are managing trees for all species as best as they can. The most immediately important members of this audience are those people who own or manage trees which are already old, but anyone in a position to influence the fate and management of old trees matters. Ultimately, this means everyone, because all trees have the theoretical possibility of becoming old, and everyone can be involved, either practically or through the writing of letters, the signing of petitions, and commenting on proposed development plans, or simply supporting organisations involved in their maintenance.

Aiming at a wide audience inevitably means that not all parts of this document are directed at all of its members. Those seeking information about the management of a tree may seek no background information. This document isn't intended to be a detailed technical manual on management or a comprehensive synopsis of the ecology of old trees. Such resources already exist and are referenced where relevant or useful. This document aims to provide an introduction to the vast breadth of information on the wildlife and management of old trees, making it more accessible to a new and wider audience. We attempt to provide a story and a framework. The story is one of the past, present and potential future of old and ancient trees; the framework is the practical methods needed to maintain old trees and their associated wildlife and generate new ones in the best settings. The story has different versions and many sub-plots; the framework can be built on almost indefinitely and will expand and change with time as more methods and variations are tried.

This document pulls together work by many other authors to collate the breadth of material in one place and make it more readily available and accessible, whilst also acknowledging the importance of their original materials. There is a huge resource of information available on the subjects it covers, from simple information sheets to learned academic articles. A considerable amount of information is readily and freely available on the internet. What is written here draws very heavily on this existing information, especially from expert organisations such as Ancient Tree Forum (https://www.ancienttreeforum.org.uk/), VETcert project (https://www.vetcert.eu/home) and the Woodland Trust (https://www.woodlandtrust.org.uk/). The debt is acknowledged by referencing wherever possible. In cases where information is considered "general knowledge" within the field or draws on many references or resources, full referencing has been considered disruptive to the flow of the text and partial referencing misleading. References and suggestions for further reading are therefore by no means comprehensive but should point the reader in the direction of the most important and informative sources, most of which contain further relevant references that can be consulted if desired. The debt to others remains, even if not acknowledged in detail. The authors take full responsibility for any factual or other errors that may have occurred in the citation of literature references.

Two aspects of this document may require clarification. First, that it aims to provide "cross-taxa guidance"; and that it is, in part, about the conservation of particular species. Later sections will discuss the range of organisms that can be associated with old trees. For the moment, suffice it to say that they are numerous and diverse. No one can have detailed knowledge of all the organisms which inhabit, or might inhabit, an old tree, and certainly not of all their habitat requirements. People's experience and training does not necessarily lead them in the direction of such broad understanding. A bat worker, for example, with training driven by legislative requirements rather than commonality of habitats, may be more familiar with Great Crested Newts than with the invertebrates that share bats' nooks and crannies in old trees; and a lichenologist may be more familiar with rock-faces and gravestones than the dark interiors of hollow trees. It is possible, however, for each person involved with old trees to be at least broadly aware of the range of organisms that there might be and what they might need. This can bring considerable benefits in, for example, the recognition of unrecorded potential and of possible conflicts of interest between different groups.

Though all biological conservation is ultimately about species, the general expectation is that management is aimed at habitats and that benefits to species will result. The doctrine of "spaces not species" is well-established and remains sound. Management for individual species is usually a sign of either desperation or legislation. The two are not independent, and both operate here, but it is desperation that is the more important to consider. Some species are so imminently threated that their future cannot be guaranteed without species-specific intervention. This extends, in some cases, to the creation of artificial habitats: this teeters towards the brink of captive breeding programmes, the ultimate act of desperation, and must be a short-term palliative. Such interventions matter. If species are not maintained, then ensuring the long-term presence of ancient trees may produce only film set habitats: convincing facades with no content behind the superficial appearance.

Necessarily, what follows is a very short and selective version of what could be written. Ancient trees are rare, culturally important and of high value for wildlife. Historically, there were more of them. There is good reason to believe that they were even more frequent prehistorically. If they and their wildlife are to be maintained, effort needs to be put into keeping those that remain alive and well. In the longer term, management of trees and the wider environment must be directed to increasing the stock of ancient trees and ensuring that the current poor situation is merely a bottleneck, not a particularly well-recorded stage in a continuing decline. In principle, increasing the stock of ancient trees is simple—take a tree, make sure its surroundings are right, and wait. The wait can be long, because trees may take a very long time to become ancient; in the interim, for some associated species, the wait can be mitigated to some degree by artificially aging trees. These simple statements hide a plethora of detail: not least, "making sure its surroundings are right" encompasses most of terrestrial habitat management. Nonetheless, the principles are simple, and the main stumbling blocks to long-term success are, with tedious predictability, ignorance, greed and fear.

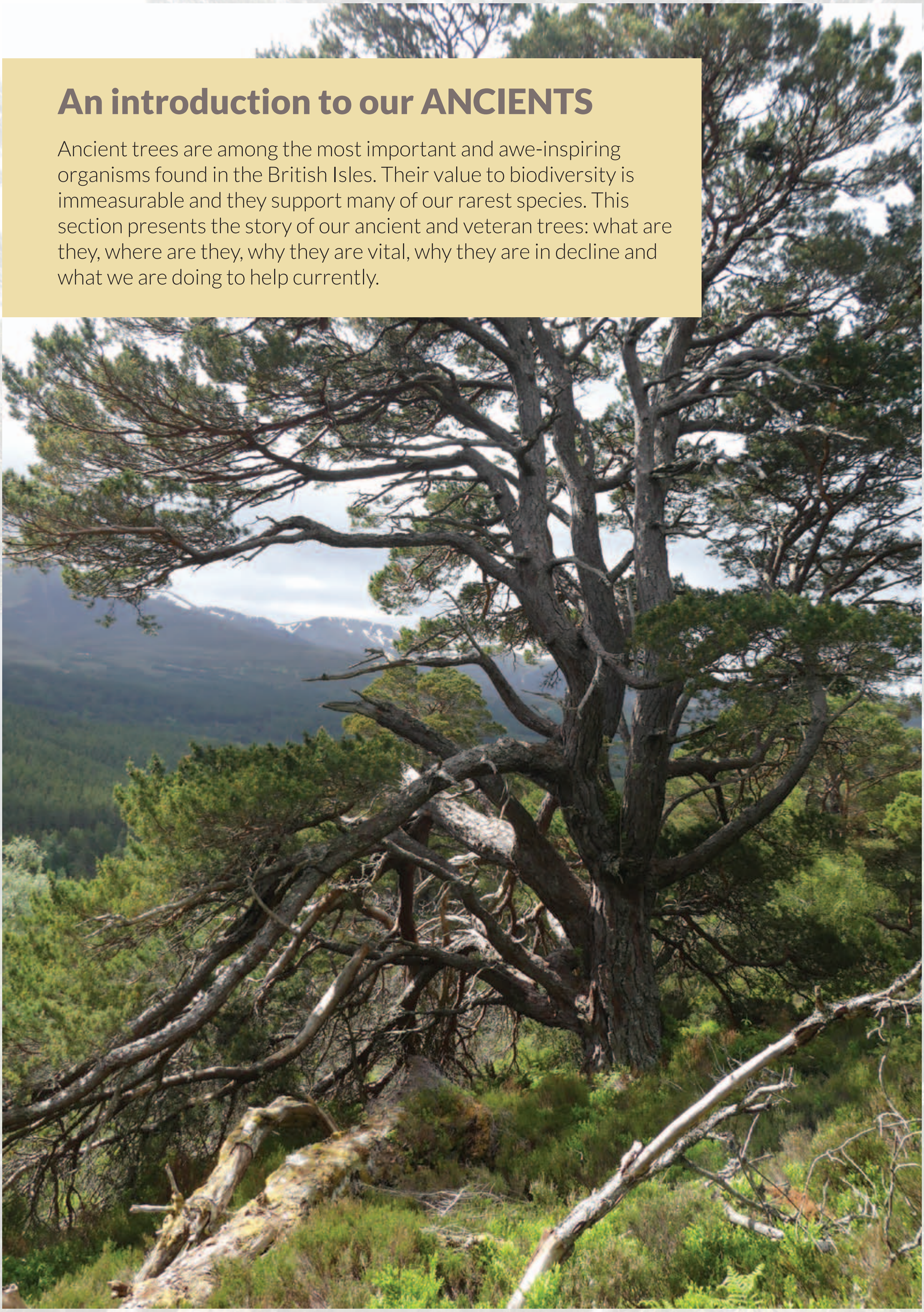
It will have escaped no one's attention that despite the promise that this document is about ancients and the future, paragraphs so far have more often used merely the word "old". It will become apparent that substantial parts are about the present, or at least about a future so immediate as to be effectively now. The commonest unit of time in conservation is possibly the five-year management plan. But the old and the now are necessary stepping stones to ancients and the future. The following paragraphs strain the subject matter still more by considering trees of all ages, their significance and their value.

References and further reading

- Ancient Tree Forum: https://www.ancienttreeforum.org.uk/.
- VETcert project: https://www.vetcert.eu/home.
- Woodland Trust: https://www.woodlandtrust.org.uk/.

An introduction to our ANCIENTS

Ancient trees are among the most important and awe-inspiring organisms found in the British Isles. Their value to biodiversity is immeasurable and they support many of our rarest species. This section presents the story of our ancient and veteran trees: what are they, where are they, why they are vital, why they are in decline and what we are doing to help currently.



PETE HUGHES

2. AN INTRODUCTION TO OUR ANCIENTS

This section is intended to provide an introduction to the story of ancient and other veteran trees in Britain. This story is a long and complex one and this will, necessarily, be only the briefest of tours. It will cover the importance of these trees, how they are defined, where they can be found, their importance to people and the reasons for their decline. It will conclude by discussing the current state of conservation efforts and the future potential for ancient trees in Britain. Little of this section can be considered essential reading but all of it will provide valuable context and reason for caring about the majestic organisms that are ancient trees.

The broad themes covered in this section are:

2.1 The value of trees
2.2 Defining ancient and other veteran trees
2.3 The state and importance of Britain's ancient and other veteran trees
2.4 Where do ancient and other veteran trees occur?
2.5 People and trees
2.6 Decline and fall
2.7 Holding the line
2.8 The future

2.1 The value of trees

Trees are of great value to wildlife, a recent tally suggested that native oaks, over the whole of the UK, support at least 2,300 species (https://www.actionoak.org/projects/purpose-uncovering-biodiversity-oak-trees). The figure is open to question, but all that matters for current purposes is that it is large. Oaks are generally considered outstanding in the number of species they support. A similar inventory of associated species for some tree species would seem disappointing, but trees such as willows, Beech, Ash and limes can also have a high diversity of associated species. A general rule across all tree species, though, is that they become more interesting and biodiverse with age. The oldest trees, the ancients, are amongst the most important and awe-inspiring organisms found in the British Isles. The value of such trees for biodiversity is difficult to overstate and they support many of Britain's rarest species.

It is true that there are species of insect, which need young growth, either of new seedlings and saplings or re-growth from cut stumps, and which rarely linger on more mature growth. But as the tree ages it develops more features and niches—for example flowers and seeds, more complexly structured bark, an internal microclimate as the crown enlarges—and this invites exploitation by a wider range of organisms. Plus, of course, more time means more opportunities for more species to colonise. It is when the tree gets old enough, or damaged enough, for decay to set in that the greatest increase in wildlife interest begins. The decay organisms themselves, the animals that feed on them and that use the hollows and spaces they create add greatly to the overall diversity of the assemblages they support. Saproxylic organisms—defined as species which depend, during some part of their life cycle, upon wounded or decaying woody material from living, weakened or dead trees—form an increasing proportion of associated organisms, and a disproportionate number of the rarer species fall into this category.

The process of improvement cannot go on for ever, and eventually the tree will be so reduced by age and wear that it begins to lose, rather than gain, niches and species. Until that point, though, ancient trees, as the oldest of the old, are the most likely to be important for wildlife.

That trees can be of great value for wildlife is unquestionable. However, in order to make good management decisions and maximise this value it is important to have realistic expectations and an understanding of situations where trees can be problematic. They are not universally good for wildlife, and their value can be exaggerated. As with all plants, the wrong tree in the wrong place is just a weed, and the fact that it may be a very large and long-lived weed serves only to make it more problematic. Uncontrolled colonisation by trees, or sometimes even the deliberate planting of trees, has done long-term or irreparable damage to many sites formerly of wildlife value. Some individual trees support species of great interest and rarity, but many do not and likely never will.

These statements are in no way intended to downplay the value of trees, especially old trees, to wildlife, but to highlight at an early stage that is important to encourage the right trees in the right places for the right reasons, and that simply throwing trees at a site without careful consideration, in the expectation that it will be good for wildlife, will often do more harm than good. Trees should not be considered a silver bullet for wildlife conservation but valued for the unique, specialised, and often rare species they support. Many of these specialist species require trees to grow old, and the older the tree the more important it tends to be. Simply aiming to have as many trees as is physically possible in a given area leads to short-lived and poorly structured trees with relatively little value to wildlife, particularly the specialist species associated with old trees. Careful management and planning to conserve existing old trees and encourage younger trees to reach old age and develop veteran features, or prematurely creating key habitat features in younger trees through veteranisation or novel conservation methods will be far more beneficial for key wildlife groups in the long term.

References and further reading

- Green, T. (2010). The importance of open-grown trees: From acorn to ancient. *British Wildlife*, 21(5).
- PuRpOsE: uncovering the biodiversity of oak trees: https://www.actionoak.org/projects/purpose-uncovering-biodiversity-oak-trees.

2.2 Defining ancient and other trees

It is important to give some definition of ancient and veteran trees at an early stage. There are no absolute and indisputable definitions of these categories of tree currently available, definitions that are widely used and generally accepted are given below. The exact definitions are the subject of ongoing discussion and are likely to be clarified further in the near future.

An ancient tree has been defined as "*a tree which has passed beyond maturity and is old, or aged, in comparison with other trees of the same species* (https://www.ancienttreeforum.org.uk/resources/ancient-tree-guides/what-are-ancient-veteran-and-other-trees-of-special-interest/)". This definition is both accurate and, of itself, somewhat vague. In practice, such trees are recognised by physical characteristics. In particular, they typically have very wide trunks, support a large amount of dead wood, and are often hollow. They are likely also to have reduced crowns, missing limbs, and, as a consequence of all these characteristics, an interesting, gnarled and careworn shape. This is a generally a consequence of the processes of ageing.

As trees age, they contain a gradually increasing volume of heartwood or ripewood, which at some point decays through the action of specialist heart-rot fungi, which hollow the tree. Oaks over 400 years old invariably have hollows. The trunk expands with age through the addition of new annual growth rings, but eventually reaches a point where the new rings can no longer adequately supply a high crown. The tree responds by reducing the upper crown in a process known as retrenchment. A new full crown may then develop at a lower height beneath the now dead upper branches in response to increased light levels. However imprecise the definition, candidates for ancient status are usually not hard to recognise, at least amongst long-lived trees.

Ancient trees are those that have passed beyond maturity and are old in comparison to trees of the same species

COLIN WILKINSON

The girth of the trunk is often a good indicator of the life stage of a tree. A useful chart illustrating this relationship for a range of important tree species can be found in the Ancient Tree Forum *Ancient Tree Guide no. 4: What are ancient, veteran and other trees of special interest*? https://www.ancienttreeforum.org.uk/resources/ancient-tree-guides/what-are-ancient-veteran-and-other-trees-of-special-interest/

A definition dependent on actual age can be inconvenient when the exact age of a tree is not often known. An ancient tree may not be of great girth if it has grown in difficult conditions.

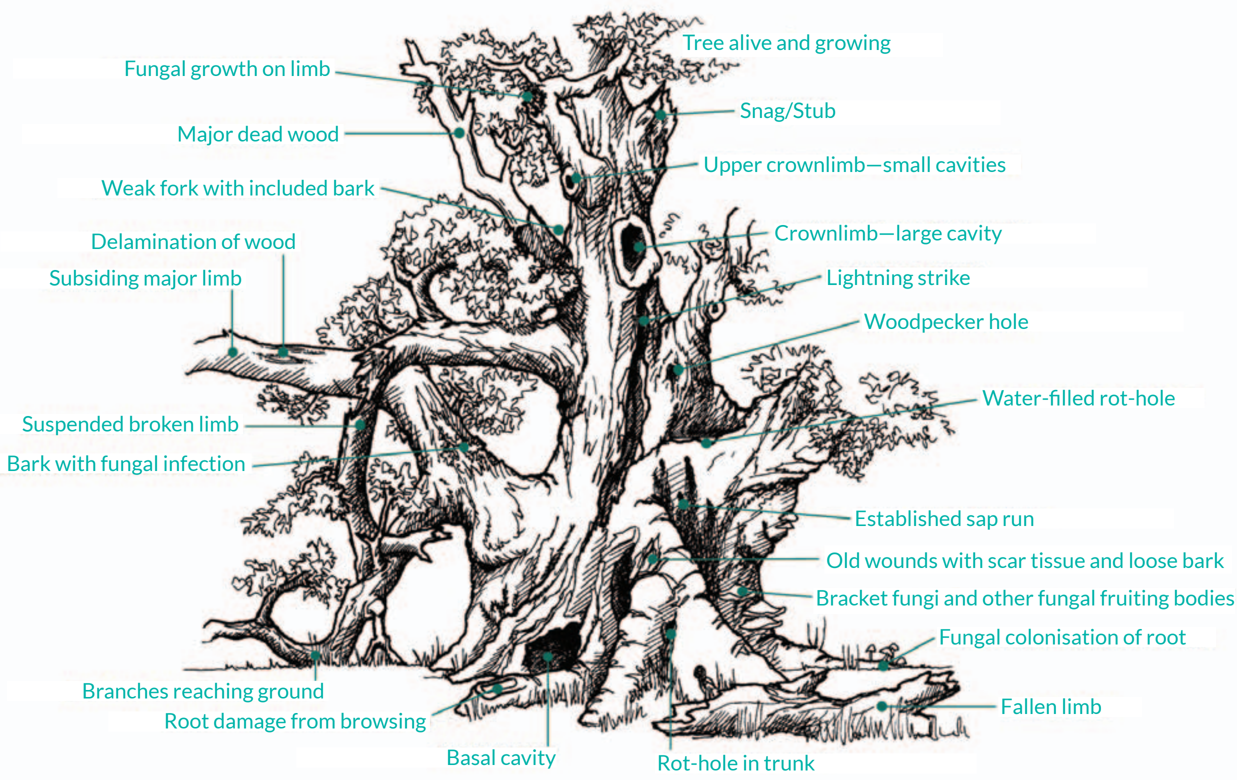
Veteran trees are trees which have many of the characteristics associated with great age, irrespective of the age of the tree. All ancient trees are veterans; not all veterans are ancient; though the two terms are sometimes used interchangeably. Trees which are old, but not ancient, may develop a large amount of dead wood and lose limbs and crowns though storms, lightning strikes and mechanical damage (more details here).

Some features genuinely take a long time to develop—bark chemistry changes over centuries, for example—and big trees are better able to support big features, but many features can develop on younger trees and be useful for wildlife. The advantage ancient trees have is that they are more likely to support more of such features at a larger scale and to have possessed them for longer.

A third category of tree is often recognised. "Notable" trees are usually mature trees which may stand out in the local environment because they are large in comparison with other trees around them, but lack any obvious veteran characteristics. Such trees may have potential in providing the next generation of veteran trees, and may be only a short time away from becoming so. However, the category is often extended to include trees which are relatively small and young but are significant in their local environment.

Different tree species vary greatly in the age at which they can be considered ancient, and at which they are likely to spontaneously develop veteran features. Though oaks may often live for a thousand years or more, Ash

AN 'IDEAL' VETERAN TREE FOR WILDLIFE



Key features of a veteran tree for wildlife from Read, H. (2000). Veteran Trees: A Guide to Good Management. English Nature, Peterborough.

rarely live beyond three hundred and can be considered ancient quite early in their third century. Many can be considered ancient at an age when an oak would not have reached maturity. Some caveats are, however, necessary here. Size may be more important than actual age in determining the value of an old tree for wildlife: some short-lived trees may become very large, and some trees are fundamentally small; and the life expectancy of trees varies greatly according to the circumstances, including altitude, geology, geography and management, in which they grow, so that usually short-lived trees have the potential to live to great age. In theory, most trees have no set lifespan, in practice the average ages reached in the absence of management or external calamity varies significantly between species (Table 1).

Table 1. Rough average life expectancies of some important tree species in Britain

Tree	Average lifespan
Yew	1,500
Native oaks	600
Sweet Chestnut	600
Sycamore	400
Limes	300–400
London Plane	>300
Horse Chestnut	300
Scots Pine	300
Beech	250
Field Maple	250
Hornbeam	250
Hawthorns	250
Walnut	>200
Ash	200
Elms	100–200
Alder	150
Poplars	50–100
Willows	50–100
Birches	60–90

References and further reading

- Ancient Tree Guide 4: What are ancient, veteran and other trees of special interest? https://www.ancienttreeforum.org.uk/resources/ancient-tree-guides/what-are-ancient-veteran-and-other-trees-of-special-interest/.
- Ancient Tree Forum definitions of ancient and other veteran trees: https://www.ancienttreeforum.org.uk/ancient-trees/what-are-ancient-veteran-trees/.
- Woodland Trust—Ancient Trees: https://www.woodlandtrust.org.uk/trees-woods-and-wildlife/british-trees/ancient-trees/.

2.3 The state and importance of Britain's ancient and other veteran trees

Britain is renowned for the number of ancient trees it contains. Ancient oaks tend to steal the limelight when the subject appears and provide the most readily obtainable facts and estimates. It must be kept in mind that many other tree species occur as important ancient trees in Britain, each with its own unique suite of characteristics and associated taxa. Recent estimates which put the number of oaks of Tudor or medieval age at around 3,400 (https://herbaria.plants.ox.ac.uk/bol/ancientoaksofengland/numbers), and the number of ancient, veteran and notable oak trees at 49,000 (https://www.actionoak.org/projects/oak-trees-did-you-know). These are impressive figures. They are also open to question, but might reasonably be taken as an indication of the order of magnitude of these populations. However, the total number of oak trees in the UK has been estimated at 121 million (https://www.actionoak.org/projects/oak-trees-did-you-know). Against such a total, the number of ancient trees is very small. It is remarkably so when it is borne in mind that any tree has at least the theoretical possibility of becoming ancient and that an oak tree may, on current definitions, be ancient for more than half its life. No such counts are available for other species of tree in Britain, but the overall pattern is certainly similar.

In a natural population of any species of tree, a reasonable proportion would be expected to be veterans or older. The exact proportion is unknown, such figures will vary between tree species and geographic locations and there are no genuinely natural populations of trees in Britain, or indeed north-west Europe to indicate exactly how a natural population would look. The number of ancient trees, of both oak and other species, is also declining. Some species associated with ancient trees are now confined to a handful of individual trees, or single sites, or both.

The international importance of the UK's ancient and veteran trees is not in doubt, but the size of the national resource is still far from fully known, not least because such trees are so widespread and so numerous. The Ancient Tree Inventory, operated by the Woodland Trust, has records of more than 122,000 ancient and veteran trees (Reid *et al.*, 2021), but a walk in almost any well-treed area of the lowlands will reveal more that have not been recorded, and many areas of land without public access, including parklands that bristle with substantial trees, remain unexamined. Epping Forest alone, admittedly one of the greatest concentrations of veteran trees in the UK, claims more than 50,000 veterans (https://news.cityoflondon.gov.uk/ancient-trees-celebrated-at-epping-forest/).

References and further reading

- Reid *et al.* (2021). State of the UK's Woods and Trees 2021. Woodland Trust. Download from: https://www.woodlandtrust.org.uk/state-of-uk-woods-and-trees/
- https://news.cityoflondon.gov.uk/ancient-trees-celebrated-at-epping-forest/.
- https://www.actionoak.org/projects/oak-trees-did-you-know.
- https://herbaria.plants.ox.ac.uk/bol/ancientoaksofengland/numbers

Key tree species with important ancients found in Britain include:

Alder	Horse Chestnut
Ash	Limes
Beech	Oaks
Elms	Scots Pine
Field Maple	Sweet Chestnut
Hawthorn	Willows
Hornbeam	Yew

2.4 The importance of habitat continuity

Just as great age can contribute to the interest of a tree allowing time for species to colonise, so it can contribute to the wider interest of a place or a landscape. The most important sites for ancient trees and their associated organisms are in places with a long history of habitat continuity. If the interest lies in long-lived trees such as oaks, there is a degree of inevitability in this. But the very best sites for ancient and veteran trees are those which can be traced back far into history and which may have had such trees continuously since it was first possible for them to appear. More than this, it must have had many of them: one or two trees will not maintain an entire assemblage of associated species.

The importance of age and continuity is increased by the fact that many of the species associated with ancient trees appear to be slow to colonise new sites, or sometimes even new trees. This is no doubt partly because some have very specialised niches which may themselves be rare, highly localised, or slow to develop. Certainly, some species can be confined to a very few trees even within a substantial population. It may also result from a lack of evolutionary pressure to disperse frequently or far. A single long-lived tree may provide stable habitat for centuries, and an associated species need only colonise a new tree once a century to not only survive, but spread. These characteristics mean that rare species can be easily lost from a site but may be unlikely to re-colonise or find a new one. The problem is progressively exacerbated as the species becomes rarer, because there are fewer individuals available for colonisation. The rarer a species becomes, the greater the chances of it becoming rarer. The best assemblages of wildlife associated with ancient trees, therefore, are found in places where there are large populations of old trees and which have had such trees for a long time.

References and further reading

- Alexander, K.N.A. (1999). The invertebrates of Britain's wood pastures. *British Wildlife*, 11(2).
- Woodland Trust Ancient Tree Guide 6—the special wildlife of trees: https://www.woodlandtrust.org.uk/trees-woods-and-wildlife/british-trees/.


PAUL RUTTER

Heavily shaded veteran tree in dense woodland

2.5 Where do ancient and other veteran trees occur?

In a game of word association, it is a reasonable bet that "tree" would produce the response "wood" on a large proportion of occasions. The two are so inextricably linked that a mention of tree-planting often brings an expectation of woodland even if none was intended. It is quite surprising that this is so, when even a brief visit to much of the countryside, and indeed towns, reveals a large number of trees which are far removed from woodland and have not even an historical connection with it.

"Woodland" is a remarkably poorly-defined term. Dictionary definitions include "*a habitat where trees are the dominant plant form*", "*land with a lot of trees*", "*land on which many trees grow*" and the marvellously unhelpful "*land covered with woods*". British and American usages are very different, which does not help. United Kingdom forestry statistics use a precise definition, of "*land under stands of trees with a canopy cover of at least 20% (or having the potential to achieve this), including integral open space and felled areas that are awaiting re-stocking*". The arbitrariness of this entirely pragmatic definition is emphasized by the fact that the cut-off point for canopy cover is raised to 25% in Northern Ireland. Any definition based on canopy cover must be arbitrary, because trees can occur at any density, so a definition merely draws a line in a continuum. But most people's mental image of a wood is probably of closely spaced trees with a continuous high canopy, perhaps with gaps for rides and occasional open spaces. This is far from an accurate image of the historical condition of most managed British woodland, but widely applicable to woods at present, whether ancient woods or recent plantations.

Dense woodland can be an important habitat for many species, but the interior of such woods is, in general, not a good place for an ancient tree. Traditional management of woodlands would not allow the survival of trees above ground into old age (though ancient woodlands may contain coppice stools of very great age indeed); and trees starting life in dense woodland are usually poorly structured, relatively short-lived, and develop few veteran features. Competition with neighbours means they grow rapidly upwards, with little low branching surviving the early years, and later retrenchment leaves little low growth to maintain the tree, which is immediately shaded by surrounding taller vegetation and liable to die quickly. The most ancient trees, and certainly the trees most valuable for wildlife, are open-grown, that is to say that they have developed without competition from neighbouring trees. They are shorter and more wide-spreading than trees that have grown within a closed canopy.


CHRIS KIRBY-LAMBERT

Open-grown ancient oak tree

Trees are ecological wild cards. They can grow in any habitat which is not under permanent deep water, on top of a mountain, profoundly saline or so unstable that any tree attempting to colonise is lost to oblivion as a sapling. They may respect ecological distinctions to the extent that different tree species are associated with different habitats, but there are rather few native British trees, the ecological tolerance of some is wide and people have moved, selected and concentrated them so extensively that natural patterns are often obscured or lost. This is as true of ancient trees as of any others. However, places that fulfil all the desirable characteristics of an important site for ancient trees—possessing many of them, in open-grown conditions, with long historical continuity—very often fall into the habitat category of wood pasture. Technically, this is a place where trees and large herbivores co-exist. This may have included much of the ancient landscape of Britain, arguably applies to most areas with many trees now, and includes a very broad range of tree densities and habitat structures. Critically important for current purposes, though, is a subset of places that were historically, and may still be, specifically managed both for growing trees and for grazing deer and livestock and have spaced trees in an otherwise largely open habitat.


ALEX HYDE/BACK FROM THE BRINK

Valuable old trees in wood pasture


KEITH ALEXANDER

Ancient trees with close neighbours

Old trees in wildlife-rich surroundings


PAUL BROCK

The name accurately reflects the dual purpose of such places, but includes places with a very wide range of characteristics. The trees may be on bracken-coated rocky slopes or in heathland as well as in grasslands, and tree cover can vary greatly. No definition of it is entirely satisfactory. The criterion used for Natural England's wood pasture is three trees within 250 metres of one another, but this is arbitrary and reflects only the need for a definition, not a structure which confers interest.

There is no ideal density of trees, except perhaps for a given species in a given place. A quite isolated ancient oak in a dry exposed position might support scarce beetles and lichens. A veteran Beech in a sheltered location would be more likely to support scarce saproxylic flies and fungi, and if grown in the exposed position of the oak would be more likely to die in a hot dry summer. With sufficient separation from others, there comes a point where a tree is just a tree, with no claim to be part of a tree-defined habitat; but the distance defining such a point for associated species varies according to their mobility. A reasonable preference for spacing might be that trees are, on average, sufficiently closely spaced to shelter one another, but sufficiently widely spaced not to unduly affect one another's growth form: but the spacing which achieves this will vary from place to place, and to adopt a "one-size-fits-all" approach would be disastrous.

The surroundings of a tree also matter. Ancient and veteran trees give the impression at least of being quite resilient to changes in their surroundings and may survive in heavily agricultural landscapes, improved grassland, or even in the middle of arable fields. But simplified and heavily improved landscapes diminish possible activities and food sources for associated species which leave the


JOHN SMITH

Old tree in a hedge, along a boundary

old tree either on a regular basis or for parts of their life cycles, and may cause eutrophication of bark and roots and likely shorten the life of the tree. The best sites have semi-natural vegetation on ground of low nutrient status between the trees.

The importance of wood pasture to the nation's stock of ancient and veteran trees should not blind us to the value of those in other habitats. Important populations of veteran trees are to be found in fens, on heathlands and along river valleys. In the latter case they are often willows. Groups of willows can be found scattered across fields as wood-pasture, but are more often in lines along watercourses or field boundaries. The number of willows may be large and the line long. Since willows develop veteran features relatively young there is a reasonable chance of long-term continuity and good age structure, and those along watercourses are well-placed to provide linkage between sites. Importantly, the rapid development of veteran features on willows means that age gaps are relatively easily filled and veteran-rich landscapes can be quickly re-created.

Traditional orchard


LAURIE JACKSON

Traditional orchards are a more intensively managed land use which can maintain veteran trees. Fruit trees are not generally very long-lived, but they can continue to be profitable well into old age, so veteran trees can be frequent. The maintenance of traditional orchards has been a subject of conservation concern for some time, and their management a topic in its own right.

There are also a great many veteran trees scattered across the countryside, often singly or in small groups or lines in hedges or around villages and more isolated habitations. Such scattered trees may be important: if they are remnants of a previously more extensive wood pasture or pollard system they may still have substantial interest; if they are close to a more extensive site they may share wildlife with it; if they are along a field boundary or road they may provide linkage or stepping stones between sites. Even if few or widely spaced, they may provide a viable assemblage of trees in themselves: though the rarer species associated with ancient trees are renowned for their immobility, and others are too sensitive to persist in an environment of farmed fields and roadsides, widely spaced trees may still share a mobile and tolerant wildlife assemblage.


LHOON (CC-BY-SA 2.0)

Line of willow pollards

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- Ancient Tree Forum trees and landscapes: https://www.ancienttreeforum.org.uk/ancient-trees/british-treescapes/.
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2.6 People and trees

The first permanent post-glacial settlements were probably close in time to the arrival of oaks and were long-established by the time now-familiar trees such as lime, Ash, Beech, Hornbeam and Field Maple appeared in the landscape. For people and trees, their post-glacial history as established species in these islands is not a particularly long one in absolute terms: an oak can live for more than a thousand years, so the entire history of the oak in Britain is that of no more than ten long-lived trees end to end; and even short-lived human beings can measure the time back to colonisation in only 400 generations. If, in imagination, one contemplates the telling of a tale by the old to the young, a mere 200 re-tellings could take us back to the first post-glacial person to stand on what is now Britain and decide to call it home. Through all this brief history, change has been continuous: sometimes slow, responding to changes in climate, the colonisation of new species and the decline and extinction of old residents, sometimes fast, and escalating in line with rapid man-made changes to the landscape; and for much of it, people and trees have profoundly influenced one another.

People have always had uses for the products of trees. From the earliest days, they would have been harvested for fruits and nuts, used as construction materials for dwellings, and to provide firewood for cooking, heating, lighting and protection. The early influence of low populations of hunter-gatherers on trees may have been limited, but evidence from around the world suggests that such groups can, over time, have much more influence on vegetation than might be expected, and we know that even in the Mesolithic hunters were at least managing the habitat of their quarry, creating clearings around water sources; and the more research that is done on these ancient people, the more complex is the cultural and ecological relationship with their surroundings that is revealed. Nonetheless, the influences of trees upon people may have been greater for a long time: especially, perhaps, the use of wood as fuel enabled or facilitated those two most quintessential of human activities: cooking and story-telling. The adoption of agriculture in the Neolithic saw the start of much more large-scale landscape change and management, with the clearance of land for agriculture and grazing and browsing livestock becoming an increasing influence on tree cover on uncultivated land.

For many years, there was a generally held view that an ancient prehistoric Britain was covered by woodland, the "wildwood", continuous except in the most inhospitable places, which was later reduced and fragmented by human clearance. Some still hold this view, but many lines of evidence, not least the presence in the British flora and fauna of many species which are intolerant of shade, and the prehistoric presence of aurochs, a species of wild cattle which lived in grassland, suggest that there have always been open habitats and that the most ancient British countryside may be better viewed as a mosaic of habitats and structures. The details can never be known, and it is futile to seek a "before" state against which to measure change. The countryside and its habitats have never reached a stable state and have never been without human influence. But at whatever point, and whatever the ratio of natural and human influences which determined it, it is a reasonable belief that there was at some point in this distant past a golden age for ancient trees, when the hand of man rested at most lightly on the land, when the age structure of tree populations approached a natural one, when most or all of our native tree species had been present for sufficiently long to reach old age, and when grazing and browsing animals maintained a habitat mosaic in which open-grown ancient trees abounded and their associated flora and fauna thrived.

Increase in the numbers and sophistication of people led to greater and more varied exploitation of trees. Fuel and construction materials remained the chief use, but the range of things being constructed increased, and once domesticated animals appeared in the human diet tree foliage was used as fodder. For millennia, trees were essential in providing basic human needs. Equally, though, for a long time they had to earn their keep. Before the agricultural revolution, agriculture was a sure way of reducing soil fertility, large areas of land were needed to support small populations, and woodland was constrained in area and managed very intensively. There would always be unmanaged trees in inaccessible or remote places—though there are surprisingly few of these in the long term; even places where people rarely ventured were often open to long-term change by flocks and herds of grazing and browsing livestock. Most of the surviving significant concentrations of old trees and are located in populated and accessible lowlands rather than remote highland areas.

For ancient trees to survive, and even to continue to develop, through such intensive use of the countryside requires either that they were still useful, or that they were conserved against change for reasons other than utility and profit. Both have happened.

The useful trees were overwhelmingly pollards. Pollarding involves cutting the tree, usually at a height of between two and four metres. New shoots grow, particularly at the point of cutting or bolling, and can be grown to

Pollarded trees

ROGER KEY

KNEPP WILDLAND

Deer park

provide a crop. Cropping from the bolling, usually at intervals of a few years but varying according to tree species and the use to which the cut material was put, avoids the destruction of the new growth by grazing animals. Foliage for fodder or crops of poles can be taken from such trees for centuries. Pollards can have great longevity and are often rich resources of ancient timber. Pollarding may extend the lives of naturally shorter-lived trees considerably. John Clare, in his poem "The Hollow Tree" describes an ancient pollard Ash with room inside its trunk for ten people to be seated comfortably, with room to spare. Such a tree would be very unlikely to arise without artificial extension of its life by pollarding. A large proportion of ancient and other veteran trees remaining in the UK were pollarded in the past, though many have not been managed for a long time.

Pollards were at one time incredibly widespread, and might be maintained by individual farms or even households for personal use. As a result, old, formerly pollarded trees can be found almost anywhere in the countryside, often in hedges or in the vicinity of old buildings. But it was on common land that the greatest concentrations of old pollards often survived. Large areas of common land contained no trees, or too few and too undistinguished to be of value, but where they did occur, and where commoners had the rights to graze livestock and to gather wood, they were frequently almost archetypally dual purpose. And the amount of common land was large, occupying millions of hectares in England and Wales. The traditional use of such commons created one form of time capsule which enabled the survival of old unimproved landscapes with ancient trees through at least the early years of agricultural improvement and sometimes to the present day.

A second sort of time capsule owes much to the Norman love of hunting. Royal Forests were established in the early years of Norman rule, and eventually covered very large areas of land. Though they had no necessary connection with trees of any sort, Forest Law controlled agriculture, the felling of trees and the killing of browsing animals within their boundaries, so conserved the landscape within their boundaries and favoured a wood pasture landscape, especially since some included large areas where commoners' rights ensured the continuation of pollarding. Much of the land formerly occupied by Royal Forests was deafforested long ago: the inconvenience of having, for example, the whole of Essex and Huntingdonshire under Forest Law was soon apparent, but they form the basis on which the survival of important sites such as the New Forest and Epping Forest has been assured.

Deer Parks formed the basis of smaller but more widespread time capsules. There were deer parks in Anglo-Saxon times, but it is in the period from the Norman conquest onwards that they became popular and numerous. The Domesday Book (1086) records thirty-five of them: by their peak, at the end of the 14th century, it has been estimated that they occupied 2% of the area of England. They were fenced or walled areas maintained purely for deer, for hunting, for the exclusive use of the landowner. They could be quite small or very large. A royal license was required to establish a deer park, and it could combine status symbol, food source and entertainment. Though deer parks declined in popularity and their number gradually diminished, some were given a new lease of life, and sometimes enlarged when landscaping became popular in the 18th century. In the more purely ornamental parks which resulted, deer became optional.

In one form or another, many such parks still survive, at least as remnants, and are a rich source of ancient and veteran trees. They are on land which was enclosed at a time when the countryside was relatively rich in old trees, have been in place long enough for the aging of more trees, and deer browsing and management, at least in their traditional form, ensured that wood-pasture predominated.

The rise of landscaped ornamental parkland is the largest-scale expression of appreciation of wood-pasture, or more generally of spaced trees in an otherwise open landscape, as things of beauty. That they are still widely appreciated as being so is clear. Parklands which have passed into public or conservation ownership, or where public access is permitted, are well-visited; recreation has replaced or overwhelmed grazing and pollarding as a public use for some large areas of common land; urban parks, of whatever scale and whatever age, imitate the parks of stately homes in their open-grown trees and managed grassland; and even golf courses tend to aim for the same landscape values. It has been suggested that the love of such landscapes is deep-rooted, and has its origins in their structural similarity to the savannah landscapes in which modern man evolved. This can only be speculative, but, whatever its origins, it is a useful factor in ensuring the preservation of the landscape type.

PAUL HEHTERINGTON

Urban park

White Road Oak, Savernake Forest

BRIAN ROBERT MARSHALL (CC-BY-SA 2.0)

The appreciation of ancient trees goes hand-in hand with the appreciation of the landscapes in which they grow, but extends to appreciation, or admiration, of them as individuals. The varied and very particular shapes of ancient trees invite consideration of them as individuals, or indeed personalities. The large number of named trees, some of these names dating back centuries, bears witness to this individual identification. The recognition and preservation of such trees has sometimes been for purely practical purposes: easily identifiable trees make useful boundary markers or meeting places. But many trees are appreciated for their own sakes, and some are well-known nationally. Of the 350,000 visitors annually to Sherwood Forest, 88% visit the Major Oak, for example (2015 figures).

The hugely complex history of land ownership and management in Britain, coupled with the impacts of wars, plagues, weather and disease, mean that the trees on any reasonably large site are likely to have had at least a mildly chequered history. The detailed history of some is astonishingly so. The character of sites as they reach us now may have been profoundly altered by single chance events: a catastrophic storm, or the predilections of a particular landowner. Though the small number of important sites and ancient trees is a source of regret and concern, it is in some ways astonishing that any single tree has managed to survive even a few centuries against this shifting backdrop of events and trends. And these varied influences add to variety. Any site worthy of conservation is unique in its particular combination of location, soil, intrinsic and surrounding features, and very old sites are likely to be particularly so; the overlay of cultural influences on the trees stretches this individuality further still.

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2.7 Decline and fall

In absolute numerical terms, ancient trees have probably been in general decline due to human activity since the Neolithic. But there were still plenty of them, widespread and often in large groups, in the Middle Ages and beyond, albeit that many of these were now managed pollards. By the late 18th century the seeds of more serious decline were sown and the 19th century witnessed dramatic decline as land use changed. Many deer parks were converted to more profitable use; Enclosure Acts removed huge areas of common land and usually the trees that had been part of it; wood-pasture was increasingly seen as an inefficient land use; traditional tree management for small diameter wood, notably including pollarding, declined in favour of silviculture and timber production, and the character of much of the countryside changed.

By 1879, John Carrington, in one of a series of articles in "The Entomologist" describing "localities for beginners" felt the need to forewarn visitors to part of Epping Forest of "*the curious appearance of the trees. Years upon years of "lopping and topping", one of the hardly contested rights of certain commoners, have caused them to grow rather into thick bushes upon tree trunks rather than into the wide-spreading shady trees of other counties.*" What had been routine management had become a curiosity. The warning was scarcely necessary: the commoners rights were removed by the Epping Forest Act of 1878. It would be more than a century before pollarding began again.

Wood pasture which is not actively maintained can be lost through either of two fates. If grazing continues at too high an intensity, then the number of trees will decline until only the pasture is left; if it is not grazed then scrub and secondary woodland invade, shading the old trees and reducing their life expectancy. In either scenario, there is a lack of open-grown trees to provide the next generation of ancients. If, when the ancient trees finally die, there are no other trees old enough to support their specialist fauna and flora, it will be lost. The problem is exacerbated if the trees are pollards. If the branches grow large, then the ancient trunk may be unable to support the weight and the trees may tear themselves apart and be lost well before their time. Managing lapsed pollards to prolong their lives is a difficult and sometimes unpredictable process. The number of ancient and veteran trees is known to be in decline even in sites which are specifically being managed for their conservation.

Lapsed and top-heavy pollard

KEITH ALEXANDER

The decline of ancient and veteran trees in traditional wood-pasture is mirrored in the wider landscape. Those left are mostly survivors from a very different landscape, and in the absence of any economic benefit have not been conserved or replaced. Where they remain, there is often a large age gap between them and other trees; at an extreme there may be no other trees at all. While the area of woodland in the UK has increased, and continues to increase through planting, the number of trees outside woodland has been declining for some time.

Ancient and veteran trees have faced other threats through the twentieth and 21st century. Tree diseases have already had a major impact and are likely to have more. Dutch Elm Disease wiped out an estimated 25 million trees by the end of the 1970s, including almost all veteran and ancient elms. Ash Dieback is currently a major concern, though its eventual impacts are uncertain. Oaks are affected by Acute Oak Decline, Chronic Oak Decline, and Sudden Oak Death, lethal fungal infections have increased in Sweet Chestnut and Alder, and there are doubtless many others yet to appear or to increase.

The likely scale of the impact of climate change is an unknown quantity, but there is no doubt that it will affect trees. The long-term changes are a matter of conjecture, and may be slow to be felt, but in the short term it is likely to be the increase in extreme weather conditions, long predicted and already manifest, which will bring the greatest concerns. A single prolonged spell of extreme weather can have a great effect. The drought of 1976 killed many trees, with Beeches proving especially susceptible to hot dry conditions. Even if they do not die, old trees may be stressed by such extremes, and stressed trees are more vulnerable to disease.

Development pressures of one sort or another have resulted in losses of ancient and veteran trees for a very long time, and the losses continue. Often the losses are of only one or a few veteran trees, and may seem individually unimportant, but they gradually deplete the nation's stock and even a few trees may be a significant proportion of those in a local area. Ancient or veteran trees may sometimes be incorporated into developments, either for their own sake or as decorative features, but when this happens, they are all too often left isolated, and potential replacement trees of a younger generation may be removed.


CHRIS KIRBY-LAMBERT

Isolated ancient oak tree within a development

Safety considerations add a final layer of very modern threat. Insurance requirements, legislation and the potential costs of litigation and compensation mean local authorities in particular, and to a variable extent other landowners, with trees near routes and places with public access, often take a zero-risk approach to tree management. Even a brief examination of websites claiming to list features by which a dangerous tree might be identified will show that these coincide to a remarkable degree with those used to identify veteran trees and which are important to biodiversity. Many veteran trees which are innocuous, or could be rendered safe with light intervention, are being lost because of safety concerns. Perhaps a more worrying and insidious danger, though, is that such a cautious approach may prevent the development of future generations of veterans, if trees are removed at the first signs of damage and decay.

