State of the UK's Woods and Trees 2021

WOODLAND TRUST

In memory of Mike Townsend

We are honoured to dedicate the first State of the UK's Woods and Trees report to Mike Townsend, our colleague and friend. He is sorely missed by everyone who loved and knew him. The environmental movement has lost a true champion, but his many legacies live on.

"Everything comes from nature, just as everything returns to it"

Mike Townsend OBE, 1957-2020

Foreword by Woodland Trust president and broadcaster Clive Anderson

Seeds of change

Trees are all around us. Found in large numbers in woodlands and forests, or strung out single file along roads and railways, country lanes and city streets. Or decorating urban and suburban squares, parks and gardens. Everywhere they are a beautiful background to human existence. Once upon a time they were in the foreground of many people's lives as well, providing a livelihood for foresters and foragers, farmers and families.

Things aren't quite so simple now, but we still depend on trees in any number of ways. Trees are multi-taskers, their leaves give us shade from the sun when it's hot and shelter from the wind when it blows cold. Their roots keep fragile soils and river banks from being washed away. They filter the air, recycle the water and provide homes and habitat for wildlife. Nowadays it may happen on a more commercial basis – we still use wood from trees to make buildings and furniture and all sorts of objects great and small.

And trees are a source of wonder and delight. Winter, spring, summer or autumn they provide the backdrop against which we measure the passing seasons, and they make us feel good. Even more than that, globally trees can play a vital role in the battle to avoid a climate catastrophe, if they are allowed to grow.

There is some good news to report. There are more woods and trees in the UK today than at any time in the last 100 years. But we remain one of the least wooded countries in Europe. And we keep losing ancient woodland – ecologically our most valuable resource. The past century has seen dramatic changes in the type, age, location and value of woods and trees. This has been in response to a host of factors which bring both risk and opportunity. Over the years our growing and largely urban population has developed ever changing needs from our land. Huge technological developments, an explosion in global trade, new transport links and climate change have all had their impact.

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Our remaining ancient woods and trees are those that have survived as the world has changed around them. Fragmentation of woods, loss of trees and the wildlife dependent on them has been brutal. The survivors that remain now form the backbone of plans for nature recovery. They are still some of our richest native habitats and provide the source of genetic material we will need to re-forest our landscapes.

We are on the edge of a new era of interdependency with trees and woods. The role of trees in fighting climate change is now well understood. The challenge is to find the space that trees need to expand and thrive across our nation. As they grow, the roots, leaves, trunks and branches of trees store carbon and, in doing so, they protect us from ourselves.

A miracle of nature, a sprouting acorn can, in time, grow to become a mighty oak – one of the largest, heaviest and oldest organisms you will ever come across. As well as holding itself upright, an oak tree provides a lifeline to thousands of other species and forms a solid storehouse of carbon.

This report from the Woodland Trust lays bare the true state of the UK's woods and trees. With knowledge comes power. The power to give trees the protection and care they need to survive and the space to grow to sustain and improve our landscapes and lives.

Clive Anderson

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Key findings, priority actions and the facts behind the story

At a time when the demand for new woods and trees is escalating, our existing woods and trees are under great pressure. They remain affected by past loss and damage while being subject to new and emerging threats. The astonishing array of benefits which people stand to gain from more wooded landscapes across the UK will only be achieved when we can stop these threats and bring back wildlife on a large scale.

Native woods and trees provide one of the best ways to simultaneously tackle both the climate and nature crises. A really good understanding of their current state, how we got here and what we can do about it, will enable us all to better realise their vital role in reducing climate change impacts, improving our health and wellbeing, and recovering nature.

The scope of this report

This first 'State of' report presents important facts and trends focusing predominantly on our native woods and trees. It reports on their extent, condition and wildlife value, the benefits people gain from them, the threats and pressures they face, what is being done to help them and what more we need to do.

Specific trends and benefits associated with more commercial forestry activities (often non-native plantations) are outside the scope of this report, because they are reported elsewhere. Here we focus on redressing the balance in reporting on the state of native woods and trees. Naturally, these two strands of the UK's treescape are intertwined - there are many links and similarities including drivers of loss and damage, and benefits such as access and pollution reduction. So, this report is relevant across all UK woods and trees.

Key findings

From the wealth of data we present in this inaugural report, our analysis has identified **four significant findings** about the state of woods and trees:

1. **Although woodland cover is gradually increasing, woodland wildlife is decreasing.** The UK's woodland cover has more than doubled in the last 100 years, however much of this increase comprises non-native trees. Existing native woodlands are isolated and in poor ecological condition. These factors, in addition to

the widespread loss of 'trees outside woods' from the landscape, including treasured ancient trees, have all contributed to wildlife loss.

2. **Woods and trees are vital for a healthy, happy society.** They lock up carbon to fight climate change; improve our health, wellbeing and education; reduce pollution and flooding, and support people, wildlife and livestock in adapting to climate change in towns and countryside.
3. **Woods and trees are subject to a barrage of coinciding threats** from direct loss to more insidious influences such as climate impacts, imported diseases, invasive plants, mammal browsing and air pollutants. These threats diminish the benefits of woods and trees for people and for wildlife.
4. **Not nearly enough is being done** to create high quality and resilient native woodlands as part of larger ecological networks; nor to put more individual trees back in the landscape; nor to restore and better manage existing damaged woods. There is hope, however, if we can learn from and extend the influence of many inspiring local initiatives, highlight best practice, and build a stronger evidence base.

Priority actions

As a result of these findings, our **recommended priority actions** to help the UK's woods, trees, wildlife and people are:

Expand woodland and tree cover

- We need to at least quadruple the current rate of woodland creation and increase the proportion that comprises native tree and shrub species to help minimise the pace and level of climate change, adapt to its unavoidable impacts and give nature a fighting chance of recovery.
- The location and quality of new woodland is the key to success. This means extending existing native woods and connecting patches of semi-natural habitat; wherever possible enabling natural colonisation by trees on suitable open ground; and ensuring targeted creation, e.g. in catchments to reduce flood risk and improve water quality, and near urban populations, to create beautiful landscapes and opportunities for access to nature.

- When planting trees, saplings should be sourced and grown in the UK and Ireland.
- More native woods and trees must be integrated into new development and infrastructure in ways that add to the value of existing woods and trees – aiming for c. 30% canopy cover. This will enhance lives, bring back wildlife and relieve pressure on more ecologically sensitive woodlands.

Enhance existing woods and trees

- Enable native woods and trees to become a source of widespread nature recovery and improve people's lives. This includes:
    - all damaged ancient woodlands restored by removing non-native trees and promoting ecosystem recovery
    - invasive species like rhododendron removed at a landscape scale
    - grazing and browsing pressure managed to enable growth of saplings, shrubs and diverse woodland flowers
    - reduced emissions of damaging nitrogen air pollution (for example, cutting ammonia emissions from intensive farming systems).
- Prevent new threats becoming a problem – evidence consistently shows that action now to avoid or remove threats reduces larger long-term 'clean-up' costs. Many woodland threats are compounded by climate change impacts. We urgently need to:
    - introduce tougher border controls to limit risks of new pests and diseases entering and becoming established in the UK, reduce demand for imports of live plants which could harbour disease and employ effective disease eradication and management strategies
    - enhance and rigorously implement protections through the planning system for ancient woodland and ancient and veteran trees, including improved direction and guidance for planners and developers
    - tackle climate change by radically reducing overall greenhouse gas emissions from all sectors and ensuring forests and peatlands can play their part in locking up and storing carbon for the long term
    - improve woodland resilience and climate adaptation

potential, by increasing woodland connectivity across landscapes (more hedges, trees outside woods and expanding woods) and the diversity of tree ages and species composition within woods.

- Boost benefits to people
    - Make existing woods more accessible e.g. with new footpaths, close to where people live, to promote health and wellbeing and a long-term connection with nature
    - Promote learning and understanding of woods and trees at all levels from school curricula through to college and university courses, as well as for communities and professionals such as land use planners, woodland managers and arborists.

Improve the evidence

- Complete and regularly update baseline inventories recording all ancient woodland, wood pasture, ancient and veteran trees and trees outside woods to more accurately identify gains and losses, and make these datasets easily accessible to all to help target action.
- Undertake regular assessments of nationally important wildlife sites with consistent standards to inform effective recovery actions.
- Fill data gaps, such as levels of soil carbon in ancient woodland, assessing the impact of landscape-scale flood risk reduction, or mapping invasive species, to direct much-needed investment at significant scale.
- Undertake regular woodland and tree monitoring to identify threats early, improve woodland quality, and enhance the long-term survival of trees outside woods.

Invest in the future

Significant resources will be required to rise to the size and scale of the challenges and opportunities for more and better woods and trees. Due to the many public benefits that can be achieved, public money, blended with innovative private finance, should be seen as a vital investment in the future, from which rewards will flow. Local authorities, regulators, and those creating and managing woods and trees for public benefits, must all have sufficient resources if we are to see a step-change in action. Creating new jobs in woodland and tree protection, management and creation, and upskilling people to fill them, will be key as we grow the benefits of a more wooded future for all.

The facts behind the story

Woodland today covers 13.2% (3.2 million ha) of the UK's land surface, up from 12% cover in 1998.

Woodland extent, condition and wildlife value

Woodland today covers 13.2% (3.2 million ha) of the UK's land surface, up from 12% cover in 1998. Half of this is predominantly native tree species, the other half predominantly non-natives (mainly as commercial conifer plantations). **Ancient woodland** covers 2.5% of the UK's land area. The UK is rich in **ancient and veteran trees** with approximately 123,000 recorded on the Ancient Tree Inventory so far – and likely hundreds of thousands yet to record. **Trees outside woodlands**, such as hedgerows, street trees, trees on farms and along rivers cover 3.2% of Britain's land area (data not available for Northern Ireland). Little comprehensive data is available to show historical trends for trees outside woodland, however, one study in eastern England showed that of 1.2 million individual trees present in 1850, only 0.6 million survive today.

Just 7% of Britain's native woodlands are currently in good ecological condition

Numbers of **woodland birds and butterflies** fluctuate annually but the general trend over the last five decades is one of steep decline, despite an increase in woodland area over this period. Some woodland wildlife species, such as the slender brindle moth, comma butterfly and nuthatch, are expanding their range northwards due to changes in climate. The extent of broadleaf woodland cover is closely correlated with **woodland plant species richness** for any given area, but no similar correlation was found with coniferous woodlands.

Just 7% of Britain's native woodlands are currently in good **ecological condition**. Those in poor ecological condition are characterised by low levels of deadwood, few veteran trees and lack of open habitats within woodland, as well as insufficient diversity in ages of trees and in some cases low tree species diversity. The **condition of statutory protected woodland wildlife sites** across all UK countries varies substantially, as do the reasons for adverse condition e.g. woodland sites in England suffer most from inappropriate management, Northern Ireland's sites from alien and problematic species, and sites in Scotland from browsing and grazing damage, as well as invasive species (no information is available for Wales).

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Recreational access to woodlands is vital for health and wellbeing.

Benefits to people

Woods and trees provide a plethora of services and benefits to people. In terms of **carbon storage,** woodlands in Great Britain together hold 213 million tonnes of carbon (in their living trees) of which **ancient and long-established woodlands** hold 36% (77 million tonnes), even though they make up only 25% of all woodland. Ancient woodland carbon stocks are not static and are projected to more than double over the next 100 years as they lock away more carbon, and in so doing help **mitigate climate change.** Trees can also help with **adaptation to changes** in the weather and climate by **reducing the risk of downstream flooding**. In Cumbria, 500 hectares of native tree planting in upland catchments, combined with restoring damaged peat bogs, made a measurable difference to reducing peak water flow downstream after just eight years. In addition, upland wildflowers and birds like black grouse are recovering as a result. **Urban woods and trees** also provide water management, pollution control, and temperature regulation in towns and cities where 80% of the UK population lives.

Recreational access to woodlands is vital for health and wellbeing. The coronavirus pandemic and resulting lockdowns of 2020 and 2021 has brought into even sharper focus the importance of natural green space for recreation. However, the number of people with easy access to woodland has declined since 2016. In 2020 16.2% of people in the UK had access to a wood of at least 2ha within 500m of their homes (down from 21.1% in 2016), and 66.6% had access to a wood of at least 20ha within 4km of their homes (down from 72.7% in 2016).

Increased appreciation of the environment starts at school. Around 23% of all **UK schools** have applied to plant native trees with the Woodland Trust since 2017, with 40% (12,830) taking part in the Woodland Trust's Green Tree Schools award which promotes environmental awareness and action.

Threats and drivers of change

Woods and trees are facing an array of historic, ongoing and emerging threats and drivers of change. **Long-term phenology records** (i.e. the seasonal timing of natural events, such as 'bud burst') show that the beginning of spring is now happening on average 8.4 days earlier when comparing the current 1998-2019 period to the historic 1891-1947 period. This matters because not all plants and animals which are interdependent can keep up with this rate of change and it may create a mismatch in their food supply, as evidenced by, for example, blue tit chicks starving when the caterpillars they feed on are unavailable in years of early leaf emergence.