Tree surgery in action: tip-pruning of ancient Ash pollard


KEITH ALEXANDER

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2.8 Holding the line

Googling "ancient trees" in the spring of 2021 produced 370 million results; "ancient trees UK" 57,300,000. It is admittedly surprising how many firms with no practical involvement with trees manage to have these two words in their names or publicity material, but even allowing for such quirks, this is an impressive total. Pages—sometimes many pages—can be found devoted to ancient and veteran trees on the websites of national conservation organisations, national parks, of many individual sites and small organisations with responsibility for old trees, and for various organisations devoted specifically to trees. The Ancient Trees Forum is a charity solely concerned with them.

Ancient trees, then, are a far from neglected topic. Indeed, in producing this overview of the subject, the sheer plethora of existing information and advice has been one of the major stumbling blocks to manufacturing a document which does not merely parrot information which is available elsewhere, often in more detail and with greater accuracy. It might be hoped that with such interest in ancient trees, in a nation that loves trees, and in a political environment that promotes trees as a weapon in the battle against global warming, all would be well. But ancient trees are declining, no laws specifically protect them, misinformation and superficial thinking abounds, and the seemingly inexorable increase in tree cover is so often of the wrong trees in the wrong places for the wrong reasons and at the wrong density.

But there are reasons to be positive. Neglected wood pastures are being restored, and it is nowadays an expectation that such restoration will be part of the management of any neglected wood pasture that comes into the ownership of a conservation organisation. The long-term aim of a programme to maintain the ancient trees and their wildlife should be to maintain existing sites, to adopt measures to maintain their associated wildlife, especially its rarest species, through any bottleneck caused by poor continuity, to increase the number of sites containing substantial populations of ancient trees, and to link those sites by a network of old and ancient trees within the wider countryside. It must necessarily be a long-term plan, but any plan involving ancient trees must be long-term, and all these things are doable within the scope of things that are happening now.

The effort to maintain the existing stock of ancient and veteran trees and to minimise the age gap—and more importantly, the habitat gap—between them means that much emphasis is placed on intervention and determined management, even micro-management, of the available resource, even to the extent of bridging the gap between generations using artificial habitats. Much of the management section of this document is devoted to ways of doing this. If this can be achieved on conservation sites, the chief remaining difficulties are that not all ancient and veteran trees are the responsibility of people who care; that even if they are, pragmatic or monetary considerations may override the need for care; and that the general trend of the countryside seems still to be towards concentration of trees in dense woodland.

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2.9 The future

It is possible, of course, simply to envisage a future in which attempts to maintain existing old trees fail, the age gap is not successfully bridged, and possible future generations are so plagued by intensification of the issues they face today that no more develop. There seems little practical point in considering this scenario. Instead, this section considers the possibilities of a rather brighter future and seeks to provide reasons that it might come to pass and guidance to help it.

Maintaining the existing legacy of ancient and veteran trees and ensuring the development of replacements requires considerable time, effort and skill. But it need not continue to do so indefinitely. Ancient trees and their associated flora and fauna are obviously not dependent on such interventions and management: they did not evolve in such conditions. If the current bottleneck can be passed successfully, all that is needed—at a minimum—in the very long term is that trees establish and grow in open-grown conditions and are allowed to remain, with a minimum of interference, into old age. This will require a more widespread and detailed knowledge of trees and their associated wildlife, and hopefully a more enlightened attitude to their management and the risks they pose, but these are not unreasonable things to hope for. There may sometimes be good cultural reasons to maintain management, but in the long term the hope must be that intervention can be relaxed and future generations of trees allowed to age naturally.

There are many trees in the countryside which are reasonably old and increasing numbers which could become so. Admittedly, much modern tree-planting is of dense plantations of slight wildlife value and unsuited to the eventual production of valuable veteran and ancient trees, tree-planting is probably at the moment more harmful than beneficial to wildlife, but there is also enlightened tree planting and increasing examples of tree establishment through natural processes.

Though development can destroy ancient trees, it can also enclose areas of countryside and protect them from intensive agriculture, as has historically conspicuously happened in and around London, and new parklands, or park-like recreation areas, provide opportunities for the establishment of open-grown trees, albeit that any potential they have for high value lies long in the future and depends on sympathetic treatment by users and managers.

Stress and disease which does not kill trees may create habitat for other organisms and hasten the development of veteran characteristics, and if a small fraction of trees are killed this will provide habitat for saproxylic species.

Good tree planting at Repton Park

KNEPP WILDLAND

Ash Dieback has improved the structure of many recent plantations; and sooty bark disease of Sycamore, though it could become more problematical if climate change brings hot dry summers, usually kills only a small fraction of Sycamores in an area and supports a specialist beetle fauna.

However, whilst the loss of trees to disease may lead to improvements in habitat structure, in the short term at least, there is no doubt that it could have serious and fundamental impacts on species and our 'treescape', as with the loss of elm to Dutch Elm Disease in the latter 20th century. Ash Dieback poses a serious threat to many species for which Ash is their only or main habitat, including the Violet Click Beetle (*Limoniscus violaceus*), and lichens such as Fragrant Jelly-lichen (*Scytinium fragrans*). Ironically, Ash is now the main habitat for a number of threatened lichen species that were formerly elm specialists. Any disease affecting oak in a similar manner would be even more devastating for both wildlife and landscape.

There is considerable interest at the moment in agroforestry, which though not necessarily an obvious source of ancient trees in itself, may at least go some way to reversing the decline of non-woodland trees and change people's expectations of the farmed landscape.

Re-wilding is becoming an increasingly fashionable topic and is used to cover a rather wide range of management changes in the countryside. In its purest form it involves a landscape-scale shift to more natural processes and potentially a return to the sort of large-scale habitat mosaic in which ancient trees and their associated faunas first developed. The rapid changes involved in re-wilding may present many short-term challenges for ancient and other veteran trees, but, in the long term, and at a large scale, the potential benefits for the wildlife associated with ancient trees is huge. Further discussion of re-wilding can be found here.

Re-wilded place

KNEPP WILDLAND

Increasing deer numbers can be a matter of concern to managers of traditional ancient woodlands because they can depress regeneration, damage the shrub layer and reduce the diversity and abundance of characteristic woodland herbs. However, deer browsing and grazing can produce more open-structured woodland which in plantation and secondary woodland can beneficial, and they can maintain existing open conditions as in parkland and wood pasture where they can be the key herbivore. As with many things it is a case of managing for whatever populations are appropriate.

Estimates of the number of species of trees native to Britain vary quite widely, depending on where the borderline is placed for "tree", but an optimistic estimate would place it at around 60, of which some 35 might be regarded as widespread and reasonably frequent. This is not a large number. In any given area of Britain, the number of frequent species would inevitably be smaller. Such limited numbers make the number of trees, and the flora and fauna associated with them, liable to be greatly affected by species-specific diseases and pests or by climate change.

It is widely, if sometimes grudgingly, accepted that the flora and fauna of Britain not only will change in the face of climate change, but must change. Trees are in some ways ahead of the curve: very many species have been introduced. Street trees in London include over three hundred species and cultivars; some large arboreta contain over 500 species, and the total number of tree species in Britain has been estimated at around 1700, albeit that many of these are extremely rare and likely to remain so.

Many of these introductions are decidedly ornamental, small, or short-lived and have little potential to contribute to our long-term supply of ancients. But others are substantial and have proved their potential: Walnut was introduced in Roman times, is increasing by natural regeneration in the countryside, and is a subject of interest in agroforestry circles, so is in a good position to make a contribution, indeed it is known to support the Sap-groove Lichen (*Bellicidia incompta*). Evergreen Oak has been in Britain since the 16th century. The original trees grown from introduced acorns are still alive, and there are self-sown Evergreen Oak woodlands. These oaks seem as long-lived as the native British species and support rare and threatened lichen species such as Southern Grey Physcia (*Physcia tribacioides*) and could become valuable contributors to the long-term stock of ancient trees. Horse Chestnut supports the only extant British population of the Western Wood-vase Hoverfly (*Myolepta potens*) at Moccas Park, where these trees also support a good population of the Sap-groove Lichen.

We do not know how useful most such species will be, because they have never been ancient in Britain. They may or may not be as good as native trees at supporting our current range of flora and fauna; but that flora and

Veteran introduced Walnut tree, Dorset

fauna is itself changing. Twelve recent issues of "The Coleopterist" included articles adding fourteen species to the British beetle list. Of these, six were saproxylic. This is a small sample number, but it is nonetheless worth noting that the proportion of saproxylics amongst the new arrivals (42.9%) is substantially higher than the proportion in the pre-existing fauna (16.95%). It is a small change in the national fauna, but these additions were made over only three years. It is scarcely feasible that saproxylic beetles will continue to be added to the British list at the rate of two a year for the next millennium, but it is possible that the ancients of the future will support an assemblage of species that a naturalist of the early 21st century would find bewildering.

Recent additions to saproxylic species extend to vertebrates. The hole-nesting Ring-necked Parakeet (*Psittacula krameria*), much attached to veteran trees, is now a common species in South East England, and is still expanding its range in the UK. Concern has been expressed as to its possible impact on native hole-nesting birds and bats which it often out-competes for nesting space, and it will surely also affect invertebrate assemblages associated with nest debris in tree cavities. The sheer numbers of birds involved make it possible that the effect on this assemblage will be both substantial and positive due to increased inputs of debris. Further tree-associated additions to the vertebrate fauna are possible and their influence potentially interesting, though whether they will be permitted to establish is uncertain.

If the past is a foreign country, the distant future is far more so. An ancient oak tree now, still an important tree with a rich associated flora and fauna, may have germinated at around the time of the Norman Conquest. A chain-mailed soldier awaiting the arrival of wooden sailing ships on the south coast in 1066, if asked about the likely state of the British countryside in the early 21st century, is unlikely to have guessed correctly. Writers who have attempted to extend the timeline of the development of humanity and the earth over the next thousand years, the end of which would meet the old age of an oak tree putting down its first roots now, have come up with possibilities ranging from a post-apocalyptic wasteland devoid of metazoic life to a benevolent pan-galactic civilization terraforming new worlds and taking earth's life to distant stars. It is perhaps disconcerting that the latter assumes considerable technological and social developments, while the former is already achievable. It is likely that none of the plethora of possibilities suggested will prove correct. What is certain is that ancient trees will still have the potential to be important for wildlife. The ecological fundamentals which determine this will not be subject to substantial change over such a geologically trivial time period.

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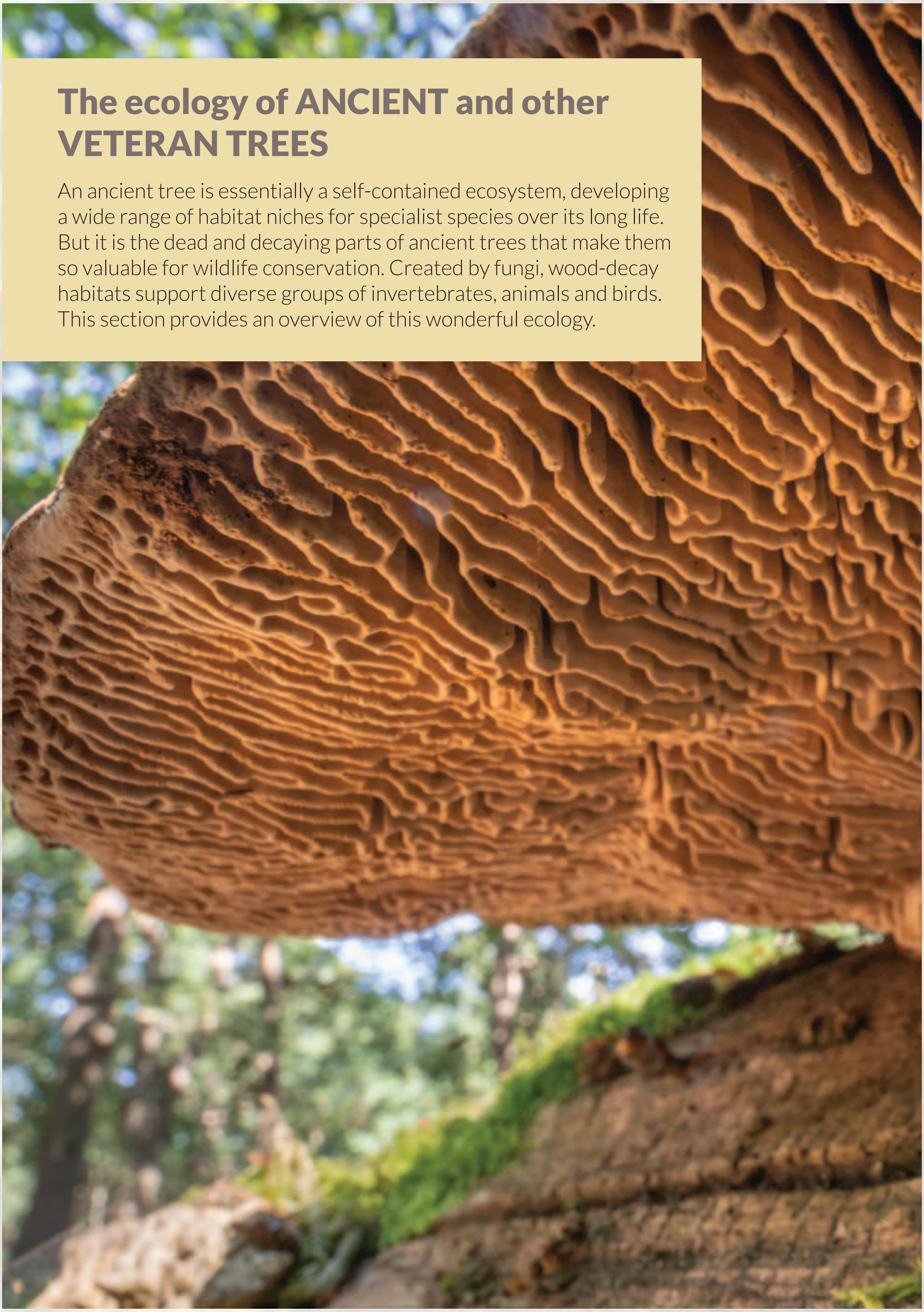
The ecology of ANCIENT and other VETERAN TREES

An ancient tree is essentially a self-contained ecosystem, developing a wide range of habitat niches for specialist species over its long life. But it is the dead and decaying parts of ancient trees that make them so valuable for wildlife conservation. Created by fungi, wood-decay habitats support diverse groups of invertebrates, animals and birds. This section provides an overview of this wonderful ecology.



ALEX HYDE/BACK FROM THE BRINK Oak Mazegill (*Daedalea quercina*)

3. THE ECOLOGY OF ANCIENT AND OTHER VETERAN TREES

This part of the document provides an overview of the ecology of ancient and other veteran trees. A single ancient or other veteran tree can be considered as a largely self-contained ecosystem providing a wide range of habitat niches. The healthy living parts of old trees provide the same habitat niches as any younger tree, although often with additional unique chemical or physical characteristics. The living parts of ancient and other veteran trees therefore support specialist species assemblages, particularly epiphytes on the bark. Old trees have also had more time to form associations with a wide range of organisms associated with the living tree than young ones, this can be very important in the development of large associated flora, fauna and fungal assemblages of conservation importance.

Whilst the living parts of old trees are important, and often unique, most of the features of ancient and other veteran trees that make them so valuable and irreplaceable for wildlife conservation are created through the processes of wood decay. Wood decay is a natural part of the ageing process of trees and, until final decline and death, the larger and older the tree is the greater the diversity of wood-decay habitat niches provided. These wood-decay habitats are created through the actions of fungi, many of which can be considered keystone species in the ecosystem of an ancient or other veteran tree. Some of these species are rare themselves, closely tied to particular species of tree and depend on them reaching old age. They then support large and diverse assemblages of invertebrates, including a great many rare species, and vertebrates such as bats and birds that utilise the physical features created by this decay.

The broad themes covered in this section are:

3.1 The living tree

Though much of the character of ancient trees stems from the loss, death or decay of various of their parts, and much of the wildlife interest they support derives from these processes, interest in the living, or undecayed, parts of the tree is often far from negligible. The living parts of a tree can be very broadly broken down into foliage, living wood, roots and bark. In most cases the habitat niches provided by the healthy parts of an old tree are no different to those provided by a younger tree. This is reflected in the low number of old tree specialists associated with healthy living material in most groups. Nevertheless, there are some cases where physical or chemical differences between old and young trees provide niches for specialist species. The age and large size of old trees also allows them to accumulate larger assemblages of associated species than younger trees with the same set of habitat niches.

3.1.1 Foliage

The foliage of old trees supports a significant number of associated organisms including bacteria, fungi and invertebrates. Many of these species are shared with the foliage of younger trees and so will not be discussed in this document. There are a limited number of species that are associated specifically with the foliage of old trees. The reasons for these specialist associations are often unclear. Structural or chemical differences between old and young trees may play a role, it may also be that such species require good habitat continuity which is provided by old trees and the sites they often occur in.

3.1.2 Roots

The healthy roots of most trees have mycorrhizal association with fungi. These fungi provide essential nutrients to the tree and are critical to their health. Ancient trees in unimproved habitats have had more opportunity to form mycorrhizal associations than most and often support rare and specialised species. Some boletes, for example, seem preferentially associated with ancient trees, though it is not always clear whether this is because the trees are ancient or because the special sites in which they live favour both the fungi and the ancient trees.

3.1.3 Living wood

The living sapwood of trees support a diverse assemblage of fungi, yeasts and bacteria. The majority of these exist symbiotically with the tree and have neutral or beneficial effects. There are also a small number of pathogenic fungi that colonise living wood and can cause the death of all or part of a tree. The interactions of such pathogenic fungi with the tree, and one another, can produce a complex


NEIL ALDRIDGE

Bark of a living ancient tree

range of features for exploitation by further organisms. In addition to aggressively pathogenic fungi there are many common 'mildly pathogenic fungi' that can colonise a tree and remain there without inflicting any harm for many years before altering their interaction to become fully pathogenic when the tree is otherwise stressed by drought or damage. This allows the fungus to be one of the first colonisers of the now dead wood. The living wood of old trees is also exploited by a range of invertebrate species. These species cause damage to the tree while they feed and can cause the death of all or part of it. Colonisation by such species and the damage they cause is often an important step in the formation of later wood-decay features.

3.1.4 Living bark

The bark of trees support specialist corticolous (bark-dwelling) animals, plants and fungi. These assemblages can be of significant conservation importance, including many rare species. The bark of ancient or other veteran trees differs from that of younger trees in a number of important ways. Most obviously it has simply been there longer, and has therefore had more time for associated species to colonise. It is also more likely to retain species that are now rare but were more widespread in the past. The open-grown conditions which favour the development of ancient trees may also favour special corticoles. The surface chemistry of old trees is often quite different to that of younger trees of the same species. The particular chemistry of the bark of ancient and other veteran trees can be essential for many lichen species. The bark of trees of large diameter is also more deeply fissured and corrugated than that of younger trees, providing varied degrees of exposure, retreats and hibernation sites, and space enough for entire invertebrate life cycles. For all of these reasons the bark of old trees supports many highly specialised associated species, and assemblages of conservation concern. In the short term dead bark can provide many of the same features but tends to fall from the tree within a few years. Live bark is therefore essential for the long-term survival of corticolous species.

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3.2 Death and decay

The most important feature of ancient and other veteran trees for associated wildlife is that they contain large amounts of dying, dead and decaying wood due to size, age and accumulated damage and stresses. A very large number of organisms depend on dead or dying wood. They may gain nutrition from it, burrow within it, or live in the spaces created by decay. This is interesting because dead wood is not obviously a temptingly nutritious material to exploit. A sun-baked branch in the canopy of a tree may remain almost unchanged for decades in defiance of all possible species that may colonise it. But this difficulty also means that dead wood can be a surprisingly long-lasting habitat and helps increase the diversity of associated species.

Different types of wood in different situations present different opportunities and niches, and different specialist species exploit them. The character of the wood changes as it is colonised and decays, and the character and rate of decay will also vary according to circumstance. Attached dead branches and limbs, fallen dead wood, standing dead trees and heart-rot all provide essential habitat niches for a wide range of associated organisms, many of which are rare. Large ancient trees provide the greatest variety of wood-decay niches and therefore species that fill them.

The distinction between life and death is far from easy, sometimes contentious and often philosophical. The distinction is more difficult in plants than animals or fungi, though of rather lesser concern, and probably more so in trees than in smaller plants. It is possible to have a perfectly healthy tree, most of which is dead, or at least non-living. A branch which has fallen from a tree and lies on the ground can be considered definitively dead, but much of the non-living material on and in an old tree is generated by natural processes which ensure the continued life of what remains. Like hair, fingernails and antlers, they are non-living but nonetheless an essential part of the living organism. Not everyone is happy with the use of the term "dead wood" in the way it is commonly employed. It is used here for convenience and because it has come into widespread and common use, but it is important to note that it is not entirely satisfactory.

Wood decay is a natural part of the ageing process of trees. Heart-rot occurs naturally as dead heartwood is broken down. Many of the most important features for organisms dependant on ancient or other veteran trees are associated with such decay. The natural process of retrenchment also produces attached dead wood. Many decay features can also occur due to external stress or damage. This can occur in much younger trees but the frequency and scale in ancient and other veteran trees is far greater due to the time they have had to accumulate them, interactions with natural senescence, and simply the size of old trees.

3.2.1 Heart-rot

Old trees are hollowed by a specialist range of heart-rot fungi. Such heart-rot is a natural part of the ageing process of trees and encourages longevity by releasing nutrients and energy from the dead heartwood to be used by the living outer layers of the tree. Heart-rot fungi can only break down dead wood and are restricted to the dead heartwood of the tree. The surrounding living wood is unaffected. The process by which fungi break down wood depends on many factors. The types of decay created can be loosely categorised as being either brown- or white-rot.

In white-rot, either the lignin is broken down first or the lignin and cellulose are broken down at the same time, which results in soft, spongy white wood which can be consumed by a wider range of organisms, leading after further decay and processing to hollow spaces. In brown or red-rot, the hemicellulose and cellulose are broken down first leaving behind the hard, dry lignin element of the wood. Soft-rot, a third type, degrades the cellulose and hemicellulose in the central layer of the secondary cell wall. In the field, soft-rot and white-rot are virtually impossible to distinguish. Either type of rot can occur in a wide range of trees, but oaks, for example, usually have red-rot and trees such as Beech and Ash usually have white-rot. Red-rot is more common in conifers and white-rot more common in broadleaved trees.

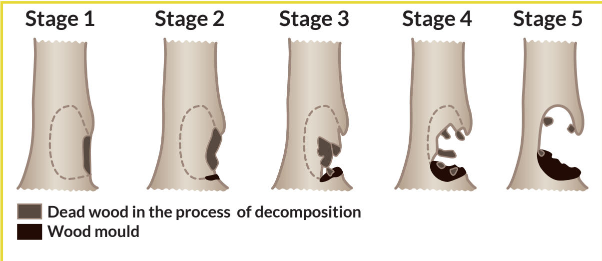

ANDREW SKINNER

An example of heart-rot


NEIL ALDRIDGE

Red-rot and white-rot

After prolonged decay, often taking many decades, the distinction between red-rot and white-rot diminishes, and the final stage, wood mould, is much the same whatever its origin. It can take a great many years for material to form and substantial amounts will occur only in large hollow trees, inevitably making this a rare and important



The stages of wood mould

habitat. It can last for a long time once it has formed, changing in character as time goes on and being added to through further decay in the tree above. It can vary in character from a relatively dry and almost powdery mould to wet mould with the consistency of porridge.

The type of rot greatly affects the associated fauna and the character of other decay features. The relatively dry conditions of red-rot in ancient oaks, for example, are of great importance for a range of rare beetles, but the relatively moist conditions produced by white-rot in ancient Beech is more conducive to important assemblages of saproxylic flies. A large proportion of the rarest invertebrates associated with old trees are associated with hollow trees and heart-rot.

As heartwood is broken down by decay fungi and consumed by associated invertebrates it slowly decreases in volume. Eventually a cavity will be formed in the decaying trunk or limb. Whilst most of the species associated with heart-rot are dependent on nutrients provided by the decaying wood itself there are also species that simply utilise the cavity itself for shelter. Such species are called structural cavity users and include vertebrates such as bats or birds or invertebrates. Structural cavity users require some way of accessing the heart-rot cavity, this access may be through burrowing invertebrates, woodpecker holes or other points where decay has broken through the bark, where the bark has been damaged due to limb loss for example. Eventually the wood decomposes entirely to form soil.

3.2.2 Retrenchment

Retrenchment is a term used to describe the natural reduction in the size of the crown of a tree that occurs with ageing. As trees become post-mature and less vigorous the crown will usually begin to die back. This is compensated by new growth lower on the tree, often in the form of epicormic growth. This process is a survival mechanism that makes the tree more mechanically sound. The death of branches, often sizeable, in the crown of the tree produces large quantities of dry, exposed, attached dead wood. Eventually this dead wood will break of from the tree and become fallen dead wood.

3.2.3 Root decay

The processes of decay are not confined to the above-ground parts of a tree. Decaying roots provide additional habitat for a very different set of organisms. These are probably less likely to be associated specifically with large

PAUL RUTTER

Final stage of retrenchment

ancient trees than organisms living in the above-ground dead wood, because substantial decaying roots can also be found beneath old coppice stools in ancient woodland and because such underground features may be less influenced by light intensity.

3.2.4 Death and decay due to external factors

Death and decay can be triggered by external factors. There are many ways for damage to the bark and cambium of trees to occur: branches can be broken by wind, lightning strikes or machinery; insects bore into the living wood; and bark can be removed by livestock or wild animals. All such damage can provide a route through which decay fungi or pathogens can colonise the tree. The effects of such damage induced death and decay can be

Insect damage and ichneumon wasp

NEIL ALDRIDGE

limited to individual damaged branches, the whole tree, and everything in between. Death and decay can also be triggered by infection by pathogenic fungi or disease without obvious wounds and environmental stress such as drought. These can induce die back of branches and, if the stress or disease is severe enough, the death of the whole tree.

All of these forms of damage, stress and disease can happen to a young tree as easily as an old tree. Ancient and other veteran trees are special for a several reasons however. Damage induced features can be larger on large trees than small trees, thereby providing a greater habitat area; a dead limb on a large tree can produce a greater volume of decaying wood than one on a small tree for example. An old tree has had more time to accumulate a range of damage induced decay features, and, just as importantly, associated fauna, flora and fungi, than a young tree. Perhaps most importantly, a large and old tree is more able to support numerous and diverse externally induced decay features than a small young one for a long time. Large and well-established trees are more likely to survive the death of a major limb than a young tree for example. The dead limb on a living veteran tree can provide diverse habitat niches for many decades. In a young tree it is more likely to trigger further decline and death fairly quickly, providing fewer niches for a shorter period as the entire tree breaks down and collapses.

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3.3 Peripheral wood-decay features

In addition to the critical heart-rot decay features of ancient and other veteran trees, they often support a range of peripheral wood-decay features that are not connected to decay columns in the dead heartwood. These can result from natural dieback through retrenchment or the effects of damage, disease or stress. In practice, the range of features created through the natural ageing process of a tree and those created by external factors inducing death and decay overlap extensively, often exist side by side and may act together. Whatever the cause and scale of death and wood decay, it provides many important habitat features and creates the habitat for most of the special associated organisms found on ancient or other veteran trees.

3.3.1 Dying and recently dead bark and sapwood

The first habitats created by the death of any part of a tree are recently dead bark and sapwood. A range of taxa utilise these features including fungi, invertebrates and epiphytes. Larger dead limbs generally support a larger assemblage but there is effectively no lower limit to the dimensions of woody material that may be used by fungi and invertebrates.

Exploitation of the relatively nutrient-rich and easily eaten material between the bark and the heartwood often leaves loose bark which may remain in place, either in patches or a continuous cylinder, for years. The space beneath the bark provides a useful shelter, nesting, or hibernation site for invertebrates, bats and even birds. There are also specialist invertebrate species that occur only in this habitat and live their entire lives here.

3.3.2 Attached dead wood

Attached dead wood can develop in various location in the tree due to natural growth and retrenchment, damage, stress or disease. One of the key distinctions between open-grown and woodland trees is in their crown-shape. In woodlands trees grow tall quickly to optimise sunlight-gathering by the foliage. Except in very shade-tolerant species, the lower branches generally remain small and soon die. Open-grown trees have light all around and grows into a characteristically domed shape, with the lower branches becoming large and spreading. As the tree grows larger and taller, these branches become increasingly shaded by the upper branches and die. Owing to the shaded position of these dead branches in the lower crown, they remain attached in humid air.

Retrenchment tends to result in dry, exposed dead wood in the crown of the tree as the crown of the tree lowers

Ancient tree with attached dead wood

KNEPP WILDLAND

SONIA REVELEY

Veteran tree with fallen dead wood

and broadens. In exposed situations, the eventual loss of the jacket of loose bark from dead branches and trunks can leave an exposed surface of hard heartwood which can be long-lasting. On large branches the chief value of this may be in providing long-term protection to a hollow interior. The exposed heartwood often supports its own special assemblage of associated organisms. The habitats provided by attached dead wood depend greatly on the circumstances. A heavily shaded dead branch low on the tree will provide a very different habitat to the dry and exposed dead branches that may be found in the crown of the same tree.

3.3.3 Fallen dead wood

Fallen dead wood can have a range of characteristics depending in where it falls. If it falls into open, sunny conditions it can have similar characteristics to hard, dry, exposed dead wood attached to the tree, at least on the upper surface. The surface of the wood touching the ground will be cooler, moister and more stable in its conditions. If it falls into shaded conditions, it will entirely be cooler and moister than attached dead wood. Fallen dead wood therefore supports different fungi, epiphytes and invertebrates to attached dead wood, although there are generally fewer rare specialist species.

3.3.4 Burnt dead wood

If a lump of dry dead wood does not appear an immediately tempting food source, then setting fire to it certainly does not increase its appeal. But burnt wood is widespread and common, and it is not surprising that some organisms exploit it. Lightning strikes are an obvious natural cause of burnt dead wood on trees—though a lightning-struck tree may simply explode and be boiled rather than burnt. Larger quantities of burnt wood of more varied character may be generated by lightning-sparked fires in dry open habitats. Currently, and for some centuries at least, people have been the main generators of burnt wood, in controlled or uncontrolled fires of varied scales. Fires for cooking, heating, light and security would have been present for millennia before that.

3.3.5 Sap runs

Trunks and branches of trees commonly have exudates which form wet patches on the bark. They may be associated with diseases such as canker of Horse Chestnut, but more often are either slime fluxes, resulting from bacterial infection and often escaping through

Sap run

ANDY GODFREY

wounds, or sap runs, formed by a split or other damage to a tree that extends from the outside of the bark to the conductive vessels. They may be the result of physical stress and injury caused by wind, drought, collision with other trees or machinery, or by wood-boring insects. Both can be temporary or persistent.

3.3.6 Rot-holes

Crown or cavity hollows develop when decay fungi colonise a tree from the outside through wounds or dead or cut branches. These may be largely or wholly independent of heart-rot in the rest of the tree. If the wood beneath is reasonably sound and water can flow in, they form small volumes of sheltered aquatic habitat which support many species of invertebrates, especially flies. Some are not dependent on wood decay at all, and can occur in crevices or branching points or amongst superficial roots and accumulate dead leaves and fine woody material: such pools are perhaps likeliest to occur low down on managed trees in sheltered situations. Others are associated more particularly with wet rotting wood sheltered within the holes. There is probably a continuum of these from those in small, isolated areas of decay to those in wet heart-rot. Small, calloused, rot-holes that hold water provide a niche for the Knothole Yolk-moss (*Codonoblepharon forsteri*), especially those on exposed roots, whist the nutrient-rich water runs from rot-holes provide another habitat for this moss and for rare lichens such as Sap-groove Lichen.


STEVEN FALK

Rot-holes in an old Sycamore tree

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3.4 The importance of tree species

Different species of ancient and veteran trees have different physical and chemical properties in both the living and dead tissue. These differences also manifest in differences in the decay process due to fungi evolving to rot only the 'dead wood' of certain species of tree, producing the specialised enzymes and chemicals to overcome the tannins and other defences of that species alone. For these reasons many species associated with ancient and other veteran trees are specific to particular tree species. Different tree species therefore support different floras, faunas and fungal assemblages. The specificity is greatest for species associated with living or very recently dead tissues, and declines with age since death, as distinctions in tree chemistry decline and differences determined by the state of decay and the fungi involved in the decay process come to dominate. It should be noted that coniferous and broadleaved trees are sufficiently distinct in chemistry that the associated flora, fauna and fungi remain substantially distinct even into late stages of decay, but within each group the distinctions diminish.

> The fly *Solva marginata* has larvae which develop under newly dead bark, and is confined to poplars.
>
> The weevil *Cossonus linearis* lives in dead heartwood, and is found in both willows and poplars.

The tree-specificity of many species means that decline of trees of any given species can have considerable consequences. The loss of elms through Dutch Elm Disease had a profound impact. Emphasis has tended to be placed on foliage-feeding animals in popular groups, such as the White-letter Hairstreak (*Strymonidia w-album*) but in practice this butterfly feeds on elms of any age. The

Southern Grey Physcia (Physcia tribacioides)


WIKIMEDIA

impact was greater on those confined to the mature and veteran trees which have now largely vanished. Lichens such as Orange-fruited Elm Lichen (*Caloplaca luteoalba*) and Eagle's Claw (*Anaptychia ciliaris* subsp. *ciliaris*) suffered serious declines for example.

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3.5 The importance of surrounding habitats

Whilst ancient and other veteran trees can be considered an ecosystem in their own right they are not isolated from their surroundings. Intensive land use such as agriculture or urbanisation can directly damage the tree through removing dead wood, damage to root or mycorrhizal systems, changes to drainage etc., application of agrochemicals and air pollution can damage associated fungal and epiphytic assemblages. Low intensity land use around old trees is one of the most important factors in ensuring long life and the development of a good range of habitat features and associated species. Guidance on appropriate management of the surroundings of old trees can be found here.

European Hornet (Vespa crabro)

STEVEN FALK

Although there are many associated organisms that live out their entire lives entirely within the tree, leaving it only to disperse, there are also many that are part-time tree users and require other associated habitats. Solitary bees and wasps nest in decaying wood or old beetle burrows but may forage some distance from their tree. Colonies of European Hornet (*Vespa crabro*), which nest preferentially in dead wood cavities in substantial trunks of trees will cover a considerable distance in search of prey. Bats and birds that use trees for roosting or nesting gather the majority of their food from other habitats and may forage a significant distance from the tree. Many invertebrate species whose larvae live in decaying wood require access to blossom as adults. For all of these groups the nature of the surroundings can be as important as the habitat features present on the tree itself.

These distant foragers can profoundly affect the ecology of their host trees. They bring with them, or directly create habitat for, a range of parasites and commensals. Woodpeckers, unusually amongst vertebrate tree-users, create dead wood niches by excavating nest and bat roost cavities. Nesting birds and roosting bats can provide a considerable nutrient input to hollow trees and tree cavities in the form of droppings, the corpses of failed young, moulted feathers and the remains of food, as well as an intermittent rain of nesting materials. Predators bring back the remains of their prey. These mean that an ancient tree may not only provide habitat directly, but also act as a storehouse of resources from the wider landscape, concentrating nutrients and materials in a sheltered environment and protecting them from degradation.

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The wildlife of ANCIENT and other VETERAN TREES

Ancient and other veteran trees provide a great range of habitat niches as they age and decay, supporting a wide variety of plants, animals and fungi. Many of these species are now incredibly rare because we have lost so many of our old trees. This section looks at the wildlife associated with old trees and the threats to their continued survival.

PAUL BROCK Black Click Beetle (*Ampedus nigerrimus*)

4. THE WILDLIFE OF ANCIENT AND OTHER VETERAN TREES

The unique ecology of ancient and other veteran trees and the great range of habitat niches created as they age and decay support a wide range of closely associated species (Table 2). Many of these are highly specialised and only occur in very narrow niches within the tree, living unique and fascinating lives. Because of these specific habitat requirements and the loss of so many of our ancient and other veteran trees many of these associated species are now very rare. This part of the document will discuss the main groups of organisms that have members with a close association with old trees. It will highlight key habitat features for these groups, the main threats to their continued survival and key conservation actions that can be taken to protect them. Links are provided to sections detailing the management methods discussed. This information will then be summarised and commonalities and conflicts in the conservation of different groups highlighted.

The broad themes covered in this section are:

4.1 Fungi

Of any group of organisms associated with ancient and other veteran trees, fungi have the most intimate relationship. Fungi are present in all parts of the tree, from leaves to roots, even within the living tissues. The fungi associated with ancient and other veteran trees can be broadly divided into nutrient gathering mycorrhizal fungi in the trees roots and saprotrophic fungi that breaking down dead organic matter, releasing nutrients that can be re-absorbed by the tree or used by associated organisms. The majority of saprotrophic fungi exist symbiotically with the tree, breaking down only already dead wood. A few are pathogenic and damage the living tree.

Fungi, as the main agents of wood decay, are a keystone group in the ecology of ancient and other veteran trees. The formation of the wood-decay habitats that support many of the other species associated with old trees are

<u>Ancients of the Future target taxa: Fungi</u>

Coral Tooth (*Hericium coralloides*)

Bearded Tooth (*Hericium erinaceus*)

Oak Polypore (*Piptoporus quercinus*)

Table 2. The wildlife value of trees common in Britain—After Alexander, Butler and Green (2006).

Tree type	Mycorrhizal fungi	Wood-decay fungi	Wood-decay inverts	Foliage inverts	Biomass of foliage in-verts	Leaf litter	Blossom for pollen and nectar	Fruits and seeds	Lichens
Pinaceae									
Norway Spruce	*****	**	***	***	***	*	*	****	*
European Larch	*****	**	*	***	***	*	*	****	**
Scots Pine	*****	***	****	****	****	*	*	****	*****1
Taxaceae									
Yew	***G	**	*	*	**	*	*	****	*****
Platanaceae									
London Plane	***G	**	**			*			*
Ulmaceae									
Elms	***G	****	***	***	***	****	*	*	*****
Juglandaceae									
Walnut	***G	**	**			***			***
Fagaceae									
Beech	*****	*****	*****	***	*	*	*	*****	*****
Sweet Chestnut	***	***	***	*	*	*	*	*****	*
Turkey Oak	*	***	***			***			*
Holm Oak	***	***	***	*	*	*	*	*****	***
Native Oaks	*****	*****	*****	*****	*****	***	*	*****	*****
Betulaceae									
Birches	*****	****	****	*****	****	***	*	****	*****
Alder	***	***	**	*	****	***	*	****	*****
Hazel	**	***	***	***	***	****	*	***	*****
Hornbeam	***	**	**	**	*	***	*	***	*****
Tiliaceae									
Limes	****	***	**	**	***	****	****	*	**
Salicaceae									
Poplars	***	***	***	****	***	***	*	*	*****
Goat and Grey Wil-lows	***	***	***	*****	***	***	*****	*	*****
Crack, White and other rough-barked willows	****	***	***	****	***	***	*****	*	*
Rosaceae									
Cherries	***G	**	*	***	**	****	****	*****	*
Plum	***G	**	***	***	***	****	****	****	*
Pear	***G	**	***	****	***	****	****	***	***
Apple	***G	**	***	****	***	****	****	****	***
Rowan and white-beams	***G	**	*	*	*	****	****	****	***
Hawthorns	***G	**	***	****	***	*****	*****	****	***
Fabaceae									
False-acacia	***G	**	***	*	*	***	****	*	*
Aquifoliaceae									
Holly	***G	*	*	*	**	*	*****	****	*****
Hippocastanaceae									
Horse Chestnut	***G	**	***	*	*	**	****	*	*****
Aceraceae									
Field Maple	***G	**	**	**	*	***	****	*	*****
Sycamore	***G	***	***	**	*****	*****	****	*	*****
Oleaceae									
Ash	***G	***	***	***	*	*****	*	*	*****

* = low value, ***** = high value
1 In native pinewoods

Trees and shrubs listed in taxonomic order (Preston *et al.*, 2002)
Most tree species are ectomyccorhizal, exceptions are indicated as G (glomalean endomyccorhizal)
After Alexander, Butler and Green (2006)

dependant entirely on the actions of saprotrophic fungi. A fungus is largely composed of microscopic mycelial hyphae that often goes unnoticed due to being hidden within the wood, soil or other substrate. Many rarely produce obvious fruiting bodies. Due to this, it is impossible to know exactly how many fungal species live in a given tree. Due to the great number of habitat niches provided by an ancient tree and the high habitat specificity of many fungal species these numbers are expected to be very high though.

The sections discussing other groups of organisms dependent on ancient and other veteran trees will be broken down largely into sub-sections detailing key habitat features used by the group and some of the species that depend on them. Because of the exceptionally close relationships between old trees and fungi and their role as keystone habitat creators it is impossible to meaningfully talk about the specific habitat features required by fungi in the same way as other groups; all will support specialist fungi and many are created by them. The headings here are as much about processes as required habitats. The main threats to fungi associated with ancient and other veteran trees and important conservation actions that can be taken to protect them are also discussed.

4.1.1 Healthy roots

The healthy roots of most trees have mycorrhizal association with fungi. These fungi extend beyond the roots and absorb non-organic nutrients that would otherwise be hard for the tree to access. They therefore provide essential nutrients to the tree and are critical to their health. Ancient trees in unimproved habitats have had more opportunity to form mycorrhizal associations than most and often support rare and specialised species. Some boletes, for example, seem preferentially associated with ancient trees, though it is not always clear whether this is because the trees are ancient or because the special sites in which they live favour both the fungi and the ancient trees. Whatever the details of the association, the greatest number of bolete species are found beneath large open-grown oaks with short grass beneath, and many of the wood-pasture sites most important for their ancient and veteran trees are also rich in boletes.

4.1.2 Living, dying, and recently dead wood

The living sapwood of trees support a diverse assemblage of fungi, yeasts and bacteria. The majority of these exist symbiotically with the tree and have neutral or beneficial effects. There are also a small number of pathogenic fungi, such as the notorious Honey Fungi (*Armillaria* spp.), that colonise living wood and can cause the death of all or part of a tree. The interactions of such pathogenic fungi with the tree, and one another, can produce a complex range of features for exploitation by further organisms. In addition to aggressively pathogenic fungi there are many common 'mildly pathogenic fungi', such as King Alfred's Cakes (*Daldinia concentrica*) on Ash and Beech Woodwart (*Hypoxylon fragiforme*) on Beech, that can colonise a tree and remain there without inflicting any harm for many years before altering their interaction to become fully pathogenic when the tree is otherwise stressed by drought or damage. This allows the fungus to be one of the first colonisers of the now dead wood.

4.1.3 Heart-rot

A key feature of ancient trees is usually columns of wood decay in the heartwood, often leading to the formation of cavities. This decay is caused by various specialist heart-rot fungi. These are of very great importance to the overall interest of veteran and ancient trees. They provide long-lasting internal habitat within living trees, and may enable the survival of many generations of associated organism. Heart-rotters are therefore considered keystone species in the ecology of ancient and other veteran trees.

Different species of heart-rot fungi create different types of heart-rot. Some, such as the Chicken-of-the-Woods (*Laetiporus sulphureus*) digest only cellulose, leaving lignin behind in the form of brittle red-rot. Others digest both cellulose and lignin leaving a soft white-rot called white-rot. This group includes members of bracket fungi in the genera *Ganoderma* and *Inonotus*. There are many species of heart-rot fungi and these are often highly specialised. The heartwood of some species of trees are particularly resistant any type of degradation and oak heartwood for example can persist for over a century. These most resistant woods are filled with anti-fungal agents, acids

Birch Bolete (Leccinum scabrum)

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Coral Tooth (Hericium corralloides)

MARTIN HLAUKA

Oak Mazegill (Daedalea quercina)

and tannins to prevent rot and so highly specialised fungi have had to evolve to overcome them. Each heart-rot fungus is usually only capable of rotting the heartwood of one or two species of trees whose particular defences it is adapted to circumvent.

Many heart-rotting fungi have evolved fascinating mechanisms to survive the challenges of their environment. For example, 'dead wood' that is high off the ground and exposed to the sun and the wind can be very dry, so many of the heartwood rotting fungi have evolved thick-walled spores that can survive dessication before colonisation, and thick-walled hyphae that can wait out dry periods, to begin rotting again once the moisture content of the wood is high enough. Other species like *Pleurotus* spp. have evolved to capture and consume nematode worms living in the wood with their hyphae as a way of surviving in a nitrogen-poor environment.

As well as acting as keystone species and providing habitat for many other taxa of conservation importance, many heart-rot fungi are of significant conservation importance in their own right. Some of the UK's rarest fungi are heart-wood-rotters. These include the Oak Polypore (*Buglossoporus quercinus*), the Coral Tooth Fungus (*Hericium coralloides*) and the Bearded Tooth Fungus (*Hericium erinaceus*).

4.1.4 Exposed dry sapwood and heartwood

A range of fungi utilise the bare and exposed dead wood of a tree. Some are present in the living wood but only spread and fruit when the wood dies, others colonise the wood from the outside. Some fungi specialise in dry seasoned timber, such as Oak Mazegill (*Daedalia quercina*) on exposed aerial dead branches of oak.

4.1.5 Shaded dead branches

Shaded dead branches found low down in old trees provide very different environmental conditions to dead branches high in the canopy, being far moister and darker. These conditions support a unique assemblage of associated species including fungi, invertebrates and epiphytes. Specialist fungi of this habitat include Waxy Crust (*Vuilleminia comedans*) and Oak Crust (*Peniophora quercina*).

4.1.6 Fallen dead wood

Fallen dead wood always supports a different fungal community to attached dead wood, this community differs depending on the conditions the fallen dead wood finds itself in and the stage of decay. Dead branches will often have dormant colonies of saprophytic fungi within that will only start to grow when the branch falls and moisture content increases. This gives them a head start against other fungi.

4.1.7 Burnt dead wood

There are a range of fungi which are found exclusively on burnt dead wood such as the fungus *Pyronema omphalodes*; some may live for part of their lives inside plant tissues, breaking out and producing fruiting bodies only in the aftermath of fire.

4.1.8 Threats

Many fungi with an ecological association with ancient trees are rare or threatened. Of the 447 macrofungi on the British Red Data Book list, nearly 400 are confined to

Ancient Woodland and/or lowland wood pasture. Many of these species have very restricted distributions, especially those that depend on the dysfunctional heartwood (or ripewood) tissues of ancient trees.

The main threats to fungi associated with ancient and other veteran trees are loss of habitat, in the form of whole old trees and the sites they are situated in, leading to fragmentation and isolation of populations, and degradation of the wider environment around old trees. Major losses appear to be happening owing to acidification and increased nitrogen enrichment of soils for example. Many rare fungi require open-grown trees in relatively open habitats. Neglect and shading of ancient and veteran trees are significant threats to such species.

4.1.9 Conservation

As fungi are so ubiquitous within ancient trees and so closely tied to the processes that create many key habitat features it is almost impossible to point to particular features of importance to them. The most important actions that can be taken for the conservation of fungi associated with ancient trees are encouraging the formation of large open-grown trees that are allowed to age and die naturally, keeping existing old trees alive and protecting and improving the conditions of the surroundings of old trees though sympathetic management of their surroundings. Heart-rot inoculation can also be used in the targeted conservation of particular species of concern.

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4.2 Invertebrates

As with fungi, there are invertebrates associated with almost every part of an ancient or other veteran tree. Some are associated with the living components of the tree, the foliage, bark, roots and living wood. The majority are more generally associated with trees and there are relatively few specialist old tree species that depend on the healthy living parts of the tree.

The most important habitat features for invertebrates found on ancient and other veteran trees are created by the process of wood decay. More than 2,000 invertebrate species in Britain are dependent on decaying wood in order to complete their life cycles. This is roughly 7% of the total invertebrate fauna. It is difficult to overstate the importance of the wood-decay process for rare and specialised invertebrates and the majority associated with ancient and other veteran trees are dependent on it in some way.

This section will highlight the diversity of habitat features that are used by invertebrates, key threats and important conservation actions.

4.2.1 Foliage

Many species of invertebrates are supported by the living canopy of trees. A great deal of this fauna is the same on ancient as on relatively young trees and is not unduly bothered by growth form. Some invertebrates are known to be more specific in their requirements. The Heart Moth (*Dicycla oo*), a greatly declined species, lives on mature open-grown oaks and is a species of wood-pasture rather than woodland or scattered trees. There may be more species with a predilection for trees of considerable age: references to species preferring "mature" trees are not difficult to find. The reasons for the association may be less clear. Structural or chemical differences between old and young trees may play a role in these special relationships.

CHRIS WILKINSON/BUTTERFLY CONSERVATION

Heart Moth (Dicycla oo)

4.2.2 Living bark

There are relatively few invertebrates associated specifically with the living bark of old trees. Some of these species are dependent on the structural characteristics of the bark, such as the spider *Leviellus stroemi*, which spins a small, delicate orb web on the surface of the trunks of pine and large oak trees, and lives in a retreat in deep fissures in the bark. Only trees of sufficient age to have developed such deeply fissured bark provide a suitable habitat.


HANNU MÄÄTTÄNEN

The spider Leviellus stroemi

Others are associated with the epiphytic vegetation that occurs on the bark of old trees. These epiphytes support specialist communities of herbivores, detritivores, predators and parasites. The best known and understood of these species are moths such as the Red-necked Footman (*Atolmis ruficollis*) and Merveille du Jour (*Dichonia aprilina*) whose larvae feed on lichens and bryophytes. This specialist assemblage also includes barkflies, whose species richness appears to be largest on old open-grown trees, and a range of predators including ground beetles (Carabidae), minute bugs (Microphysidae) and jumping spiders (Salticidae).

4.2.3 Living wood

A small but significant range of invertebrates feed on components of the living wood. These species cause damage to the tree while they feed and can cause the death of all or part of it. Colonisation by such species and the damage they cause is often an important step in the formation of later wood-decay features. Some species mere assistants to the true agents of death and damage or kill trees by acting as vectors for pathogens: Elm bark beetles carrying the fungus responsible for Dutch Elm Disease from tree to tree being the most noteworthy example from recent UK history. Others can kill directly by consuming the cambium layer beneath the bark which carries nutrients from the canopy. Some bark beetles can do this, as can some jewel beetles of the family Buprestidae. The latter group include invasive species, such as the Emerald Ash Borer (*Agrilus planipennis*), a potential future threat to British trees. The Hawthorn Jewel Beetle (*Agrilus sinuatus*) is a more benign example, rarely if ever killing its host tree outright. Its larvae eat out burrows beneath the bark of Hawthorn, and large numbers kill the branch. The beetle is quite dispersive and can be a transient resident in many places, but the adults are strongly sun-loving; large old Hawthorns with open-structured crowns are most likely to support long-term colonies.

Some insects which bore into living trees leave the tree intact and relatively unharmed but cause localised damage and tissue death allow entry to other organisms. Such organisms occur particularly amongst beetles—including longhorn beetles such as the Musk Beetle (*Aromia moschata*),—and moths, especially clearwing moths of the family Sesiidae and members of the Cossidae e.g Goat Moth (*Cossus cossus*) and Leopard Moth (*Zeuzera pyrina*). There is little association between these species and ancient trees, and some occur preferentially on young trees, though the consequences of their colonisation may contribute to the development of veteran features.


ALEKSANDRS BALODIS (CC BY-SA 4.0)

Hawthorn Jewel Beetle (Agrilus sinuatus)

4.2.4 Invertebrates and fungi

Few invertebrates possess the specialised gut enzymes required to break down the cellulose and lignin of living wood. The difficulty of digesting wood leads to a complex inter-relationship between the tree, fungi and invertebrates. Many species of both fungi and invertebrates are associated with dead wood and are specialised to particular circumstances. Some invertebrates feed directly on wood, and rely on gut

The ambrosia beetle Trypopendron domesticum


S.RAE (CC BY 2.0)

symbionts to break it down; others do not consume the wood itself but fungi growing on and in the wood; some live only in wood in which cellulose and lignin have been quite thoroughly broken down into more digestible components by fungi; and many saproxylic species do not feed on wood in any form, but are predators or parasites of organisms that do. Some beetles, collectively known as ambrosia beetles, carry fungi with them and cultivate them on the inside of deep burrows in dead wood. The fairly common *Trypodendron domesticum* burrows into newly dead wood and cultivates *Ceratocystis pilifera*.

It is crucial to note that, although these species feed on decaying dead wood, it is the living tree that produces the wood that will eventually decay. Dead wood has a limited existence; decaying and being recycled. Without replenishment from the living tree this resource is quickly depleted. Conservation of wood-decay communities therefore requires conservation of a diverse age structure of woody plants to ensure continuity of wood-decay habitats.

4.2.5 Dying or recently dead wood

Many species of invertebrates are associated with the dying or very recently dead tissues of trees. Conspicuous amongst these are some bark beetles (Scolytidae) which tunnel through the cambium layers of recently cut, broken or fallen branches and trunks. Such species are highly sensitive to chemical compounds released by damaged timber and may arrive within minutes of a branch being broken or cut. These beetles have only a single season to exploit the decaying cambium. Such initial colonists of dead wood support predators such as the Ant Beetle (*Thanasimus formicarius*) and larvae of flies such as Common Awl-fly (*Xylophagus ater*) and the long-leggeed flies (Dolichopodidae) in the genus *Medetera*.

Such pioneer species are necessarily highly mobile species, at least over short to moderate distances, and are not amongst the slow colonists of old timber which provide the greatest conservation concerns. However, the loosened bark, the partially processed wood behind it, and the entry holes produced when they emerge by tunnelling through the bark are critical in determining the next phase of exploitation.

A very large number of invertebrates live, either throughout their lives or as larvae, beneath the bark of recently dead trunks and branches, feeding in the underlying sapwood. This is a relatively nutrient-rich and short-lived resource. Many species are flattened to facilitate their way of life. Some, such as the flatbugs *Aneurus laevis* and *A. avenius*, occur selectively under very thin bark of fine branches, but rather more are found under thicker bark. This is a short-lived resource, which may be gone within a single year and will not last more than three years, and the species involved are necessarily reasonably mobile and efficient colonists. Nonetheless, many are highly localised in distribution, and some are confined to ancient sites with long continuity.

Even fine dead twigs support a surprising number of species while on the tree, and a different set of species once they have fallen. Such fine material can occur on and beneath trees and shrubs of almost any age, and a strong association between any of these species and ancient trees would be surprising. Nonetheless, such species are often rarer than expected given their apparent habitat requirements.

> The Nationally Scarce *Acalles roboris* has larvae which develop in fine fallen twigs. It is unclear why it is so restricted as its habitat requirements seem easily met.

4.2.6 Loose bark

Loose bark provides shelter to many species of beetles and flies, as well as a permanent home for a number of invertebrates. The invertebrate fauna includes various spiders, such as the flattened Walnut Orb-weaver (*Nuctenea umbratical*), and their webs are often conspicuous and sometimes dense. Some beetles in the family Dermestidae, the hide beetles, live amongst the webs and debris, feeding on the remains. The Common

Uleiota planatus—a flat beetle that lives under bark

CHRIS KIRBY-LAMBERT

The larder beetle Trinodes hirtus

INSEKTARIUM.NET


CHRIS KIRBY-LAMBERT

The clerid beetle Tillus elongatus

Cobweb Beetle (*Ctesias serra*) is widespread in the lowlands and can occur anywhere there are mature trees; Trinodes hirtus is confined to large ancient trees, especially oaks. Britain's largest false scorpion, the Large Tree-chernes (*Dendrochernes cyrneus*) is another predator found beneath loose dead bark on tree trunks and larger branches feeding on small wood-decay invertebrates. This species also hunts on the outside surfaces of the trunk on calm warm summer evenings and is therefore dependent on both epiphyte and saproxylic invertebrate communities.

4.2.7 Dry exposed heartwood

Rather few invertebrates are primary colonisers of hard dry barkless wood, whereas it is a very important niche for ancient tree lichens. Dead dry branches in a tree canopy are long-lasting and small standing trunks in full sun will often fall over because of decay at their bases before insects and fungi have made much headway above ground. But the few species that can often have large populations and important consequences. Unsurprisingly, perhaps, the familiar Common Furniture Beetle (*Anobium punctatum*) is one species which can cope with these conditions; but it's relative the Fan-bearing Wood-borer (*Ptilinus pectinicornis*) is usually more conspicuous, with colonies often producing hundreds of holes on the sunny sides of standing dead trunks and in exposed dead dry wood of living trees. Specialist predators of the larvae, such as the beetle *Tillus elongatus*, stalk these tunnels and when the beetles are gone the holes can provide nest sites for many generations of solitary bees and wasps, in sufficient numbers to support their own parasites, as well as access to decay for species that are unable to bore into the wood themselves, such as the scarce tumbling flower beetle *Tomoxia bucephala*.

4.2.8 Shaded attached branches

Shaded dead branches found low down in old trees provide very different environmental conditions to dead branches high in the canopy, being far moister and darker. These conditions support a unique assemblage of associated species including fungi, invertebrates and epiphytes. Many invertebrate species found in this habitat feed on the specialist fungi found on shaded dead branches. The beetle *Phloiophilus edwardsii* develops exclusively in the fruit bodies of the fungus *Peniophora* sp.—found almost exclusively in this situation. Once the branch breaks and falls to the ground it will be colonised by different fungi and *Phloiophilus* is obliged to fly off and find new dead aerial branches. Other beetle species such as the tetratomid beetle *Tetratoma desmaresti* and the false darkling beetles *Abdera biflexuosa* and *Abdera quadrifasciata* are also confined to shaded aerial dead branches on open-grown oak trees.

4.2.9 Fallen dead wood

The different characteristics of fallen dead wood mean it supports unique invertebrate assemblages. The composition of associated assemblages depends largely on the location of the fallen wood. If in open, sunny conditions it can have similar characteristics to hard, dry, exposed dead wood attached to the tree, at least on the upper surface. The surface of the wood touching the ground will be cooler, moister and more stable in its conditions. If it falls into shaded conditions, it will entirely be cooler and moister than attached dead wood. Submerged fallen dead wood also has its own unique invertebrate assemblage, including the beetle *Cyanostolus aeneus* (Monotomidae) which occurs only under bark on trunks and boughs which have been saturated with water in rivers and streams subject to spates.

The tiny clown beetle *Acritus homeopathicus* lives on and around burnt wood, where it feeds on the fungus *Pyronema omphalodes*. Its distinctive habitat means that it is easily searched for and is undoubtedly very rare.

4.2.10 Burnt dead wood

Burnt wood specialist fungi support specialist insects which feed on them. The tiny clown beetle *Acritus homeopathicus* lives on and around burnt wood, where it feeds on the fungus *Pyronema omphalodes*. Though very small, its distinctive habitat means that it is easily searched for and is undoubtedly very rare.

4.2.11 Sap runs

All exudates may be exploited by insects, but the relatively nutrient-rich sap runs, often quickly colonised and fermented by yeast fungi are the most important. They can occur on trees of any age, but tend to be more frequent, larger and more persistent on old trees. Sap runs support a very interesting and varied assemblage of invertebrates, composed chiefly of beetles and flies. The larger and longer-lasting sap runs support larger assemblages and a greater number of rare species. Sap runs resulting from deep-seated injury and which run year after year are better than transitory ones. Sap flows from cut stumps of trees may support a somewhat similar set of species to sap runs, but the more specialised invertebrates appear to require more or less vertical surfaces.

STEVEN FALK

Dark-saddled Sap Hoverfly (Brachyopa bicolor)

4.2.12 Rot-holes

The invertebrates dependent on damp rot and accumulated decaying material in rot-holes include the larvae of hoverflies (Syrphidae), moth flies (Psychodidae), wood gnats (Mycetobiidae), and long-legged flies (Dolichopodidae). This assemblage includes species dependant on decaying mulch, scavengers, predators and parasites. Water-filled rot-holes even support a specialist freshwater fauna including the copepod crustacean *Moraria arboricola*, non-biting midges (Chironomidae) such as *Metriocnemus martinii*, and mosquitoes and gnats such as *Anopheles plumbeus*. The last develops in water-filled holes on mature trees; the eggs are laid on the sides of tree holes just above the waterline and hatch only when flooded. The detritus feeding larvae of the beetle *Prionocyphon serricornis* also develops in water-logged hollows in old trees, especially favouring those hollows amongst roots at the base of the trunk. Two rare hoverflies are particularly associated with rot-holes. The Bumblefly (*Pocota personata*) is found mainly in rot-holes high in canopy. The Western Wood-vase Hoverfly (*Myolepta potens*) is a very rare hoverfly, recently recorded only from Moccas Park and the Forest of Dean. The larvae develop in water-filled rot-holes of mature broadleaved trees such as Horse Chestnut.

Western Wood-vase Hoverfly (Myolepta potens)

WILL GEORGE

Ancients of the Future target taxa: Invertebrates

Black Click Beetle (*Ampedus nigerrimus*)

Red-horned Click Beetle (*Ampedus rufipennis*)

Golden Hair Click Beetle (*Brachygonus ruficeps*)

Royal Splinter Cranefly (*Gnophomyia elsneri*)

Variable Chafer (*Gnorimus variabilis*)

Moccas Beetle (*Hypebaeus flavipes*)

Oak Click Beetle (*Lacon querceus*)

Violet Click Beetle (*Limoniscus violaceus*)

Queen's Executioner (*Megapenthes lugens*)

Bearded False Darkling Beetle (*Melandrya barbata*)

Western Wood-vase Hoverfly (*Myolepta potens*)

Cosnard's Net-winged Beetle (*Platycis cosnardi*)

4.2.13 Heart-rot

By far the most important wood-decay feature for invertebrates is a large standing living tree with extensive columns of heart-rot. A large proportion of the rarest invertebrates associated with old trees are associated with hollow trees and heart-rot, conversely, a very large proportion of the species closely associated with this habitat are rare. The type of rot greatly affects the associated fauna and the character of other decay features. The relatively dry conditions of red-rot in ancient oaks, for example, are of great importance for a range of rare beetles, but the relatively moist conditions produced by white-rot in ancient Beech is more conducive to important assemblages of saproxylic flies. Many of these insects gain access to the hollowing interior of old trees through patches of wood which have been exposed to the air through physical damage to the bark, e.g. through lightning strikes or damage caused by the collapse of a neighbouring tree. The exterior of this dead wood is sapwood in origin and tends to be decayed by white-rot fungi, although brown-rot fungi deep in the heartwood (or ripewood) within can fruit through it. The stage of decay is also a crucial determining factor in the associated invertebrate species that may occur. For these reasons sites with a long continuity and large populations of hollowing trees, supporting all stages of heart-rot, and with tree species that produce both white-rot and red-rot tend to support the best assemblages of saproxylic invertebrates.

White-rot supports many rare and fascinating insects. In the early stages of decomposition white-rot is fed on by the larvae of Lesser Stag Beetle (*Dorcus parallelepipiedus*) and Rhinoceros Beetle (*Sinodendron cylindricum*). The

PAUL BROCK

Two related, rare click beetles associated with heart-rot: above—the Black Click Beetle (Ampedus nigerrimus) breeds in red-rotten oak; below—the Red-horned Click Beetle (Ampedus rufipennis) breeds in white-rotted Beech, Ash and elm.

CHRISTOPHE QUINTIN

bright red net-winged beetle *Platycis minutus* develops in the soft moist white-rotted heartwood of Beeches and Ash. The Brassy Tortoise Beetle (*Thymalus limbatus*) develops both beneath loose bark on decaying broadleaved trees and in dry, soft, late-stage white-rot. The large shining black darkling beetle *Melandrya caraboides* and the bright green *Ischnomera cyanea* both develop in relatively soft, moist, white-rotting heartwood various broadleaves. The larvae of the spectacular *Ctenophora* craneflies also develop in soft, moist, white-rot.

Red-rot supports a different invertebrate fauna. The Hairy Fungus-beetle (*Mycetophagus piceus*) feeds on the mycelium of Chicken-of-the-Woods deep in decaying trunks. In turn, it is predated by the larvae of the rare and impressive Oak Click Beetle (*Lacon querceus*) which is found only in Windsor Forest in Britain. Other rare heartwood click beetles like Black Click Beetle (*Ampedus nigerrimus*) and Cardinal Click Beetle (*Ampedus cardinalis*) also develop in the red-rotted heartwood of oaks. Both are active predators of fly and beetle larvae. The red-rot itself is bored into by beetle species such as *Dorcatoma chrysomelina* and *Anitys rubens*. The larvae of several fly species also live in red-rotted wood. The larvae of the stiletto fly *Pandivirilia melaleuca* is an aggressive predator in very dry red-rotted oak heartwood. The Forest Window Fly (*Scenopinus niger*) is a scarce fly that is a specialist predator on beetle larvae in red-rotting heartwood of various broadleaved trees.

Both red- and white-rot eventually produce a black mould—wood mould—which accumulates in the hollow trunk. Wood mould, with its relatively constant temperature and humidity, protected by the living trunk, supports some of Britain's rarest insects. These species include the striking Noble Chafer (*Gnorimus nobilis*)—found in the wood mould of hollowing old fruit trees, oaks, willows. Many rare species of click beetle, including many *Ampedus* species and the exceptionally rare Violet Click Beetle, one of Britain's very few legally protected beetles, also develop in wood mould.

The larvae of most of the beetles living in wood mould seem to develop in hollow trees that are inhabited by cavity-nesting birds such as Jackdaw (*Corvus monedula*), Stock Dove (*Columba oenas*) or owls. These provide inputs of additional nutrients in the form of droppings, feathers, bones and other detritus to the otherwise nutrient poor wood mould.

Another exceptionally rare species associated with wood mould is the Royal Splinter Cranefly (*Gnophomyia elsneri*) which develops only in wet wood-mould, described as having "the consistency of porridge". This species is known from only two sites worldwide, one in Slovenia and the other Windsor Park.

Most invertebrates associated with heart-rot habitats seem to be very poor dispersers, probably due to the relatively stable and long-lived habitat niched provided by decay in ancient trees providing little evolutionary pressure to disperse. This is one reason for the great rarity of many of these species and they are often tied to sites with long habitat continuity.

A. SANDS

Royal Splinter Cranefly (*Gnophomyia elsneri*)

STEVEN FALK

Tanner Beetle (*Prionus coriarius*)

4.2.14 Decaying roots

Wood decay is not limited to the aerial parts of the tree. Decay in the roots is a further important habitat for invertebrates. The most famous associated invertebrate species is the Stag Beetle (*Lucanus cervus*), the larvae of which develop in white-rot below the soil surface, especially the decaying roots of old stumps, although it is not closely tied to old trees. Another large and impressive beetle, the Tanner Beetle (*Prionus coriarius*), develops in large stumps and decaying roots, especially of old oaks, and is usually found in old parkland or wood pasture. The invertebrates associated with decaying roots is relatively poorly known, mostly because many associated species rarely appear above ground. Several hoverfly species such as *Criorhina* spp. and *Xylota* spp. also specialise in decaying roots. Of particular note is the rare Green Forest Hoverfly (*Caliprobola speciosa*) which develops in wet-rot in the underground roots of Beech stumps. The larger roots of ancient trees clearly provide valuable habitats for such species.

4.2.15 Fungal fruiting bodies

The decay habitats already discussed are created by the activities of the fungal mycelium—the wood—feeding part of the fungus. The fruiting bodies of fungi themselves provide specialist habitats for many more invertebrate species. Amongst invertebrates, as specificity to tree declines in importance, specificity to fungus increases.

This specificity is most apparent amongst species which feed on bracket fungi. Annual bracket fungi have many

The darkling beetle *Eledona agricola* (inset) has a close association with the Chicken-of-the-Woods (*Laetiporus sulphureus*) bracket fungus

CHRIS KIRBY-LAMBERT; INSET: ROGER KEY

close invertebrate associations, such as that of the darkling beetle *Eledona agricola* with the Chicken-of-the-Woods or the false darkling beetle *Orchesia micans* with the Shaggy Bracket (*Inonotus hispidus*). Neither of these beetles are strongly associated with ancient trees, but the fungi are both heartwood-rotting. Trees on which they occur are likely to be veteran, and if they are not then the fungi are nudging them towards a veteran state. Even the short-lived brackets of Beefsteak Fungus (*Fistulina hepatica*) have special associates, notably the fly *Tephrochlamys flavipes* (Heleomyzidae). The soft fruit bodies of Oyster Mushroom (*Pleurotus ostreatus*) are favoured by the bright red and blue or black *Triplax* beetles and many Diptera such as *Brachypeza* species of fungus gnats (Mycetophilidae). More persistent annual brackets and the perennial brackets of other fungi support a host of further species, including many which require longer time intervals to complete their life cycles. The small black beetle *Dorcatoma dresdensis* is mainly found in the hard perennial brackets of *Ganoderma* spp. and *Phellinus* spp. for example.

The hard, black fungi King Alfred's Cakes and *Hypoxylon* spp. also have an associated invertebrate fauna. The Cramp Ball Fungus Weevil (*Platyrhinus resinosus*) strongly favours King Alfred's Cake fruiting on the dead bark of Ash trees but is also found in Beech Woodwart fruiting on dead Beech bark. Other beetles such as *Biphyllus lunatus*, *Litargus connexus* and *Mycetophagus atomarius* behave similarly.

4.2.16 Guest species and part-time users

A further set of invertebrate species utilise wood-decay features for structural reasons. Some beetles are associated with the galleries of wood-decay insects. The rare beetle *Aeletes atomarius* (Histeridae) is usually found in the burrows of Lesser Stag Beetle in moist crumbly decaying heartwood. Other beetles, notably the scydmaenids, are specialist predators of mites, inhabiting and scavenging amongst the galleries.

Two ant species form their nests in the decaying heartwood of trees: Brown Tree Ant (*Lasius brunneus*) and Jet Ant (*Lasius fuliginosus*) both create carton nests from macerated wood within heartwood cavities. The workers forage over the leaf canopy for food. The nests of these ants support a wide range of other insect species which live within them. Good examples are the rove beetles (Staphylinidae) of the genus *Zyras* which live in the runs and nests of Jet Ant.

Social wasps, including European Hornets and bees such as Honey Bee (*Apis mellifera*), and some bumblebees, will also use cavities in ancient and other veteran trees as nest sites. Many solitary bee and wasp species also exploit the exit holes of wood-boring insects and other cavities in timber as nest sites. Hole-nesting digger wasps (Crabronidae) are good examples. These have their own specialist parasites including certain sarcophagid flies such as the rare Painted Satellite Fly (*Macronychia polyodon*) and *M. striginervis*.

Solitary bees and wasps nesting in decaying wood or old beetle burrows may forage some distance from their tree will cover a considerable distance in search of prey. Even small predatory wasps nesting in narrow beetle burrows accumulate, over years and decades of occupation by many wasps, a huge, if dispersed, volume of insect exoskeletons which provide food for some specialist species. The nests of social wasps are habitats in themselves, with their own range of parasites and commensals, and the nests they create, and the middens of insect remains they leave behind, leave food and dwelling places for other animals when the colonies themselves have gone.

4.2.17 The importance of blossom

The adults of some of the insects which develop in wood-decay require access to blossom. Nectar provides an energy-rich food which can rapidly be assimilated and used to fuel flight, and pollen is a protein-rich food which aids egg production. Flowering trees and shrubs are by far the most important sources of nectar and pollen, although other plants such as Hogweed and Angelica can also be important. Hawthorn is particularly important, partly due to its flowering in late spring when so many wood-decay insects are in the adult stage. Blossom can be important right through the season and the longer plentiful sources of nectar and pollen are present in close proximity to old trees, the better for the saproxylic invertebrate assemblage. The presence of species such as sallow, Holly, Privet, Rowan, Crab Apple, Wild Pear, Guelder Rose, bramble, and many more, are all beneficial. Even Elder, generally poor for invertebrates, can be important for a select few, including the nationally scarce beetle *Aderus oculatus*, for instance, which develops in red-rot in old oaks.


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Noble Chafer (Gnorimus nobilis)

4.2.18 Threats

Almost all features of ancient and other veteran trees can support specialist invertebrates of conservation concern. The rarest and most important are largely associated with heart-rot decay. As with other groups, the loss of old trees and sites supporting them is a great threat, leading to fragmentation and isolation of populations. Many rare invertebrates that develop in decay habitats of old trees also rely on access to additional resources in the surrounding habitat, such as blossom to provide nectar and pollen.

One of the most significant threats to invertebrates associated with wood-decay features on ancient and other veteran trees in Britain is the large gap in the age structure of trees on many sites. Overgrazing by domestic animals and deer has all but prevented natural regeneration in most parklands and wood pastures for long enough that on many sites young or middle-aged trees are almost entirely absent and little thought has been given to planting replacements until quite recently. This gap in tree age structure will lead to a gap in provision of habitat niches essential to these species.

Tidying up of trees and removal of dead wood destroys habitat features that are critical for many invertebrate species.

4.2.19 Conservation

Key conservation actions for invertebrates include encouraging the formation of large open-grown trees that are allowed to age and die naturally, developing a full array of wood-decay features. Existing old trees should be carefully conserved, using direct management where necessary. Surrounding habitats should be managed to protect the tree and maintain good-structure. Flowering shrubs or plants should be encouraged as long as these do not shade the tree to ensure requirements for pollen and nectar. In wood pasture habitats, where most of the highest value trees are found, low-intensity grazing is the ideal management.

Suitable replacement trees should be encouraged to ensure continuity of decay habitats. If the generation gap is too large veteranisation or novel conservation techniques can be used to bridge the generation gap. Connectivity between sites should be increased by planting suitable trees, encouraging natural regeneration or veteranisation to create suitable habitat. This increases the chances of successful dispersal and reduce the chances of local extinctions.

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4.3 Lichens

Great Britain supports internationally significant populations of lichen species associated with ancient trees. This is to a large extent down to the relatively large number of ancient trees, in comparison to other European nations. Our historic management of them as part of wood pastures, royal hunting forests and parklands has maintained the open, well-lit conditions these species require in our temperate climate. For example, Great Britain has the bulk of the world resource of the 'ancient dry bark' lichen community, typified by the lichen *Cresponea premnea*.

4.3.1 Lichen communities and their habitat requirements

All lichen species have specific requirements around chemistry, moisture and light for example, with different species being adapted to different combinations of conditions, for example, the compound that gives the common urban lichen *Xanthoria parietina* its yellow colour is UV-protective to the fungal and algal partners in the lichen. As such, lichen species tend to form associations—or communities—with others that share similar requirements, and these have been defined in the work of Peter James, David Hawksworth and Francis Rose (see References and Further Reading). Some are quick to establish mobile pioneer communities such as of the tree canopy, but others can take much longer to establish, and this tends to be the case with the lichens of ancient

Ancients of the Future target taxa: Lichens

Eagle's Claw (*Anaptychia ciliaris* ssp. *ciliaris*)

Sap-groove (*Bellicidia incompta*)

Spiral-spored Head Pinhead (*Calicium adspersum*)

Coral Firedot (*Blastenia coralliza*)

Fragrant Jelly (*Scytinium fragrans*)

Oak Rim Lichen (*Lecanora quercicola*)

Lemon Tart (*Lecanora sublivescens*)

Southern Grey Physcia (*Physcia tribacioides*) trees. The most important species and communities, such as that typified by *C. premnea*, establish on trees that are 200+ years old but takes 400 years for the community to fully develop. The key lichen communities associated with ancient trees are detailed below.

On account of their age, size and history ancient trees provide many niches for specialist lichen species such that a number of these communities can be present on a single tree according to variations in aspect, light, moisture, bark chemistry and texture, presence of exposed wood, etc.

4.3.2 Ancient dry bark community, the *Lecanactidetum premneae*

In a global context this is the single most important lichen community of ancient trees; it is internationally rare, otherwise known only from a few sites in France, and has its world headquarters between East Cornwall and the New Forest. Several characteristic species are 'International Responsibility' species, and the community is of great conservation importance.

It is a community found on craggy bark on the dry sides of ancient trees, especially oak. Such bark is sheltered from direct wetting by rain or the flow of water down a tree, remaining largely dry with the lichens obtaining moisture from dew precipitated directly onto their surface. It is confined to warm temperate oceanic climates, where there are frequent dews but the climate is not so humid that moss can invade even the driest bark. The community is not restricted to woodland but occurs equally on sheltered but well-lit old oaks in pasture woodland, parkland and on field trees.

Key species: the common staining spiloma lichen *Schismatomma decolorans* usually dominates but specialist lichen species include *C. premnea*, *Enterographa sorediata*, *Lecanographa amylacea*, *Bactrospora corticola*, *Tylophoron hibernicum* and *Arthonia vinosa*. Most are internationally rare or very restricted and some are Section 41 species.

4.3.3 Ancient dry wood pinhead communities, the *Calicetum hyperelli* and *Calicietum abietinae*

Damper lignum, especially of fallen oak supports typical woodland acid bark species from but drier oak lignum, including on standing dead trees (both large and small), on live trees and large sections of fallen wood supports a very different assemblage, including many pinhead lichens. These are best developed in eastern sub-oceanic areas of Britain e.g. Welsh Marches, North East England and central and eastern Scotland, extending well into more oceanic areas in sites with many old oaks and abundant retained dead wood, but are absent from hyper-oceanic woods.

The *Calicietum abietinae* is a predominantly northern community, found especially on pine in the Scottish Highlands, but can be found throughout Great Britain where the right conditions are found—dry, well-lit exposed wood.

Key species: *Calicium glaucellum*, *Calicium abietinum*, *Chaenotheca brunneola* and *Chaenotheca trichialis*.

The *Calicietum hyperelli* is more widespread and occupies bark as well as exposed wood.

Key species: The pinhead *Calicium salicinum*, along with other species such as the *Cliostomum griffithii* and *Dendrographa decolorans*. The rare Ancients of the Future target species *Chaenotheca gracilenta* and *Calicium adspersum* sit in this community.

4.3.4 Mature damp bark community

This is a southern community in Britain, not as prominent in more northerly oceanic areas, and is typically best developed on trees with well-lit less acidic bark such as older oak, Beech and Ash where it is found on the damper side of trunks. The community is widespread and usually dominated by common white and grey crustose species (*Lepra* species) and rarely supports species of high conservation interest except in old growth woodland and parkland with veteran trees. In these situations, special species can occur such as Geranium Firedot (*Blastenia herbidella*), Lemon Tart Lichen (*Lecanora sublivescens*), Rimmed Wart Lichen (*Varicellaria velata*) and Speckled Script-lichen (*Schismatomma graphidioides*).

Key species: Lemon Tart Lichen, Geranium Firedot, Coral Firedot (*Blastenia coraliza*), Rimmed Wart Lichen.

4.3.5 Wound and rain tracks community, the *Gyalectinetum carneoluteae*

Wound tracks and well developed rain tracks on trees with base-rich bark can support a series of specialist species that tend to occur alone or with a small number of others. This assemblage was best developed on veteran elms and has obviously drastically declined in recent years; many characteristic species are now very rare due to the total loss of veteran elm in the lowlands.

This community can occur in a wide range of treed habitats; woodlands, wood pasture, parklands and on wayside trees and is found throughout Britain.
Key species: Sap-groove Lichen, Fragrant Jelly-lichen, Shy Cross-your-heart Lichen (*Cryptolechia carneolutea*) and *Gyalecta flotowii*.

4.3.6 Base-rich Bark Woodland Community, the Lobarion

This is considered the climax community of trees with base-rich bark and includes some of our most conspicuous epiphytic lichens such as Tree Lungwort (*Lobaria pulmonaria*). The community was formerly widespread in the UK, but declined drastically through the nineteenth and twentieth centuries, primarily as a result of acidic air pollution, which although now much declined has had a lasting effect.

As a result, in Britain, this community is now best developed in the rainforests of the west, although it does extend eastwards where conditions allow and where it has not been exposed to high levels of acid deposition. Crustose species of the community seem to have survived better than the leafy species like the lungworts.

Whilst not limited to them, it does becomes very well developed on mature and ancient trees.

Key species: Tree Lungwort, *Bacidia biatorina*, *Catinaria atropurpurea*, *Thelopsis rubella*.

4.3.7 Threats

One of the key requirements of these species and communities is habitat continuity, both very long standing presence of trees on a site, and continuity of conditions around them. Whilst we have trees in Britain that were standing at the time of the Norman conquest, the communities of lichens dependent on them are much older, links to our distant past.

Interruptions to this continuity and future continuity are one of the main threats they face; the universal threat of habitat loss, changes in management (especially reductions in grazing/browsing) leading to a loss of well-lit conditions and a lack of future veteran trees.

As the lichen interest of ancient trees requires well-lit conditions it is vulnerable to any changes in management—grazing and browsing—that lead to increases in the shrub layer. Removal or significant reductions in grazing and browsing pressure can also lead to increases in both native and non-native invasive species. Grazing and browsing pressure does of course have to be balanced with tree regeneration to ensure long-term continuity of the habitat, and this can be achieved in different ways in different scenarios e.g. a parkland situation will require a different approach to a woodland. In all cases grazing and browsing should be seen as the main tool for long-term management of lichen-rich ancient tree habitats, it just needs to be adapted to suit the particular circumstances of each site.

Eagle's Claw was formerly widespread in pasture and on roadside trees, but decreased during the 20th century due to Dutch Elm Disease and pollution. Relict populations persist in old pastures and parklands.


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Non-native invasive species, especially evergreen species such as Rhododendrons and laurels can have such significant impacts on lichen that populations can be lost. Invasive non-native species tend to require specific eradication programmes. Invasive native species can be just as damaging to both species and their habitats as non-native invasive species; Ivy can come to dominate tree trunks, dense Holly can have similar impacts to Rhododendrons and laurels, and Beech can both cast heavy shade and alter the species composition of woodlands. In many cases, these issues can be avoided and managed with grazing and browsing but some situations may require more concerted management programmes.

Air pollution has had a major influence on British lichen distributions since the industrial revolution. Sulphur dioxide, in the form of acid rain, has had a very significant impact both directly on species and on their habitat by acidifying bark, resulting in changes in lichen communities. Sulphur dioxide deposition is now much reduced, but nitrogen in the form of ammonia and nitrogen oxides is an increasing issue. Ammonia, largely from agricultural sources, is leading to base enrichment of bark, whilst nitrogen oxides from e.g. transport sources are acidifying. Both can operate over both short and long range, making mitigation difficult.

Agricultural activity can have both direct and indirect impacts on ancient trees and their lichens. Ancient trees and their lichens can be impacted directly such as by compaction of root systems, machinery damage and by manure spreading reaching tree trunks, and indirectly through nitrogen deposition from agricultural activity impacting on tree health and lichen community composition (linked to changes in bark chemistry).

Large diameter fallen dead wood in well-lit situations is a very important habitat for specialist lichen species. In more managed or formal situations e.g. parkland the 'tidying up' of fallen dead wood can consequently have an impact—in terms of removal and of cutting and stacking fallen material against a tree trunk.

4.3.8 Conservation

Many conservation actions that benefit other groups of taxa such as invertebrates are also beneficial to ancient tree lichens.

Continuity of habitat and future veteran trees can be encouraged by allowing trees to age and decay naturally as far as possible, following guidance if direct management is necessary. The development of large-crowned, well-lit open-grown trees should be encouraged. Where planting is being considered, refer to Table 2 for the most important tree species for ancient tree lichens, and ensure tree species are both appropriate to the site and planted at densities that will achieve well-lit conditions and/or large-crowned open grown trees. To address the age gaps in ancient trees, consider veteranisation and other novel conservation techniques of younger trees to address age gaps in ancient trees.

Ensure the continuity of open well-lit conditions across the majority of the site and especially in known lichen-rich areas and known important trees. Given the importance of long-term continuity of conditions it is important to plan ahead and maintain suitable conditions in known rich areas but also to aim for suitable conditions more widely on a site to allow for future colonisation. Grazing and browsing is the best long-term management to maintain suitable conditions. It needs to balance the need for regeneration and needs to be adapted to suit the particular circumstances of each site.

Take a zero-tolerance approach to invasive non-native species. An exception may be in more formal parkland situations where non-native species may be important features of the site. In these scenarios take measures to control any spread. Many invasive native species can be controlled with grazing and browsing—notably Ivy and Holly—which can thrive with a reduction in grazing pressure. Tree regeneration such as of Sycamore and Beech can also be controlled with grazing and browsing. In all cases, this can be problematic if the issues have developed unchecked over time and get beyond the level at which they can be controlled by grazing and browsing in which case other interventions will be required e.g. mechanical clearance and chemical treatment.

In agricultural environments, follow general good practice when it comes to looking after ancient trees e.g. avoiding root compaction. Reduce or remove agricultural inputs such as fertiliser, manure, or slurry on ancient tree sites and give trees a wide buffer as with avoiding compaction. Aim for grazing levels that allow the development of a varied sward, ideally combined with the above to move towards reversion to more species-rich diverse grassland swards. Refer to section 'Management of land around old trees'.

Leave fallen wood in situ and it fell wherever possible, avoid cutting and stacking fallen wood and particularly do not stack wood against tree trunks.

4.4 Bryophytes

Given the importance of ancient trees to specialist lichen species it is surprising that there are very few specialist ancient tree bryophytes. Some of the rarer species of well-lit ancient trees like Pendulous Wing-moss (*Antitrichia curtipendula*), Squirrel-tail Moss (*Leucodon sciuroides*) and *Pterogonum gracile* are equally found on other habitats such as calcareous upland-edge rock. The most prominent ancient tree specialist is the Knothole Yolk-moss.

> Ancients of the Future target taxa: Mosses
>
> Knothole Yolk-moss (*Codonoblepharon fosteri*)

4.4.1 Knothole Yolk-moss (*Codonoblepharon forsteri*)

The Knothole Yolk-moss is known from 205 sites in 19 countries, largely in Europe. In Britain is it currently known from just three sites—Burnham Beeches, Epping Forest and the New Forest—where it is closely associated with veteran Beech pollards. Although there are historic records from single Sycamore, birch and possibly oak, it is currently only known on Beech in Britain, and only within its core native British range i.e. where Beech has been present for the longest time post ice age.

A study of the Knothole Yolk-moss at Burnham Beeches carried out as part of the Ancients of the Future project, showed it to be almost exclusively associated with areas around water-filled rot-holes on live trees, a specialist niche it occupies throughout its world range, but it is also known to occupy exposed wood on the trunks of Beech. The water-filled rot-holes—known as dendrotelmata—are mostly associated with rot-holes on the exposed root plates of ancient Beech trees, but is also known from seepage tracks on trunks, a niche shared with the Fragrant Jelly-lichen and Sap-groove Lichen, and invertebrates such as the Western Wood-vase Hoverfly, albeit in all cases on trees other than Beech too.

The exact reasons for this associated with water-filled rot-holes are not known but are likely to be related to water availability and chemistry.

4.4.2 Threats

The main threats to the Knothole Yolk-moss are competitive exclusion by other bryophytes such as Slender Mouse-tail Moss (*Isothecium myosuroides*) and tree death. with around half the population at Burnham Beeches on ancient pollards. Localised shading issues from Holly, bramble and Beech saplings are another threat. An increase in competitive exclusion from pleurocarpus mosses like Slender Mouse-tail Moss may be the result of increasing ammonia deposition.

4.4.3 Conservation

Many conservation actions that benefit other groups of taxa e.g. invertebrates are also beneficial to the Knothole Yolk-moss.

Continuity of habitat and future veteran trees can be encouraged by allowing trees to age and decay naturally as far as possible, following guidance if direct management is necessary. The development of large-crowned, well-lit open-grown trees should be encouraged. Many trees that support the moss are ancient pollards, so establishing a pollarding programme is likely to be beneficial.

Ensure the continuity of open well-lit conditions across the majority of the site and especially around known important trees. Given the importance of long-term continuity of conditions it is important to plan ahead and maintain suitable conditions in known rich areas but also to aim for suitable conditions more widely on a site to allow for future colonisation. Grazing and browsing is the best long-term management to maintain suitable conditions. It needs to balance the need for regeneration and needs to be adapted to suit the particular circumstances of each site.

Take a zero-tolerance approach to invasive non-native species. An exception may be in more formal parkland situations where non-native species may be important features of the site. In these scenarios take measures to control any spread. Many invasive native species can be controlled with grazing and browsing—notably Ivy and Holly—which can thrive with a reduction in grazing pressure. In all cases, this can be problematic if the issues have developed unchecked over time and get beyond the level at which they can be controlled by grazing and browsing in which case other interventions will be required e.g. mechanical clearance and chemical treatment.

In agricultural environments, follow general good practice when it comes to looking after ancient trees e.g. avoiding root compaction. Reduce or remove agricultural inputs such as fertiliser, manure, or slurry on ancient tree sites and give trees a wide buffer as with avoiding compaction. Aim for grazing levels that allow the development of a varied sward, ideally combined with the above to move towards reversion to more species-rich diverse grassland swards. Refer to section 'Management of land around old trees'.

Leave fallen wood in situ and it fell wherever possible, avoid cutting and stacking fallen wood and particularly do not stack wood against tree trunks.

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4.5 Bats

Ancient and other veteran trees provide important roost sites for many bat species, from the commoner Noctule (*Nyctalus noctule*) in Britain and Leisler's Bat (*Nyctalus leisleri*) in Ireland to rare old forest bats such as Barbastelle (*Barbastella barbastellus*) and Bechstein's Bat (*Myotis bechsteinii*). Bats use a wide range of features for roosting including many types of damage that create holes or cracks in the tree; accessible heart-rot cavities, loose bark and mature Ivy. This section will highlight key habitat features that are used by bats, key threats and important conservation actions.

> Ancients of the Future target taxa: Bats
>
> Barbastelle Bat (*Barbastella barbastellus*)
>
> Bechstein's Bat (*Myotis bechstinii*)
>
> Noctule (*Nyctalus noctule*)

4.5.1 Heart-rot cavities

Some species of bat are more strongly associated with heart-rot cavities. The Noctule primarily roosts in trees, using them year-round for mating, rearing their young and for hibernating. Key features used by Noctules are knot holes, woodpecker holes found in mature, deciduous trees, wounds and natural cavities. Bechstein's bats are even more closely associated with heart-rot cavities and typically roost in deep tree cavities on either the main stem or branches. Woodpecker holes appear the most favoured, with knot holes, tear outs, wounds and splits also used.

The impacts of the accumulation of bat droppings and urine within the tree have not been studied. Bat guano makes good garden compost so presumably the tree is able to benefit from its degradation within its cavities. The guano probably supports an interesting invertebrate fauna, but this too has not been studied.

4.5.2 Loose bark

A range of bat species use loose bark for shelter, roosts and hibernation sites. Of particular note is the Barbastelle, a rare species that preferentially uses loose bark on ancient and other veteran trees as a roost feature, a maternity roost, for mating and for winter use. Barbastelles are associated with woodland habitat that has a high proportion of standing dead wood or trees and a fairly dense understory.

4.5.3 Foraging habitat

It is tree-associated bats and birds, using the tree only for nesting or roosting, which range the furthest. The species that will utilise any given tree depend largely on the nature of the surrounding habitats. Some bats, such as the Noctule, are fast, high-fliers able to travel long distances (a typical nightly foraging radius is 4 km), and will forage very widely over open countryside. This species may benefit from extensive open parkland

and wood pasture. Others, such as Bechstein's bat, predominantly forage within woodlands, often feeding intensively in very small areas close to their roosts. They prefer unevenly aged, deciduous woodland and are unwilling to visit areas without a tree canopy. They therefore require closely spaced trees or continuous woodland adjoining their roost tree. They have a typical nightly feeding radius of only 1 km. The Barbastelle, a fast agile flyer that forages in a range of habitats, from open habitats like wood pasture, parklands, wetlands, herb-rich meadows and alongside hedgerows, vegetated waterways and tree lines, has the furthest foraging range and can cover a wide area, with a typical nightly foraging radius of 7 km.