Irreplaceable ancient woods continue to be lost and damaged by house building, new roads and railways.

JAMES READER

Irreplaceable ancient woods continue to be lost and damaged by house building, new roads and railways. Over 1,225 ancient woods across the UK are under **threat from development** while during the last 21 years at least 981 have been permanently lost or damaged. More **insidious threats** facing woods and trees include unseen reactive **nitrogen air pollution** from agriculture which strips trees of their layer of protective lichens and causes a fertiliser effect where grasses out-compete more delicate woodland flowers. This disrupts woodland ecosystems in ways we are only beginning to understand.

Around half our ancient woodlands have been damaged by either plantations of non-native trees and/or invasion of rhododendron

Invasive species of plants and animals, as well as **pests and diseases**, are wreaking havoc on some native woodland ecosystems. With ash dieback alone we stand to lose millions of ash trees, resulting in local extinctions of wildlife species which are dependent on ash. The incidence of new pathogens entering the UK mirrors the rise in plant imports. The cost to the economy in lost benefits outweighs the market value of imported plants by up to a factor of 50. Around half of the remaining ancient woodlands have been damaged by either **plantations of non-native trees** and/or invasion of **rhododendron. Excessive deer browsing** causes significant damage, negatively affecting woodland structure, species composition and re-growth (natural regeneration).

Over the last five years, the UK rate of woodland expansion has been on average just under 10,000ha per year.

What is being done for woods and trees?

There is much positive action currently taking place to benefit woods and trees, though this is often dwarfed by the scale of the challenges faced. We urgently need to scale up the many inspiring initiatives to date. **Tree cover in the UK is increasing, but nowhere near fast enough, particularly native tree cover.** Over the last five years, the rate of woodland expansion has been on average just under 10,000ha per year – with 45% comprising broadleaved trees[†]. The UK is failing to reach anywhere close to the target of around 30,000ha per year that is estimated to be needed to reach net zero carbon emissions by 2050.

The UK and Ireland Sourced and Grown (UKISG) assurance standard will have produced 27 million home-grown trees between 2014 and 2024, avoiding importing new pests and diseases on seeds or saplings from abroad. However, UK and Irish tree nurseries cannot currently supply enough UKISG native trees to meet demand.

Farmland presents a huge opportunity to increase canopy cover from trees outside woods through integrating trees or shrubs with crops and/or livestock as **agroforestry** systems; yet, it is estimated that only 3.3% of the 72% of the UK's land area that is agricultural is under agroforestry. Local organisations and communities have stepped up to restore lost trees outside woods, but they can't do it alone.

[†] 'Broadleaved' is not exactly synonymous with 'native', but is a reasonable proxy in the absence of data for native trees.

Expansion of woodlands and trees outside woods must be targeted to improve **ecological connectivity,** which requires measuring and monitoring progress at a landscape scale. A novel analysis for the Northern Forest flagship woodland creation project in the north of England provides a baseline from which to gauge the project's success over time in joining up the landscape.

Progress with **restoration of plantations on ancient woodland sites (PAWS)** on the public forest estate across the UK has been slow: huge areas of ancient woodland remain in a critical or threatened condition. Sixty-six per cent of PAWS are on private land and since 2015 the Woodland Trust has assessed the condition of 7.2% (21,547ha) of this, resulting in active restoration management taking place on more than 3,700ha.

A call to action!

We have no time to lose. The State of the UK's Woods and Trees 2021 provides clear evidence that there is an urgent need to act now in all corners of the UK. We must create more woodland, bring back wildlife and repair the woods and trees of our countryside and towns to benefit us all.

This will require all those whose lives are touched by trees to play their part in acting on these findings, including the formation of new collaborations and a fresh sense of purpose around those already underway. We need genuinely innovative strategies for change which will inspire people, boost public investment, draw in new sources of funding, fix broken policies and target action to where it can really make a difference to the woods, trees and wildlife that we love.


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Introduction

We live in a rapidly changing world. For long-lived organisms like trees, this can pose great challenges. A young tree emerging in spring 2021 may go on to live for a hundred or even a thousand years (3021!). All that time the benefits it provides for people and wildlife will be accruing and changing, along with the values people place on it. Although we can hardly imagine what the needs of society will be so far from now, the better informed we are about the current state of woods and trees and how they have changed over time, the more able we will be to set up a secure future for ourselves and our woody companions.

Native focus

This report tracks the changes woods and trees are experiencing so we can better appreciate, understand and support the many crucial roles they have in shaping our world. Our focus is on native woods and trees to address the knowledge gap in our understanding of their state. Since the advent of the Forestry Commission over 100 years ago, data has been regularly published on the UK timber resource and associated markets, and the focus has been on developing the science and delivery of commercial forestry. More recently the specific public benefits – including from native woodlands – provided by government-owned forest estate have been reported on[1]. There remains however, no regular reporting across the multiple and diverse aspects of the significant contribution of native woods and trees. So here, we aim to present data not already available elsewhere in this form, that explores many aspects of predominantly native woods, trees and their wildlife, and how they benefit people.

About the data – possibilities and limitations

The data in this report draws on multiple sources, including official statistics, published and unpublished reports, academic research, outputs from citizen science projects and trends data from regularly updated datasets held by government(s) and non-governmental organisations. Some 200 datasets were assessed for their relevance for inclusion.

We have found huge variability in the data available. There are often no equivalent datasets across all four countries of the UK – some cover single countries (e.g. Native Woodland Survey of Scotland), Great Britain only (e.g. National Forest Inventory), and others are UK wide (e.g. wildlife indicator trends). Many governmental organisations and other data providers are devolved across the UK (e.g. the statutory nature conservation bodies) and have adopted slightly different standards and thresholds or delivery methods (e.g. assessment of condition on designated sites).

Variable baseline dates and coverage can be a challenge, as well as data recording methods changing over time as technology and objectives evolve. Several datasets are incomplete and only record a proportion of the resource (e.g. the Ancient Tree Inventory), yet others were developed several decades ago and have never been comprehensively updated (e.g. the Ancient Woodland Inventory). New issues have emerged where data recording is in its infancy (e.g. values of urban trees or trends in woodland condition).

Where we do not have complete UK, or at least GB coverage, we have relied on case studies to demonstrate the importance of a wider issue and hopefully inspire future recording efforts (e.g. recording losses of trees outside woods).

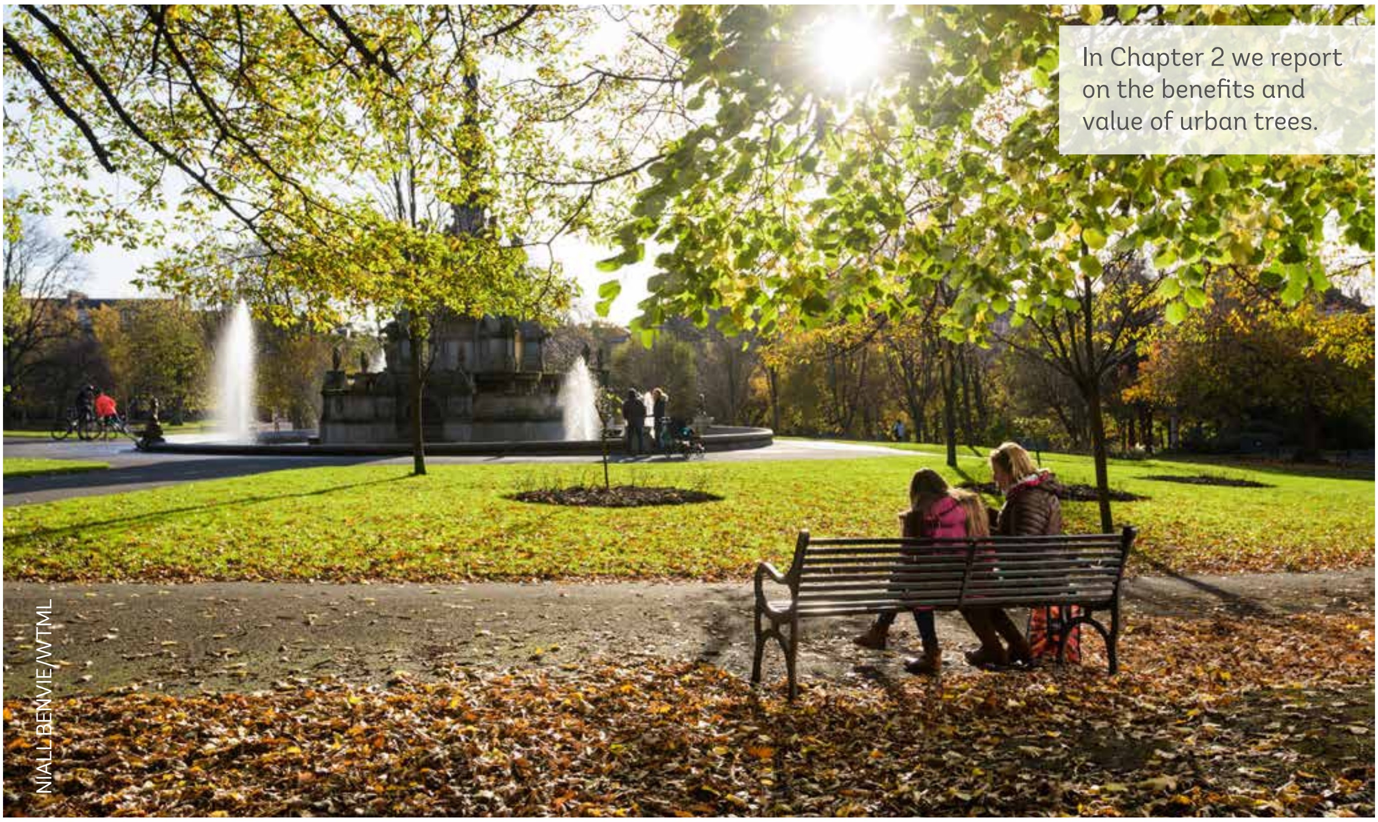
This is the first iteration of this report and over time we hope to build knowledge and fill gaps. For example we have not included comparisons with global forest or nature trends (e.g. the Biodiversity Intactness Index[2]) and this could be significant for future editions.

This report

For the first time we draw together disparate sources of data on woods and trees to give a more complete view across many aspects of their state. We have analysed and interpreted the data to draw out key messages about what today's woods and trees are telling us. This report will be the start of a regular reporting cycle, which draws attention to the challenges woods and trees are facing, the opportunities to support them and progress with action. We intend to build up the sources of information and data over time, addressing new questions and filling gaps in our understanding.

In **Chapter one**, we use data and evidence on the extent of canopy cover of woods and trees, and how this is changing over time. This includes new maps from the Ancient Tree Inventory. We show new analyses of the ecological condition of woods across the UK and we collate condition information from the four UK countries on our nationally important woodland wildlife sites. We also produce new analyses which show how important native woods and trees are for wildlife, and track how that wildlife is faring.

In **Chapter two**, we highlight the benefits people gain from woods and trees. We present maps of the variation in public access to woods



In Chapter 2 we report on the benefits and value of urban trees.

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throughout the UK. We look at how many schools have planted trees in recent years as one indicator of how valued trees are within communities. Information from our towns and cities shows the increasing value of urban trees. In this time of climate crises and a rush to plant new trees, we highlight the role of existing ancient woodland in locking up and storing carbon. We also show how woods and trees are helping to mitigate the impacts of flooding.

In **Chapter three**, we pull together some sometimes startling facts and figures on the threats facing woods and trees today, and the factors driving change. We show data on the impacts of climate change on phenology, the increasing risks from pests and disease, woods under threat from new developments and transport infrastructure, and more insidious factors impacting woods, like nitrogen pollution and invasive and non-native species, which are eroding the quality of our woodlands.

In **Chapter four**, we focus on what is being done to improve the state of woods and trees and assess how effective this is, including at a landscape scale. We show the figures for woodland creation, look at case studies on projects which are leading the way to getting more trees back in the landscape, highlight the untapped potential of agroforestry and track progress with the vital restoration of ancient woodland. We also report on woodland owners' experiences of environmental change.

Much of the data we present is gathered by others – government organisations, academic researchers, environmental charities and importantly citizen scientists. We are hugely grateful to them all for sharing their data and time to enable us to present these significant results here. The final chapter of the report discusses the issues we would like to bring to your attention, but where there is no available data. We hope that over the coming years these gaps in our knowledge can be filled so that we can present an ever more complete understanding of the **State of the UK's Woods and Trees**.

Chapter one

Extent, condition and wildlife value

JAMES READER

Contents

Introduction

Looking back over the last 100 years of trees and woodland in the UK; their age, location and composition provides a constant physical reminder of policies devised, implemented and superseded. It is also a reminder of emerging technologies, economic realities and changing objectives which have led to wholesale changes in our approach to trees and woodland through proactive intervention or casual abandonment.