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Noctule Bat (Nyctalus noctula)

4.5.4 Threats

As with other groups, the loss of old trees and sites supporting them is the most immediate threat to bats associated with old trees. Gaps in the tree age structure on many sites and the subsequent gap in provision of habitat niches essential to these species is another key threat.

Many bat species prefer trees in shaded conditions such as closed canopy woodland. This is not the ideal habitat for large open grown trees or most of their associated species. Management for ancient trees or other associated species groups, such as clearing surrounding younger trees to reduce shading, can be detrimental to bats. Some bats also regularly use dense Ivy on trunks as a roosting site. The removal of such Ivy, to conserve lichen assemblages for example, can destroy bat roosts.

4.5.5 Conservation

Key conservation actions for bats include allowing trees to age and die naturally, developing a full array of wood-decay features, keeping existing old trees alive and protecting and improving the conditions of the surroundings of old trees to ensure wider foraging requirements are met. Existing old trees should be carefully conserved, using direct management where necessary. Surrounding habitats should be managed to protect the tree and maintain well-structured surroundings.

Suitable replacement trees should be encouraged to ensure continuity of decay habitats. If the generation gap is too large veteranisation can be used to bridge the generation gap.

Surveys should be carried out before any work that removes vegetation shading or growing on an ancient or other veteran tree that may be a bat roost, probably any such tree, to ensure that bat roosts are not damaged or destroyed.

Individuals and roosts of all bat species are protected from damage and disturbance by law. It will be necessary to carry out surveys before undertaking any action that may damage or disturb a bat roost.

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- Woodland Trust Ancient Tree Guide 6—the special wildlife of trees: https://www.woodlandtrust.org.uk/trees-woods-and-wildlife/british-trees/.

4.6 Birds

Relatively few bird species are strongly associated with ancient or other veteran trees, but those that do regularly utilise them play an important role in the ecology of old trees. The cavities created by the process of heart-rot decay are used by a number of bird species for nesting. Most of these cavity nesters, such as the Jackdaw, Stock Dove and owls use pre-existing cavities. Woodpeckers, unusually amongst vertebrate tree-users, create dead wood niches by excavating nest and bat roost cavities. Loose bark also provides a nesting site for the Treecreeper (*Certhia familiaris*). This section will highlight key habitat features that are used by birds, key threats and important conservation actions.

4.6.1 Structural cavity nesters

Nesting birds can provide a considerable nutrient input to hollow trees and tree cavities in the form of droppings, the corpses of failed young, moulted feathers and the remains of food, as well as an intermittent rain of nesting materials. Roosting bats also provide droppings. Predators bring back the remains of their prey: a cavity occupied by an owl may become carpeted with pellets of fur, feather and bones; bat droppings provide a dense concentration of insect remains. These contributions from external foragers mean that an ancient tree may not only provide habitat directly, but also act as a storehouse of resources from the wider landscape, concentrating nutrients and materials in a sheltered environments and protecting them from degradation.

Many of these birds will nest in any tree with the required habitat features, accessible cavities or loose bark, regardless of age, although ancient and other veteran trees generally support more of these features. There are species that are somewhat more selective however. The colonial Jackdaw, a regular inhabitant of parkland trees, will colonise enthusiastically only if there is a substantial population of suitable large nesting trees.

4.6.2 Threats

As with other groups, the loss of old trees and sites supporting them is the most immediate threat to cavity nesting birds. Gaps in the tree age structure on many sites and the subsequent gap in provision of habitat niches essential to these species is another key threat.

4.6.3 Conservation

Key conservation actions for structural cavity nesting birds include encouraging the formation of large open-grown trees that are allowed to age and die naturally, developing a full array of wood-decay features, keeping existing old trees alive and protecting and improving the conditions of the surroundings of old trees to ensure wider foraging requirements are met. Existing old trees should be carefully conserved, using direct management where necessary. Surrounding habitats should be managed to protect the tree and maintain well-structured surroundings. In wood pasture habitats, where most of the highest value trees are found, low intensity grazing is the ideal management.

Suitable replacement trees should be encouraged to ensure continuity of decay habitats. If the generation gap is too large veteranisation can be used to bridge the generation gap.

References and further reading

- Alexander, K.N.A., Butler, J.E. & Green, E.E. (2006). The value of different tree and shrub species to wildlife. *British Wildlife*, 18(1).
- Fuller, R.J. & Warren, M.S. (1996). Management for biodiversity in British woods—striking a balance. *British Wildlife*, 7(1).
- Woodland Trust Ancient Tree Guide 6—the special wildlife of trees: https://www.woodlandtrust.org.uk/trees-woods-and-wildlife/british-trees/.

4.7 Commonalities and conflicts

This section will briefly discuss commonalities in the habitat requirements of different groups of organisms associated with ancient and other veteran trees. It will also consider those cases where conflicts of interest between different groups may arise.

4.7.1 Shared habitat requirements and threats

The previous sections should highlight the fact that the main threats, and appropriate conservation actions, are often shared between most of the groups of organisms associated with ancient and other veteran trees. All of the groups of associated organisms reach their greatest diversity and interest in old, large, open-grown trees that are allowed to age and die naturally. The main threats to all groups are the loss or degradation of existing old trees and the lack of suitable replacements in the landscape. The most pressing and important issue is therefore ensuring the continued survival of existing ancients on which the associated species depend and encouraging replacement trees that are allowed to develop naturally in good quality surrounding habitat (Table 3).

Heart-rot features are created by specialist fungi, used by many rare invertebrates and occupied by bats and birds. These features are only naturally found in old trees. In some cases, there will be an unavoidable gap in the provision of these habitats due to the age structure of trees on a site. In such cases taking actions, such as veteranisation, to bridge any gaps in the age structure on a site will be universally beneficial.

Many groups of associated organisms have close relationships with one another. For example, fungi create decay habitats, a great diversity of invertebrates utilise this habitat and further break down the decay, vertebrates then use the resulting cavities to roost or nest and in doing so introduce nutrients back into the cavity through detritus, excrement and food foraged from the surrounding countryside. In most cases therefore conservation actions that benefit one group are likely to benefit other associated groups of organisms.

4.7.2 Conflicts of interest

There are a number of cases where the needs of different groups of organisms may conflict (Table 3). One of the more obvious is the challenge posed by bats. Some of our rarest ancient and other veteran tree associated bats, such as Barbastelle, preferentially roost in heavily shaded trees and prefer to forage close to the tree under a closed canopy. These conditions are not conducive to interest in other groups of organisms associated with ancient and other veteran trees and are not ideal for the tree itself. This can result in conflicts when making management decisions and deciding on priorities. Taking no action can hasten the death of the tree and damage epiphyte and invertebrate communities. Clearance of surrounding vegetation to benefit these groups may make the tree unsuitable for the bat.

Ivy is used by a wide range of species; it can be used as a roost by bats and is an important late season nectar source for invertebrates. But it can also be severely detrimental to ancient tree lichen and bryophyte communities and it is increasing in abundance throughout western Europe (Perring *et al.*, 2020). In many cases, established mature crown Ivy i.e. the stage which produces flowers can be left, with control efforts focused on young Ivy invading new trees. Grazing and browsing management can help keep both mature and young Ivy in check.

Table 3. Summary of key threats, mitigating conservation actions and groups of associated wildlife damaged or favoured by the threat.

Threat	Description	Conservation action	Groups Threatened	Groups favoured
Habitat destruction-trees or sites	Individual old trees or entire sites may be lost to felling, development, competition, disease or mechanical failure. This will result in the loss of the habitats and wildlife associated with the tree.	Protect existing ancient and other veteran trees from damage or destruction. Direct management interventions to prolong the life of ancient and other veteran trees if absolutely necessary.	All	None
Removal or destruction of dead wood	Dead wood is an important habitat for many species. Removal of attached or fallen dead wood will destroy this habitat and the associated wildlife.	Do not remove attached dead wood from trees. Do not move or destroy fallen dead wood.	Fungi Invertebrates Lichens Bryophytes	None
Intensive land use	Intensive land uses can be seriously damaging to old trees and therefore their associated wildlife. Intensive agriculture and urban developments are the most damaging.	Encourage low intensity land use around old trees. Provide low-intensity buffers around old trees in surroundings such as arable farmland or urban areas.	All	None
Shading due to reduced management or plantation	Many rare species require open-grown trees in relatively open habitats. Shading of the trunk by surrounding vegetation or climbing plants reduces habitat suitability for many epiphyte, invertebrate and fungal species. Shading and competition by younger trees can lead to the decline and death of existing ancients and other veterans.	Prevent shading by scrub through continued management—grazing or cutting. Do not plant trees or shrubs close to existing old trees. Clear young plantation woodland and scrub from around old trees.	Many invertebrates Lichens Bryophytes	Some invertebrates
Atmospheric pollution/ agrochemicals/fertilisers	Atmospheric pollution by sulphur dioxide, nitrous oxides and ammonia can have direct and indirect impacts on lichens and bryophytes. Environmental degradation, e.g. acidification and nitrogen enrichment are detrimental to fungi. Agrochemicals and fertilisers drifting onto or splashing the trunk can kill epiphytes and fungi.	Provide low-intensity buffers around old trees in surroundings such as arable farmland or urban areas. Do not spray agrochemicals or fertilisers close to the trunks of old trees.	Lichens Fungi Bryophytes Invertebrates	None
Habitat fragmentation and isolation of populations	The loss of many ancient and other veteran trees from the wider landscape has led to fragmentation of populations of associated wildlife. Isolated populations are more vulnerable to extinction.	Encourage connectivity between existing sites through natural regeneration or tree planting that will allow the development of large open-grown trees in the long term. Use veteranisation techniques or dead wood boxes to create stepping stones through the landscape.	All	None

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Table 3 cont. Summary of key threats, mitigating conservation actions and groups of associated wildlife damaged or favoured by the threat.

Threat	Description	Conservation action	Groups Threatened	Groups favoured
Gaps in age structure and habitat provision	Many sites have very uneven age structures of trees. Overgrazing often prevents natural regeneration in most parklands and wood pastures. In some cases there are only old trees, in others, young trees are now being encouraged but there are few middle aged trees leading to a large future gap in the provision of decaying wood habitats.	Encourage the formation of large open-grown trees that are allowed to age and die naturally. Use veteranisation techniques to prematurely encourage the formation of wood-decay habitat features on younger trees. Use dead wood boxes, artificial rot-holes and other facsimiles to bridge gaps in habitat provision if necessary.	All	None
Clearance of climbing or surrounding vegetation	Climbing vegetation e.g. Ivy will overgrow lichens and come to dominate the lichen and bryophyte habitat. Bats roost in Ivy and often prefer foraging in wooded environments. Some saproxylic invertebrates, especially flies, prefer damp and shaded conditions.	Clear surrounding vegetation slowly and carefully. Do not clear vegetation where it will be detrimental to existing wildlife. Survey before any clearance. Do not clear climbing vegetation from trees that have or are likely to support bat roosts without thorough survey.	Bats Breeding birds Some fungi Some invertebrates	Many fungi Many invertebrates Lichens Bryophytes

References and further reading

- Perring, M.P., De Frenne, P., Hertxog, L.R., Blondeel, H., Depauw, L., Maes, S.L., Wasof, S., Verbeeck, H., Verheyen, K. 2020 Increasing liana frequency in temperate European forest understories in driven by ivy. *Frontiers in Ecology and the Environment*, 18(10) pp550-557.

4.7.3 Resolution of conflicts

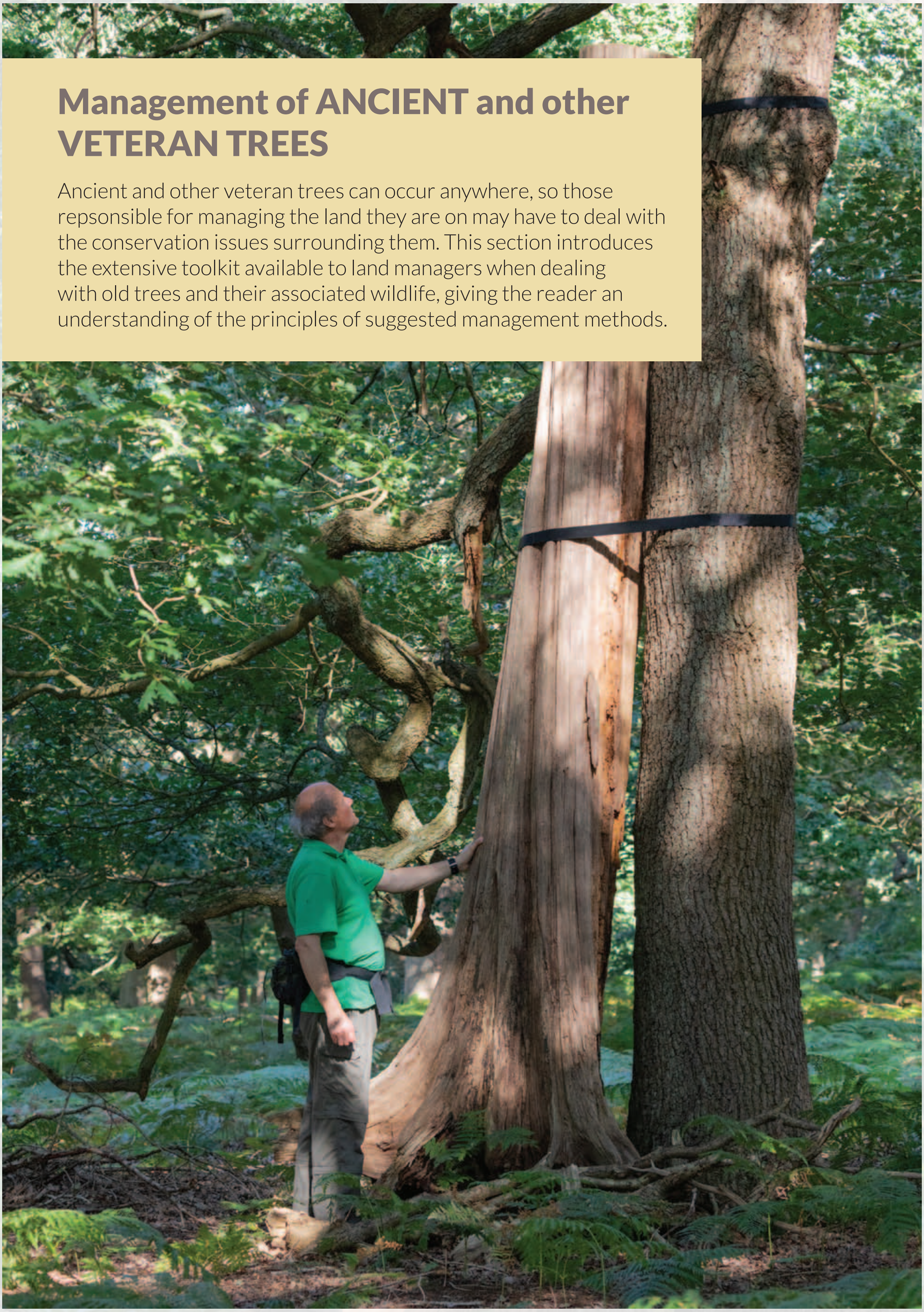
There are no straightforward one-size-fits-all methods to resolve conflicts. When such conflicts of interest are encountered during management planning it is important to carefully consider the likely impacts of any action on both groups/species before any work is carried out. In some cases, there may be an obvious reason to favour one side, if one community or species is far rarer than another for example. In others there may be no entirely satisfactory solution and careful compromise may be required, reducing the scale of planned management for example. In all cases the more information the person making the management decisions has available the better the decision will be. Carrying out survey work prior to planned management to ensure that there are no groups that will be adversely affected, or to more accurately gauge the relative value of the assemblages or species that may be affected is essential for this. Monitoring of the results of any management intervention on associated organisms is also essential to guide future decisions.

References and further reading

- Fuller, R.J. & Warren, M.S. (1996). Management for biodiversity in British woods—striking a balance. *British Wildlife*, 7(1).

Management of ANCIENT and other VETERAN TREES

Ancient and other veteran trees can occur anywhere, so those repsonsible for managing the land they are on may have to deal with the conservation issues surrounding them. This section introduces the extensive toolkit available to land managers when dealing with old trees and their associated wildlife, giving the reader an understanding of the principles of suggested management methods.



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5. MANAGEMENT OF ANCIENT AND OTHER VETERAN TREES

This part of the document aims to provide an introduction to the extensive toolkit available to land managers when dealing ancient and other veteran trees and their associated wildlife. Producing a full synopsis of currently available management techniques would be a monumental task and far beyond the scope of this document. Here, we provide an introduction to the principles behind both well established and experimental techniques that can be used to manage trees and their surroundings to benefit the taxa associated with old trees. Basic guidance on their real-world application is also given.

Much of the information given in this section, especially that related to directly managing existing ancient or other veteran trees, is based heavily on the book ***Ancient and other Veteran Trees: Further guidance on management*** (Lonsdale, 2013), and to a lesser extent, due to advances in understanding since its publication, ***Veteran Trees: A Guide to Good Management*** (Read, 2000). These are considered standard texts on the subject of Ancient and other veteran trees in Britain and should be consulted for more detailed information on many of the topics covered. These sources have been supplemented by information from additional sources and more recent research or experience where necessary. Both of these books are freely downloadable from the Ancient Tree Forum website: https://www.ancienttreeforum.org.uk/resources/ancient-trees-books-shop/. The following sections also draw heavily on the excellent and freely available video transcripts produced by the VETree (www.vetree.eu) and VETcert (www.vetcert.eu) projects.

Old trees can occur almost anywhere and therefore anyone responsible for managing land may have to deal with the wildlife conservation issues that surround them. No assumptions have therefore been made about the prior experience of the reader. It should be possible for someone from any background to use this document to gain a basic understanding of the principles and applications of the management methods discussed. The reader can then use the references and links provided in the references and further reading recommendations at the end of each section to gain a deeper understanding of the management methods relevant to their needs.

The broad themes covered in this section are:

- 5.1 Direct management to prolong the life of existing ancient or other veteran trees
  - 5.1.1 Deciding if a tree needs management
    - Assessing mechanical integrity
    - Health and safety issues
    - Legal issues relating to managing ancient and other veteran trees
  - 5.1.2 Health and safety of workers during tree work
  - 5.1.3 Pruning ancient and other veteran trees
    - Limb reduction and pruning
    - Crown reduction and retrenchment pruning
  - 5.1.4 Unconventional pruning methods
    - Rip cutting
    - Fracture simulation cuts
    - Ring-barking
  - 5.1.5 Pollarding
    - Management of ancient and other veteran pollards
    - Creation of new pollards
  - 5.1.6 Timing of tree work
  - 5.1.7 Management of dead wood
    - Management of attached dead wood
    - Management of fallen or cut dead wood
    - Making the most of wood and timber from management operations
  - 5.1.8 Other useful management methods
    - Intervention to assist phoenix regeneration
    - Propping and strapping
    - Protection of cavities against fire or disturbance
    - Removal or control of climbing plants
- 5.2 Bridging the generation gap
  - 5.2.1 Veteranisation
    - General principles
    - Use of climbing spikes
    - Woodpecker holes
    - Nest boxes
    - Ring-barking branches
    - Ring-barking entire trees
    - Trunk damage through bark removal
    - Fire damage
    - Cutting into the trunk
    - Bruising the trunk
    - Eiffel Tower technique
    - Cutting of branches or limbs
    - Winching
    - Heavy crown reduction
    - Explosives
  - 5.2.2 Creative use of existing dead wood
    - Re-attaching fallen dead wood
    - Re-erecting dead trunk
    - Burying dead wood
    - Creation of stump cavities
  - 5.2.3 Other methods of bridging gaps in habitat provision
    - Heart-rot inoculation
      - Veteranising inoculations
      - Consveration inoculations
    - Dead wood boxes
    - Artificial rot-holes
    - Lichen translocation
- 5.3 Management of land around old trees
  - 5.3.1 Roots and mycorrhizal fungi

5.1 Direct management to prolong the life of existing ancient or other veteran trees

Pruning of existing ancient and other veteran trees should be avoided wherever possible and never undertaken lightly. Every ancient or other veteran tree is a rare and precious resource, providing habitat to a great many species. If a tree has reached this stage in its life the most fundamental principle to follow is that they should be left alone. Any work involving cutting the tree will cause stress and could result in reduced lifespan or death. Many old trees are especially sensitive to the adverse effects of pruning or changes in their growing habits. They may also support rare and vulnerable species that have exacting habitat requirements found in the tree as it currently exists. Any work may change those habitats to the detriment of associated species (Lonsdale, 2013).

There are reasons for pruning ancient or other veteran trees. The primary reason, and the only one justifiable in the name of wildlife conservation, is to extend the lifespan of the tree. The best way to ensure continuity of dead wood habitats and other niches associated with ancient trees is to keep the tree alive for as long as possible. If an ancient or other veteran tree is at high risk of major mechanical failure which will kill the tree, or destroy much of its conservation value, remedial action should be taken where possible. If work has been carried out on the tree in the past it may also be necessary to work on the tree to maintain mechanical integrity after new growth. Veteran trees or their neighbours should never be pruned for frivolous reasons, such as to facilitate access.

5.1.1 Deciding if a tree needs management

The decision to carry out direct management on an ancient or other veteran tree is a serious one. Every effort should be made to ensure that the tree truly requires management and that there are no other alternatives. This section highlights some of the key issues to consider when making this decision.

1) Assessing mechanical integrity
2) Health and safety considerations
3) Legal considerations

- ***Assessing mechanical integrity***

Assessing if a tree is at risk of life-shortening mechanical failure is complex and requires skill and experience. Decay, limb loss, and production of dead wood are normal, and, for the purposes of providing habitat niches for associated wildlife, desirable, features of old trees. They should never be considered a reason for tree work in their own right. Old, open grown trees are remarkably good at stabilising themselves through natural processes such as retrenchment (gradual lowering of the crown). Old hollow trees with reduced crowns are often more stable than mature trees with a full crown. Trees with full crowns have much greater wind resistance, and are far more likely to fall in gales (Lonsdale, 2013).

Mechanical failure occurs most frequently in lapsed pollards. Many ancient trees in Britain are lapsed pollards, unmanaged for many decades. These have a tendency to grow many thick limbs from the old pollard point and become extremely top heavy. This, coupled with a decayed and hollowed trunk, can make them vulnerable to catastrophic collapse. It should not be automatically assumed that such trees need work however, and, as in any other old tree, they should be individually assessed and action only taken when deemed unavoidable. Such trees should never be re-pollarded back to the original pollard point. Crown reduction is a possible alternative, but only when necessary.

The tree should also be assessed for its capacity to tolerate planned pruning and grow well in response. There is no point in saving a tree from mechanical failure through costly pruning if it is likely to die soon after due to the stress of the work. The tolerance of a tree is dependent largely on the vitality and tree species. Assessment of suitability should take account of these factors as well as the form of the crown and the capacity for individual branches of the tree to survive after cutting. If there is no reasonable prospect of successfully increasing tree lifespan non-intervention may be the only practicable option (Lonsdale, 2013).

The intricacies of assessing the biomechanical integrity of trees and their tolerance of pruning are beyond the scope of this document. It is recommended that Lonsdale (2013a): Section 4.3 be consulted for further information on the process. Videos giving further guidance are freely available at https://www.vetcert.eu/node/53 and https://www.vetcert.eu/node/14. The key point is that every tree is an individual and the appropriate management can only be determined by an appropriately qualified person carefully assessing the tree and its surroundings (e.g. www.vetcert.eu/certified-specialists).

References and further reading

- VETcert video on assessing trees before considering management options: https://www.vetcert.eu/node/53.
- VETcert video on techniques for crown reducing a veteran tree: https://www.vetcert.eu/node/14.
- Davies, C., Fay, N. and Minor, C. (2000). *Veteran Trees: A Guide to Risk and Responsibility*. English Nature.
- Lonsdale, D. (ed.) (2013). *Ancient and other veteran trees: further guidance on management*. The Tree Council, London. Chapters 4.3 and 7.
- Read, H. (2000). *Veteran Trees: A guide to good management*. English Nature. Chapter 4

- ***Health and safety issues***

It may be necessary to carry out pruning on an ancient or other veteran tree is if it poses, or is likely to pose in the near future, an unacceptable level of risk to people, property or structures of archaeological value.

The health and safety risks associated with old trees are often seriously overestimated and much damage has been done by unnecessary pruning and felling. Normally the risk of death or injury from trees is extremely low and no work will be required. There is a roughly one in ten million chance of being killed by a tree in Britain. In Britain risks of death of below one in one million are considered insignificant (https://www.vetcert.eu/node/17).

If a detailed risk assessment of a tree, carried out according to appropriate criteria (e.g. Ellison, 2005; https://www.forestresearch.gov.uk/documents/7086/Commonsense_management_of_trees.pdf), shows an overwhelming need to protect property or people, the first step to mitigate the risk should always be to try to "relocate the target". Access should be re-routed away from the tree, property, materials or infrastructure should be moved if possible and fencing can be used to further restrict access to the area. Providing new or improved access below ancient or other veteran trees should be avoided, and, where possible, paths and seating should be moved from the immediate vicinity of any old tree to further reduce risk to both people and the tree (Lonsdale, 2013; https://www.vetcert.eu/node/17).

Only if measures such as relocating the target are impossible should pruning be carried out (Lonsdale, 2013; https://www.vetcert.eu/node/17). If a branch is genuinely in imminent danger of falling, it will do little harm to hasten it on its way by removing it from the tree and placing it on the ground beneath. Such branches should not, however, be removed from the area as this reduces the value of the dead wood for wildlife. Further guidance on common-sense risk assessment of trees is available in a free training video on the VETCert website (https://www.vetcert.eu/node/17).

The possession of limbs that are at risk of failing, is not, under any circumstances, a reason for the felling of an entire tree. Proper assessment, by a suitably qualified professional, of the risk of failure of the whole tree or elements of the tree should provide the basis for any management action. If, despite all other options, the tree must be felled, it should be left, wherever possible where it falls, in as large pieces as possible. If it must be moved, appropriate guidance, available at https://vetree.eu/action?action=downloadables-download&file=38, should be followed.

Pruning or felling in the interests of safety should always be kept to a minimum. In particular, pruning which involves the cutting out of rot, the concreting of cavities or the use of wound paint should not be undertaken. If possible, it is better if the public is kept away from the immediate vicinity of trees which are viewed as potentially dangerous.

References and further reading

- Guidance on common-sense risk assessment of trees is available in a free training video on the VETCert website: https://www.vetcert.eu/node/17.
- Guidance on managing dead and decaying wood: https://vetree.eu/action?action=downloadables-download&file=38.
- National Tree Safety Group guidance in common sense risk management of trees: https://www.forestresearch.gov.uk/documents/7086/Commonsense_management_of_trees.pdf.
- Davies, C. Fay, N. & Minor, C. (2000). *Veteran Trees: A Guide to Risk and Responsibility*. English Nature.
- Lonsdale, D. (ed.) (2013). *Ancient and other veteran trees: further guidance on management*. The Tree Council, London. Section 4.3.2.
- Ellison, M.J. (2005). Quantified tree risk assessment, used in the management of amenity trees. *Journal of Arboriculture*, 31.

• *Legal issues relating to managing ancient and other veteran trees*

There are a number of legal issues that may arise surrounding the management of ancient and other veteran trees. Ancient and other veteran trees are a Priority Habitat under the Natural Environment & Rural Communities (NERC) Act 2006 and may be covered by tree preservation orders. Many are likely to be within Sites of Special Scientific Interest, requiring statutory consent for certain activities and may also be part of a Scheduled Monument, or at least be within one.

Ancient and other veteran trees may be a habitat for legally protected species. Bats are of particular importance, as any ancient or other veteran tree will be a potentially suitable roost for several species. All bats and their roosts are protected by law and it may be necessary to commission bat surveys before work can commence (https://www.gov.uk/guidance/bats-protection-surveys-and-licences). Further details on the legal issues relating to bats can be found here https://www.bats.org.uk/advice/bats-and-the-law.

It is also an offence to kill or injure any wild bird or their nests or eggs. Schedule 1 species are protected from disturbance as well (https://www.gov.uk/guidance/wild-birds-protection-surveys-and-licences). This can be a serious constraint to any work on ancient or other veteran trees during the nesting season—officially considered to run from March until August (https://www.gov.uk/guidance/wild-birds-surveys-and-mitigation-for-development-projects). When tree work must be undertaken during the nesting season, survey for nesting birds needs to be carried out by a suitably competent person. It should be assumed that birds will be nesting in trees unless proven otherwise. Surrounding vegetation and trees adjacent to the work area may also support nesting birds that might be disturbed by work and access to the site. This can lead to established nests being abandoned or damaged. This action is also a breach of the act and therefore could lead to prosecution. Additional care and controls should be taken to minimise disturbance of surrounding vegetation during access and egress and whilst carrying out the necessary work (https://www.trees.org.uk/Help-Advice/Public/When-is-the-bird-nest-season).

Several other species of rare invertebrate, lichen and bryophyte associated exclusively with old trees are legally protected. A number of species are listed under Schedule 8 of the Wildlife & Countryside Act 1981. On sites where such species are known to occur their habitat requirements should be accounted for in any work carried out. Whenever there is reason to believe that work might affect a protected species appropriate advice should be sought from a suitably qualified ecologist. Applications may be made for licences to work on trees or fallen wood used by protected species. Grants of licence may have special conditions attached such as employment of specialist personnel.

A summary of current legislation (2019) relating to trees has been produced by the VETCert initiative and can be accessed here https://www.vetcert.eu/sites/default/files/2019-11/Legislation%20update%20UK.pdf. This also includes details of various grants available for the management and protection of trees.

Any work on veteran trees should be done according to published standards and procedures for tree work (see BS 3998: 2010) and in accordance with all applicable laws and regulations.

References and further reading

- A fact sheet covering the main legislation and implications for ancient and other veteran trees in the UK can be found here: https://www.vetcert.eu/sites/default/files/2019-11/Legislation%20update%20UK.pdf.
- Bat Conservation Trust information on Bats and the law: https://www.bats.org.uk/advice/bats-and-the-law.
- British Standards for tree work document: BS 3998: 2010
- Details of the legal responsibility of tree owners and managers can be found in: Davies, C., Fay, N. & Minor, C. (2000). *Veteran Trees: A Guide to Risk and Responsibility*. English Nature.
- Government guidance on bat surveys and licences: https://www.gov.uk/guidance/bats-protection-surveys-and-licences.
- Government guidance on birds and the law: https://www.gov.uk/guidance/wild-birds-protection-surveys-and-licences.
- https://www.gov.uk/guidance/wild-birds-surveys-and-mitigation-for-development-projects.
- Lonsdale, D. (ed.) (2013). *Ancient and other veteran trees: further guidance on management*. The Tree Council, London. Appendix C provides a full list of UK laws that relate to the management of trees.
- Read, H. (2000). *Veteran Trees: A guide to good management*. English Nature. Chapter 4

5.1.2 Health and safety of workers during tree work

Tree work is dangerous, especially when using a chainsaw at height. This is doubly true when dealing with veteran trees that are likely to have dead branches, areas of decay and unstable areas. Tree work should only be undertaken by suitably qualified professional arborists. Anyone employed in such work should have all relevant qualifications (chainsaw, etc.) and ideally have experience of working with veteran trees. The VETCert certificate (https://www.vetcert.eu/) is a preferred qualification for working with ancient and other veteran trees. This is relatively new and thus there are currently relatively few that have the certification in the UK, but numbers are expected to increase. Any tree work should follow relevant standards as laid out in British Standards document BS 3998:2010. The Arboricultural Association also have a register of approved contractors, which can be checked when searching for an appropriate contractor (https://www.trees.org.uk/Registered-Consultant-Directory).

References and further reading

- Arboricultural Association register of approved contractors: https://www.trees.org.uk/Registered-Consultant-Directory.
- British Standards for tree work document: BS 3998: 2010
- Lonsdale, D. (ed.) (2013). *Ancient and other veteran trees: further guidance on management*. The Tree Council, London.
- VETcert initiative: https://www.vetcert.eu.

5.1.3 Pruning ancient and other veteran trees

Once it has been established that pruning is required to prolong the life of an ancient or other veteran tree, and that it is possible to do so safely (for both the tree and workers), it is necessary to decide on the most suitable method for the job. Commonly used techniques, along with their suitability in different scenarios, are discussed in the following sections. The work carried out should always be the minimum necessary for the purpose. The guidance given in this section draws heavily on information given in chapter 4 of Lonsdale (2013a). It is recommended that this source be consulted prior to carrying out any work. Table 4 summarises the methods discussed in this section.

- ***Limb reduction and pruning***

If a small number of limbs or branches are compromising the structural integrity of the tree they should be pruned to reduce their length and loading. Pruning should be just sufficient to reduce stress and the likelihood of mechanical failure. Avoid trying to impose any pre-conceived aim of re-balancing the tree. Prune only where required to prevent catastrophic damage.

Avoid the creation of large wounds that may expose dysfunction prone central wood during management. This is especially important in trees that lack durable heartwood, such as Beech and Hornbeam. Fungal colonisation of such wounds in these species can be overwhelming and rapidly kill the tree. Decay is rapid and the overall provision of wood-decay habitats is significantly reduced by the death of the tree.

If it is necessary to cut large-diameter branches, they should be shortened rather than removed entirely.

Table 4. Summary of methods for pruning ancient and other veteran trees.

Method	Action	When to use	Key considerations
Limb reduction and pruning	Pruning individual branches to reduce their length and loading	If a small number of limbs or branches are compromising the structural integrity of the tree	Prune only where required to prevent catastrophic damage Avoid the creation of large wounds Never cut into or drain holes or decaying cavities Leave a stub beyond a suitable side branch with lateral branches and plenty of foliage Never treat cut branches with herbicide or insecticide Ensure good functional units are retained around the whole tree Stress factors, such as drought or soil compaction, should be taken into account and pruning delayed until the tree is no longer stressed
Crown reduction	Pruning a selection of branches and limbs across the tree to reduce crown size and increase biomechanical stability	If the structural issues are more serious, as is the case in many top-heavy lapsed pollards	In addition to the considerations for limb reduction and pruning: Never remove more of the crown than is absolutely necessary Prune in several stages to reduce stress to the tree where possible Separated stages of by several years to allow regrowth and recovery If further stages of pruning are planned retain new growth on cut branches
Retrenchment pruning	Retrenchment pruning is a particular type of pruning that aims to mimic natural retrenchment	If it is desirable to imitate and encourage natural retrenchment in a tree to increase biomechanical stability	In addition to the considerations for limb reduction and pruning and crown reduction: Remove young, small-diameter branches first Position cuts to retain small branches and twigs that will produce good foliage cover in the next growing season Successive pruning should only be undertaken when new twigs and foliage have been well established for at least three years

Complete removal or cutting too close to the parent stem could lead to serious dysfunction and decay. Never cut into or drain holes or decaying cavities as these provide valuable habitat for invertebrates (Lonsdale, 2013: 4.4.1).

The retained portions of cut branches should have lateral branches and plenty of foliage to increase the chances of regrowth. If the retained portion will be unavoidably bare of foliage or lateral branches, assess whether it is likely to produce new shoots from dormant or adventitious buds. If not, the branch will die back. The younger the cut branch the more likely it is that the bare portion will develop shoots. Knowledge of previous success or failure, especially on the same site, is very useful in making this judgement.

When shortening a stem or branch it is best to leave a stub beyond a suitable side branch. A stub can produce new shoots and help to sustain the stem or branch but will die back if no strongly growing shoots develop. Retained stubs also provide egg laying sites for invertebrate species. Even if the stub dies it will provide valuable decaying wood habitat.

A retained stub should be the maximum length that still provides sufficient reduction in loading. Longer stubs include more growing points, are less likely to dry out, more likely to extend far enough to receive adequate sunlight, and provide a greater volume of potential habitat for associated flora and fauna.

If it is necessary to remove an entire branch the final cut should leave a small stub and avoid the creation of flush cuts. Flush cuts cause injury to the branch bark ridge and often initiate extensive wound related dysfunction of the parent stem or branch.

Always ensure good functional units are retained around the whole tree after pruning, with connections between the roots, trunk, branches and leaves, taking account of the size and viability of the foliage bearing twigs and the structure likely to be present after pruning (Lonsdale, 2013: 4.4.1).

Cut branches should never be treated with herbicide or insecticide. Sealant, in the form of non-toxic wound dressing, may be used if moisture loss from the wound is likely to cause severe dysfunction or death to the tree. In all other cases, its use is not encouraged.

- ***Crown reduction and retrenchment pruning***

If the structural issues are more serious, as is the case in many top-heavy lapsed pollards, the entire crown of the tree may need to be reduced in size. A crown reduction involves pruning a selection of branches and limbs across the tree to reduce crown size and increase biomechanical stability. You should never remove more of the crown than is absolutely necessary. Over-pruning may reduce the leaf area of the tree to a point where it is too small to sustain it.

Depending on the condition of the tree and the amount of pruning required it may be necessary to prune in several stages over many years, even decades. This reduces the stress to the tree and is the best strategy when managing veteran trees, provided the required reduction in mechanical stress can be achieved in time to avert major failure. Each stage of pruning should be separated by several years to allow regrowth and recovery of the tree. If further stages of pruning are planned some new growth should be retained on cut branches to help keep them alive.

Retrenchment pruning is a particular type of pruning that aims to mimic natural retrenchment by encouraging the tree to produce growth lower down, thus encouraging retrenchment to occur more quickly.

The first stage of retrenchment pruning should remove young, small-diameter branches which have enough growing points to produce plentiful lateral growth. Any retrenchment plan should allow for the possibility that young branches will respond by producing shoots near the cuts rather than diverting resources to the lower crown. If this happens further pruning of these branches may be required, or alternative pruning strategies adopted.

Pruning cuts should be positioned to retain small branches and twigs that will produce good foliage cover in the next growing season. This will stimulate twig growth lower in the tree. Plentiful epicormic growth on the stem and major branches is a good indicator that the tree will respond well.

Each successive phase of pruning should be undertaken only when new twigs and foliage have been well established for at least three years. Any active stress factors, such as drought or soil compaction, should be taken into account and pruning delayed until the tree is no longer stressed.

Allowance must be made for future growth re-establishing the former crown size. If this happens further pruning will be necessary. If a tree is very vigorous it may grow back to its pre-pruning size within a few years. In the worst case such a response may suppress lower growth and leave no suitable positions for further pruning. The best-case scenario in such cases is likely to be several further stages of pruning to bring the tree to a mechanically safe height (Lonsdale, 2013: 4.4.4).

If the risk of mechanical failure is acute, then more significant pruning may be considered, in one or two stages. This is likely to lead to significant dysfunction and few ancient or other veteran trees will thrive after such treatment. It should be considered a last resort if needed to avoid major failure and there is a good lower crown structure (Lonsdale, 2013: 4.4.4). This may be a suitable alternative if felling would be the only other option. Further guidance on pruning and crown reduction in ancient trees can be found in a freely available training video available on the VETCert website (https://www.vetcert.eu/node/14).

References and further reading

- Guidance on pruning and crown reduction in ancient trees can be found in a freely available training video available on the VETCert website (https://www.vetcert.eu/node/14).
- Lonsdale, D. (ed.) (2013). *Ancient and other veteran trees: further guidance on management*. The Tree Council, London. Chapter 4.4.
- Read, H. (2000). *Veteran Trees: A guide to good management*. English Nature. Chapter 4

5.1.4 Unconventional pruning methods

It may be desirable to create a more natural looking fracture, rather than a flat cut at the end of a retained stub. This more closely mimics the effects of natural shedding of branches and limbs and can be done for aesthetic purposes, to soften the cut and give the tree a more natural appearance, or for nature conservation, encouraging colonisation by fungi and saproxylic invertebrates. Such methods may also encourage greater shoot development in the cut branches.

All of these methods result in a greater area of cut and exposed wood. If moisture loss from a large cut is considered likely to cause excessive dieback, either due to dry conditions or the stub being short, the risk to the tree's health involved in creating a natural looking break may outweigh any benefit and conventional pruning should be adopted. There has been limited evaluation of the effectiveness of these unconventional pruning techniques. They should therefore be used in moderation on ancient and other veteran trees. Using the techniques on no more than 15% of the cut branches on a given tree has been suggested (https://www.vetcert.eu/node/51). Table 5 summarises the unconventional pruning methods discussed in this section.

- ***Rip cutting***

Rip cutting involves partially cutting a branch and allowing it to tear off to mimic storm damage (Lonsdale, 2013a: 4.4.5). This method works best on light branches (less than 30 cm diameter); larger branches can be very difficult to control when they break and may therefore be dangerous. It is always necessary to ensure that the rip does not extend far enough to damage the main stem or branch. A small undercut at the desired rip termination point can ensure this (https://www.vetcert.eu/node/51).

- ***Fracture simulation cuts***

Fracture simulation cuts aim to produce natural looking results by carving diagonally into the retained stub of the branch using a chainsaw to leave a complex and jagged edge (Lonsdale, 2013: 4.4.5). This method requires considerably more work than flat or rip cuts. They are best suited to trees in high profile locations. This technique

Table 5. Summary of unconventional pruning methods.

Method	Effects	When to use	Key considerations
Rip cutting	Partially cutting a branch and allowing it to tear off to mimic storm damage	When a more natural looking stub is desired to encourage utilisation by wildlife or for aesthetic reasons	Works best on light branches as larger branches are difficult to control and may therefore be dangerous Ensure that the rip does not damage the main stem or branch
Fracture simulation cuts	Produces natural looking results by carving diagonally into the retained stub of the branch using a chainsaw to leave a complex and jagged edge	When a more natural looking stub is desired to encourage utilisation by wildlife or for aesthetic reasons	This method requires considerably more work than flat or rip cuts Best suited to trees in high profile locations Involves an increased risk to the operator and should only be carried out by qualified practitioners
Ring-barking	Causes a branch to die back slowly giving the tree a longer time to respond and providing attached dead wood habitat	When a more natural looking stub is desired to encourage utilisation by wildlife or for aesthetic reasons When it is desirable to place minimum stress on the tree To create attached dead wood habitat	The time taken for the branch to die, decay, and drop depends on the species of tree Risks of falling dead wood make this less suitable for areas frequently used by the public

Coronet and natural fracture cuts were pioneered at Ashtead Common in Surrey. A series of bracken fires on the site in 1980s killed many maiden and lapsed pollard oaks, leaving hundreds of standing dead trees. Those overhanging paths required reduction of limbs to make them safe. Flat cutting the branches resulted in a uniform and artificial look, leading to attempts at creating a more natural looking fracture. The results have been well received by the public and potentially provide additional benefits to wildlife using the trees. These techniques have subsequently been used more widely and on living trees as a means to potentially mimic natural breakage.

Curtis, A., Warnock, B., Green. J. (2000). Mimicking natural breaks in trees. *Enact*, 8(3), pp. 19-21

does involve an increased risk to the operator and should only be carried out by qualified practitioners (https://www.vetcert.eu/node/51).

- ***Ring-barking***

Ring-barking is an alternative to pruning that causes a branch to die back slowly. This gives the tree a longer time to respond. The branch may eventually fall off but provides attached dead wood habitat in until that time. The time taken for the branch to die, decay, and drop depends largely on the species of tree. A 3-4 cm wide strip of bark and cambium should be removed around the branch at the desired point. This should be some distance from any side branch that is to be retained to ensure the side branch is not damaged when the dead portion falls (https://www.vetcert.eu/node/51).

5.1.5 Pollarding

Pollarding is a traditional management method used to provide a continuous and renewable resource of boughs, branches and winter fodder from a tree by repeatedly cutting smaller branches (poles) from the main trunk (bolling). Such trees were often maintained long into senility (Green, 1996; https://www.vetcert.eu/node/9). The repeated wounding from cutting the poles, when pollarding potentially induces decay and other veteran features much earlier than would normally be the case (Sebek *et al*., 2013). Pollarding may also extend the lifespan of trees (Read, 2008). This allows pollarded trees to survive to old age and partially decay whilst maintaining usefulness in producing wood. As a result, many pollards are old and gnarled with many pockets of fungal decay, retained water, loose bark and sap runs. Ancient pollards are very important for wildlife, particularly invertebrates and fungi, because of these features (Green, 1996; Read, 2008).


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Lapsed and top-heavy pollard

Old pollards also have significant landscape and heritage value. Pollards are frequent in wood pasture where it was important to protect young re-growth from grazing animals, hence cutting the trees at a height above the reach of the animals. They also occur more widely in neglected wood pasture, common land, hedgerows and along boundaries. Such trees were widespread in the landscape when small scale production of poles or leaves and twigs for fodder was an important part of the rural economy (Green, 1996).

As agriculture and forestry became more intensive most pollards were lost or management of the trees lapsed, leading to the pollard becoming top-heavy and collapsing. Pollarding declined in popularity through the 19th and 20th centuries with only willows and street trees being pollarded with any frequency by the late 20th century. There are few pollards in Britain that are still in a regular cutting cycle. Most have been out of a regular cutting cycle for several decades and are now considered lapsed pollards (https://www.vetcert.eu/node/9).

The lack of cutting of pollards usually results in multiple large limbs developing from the previous pollard point and the tree becoming very top heavy and vulnerable to limb failure or complete collapse in high winds. This is a frequent cause of the loss of lapsed pollards.

Pollarding is currently undergoing something of a revival as the value of these trees, for wildlife and heritage, is increasingly acknowledged. Management of pollards is currently divided between managing ancient and lapsed pollards and the creation of new ones. The methods and approaches to these are very different (Green, 1996; Lonsdale, 2013: 4.5.1 and 4.5.2; https://www.vetcert.eu/node/9). Methods for managing old pollards are discussed in the following section. The creation of new pollards is discussed further when considering methods for bridging the gap in habitats between existing old trees and new generations of younger trees.