The ebb and flow of our approach to trees, woodland and management of the agricultural landscape within which trees and woodland sit – often as islands in an ocean of farmland – means that the wildlife they support has been swept along in the same tide of change. Currently many UK woodland wildlife populations are experiencing declines, possibly even facing local extinction, largely due to changes in the intensity and type of woodland management. Therefore we must consider trees, woods and the full range of species that depend on them.

1.1 The extent of woods and trees

What do we already know?

Woodland and wooded habitats which naturally colonised the UK after the last ice age likely covered much of the country. Over centuries humans began to use and develop the land to their advantage. This included converting woodland to other land uses, particularly agriculture, as well as managing woods for timber and other resources. It is possible that some areas of woodland that remain today descend from this original 'wildwood', but all woodland is now considered to be 'semi-natural', as no areas remain that haven't been touched by people in some way.

Ancient woodland describes woods with centuries of continuity. For practical identification purposes, woods that are thought to have been present since 1600 in England and Wales and 1750 in Scotland are identified as ancient, because planting was uncommon at that time and reliable maps are available from these dates. These ancient woodlands and their soils and wildlife have co-evolved for thousands of years, creating diverse, distinctive and valuable ecosystems that cannot be re-created.

In the years after the Second World War, many of the surviving **ancient semi-natural woodlands (ASNW)** were cleared to increase the area available for crops and livestock, or felled and replanted as conifer plantations for timber production, now known as **plantations on ancient woodland sites (PAWS)**. This has had devastating consequences for the species dependent on ancient woods and compromised woodland ecological functioning (see 3.7). In recognition of the irreplaceability of ancient woodlands, many PAWS are now being restored to predominantly native woodland (see 4.6).

As well as these remnant ancient woodlands, newer woods have been planted or grown naturally on land previously cleared of trees. These are classified as **recent woodlands**, which may consist of broadleaf, conifer or mixed species and may be native or non-native in composition.

In addition, the canopy cover in modern UK landscapes also exists as **trees outside woods (TOWs)**, such as small copses, hedgerows, street trees, trees on farms and along rivers, and in wood pastures and parklands (see 1.2). Trees outside woods can contribute significantly to total canopy cover and provide valuable habitat, ecological corridors and stepping stones between woodland patches, as well as many benefits to people[1]. Traditionally, TOWs have been managed as an important resource for timber, fuel, fodder and other tree products and used to mark land boundaries. These long-established management practices, along with reduced competition from neighbouring trees, allowed many TOWs to become **ancient and veteran trees** (see 1.3).

Wood pastures are mosaic systems which typically include the following features: grazing animals, an open ground layer or grassland or heath, shrubs and scrub, veteran trees and decaying wood[2]. This wood pasture structure arises, and has historically been derived, through a combination of management and land use. We see it in some parks or common land, Royal Forests and in agroforestry systems (see 4.4). Where there is a long continuity of this habitat, some wood pastures also overlap with the definition of ancient woodlands.

The mosaic of features in wood pastures means they host a distinctive suite of wildlife. Indeed, 105 of the priority species in England[3] are associated with wood pasture, including fungi, lichens and invertebrates which require the crevices, cavities and decaying wood of veteran trees.

Historical trends and the current extent of woodland and tree canopy cover at a national level are reported here across all these categories. Tracking change is necessary to measure progress towards targets for woodland and tree expansion, to assess losses and better protect existing woodland, including progress with restoration of damaged woodland.

About the data

Canopy cover can be measured from above using remote sensing technologies to determine the area of land covered by leaves, branches and stems of trees. In recent years this technology has moved on rapidly, with accuracy increasing and costs of the data products falling. This technology is used to produce canopy cover maps for the UK. It is not, however, possible to determine ancient woodland status or tree species with this method, which still require on-the-ground field surveys. Due to the survey effort and associated cost, only a sample of woodland areas have been field surveyed and results are scaled up to make estimates at country level. Here we draw on data that uses a combination of these approaches, such as the National Forest Inventory for Great Britain, the Northern Ireland Woodland Register and the Ancient Woodland Inventories.

What does this tell us?

It is estimated that in 1905, only 4.7% of the UK was covered by woodland[4]. The area of woodland has nearly tripled since then to 13.2% (Table 1.1.1). But the rate of woodland expansion has slowed dramatically in recent years; since 1998 only a further 1.2% (c. 290,000ha) of the UK is now woodland (Table 1.1.1). Almost two thirds of this woodland expansion occurred in Scotland, a quarter in England, a tenth in Wales, with very little change in Northern Ireland.

The area of woodland in the UK in 2020 is estimated to be 3.2 million hectares (Table 1.1.1). Of this total, c. 1.3 million hectares (41%) is in England, c. 0.1 million hectares (4%) is in Northern Ireland, c. 1.5 million hectares (46%) is in Scotland, and c. 0.3 million hectares (9%) is in Wales.