- ***Management of ancient and other veteran pollards***

Old pollards are frequently encountered in wood pasture and more widely in the countryside. As such trees have a long history of intensive management it is often necessary to intervene to some degree to ensure their continued survival.

If a pollard is still in a regular cutting cycle, or has only experienced a short lapse in management, it is best to continue with the established cutting cycle and techniques. Don't change a system that is working, you can never be sure of how the tree will respond. New cuts should be made just above the previous ones, leaving small stubs. It is important not to cut below the branch collar, even in young pollards, as this can lead to dysfunction in the tree (https://www.vetcert.eu/node/9).

For trees in a regular cutting cycle, it is normally possible to cut most or all of the branches from the tree. Past management of the tree should be used as a guide to what it can tolerate. If the tree is old, it is always prudent to leave some small leaf bearing branches when cutting, ideally all of the way around the bolling to retain function. It must be remembered that old trees generally respond more poorly to cutting than younger ones and it is always best to be cautious when managing them. Overcutting could kill the tree; undercutting is unlikely to cause any harm. A training video on pollarding is freely available on the VETCert website: https://www.vetcert.eu/node/9.

If the pollard has been out of the cutting cycle for some time (a lapsed pollard), a very different approach is required and re-pollarding these is not recommended. This is because the removal of most of the branches, and the associated loss of leaf area, is likely to result in the death of the tree or at least cause extensive dieback and even death (https://www.vetcert.eu/node/9; Lonsdale, 2013: 4.5.1). Lapsed pollards that do survive a harsh re-pollarding may respond by producing extensive foliage but this is often coupled with severe decay at the top of the main trunk, made more difficult to see by the foliage growth, that can significantly shorten the lifespan of the tree. Old lapsed pollards of even vigorous species, such as willow, poplar and Hornbeam, are often far less responsive than anticipated and it is thus not recommended even for these species (https://www.vetcert.eu/node/9).

Stabilising lapsed pollards is challenging and should focus on pruning rather than re-establishing a traditional pollarding cycle. The best approach is usually a staged crown reduction. The reduction should progress slowly removing only 2-4 m from crown at any one time. Once the tree has reached the desired height, often several metres above the original pollarding point, it may be desirable to manage the regrowth on a regular cycle. This can be done by removing the larger branches and retaining smaller ones, a practice known as pole thinning. Cuts should be made above the original bolling and always leave stubs (https://www.vetcert.eu/node/9l Lonsdale, 2013: 4.5.1). A training video on pole thinning is freely available on the VETCert website: https://www.vetcert.eu/node/50.

References and further reading

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- VETcert guidance video on pollarding: https://www.vetcert.eu/node/9.
- VETcert guidance video on pole thinning—https://www.vetcert.eu/node/50.

- ***Creation of new pollards***

Humans have been unintentionally inducing veteran features in trees for millennia. Two traditional methods of management, coppicing and pollarding, enable part of a tree to survive into old age and partially decay while maintaining its usefulness in producing wood. The repeated cutting of the tree induces veteran features such as tree hollows and dead wood far earlier in a trees lifespan than would naturally be the case (Sebek *et al*., 2013).

Coppicing is only relevant to managing woodlands and is discussed briefly in the section considering management of surrounding woodland habitat. A great deal of literature and information is available on managing woodlands by coppicing (e.g. Lonsdale, 2013).

Pollarding is more widely relevant. The creation of new pollards can be a valuable way of creating niches for fungi and invertebrates dependent upon decaying wood. While pollarding potentially increases the life expectancy of trees, the repeated damage which it inflicts on younger trees can encourage the development of decay. This damage early in the tree's life has been shown to result in hollowing more quickly than would occur in an unmanaged tree (Sebek *et al*., 2013).

Pollarding as an economically viable activity is now largely a thing of the past, although there is an increasing movement to reinstate the use of pollards for tree fodder and agroforestry (e.g. Green, 2016). For this reason, there are relatively few young pollards and most existing ones are now lapsed (https://www.vetcert.eu/node/9).

The creation of new pollards is a valid way to encourage the formation of veteran features in young trees to bridge gaps in dead wood habitat continuity and is the only long-term way to maintain the cultural values and potentially the fauna of a wood pasture site with existing pollards (Read, 2008; https://www.vetcert.eu/node/9). Pollarding is not a route to "instant" habitat for dead wood species. Pollarding must be started when the trees are quite young and it is likely to take several rounds of pollarding before any dead wood habitat develops. Young pollards can never be a full substitute for ancient trees, but may help to bridge an age gap and establish a continuity of dead wood habitats.

The small crown size of pollarded trees allow a greater density of trees to reach old age in a given area than if the trees are allowed to grow without being cut. Pollarding also has the benefit of potentially extending the lifespan of a tree. There is no need to maintain the pollarding cycle in the long term unless necessary for cultural or aesthetic reasons. Once decaying wood habitats have developed cessation of management will not be detrimental, and may actually increase the volume of dead wood available in the tree.

Pollards can be created from a wide range of tree species of a variety of sizes. Trees with a naturally divided stem at the required height and limbs below the division are ideal candidates for pollarding and should be selected where possible. The limbs should be cut at the division of the stem (Green, 1996).

The ideal trunk diameter at which to start pollarding is 10-15 cm, although this is to some degree dependent on the tree species. Smaller trees can be pushed over by grazing animals to reach the shoots. Larger trees will callus over the cuts more slowly and the potentially larger amount of dysfunction may mean they have a shorter lifespan (https://www.vetcert.eu/node/9). It is generally not recommended to pollard trees with a stem diameter of more than 20 cm, especially if the tree has a single-pole form. If it is required to close an age gap in the tree population larger diameter trees can be cut with a reasonable success rate, especially if they are a species that generally pollards well. Pollarding larger trees provides more decaying wood more rapidly but carries an increased chance of failure and seriously damaging or even killing the tree (https://www.vetcert.eu/node/9). If larger limbs need to be cut crown reduction should be considered instead.

Pollarding should preferably be initiated when the branch is between 25 mm and 50 mm in diameter at the point of pollarding, usually around 2 m to 3 m above the ground (Lonsdale, 2013: 4.5.2). In species that do not respond well to cutting, such as Beeches, some lower leaf bearing branches should always be retained below the point of cutting. This is prudent when pollarding most other species too. It is still important to retain some leaves on the tree to help ensure its survival. Cutting back the lower branches of a tree encourages growth in the upper branches. This is most effective in younger trees and is more likely to cause serious damage to the tree the older it is (https://www.vetcert.eu/node/9).

Table 6. Optimal timing of management for different groups.

Group	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Trees	***	***	***	X	X	X	*	*	X	X	**	**
Bryophytes	**	**	**	**	**	**	**	**	**	**	**	**
Fungi and Lichens	**	**	**	**	**	**	**	**	**	**	**	**
Invertebrates	**	**	**	*	*	*	*	*	**	**	**	**
Birds	***	***	***	X	X	X	X	X	*	***	***	***
Bats	X	X	*	***	X	X	X	X	***	***	X	X
X = Bad, * = Possible, ** = Better, *** = Best												

Barley and Simpson (2012) provide step by step guidelines on pollarding both young and mature oak trees in Britain.

5.1.6 Timing of tree work

Excluding emergency situations, pruning should be timed to avoid seasons or conditions that increase susceptibility of the tree to wound-induced dieback. This means avoiding pruning when new foliage is developing in spring and early summer or when the tree is entering dormancy in autumn. Pruning should also avoid periods of stress, such as after periods of drought. Any pruning should be deferred until after the following midsummer to allow the tree time to fully recover (Lonsdale, 2013: 4.4.1).

Summer pruning gives good results if it is after new foliage has developed, but there is a higher likelihood of drought at this time. With regard to oak, summer pruning may result in greater amounts of mildew, which in turn can lead to decline. Winter pruning is preferable if the work would leave substantial areas of the main stem newly exposed to sunlight for long periods. Sudden exposure to direct sunlight can overheat the sapwood and bark causing damage. Winter cutting avoids any overheating issues but there can be dieback around cuts in the event of freezing weather (Lonsdale, 2013: 4.4.1).

It is also essential to consider the impacts of any direct management on the wildlife associated with the tree. Timing of work is essential to avoid detrimental impacts. Invertebrates, lichens, fungi and bryophytes are generally present on or within the tree in one life stage or another throughout the year, the timing of tree work is therefore less important for species in these groups. Birds and bats utilise old trees in a more seasonal manner. The impacts of management on birds will be greater in the spring and summer when they are breeding. There are also legal considerations surrounding disturbance of breeding birds. Bats are most vulnerable to disturbance during hibernation in winter and during the maternity period when females are raising unweaned pups during the summer. It is a criminal offence to cause injury or disturbance to bats or damage or destroy known bat roosts.

The ideal timing of work varies between groups of associated species (Table 6), this can lead to challenging conflicts of interest. Resolving such conflicts depends on careful assessment of the taxa present and the likely impacts of management on these species. Consultation of past records can be used to some extent but it is always preferable to carry out contemporary surveys. In bats, for example, roost switching can occur, with some species (e.g. Noctule, Barbastelle and Bechstein's Bats) using several tree roosts within their territory. Once identified as a roost however, no matter how old the record is, the tree is a confirmed roost (bats are loyal to their roosts and will return regularly), even if bats are not occupying the roost at the time.

As features develop on a tree they may also become more suitable for particular species or species groups than in the past. Older records should therefore be treated with caution, as the absence of historical records does not mean a species isn't present now. For many groups it is also highly likely that detailed surveys have never been carried out and no past records exist for this reason. Current surveys for taxa associated with ancient and other veteran trees are therefore always advised.

It will likely be impossible to carry out management at the ideal time for all groups and it is often necessary to decide on a least bad option, based on the associated wildlife known to be present (Table 6). More detailed guidance on the ideal timing of work based on the phenology of the tree is available in Lonsdale, 2013: Table 4.15.

5.1.7 Management of dead wood

All old trees produce or contain some quantity of dead wood in the form of fallen branches, fallen and standing trunks, dead branches in the crown, rotten heartwood in standing trees, fallen twigs and fine branches and any wood that may have been removed by management. It is important that all these types of dead material should be retained in reasonable quantity.

The simplest rule about dead wood is that it should be left where it is to undergo natural decay processes. There will be times when things prove not to be quite so simple, but on most sites for most of the time this simple rule can be followed. It is surprising how often the rule is broken, even on sites managed solely or chiefly for conservation, despite the fact that following it requires no expenditure of time, effort or money.

Though any dead wood can be valuable, timber of large diameter is particularly important. Most sites with trees, unless very intensively managed, contain a good quantity of fine and medium-sized material in the crowns of trees and on the ground below them. Large dead timber is usually much scarcer.

On a site where there is public access, bark stripping and breaking up rotten wood can do considerable damage to the invertebrate fauna. A large proportion of such damage is not malicious or wilfully destructive. Since the material being broken up is obviously dead, it is not immediately obvious to the perpetrators that such actions are damaging to wildlife. Interpretative boards, explaining the interest of dead wood, may be the best way of limiting such damage (Kirby, 2001). Table 7 summarises actions that can be taken to manage dead wood on a site.

- ***Management of attached dead wood***

If decaying wood is causing a particular weight or safety problem, then removal may be advisable, although as little as possible should be removed. In any other circumstance attached dead wood should be retained (Lonsdale, 2013: 4.4.6). Attached dead wood of this sort provides a different wood-decay habitat to rot in the trunk or in fallen dead wood and supports its own unique invertebrate and fungal assemblage. It is therefore of great importance that as much attached dead wood is retained as possible (Bouget *et al.*, 2011).

- ***Management of fallen or cut dead wood***

Cutting up and removing, or burning, dead and fallen trunks and major branches of large and particularly ancient trees, can never be justified in wildlife conservation terms. Wherever possible, such large material should be left where it stands or falls. If for access or safety reasons it must be moved, it should be shifted to another position within the site and kept as intact as possible (Kirby, 2001).

If it is necessary to move fallen timber it should be moved as soon as possible and as short a distance as possible. It is best to move it into conditions as close as possible to those found where it would have naturally fallen (https://vetree.eu/action?action=downloadables-download&file=38). Larger fallen branches in open grassland or arable which impede access may be dragged beneath the shade of the tree from which they fell. This has the added benefit of protecting the roots and trunk of the tree from trampling and nutrient enrichment by animal urine and dung. This also reduces the risk of injury to members of the public. Large material falling across woodland rides should be moved to the ride edge.

- ***Making the most of wood and timber from management operations***

Management operations within a woodland may produce considerable quantities of timber, underwood and brushwood. Most of this can usually be burned on site, or removed, without conflicting with the needs of the dead wood fauna. Burning should never take place within the Root Protection Area (RPA) of ancient and other veteran trees. The heat can cause root damage and damage to the soil fungi, flora and fauna. Use of a suitable burning platform is advised (Lonsdale, 2013). Chipping is also an acceptable way to deal with material produced by management if the quantity of material being produced is too large to be left in situ. The chippings produced can be spread under the crowns of veteran trees (mulching) if necessary, or placed in piles. Freshly cut sound material will usually have limited wildlife interest and its removal will likely have little impact provided sufficient dead wood is left elsewhere on the site.

> At Durham Massey Park in Greater Manchester fallen dead wood is removed from the historic, designed parkland landscape and placed in an unobtrusive location that doubles as designated deer sanctuary and non-intervention management area. This provides a suitable location for dead wood habitat and a safe space for grazing deer. The accumulation of fallen wood provides the added benefit of allowing some natural regeneration by acting as a protective nursery.
>
> Bullcock, D. and Collis, P. (2000). Managing Deer in Parklands. *Enact*, 8(3).

If material resulting from management is to be burned or removed from site, this should be done quickly. If material is left on site for any length of time, invertebrates and fungi associated with dead wood will begin to colonise it, and its removal or destruction may act as a sink for these species. If material for sale or use must be stacked for a time, to season prior to removal, it is best if this is done in a shed or well outside the woodland boundary, or if the stacks are tented with polythene, which will hasten the drying of the wood and prevent the entry of invertebrates. If this is not possible, then at the very least, remove the topmost layer of the material and retain on site (Kirby, 2001).

Unwanted sound material can be left scattered through the wood. If there is a very large amount of it and some must be removed to enable access or future management, it can either be scattered thinly through other parts of the wood, or made into a pile in a convenient corner. Partly decayed timber should never be burned or removed.

Log piles made from unsound and excess timber, though not as valuable as wood left scattered through a wood, can provide useful habitat and will eventually gather an interesting invertebrate community. The best place for such piles is at the edge of a ride or clearing, on an area with relatively low intrinsic conservation interest. In such a position, one face of the pile will be in the sun and the other in shade. A pile in such a position should attract a greater range of invertebrates than either one in full sun or one in complete shade.

Table 7. Summary of management actions for dead wood.

Issue	Actions	Reason	Key considerations
Management of attached dead wood	Retain attached dead wood and leave undisturbed	Attached dead wood provides a unique wood-decay habitat and supports its own unique invertebrate and fungal assemblage	Attached dead wood should be retained whenever possible
	Removal of attached dead wood	If decaying wood is causing a particular weight or safety problem that cannot be mitigated in other ways removal may be advisable	As little as possible should be removed Removed dead wood should be retained on site
Management of fallen or cut dead wood	Leaving dead wood where it stands or falls to decay naturally	Dead wood left where it falls and allowed to decay naturally has the highest value for wildlife conservation and is always the optimum solution	Removing or destroying dead and fallen trunks and major branches can never be justified in wildlife conservation terms
	Moving fallen or cut dead wood	If fallen dead wood presents a particular issue for access or safety it may be necessary to move it Fallen dead wood can be moved to protect the roots and trunk of the tree from trampling and nutrient enrichment by animal urine and dung	Dead wood should be moved to another position within the site and kept as intact as possible It should be moved as soon as possible and as short a distance as possible It should be moved into conditions as close as possible to those found where fell
Making the most of wood and timber from management operation	Burning material on site or removing it	If large amounts of sound dead wood is produced by management its removal or burning will likely have little impact provided sufficient dead wood is left elsewhere on the site	Burning should never take place within the RPA of ancient and other veteran trees This should be done quickly, before invertebrates and fungi associated with dead colonise it Partly decayed timber should never be burned or removed
	Chipping	Can be used to deal with material produced by management if the quantity is too large to be left in situ	Chips can be spread out under the crowns of veteran trees (mulching) if necessary, or placed in piles
	Stacking material to season	Material for sale or use must be stacked for a time to season prior to removal Unwanted sound material can be left scattered through the wood	Best done in a shed or well outside the woodland boundary to prevent colonisation by saproxylic species Tent stacks seasoning outdoors with polythene to hasten the drying of the wood and prevent the entry of invertebrates If this is not possible remove the topmost layer of the material and retain on site
	Log piles made from unsound and excess timber	Can provide useful habitat and will eventually gather an interesting community of fungi, epiphytes and invertebrates	Not as valuable as wood left scattered through a or naturally positioned dead wood Should be placed on an area with relatively low intrinsic conservation interest where one face of the pile will be in the sun and the other in shade Several smaller piles of different aspect scattered through a site are better than a single large one. New piles are best made adjoining or within easy reach of the old ones
	Creating litter piles out of finer material and brash	Piles of brashings and other fine material will support a wide range of invertebrates as well as certain species of fungi, lichens and bryophytes	Attempts to dispose of all material from extensive management operations in this way can damage to the underlying flora and its associated invertebrates Few large piles are better than many smaller ones There little advantage in producing a pile more than a few feet across A pile in shade will develop a different and richer fauna to one exposed to the sun A loose pile of brashings will contain fewer niches for invertebrates than one which is closely packed If several piles are to be created they should be placed in different situations and with different aspects Tying brashings into a bundle and stacking is likely to be more valuable than loose piles and occupies less space

The size and proportions of a log pile will depend on the size, nature and quantity of the material to be incorporated. The location of the log pile is also an important factor. A pile one metre high and two to three metres long probably provides as great a range of niches as could be hoped for from a log pile of any size. If the volume of material is very large, it is best to create several piles of different aspect scattered through a site rather than to make a single very large one. If successive management operations in subsequent years create more logs to be disposed of, new piles are best made adjoining or within easy reach of the old ones. It should be emphasised that however carefully log piles are designed, the logs would be of greater value for invertebrates and fungi if left scattered on the woodland floor, largely due to the greater moisture content of wood on the ground compared to that raised in a log pile.

Fine material can be used to create litter piles. Piles of brashings and other fine material will support a wide range of invertebrates as well as certain species of fungi, but this is an easy piece of creative conservation to get carried away with. A few piles scattered through a wood may be interesting and valuable, but attempts to dispose of all material from extensive management operations in this way can result in damage to the underlying flora and its associated invertebrates.

If piles of brashings and finer branches are to be created, a few large piles are better than many smaller ones. Even so, there is probably little advantage in producing a pile more than a few feet across. If several piles are to be created in a single wood, they should be placed in different situations and with different aspects. A pile in shade will develop a different and richer fauna to one exposed to the sun.

A loose pile of brashings will contain fewer niches for invertebrates than one which is closely packed. If brushwood can be gathered and tied into tight bundles, and then stacked, this is likely to be much more valuable, in addition to occupying less space. The close packing will allow more moisture to be retained and provide relatively constant moist conditions in the centres of the bundles. These conditions benefit a greater number of wood rotting fungi and mean that denser piles will be more rapidly colonised by progressive waves of invertebrates and bryophytes. The narrow spaces between twigs and branches will also provide safe shelters for invertebrates. In a looser pile, the outer layers are subject to alternate wetting and drying out, unless rapidly covered by rank vegetation.

References and further reading

- Alexander, K. and Green, T. (2018). Managing trees for a sustainable resource of decaying wood habitat. *Conservation Land Management*, 16(2).
- Bouget, C., Nusillard, B., Pineau, X. and Ricou, C. (2011). Effect of dead wood position on saproxylic beetles in temperate forests and conservation interest of oak snags. *Insect Conservation and Biodiversity* (published online).
- Kirby, P. (2001). *Habitat Management for Invertebrates: A Practical Handbook*. RSPB, Sandy.
- Read, H. (2000). *Veteran Trees: A guide to good management*. English Nature. Section 5.4.
- VETree fact sheet on management of dead wood (2014): https://vetree.eu/action?action=downloadables-download&file=38.

5.1.8 Other useful management methods

In addition to directly pruning ancient and other veteran trees, there are a range of management techniques that are widely used to prolong the life of such trees. Some of the most widely used and useful of these are discussed in the following sections.

- ***Intervention to assist phoenix regeneration***

Low branches or the branches of partially uprooted trees can establish new roots where they touch the ground. This stabilises the tree and allows continued survival. If the tree is still standing and low branches have rooted this is called layering. In the case of uprooted trees re-rooting from the trunk it is known as phoenix regeneration (Lonsdale, 2013: 4.5.3; Read, 2000). Intervention to ensure the success of natural layering or regeneration can prolong the life of the tree and ensure continuity of the habitats it provides.

If low branches have not yet reached the ground, and are unlikely to do so before snapping or tearing away from the tree, the branch can be partially cut. The cut should be just deep enough to allow the branch to reach the ground whilst maintaining good vascular connection with the tree (Lonsdale, 2013: 4.5.3).

An alternative to cutting is to raise a mound below the branch. This should incorporate coarse material, such as gravel, to maintain aeration and moisture supply to the roots. The material used to create the mound should be of local provenance and a similar pH to the soil below the tree (Lonsdale, 2013: 4.5.3).

If attached branches have already reached the ground but have not layered naturally, stakes can be used to reduce movement and encourage rooting (Lonsdale, 2013: 4.5.3). Where living branches or prostate stems are close to, or in contact

Phoenix oak on the shores of Loch Lomond

CHRIS KNAPMAN


BUGLIFE

The Major Oak is an example of a propped tree

with, the ground, they should be protected from browsing and disturbance by livestock or people that may prevent layering and phoenix regeneration (Lonsdale, 2013: 4.5.3).

If less than a third of the root system is still in the ground it may be necessary to protect the roots from desiccation until phoenix regeneration begins. Whether this is necessary depends on the tree species, previous vitality of the tree, climate, weather, soil type, and the degree of exposure to sunlight. Desiccation can be prevented by mounding soil over part of the exposed root system. Artificial shading of the stem and foliage can also be considered if feasible. In very dry weather the base of the tree and potential rooting area can be watered to help prevent drying. In some cases, shading may be a greater threat than desiccation. If so, a proportion of overhanging foliage may be removed, provided that this would not harm other valuable trees (Lonsdale, 2013: 4.5.3).

References and further reading

- Lonsdale, D. (ed.) (2013). *Ancient and other veteran trees: further guidance on management*. The Tree Council, London. Section 4.5.3.

- ***Propping and strapping***

If a tree is at risk of serious mechanical failure or collapse but limb or crown reduction has been deemed undesirable or unlikely to succeed, bracing or propping may be appropriate.

This is often done on famous or feature trees where the risk of cutting is considered too great, and maintaining a particular appearance is important. It is possible to prop up limbs with wooden or metal supports, construct bracing systems to provide mechanical support, or use guy lines to counter the pull of an unbalanced or unstable tree (Lonsdale, 2013: 3.8.2). This should only be undertaken by a suitably qualified professional. It should also be noted that propping and bracing require regular monitoring and assessment once in place.

References and further reading

- Lonsdale, D. (ed.) (2013). *Ancient and other veteran trees: further guidance on management*. The Tree Council, London. Section 3.8.2.

- ***Protection of cavities against fire or disturbance***

Hollow trees are vulnerable to disturbance of their cavity by human activity or damage by fires, whether natural or arson. Sealing of cavities can deter arson and prevent access to the cavity. There is no method of doing this without disturbing the natural processes involved in decay and altering the habitat provided by the cavity e.g. for specialist lichen species that occupy the bare wood inside hollow trees.

Cavities should never be obstructed unless the risk of natural fires or human vandalism is very serious. If necessary, only the entrance should be blocked and the cavity left unfilled. If cavity entrances are to be blocked this should be done with wood or logs from the same tree species (Lonsdale, 2013: 3.8.2).

References and further reading

- Lonsdale, D. (ed.) (2013). *Ancient and other veteran trees: further guidance on management*. The Tree Council, London. Section 3.8.2.

- ***Removal or control of climbing plants***

Native climbing plants, in particular Ivy, should only be removed if they are evidently increasing the probability of tree failure or excessively shading the trunk, thereby damaging epiphytic communities. Ivy rarely compromises the biomechanical integrity of the tree unless it is very fragile for other reasons. Climbing plants are more of a strain when on horizontal limbs than vertical.


REG HARRIS

In some rare situations it may be necessary to prevent human access to hollow trunks. Here, logs have been carefully stacked into the basal cavity of a tree to prevent members of the public from entering it, causing damage and compaction of the wood mould. Work done by Buglife in Sherwood Forest.

Ivy is a valuable late season nectar source and overwintering site for invertebrates, provides roosts for bats and nest sites and a source of nutritious high fat berries for a range of bird species. Ivy is also a highly competitive and aggressive climber that can quickly cover the trunk of an ancient or other veteran tree, and is increasing in woodlands in temperate Europe. This is highly damaging to lichens or byrophytes present on the tree bark (Lonsdale, 2013; 5.4.3). Evidence also suggests that Ivy is increasing significantly in temperate Europe (https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1002/fee.2266) and can now have major negative impacts on the wider woodland floor, smothering bryophytes and flowers and reducing habitat suitability for invertebrates that require open conditions or access to soil or flowers. Control of Ivy in woodlands and on trees is therefore increasingly necessary despite the positive contributions it makes for many species groups. It is desirable to maintain a balance on any given site, with enough mature Ivy retained to provide nest sites for birds, roosts for bats and a late season nectar source and hibernation site for invertebrates, whilst preventing expansion of young Ivy and maintaining open conditions on most tree trunks.

Non-native climbing plants that can sometimes occur in parks or gardens should be removed to prevent damage to lichen or bryophyte communities.

If young Ivy is colonising an ancient or other veteran tree it is best to remove it to prevent any damage to lichens or bryophytes. Mature long-established Ivy should generally be left alone. Any lichen or bryophyte interest present on

Petworth Park: The Ivy conundrum

Petworth Park supports an important lichen flora including the Ancients of the Future target species Eagle's Claw (*Anaptychia ciliaris* subsp. *ciliaris*) (Endangered GB Red List), *Lecanographa amylacea* (Vulnerable GB Red List), *Ramonia chrysophaea* (Near Threatened GB Red List) and *Opegrapha prosodea* (Near Threatened GB Red List). All are listed on Section 41 of the NERC Act 2006 and as such, are of principal importance for the conservation of biodiversity in England. In addition, the park supports the only known British population of *Sphinctrina leucopoda*, a fungus parasitic on a common species of wart lichen *Pertusaria pertusa*. Many of these species occur on single trees within the Park and are therefore very vulnerable. One of the most pressing threats identified is shading by Ivy growth. Ivy is typically controlled by grazing and browsing but can increase rapidly and come to dominate important lichen habitat if grazing and browsing pressure falls. The control of Ivy becomes particularly important when rare lichen species are found on only single trees as at Petworth Park. Mature Ivy on trees is also a valuable nectar source for many invertebrate species however, as well as often being used by bats for roosting and birds for nesting. Ivy control therefore represents something of a conundrum for conservation management. At Petworth Park the current management advice is that Ivy removal should focus only on known important lichen trees and that establishment of young Ivy on mature trees should be controlled if it begins to increase. In the long term, the aim should be to control Ivy through grazing and browsing. Removal of well-established mature Ivy should be avoided unless absolutely necessary. If removal of mature Ivy is required to protect rare lichens, a survey for bats should be undertaken before any Ivy is removed. These principles should be followed wherever such management conflicts are identified.

the tree will almost certainly have been lost already and the Ivy is valuable to other groups.

If it is necessary to kill or remove Ivy from a tree it is generally advised to cut through or ring-bark the stem close to the ground, killing the Ivy and removing the shading of the trunk. Attempting to physically remove established Ivy is very difficult and may cause further damage to the trees bark and any associated lichens or bryophytes. If removing mature Ivy, it should always be checked for nesting birds or bat roosts prior to removal or disturbance as destruction or disturbance of bats or nesting birds will have legal implications.

References and further reading

- Lonsdale, D. (ed.) (2013). *Ancient and other veteran trees: further guidance on management.* The Tree Council, London. Sections 3.4.2, 4.4.8, 5.4.3, 5.5.1.
- Perring, M.P., De Frenne, P., Hertzog, L.R., Blondeel, H., Depauw, L., Maes, S., *et al*. (2020). Increasing liana frequency in temperate European forest understories is driven by ivy. *Frontiers in Ecology and the Environment*, 18(10): https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1002/fee.2266.

5.2 Bridging the generation gap

One of the most pressing issues facing the wildlife of ancient trees in Britain is the large gap in the age structure of trees on many sites. Overgrazing by domestic animals and deer has all but prevented natural regeneration in most parklands and wood pasture for long enough that on many sites young or middle-aged trees are almost entirely absent and little thought has been given to planting replacements until quite recently. Forestry operations have often retained the oldest trees as it is not economically viable to remove them but harvest all of the mature middle-aged trees from a site before they develop veteran features leaving scattered ancient trees surrounded and often shaded out by dense evenly aged cohorts of young trees that support relatively little wildlife interest. Developments have often retained the oldest trees as desirable features or due to legal protections but removed any middle-aged trees that have no protection. Replacement plantings are often selected for aesthetic reasons rather than their potential wildlife value and will usually all be planted at the same time and therefore all be the same age. All of these elements have contributed to and continue to exacerbate the generation-gap problem.

Caring for existing ancient trees and extending their lifespans as far as possible is of great importance, but, if there is a gap in the availability of wood-decay habitats between the deaths of existing ancient trees and the development of veteran features in younger trees, any associated fauna and flora dependent on such features will be lost.

This problem can be approached from two directions: increasing the life expectancy of the trees long enough for new veterans to develop, as discussed in the previous sections, and by speeding up the development of veteran features in younger trees by deliberate damage to make them more suitable for colonisation by species normally associated with veteran trees (veteranisation). Prematurely inducing the development of veteran features in younger trees may help ensure a continuity of dead wood habitat on a site and can therefore conserve the associated wildlife interest. Methods of inducing or replicating veteran features in younger trees will be discussed in this section.

5.2.1 Veteranisation

Healthy trees contain a considerable amount of heart wood which, after fungi and bacteria begin the decomposition process, could provide a habitat for many invertebrates, while the sapwood remains intact. Injuries to trees create the conditions favourable for the development of fungi, bacteria and the first wave of invertebrate colonists. In nature, a number of insect species, particularly beetles but also some moths, bore into living wood and may provide entry holes for decay organisms. Mechanical or stress injuries, caused by weather or accident, may also provide convenient entry points. Branches which die through disease or natural self-pruning will begin to decay in situ and may eventually break off. The decay may then spread to the heartwood of the tree, and the broken stump can provide a convenient access point for invertebrates. Trees which are damaged by lightning or wind, or even by mechanical damage by machinery or large animals, may develop niches which can be colonised by invertebrates. Jagged stumps, and splits and holes in the trunks of trees, are potentially very useful and should never be treated or tidied (Kirby, 2001).

In the UK, there is a serious problem in the continuity of wood-decay habitats on living trees. Many old trees have been lost from the landscape and the majority of younger trees were planted or regenerated too recently to have naturally developed these features. This age gap problem is one of the largest issues surrounding the conservation of species associated with ancient and other veteran trees and the habitat niches they provide.

On sites which currently lack veteran tree features, or are likely to experience a large gap in habitat continuity due to a gap in tree age structure, it may be desirable to artificially induce veteran features at a younger age than they would naturally develop. The aim of this is to bridge the gap in habitat availability for species associated with veteran tree habitat features. There is much scope for deliberate damage to trees to encourage the early development of veteran features. Such damage quickly provides habitat for structural cavity users like birds and bats and more generalist saproxylic invertebrates. It is hoped that in the longer term, as rot establishes and decay cavities form, it will also make younger trees more suitable for a range of epiphytes, fungi, and saproxylic invertebrates dependant on veteran tree features. Such techniques are collectively termed veteranisation.

The term covers a vast variety of management methods that prematurely induce or create veteran features. These techniques mimic natural processes that damage trees, exposing them to aeration of the wood and fungal colonisation, and encouraging the development of decay columns and associated habitat. Veteranisation should be seen as a complementary tool to natural habitat development when where natural timescales are too long (Bengtsson *et al.*, 2015).

Unlike the management techniques discussed previously, veteranisation is undertaken in the interests of rapid creation and continuity of saproxylic habitat, not of enhancing the longevity of the tree. There are a number of basic guiding principles that should be followed when undertaking veteranisation of trees.

- ***General principles***

Veteranisation should generally be attempted on sites which have a large population of young trees, with plenty that can be left without treatment to naturally reach old age (Bengtsson *et al.*, 2015). Ideally, veteranisation should be carried out on trees that would otherwise be removed from the site (Bengtsson *et al.*, 2015). Veteranisation should never be carried out on trees with existing veteran features or those with the potential to develop them in the near future and should only be carried out where there is a need to fill a gap in the provision of decaying wood habitat on a site, for example on a site with few existing veterans and no late mature trees that will replace them (Bengtsson *et al.*, 2015).

If a site already has good dead wood habitat continuity, with trees of a range of ages and states of decay, veteranisation serves no purpose. Some veteranisation techniques can reduce the structural integrity of a tree methods should be avoided where there are safety concerns.

Whatever veteranisation method or methods are used, the treatment should generally allow the tree to survive for many years, but be adequate to induce decaying wood habitats in younger trees (Bengtsson *et al.*, 2015). Whilst dead trees, particularly if standing, provide valuable habitat, living but damaged and decaying trees provide a greater range of decay features over a longer period, providing a greater volume of dead wood habitat through time. Where trees need to be removed for other reasons, for example haloing existing ancients, they can be ring barked or damaged to such an extent that they die to provide standing dead wood (e.g. Agnew & Rao, 2014).

Different tree species respond differently and environmental conditions such as droughts and cold spells can drastically change the outcome of treatments. This is one of the main reasons that veteranisation should be carried out primarily on sites with a large population of young trees with relatively little intrinsic value so that individual failures are not overly damaging (Bengtsson *et al.*, 2012). If trees would need to be removed for other reasons or there is an overwhelming need for continuity of dead wood habitat on a site, veteranisation can be considered even where there are relatively few younger trees as the risk associated with losing younger trees is outweighed by the risk of losing saproxylic species due to a long gap in the provision of decaying wood habitats.

Carrying out veteranisation work at different times of year can encourage different habitat to develop. If the tree is cut at budburst (spring) for example, the tree will be placed under maximum stress, likely triggering greater dieback, and may also better stimulate sap runs.

It should be borne in mind that intentional veteranisation as a concept has not existed for long, at least in the timescales of trees and wood-decay habitats.

General principles for veteranisation

1. Best used on sites which have a large population of young trees, with plenty that can be left without treatment to naturally reach old age.
2. Should never be carried out on trees with existing veteran features or those with the potential to develop them in the near future.
3. Should only be carried out where there is a need to fill a gap in the provision of decaying wood habitat on a site.
4. Treatment should be mild enough to allow the tree to survive for many years, but adequate to induce decaying wood habitats in younger trees.
5. Trees need to be assessed for existing interest e.g. lichen interest before any veteranisation work is carried out, and planned work adjusted or abandoned accordingly.

Veteranisation techniques that encourage the formation of heartwood decay and cavities will benefit a wide range of invertebrates, including several rare Ancients of the Future target species that depend on these habitats:

Black Click Beetle (*Ampedus nigerrimus*)

Red-horned Click Beetle (*Ampedus rufipennis*)

Golden Hair Click Beetle (*Brachygonus ruficeps*)

Variable Chafer (*Gnorimus variabilis*)

Oak Click Beetle (*Lacon querceus*)

Violet Click Beetle (*Limoniscus violaceus*)

Observations and recording of veteranised trees provide strong evidence that birds and bats make rapid use of them and that commoner saproxylic invertebrates also take advantage quite quickly. Rarer saproxylic species with more exacting habitat requirements seem less likely to use veteranised trees, although this may be largely because suitable habitat has not yet developed (Agnew & Rao, 2011; Bengtsson *et al.*, 2012; Bengtsson & Wheater, 2021). Much of the veteranisation work carried out so far has been on an ad hoc basis and monitoring of the results is largely based on casual recording and observation. This makes the effects of veteranisation difficult to evaluate. Larger and more scientifically rigorous trials (e.g. Bengtsson *et al.*, 2012 and Bengtsson & Wheater, 2021), are underway and are now beginning to deliver useful data. The results are generally positive, with most trialled veteranisation treatments successfully creating many of the desired microhabitats after eight years. These microhabitats are being utilised by a wide range of taxa and tree survival has been better than expected. There was, however, almost no heart-rot establishment, most likely due to the age and vigour of the trees and high concentrations of tannins (Bengtsson & Wheater, 2021). This means that it is going to take longer for many dead wood habitats to form after veteranisation than was originally predicted.

Some of the most widely used veteranisation techniques are summarised in Table 8 and detailed in the following sections. This list is far from exhaustive. There is almost infinite scope for experimentation and creativity. Inspiration should be taken from natural processes, such as storm damage, that can be mimicked to create damage. Whatever methods are used it is of great importance that you record what you do, the response of the tree, and preferably which species are utilising the veteranised tree to inform future veteranisation work.

- ***Use of climbing spikes***

Using climbing spikes to access trees for other work creates small holes that can stimulate sap runs and even decay, creating small hollows. This can be used when carrying out other veteranisation methods, making them quicker and safer in the process. More complex veteranisation methods that require working from a number of positions on the tree are more likely to produce sap runs (Bengtsson *et al.*, 2015).

- ***Woodpecker holes***

Holes in trees are an important habitat. They are used for nesting by birds, roosting by bats such as Bechstein's and Noctule, and allow colonisation of the heartwood by fungi and invertebrates. Woodpecker holes can be mimicked by drilling several holes, approximately 5 cm in diameter and at least 6-7 cm deep, in a row on the trunk of a tree. Anything smaller than 5 cm will usually callous over too quickly to be effective. The holes should be drilled from 4-5 m high in the tree. Alternatively, a single larger hole, 10-12 cm in diameter, can be cut into the centre of the tree above 4 m high on the trunk. Varying the angle of the holes will produce habitat with different water collection capacity. Holes drilled downwards will collect water


ALEX HYDE/BACK FROM THE BRINK

Woodpecker holes

whilst those drilled slanting upwards will stay dry. This is a simple way to enhance the diversity in subsequent succession of colonising species. Over time, it is hoped that these holes will induce heartwood decay and the formation of larger cavities (Bengtsson *et al.*, 2015).

Even larger woodpecker holes have a tendency to become occluded by callous formation too rapidly to achieve the desired results. In trials in Sweden this happened approximately a fifth of the time on oak, after eight years. Removal of bark around the hole has been suggested as a method to prevent occlusion (Bengtsson *et al.*, 2021).

- ***Nest boxes***

Nest boxes for birds or bats can be created in living trees. These mimic larger hollows in tree trunks. A wedge-shaped section around 50 cm long and a third of the trunk diameter in width is removed from the trunk at a height of around 4 m. The removed section is then cut down from the narrowest point to leave space for a cavity within the tree and partially replaced, retaining an access hole (Bengtsson *et al.*, 2015). The access can be at the top, more suitable for birds, or bottom, more suitable for bats. The replaced section can be secured with nails. Wound healing will often further secure the lid of the box within a few years. Creation of such nest boxes weakens the tree,

Bird box


ALEX HYDE/BACK FROM THE BRINK

Table 8. Common methods for veteranising living trees (continued overleaf).

Method	Effect	Feature created	Beneficiaries	Key considerations
Use of climbing spikes when carrying out other veteranisation	Damages bark	Creates small holes that can stimulate sap runs and even decay	Wood-decay fungi that may colonise the wound Lichens and bryophytes associated with nutrient runs	Methods that require working from a number of positions on the tree are more likely to produce sap runs Makes other veteranisation work quicker and safer
Drilling woodpecker holes	Woodpecker holes can be mimicked by drilling holes into the trunk of a tree	Woodpecker holes and small cavities Hoped to eventually encourage heart-rot and associated habitats	They are used for nesting by birds, roosting by bats such as Bechstein's and Noctule, and allow colonisation of the heartwood by fungi and invertebrates	Holes drilled downwards will collect water Holes drilled slanting upwards will stay dry
Creating nest boxes in trunks	Nest boxes for birds or bats can be created in living trees	Mimic larger hollows in tree trunk Creates cavities for cavity nesting species Hoped to eventually encourage heart-rot and associated habitats	Cavity nesting birds Cavity roosting bats Long-term hope: Will allow colonisation of the heartwood by fungi and invertebrates	Weakens the tree; topping half of the crown can help to avoid failure Have a better temperature buffering capacity than normal nest boxes
Ring-barking branches	Ring-barking can be used to slowly kill a branch mimicking natural death	Creates attached dead wood habitat Can create small decay hollows when branches fall	Saproxylic invertebrates associated with attached dead wood Fungi associated with attached dead wood Lichens and bryophytes associated with attached dead wood	Ring-barked branches should be more than 20 cm in diameter to be effective Ring-barked branches may have different fungal and invertebrate communities to naturally dead or decaying branches
Ring-barking entire trees	Entire trees can be ring-barked at the base to kill them	Create standing dead wood habitat Remove trees that are shading existing ancients Creates a large volume of decaying wood habitat	Woodpeckers Commoner saproxylic invertebrates Wood-decay fungi Lichens and bryophytes found on dead wood Long-term hope: Scarcer wood-decay fungi and saproxylic invertebrates will colonise	Trees can be ring-barked higher on the trunk to mimic stag-headedness of veteran trees undergoing retrenchment to and provide a large volume of attached aerial dead wood
Trunk damage through bark removal	Bark and sapwood can be removed from the base of the trunk to induce dieback and decay on one side	Exposes sapwood that may encourage the development of decay fungi It is hoped that this will eventually encourage basal hollowing of the tree and the formation of a decay cavity	Wood-decay fungi Long-term hope: Formation of a basal decay cavity will provide valuable habitat for saproxylic invertebrates	
Fire damage to trunk	Damage to one side of the trunk with a small, well controlled	Creates a triangular fire scar exposing dead wood once the bark has fallen of May also reduce crown vitality on one side and induce root decay	Wood-decay fungi, including those associated with burnt wood Saproxylic invertebrates, including those associated with dead wood Long-term hope: Reduction in vitality and root decay will provide increased dead wood habitat provision throughout the tree providing valuable habitat for a wide range of taxa	This treatment should only be carried out when there is no risk that the fire will spread
Cutting into the trunk	V-shaped cuts into the trunk, cutting long vertical wounds of carving aerial cavities in the living trunk	Encourages the development of strips of dysfunction and decay Mimics the damage caused by a lightning strike Creates large aerial cavities Encourages extensive heartwood decay	Wood-decay fungi Saproxylic invertebrates Cavity roosting bats Long-term hope: Will allow colonisation of the heartwood by fungi and invertebrates	Hollows can be created in the base of the cavity to collect water, mimicking natural rot-holes and providing habitat for associated invertebrates and bryophytes Slits can also be cut into the top of the cavity to provide a roosting site for bats

Table 8 continued. Common methods for veteranising living trees.

Method	Effect	Feature created	Beneficiaries	Key considerations
Bruising the trunk	Bruising of the base of the trunk (e.g. with sledgehammer)	May encourage colonisation of the trunk by fungi and subsequent basal decay It is hoped that this will promote hollowing of the trunk approximating a natural heart-rot decay cavity	Wood-decay fungi Long-term hope: Will allow colonisation of the heartwood by fungi and invertebrates	The tree will need to be hit many times and with some strength to have the desired effect
Eiffel tower technique—hollowing the base of the trunk in an Eiffel Tower shape with a chainsaw	Cutting the base of a young tree into an Eiffel Tower shape to mimic the effects of decay caused by *Pseudoinonotus dryadeus.*	It is hoped that this will also encourage hollowing of the trunk and formation of decay cavities	Long-term hope: Will allow colonisation of the heartwood by fungi and invertebrates	Relatively untested
Cutting of branches or limbs	Natural fracture style cuts when removing limbs Partial cuts at some distance from the trunk and allowing the branch to break off creates jagged stubs or wounds mimicking storm damage	Mimics the structure caused by natural limb loss May encourage the formation of water pockets Naturalistic shape may encourage colonisation by saproxylic invertebrates Flush cutting simulates damage caused when branches are torn from a tree Cutting into the branch bark ridge leads to decay and often the formation of rot pockets	Wood-decay fungi Saproxylic invertebrates Invertebrates associated with rot-holes Lichens and bryophytes associated with rot-holes and nutrient runs	
Winching	Controlled fractures can be also achieved by winching the branch	Mimics the structure caused by natural limb loss May encourage the formation of water pockets Naturalistic shape may encourage colonisation by saproxylic invertebrates Flush cutting simulates damage caused when branches are torn from a tree Cutting into the branch bark ridge leads to decay and often the formation of rot pockets	Wood-decay fungi Saproxylic invertebrates Invertebrates associated with rot-holes Lichens and bryophytes associated with rot-holes and nutrient runs	Can damage the roots and reduce the stability of the tree Difficult to control and often involves having to make several cuts in the tree Requires access by a vehicle with a winch—potential ground damage Should not be carried out on trees that are at risk of collapse Effect can also be achieved by a natural fracture cut
Heavy crown reduction	Heavy crown reduction (more than a third of the live tree) using natural fracture and rip cuts can be used to seriously stress the tree	Impacts root system and may encourage decay in the cut branches, mimicking storm damage. May lead to more widespread dieback providing a range of dead wood habitats Topping younger trees removes apical dominance and mimics storm damage	Wood-decay fungi Saproxylic invertebrates Neighbouring trees due to increased light	Can be very damaging to the tree
Damaging tree with explosives	Explosives may be used to remove branches or even whole sections of a trees crown	This mimics storm damage and can result in internal longitudinal cracks in the trunk May produce good results that closely mimic storm damage or freezing cracks	Wood-decay fungi Saproxylic invertebrates	Expensive in both time and money Dangerous and difficult to organise

topping half of the crown on trees treated in this way can help to avoid failure (Bengtsson *et al.*, 2015). Nest boxes provide an immediate habitat for cavity-nesting birds and bats and allows colonisation of the heartwood by fungi and invertebrates. It should be noted that studies from Australia have shown that cavities in living trees have a much better temperature buffering capacity that normal nest boxes (Griffiths *et al.*, 2018). This will make them a more attractive and stable environment for cavity-nesting or roosting species, especially for those that overwinter in these cavities.