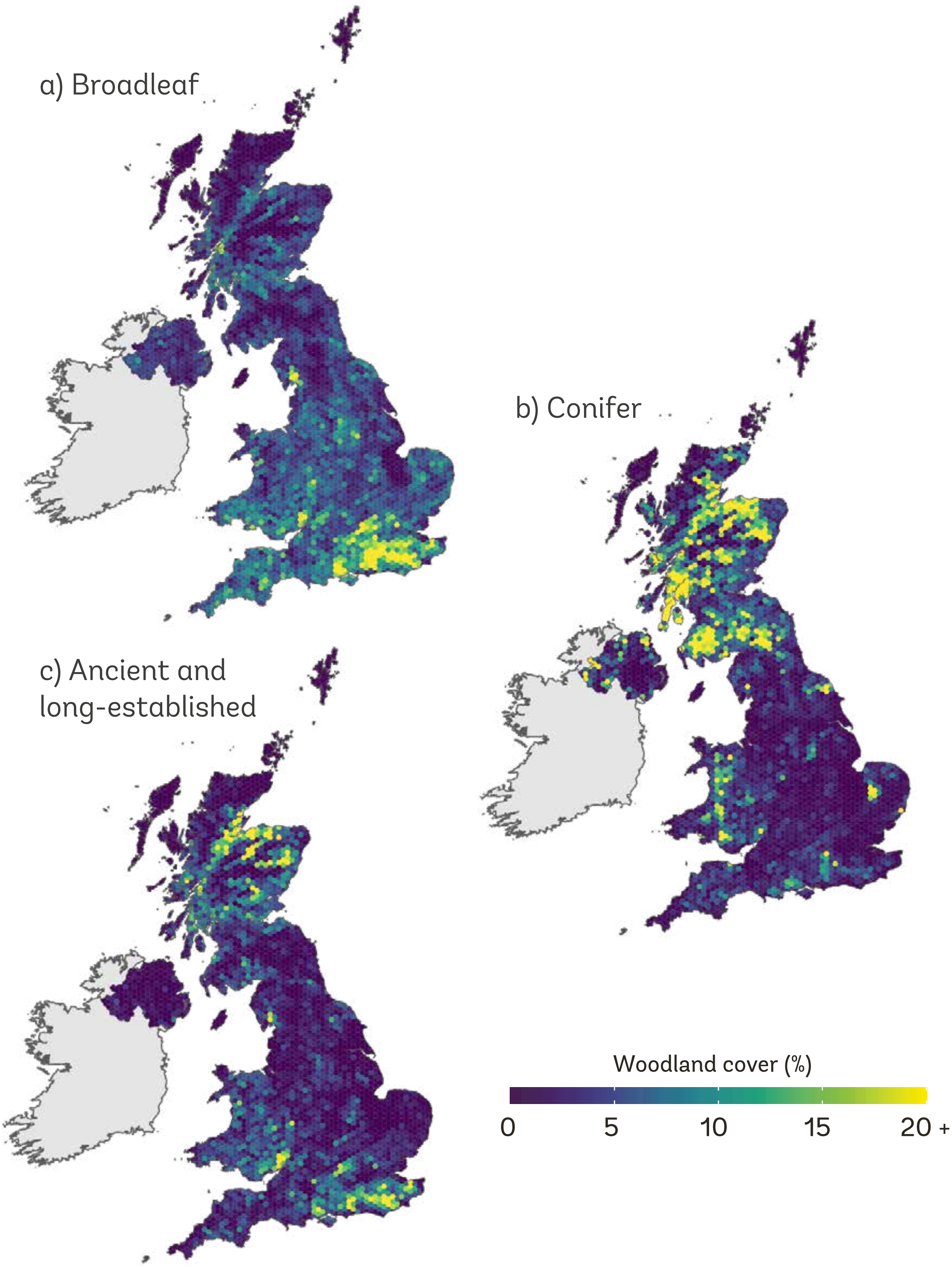


Figure 1.1.1. Percentage of woodland cover per 10km high hexagon across the UK a) Broadleaf b) Conifer c) Ancient and long-established

Source: National Forest Inventory 2019 (NFI)[5] and the Northern Ireland Woodland Register (NIWR)[6] for conifer and broadleaf, and the Ancient Woodland Inventories

Table 1.1.1. Woodland area by UK country in 1998 and 2019 (million hectares) and in brackets as a percentage of total land area

Source: Forest Research (2020)[4]

Year	England	Northern Ireland	Scotland	Wales	UK
1998*	1.24 (9.5%)	0.08 (5.8%)	1.30 (16.6%)	0.30 (14.5%)	2.92 (12%)
2020	1.31 (10%)	0.121 (8.7%)	1.47 (18.8%)	0.31 (14.9%)	3.21 (13.2%)

*1998 is selected as the baseline year because figures for England, Wales and Scotland have been revised to produce estimates that are consistent with subsequent data from the National Forest Inventory, which are therefore comparable to 2020 figures.

Broadleaf and conifer cover

Although UK woodland is almost evenly split between broadleaf (49%) and conifer (51%), the distribution is uneven across the UK (Figure 1.1.1 a, b). The highest proportion of broadleaf woodland is in southern England, and the highest proportion of coniferous woodland is in Scotland. Northern Ireland, areas of Scotland, and northern England are particularly low in broadleaved woodland cover.

Native or non-native?

It is important to note that in the above analysis, broadleaf and conifer woodlands will contain non-native species in both categories – Scotland has the only native forest-forming conifer, Scots pine, while the UK's commonest non-native broadleaves are sycamore and sweet chestnut. More detailed field-based surveys[7] across Great Britain (Northern Ireland not surveyed) enabled the classification of woods into native or non-native, which estimated that approximately 49.5% are dominated by native tree species and 48% are dominated by non-natives. The remaining area is made up of 'near-native' woodland, and woodland fragments or woodland which was not able to be determined. This varies across the countries of Great Britain however; Scotland has around 65% non-native woodland cover, whereas England has around 30%, while Wales has a near even split.

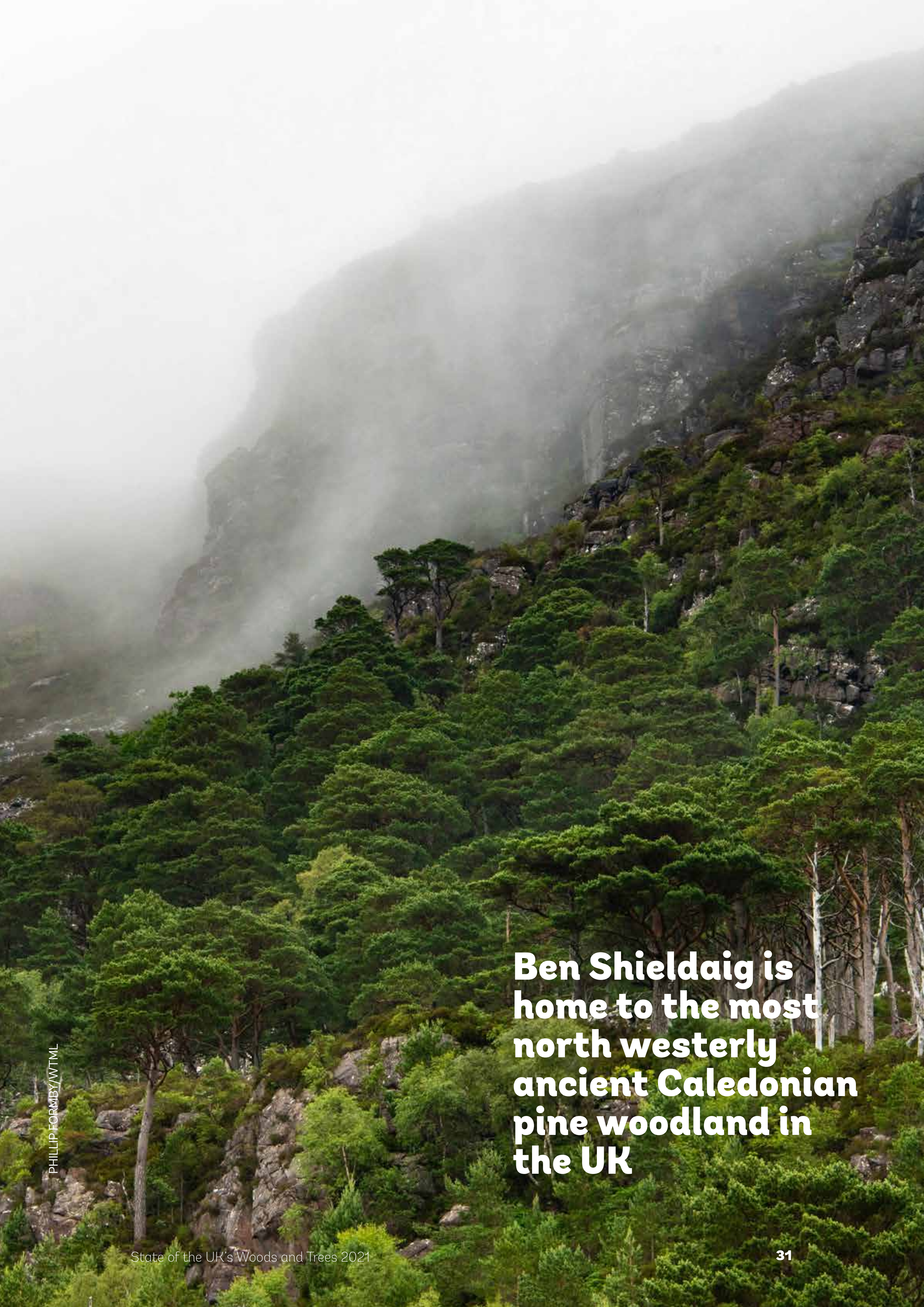
Ancient woodland extent and distribution

Calculating the total area of ancient woodland is not straightforward because each of the country **Ancient Woodland Inventories (AWIs)** were developed from the 1980s onwards in slightly different ways and some areas have been more recently updated (e.g. south-eastern counties of England) and are consequently more accurate than others. The inventories are owned by the statutory nature conservation body in each country (Natural England, NatureScot, Natural Resources Wales, data available here data.gov.uk), with the exception of the Northern Ireland inventory, available from the Woodland Trust. In Scotland additional categories of woodland were added, including 'long-established woodland of plantation origin' (LEPO) and 'Other Roy' woods (present day woodlands which appeared on the Roy maps but not on the OS first edition). In some cases, on the ground, these categories are almost indistinguishable from ancient woodland and are commonly regarded as such.

The current Ancient Woodland Inventories (Table 1.1.2) identify 609,990ha of ancient woodland (rising to 821,870ha if LEPO are included in Northern Ireland and Scotland), equivalent to 19% (25.6% with LEPO) of the UK's woodland area and 2.5% (3.4% with LEPO) of the UK's land area. Around 61% is classed as ancient semi-natural woodlands (ASNW) and 39% as plantations on ancient woodland sites (PAWS) in the UK (see also 3.7).

Ancient woodland covers 2.5% of the UK

An addendum to these figures comes from the Native Woodland Survey of Scotland (NWSS)[8] carried out from 2006-2013, which provided the first authoritative picture of Scotland's native woodlands. NWSS found 120,305ha of ancient woodland, with 65% being mainly native in composition. A comparison with the Scottish AWI suggests a significant reduction in ancient woodland over a 40-year period of 21,044 (14.2%) in mainly unenclosed upland areas. This is most likely due to a combination of herbivore pressures and the poor regeneration capacity of older trees, although more work is required to confirm the precise extent and causes of ancient woodland losses.



PHILLIP FORMBY/WTML

Ben Shieldaig is home to the most north westerly ancient Caledonian pine woodland in the UK

Table 1.1.2. Estimated area (ha) of ancient woodland across UK countries and % of total land area

Source: Ancient Woodland Inventories

Woodland type	England	NI	Scotland	Wales	UK
Ancient woodland	364,200 (2.8%)	2,700 (0.2%)	148,150 (1.9%)	94,940 (4.6%)	609,990 (2.5%)
LEPO (and 'other Roy' in Scotland)		7,270 (0.5%)	204,610 (2.6%)		211,880 (0.9%)
Total	364,200 (2.8%)	9,970 (0.7%)	352,760 (4.5%)	94,940 (4.6%)	821,870 (3.4%)

Figure 1.1.1c (page 28) shows the distribution of ancient woodland across the country (including the LEPO and 'other Roy' sites in Scotland). The current distribution reflects the places where ancient woodland managed to survive over the centuries – either because of low human population levels, so less clearance for agriculture and other land uses (e.g. concentrations in north and east Scotland), or in areas of higher population where the ancient woodland soils were deemed too poor for conversion to other land uses (e.g. Sussex Wealden clays), or where the woods themselves were too useful to clear (e.g. the coppicing industries along the Wye Valley, the West Midlands, or wood pasture systems in the New Forest). The establishment of protected landscapes such as National Parks and AONBs has also helped to protect surviving ancient woodland.

Trees outside woods

In 2016 it was estimated that there were 742,000ha of tree cover outside woodland in Britain[9] (Table 1.1.3). TOWs therefore represent 19.4% of Britain's total canopy cover and 3.2% of total land area, increasing the total canopy cover in Great Britain to 3,719,000ha (data is not available for Northern Ireland). Since around 94% of TOWs are native broadleaved species, this represents as much as 30% of the total native tree cover in Britain. **Hedgerows and tree lines** are other important non-woodland landscape features. These were surveyed for Great Britain in 2007 as part of the Countryside Survey[10] but also more recently by the Forestry Commission in 2016[9] (Table 1.1.4). Due to methodological differences these are not comparable to look at trends over time, but if either survey is repeated in the future it will be possible to report on losses or gains. Previous Countryside Surveys revealed that the total length of woody linear features decreased by 1.7% in Great Britain between 1998 and 2007 following an increase between 1990 and 1998 and a decrease between 1984 and 1990[10].