- ***Ring-barking branches***

Ring-barking can be used to slowly kill a branch by removing a complete ring of bark and cambium, thereby preventing the flow of water and nutrients in the trunk. It can be used to create a range of results depending on where the ring-barking is carried out.

Large branches can be ring-barked, mimicking natural death. Attached dead branches are an important habitat in themselves and can lead to the creation of small hollows when they fall off. Ring-barked branches should always be more than 20 cm in diameter to provide a good volume of dead wood that will remain attached for some time (Bengtsson *et al.*, 2015). It is important to note that naturally dead branches tend to dry out slowly with gradual loss of function compared to ring-barked ones. This results in ring-barked branches supporting a very different fungal community to branches that have died naturally. It is currently unclear what this means for community assembly as the branch decomposes, but it may result in differences in the fungal and invertebrate communities naturally dead or decaying branches and those created by ring-barking.

- ***Ring-barking entire trees***

In its most extreme form entire trees can be ring-barked at the base. This leads to the death of the tree and can be used to create standing dead wood habitat. This is probably the most widely used veteranisation method worldwide. It is used extensively for habitat creation in North America and Scandinavia, largely on coniferous trees.

Ring-barking

ALEX HYDE/BACK FROM THE BRINK

The National Trust has carried out a study of the effectiveness of ring-barking of Scots Pine for the creation of habitat diversity and dead wood in the Cairngorms National Park. The results show that ring-barked trees are rapidly utilised by woodpeckers and commoner saproxylic invertebrates (Agnew & Rao, 2014).

Ring-barking may be particularly useful where it is necessary to remove trees that are shading existing ancients as it is possible to remove shade and competition whilst simultaneously creating a large volume of decaying wood habitat. This also minimises the impacts of dropping cut material in the RPA of the existing ancient or other veteran (Lonsdale, 2013; 7.5.6)

Trees can be ring-barked higher on the trunk, preferably at a height above at least half of the live crown to mimic the stag-headedness which occurs in veteran trees undergoing retrenchment. This results in a tree with dead antler-like branches extending beyond the live crown and provides a large volume of attached aerial dead wood (Bengtsson *et al.*, 2015). In all cases, a minimum of a 20 cm width of bark should be removed to ensure sufficient breakage of the cambium to kill the tree.

- ***Trunk damage through bark removal***

Bark and sapwood can be removed from the base of the trunk to induce dieback and decay on one side. Damage should be to a height of around 1 m and not exceeding one-third of the trunk girth. This treatment mimics damage caused by animals or lightning and can produce exposed sapwood that may encourage the development of decay fungi. It is hoped that this technique will eventually encourage basal hollowing of the tree and the formation

Horse damage

ALEX HYDE/BACK FROM THE BRINK

of a decay cavity that will provide valuable habitat for invertebrates (Bengtsson *et al*., 2015).

- ***Fire damage***

Creation of a small, well-controlled, fire on one side of a tree can be used to damage that portion of the trunk and cause a triangular fire scar. This scar exposes dead wood once the bark has fallen off, usually after a few years. And may also reduce crown vitality on one side and induce root decay. This treatment should only be carried out when there is no risk that the fire will spread (Bengtsson *et al*., 2015).

- ***Cutting into the trunk***

V-shaped cuts into the trunk can be used to encourage the development of strips of dysfunction and decay. Using a chainsaw to create a long vertical wound in the trunk of a tree in this way can be used to mimic the damage caused by a lightning strike.


ALEX HYDE/BACK FROM THE BRINK

Lightning strike

Larger aerial cavities can also be carved into tree trunks with a chainsaw to encourage extensive heartwood decay which is valuable for fungi and invertebrates. Hollows can be created in the base of the cavity to collect water, mimicking natural rot-holes and providing habitat for associated invertebrates and bryophytes. Slits can also be cut into the top of the cavity to provide a roosting site for bats.

- ***Bruising the trunk***

Bruising of the base of the trunk (e.g. with sledgehammer) may encourage colonisation of the trunk by fungi and


ALEX HYDE/BACK FROM THE BRINK

Aerial cavity

subsequent basal decay. It is hoped that this will promote hollowing of the trunk and provide habitat approximating a natural heart-rot decay cavity. Such habitats are of exceptional value for invertebrates. The tree should be hit up to a height of about 20 cm above the ground, over a third of its girth. The tree will need to be hit many times and with some strength to have the desired effect (Bengtsson *et al*., 2015).

- ***Eiffel Tower technique***

Buglife has been trialling a method dubbed the Eiffel Tower technique in Sherwood Forest. This method involves cutting the base of a young tree into an Eiffel Tower shape to mimic the effects of decay caused by *Pseudoinonotus dryadeus*. It is hoped that this will also encourage hollowing of the trunk.

Eiffel Tower technique


ALEX HYDE/BACK FROM THE BRINK

- ***Cutting of branches or limbs***

The use of natural fracture style cuts when removing limbs mimics the structure caused by natural limb loss and may also encourage the formation of water pockets. The naturalistic shape of the cut branches may also encourage colonisation by saproxylic invertebrates. Flush cutting of limbs simulates damage caused when branches are torn from a tree. Cutting into the branch bark ridge leads to decay and often the formation of rot pockets. Ideally the branch should be allowed to rip off, mimicking storm damage. Alternatively, the branch can be partially cut at some distance from the trunk and allowed to break off. This is known as controlled fracture (rip) cutting and creates jagged stubs or wounds (Bengtsson *et al.*, 2015).

- ***Winching***

Controlled fractures can be also achieved by winching the branch. It must be borne in mind that winching can cause damage to the roots and reduce the stability of the tree, it is also difficult to control and often involves having to make several cuts in the tree. It should therefore not be carried out on trees that are at risk of collapse. The fact that a vehicle with a winch needs to be brought onto site should also be a consideration in terms of potential ground damage. The effect can also be achieved by an arborist creating a natural fracture cut.

- ***Heavy crown reduction***

A heavy crown reduction (more than a third of the live tree) using natural fracture and rip cuts can be used to seriously stress the tree. This will have an impact on the root system and may encourage decay in the cut branches, mimicking storm damage. In some cases, it will lead to more widespread dieback (Bengtsson *et al.*, 2015).

Topping younger trees removes apical dominance and mimics storm damage. Topping should generally be carried out at a height that retains at least half of the crown. The cut should mimic a natural fracture to provide a large area of damaged wood, releasing moisture and allowing oxygen in, to encourage colonisation by fungi and saproxylic invertebrates (Bengtsson *et al.*, 2015). This method also increases light available to neighbouring trees thereby improving conditions for them and encouraging an open growth form and the development of greater wildlife value (Green, 2010).

- ***Explosives***

At the extreme end of the veteranisation toolkit lie explosives. Explosives may be used to remove branches or even whole sections of a trees crown. This mimics storm damage and can result in internal longitudinal cracks in the trunk (Bengtsson *et al.*, 2015). This method is expensive in both time and money. It is dangerous, difficult to organise, and requires individuals with the expertise in explosives necessary to carry out the work safely. For these reasons it is rarely used and not often practical. In the rare circumstances in which it is practical it may produce good results that closely mimic storm damage or freezing cracks.

5.2.2 Creative use of existing dead wood

Whilst it is generally best to leave dead wood where it is, there may be cases where it is desirable to exercise more creativity, when a site lacks particular types of dead wood habitat for example (Table 9). Some of the ways that existing dead wood can be creatively utilised in habitat creation are discussed below.

Method	Feature created	Beneficiaries	Key considerations
Re-attaching fallen dead wood to the tree using straps	Attached dead wood habitat	Saproxylic invertebrates associated with attached dead wood Fungi associated with attached dead wood Epiphytes associated with attached dead wood	Re-attaching dead wood reduces the volume of fallen dead wood. It should only be done where there is abundant fallen dead wood or a specific need for attached dead wood e.g. for rare species associated with this habitat Wood reattached in this way should be recently fallen dead wood that hasn't yet developed a fauna
Re-erecting dead trunks	Standing dead wood habitat	Saproxylic invertebrates associated with standing dead wood Fungi associated with standing dead wood Epiphytes associated with standing dead wood	Should only be used if a site lacks existing standing dead wood Should only be done using dead wood that has recently fallen
Burying dead wood	Subterranean decaying wood niches that are essential for many invertebrates	Saproxylic invertebrates associated with subterranean dead wood such as Stag Beetles Fungi associated with subterranean dead wood	Smaller, thinner, dead wood will decay faster Larger pieces should provide habitat for many years Leaving some of the dead wood protruding above the soil surface may make it easier for invertebrates to locate it
Creation of stump cavities	Stumps of felled trees can be hollowed to create artificial stump cavities	Saproxylic invertebrates Wood-decay fungi	

Table 9. Summary of creative uses of existing dead wood.

- ***Re-attaching fallen dead wood***

On sites where there is a good dead wood resource but little is attached to living trees, fallen or cut dead wood can be reattached to the branches of a living tree using straps. Using dead wood in this way reduces the available fallen dead wood habitat and may be detrimental to species associated with it. It should only be carried out where it will have a minimal impact on the availability of fallen dead wood or where there is a specific reason to do so, e.g. for the conservation of a specific species or assemblage associated with the habitat and under threat on the site. Wood reattached in this way should be recently fallen dead wood that hasn't yet developed a fauna associated with fallen dead wood.

- ***Re-erecting dead trunks***

If a site lacks standing dead wood, or existing standing dead wood has recently fallen, it can be beneficial to the decaying wood fauna, flora and fungi to create or restore such habitat. This can be relatively easily achieved by re-erecting fallen or cut trees and attaching them to the trunk of living trees to hold them upright. This can be done using ratchet straps, or any other convenient method that will hold the dead trunk securely for a long period. It is also important to ensure a stable base for the re-erected trunks (Green, 1995, Jansson, 2009a; 2009b; 2019). The concepts this method introduced have been further expanded in the creation of dead wood boxes.

- ***Burying dead wood***

Dead wood produced by management can be buried to provide subterranean decaying wood niches that are essential for many invertebrates. Smaller, thinner, dead wood will decay faster whilst larger pieces should provide habitat for many years. Partially burying dead wood has been successfully used in stag beetle conservation for some time. Leaving some of the dead wood protruding above the soil surface may make it easier for invertebrates to locate it.

Re-erecting standing dead wood

ALEX HYDE/BACK FROM THE BRINK

BEN ANDREW

Stag Beetles (Lucanus cervus)

- ***Creation of stump cavities***

If it is necessary to fell trees in the course of management, the stump can be used for additional habitat creation. If the tree is felled at a point that retains at least a metre high stump it is possible to use this to create artificial stump cavities. The top should be removed using a chainsaw before the remaining stump is hollowed out. This hollow can then either be left as it is or filled with a substrate mimicking decaying wood (see section on rot boxes for further details). A small entrance hole should be cut at the top of the cavity and the removed top section replaced and secured.

TED GREEN

Stump cavity

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5.2.3 Other methods of bridging gaps in habitat provision

Increasing understanding of the wildlife value of ancient and other veteran trees, and the challenges they and their associated flora, fauna and fungi face, has led to great advances in the range of management techniques available for creating decaying wood habitat in younger trees over the past decade. Many of the techniques discussed in the previous section, whilst recently pioneered, are rapidly becoming more mainstream. This section deals with a range of novel techniques that are currently being trialled and developed. Although these methods are currently largely unproven, they have great potential in the conservation of wildlife associated with decaying wood habitats. Table 10 summarises the techniques discussed.

• *Heart-rot inoculation*

Heart-rot is one of the most important features of ancient and other veteran trees for invertebrates and leads to the formation of cavities that are used by roosting bats and nesting birds. Tree species that support large numbers of heart-rot dependent associated species are generally long-lived. Heart-rot and the fungi that create it usually only develops in mature trees. It is estimated that Beech trees must be over 120 years old and oak more than 180 before colonisation occurs. Once fungi colonise it may take a further 50 years or more for a heart-rot cavity to form. This means that trees of some of the species that support the largest assemblages of saproxylic species will take more than 200 years to develop the heart-rot cavity habitat that many of these associated species depend on.

Whilst the ideal situation is to allow trees to mature and develop heart-rot naturally, sites with a tree generation gap are likely to lose the heart-rot invertebrate fauna in the period between old trees being lost and younger trees reaching a suitable level of maturity. This is one of the most difficult veteran features to artificially create or encourage. Artificial veteranisation of trees to bridge age structure gaps has become increasingly popular but colonisation of cut limbs or wounds by heart-rot fungi remains stochastic and unpredictable (e.g. Bengtsson & Wheater, 2021). Even after initial colonisation it can take a long time for decay processes create the desired habitat features. Inoculation techniques are being developed to try to speed up this process and bridge the gap in heartwood decay habitats. This technique is referred to as veteranising inoculation. Fungal inoculation can also be used in the conservation of rare heart-rot fungi that have exacting habitat requirements and are poor dispersers. This is referred to as conservation inoculation.

– Veteranising inoculations

The principle behind veteranising inoculations is that by wounding the tree and directly applying a specific heart-rot fungus, fungal colonisation of the heartwood will be accelerated. It is hoped that this will allow the development of heart-rot and associated cavities in trees long before this could naturally occur, and faster than veteranisation. The inoculation method can be tailored to the needs of the site, or the species that is intended to benefit by selecting specific fungi to inoculate the tree with. For example, choosing a white or brown-rot to

Fungal inoculation

MATT WAINHOUSE

Table 10. Summary of other methods for bridging gaps in habitat provision.

Method	Description	Uses	Beneficiaries
Heart-rot inoculation	Use of fungal inoculation to induce decay in a tree (veteranising inoculation) or to directly conserve a rare fungal species (conservation inoculation)	To encourage wood-decay habitats in younger trees as a form of veteranisation Inoculation with a particular type of fungus to conserve associated species or assemblages Inoculation with rare wood-decay fungi to conserve the species	Wood-decay fungi Saproxylic invertebrates Structural cavity users such as birds and bats
Dead wood boxes	Creation of a box filled with substrate mimicking wood decay	To provide suitable wood-decay habitat for saproxylic beetles To bridge gaps in decaying wood habitat provision on sites with established interest To act as stepping stones of suitable habitat between existing sites As arks to move species to new sites with suitable habitat that are too distant for natural colonisation	Saproxylic invertebrates associated with heart-rot—especially beetles
Artificial rot-holes	Creation of artificial rot-holes by filling a container with a substrate mimicking waterlogged wood mould	To provide habitat for saproxylic invertebrates associated with rot-holes To bridge gaps in rot-hole habitat provision on sites with established interest To act as stepping stones of suitable habitat between existing sites As arks to move species to new sites with suitable habitat that are too distant for natural colonisation	Saproxylic invertebrates associated with rot-holes—especially flies
Lichen translocation	Translocation of lichens from trees or sites that are at risk to more secure habitat. It must be noted that whilst transplanting of foliose and fruticose species has been tried with mixed success, transplanting crustose species is very much at the trial stage	To move rare lichens from dead, dying or at-risk trees to a more secure habitat on the same site To increase population resilience by introducing rare lichens to a larger number of trees on a site To re-introduce rare lichens sites from which they have been lost	Lichens threatened by tree loss, and very rare species

target the specific invertebrate community associated with each. Another example of the potential application of fungal inoculation would be to inoculate an oak tree with Chicken of the Woods (*Laetiporus sulphureus*) to encourage the beetle *Mycetophagus piceus* that feeds on it, which in turn, benefits its predator, the Oak Click Beetle. Further guidance on the use of veteranising inoculations can be found in Wainhouse & Boddy (2021).

Fungal inoculation of trees has been effectively used in North America to induce heart-rot to encourage woodpecker nesting (Bednarz *et al*., 2013; Filip *et al*., 2011) and is currently being used to mitigate forestry impacts in logged forests of British Columbia (Manning & Manley, 2015).

Cardiff University, part funded by Back from the Brink, The Crown Estate and the City of London, are trialling fungal inoculation of Beech trees in the UK to accelerate heart-rot as part of the Ancients of the Future project (https://naturebftb.co.uk/2020/11/13/cavities-in-chaos-bridging-the-gap-of-a-microhabitat-in-decline/). The inoculation project is still in its early stages and the effectiveness of inoculation for saproxylic fauna is not known. Given the timescales involved in heart-rot cavity formation it will be several years before the benefits to the saproxylic invertebrate fauna can be properly assessed. However, looking at some of the successes seen with veteranising methods that create similar sized wounds without the addition of fungi, it is likely that, at the least, veteranising inoculations will provide similar benefits.

Fungal inoculation has been successfully used to reintroduce the rare wood-decay fungi Bearded Tooth (*Hericium erinaceus*) and Coral Tooth (*Hericium corraloides*), as part of the Ancients of the Future project. This could play an important role in species level conservation of wood-decay fungi.

There are many limitations to this method. Success in establishing heart-rot fungi in a tree seems to be extremely variable. Time of year, tree species, fungus species and the interaction between the three all have an effect. In many cases it is unknown how the fungus colonise the heartwood and what conditions encourage this. This results in an element of trial and error in the application of this method. When the technique works well the fungus has been seen to create a decay column several meters in length. Heart-rot and cavities in younger smaller diameter trees are by default going to provide a smaller volume of habitat than a large ancient or other veteran tree. It is also uncertain what proportion of heart-rot associated invertebrates will utilise these habitats in younger trees. There may be other factors influencing colonisation such as or differences in chemical responses, temperature buffering capacity by differently aged trees or even the volatiles given off by specific species or communities of fungi. Heart-rot created in this way is not a replacement for that found in ancient trees and will undoubtedly be less valuable in the short term. It may, however, be a useful emergency measure to bridge gaps in the availability of heart-rot habitats and reduce the chances of associated species becoming locally extinct.

As with any intrusive tree work, fungal inoculation does involve a risk to the tree, though this greatly depends on the size and location of the inoculation site. Fungal inoculation should only be used on young trees on sites with a good number of similar aged trees of the same species. Inoculation should only take place on a small number of the trees present. Fungal inoculation should never be used on trees with existing interest or veteran features. Fungal inoculation should not be used on trees that might pose a future health and safety risk. There are also regulations in place at protected sites which limit the introduction of species, including via inoculation. This needs to be checked before any work of this type is undertaken.

– Conservation inoculations

Heart-rot inoculation can also be used as a conservation tool for rare wood-decay fungi. Inoculation of suitable trees with fungi of conservation concern can be used to increase occupation on a site or introduce/reintroduce them to new sites where conditions are suitable. Many rare wood-decay fungi seem to be very poor colonisers of new sites and habitat, meaning that without inoculation they are unlikely to reach new areas of suitable habitat. This method is currently being successfully used in the conservation of the Ancients of the Future target species Coral Tooth and Bearded Tooth fungi (Wainhouse & Boddy, 2021).

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• *Dead wood boxes*

Many sites with a tree generation gap may not be suitable for fungal inoculation or veteranisation techniques due to a lack of suitable trees, health and safety concerns, or other practical limitations. If it is necessary to provide continuity of heart-rot habitat in such sites the only viable option might be to artificially imitate heart-rot cavities.

Dead wood boxes are relatively simple constructions consisting of a wooden box filled with substrates mimicking wood mould that are then attached to tree trunks. A study in Sweden found that around 70% of the beetles associated with cavities, birds' nests and decay of oaks also utilised dead wood boxes installed on three species-rich sites with hollow oaks (Jansson *et al*., 2009a).

The core component of the substrate is the sawdust and leaves of the tree species being mimicked. Water is then added to achieve the structural consistency of natural wood mould. Further additives can be included in the substrate: the addition of protein sources such as Lucerne flower and oat flakes was found to correlate with a greater number of rare beetle species in the Swedish study whilst the inclusion of a whole dead hen, to mimic conditions found in cavities which birds have nested in, produced the greatest abundance of saproxylic beetles. Making the boxes more attractive to nesting birds by increasing the size of access apertures may also increase habitat quality for saproxylic invertebrates and provide benefits to both groups (Jansson *et al*., 2009a).

The simplest example of such a box is a large nest box, much like those used for owls, filled with the above-mentioned mix. Holes should be drilled in the corners of the roof to allow a small amount of water to seep in. The entrance hole should be from 2-10 cm diameter, depending on whether it is desirable to encourage nesting birds and roosting bats. There are many refinements and variations on this basic structure depending on the purpose of the boxes, available resources, and site characteristics. The boxes being trialled by Buglife and the Sustainability Research Institute, for example, are semi-subterranean and incorporate soil into the base substrate (https://naturebftb.co.uk/2019/03/18/im-livin-in-a-box-artificial-habitats-for-beetles/).

It is also possible to create a similar effect by hollowing fallen trunks with a chainsaw and filling them with a wood mould mimicking substrate. This method has had proven success in providing habitat for Violet Click Beetle at Windsor Forest and was the inspiration behind dead wood boxes (Green, 1995).

STEPH SKIPP

Buglife and the Sustainability Research Institute are currently trialling the use of dead wood boxes in the conservation of saproxylic invertebrates in Britain. This work is focusing on the Violet Click Beetle and the boxes used have been specifically designed to mimic hollows at the base of trees, the specific habitat of this species.

Population sizes of specialist species are larger in tree hollows with a greater volume of wood mould. Larger wood mould boxes will provide a greater volume of habitat and are likely to be of greater conservation value. This greater value must be balanced against the greater logistical challenges in construction and placement of larger boxes. The ideal size is likely to be the largest box that can be constructed and safely mounted in the desired location on the tree. Boxes ranging from 70 to 600 litres volume have been used (Jansson *et al*., 2009a).

The number of saproxylic species utilising dead wood boxes decreases fairly rapidly with distance from existing hollow trees. This effect is particularly pronounced in heart-rot cavity specialist invertebrates. If wood mould boxes are to be used as stepping stones between habitat patches, they should be placed no more than a couple of hundred metres from existing hollow trees, preferably closer. Closer spacing between stepping stone boxes will increase the likelihood of utilisation (Jansson *et al*., 2009a). It should be noted that boxes mounted directly on trees with pre-existing natural hollows perform comparatively poorly in beetle colonisation (Carlsson *et al*., 2016). It is thought that the local hollows 'directly compete' with the boxes if they are too close. Boxes are not as attractive to dispersing beetles and therefore colonisation rates are reduced.

Dead wood boxes can also be used as "arks" for heart-rot species. This entails the installation of boxes on sites with a species-rich saproxylic invertebrate fauna for long enough to allow colonisation, probably several years in most cases. These boxes can then be translocated to new areas with suitable habitat but a depauperate fauna to encourage colonisation. Translocation of this nature is far more practical with tree-mounted boxes than semi-subterranean, which would require considerable effort to excavate and re-bury at the recipient site. This is useful as many remnant concentrations of ancient trees are too distant from one another for the stepping stone method to be practical. Source sites for arks should always have many ancient trees and large populations of saproxylic invertebrates and ark boxes should be used at low density to ensure the source fauna is not damaged. Source and recipient sites should be as close as possible to minimise movement of species around the county and retain local genetic distinctiveness.

Low placement of boxes is convenient but placement should generally be high enough to avoid interference from people or livestock if not fenced. It is important to consider which livestock are present in the target site before planning which beetle boxes to use. For example, basal rot-hole mimicking boxes have experienced minimal wildlife interference in current British trials but would be unsuitable for use on sites with wild boar or pigs present due to their rooting habits. Some saproxylic species are only found in higher cavities—likely due to a different microclimate and protection from predation. A broad guideline is that boxes should ideally be placed more than 2 m above the ground (Jansson *et al*., 2009a). Some species, such as the Violet Click Beetle, are specifically associated with cavities at the base of trees. If such species are a priority for conservation boxes should be placed near the base of the trees to mimic the natural habitat (https://naturebftb.co.uk/2019/03/18/im-livin-in-a-box-artificial-habitats-for-beetles/). The ideal placement of dead wood boxes will largely depend on the conservation objectives or species of interest on the site. Research on placement of dead wood boxes in the UK is currently ongoing (https://naturebftb.co.uk/2019/03/18/im-livin-in-a-box-artificial-habitats-for-beetles/).

Despite generally promising results from trials of dead wood boxes mimicking oak heart-rot, many saproxylic species, including a disproportionate number of the rarest species and specialists of red-rotted oak, do not seem to utilise them (Jansson *et al*., 2009a). Dead wood boxes do not emulate the variability of natural cavities regarding microclimate, decay type and successional stage. Natural wood mould represents late stage of the decay process. Sawdust based substrate has similar structure but is closer to early-stage natural decay in chemistry and fungal decay process. Inoculation of dead wood boxes with red-rot fungi species might improve suitability for specialist taxa (Jansson *et al*., 2009a). It should be noted that most studies have been relatively short-term and saproxylic species with a narrow ecological niche are notoriously poor colonists. It may be that such species simply require more time to colonise (e.g. Hilszczański *et al*., 2014).

The stability of tree hollow habitats is one of their most important features. They have a more stable microclimate than other dead wood habitats. Tree hollows in large trees may have a more stable microclimate than artificial wood mould boxes due to the thicker walls of the living trunk and perhaps also the flow of moisture through the sapwood, although it has also been observed that there is little difference in temperature between beetle boxes and natural tree hollows (Hilszczański *et al*., 2014).

Dead wood boxes will always be inferior to natural heart-rot cavities and should never be regarded as a replacement for them. They are an emergency measure for bridging generation gaps or linking remnant concentrations of old trees in the landscape. It should also be noted that although they have the capacity to bridge temporal or spatial gaps for some invertebrates dead wood boxes as currently used are not useful for other groups such as rare and specialised heart-rot fungi.

Almost all studies on the value of dead wood boxes are based on oaks. There is relatively little information available on the suitability of this method for other tree species which support heart-rot cavity saproxylic assemblages. Use of hollowed Beech trunks has been effective in providing habitat for Violet Click Beetle (Green, 1995).

Dead wood boxes require monitoring and maintenance. Saproxylic species of heart-rot cavities require habitat that is stable in the long term. Wood mould volume declines over time (15-30% volume in 3 years) and may need topping up after some years. They may also require periodic structural repairs (Jansson *et al*., 2009a). If being used to bridge a gap in the availability of natural heart-rot cavities on a site they are likely to require maintenance for many decades. If being used to link existing concentrations of old trees they will also require long-term maintenance. Wooden boxes have been found to show warping and damage fairly quickly in field trials and research is currently underway investigating the use of longer lasting plastic and concrete boxes. Many saproxylics are poor dispersers and, depending on the distance between sites, may require decades to move between sites. For dead wood boxes to be effective in either capacity a long-term maintenance plan will be necessary.

References and further reading

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• *Artificial rot-holes*

Another valuable habitat feature of old trees are rot-holes that form when a wound, usually due to branch loss, is decayed by fungi and bacteria. These holes often collect water and are characterised by wet porridgy rot, very different in character from brown-rot. These features support a different suite of saproxylic species and are of particular importance for saproxylic Diptera (Rotheray, 2004). The availability of rot-holes has declined in the same way as other old tree habitats and require significant time to re-form naturally (although far quicker than heart-rot cavities).

The use of artificial rot-holes to increase the available habitat for Golden Hoverfly (*Callicera spinolae*) was successfully trialled at several East Anglian sites (Rotheray, 2004). The results indicated that Golden Hoverflies will breed in carefully prepared artificial breeding holes and these may have the potential to increase breeding habitat and be used to boost and maintain hoverfly populations. This method could potentially be used more widely to provide rot-hole habitats to bridge gaps in the availability of this habitat on a site or to contribute to the conservation of particular rare species.

Artificial rot-holes can be made using two-litre plastic bottles with the top cut off to create an opening as an access point. Drainage holes below the opening prevent flooding in heavy rain. A two-litre plastic bottle can hold 1.25 -1.5 L of wet decaying breeding medium. Smaller volumes than this tend to quickly dry out. The bottles

> Rot-holes in veteran or ancient trees are particularly important for saproxylic flies. Species associated with rot holes include rarities like Golden Hoverfly (*Callicera spinolae*) and the Critically Endangered Western Wood-vase Hoverfly (*Myolepta potens*).

should be wrapped in double-layered black plastic to ensure dark conditions inside.

The decaying heartwood that was placed in the bottles in the original trial was prepared by collecting small (about 7 cm diameter) fallen Beech branches with soft, friable decayed wood from a site well outside the known range of the Golden Hoverfly. The bark was removed and the wood pulped by hand with water from a nearby river. Any invertebrates were removed. This wet wood was stored in buckets, each with an additional 500 ml of wet decaying heartwood taken from Beech tree holes added to add bacteria and other microbes within this material to promote decay. Decay odours are likely to be a significant attractant to gravid female hoverflies, and bacteria are the main source of food for their larvae. Only a small amount of decaying material was removed from each rot-hole and any insect larvae found were replaced.

Each bucket was covered and stored in the dark at room temperature for five months. The contents were stirred and river water added to maintain wetness at four-week intervals. After five months the material had a distinctive 'woody-decay' smell and was the consistency of porridge. This method may not be ideal for more general use as the collection of fallen decaying wood removes this resource from the source habitat and collection of material from rot-holes might damage the habitat. Creation of a suitable wood decay substrate using, for example, sawdust created as a by-product of other work would be more sustainable but may not be as effective. Further trials would be useful.

The bottles were positioned on mature to over-mature trees between 3-8 m above ground in branch forks in shaded positions, conditions in which rot-holes often form naturally. Each bottle was filled two thirds full with the wet decaying material. Dried leaves and small pieces of bark were placed on top to a level almost to the top of the bottle to help prevent desiccation and provide oviposition points for females.

Artificial rot-holes could conceivably be used as habitat stepping stones or arks in the same way as dead wood boxes.

References and further reading

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• *Lichen translocation*

The translocation of foliose (leaf-like) lichens, including the Tree Lungwort, is fairly well studied. The technique usually involves removing fragments of the leafy thallus of the lichen from the donor tree and attaching them to a carefully selected receiver tree using mesh, staples or glue. Translocation of crustose lichens provides an additional challenge as they grow immersed amongst the bark cells it requires the bark and cambium to which the lichen is attached to be transplanted along with the lichen.

Translocation of several species of rare Beech Marble Lichen (*Pyrenula nitida*), Sap- groove Lichen, and *Thelopsis rubella* is being trialled at Burnham Beeches as part of the Ancients of the Future project. The first species has a very limited distribution nationally and with what was thought at the time to be the only population at Burnham Beeches (it has since been found on a number of trees) on a single dead pollard Beech that seemed increasingly likely to fall in the near future, translocation was considered an acceptable risk to rescue part of the population. The other species were collected from the dead tree and also presented opportunities for a trial.

Donor material was taken from the original tree by cutting and prising with a knife. Only apparently healthy material on sound bark was collected.

Identification of the correct niche to transplant into is clearly key. This was easily done in this instance thanks to familiarity with Beech Marble Lichen and its ecology in the New Forest which allowed identification of suitable transplant locations using physical characters of the tree and key indicator species. This level of knowledge may not be available for other scarce species, providing an additional hurdle to successful translocation.

The Beech Marble Lichen is known as a specialist of rain tracks on Beech with base-rich bark. Mature trees, preferably with post-mature features were selected. Veteran trees were not selected to avoid the risk of tree death or bark loss becoming an issue in the near future. On the receptor trees base-rich flushed bark, identified by the presence of key indicator species—the bryophytes *Metzgera furcata* or *Orthotricum* species and the lichens *Porina borreri* and *Enterographa crassa*. Rain tracks were also identified based on the architecture and features of the tree such as areas of flushing down the trunk and below knotholes. Ultimately rain tracks that were colonised by *Porina* species but not yet by the more ‘aggressive’ *E. crassa* were selected as transplant sites. In addition, trees were checked for presence/absence of the species being transplanted, with transplants only taking place where the transplant species was absent. The criteria above were also followed for selecting receptor sites for Sap-groove Lichen, but bare rain tracks that were

A Beech Marble Lichen (Pyrenula nitida) translocation

DAVE LAMACRAFT

not yet colonised by lichens were selected for the actual transplant location.

It was initially planned to attempt a graft of the cambium from the transplant bark fragment with that of the receptor tree using grafting wax and stainless steel panel pins. In practice the cambium on the donor tree was largely dead making grafting impossible. Araldite was therefore used to glue the removed fragments in place on the recipient tree. If the cambium is still alive the original approach should be considered. Sections were cut from the bark of the recipient tree with a knife and/or chisel to match the transplant fragment in size and shape as closely as possible. This allowed the transplant fragments to sit flush with the bark surface (initially thinking this would encourage knitting of the cambium) to allow rain water to flush over the transplanted lichen, thereby moving spores across the trunk of the tree.

Collection and transplant of bark fragments with Beech Marble Lichen, Sap-groove Lichen and *Thelopsis rubella* proved to be straightforward. The practice of trying to cut the right size and shape (including depth) recess within which to sit the transplant fragment proved more challenging. For future translocation of crustose species use of a technique that could take a regular sized and shaped fragment of donor material and create a matching recess or hole at the receptor site would be beneficial. The use of a coring attachment on a handheld electric drill was considered but not used due to the state of the bark of the old Beech pollard, anticipated difficulties of extracting the bark core and the weight and bulk of the equipment. An increment borer, a specialist tool for extracting a section of wood from a living tree without causing excessive damage, may work.

The use of Araldite in the translocation proved problematic. Mixing small amounts of the two-part adhesive in the field was overly complex and applying the adhesive to the bark fragment and/or the recess not always accurate or easy using the 'applicator' provided with the adhesive. There were also issues with the adhesive ending up covering some of the transplanted lichen, either due to it overflowing from the sides of the transplanted fragment or being rubbed from fingers onto the lichen thallus. The use of beeswax based grafting wax in place of glue was considered, but not used due to concerns that the grafting wax would be attractive food for squirrels.

For future translocations where an adhesive is required, a more controllable method of applying an inert adhesive should be investigated. An aquarium adhesive may prove to be suitable. These are available in tubes that fit a sealant gun and may prove to be much more controllable if a very small hole is cut into the nose of the tube.

If a method that can take and insert cores can be found this may not require the use of any adhesive, and would have the added advantage of maximising the chances of the cambium of both transplant and recipient tree grafting. The use of growth hormone may also be advantageous.

Subsequent monitoring has shown good survival of transplanted bark fragments for the Beech Marble Lichen and for the *Thelopsis* but less so for the Sap-groove Lichen. It seems the thicker thallus, of the Beech Marble Lichen in particular, may help to hold the bark fragment together, and this could explain the continued survival of some Beech Marble Lichen transplants made by William Purvis in 2001. The bark fragments with Sap-groove Lichen have all disintegrated to varying degrees. There is not yet any sign of colonisation elsewhere on the trunks, and no sign of any grafting taking place. Monitoring will continue.

Previous attempts at translocating lichens have mixed rates of success and any lichen translocation should be considered a last resort. It should only be attempted when the current population is imminently threatened, due to the collapse of the host tree for example, and it may be a particularly important with Ash specialists threatened by Ash Dieback.

5.3 Management of land around old trees

Ancient and other veteran trees can occur in almost any habitat. The management of the land surrounding ancient and other veteran trees is in many ways more important than the management of the trees themselves. If external factors remain constant old trees will almost always increase in interest over time if left alone. Direct management is only needed as an emergency intervention to extend the life of the tree. Changes in the management of the surrounding land can have dramatic impacts. If the changes decrease the suitability of the environment, they can rapidly lead to the loss of much of the associated wildlife interest of the tree and/or the decline or death of the tree or trees. Ancient and other veteran trees are often found in relative isolation in the landscape, for example: rows of willows along watercourses, trees left in hedges and arable land and isolated veterans within younger woodland.

Changes in land management practices over the last century or two have been the major cause of loss of old trees and their associated habitats and species. Neglect of parkland and woodland, abandonment of pollarding and coppicing and agricultural intensification have been devastating. If the land surrounding an old tree is managed in an unsympathetic manner it can quickly lead to the decline and death of the tree. If managed well it can extend the life of the tree and maintain or increase its wildlife interest.

5.3.1 Roots and mycorrhizal fungi

A tree extends far further than might be guessed by its visible size. A large portion of any tree is hidden beneath the ground in the form of roots. The root system and crown are generally of approximately the same volume but are quite different in structure. Young trees have a deep reaching tap root but this dies back in older trees who are more reliant on lateral roots (https://www.vetcert.eu/node/16). The majority of roots are active in the top 30-60 cm of the soil and can extend a long way from the trunk, usually reaching 1.5-2.5 times the radius of the canopy (https://www.woodlandtrust.org.uk/media/1838/ancient-trees-and-farming.pdf).

The network of mycorrhizal fungi that help to feed all the tree species discussed in this document link with roots and vastly increase the size of the area available to the root system. Some of these fungi are generalists, and have no distinction between the age or continuity of wooded areas.

Some, however, are particularly known for their associations with areas that have had extremely long continuous wooded cover, and with veteran trees in particular (especially oaks, but also Beech). These important fungi include Section 41 species, in particular groups like the thermophilous boletes of open woodland and parkland in the south of England and the tooth fungi of more heavily wooded areas.

Most mycorrhizal fungi have a preference for fruiting in unimproved, well grazed, short sward or open/mossy habitats surrounding the base of trees.

When new, young trees are planted in the vicinity of veterans, the mycelium of these fungi will connect with the new trees and support them with additional water and nutrients and even have the capacity to share resources between the veterans and young trees in either direction as needed.

All mycorrhizal fungi gather essential nutrients and may help the tree to cope with stress and pathogens. Damage to the communities of mycorrhizal fungi therefore affect nutrient recycling and uptake of essential elements by the tree.

Activity even at a significant distance from the tree can have severe impacts by affecting the mycorrhizal network and root system. Disturbance of the soil directly damages the roots and associated mycorrhizal fungi, whilst compaction and waterlogging squeeze out air spaces and deprive the roots of gas exchange. Such damage can often be visible on the tree, strips of dieback on trunk are often caused by damage to roots in this area.

Old trees more likely to have hollow trunks and spreading roots that cover a larger area and are more vulnerable to damage. Old trees are also less able to rapidly respond to changes in their environment (https://www.vetcert.eu/node/16). Wherever an old tree is present on a site a RPA should be established. The RPA should extend all around the tree to a distance of 15 times the diameter of the stem or 5 m beyond canopy, whichever is greater (Lonsdale, 2013: 3).

Table 11 summarises some of the key management issues and potential solutions for broad habitat categories within which ancient or other veteran trees frequently occur. The following sections deal with managing each of these categories of habitat in a manner that is sympathetic to ancient or other veteran trees.

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- VETcert video on the importance of managing the land around a tree: https://www.vetcert.eu/node/16.
- VETcert videos on mycorrhizae and their importance for ancient and other veteran trees: https://www.vetcert.eu/node/43 and https://www.vetcert.eu/node/44.

Root Protection Area

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Table 11. Summary of key management issues and potential solutions for broad habitat categories within which ancient or other veteran trees frequently occur (continued overleaf).

Surroundings	Management issues for ancient or veteran trees	Management solutions	Additional considerations	Potential conflicts
Parkland, wood pasture, commons and other grasslands	Scrub invasion and shading	Grazing and browsing by animals such as cattle, sheep, ponies or deer Cutting of grass where grazing is impractical Targeted mechanical or physical removal of scrub or shading vegetation where localised	Hedgerows and lines of trees should be maintained as flight paths for bats and invertebrates Encourage flowering plants and shrubs to provide a nectar source for saproxylic invertebrates	Maintaining open flowery habitats or flowering scrub without shading trees can be difficult on small sites
	Overgrazing preventing natural regeneration	Fenced exclosures to protect saplings Tree planting	Thorny shrubs act as nurseries for the natural regeneration of trees	
	Damage to the tree by stock—trampling, compaction, nutrient enrichment, direct damage to the trunk	Fencing around the RPA of sensitive trees Use dead wood to protect tree trunks Place shelters, water troughs, feeding stations and mineral blocks away from veteran trees		Moving dead wood to protect the trunks of trees may be detrimental to the wildlife associated with the dead wood Stacking dead wood against lichen-rich trees should be avoided
	Damage to decomposing insect communities and nutrient recycling processes by internal parasite treatments	Do not use internal parasite treatments on stock		
	Damage to fungal communities, soil fauna and epiphytes by agrochemicals such as fertilisers, herbicides, pesticides and fungicides	Do not use agrochemicals		
	Tidying up of fallen dead wood and removal of dead limbs from trees in formal parkland	Do not remove or move dead wood Public engagement explaining the value features such as decaying wood	Tidying may be required to maintain cultural and historical value Different factors can be prioritised in different areas of the site to create an overall balance	Management to conserve the historic and aesthetic value of wood pastures and often conflicts with management for biodiversity Balance should be aimed for but this can be difficult, especially on smaller sites
Arable farmland	Ploughing and ditching directly damage tree	No ploughing or cultivation close to old trees Establish RPA around any veteran tree and convert from arable to grass (managed by cutting)	RPAs prevent direct root damage and compaction do not protect from drifting agrochemicals If trees are grouped, a no-ploughing area should be established that covers twice the RPA of all trees	
	Compaction by heavy vehicles and stacked material damages roots and soil structure	Establish RPA around any veteran tree and convert from arable to grass (managed by cutting) Move vehicle access routes and storage areas away from old trees		
	Removal of lower branches to allow better access for the farm vehicles	Never prune an ancient or other veteran tree for access purposes Move vehicle access routes away from old trees		

Table 11 continued. Summary of key management issues and potential solutions for broad habitat categories within which ancient or other veteran trees frequently occur (continued overleaf).

Surroundings	Management issues for ancient or veteran trees	Management solutions	Additional considerations	Potential conflicts
Arable farmland	Damage to fungal communities, soil fauna and epiphytes by agrochemicals such as fertilisers, herbicides, pesticides and fungicides	Establish RPA around any veteran tree and convert from arable to grass (managed by cutting) Enforce low impact organic zone covering twice the RPA to minimise the negative effects of agrochemicals If organic fertilisers are used do not splash the trunk of any tree	If trees are grouped in arable fields conversion of the whole area to pasture separated from adjoining arable by hedges to minimise spray drift should be considered	
	Damage to and loss of veteran trees in hedgerows	Clearly mark trees in hedgerows to protect them during management	Pollarding young trees ensures they do not encroach on roads, tracks or fields and simultaneously encourages the development of veteran features and dead wood habitat	
Woodland	Neglect of coppice	Re-instate a coppice rotation		
	Conversion of wood pasture to plantation	Clearance of the plantation Maintain existing glades or rides to provide open warm habitats and nectar sources for saproxylic invertebrates Release ancient or other veteran trees from shading and competition by haloing Create large glades around existing ancient and other veteran trees	Restoration of wood pasture may also be the long-term aim Ensure the veteran trees are not exposed to rapid environmental changes using phased haloing	Clearance has a negative impact on woodland bats like the Barbastelle, Bechstein's Bat and Brown Long-eared Bat Wayside lichens require sunlight and nutrient enrichment. Woodland lichens like cool, moist, shaded habitats. Management needs for these groups conflict The needs of the lichen community must always be balanced against the needs of other taxa and the tree itself Opening up dense woodlands is detrimental to invertebrate species that favour shaded and moist habitats Resolution of these conflicts should be based on knowledge of the species/groups present on the site
	Development of secondary woodland through the abandonment of wood pasture	Maintain existing glades or rides to provide open warm habitats and nectar sources for saproxylic invertebrates Release ancient or other veteran trees from shading and competition by haloing Create large glades around existing ancient and other veteran trees	Restoration of wood pasture may also be the long-term aim Ensure the veteran trees are not exposed to rapid environmental changes using phased haloing	As above
	Damage to ancient or veteran trees by forestry operations	Make workers aware of important trees New roads or tracks should not be positioned outside RPAs of old trees Use brush mats and track mats to protect the soil from compaction Use sympathetic methods of extracting timber such as horses or vehicles with low impact tyres		

Table 11 continued. Summary of key management issues and potential solutions for broad habitat categories within which ancient or other veteran trees frequently occur (continued overleaf).

Surroundings	Management issues for ancient or veteran trees	Management solutions	Additional considerations	Potential conflicts
Other semi-natural habitats	Overgrazing preventing natural regeneration (unlikely to be a serious issue at the densities used in conservation unless the site as a whole is overgrazed)	Changing stocking density to be more appropriate to the site as a whole It may be necessary to protect particular trees that stock congregate around even if grazing levels are appropriate	On larger sites natural regeneration can be encouraged in lower value areas (e.g. fencing)	Conflict between the management needs of trees and those of the habitat they are found in can occur Conflicts should be resolved based on relative value of the features and the time taken to recreate them If an old tree requires management to protect another habitat feature work should always be the minimum necessary Tree planting should be avoided on sites with nature conservation interest associated with open habitats
	Undergrazing and scrub invasion leading to excessive shading around old trees	In habitats where grazing is suitable, such as unimproved grasslands, old trees can be protected as they are in parklands and pasture In open sites this is likely to be addressed by the site management plan and manual or mechanical scrub clearance are likely to benefit any ancient and other veteran trees too	Cut material should not be burnt within the RPA of any old trees Do not clear scrub too abruptly around old trees to minimise rapid changes in environment	Scrub is increasingly valued for wildlife and is often encouraged or retained as a feature If areas of scrub are being encouraged or allowed to develop on a site this should be away from ancient and other veteran trees Shrubs are often valuable nectar sources for saproxylic insects and Hawthorn for example shares many mycorrhizal fungi with oak
	Dense growth of bracken around tree presenting fire risk	Bracken may need to be controlled in the immediate vicinity of ancient and other veteran trees		Removes habitat for species/ assemblages associated with bracken (these are not normally of significant conservation value)
Development and urban areas	Compaction due to heavy footfall or vehicle access	Fencing to discourage access Move paths away from tree roots and outside the RPA Formalise parking or vehicular access in areas where it will not damage ancient and other veteran tree Benches, bins or other features should not be placed directly below old trees	Ensure boardwalk construction does not damage the roots	
	Vandalism	Construction of walkways over ground surface within RPAs where access cannot be avoided Mulching to reduce the impacts of soil compaction and competition		
	Health and safety work on old trees	Move the target away from the tree If the target cannot be moved it may be necessary to remove branches or limbs	Work should only be carried out where it is absolutely necessary and should always be the minimum required to make the tree safe Do not remove the whole tree and retain the trunk even if dead	Health and safety work on old trees is always damaging to the tree and associated wildlife and must be considered a last resort

Table 11 continued. Summary of key management issues and potential solutions for broad habitat categories within which ancient or other veteran trees frequently occur.

Surroundings	Management issues for ancient or veteran trees	Management solutions	Additional considerations	Potential conflicts
Development and urban areas	Destruction or damage to trees during development	New developments should ideally not take place close to ancient or other veteran trees Old trees should always be fully accounted for and protected in development plans RPAs should be established for all trees Trees should be fenced at the edge of the RPA to protect them from damage during development Ancient and other veteran trees should never be felled to make way for a development Existing old trees should be incorporated into sympathetically managed green spaces Appropriate measures should be taken to protect the trees from compaction or vandalism Suitable future replacements should also be planted in green spaces	Planting new trees should never be considered mitigation for loss of or damage to old trees Networks or corridors of green space should be planned into developments to maintain connectivity with the wider landscape	There are inevitably conflicts between the desires of developers for profitability and functionality and the needs of old trees These conflicts can often be resolved through careful and considered planning to the benefit of all parties

5.3.2 Parkland, wood pasture, commons and other grasslands

The habitat with the largest remaining concentrations of ancient trees is wood pasture. This is now usually associated with parkland on large estates, royal hunting forests or chases and commons. This habitat is an approximation of the open wooded conditions that would have occurred across much of lowland Britain before human intervention, but one created by human agency. These habitats were originally used for grazing of livestock or hunting and later evolved an aesthetic aspect in the great parks of Britain. Many have been converted to arable farmland, overgrazed or neglected.

Apart from formal parkland, which is primarily managed for aesthetics, the original uses of most wood pastures are now largely obsolete, and many have been badly neglected as a result. Others have been converted to arable or plantation woodland, or are seriously overgrazed. Where neglect or plantation has led to the formation of secondary woodland the advice given on woodland management for old trees should be followed. If the site has already been converted to arable management advice in the arable section should be followed to protect any remaining old trees.

In the case of wood pastures that have survived in something close to their traditional state, the default management is grazing and browsing by animals. This can be done by livestock, such as cattle, sheep, ponies or deer, which would traditionally have been maintained for hunting. Grazing and browsing by large herbivores mimics the condition of the ancient mosaic and is the traditional management in wood pasture and parkland. This management advice is equally applicable to any other site where ancient or other veteran trees occur in grassland or heathland.

Determining the correct stocking densities and species compositions can be challenging. Tradition may provide a guide, historically used stocking densities and breeds may be followed where the information exists. However, in many cases this information may not be available, economic pressures and stock availability may affect the selection of breeds, and historic stocking rates can be misleading. Increased nitrogen in rainfall, coupled with warmer winters, are leading to greater growth of herbaceous vegetation over a longer season and a need

Parkland

BUGLIFE

ALEX HYDE/BACK FROM THE BRINK

Well-grazed wood pasture

for heavier or more frequent management (https://www.vetcert.eu/node/16). This will be exacerbated if the open habitat between the trees has been improved or semi-improved. Grazing will still manage it, but a high stocking density, especially of large heavy animals, may result in damage to the trees, and especially to lichens on the bark, may compact the soil beneath trees and thus their roots, and may result in lower air quality.

The ideal is to have management pressure a little too low to prevent invasion by woody vegetation and to correct by occasional local clearance and cutting (https://www.vetcert.eu/node/16). This maintains a varied overall structure, gives space for flowering plants, and allows an opportunity for natural regeneration from which a future generation of ancient trees can be selected. This level of grazing will not, however, be suitable in a formal parkland, where a neater and more uniform appearance is likely to be needed and where new trees must usually be planted, often in rather precise formations.

Overgrazed wood pasture

ROGER KEY

Overstocking can be highly damaging to ancient and other veteran trees. Overgrazing will prevent any natural regeneration of woody vegetation and leads to gaps in the age structure of the site. Livestock may rub or chew bark at the base of the trunk causing direct damage to the tree and removing lichens or bryophytes. Nutrient enrichment of the base of the trunk through urine and dung alters the bark chemistry and usually results in the loss of specialist lichens and bryophytes. Trampling and compaction of the soil are also significant issues that can have a negative impact on both mycorrhizal fungi and root systems. High stocking rates of horses is especially damaging (https://www.vetcert.eu/node/16).

If stocking density is unavoidably too high and are preventing regeneration, compacting soil around old trees, or damaging the trunk by rubbing, chewing and nutrient enrichment from urine and dung, additional action will be required. The trunks and soil around trees that are being damaged should be protected. Fencing at the edge of the RPA is the most straightforward and widely used method (https://www.vetcert.eu/node/16). More high-tech solutions such as GPS collars (https://www.nofence.no/en) now exist that can achieve the same effect without potentially unsightly fencing where this is a concern. It is also possible to reduce pressure from grazing animals by piling dead wood close to the base of the trunk (Bullcock & Collis, 2000). It should be borne in mind that if stock are excluded from the area around trees it may be necessary to manually or mechanically remove

developing scrub to prevent shading of the trunk which is detrimental to epiphytic communities and saproxylic invertebrates and, in southern Britain, to maintain open habitats for thermophilous bolete assemblages in oak parkland.
Even if stocking densities are ideal trees may still be damaged. Livestock often congregate in particular areas. Large, old, trees provide shade and shelter and are therefore often favoured. For this reason, even when stocking density is relatively low, trampling, compaction and nutrient enrichment can be disproportionate in the immediate vicinity of old trees. This can be prevented using the methods described previously. Additionally, the provision of alternate shelters or diversionary feeding stations can be used to encourage congregation in less sensitive areas.


ALICE PARFITT

Trampling around a tree

Water troughs, feeding stations and mineral blocks should always be placed away from veteran trees. If placed close to old trees these will encourage congregation in these areas and exacerbate associated problems (https://www.vetcert.eu/node/16).

Where grazing is completely suppressing natural regeneration of trees, and sufficient reduction in stocking density cannot be achieved, small fenced exclosures can be created to protect saplings.

Low stocking densities can also be a problem. If grazing pressure is insufficient to slow or prevent succession the site will eventually become scrub and secondary woodland. This generally results in any ancient and other veteran trees being shaded out leading to a loss of wildlife interest and the decline and eventual death of the tree.

If stocking densities are unavoidably too low to maintain the desired open structure of the habitat it will be necessary to use manual or mechanical means to prevent natural regeneration of woody vegetation in the vicinity of ancient and other veteran trees (https://www.vetcert.eu/node/16).

The ideal intensity of grazing around old trees varies depending on the associated wildlife. The exact details of the grazing regime of a site should, wherever possible, be based on available information on the associated species present on the site. If trees on the site are known to support a notable community it may be decided that heavier grazing is necessary than would otherwise be desirable for example. It should always be ensured that the trees do not become damaged by grazing livestock.

Grazing is not always practical, particularly on small or unfenced sites. In such cases cutting is a viable alternative management to grazing and ancient trees in association with traditional hay meadows are not unknown. In fact, in much of Europe hay cutting is the traditional management below pollarded trees (Peterken, 2009). The grass should be cut as appropriate for the grassland, but it is potentially useful to leave small patches of flowery habitat close to the tree until later in the season, after traditional management time, to provide nectar sources for saproxylic invertebrates.

Internal parasite treatments, such as Ivermectin, can damage decomposing insect communities and slow nutrient recycling processes. Use of veterinarian treatments such as wormers should therefore be avoided on sites with ancient or other veteran trees. Agrochemicals such as fertilisers, herbicides, pesticides and fungicides should never be applied to grasslands that contain ancient or other veteran trees (https://www.vetcert.eu/node/16).

Linear habitat features such as hedgerows and lines of trees in the landscape should always be maintained. Bats and invertebrates use these features as flight paths and even small gaps can be a barrier to movement. Many saproxylic invertebrates have different habitat requirements at different life stages; saproxylic larvae may be dependent on old trees whilst adults require open flowery habitats. Areas of flowering plants and shrubs should be encouraged to provide a nectar source for invertebrates. These can be herbaceous plants such as umbellifers or composites, flowering shrubs such as Hawthorn and Blackthorn or flowering Ivy. Healthy invertebrate populations will then support birds and bats. Thorny shrubs provide the added benefit of acting as nurseries for the natural regeneration of trees. The flowers of the trees themselves should be considered part of the nectar resource of a site and valued appropriately. On small sites maintaining a large enough area of open flowery habitats or flowering scrub without compromising the health of trees can be challenging.

In more densely wooded situations, mosses and liverworts may benefit from more humid microclimates that still receive a reasonable amount of sunlight (Read, 2000). In these situations, management that results in changes in humidity can be damaging to communities of mosses and liverworts. Streams or damp hollows in the vicinity of veteran trees that may contribute to the overall humidity of the area should not be drained or diverted, and in general terms canopy cover should be maintained over such water features.

It must be remembered that many remaining wood pastures and parklands are of historic and aesthetic value; are often accessed by the public who appreciate and expect a certain appearance; and may still be privately owned. In most cases a balance must be struck between management for biodiversity and maintaining a certain historically or culturally defined aesthetic. This should not be viewed as an insurmountable problem. Many sites have achieved a satisfactory balance. Different factors can often be prioritised in different areas to allow the site as a whole to maintain cultural and historical value whilst promoting biodiversity associated with old trees. Public awareness and engagement initiatives on the value of old trees for wildlife can also be quite successful in encouraging people to have a greater understanding of the value of untidy habitat features, such as decaying wood, for wildlife.

References and further reading

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Petworth Park: Balancing wildlife and cultural value

Petworth Park is a site of potentially international significance for its concentration of ancient trees and associated species. It is considered the best site for saproxylic invertebrates in Sussex and also supports high value assemblages of bats, lichens and saproxylic fungi. It is also of significant cultural value, being originally landscaped by Capability Brown. This creates potential conflicts for the National Trust between managing ancient trees for their saproxylic interest and the conservation of the Capability Brown landscape at Petworth Park. Ideal management for invertebrates and lichens includes cessation of timber removal, a reduction in grazing pressure to encourage more flower-rich grassland, planting of trees chosen for wildlife value and increasing the available nectar source by planting flowering shrubs. These actions will noticeably change the aesthetics of the landscape and therefore conflict with the cultural and historical goal of maintaining the Capability Brown parkland in a form close to that originally planned. These issues have been addressed through the drawing up of a zoned map showing areas that will be managed primarily for their landscape value and areas that will be managed for their saproxylic interest.

5.3.3 Arable farmland

The habitat most inimical to old trees is arable farmland. There are a relatively large number of veteran trees in old hedgerows or situated within arable fields that were once pasture, wood pasture or hedgerows. Veteran trees in arable farmland are often in poor condition. Ploughing is often carried out right up to the trunk. Ploughing and ditching directly damage the roots of the tree interfering with the uptake of water and nutrients. Compaction by heavy vehicles and stacked material also damages roots and soil structure. This can lead to waterlogging in winter or drying out in the summer. Lower branches are often removed to allow better access for farm vehicles.

PHILIP HALLING (GEOGRAPH.ORG.UKP5141104)

Oak in arable field

The use of agrochemicals such as fertilisers, herbicides, pesticides and fungicides have a severely negative impact on soil fauna and fungal communities. The use of agrochemicals often results in the loss of mycorrhizae and thus can potentially make the trees more susceptible to stress and disease. If organic fertilisers are used care should be taken not to splash the trunk of any trees (https://www.vetcert.eu/node/16).

There is no way of knowing exactly where the roots of a tree lie so a precautionary principle should be followed. Ploughing or cultivation close to old trees ought to be avoided at all costs. An RPA should be established around any veteran tree as detailed above and the area within this zone converted from arable to grass and managed by cutting. Whilst this prevents direct root damage and compaction, the tree will still be vulnerable to damage from agrochemicals which can drift a significant distance. A low impact organic zone covering twice the root protection area will minimise the negative effects of agrochemicals (https://www.vetcert.eu/node/16). If there are grouped trees in arable fields conversion of the whole area to permanent vegetation cover, separated from adjoining arable by a hedge to minimise spray drift and managed by grazing, should be considered. As a minimum, a no-ploughing area should be established that covers twice the RPA of all of the trees present (https://www.vetcert.eu/node/16).

Both old and young trees in hedgerows should be clearly marked to protect them from normal hedgerow management and allow them to reach old age (Lonsdale 2013a; 3.3). Historically trees in hedgerows may have been pollarded. Creating new pollards in hedgerows has the combined benefit of ensuring they do not encroach on the road and simultaneously encourage the development of veteran features and dead wood habitat.


EVELYN SIMAK (CC-BY-SA2.0)

Tree in a hedgerow

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- Ancient Tree Guides—caring for special trees on farms: https://www.ancienttreeforum.org.uk/resources/ancient-tree-guides/trees-and-farming/.
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- VETcert video on the importance of managing the land around a tree: https://www.vetcert.eu/node/16.
- VETcert videos on mycorrhizae and their importance for ancient and other veteran trees: https://www.vetcert.eu/node/43 and https://www.vetcert.eu/node/44.

5.3.4 Woodland

The conditions found in closed-canopy woodland do not always encourage trees to reach old age and there are few true ancients in even the finest ancient woodlands. Semi-natural broadleaved woodland may however support large populations of relatively old veteran trees. In semi-natural broadleaved woodland minimal intervention is recommended (Fuller & Warren, 1996). If the woodland was previously coppiced it may be beneficial to veteran trees within the coppiced area to re-instate a coppice rotation, as long as the coppice is not too far lapsed, thereby reducing shading of ancients as well as providing the general benefits associated with coppicing (Bratton & Andrews, 1991; Kirby, 2001). Old coppice stools can also support a reasonable dead wood fauna in themselves and thus care should be taken before reinstating coppicing after a long period as the stools may be very ancient (Kirby, 2001; Lonsdale, 2013: 4.5.4). Any already existing glades or rides should be maintained to provide open warm habitats and nectar sources for saproxylic invertebrates.


ROBIN WEBSTER (CC-BY-SA 2.0)

Old coppice

The commonest situation where ancient trees occur in woodland is on sites where wood pasture or parkland has been converted to plantation woodland or developed into secondary woodland through the abandonment of grazing and the consequential natural regeneration.

Due to the size and poor timber value of decaying veteran trees it was often cheaper to leave them when planting rather than fell and remove them. Such trees now survive, heavily shaded and declining, within commercial forestry plantations. Where veteran trees occur within plantations or secondary woodland they should be released from shading and competition by haloing, following the principles set out above. When the surrounding trees are part of a commercial plantation the desirable long-term aim is clearance of the plantation. This will inevitably happen when the trees reach commercial maturity and are felled, but can be expedited when the argument for conservation of ancient and other veteran trees is strong, or the landowner sympathetic. Wider clearance should follow the same basic principles detailed in the haloing section, ensuring the veteran trees are not exposed to rapid environmental changes and protecting the trees from damage. Clearance of plantation woodland can be the first step in wood pasture restoration (e.g. Barker and Carter, 2018). Restoration of wood pasture may also be the long-term aim when dealing with naturally regenerated secondary woodland. Alternatively, the creation of large glades around existing ancient and other veteran trees will benefit the tree and provide an open habitat component within the wood that is valuable for invertebrates and plants.

KEITH ALEXANDER

Haloing of ancient oaks at Windsor Great Park

Clearance of secondary woodland and woodland understories to release ancient or other veteran trees from competition will inevitably have an impact on the species currently present. It is therefore important to consider species needs before opening up these 'neglected' woodlands. Of particular note are many obligate woodland bats like the Barbastelle, Bechstein's Bat and Brown Long-eared Bat, that favour habitat that is generally classed as unmanaged, undisturbed woodland, (shady interiors, with closed canopy and dense native understorey layer), to meet their roosting and foraging needs (Greenaway, 2001; Hill & Greenaway, 2008). Bat surveys should be carried out prior to such work and any impacts accounted for and mitigated.

Opening up dense woodlands may also be detrimental to those invertebrate species that favour shaded and moist habitats. This is particularly true of many saproxylic flies, including the Royal Splinter Cranefly, which generally favour more shaded conditions than saproxylic beetles. Surveys of associated species prior to any work can help guide suitable management.

Whenever forestry operations are being carried out in woodlands which contain ancient and other veteran trees workers should be made aware of their importance. Veteran trees in worked woodlands are vulnerable to root damage, especially where new vehicle access is being put in or timber extracted.

New roads or tracks should not be made over roots of old trees and vehicles should not be driven within the RPA. Brush mats and track mats may be used to protect the soil from compaction and conserve the roots of trees in conditions where the soil is not too easily rutted. Sympathetic methods of extracting timber such as horses or vehicles with low impact tyres should be considered (https://www.vetcert.eu/node/16; Lonsdale 2013a, 2013).

Bonfires damage both roots and soil structure. Never light a bonfire within RPAs. Consider using a burning platform to keep the fire off the ground (https://www.vetcert.eu/node/16; Lonsdale 2013a, 2013).

References and further reading

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• *Haloing*

Many ancient and other veteran parkland trees have become heavily shaded, either through natural regeneration of scrub and secondary woodland after the cessation or decline of management, or by deliberate plantation, often of conifers, for timber production. Past plantings of replacement trees can also be an issue where these have been planted too close to the existing ancient. The rapid growth of vigorous young trees can quickly overtop and shade out the retrenching canopy of old trees. This can lead to their death (Alexander *et al.*, 2011). Heavy

Oak pollards engulfed within secondary woodland on Exmoor

KEITH ALEXANDER

shading of the trunk also reduces the suitability of the tree for rare lichens, bryophytes and saproxylic invertebrates and can lead to their loss (Lonsdale 2013a: 5.4.3).

Shade from other trees surrounding a veteran should be removed to allow light through the canopy. This is usually the single most important piece for management for ancient and other veteran trees and should be done before any thought is given to pruning. It is worth noting that the requirement for light is virtually independent of species, to allow the trees to go through the natural retrenchment process.

Release of ancient and other veteran trees from shading and competition is usually achieved through haloing. This involves removing a circle of shading trees from around the ancient or other veteran. It may not be necessary or desirable to completely remove shading trees, if, for example they are native species that may hold some value themselves. It might be possible to sufficiently reduce shading through topping or crown lifting of surrounding trees. The decision as to whether sufficient reduction in shading can be achieved this way must be assessed on an individual basis. If the ancient or other veteran tree will still be unacceptably shaded after crown reduction of surrounding trees priority should be given to protecting the ancient tree and the younger trees should be felled or killed by ring-barking. Dead wood from felling should be left in situ wherever possible.

Never remove all surrounding vegetation in one go, the removal of shading trees should be gradual and carried out in stages over a period of several years. Rapid exposure of the veteran tree to increased sunlight or wind may lead to unaccustomed loss of moisture through evapotranspiration and kill the tree. Previously shaded areas of bark and sapwood can also become overheated and die (Lonsdale, 2013: 3.4.1.1).

Phased haloing also means that the environmental conditions provided by the buffer of vegetation that certain associated species may rely on do not change too rapidly or drastically, causing the species to die out or move on from the tree (Alexander *et al.*, 2011).

Trees growing though the canopy of the old tree should be removed first, aiming to ensure there is a gap between the canopy of the old tree and its nearest neighbours. A few years later true haloing can begin, clearing trees in a larger area around the veteran. The number and frequency of clearance phases depends on the density of surrounding trees and the location. If in heavy shade or an area subject to drought or heavy winds, then haloing should proceed more slowly (Lonsdale, 2013: 3.4.1.1).

The guiding principle in staged haloing should be to prevent any sudden change in conditions for the ancient or other veteran trees and its associated wildlife. Whilst every situation is different and should be assessed on an individual basis there are some fairly universal principles that can be followed when deciding which trees to fell or reduce first. Trees or shrubs on the most sun-exposed side of the tree should be retained in the early phases. Shading trees furthest from the trunk should be removed first, leaving a narrow ring of retained trees to prevent an abrupt reduction in shade. Trees growing directly under the canopy can also usually be removed early on. Account should be taken of both exposure to sun and to wind.

Woodland obligate bats, including Barbastelle and Bechstein's Bat, preferentially forage in woodland habitats and/or primarily roost in veteran trees situated in the interior of woodland with dense understorey and a closed canopy. This is the opposite of most other taxa associated with old trees and the tree itself. Opening up the surroundings of old trees by haloing or clearance of secondary woodland will destroy a key foraging and potentially a roosting habitat for these species. If a site has bat interest it is important that corridors of mature trees are retained when clearing trees to allow bats to use them as flightpaths. Achieving the correct balance between the needs of some bat species and other taxa may prove challenging but a pragmatic solution based on gathered evidence is always possible. It is also illegal to disturb, damage or destroy bat roosts. Bat surveys should be carried out before any clearance of woodland around existing veteran trees. If bats are present plans for clearance may need to be revised with areas of denser trees retained.

Hill, D.A, & Greenaway, F. (2008) Conservation of bats in British Woodlands. *British Wildlife*, 19(8)

Greenaway, F. (2001). The Barbastelle in Britain. *British Wildlife*, 12

Sudden exposure to wind may damage the tree and wind-blown agrochemicals, other pollution, or salt spray might damage any bark flora. Density and seasonality of shade should be taken into account (Lonsdale, 2013: 3.4.1.1).

The potential habitat value of trees to be removed or reduced should be considered, especially where there is a need to fill a gap in habitat succession. Whenever management involves the removal of trees, young and healthy trees should be selected in preference to old, damaged or unhealthy trees. It is worth retaining as many as possible of those trees which seem likely to support invertebrate interest: those with regular sap runs, splits, or damage from lightning and weather, and those regularly producing bracket fungi. If, once these considerations have been taken into account, there is still a need to prioritise trees for felling, those of higher timber value may be selected. This can provide revenue for further conservation management (Lonsdale, 2013: 3.4.1.1).

It may be desirable to retain the main trunk of surrounding trees to provide standing dead wood. Ring-barking surrounding trees or their branches can also be used and causes a more gradual death and release from shade. This slows the speed of environmental change and shock experienced by the veteran tree and will provide valuable standing dead wood.

Croft Castle—Accounting for bats

The 655 ha Croft Castle Estate in Herefordshire supports an excellent collection of ancient trees. Around 60 ha of parkland on the Estate was coniferised by the Forestry Commission around 1925. The conifers in this area reached maturity in 2010 and their removal provided an ideal opportunity to restore the parkland by completely clearing the conifers from the vicinity of ancient and veteran trees, thereby releasing them from competition, and re-establishing grazing to maintain open conditions. Extensive ecological surveys were carried out to identify any constraints on the plan. For most groups no specific constraints were identified, however, bat surveys identified an important assemblage present on the site. Most bat species, especially woodland obligate species, require denser trees and vegetation than other groups associated with old trees. Corridors of trees are also very important features for commuting and foraging bats. and this significantly influenced the design and implementation of the restoration. The plan was revised to ensure that conifers were removed from the vicinity of veteran trees incrementally and ensure the retention of corridors of conifers for commuting and/or foraging bats until broadleaved replacements had established.

Barker, S. and Carter, I. (2018). Restoring wood pasture: a case study from Croft Castle, Herefordshire. *Conservation Land Management*, 16(1)

Unless there is case-specific evidence to the contrary felling should take place in late autumn or winter to minimise sudden exposure of foliage and maximise the period available for bark to adapt before exposure to strong sunshine in spring or summer (Lonsdale, 2013: 3.4.1.1).

Any tree removal or forestry operation should minimise damage and unnecessary disturbance to veteran trees. Root damage due to ground disturbance by heavy machinery can be severely damaging. RPAs should be created around ancient and other veteran trees during any clearance work and, if ground conditions allow, ground protection should be used (Lonsdale, 2013: 3.4.1.2).

The long-term aim is to maintain unshaded conditions. Light grazing is the ideal management to prevent regrowth and maintain the desired conditions. On sites where grazing is not possible regular intervention by mechanical or manual cutting to remove growing trees or shrubs will be necessary. Further guidance on haloing is given in a training video freely available on the VETCert website (https://www.vetcert.eu/node/15).

References and further reading

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- Lonsdale, D. (ed.) (2013). *Ancient and other veteran trees: further guidance on management*. The Tree Council, London. Sections 3.4.1 and 5.4.3.
- VETcert training video on the principles and guidelines of haloing can be found here: https://www.vetcert.eu/node/15.

5.3.5 Other semi-natural habitats

Scattered old trees can be found in many other semi-natural habitats that have nature conservation value in addition to the trees, such as heathlands, moorlands, unimproved grasslands and wetlands. In all cases a simple principle can be followed. The site should be managed in the most suitable way for the surrounding habitat whilst avoiding damage to ancient and other veteran trees or excessive disturbance in their immediate vicinity.

In habitats where grazing is suitable, such as unimproved grasslands, old trees can be protected as they are in parklands and pasture. Overgrazing is unlikely to be a serious issue at the densities used in conservation, assuming the site as a whole is not overgrazed, if it is this is a more general management issue and changing stocking density to be more appropriate will benefit the site as a whole. It may be necessary to protect particular trees that stock congregate around even if grazing levels are appropriate.


PETE HUGHES

Old tree in semi-natural habitat

Undergrazing is more likely to be an issue on most sites managed for nature conservation. It is often a challenge for conservation organisations to maintain sufficient grazing with limited resources. On many open sites scrub invasion is a serious issue, this can lead to excessive shading around old trees. In open sites this is likely to an issue that is addressed by the broader site management plan and any proposed solutions, such as manual or mechanical clearance, are likely to benefit any ancient and other veteran trees too. Care should be taken not to clear scrub too abruptly around old trees to minimise rapid changes in environment. Cut material should not be burnt within the RPA of any old trees.

There is an increasing recognition of, and interest in, the value of scrub for wildlife. Where traditionally scrub would have been regarded as an almost universally negative and threatening feature on open sites there is now, quite reasonably, a greater focus on mosaics of open habitat and scrub where the size of the site allows it. If areas of scrub are being encouraged or allowed to develop on a site this should not be so close as to impact on the ancient and other veteran trees, however bushes are often valuable nectar sources for saproxylic insects and Hawthorn for example shares many of the mycorrhizal fungi that oak has.

Bracken may need to be controlled in the immediate vicinity of ancient and other veteran trees as it presents a serious fire risk (Lonsdale 2013a: 3.4.3).

There is sometimes a potential conflict of interest in trying to balance the needs of trees against the needs of habitat they occur in. Where such a conflict occurs decisions should be made based on relative value of the features and the time taken to recreate them. This is always something of a judgement call and the decision should be based on expert opinion, available data (e.g. records of scarce associated species), site history, and local knowledge. If it is decided that an old tree requires management to protect another habitat feature, the work done should always be the minimum necessary to achieve the desired result.

Whilst generation gaps and lack of replacement is a serious issue facing old trees and their associated wildlife, planting should be avoided on sites which have, or are likely to have, nature conservation interest associated with open habitats. On larger sites it may be possible or desirable to allow or encourage natural regeneration in lower value areas. On smaller sites it is probably best to look outside the site into the wider landscape for opportunities for replacement and continuity. Planted trees can become ancients almost anywhere if the surrounding management is sympathetic. It is not sensible to sacrifice other high value habitats in the pursuit of continuity when so many low value habitats would do the job just as well.

References and further reading

- VETcert guidance video on the importance of the land around veteran trees: https://www.vetcert.eu/node/16.
- Lonsdale, D. (ed.) (2013). *Ancient and other veteran trees: further guidance on management.* The Tree Council, London. Section 3.4.3.

5.3.6 Development, urban environments, and public access

Old trees in urban environments or sites with heavy visitor pressure present a unique set of challenges. The presence of many people, buildings, and vehicles close to old trees inevitably leads to increased likelihood and severity of damage to the trees due to real or perceived risk. Although there is relatively little risk of damage, injury or death from trees in urban environments or where people are frequently in close proximity to old trees, such as along paths and in parks, there may be occasions when work to old trees is considered necessary and may require mitigation (https://www.forestresearch.gov.uk/documents/7086/Commonsense_management_of_trees.pdf). Heavy footfall or vehicle access close to trees also damages the tree through soil compaction, root damage and sometimes vandalism. Old trees in urban environments are also often subject to significant stress, in particular drought stress, either directly or indirectly e.g. due to compaction (https://www.vetcert.eu/node/16).

The ideal solution to both health and safety risks and damage to trees is the same. Move the target, whether people, property or vehicles, away from the tree. Fencing a tree discourages access and reduces compaction pressures. Paths should be moved away from tree roots and outside the RPA where possible and parking or vehicular access should be formalised in areas where it will not damage ancient and other veteran trees. Benches, bins or other features should not be placed directly below old trees (https://www.woodlandtrust.org.uk/publications/2011/12/ancient-trees-and-development/).

If it is impossible to move the target away from the tree it may be necessary to remove branches or limbs where the risk to people or property has been assessed as unacceptable. This is often the case in urban environments where old trees occur close to buildings, roads and paths. This infrastructure cannot reasonably be moved. In such cases work should only be carried out where it is absolutely necessary and should always be the minimum required to make the tree safe. It is very rarely necessary to remove the whole tree and the trunk should be retained even where the tree is dead (https://www.vetcert.eu/node/17).

If root damage or soil compaction is an issue, and it is not possible to move paths away from ancient and other veteran trees in parks or gardens, the construction of a walkway over the ground surface may be required if the site is subject to intense visitor pressure. It is important to ensure however that the construction of such a boardwalk does not damage the roots (https://www.vetcert.eu/node/16).

Once the causes of root damage or compaction have been removed further remedial action can be considered. There are a number of methods that have been used to aerate and restore soil structure after compaction. Most are unproven in relation to ancient and other veteran trees, and could be potentially damaging and are not generally recommended. One method that that has a long and relatively proven history of benefitting ancient trees that have been damaged by compaction is mulching. Mulching reduces competition from surrounding vegetation, encourages earthworm activity and increases soil moisture. The mulch should be made of chippings of the same tree species, preferably sourced from nearby. The chippings should be spread 5-10 cm deep around tree and not mounded close to the trunk. They can be applied in patches in particular locations rather than all around the tree so as not to change environment too drastically (https://www.vetcert.eu/node/16; Lonsdale 2013a, 3.5).

New developments should ideally not take place close to ancient or other veteran trees. Where such trees are within the footprint of a development they should always be fully accounted for and protected in the development plans. RPAs should be established for all trees. Each tree should be fenced at the edge of the RPA to protect them from damage (https://www.woodlandtrust.org.uk/publications/2011/12/ancient-trees-and-development/). Ancient and other veteran trees should never be felled to make way for a development (https://www.vetcert.eu/node/16).

Even if trees are adequately protected during development the surrounding environment of the tree will change significantly, increasing the isolation of trees and pressure from people and vehicles. Old trees should be incorporated into sympathetically managed green spaces wherever possible. Appropriate measures should be taken to protect the trees from compaction or vandalism. Suitable future replacements should also be planted in green spaces. Planting new trees should never be considered mitigation for loss of or damage to old trees. Networks or corridors of green space should be planned into developments to maintain connectivity with the wider landscape.

Whilst developments have historically been almost universally damaging to any old trees within their footprint this does not have to be the case. If they are suitably considered during planning and protected during the development, there are potential benefits for existing old trees. If they can be incorporated into sympathetically managed green space of suitable size this may represent a noticeable improvement in conditions compared to being situated in an intensively managed agricultural landscape. In such green spaces suitable trees can be planted with the long-term aim of establishing future ancients. These benefits can be even greater where green spaces form part of a larger network.

Unfortunately, despite the increased knowledge of the value of old trees, there are often conflicts even when the old trees are retained. They are rarely given sufficient space to maintain their health and may be subject to greater amounts of pruning due to real or perceived risk.

References and further reading

- Lonsdale, D. (ed.) (2013). *Ancient and other veteran trees: further guidance on management.* The Tree Council, London. Section 3.5.
- National Tree Safety Group guidance on common sense risk management of trees: https://www.forestresearch.gov.uk/documents/7086/Commonsense_management_of_trees.pdf.
- VETcert video on the importance of the land around veteran trees: https://www.vetcert.eu/node/16.
- VETcert video on common sense risk management of veteran trees: https://www.vetcert.eu/node/17.
- Woodland Trust guidance on trees and development: https://www.woodlandtrust.org.uk/publications/2011/12/ancient-trees-and-development/.

Planning for the FUTURE

The toolkit of suggested management methods for old trees presented in this document will only provide maximum benefits when applied as part of a cohesive, long-term management plan. Such a plan provides a place to record what has been done and what is envisaged in the future—potentially over many human lifespans. This section provides an insight into creating these long-term plans.

ALEX HYDE/BACK FROM THE BRINK

2. PLANNING FOR THE FUTURE

The management of ancient and other veteran trees section introduced a broad toolkit of methods for extending the lifespan of existing ancient trees for as long as possible and bridging gaps in the provision of decaying wood habitats on a site. These techniques may be of some value when applied on an ad hoc basis but to achieve maximum benefits they should be applied as part of a cohesive and long-term plan. Any very old trees should be very carefully recorded and conserved through any management programme. Where there is any significant age variation amongst younger standard trees it is always worth retaining the oldest (largest) with a view to allowing them to reach old age. A management plan gives a place to record what has been done on a site and what is envisaged in the future; provides the structure to identify the best management options for trees and integrate this with other management objectives; gives a firm basis for discussing management objectives and methods with outside parties; and allows long-term objectives to be maintained through changes of staff.

A management plan involving ancient trees is necessarily very long-term, trees, especially those of the greatest wildlife conservation value, operate over timescales of many human lifespans and, even some of the more short-term management interventions, can take decades to fully play out or evaluate. A good long-term management plan for a site with ancient trees involves considering management over timescales of centuries. For the lucky few, this may involve only the maintenance of the approximate status quo into the indefinite future. For most, it will involve getting the number, composition and age structure of the site's trees into a sustainable state and maintaining that. For all, it will involve attempting to future-proof the ancient tree resource in the face of inevitable environmental, economic and political change. This section aims to cover the most important considerations when planning for the future of ancient trees, the habitats they provide, and the wildlife associated with these.

The broad themes covered in this section are:

6.1 Survey and monitoring
- 6.1.1 Recording individual trees
- 6.1.2 Recording the overall resource
- 6.1.3 Age structure assessments
- 6.1.4 Monitoring dead wood resources
- 6.1.5 Survey of associated organisms

6.2 Creating a management plan
- 6.2.1 Site management plans
- 6.2.2 Individual tree management plans (ITMP)
- 6.2.3 Managing gaps in age structure and planning for the continuity of dead wood resources
- 6.2.4 Monitoring
- 6.2.5 Vision

6.3 Establishing new trees
- 6.3.1 Natural regeneration
  - Identifying regnerating species
  - Limitation of regeneration by grazing
  - Limitation of regeneration by disease
- 6.3.2 Tree planting
  - Utilising wider tree planting schemes
  - Provenance of planted trees
  - Density of planting
  - Location of planting
- 6.3.3 Choosing tree species to prioritise
  - Ensuring continuity of current interest Selecting trees that will provide the right habitats
  - Wider wildlife value
  - The importance of native trees
  - The role of non-native trees

6.4 Looking to the future
- 6.4.1 Wood pasture restoration and creation
- 6.4.2 Abandoning tradition
- 6.4.3 Re-wilding
- 6.4.4 Starting from scratch
- 6.4.5 The wider landscape

6.1 Survey and monitoring

An essential starting point for considering management on any timescale is a clear picture, and record, of the existing resource. In principle there is no upper limit to how much information it is potentially useful to record, or to how much survey it might be useful to undertake. The more information available to site managers and workers, the more able they will be to make good management decisions and accurately assess the effects of the management carried out. Importantly, it is not easy to know exactly what information might prove useful in the future and there is no way of going back to gather more.

On the other hand, it would be entirely possible for a knowledgeable individual to undertake sensible management based simply on a personal visual appraisal of the interest and possibilities of a site and for the necessary work to be carried out entirely opportunistically. Recording the details of a site should not overshadow management. Knowing everything and doing nothing is likely to be less useful than knowing a little and acting accordingly.

There are practical constraints on the amount of survey and monitoring that can be carried out on any site. Survey and monitoring can be both time consuming and expensive. Whilst any and all survey work is interesting; rather less is of practical value; still less is essential. It is important to identify and differentiate between basic information that will be essential to effectively managing a population of old trees and auxiliary information that may be of great interest but is not essential to most management decisions.

There may be existing information regarding the trees on the site; old maps and historical records of planting or management can be valuable to understanding the history and composition of the trees on a site. There may also have been previous surveys. All of these sources of information should be checked for when considering the management of trees on a site.

The amount of information desirable will vary considerably from site to site. As a minimum the number, location, species, size and condition of any ancient and other veteran trees on a site should be recorded and mapped. On a small site with only a few old trees this may be quite enough to allow good management and monitoring to be carried out.

On sites with a large and/or important population of trees, a more detailed baseline survey of the trees, collecting information on the physical features, health, structural integrity and veteran features present, is likely to be important. It may also be desirable to collect information on associated wildlife. Surveys of any level should be designed to enable the condition of trees to be determined and then monitored in order to decide how best to manage them and their surroundings.

6.1.1 Recording individual trees

The basis of a survey of the trees on a site is recording the details of each individual tree, or at least veteran or ancient tree, on the site. There are a wide range of different methods for recording the details of ancient and other veteran trees in Britain. One of the most widely used is the Specialist Survey Method (Fay & de Berker, 1997). This can be used to record varying levels of detail and is a good basis for survey and monitoring. For any survey data to be useful a system of marking the trees is required. Coordinates are one option, but are often not accurate enough when there are several trees close together. The most commonly used method of marking trees recorded during survey for future reference is tagging. This generally involves affixing a small numbered metal tag to the tree with a nail and allows trees to be quickly identified and cross-referenced with any existing data. It is important to use stainless steel tags and nails so as to avoid erosion that can be caused by aluminium nails which can create poisonous run off on the bark of old trees.

One of the most straightforward and time efficient ways of recording individual trees is photography. A good photograph (or series of photographs) that capture the key features of a tree provides an enormous amount of information and needs only a matter of seconds to take. It is always worth taking photographs as part of both survey and monitoring. In some cases, especially where resources for survey are limited, fixed point photography may be a quick and cheap way to survey and monitor trees.

The more management is likely to be required by a given tree, the more detailed information on its condition is desirable. The information gathered can then be used to development individual tree management plans.

References and further reading

- Ancient Tree Inventory website: https://ati.woodlandtrust.org.uk/.
- BSI, 2015. BS 8596: 2015 guide. Surveying for bats in trees and woodland: https://shop.bsigroup.com/products/surveying-for-bats-in-trees-and-woodland-guide.
- Butler, J., Alderman, D. & Muelaner, B. (2015). Recording ancient trees. *British Wildlife*, 26(6).
- Government guidance on managing and protecting woodland wildlife: https://www.gov.uk/guidance/manage-and-protect-woodland-wildlife.
- Specialist Survey Method (SSM)—Fay & de Berker (1997)—Appendix A in Lonsdale (2013)—download here: https://www.ancienttreeforum.org.uk/resources/other-publications/.
- Woodland Trust Ancient Tree Inventory recording form: https://ati.woodlandtrust.org.uk/how-to-record/recording-guide/how-to-record-a-quick-guide/.
- Woodland Trust guidance on ageing ancient trees: https://www.ancienttreeforum.co.uk/wp-content/uploads/2020/04/Ageing-Veteran-Trees.pdf.
- Woodland Wildlife Toolkit: https://woodlandwildlifetoolkit.sylva.org.uk/.

6.1.2 Recording the overall resource

The cumulative recording of individual trees in an organised survey will give a picture of the overall resource of ancient and other veteran trees on a site. Ideally all of the trees on a site should be recorded. On sites with a great number of such trees, or where resources are very limited, it may be necessary to record only a representative sample of the trees and map some in groups. Whilst not ideal, this is still better than nothing, and can be usefully used to guide future management. Any overall survey of a site should aim to answer following questions:

- How many ancient and other veteran trees are present (at least approximately)?
- How were ancient and other veteran trees previously managed (e.g. managed pollards, lapsed pollards, maiden trees)?
- How many trees are in different categories of vitality (e.g. good, moderate, poor, dying, dead)?
- How many trees could become future ancients or at least veterans?
- How ecologically or culturally valuable are the trees on a local, regional, national or international basis?
- Are there any trees or groups of trees whose survival is threatened by unfavourable land use or other activities?
- Is there any need for tree work in order to protect trees from major mechanical failure?
- Are any of the trees posing (or likely to pose) an unacceptable risk to people or property?

6.1.3 Age structure assessments

The number of trees of different ages on a site is referred to as its age structure. Age structures are the product of past recruitment and mortality and can, to some degree, be used to predict future trends in population. They can therefore be very useful when developing a strategy to ensure continuity in the succession of ancient trees and their associated habitats. Tree age is best estimated by measuring the girth of the tree at breast height (roughly 1.5 m). Most other techniques that give a more accurate age also risk damage to the tree. The girth to age relationship varies depending on the tree and its growing conditions. Further information on ageing trees by girth is given in Lonsdale (2014) chapter 2.3.

Age structure assessments can be used to identify potential gaps in habitat provision, for example if there are few young trees because of a lack of current recruitment or no middle-aged trees due to a period of low recruitment or high mortality in the past. The data collected during survey can also be used to predict future attrition and recruitment on a site. This is of great value in long-term planning. Analysis of the age structure of trees on a site does not give any information about trees that no longer exist on the site however, and cannot show whether past tree cover was greater or less than at present. It is important to record mortality of trees on a site over a given interval of years to allow an estimate of mortality rate.

References and further reading

- Lonsdale, D. (ed.) (2013). *Ancient and other veteran trees: further guidance on management.* The Tree Council, London. Appendix B—estimates of mortality rate in a tree population.
- Lonsdale, D. (ed.) (2013). *Ancient and other veteran trees: further guidance on management.* The Tree Council, London. Section 2.3.

6.1.4 Monitoring dead wood resources

Dead and decaying wood is arguably the most important habitat associated with ancient and other veteran trees. This is particularly true for fungi and invertebrates, a great number of species of which depend on these habitats. The amount and quality of dead wood required to support a diverse fauna is often underestimated and the resource under-recorded. It is important that the dead wood resource is recorded and monitored.

Simple quantitative measures of the volume of dead wood of various characters are useful for long-term monitoring, but not necessarily very informative on the value of the resource. The simple volume of dead wood is a poor guide to its value; the number and interest of associated organisms is not very strongly correlated with such simple figures, and the subtle characteristics of individual pieces of dead wood are not easily converted to tick-lists. However, it is useful to have such broad-brush figures as a measure of changes wrought by management.

There is currently no standard method for assessing dead wood habitat in the UK. Survey of the invertebrate fauna requires considerable specialist expertise, is time-consuming, and often prohibitively expensive. Calculation of fallen timber volume using line transects has been widely used in the past but misses most of the dead wood on the site and is of limited practical value.

Perhaps the most useful method currently available is that developed by Hubble and Hurst (2007a, 2007b, 2008). This method is quick, cheap, inclusive of a wide range of dead wood types, usable by non-specialists and can be undertaken at any time of year. The output of this method is based on a description of the current status of dead wood in the survey area and management recommendations designed to maintain or improve this.

References and further reading

- Hubble, D.S. & Hurst, D.T. (2007a). Rapid dead wood habitat assessment. *In Practice*, 56.
- Hubble, D. & Hurst, D. (2007b). A new dead wood habitat survey method. *British Wildlife*, 18(5).
- Hubble, D. & Hurst, D. (2008). Rapid dead wood habitat assessment. *Quarterly Journal of Forestry*, 102 (1).
- Hubble, D. & Hurst, D. (2008). Leave them where they lie. *Tree News*, Spring/Summer 2008.
- Lonsdale, D. (ed.) (2013). *Ancient and other veteran trees: further guidance on management*. The Tree Council, London. Chapter 2.

6.1.5 Survey of associated organisms

Any management plan should take account of the organisms associated with the old trees on the site. Taxon specific surveys, conducted by qualified experts, should ideally be carried out to guide the development of a site management plan. Such surveys will provide detailed information on the range of species present and

Moccas Park: The value of surveys

Moccas Park is a large site, well known for its ancient and veteran trees and an extensive suite of associated wildlife, including many rare species. This can make deciding how to allocate limited resources to management or habitat improvements challenging. During work carried out on the site as part of the Back from the Brink: Ancients of the Future project, extensive surveys of associated taxa were used to identify synergies in the requirements of old tree dependent species. As well as providing data to support more general site management, this also allowed the identification of specific synergies requiring more targeted management. For example, it was noted that both the Western Wood-vase Hoverfly and Sap-groove Lichen favoured the same trees—veteran Horse Chestnuts with damage from major limb loss. The Western Wood-vase Hoverfly breeds in rot holes on the trunk whilst Sap-groove Lichen grows on the seepages created by the overflowing rot-holes. The surveys also identified the areas in which these species are concentrated. This has allowed appropriate management, such as planting replacement Horse Chestnuts, to be targeted in the areas where it will be most beneficial.

their distribution on the site allowing management to be targeted to where it will be most effective, requirements for specific management interventions to be identified and any potential conflicts to be identified and resolved. Surveys to monitor the impacts of management are also strongly desirable to ensure the management is having the desired effect, bearing in mind the timescales that may be involved; it can take a long time to see the outcome of management. Professional surveyors can be commissioned to carry out such work.

Commissioning surveys can be relatively costly however. An alternative is to contact recording schemes or local conservation organisations in the hopes that they can assist in organising survey, or at least some degree of recording. However, there are often very few individuals with the necessary skills available and their time tends to be in high demand.

There may also be pre-existing information from previous surveys, recording schemes or even casual observation, this should also be incorporated into any management plan. National databases such as the National Biodiversity Network, local environmental records centres, or recording schemes for taxa of interest can be consulted to gather this information.

Organisations that may be able to assist with organising surveys of associated species or interpreting data

- British Bryological Society: https://www.britishbryologicalsociety.org.uk/
- British Lichen Society: https://www.britishlichensociety.org.uk/
- British Mycological Society: https://www.britmycolsoc.org.uk/
- Dipterists Forum: https://dipterists.org.uk/home
- UK Beetles: https://www.coleoptera.org.uk

6.2 Creating a management plan

Once you have taken stock of the number, composition, age structure and preferably associated wildlife, of the trees on your site, it is necessary to use this information to create a management plan. Every management plan should identify the objectives for management, actions, observations or triggers for management and the types of intervention that might become necessary during the period concerned. It is important that allowance should always be made for revision based on improvements in knowledge.

Management objectives should account for the following needs:

- Protecting the tree and the habitats it provides.
- To address any external threats to the health of the trees and objectives of the management plan.
- Safeguarding the mechanical integrity of the tree and the safety of people and property.
- Ensuring that the surrounding vegetation includes essential nectar and pollen resources for saproxylic invertebrates.

Management plans should always aim to minimise direct intervention as much as possible and allow trees to undergo a natural ageing process. This provides the greatest volume and diversity of habitats and minimises the costs of management. Only when the long-term survival of existing old trees is threatened, or if serious health and safety risks that cannot be mitigated in other ways develop, should intervention be considered.

6.2.1 Site management plans

The primary aim of a management plan for a population of ancient and other veteran trees is to prevent avoidable harm to, or life-threatening mechanical failure of, existing ancient and other veteran trees, as these represent the greatest current ecological value.

If many trees are present and in need of intervention, it may be necessary to decide which of them will benefit most from the use of available resources. Trees that are likely to die or collapse in the near future, regardless of intensive management, may not merit significant investment. Effort should be focused on those trees that require intervention but have good vitality and are thus more likely to survive for the foreseeable future if suitably managed, coupled with provisions for replacing lost trees and ensuring habitat continuity.

Caring for existing ancient or other veteran trees will generally protect the wildlife associated with the trees by preserving their habitat. If there is an age gap on the site that will lead to a gap in habitat provision for these species it will be necessary to intervene to mitigate this. It is also crucial to take account of particular associated species or species groups present on the site however. For example, if there is a known roost of Barbastelle bats in a veteran tree on site it may be necessary to retain more scrub or Ivy on the tree than would otherwise be ideal. Conversely, if a tree is known to support rare light-loving lichens, clearance of scrub or climbing plants from this tree to maintain open conditions should be a priority.

An overall site management plan should take account of:

- The current tree population within the area concerned, including age structure and rates of recruitment and mortality (if these are known or have been estimated).
- Factors which might affect the rate of mortality compared to the past—e.g. land use change, changes in surrounding habitat, disease, pollution, climate change, etc.
- Continuity and connectivity of habitats associated with the trees and the surrounding land.
- The surrounding environment, and whether there is any need to continue or modify aspects of land management which are important for the survival of the trees or for the continuity or enhancement of the habitats.
- Associated wildlife interest, e.g. are there bat roosts present on the site? Have rare lichens been recorded from the trunks of any of the trees?
- The individual trees present. Each ancient and other veteran tree is valuable and important, each should be assigned its own individual tree management plan (Fay, 2008b).

Long-term management plans should also include provision for encouraging natural regeneration or planting replacement trees or making management interventions to ensure a continuity of ancient and other veteran trees and their associated habitats. Every effort should be made to ensure there are no complete gaps in habitat continuity due to a lack of ancient and other veteran trees.

6.2.2 Individual tree management plans (ITMP)

Individual trees that are identified as vulnerable to damaging activities or collapse, or are considered to be of particularly high value, should be assigned an Individual Tree Management Plan (ITMP). An ITMP specifies a series of assessments and potentially necessary interventions over a defined period, 30 years is a suggested minimum. If the tree is still alive and in need of management at the end of this period a new ITMP can be created. Monitoring, whether periodic or opportunistic, should be a key component of any such plan and should ensure that required actions take place on an appropriate timescale.

When formulating ITMP you should initially assess the vitality and mechanical condition of the tree. This information can then be used to decide if it is likely to survive for the duration of the plan, identify any work to the surroundings or other type of tree work necessary to maintain the current state of the tree or prevent deterioration or collapse, and decide when this work needs to be carried out to achieve the desired result.

These decisions should be made in context of the whole tree population on the site. If there are many veterans and future veterans on the site it might be best to let the ones with low vitality have a lower priority whilst focussing management efforts on the trees with good vitality and ability to respond to management until younger cohorts mature. However, if there are very few old trees present it is probably worth taking every effort to maximise survival of all the trees for as long as possible.

Any ITMP should be tailored to the species and particular characteristics of the tree. Always remember that every ancient or other veteran tree is unique. If it is decided that a series of actions are needed to maintain a tree the ITMP should specify the details and probable timing required for each intervention. Allowance should always be made for adjustments in light of monitoring, the response from the tree and/or increased knowledge.

References and further reading

- Curtis, T. (2010). Ancient woods—managing the fundamentals. *Conservation Land Management*, 8(2).
- Lonsdale, D. (ed.) (2013). *Ancient and other veteran trees: further guidance on management.* The Tree Council, London. Sections 2.3, 7.3.5 & 7.3.6.
- Fay, N. (2008b). Guidance Example for Retrenchment Pruning based on Individual Tree Management Plan (ITMP). Treework Environmental Practice, Bristol. www.treeworks.co.uk.
- Woodland Wildlife Toolkit, management planning: https://woodlandwildlifetoolkit.sylva.org.uk/manplan.

6.2.3 Managing gaps in age structure and planning for the continuity of dead wood resources

Once the immediate survival of existing ancient and other veteran trees has been considered, the next most pressing issue is to ensure a continuity of such trees and the habitats they provide into the future. A lucky few might be dealing with a site that already has a good age structure. In these cases, simply looking after existing trees and maintaining a good surrounding environment will usually result in a continuity of habitat.

On many sites there are likely to be one or more gaps in age structure that will result in unacceptable gaps in the provision of decaying wood habitats and other veteran features. The specialist wildlife associated with old trees is dependent on such features for survival so any gap in provision is likely to mean the loss of such species from the site. Such gaps, once identified, must therefore be addressed and their impact mitigated as much as possible.

The best way to address a gap in age structure depends on the nature of the gap. Survey may show little prospect of natural regeneration resulting in a gap at the base of the age structure. Relatively few young trees live long enough to become ancient, so a fairly high rate of recruitment is necessary to ensure some of the cohort to reach ancient status. In such cases the management strategy should aim to reduce any future age gaps due to continued lack of recruitment. This may involve protecting seedlings from browsing and grazing or, if necessary, tree planting.

Establishment of new trees on a continuous basis is not necessary. Many sites with good habitat continuity are a product of repeated isolated peaks of recruitment, due to mast years, mass planting or periods of better weather or reduced grazing pressure. As long as such recruitment peaks occur repeatedly, ensuring trees of a range of ages are present on the site, good habitat continuity can be achieved.

If there are few or no mature middle-aged trees (a gap in the middle of the age structure) there will be an unavoidable gap in the succession of veterans and associated habitat features if natural processes are relied upon. It is impossible to magic up mature trees on a site—at least given the resources available to most land managers. In such cases the focus must be on ensuring continuity of habitat features rather than an unbroken succession of true veteran trees. Many such features seem possible to artificially create or induce using various veteranisation techniques.

If there are no young trees available for veteranisation it will be necessary to tackle the gap at the base of the structure through planting or encouraging natural regeneration first. Some of these young trees can then be veteranised once they reach an appropriate age. It is important to keep existing ancient and other veteran trees alive for long enough to overlap with future veteranisation. Novel techniques such as dead wood boxes could be used to provide decaying wood habitat to bridge the gap in availability in such cases.

References and further reading

- Lonsdale, D. (ed.) (2013). *Ancient and other veteran trees: further guidance on management.* The Tree Council, London. Sections 7.2 and 7.3.

6.2.4 Monitoring

Once a baseline survey has been conducted, it is important to carry out ongoing monitoring to identify any changes or arising issues and so that the effects of management can be assessed.

Any loss of, substantial changes in, or damage to, individual trees should be recorded as soon as possible after the change. Management events should be recorded as and when they happen, together with their immediate consequences.

There is currently no generally applied standard frequency at which to routinely monitor a population of old trees. It is fundamentally desirable that such sites and features should not change rapidly, common sense therefore dictates that complete monitoring surveys need not be frequent. Every five years is perhaps the preferred default timing, particularly to undertake a simple review of the trees that have died. This should be regular enough to monitor changes in the tree population, detect any issues and allow a suitable response, but will not impose an onerous burden on those responsible for the surveys.

This is a guideline not a rule. On sites with many trees in a poor state of health for example, more regular monitoring might be required as changes can be expected to be more rapid. More regular monitoring will also be desirable on sites where veteranisation has been carried out to fully understand what habitats are developing.

It is advisable to carry out more regular basic inspection of any trees of particular interest or value, if practical. An annual inspection, preferably documented by photography at the least, for high value ancient trees would be an ideal. This can be brief and carried out on an opportunistic basis if necessary but will allow any unexpected changes in the condition of the tree to be identified and responded to in a timely fashion.

References and further reading

- Ancient Tree Inventory website: https://ati.woodlandtrust.org.uk/.
- Lonsdale, D. (ed.) (2013). *Ancient and other veteran trees: further guidance on management.* The Tree Council, London. Section 2.2.
- Specialist Survey Method (SSM)—Fay & de Berker (1997)—Appendix A in Lonsdale (2013)—download here: https://www.ancienttreeforum.org.uk/resources/other-publications/.
- Woodland Trust Ancient Tree Inventory recording form: https://ati.woodlandtrust.org.uk/how-to-record/recording-guide/how-to-record-a-quick-guide/.

6.2.5 Vision

It is useful to have a clear overarching view of the long-term goals of management. "Vision statements" are commonly seen for large, long-term environmental projects, and they can all too easily seem twee or wildly over-optimistic. But, if an oak tree is planted now in the hope that it will be valuable for wildlife in 500 years' time, it is important to be able to visualise the context in which it will be set and to be able to communicate the aims to generations of site managers to come.

Such long-term aspirations should focus on broad habitat character rather than on the details of what wildlife they might support. After all, a site of high interest for its ancient trees now may have reached this state after being initially managed by people trying to survive and eke out a living in a difficult landscape, conserved at the whim of an autocratic ruler seeking hunting forests, emparked as a status symbol by a wealthy aristocrat, sculpted to an aesthetic ideal by a landscape architect, and maintained as a matter of pride and family heritage through subsequent centuries, all without a single thought given to the wildlife it supports.

Vision statements serve a different purpose to management plans. Whilst a management plan aims to quite tightly define objectives and a series of actions needed to achieve them, an effective vision statement provides an overarching ethos and vision that site management can be directed towards achieving.

The starting point for such statements is to ask a question along the lines of; "what do we want this site to look like in 500 years?".

Whilst a written statement laying out the desired structure and features of a site in the long term can be effective, it is arguably most effective to communicate this visually. An artistic rendering of the site in an imagined future state can be both useful to site managers and help to inspire wider passion.

6.3 Establishing new trees

Any attempt to ensure future generations of ancient trees exist in the British landscape must include some plan for the establishment of the new trees that will one day become them. At its core this is not a complicated process. Many species of tree will readily regenerate naturally in almost any open habitat. The climax vegetation for the vast majority of the British Isles is broadleaved deciduous woodland and almost any open land left unmanaged and undisturbed will eventually be colonised by scrub and trees. In fact, much effort in the conservation world is dedicated to preventing such natural succession in high value open habitats. The current prevalence of tree-planting schemes also provides a ready source of new young trees. Not all trees are equal however. For maximum benefit it is necessary to give deeper consideration to the method by which future generations of trees will be encouraged, the tree species that are needed or desired and the density of new trees to encourage. In many cases the answers to these questions are fairly obvious. In some, the process is far more complex. This section discusses some of the key choices and considerations that should be made when establishing new trees on a site.

6.3.1 Natural regeneration

Natural regeneration is undoubtedly the best option for establishing new trees for wildlife and should always be preferred to planting in principle. It allows local tree species and individuals to provide the next generation of trees, benefiting established wildlife interest in the area; requires no input of cost or energy to get started; and provides better diversity of structure and cohort age than planting. In practice, however, allowing natural regeneration is not always ideal or possible and tree planting will be necessary.

- ***Identifying regenerating species***

If natural regeneration is occurring on a site it is important to identify the tree species that are regenerating early in the process. Not all tree species have equal wildlife value and many species never develop the range of habitat niches required by the wildlife associated with old trees, this is particularly true of slow developing wood decay habitats such as heart-rot cavities, but can also be true of features such as bark chemistry and texture, which is important for many rare lichen species. A range of literature and online resources are available to assist in this.

> The Woodland Trust has an A-Z of British Tree species available on its website and has produced a free Tree ID app for Android and iPhone to assist in the identification of native and common non-native trees. These resources can be accessed by following the link below.
>
> https://www.woodlandtrust.org.uk/trees-woods-and-wildlife/british-trees/

- ***Limitation of regeneration by grazing***

If natural regeneration on a site is being suppressed by grazing due to high stocking densities of domestic animals or grazing by wild animals such as deer or rabbits it is worth considering options to reduce this suppression before resorting to planting. Regeneration can be encouraged by the control or local exclusion of grazing, or the encouragement of thorny bushes. If all grazing is prevented, for example by fencing, some manual intervention may be required to prevent trees regenerating at excessive density or succession to dense scrub. If overgrazing is due to domestic stock the ideal solution is to reduce the stocking density to a more sustainable level.

- ***Limitation of regeneration by disease***

The process of natural regeneration can also be stymied or radically changed by pathogens. Recent studies have shown that Ash Dieback has a severe impact on regeneration of Ash saplings (du Feu & Gillman, 2021). The overall process of natural regeneration can be significantly slowed by disease induced mortality. High mortality of particular species can also significantly change the trajectory of regeneration, with unaffected species coming to dominate the regenerating area and leading to quite different species composition to the source woodland or trees.

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6.3.2 Tree planting

There are a number of reasons that allowing natural tree regeneration may be inappropriate or impossible. Formal parkland, for example, might require precise arrangements or species to maintain aesthetics for example. On other sites opportunities for natural regeneration may be limited by a local lack of mature trees of the species desired on the site or environmental suppression of natural regeneration by grazing, soil conditions or other disturbance. In such case the only option may be to plant trees to provide replacements for existing ancient or other veteran trees.

- ***Utilising wider tree planting schemes***

Tree planting is currently very popular, both politically and in wider society. There is already a lot of tree-planting happening as part of landscaping, environmental schemes and, increasingly, climate change mitigation strategies. There is apparently far less passion, outside conservation circles, for allowing natural regeneration where appropriate. Current planting is often very poorly structured for wildlife, with trees being planted at excessive density, even when allowing for thinning. In many cases the best available option for ensuring a generation of ancients for the future may be to guide already planned tree planting in the preferred direction, encouraging less dense plantings of preferred native species that can develop high-quality, open-grown trees in the future.

Brankley Pastures—balancing natural regeneration and planting

Brankley Pasture in Staffordshire is a small wood pasture reserve managed by the Staffordshire Wildlife Trust (SWT) that was once part of the ancient forest of Needwood and is now situated at the western end of National Forest. The site contains several veteran trees, including one of largest oaks in Staffordshire and is a tiny remnant of a once extensive parkland.

In 2007 a larger adjacent area of ex-arable rough grassland was acquired by the SWT. This was identified as an opportunity to restore wood pasture over the long term and extend the area of the current site.

The initial restoration plan was to establish oaks by planting in small groups and manage the surrounding grassland by grazing. It was noticed early in the project that disturbance caused by ploughing for the final arable crop had allowed prolific natural regeneration of trees. It was therefore decided to allow natural processes to lead where possible and work with what regeneration provided.

This approach proved problematic as fast-growing birch and willow regeneration was far more abundant than oak, the key species in the adjacent parkland. There was particular concern that willow was forming dense stands. This problem was tackled by cutting willow in worst affected areas and treating with herbicide.

Locally sourced acorns were then sown on the site to improve the balance of tree species on the site. Regenerating oaks were protected from grazing animals using tree guards to ensure increased survival rates.

The final approach has been a mix of natural regeneration and selective sowing and retention of oak on the site.

CLM spring 2011 9(1): Site visit—Brankley Pasture Staffordshire—Tony Robinson

- ***Provenance of planted trees***

If planting of native trees is appropriate, trees should always be sourced from local stock—it is not worth gaining a year or two by bringing in nursery-grown trees at the expense of local provenance and propagation. Importing or moving trees long distances not only erodes regional genetic diversity but runs the risk of introducing or spreading pathogens. Devastating tree diseases such as Dutch Elm Disease, Sudden Oak Death and Ash Dieback may have been introduced through imported tree stock and have almost certainly been spread more rapidly by the horticultural trade. If it is absolutely necessary to import trees, if specific non-native species are required to maintain a design in formal parkland for example, it should be ensured that strict biosecurity measures are followed by the nurseries and importers involved.

- ***Density of planting***

When planning the establishment of trees with the intention of allowing them to become future ancients it will be necessary to decide how many trees should be planted now as replacements: or, if the site has experienced planting or natural succession, how many trees should be retained. There is currently no clear or generally applied guidance on what is an appropriate density of successor trees of various ages.

Key factors to be considered are: how many ancient trees should there eventually be? How long does this species of tree live, and for what proportion of that time is it ancient? What proportion of planted trees can be sacrificed and at what age?

Any site will have a limited capacity for trees of any age if they are not to become too crowded when mature. If young trees are too dense to develop an open-grown habit or compete for light with existing veterans there will be a long-term loss of the special habitats associated with ancient trees (Green, 2010).

The area required for a tree to reach its full open grown potential depends on the species, soil type and climate. In most parts of lowland Britain an area of at least 700 m^2 (a 15 m radius around the trunk) is considered necessary for the proper development of an open-grown oak (Lonsdale, 2013: section 7.3.3). Pollarded trees, because of their smaller canopies, require a smaller area, meaning more can be fitted into a given space.

This ideal area far larger than that generally allowed for planted trees, which tend to be packed in at high density based on forestry principles (Pryce, 2021). On the other hand, planting at densities as low as dictated by the area required might mean that very few trees survive to old age on a site. A balance must be struck; avoid overcrowding but ensure there are enough young trees to allow for losses. Planting fewer trees at wider spacing and with appropriate aftercare, such as watering and weed control when necessary, is likely to result in far greater survival rates and better long-term results than traditional forestry style planting where mortality rates are generally very high and most of the planted trees serve little useful purpose during their short lives (Pryce, 2021).

It is always sensible in principle to over-plant and remove excess trees when it is clear what natural losses there may have been. However, this may not be the best route for the replenishment of ancient trees. If planned thinning does not take place for any reason, the trees will lose their open-grown habit and never reach their full potential (Green, 2010). Additionally, the removal of trees, even if young, always runs the risk of attracting criticism. Planting exactly the desired number and replacing any which die on a one-to-one basis may be equally successful. This approach also allows the trees to establish an open-grown character at the earliest opportunity. The planting of occasional replacements over the years will also improve the age diversity of trees on a site.

Over-planting at an early stage will also create a situation in which a large proportion of trees are of a single generation and long-term continuity can be maintained only by sacrificing old trees or developing an undesirably high density of trees. If oaks are being replaced, it may be that an average of one new tree per year may exceed the desired replacement rate even in a greatly depleted site.

It is entirely possible to find a situation in which a site has many ancient trees, to the extent that a greater density is undesirable, but where there is also a large age gap with few replacements. This presents a challenging problem; doing nothing jeopardises the site in the long term, planting trees or encouraging regeneration risks damage to existing ancients in the short term. This may be an impossible compromise to judge. Replacement trees should be planted as existing ancients die or, if natural regeneration is occurring on the site, enough trees should be retained to more than compensate for losses. The optimal solution may be to expand the site by planting trees in neighbouring areas with the intention of allowing them to reach ancient status. There is still likely to be a significant problem caused by a gap in habitat provision in such a situation but novel techniques such as dead wood boxes may help to bridge this gap to some degree. This will not be possible in all situations and such sites present a serious challenge when planning for the future of ancient trees and their associated wildlife.

- ***Location of planting***

Tree planting should not be carried out, encouraged or supported on open habitats with existing nature conservation value beyond that associated with trees, for example species-rich grasslands, heathlands, wetlands, open mosaic habitats and others. The one exception to this is where existing ancient or veteran trees are situated within such habitat, adding to the overall site interest, and natural regeneration is not occurring. In such cases limited and careful planting to provide replacements can be considered. This should always be balanced against the needs of open habitats on the site.

New trees should be planted in the vicinity of those they are meant to replace or provide similar habitats to. This allows associated wildlife to colonise the tree more easily. It is also likely that environmental conditions will be more suitable for the young tree and important mycorrhizal fungi will be present in the soil. It is important not to plant too close however, as the young tree may begin to compete with the existing ancient or other veteran. Planting just outside the RPA is advisable.

Young trees should be planted at a sufficient distance from existing trees or shrubs (and other planted trees) to allow them to develop an open growth form with minimal competition and allow sunlight to reach the trunk of the tree.

The final size and form of the planted trees must be accounted for when planting. Young trees should be positioned where they will not cause problems when they reach maturity. They should be positioned sufficiently far from access, buildings or infrastructure that they will not require potentially damaging pruning to mitigate health and safety risks in the future.

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6.3.3 Choosing tree species to prioritise

When a survey has identified the need to plant trees, or remove them to make space for others, it will be necessary to decide which tree species to prioritise. It is important to select suitable tree species to guide towards becoming future veterans. These should provide a continuity of the habitat provided by existing veterans.

- ***Ensuring continuity of current interest***

The obvious priority when choosing the species of tree to plant or retain should always be to provide continuity of current interest. Ensuring replacements of the species of veteran tree currently present on the site, particularly those with established associated wildlife interest as identified during surveys, monitoring or consulting past records is the most important consideration on any site with a population of ancient or other veteran trees. If particular associated species or assemblages of conservation interest occur then the tree species supporting them should be prioritised when considering planting or encouraging natural regeneration of new trees, even if they are not the dominant veteran species. Always work to maintain existing interest first.

- ***Selecting trees that will provide the right habitats***

It is important to ensure that new trees will provide the same habitat features as the current ancient or other veterans present on the site. This will usually be automatically accounted for if replacement trees are of the same species as the current veterans. There may be occasions when it is impossible or undesirable to replace trees with the same species however. The increasing impacts of pathogens such as Dutch Elm Disease and Ash Dieback means that planting trees or encouraging natural regeneration of affected species may no longer be an option. In these cases, it may be necessary to plant trees of a different species that share key characteristics with those trees impacted by the pathogen. If it is necessary to encourage species other than the trees of current high wildlife value, important factors to consider are the type of rot formed by decay of the tree, for saproxylic fungi and invertebrates, and the chemical and physical characteristics of the bark for epiphytes. Species without durable heartwood or ripewood will tend to form central white-rot; species with durable heartwood will tend to form red-rot. These provide a different range of habitats and support different species. Species with durable heartwood that develop red-rot tend to be very long-lived and will provide decaying wood habitat over a long period; those with non-durable heartwood can often provide decaying wood habitats much faster but will potentially have shorter lifespans and different associated species. A wider range of tree species will also improve resilience of the population of old trees against pests, pathogens and climate change.

There may also be a requirement for faster provision of wood decay habitats than could be provided by young trees of the currently dominant species. On sites with a large age gap that are dominated by slow-ageing and long-lived trees planting replacements of the same species may not provide replacement veteran tree features until long after the existing ancients have died, taking with them any associated wildlife interest. Faster-growing trees will provide ancients more quickly, but may not always provide the same habitat: some insects are only ever found in rotting oaks for example so there is no easy shortcut available by planting fast-growing trees.

However, some tree species develop similar habitats to longer-lived trees at a faster rate. For example, Sweet Chestnut develops red heart-rot that is very similar to that of native oaks over shorter timescales. Many of the same species will use the decaying wood of both trees. Most of the rarest oak specialist species are, however, thought to be restricted to oaks, although it must be noted that there are probably few sites that have had a long overlap of ancient trees of both species where rare oak specialists have had opportunity to colonise Sweet Chestnut heart-rot.

Poplars, willows and Horse Chestnuts all develop white-rot earlier than Beech and Hornbeam. There is a degree of overlap in the habitat niches provided by decay in all of these species. In all cases, faster ageing species of similar character to slow-ageing trees might be used to help to bridge gaps in habitat provision where necessary, for example planting scattered Horse Chestnuts on a site with a high quality Beech-associated saproxylic fauna might help to bridge a gap in habitat provision until slower ageing planted Beeches reach maturity and develop veteran features.

- ***Wider wildlife value***

The wildlife value of planted trees before they reach old age should also be accounted for. Trees take up a lot of space for a long time before they reach a stage of maximum biodiversity value. In a country with a very limited area devoted to wildlife conservation encouraging tree species with little biodiversity value for the first few centuries of their life could be considered a serious lost opportunity. Prioritising tree species that also support a good foliage fauna, where this does not conflict with the long-term goals of providing ancients for the future and ensuring continuity of existing ancient or other veteran trees and their associated habitat, will give wildlife value throughout their lifespan (Alexander, Butler and Green, 2006). Willows provide a good example of the need for careful consideration of which trees to prioritise. Willows support a moderately large and distinctive saproxylic fauna and can be rapidly encouraged by hammering in stakes from existing trees. Not all willows are equal, however. Crack Willows are not a full species and consequently very few foliage feeding invertebrates will use them. They would therefore be of little wildlife value until they began to decay. Full species of native willow will provide far more wildlife value throughout their lifespan (Table 2).

- ***The importance of native trees***

Trees generally support a greater number of associated species within their native range, and normally more at the centre of their range than the edges. There are also regional differences in how valuable a tree is. Where a tree species is more common it will usually be more important and support more associates. Trees with generally high wildlife value may not support many species if they occur in a landscape where they are very uncommon. Conversely, trees with relatively poor associated faunas can be of great importance where they are the most abundant species, for example Ash in the Cotswolds (Alexander, Butler and Green, 2006). It is important to remember that different tree species have different associates in different parts of their ranges.

The local context should always be accounted for when deciding which tree species to plant or encourage. In the absence of other influencing factors, it is generally best to favour native species that are widespread and common in the local landscape and known to support a good range of associated species. However, if locally scarce tree species are known to support associated wildlife of conservation value on the site ensuring continuity of these species and their associated wildlife and habitats should be prioritised.

In the context of increased risks associated with climate change and pathogens it may be best to encourage or plant a mix of species on a site as insurance against future changes. This should not compromise ensuring that there are sufficient replacements for tree species of established interest however.

- ***The role of non-native trees***

Non-native trees are not necessarily poorer for wildlife than native species. Many species dependent on trees are not precisely tied to a particular tree species but to certain structural or chemical features or the fungi that creates the type of preferred decay. Non-native species may be taxonomically close to natives, or simply have similar characteristics and can provide important habitat where natives are not present. For example, many invertebrates associated with Field Maple can live on Sycamore; the basic bark conditions of Sycamore are also very beneficial to many epiphytes, including rare species, and may to some degree be a potential substitute for elms. Sweet Chestnut and False Acacia heartwood decay in a very similar way to oak and can therefore potentially support many of the same saproxylic invertebrate species. The linking feature in this case seems to be the presence of Chicken-of-the-Woods decay fungus (Alexander, Green & Morris, 2016). Sweet Chestnut is also now a key host species for the rare Bitter Tooth Fungus (*Sarcodon scabrosus*) (Marren & Dickson, 2000).

The line between native and non-native species is more blurred than many would think. Many introduced tree species are within their potential climatic range and may have colonised Britain naturally given enough time. Some species' status is uncertain; there is ongoing debate on the status of Sycamore in Britain for example (Green, 2005). Climate change is also causing a rapid northward shift in the distribution of many species, especially invertebrates. Introduced tree species (especially those native to southern Europe) may therefore be increasingly valuable in Britain as associated species reach the country.

If mature non-natives trees are present on a site, it is best to leave them be unless they are directly detrimental to old native trees or surrounding habitats of high conservation value. This is especially true in more formal landscapes such as parks and gardens.

Planting of non-native trees for aesthetic reasons can provide benefits for wildlife if they are not compromising existing habitats. Such aesthetic plantings should be restricted to formal parks and gardens or urban areas. They should never be planted in semi-natural habitats. If it is necessary to plant non-native trees for aesthetic reasons it is best to favour European tree species that may accumulate a larger fauna in future as species ranges shift in response to climate change.

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6.4 Looking to the future

An oak tree planted now will not develop its full potential for wildlife for several centuries, and will ideally still be there in a thousand years. It is therefore essential to look ahead, far into the future, and consider not just the tree and its immediate surrounding but the wider landscape and context within which it will be situated. Carefully managing sites which currently support good populations of ancients is unlikely to result in significant improvements for ancient trees and their associated wildlife without wider improvements in the suitability of the landscape for old trees and their associated wildlife. Whilst this is unlikely to be of immediate use for the vast majority of land managers it may have value in contextualising and guiding the individual small scale management decisions and actions that, cumulatively, will contribute to a healthier future “treescape” in Britain. It is this long-term wider context that is considered in this section.

6.4.1 Wood pasture restoration and creation

Wood pasture is the habitat that supports the greatest concentration of ancient trees in Britain and management of sites as wood pasture is particularly conducive to the development of high quality ancient trees. Many wood pastures have been lost or degraded through development, afforestation or conversion to intensive agriculture. Their restoration or creation is therefore of increasing interest in nature conservation circles. This is a large scale and long-term commitment. For this reason, it is important to select sites that will respond well before investing the resources required for any such project.

In restoration of degraded sites, the primary consideration must be the survival of the ancient and other veteran trees, and associated fauna and flora on the site. The secondary consideration is the survival of associated features such as grassland. The vegetation of associated grassland habitats can often be restored from the seed bank but the associated fauna is only likely to have survived if areas of suitable open habitat remained somewhere on site (Chatters & Sanderson, 1994).

The composition of younger trees already present on a site is important when considering restoration. If they are mostly native then restoration is more likely to be successful and any age gaps are likely to be smaller. If most younger trees are non-native, especially conifers, the age gap between any new generation of native trees and existing ancients may be prohibitively large (Chatters & Sanderson, 1994).

Site size is also very important. It is difficult to create or restore functional wood pasture in small pockets within intensive silviculture or farmland. The quality of the site for wildlife is likely to be compromised by the hostile nature of its surroundings. Large areas are ideally required, preferably hundreds of hectares rather than tens (Chatters & Sanderson, 1994).

Although restoration of large areas of wood pasture is undoubtedly more efficient and yields the best results, there is a good argument to be made that, in the long term, creating or restoring many small pockets of wood pasture wherever possible is still of high value. Whilst the value of each small site may not be great in isolation, the creation of a larger and interconnected network of sites could be of very high value in the long term. In the mean time they will still provide more wildlife and amenity value than intensive land use.

If the area to be restored or created is adjacent to existing wood pasture then restoration is much more likely to be a success as associated organisms, many of which are poor dispersers, can colonise from existing sites in close proximity. The newly created area might also be effective in extending the size of fragmented areas of wood pasture, increasing their long-term resilience.

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6.4.2 Abandoning tradition

Traditional management methods such as pollarding are not necessary for the maintenance of ancient trees or their associated wildlife. A tree allowed to grow and age naturally in a sympathetically managed environment will require no direct human interference to attain high conservation value and support a high quality assemblage of associated wildlife. Many existing ancient trees require continued management to maintain both the tree and associated wildlife simply because they were managed in a particular way in the past, often for commercial or aesthetic reasons that are no longer relevant. For example, ancient pollards, managed to provide a crop in the past, often require continued intervention and management to prevent collapse. Whilst such management of existing ancients is often necessary due to the management history of a site, it can be both time-consuming and expensive. The long-term aim in many places may be to abandon them and allow natural ageing of trees to become future ancients.

There are valid arguments for maintaining traditional managements in some cases. There may be cultural and aesthetic reasons to maintain pollarding on a site or within a landscape. Pollards, when in a regular cycle lack large, potentially failure prone limbs. Safety might be an important consideration in areas that are likely to experience heavy human use. The use of tree foliage as forage for livestock is currently a topic of interest, so short-rotation pollarding may yet reappear as an economically valid option in some places. Finally, there is the simple physical fact that more ancient trees can be fitted into a given space if they are pollarded. It may be decided that having a greater number of ancient trees is worth the continued investment in management and the usually lower volume of decaying wood per tree.

If planting trees with the intention of allowing them to become ancients it is crucial to carefully consider how the trees will be managed. Is there any good reason to start pollarding the trees? Once pollarding is begun it can be difficult to stop without compromising the integrity of the tree in the long term. If no good reason can be found to begin managing the trees it is probably best to leave them to age naturally.

6.4.3 Re-wilding

Re-wilding is a term nowadays used to cover a rather wide range of management changes in the countryside. In its purest form, it involves a landscape-scale shift to more natural processes and a return to the large-scale habitat mosaic in which ancient trees and their associated faunas first developed. In the long term, and at a large scale, the potential benefits for the wildlife associated with ancient trees is huge, especially if the re-wilded area includes one or more groups of ancients of established value.

Whilst the Platonic ideal of re-wilding is perfect for ancient trees in the long term, there are issues related to scales of time and space. Fragmentation and destruction of the ancient mosaic landscape means that areas of high wildlife interest are now often very small. The smaller they are, the more that management to maintain their interest may have to veer towards careful manicuring rather than natural processes.

Shifts in habitat character at the local level are expected in a truly wild landscape, but such changes are usually gradual, measurable in centuries: re-wilding can produce very rapid changes. This is in many ways a good thing as it can provide rapid improvements in habitat quality. It does, however, mean that small areas of already good habitat can be swamped by rapid change. Ancient trees in open habitat can be quickly shaded out by scrub if grazing or cutting is stopped for example. The closest historical approaches to inadvertent re-wilding, in the abandonment of parkland, have been disastrous for the wildlife of their ancient trees. Although most re-wilding projects incorporate grazing or browsing animals to some degree these are generally, quite appropriately given the context, only very loosely managed. This means that grazing or disturbance is stochastic and unpredictable leaving individual high value trees vulnerable to the impacts of both over and undergrazing unless additional interventions are made.

If ancient or other veteran trees occur within the area of any re-wilding project, their needs should be accounted for in the project plan. This may mean maintaining management in their immediate vicinity to prevent detrimental habitat changes, at least in the short term. Re-wilding should not risk damage to or the loss of existing high value trees. It will be necessary to consider each case on its individual merits and to ensure that the development of ancient trees is considered in the aims of the project.

Provided key areas of ancient trees are conserved through the changes and grazing and browsing levels maintain a suitably open structure, re-wilding could yield enormous benefits to the wildlife of ancient trees. In the short term, however, some sites need re-taming rather than re-wilding.

6.4.4 Starting from scratch

Future ancient trees do not have to be in places where there are currently ancient trees. The emphasis undoubtedly has to be placed on conserving current ancients and ensuring their legacy in order to conserve existing interest, but single or grouped ancient trees can be created anywhere. How interesting they will become for wildlife is a matter of speculation. For lichens and fungi distributed by spores, there is reason to hope that they may colonise provided the right trees reach a suitable age in a suitable environment and location.

Many of the scarcest invertebrates appear to be very unwilling colonists. Dispersal must occur sometimes however, or such species would never have colonised Britain. In a natural environment the habitats provided by old trees are generally quite stable over long periods. Species associated with them would not need to disperse often to colonise new habitat when such trees were widespread in the landscape. In the current landscape, where ancient trees are rare, dispersal is very unlikely to result in successful colonisation of suitable habitat. How willing they are to disperse, and how successful such dispersal is, will depend on how far away the

Knepp Estate: The challenges of re-wilding

The Knepp Estate is probably the best-known re-wilding project in Britain and includes a good population of ancient trees, concentrated in the Repton Park area. The cessation of arable farming in Repton Park has undoubtedly been of great benefit to the existing ancient trees, reducing compaction around the roots and reducing nutrient enrichment levels, particularly that of ammonia from intensive agriculture. Re-wilding has also hugely improved the management of the dead wood resource on the estate with most being left in situ.

A large number of trees in the former parkland areas show signs of both high acidification and high nutrient enrichment from historic SO_2 deposition and recent/current ammonia respectively resulting in a poor lichen assemblage. Significant interest remains in more sheltered situations however, such as Lemon Tart Lichen (Vulnerable GB red list, S41 species) and Sap-groove Lichen (Near Threatened GB red list, S41 species), occurring on the estate. Reductions in nutrient input will increase the available habitat for these species. Re-wilding has not been an entirely positive process for the lichen assemblage however. Re-wetting projects on the estate seem likely to have caused the death of at least one mature oak supporting a good population of Lemon Tart Lichen.

The Knepp Estate is grazed and browsed by a range of free-roaming herbivore species including cattle, pigs, ponies and deer. The current grazing regime is considered to be at about the right level for maintaining open conditions around mature trees. Opening up woodlands to grazing is also increasing the number of well-lit but sheltered mature trees required by lichens. However, invertebrate survey carried out as part of the Ancients of the Future project identified the sward as potentially being slightly overgrazed and it was suggested that animal numbers could be reduced to benefit invertebrate populations without affecting the lichen interest on site to encourage flowering shrubs and plants as a nectar source for invertebrates.

To enable some natural regeneration of both the sward and establishment of future large open grown trees, grazing may need to be relaxed or removed for short periods (pulse grazing) to allow flushes of natural regeneration or allow any planted saplings to establish. Conversely, if herbivore numbers are reduced too far, or they choose to avoid some areas, old trees may be rapidly shaded by scrub regeneration. Careful management of grazing levels is more problematic on large sites with free-roaming herbivores than on more traditionally managed sites and could be considered to conflict with the ethos of re-wilding. On sites without a large pool of herbivores re-wilding may quickly lead to formation of dense scrub and the shading out of old trees.

Good populations of many of Britain's rarest bats are known from Knepp. Acoustic surveys of the Estate picked up all three Ancients of the Future target species (Barbastelle, Bechstein's and Noctule bats). All use the site for foraging and roosts of all three species have been identified. Work carried out by the Knepp Estate has shown the importance of the river restoration area for foraging bats and the woodland around this area for roost sites.

The experiences of the Knepp Wildlands Project illustrate well both the huge benefits to old trees to be had through re-wilding projects and the challenges that such projects present when caring for this precious resource. If some degree of compromise of purist re-wilding ideals is accepted to protect existing ancients and veterans such changes should be largely beneficial.

nearest suitable habitat is and the nature of intervening habitats. Though there is little doubt that many of these species are poor colonists, the evidence is to some extent circumstantial. Some of the rarest species are overwhelmingly associated with ancient sites; but any site containing ancient oaks, for example, is, by definition, an ancient site. Ultimately, the only way of determining how mobile a species can be is by giving it plenty of places to move to.

Lack of historical continuity is no reason not to try establishing ancient trees. It is an opportunity to start a history. Current trends favouring tree planting and agroforestry could represent ideal opportunities to establish future populations of ancients in new locations. Giving consideration to the development of ancients over the very long term at the outset of such projects is of utmost importance to allow planted trees to reach full potential. Trees planted in more formal landscapes such as parks or developments could also develop significant interest if allowed to reach ancient status. It is important that trees in such situations be given the space to do so.

When starting from scratch there is a risk of starting a new age-gap problem if all of the planting takes place at one time. This can already be widely observed in many sites that currently support old, but not veteran, trees which have the potential to develop significant interest in the future. They were often all planted up on a single occasion as part of a landscaping scheme and will age and die at approximately the same rate. Such situations risk re-creating the exact problems of habitat continuity we face today in several centuries time. When starting from scratch provision should be made in any plans for long-term staggered planting to ensure a diverse age structure.

6.4.5 The wider landscape

Trees do not exist in isolation and should be managed as a component of the wider landscape. Whilst particularly important concentrations of old trees exist in wood pastures and parklands, even these are rarely completely isolated and self-sufficient, more normally existing as part of a wider tree population that extends far beyond the area of ownership and incorporates many old trees that remain scattered throughout the wider landscape (i.e. land that is not part of a protected site or managed specifically for wildlife). Old trees, and especially concentrations of them, have become increasingly isolated over time due to loss and lack of replacement. This isolation has been a significant contributor to local extinctions of associated species, and increases the vulnerability of those that survive. Much of the wildlife associated with old trees has limited dispersal ability. Even relatively small spatial gaps in habitat availability can prove to be significant barriers. There is now little possibility for successful dispersal to suitable habitat across a largely hostile intervening landscape.

It is necessary to consider tree populations at landscape level. It is all too easy to lose isolated young or middle-aged trees from the wider landscape. They often support little current wildlife interest and have no legal protection. However, these trees, if retained, would become the ancients of the future. When trees are removed there is often only consideration of the immediate impact of the lost habitat, there is little thought given to the loss of potential future value.

It is important that greater consideration is given to trees in the wider landscape as these have the potential to link existing sites in the future, increasing the resilience of metapopulations of associated species by providing habitat bridges across the landscape, as well as having wildlife value in their own right. If enough old trees providing suitable habitat are scattered across the wider landscape it should be possible for even poor dispersers to move around the country given enough time. It is therefore crucial to encourage wide networks of old trees and to increase connectivity between high-quality sites into the future (Alexander & Green, 2018).

Proper account should be taken of both spatial connectivity and temporal continuity of the wildlife habitats supported by trees themselves, and additional habitat components that are required for species associated with ancient trees, such as pollen and nectar sources for saproxylic invertebrates or grasslands, woodlands and wetlands for foraging bats (Alexander & Green, 2018). There is little value in having many old trees in the landscape if other habitats necessary for associated species to survive are absent.

It is important to maximise the area of sympathetically managed land around ancient and other veteran trees. They should be protected from damaging land use such as ploughing or heavy vehicle use in the immediate vicinity. The creation of wider corridors of low intensity land use in areas connecting current or potential future ancient trees will also have significant benefits to species associated with the tree.

Building networks across the wider landscape requires co-operation between the organisations and landowners responsible for managing both nature conservation sites and the intervening land (Alexander & Green, 2018). When the managers of a site with ancient trees plan for the future, every opportunity should be taken to engage with neighbouring landowners and encourage retention or establishment of trees in hedgerows, fields, and anywhere else opportunities exist, with the aim of allowing them to reach old age. Ideally all parties should coordinate on a plan for the development and continuity of a large population of ancient and other veteran trees across the landscape in the future—a wider “treescape” (Alexander & Green, 2018).

References and further reading

- Alexander, K. and Green, T. (2018). Managing trees for a sustainable resource of decaying-wood habitat. *British Wildlife*, 16(2).
- Green, T. (2010). The importance of open-grown trees: From acorn to ancient. *British Wildlife*, 21(5).

7. FINAL WORDS

Ancient and other veteran trees have suffered at the hands of people in the recent past.

Mismanagement, neglect and destruction have all taken their toll on our population of these majestic organisms. Despite this, the United Kingdom still holds an internationally important assemblage of ancient and other veteran trees and these, in turn, support a diverse range of organisms.

Increasing awareness and understanding of the value of these trees has largely halted wholesale destruction of them but mismanagement and inadvertent damage and destruction still pose grave threats. For many associated taxa the gravest threat may still lie on the horizon. When current ancients and other veterans die there are often no mature trees ready to take their place and continue providing the key habitat niches associated with old trees. Without these habitats the species that depend on them will be lost.

The future of our old trees and their associated wildlife remains far from secure. There is, however, every reason to be optimistic. The ever-increasing body of knowledge on the ecology and biology of our old trees has led to the development of many new techniques for conserving existing ancient and other veteran trees and creating or mimicking essential habitat features in younger trees to bridge looming gaps in habitat provision.

The core principle of conserving and encouraging old trees and their wildlife is incredibly simple; leave a tree to age naturally in suitable surroundings, ideally with enough space to develop an open-grown growth form. In ideal circumstances, no additional direct inputs are required as long as the surroundings of the tree are suitably maintained. Looking beyond the triage situation we are currently experiencing, in which more complicated methods are required to bridge temporal and physical gaps in habitat provision, there is no good reason that this principle cannot be followed on a large scale across the country with little effort by land managers.

This combination of ever-expanding toolkits for managing trees, increasing understanding and appreciation of their value, and the fundamental simplicity of managing trees to allow them to grow old and achieve maximal biodiversity value mean there is great potential for a bright future. It is easy to imagine a future in which an extensive network of venerable ancient and other veteran trees has once again formed a vast and robust network or "treescape" across the British landscape, supporting a multitude of specialist associated species in far greater numbers and across far wider areas than is currently the case. With work, care and attention in the present day this vision is well within our reach.

Photo on page 116: Savernake Forest by Paul Brock

BACK FROM THE BRINK

Ancients of the Future: Managing veteran trees and dead wood for species

Produced by Buglife on behalf of the Back from the Brink Partnership, 2023

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Creating the conditions threatened species need to thrive: our unique programme at a glance.

Back from the Brink is the first time ever that so many conservation organisations have come together with one focus—to bring back from the brink of extinction some of England's most threatened animals, plants and fungi. Natural England is working in partnership with Rethink Nature, and the entire project is made possible thanks to funding from the National Lottery.

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