Table 1.1.3. Area of tree cover outside woods in hectares and as % of total land area

Source: Brewer *et al.* (2017)[9]

Category	England	Scotland	Wales	Great Britain
Small woods[a]	295,000	46,000	49,000	390,000
Groups of trees[b]	193,000	29,000	33,000	255,000
Lone trees[c]	78,000	9,000	10,000	97,000
Total area	565,000 (4.3%)	84,000 (1.1%)	93,000 (4.5%)	742,000 (3.2%)

[a]Woodlands below 0.5ha but over 0.1ha in size
[b]Woodlands less than 0.1ha in extent
[c]Trees over 2m tall, or 3m in a hedgerow

Table 1.1.4. Length of hedgerows (km) in 2016 and total woody linear features in 2007

Source: Brewer *et al.* (2017)[9] and UKCEH (2007)[10]

Category	England	Scotland	Wales	Great Britain
Hedgerows[a]	336,000	41,000	76,000	452,000
Total woody linear features[b]	547,000	46,000	106,000	700,000

[a] Boundary lines of trees and shrubs over 20m long, less than 3m in height, and a mean width of less than 4m at the base
[b] Hedge, line of trees/shrubs/relict hedge

There are no reliable statistics on the extent of **wood pasture and parkland**. In Great Britain the area was estimated at 10,895ha[7], based on the NFI definition of woodland (minimum of 20% canopy cover). However, this would exclude wood pastures with lower densities of trees, which is often the case as there are open grazed areas within them. An updated inventory suggests there are 278,004ha of wood pasture and parkland in England[11]. This is considerably higher than the NFI-estimated area and highlights the need for better national recognition and accounting of this habitat. Equivalent datasets are not available for other UK countries. For example, although grazed land with some tree cover is abundant and forms much of the landscape of the upland fringe (the ffridd) in Wales, there are no area estimates. Poor knowledge of the current extent of wood pasture and parkland in the UK means that loss of and threats to these once extensive systems are difficult to communicate.

Trees outside woods make up 19.4% of total canopy cover in Britain.

Why does it matter?

Canopy cover is a fundamental measure of the state of the UK's woods and trees, against which we can track progress with achieving goals for woodland expansion and replacing and planting new trees outside woods. Broad figures about total extent however, hide many nuances in the quality of habitat for nature, the importance of trees for providing many benefits and services for people, and their significant role in regulating our climate. Often where woods and trees are located in the landscape is intrinsically linked to their value for nature and people. Woodland patch size is also a critical factor and much remains in small fragmented blocks. Enlarging woods and increasing their connectivity to other woodland is vital. Trees outside woods provide linkages between these fragments and make up a significant proportion of total canopy cover in the UK, yet they have suffered from the same external pressures as woodland (see 1.2). Many ancient trees are found outside woodland: they represent a critical resource for wildlife, are vital for landscape connectivity, as well as providing a wide range of ecosystem services.

All these aspects are explored further in different chapters of this report.

What needs to happen?

Better data: refining and updating inventories of ancient woodland would enable far better monitoring of any losses and enable unrecorded sites to be better protected.

Protection: protection of existing trees and native woodland, in particular ancient woodland.

Expansion: increase UK woodland cover to at least 19% by 2050 (see 4.1), and separately, there should be expansion targets for trees outside woods.

Investment: target public money investment in new native tree cover to maximise public goods like wildlife, and increase capacity in tree and woodland teams at all levels of national and local government.

Connectivity: targeted woodland creation is needed to enhance connectivity between woodlands. Maintaining and increasing the extent of TOWs will be a vital part of increasing overall canopy cover.

CASE STUDY

Field trees have been lost as farm machinery has got bigger.

1.2 How many trees outside woodland have been lost in the Eastern Claylands?

What do we already know?

Trees outside woodland (TOWs) provide valuable ecosystem services for people and habitats for wildlife, yet face many threats including disease, urban expansion and agricultural intensification. Older TOWs, particularly ancient or veteran trees with complex structure, are most valuable, providing the greatest amount and diversity of benefits. Management and policy are urgently required to conserve vulnerable remaining TOWs, particularly longer-lived trees, and enhance this resource by establishing new TOWs in a way that maximises their value to people and wildlife and their resilience to future change. These actions require reliable estimates of the long-term TOWs loss to inform where action is most needed, and how it can be most effective.

TOWs act as **refugia for wildlife** within otherwise hostile landscapes. They enhance biodiversity by providing resources including shelter, sites suitable for feeding and breeding and equitable microclimates[1-4].

Perhaps most importantly, TOWs contribute to **landscape connectivity** by facilitating the dispersal of organisms between otherwise isolated woodland patches. This has numerous ecological benefits, including countering genetic problems associated with small populations, allowing the colonisation of patches where species are absent, and facilitating the spread of species in response to climate change[5].

Intensification of agricultural landscapes (particularly the amalgamation of small fields and farms and the use of increasingly larger machinery) and urban expansion have resulted in the clearing of many trees and hedgerows. Historic and emerging **diseases** particularly threaten TOWs, with ash dieback now threatening many of the trees which replaced those lost to Dutch elm disease between 1920 – 1980. Regeneration of new TOWs is hindered by modern hedge management practices and high browsing pressure from deer.

Trees outside woods contribute to landscape connectivity by enabling wildlife to move between otherwise isolated woodland patches

Figure 1.2.1. Eastern Claylands study area

The Eastern Claylands of Essex and Suffolk (Figure 1.2.1) is a 5,000km^2 agricultural landscape characterised by its TOWs, which importantly make up 19% of all tree cover in an area where woodland accounts for only 7% of land. TOWs once formed an important part of the culture and local character of the area, as exemplified by their prominence in the romantic landscape paintings of John Constable. The area provides a case study in which to develop a method for obtaining crucial evidence to guide the conservation of TOWs and the benefits they provide.

JOHN CONSTABLE, ART COLLECTION / ALAMY STOCK

The Cornfield, a painting from 1826 by John Constable, showing an abundance of trees outside woods in Essex.

About the data

Volunteer citizen scientists digitised the locations of over 100,000 trees recorded in Epoch 1 Ordnance Survey maps from c. 1850[6] within 350 randomly selected 1km^2 grid cells (Figure 1.2.2a and b). These maps are considered to provide one of the first relatively accurate descriptions of the locations of TOWs. However, it should be noted that this period is not intended to be viewed as an ideal state for woods and trees in the landscape.

From these digitised trees, any located within the current National Forest Inventory of woodland[7], or within 15m of a woodland boundary, were removed as they were not considered to be TOWs. A random sample of 500 of the remaining tree locations was interrogated visually to determine what configuration the trees occurred in; some formed part of linear boundaries, as lines of trees or standards within hedgerows (boundary trees), while others were lone trees in fields (scattered). The remainder was predominantly trees in small copses under 0.5ha (grouped). We also visually determined whether each of these 500 trees had been lost or if a tree was present in the same location in 2020 by comparing their locations to modern satellite imagery (example in Figure 1.2.2).

The >100,000 tree locations from c. 1850 were compared to the remote sensing-derived National Tree Map™[8] using a bespoke analysis developed to estimate the number of each TOW type present in the landscape in c. 1850 and the number lost prior to 2015 without being replaced by a tree in the same location, while accounting for mapping error and spatial structure in the data (details available from the Woodland Trust).

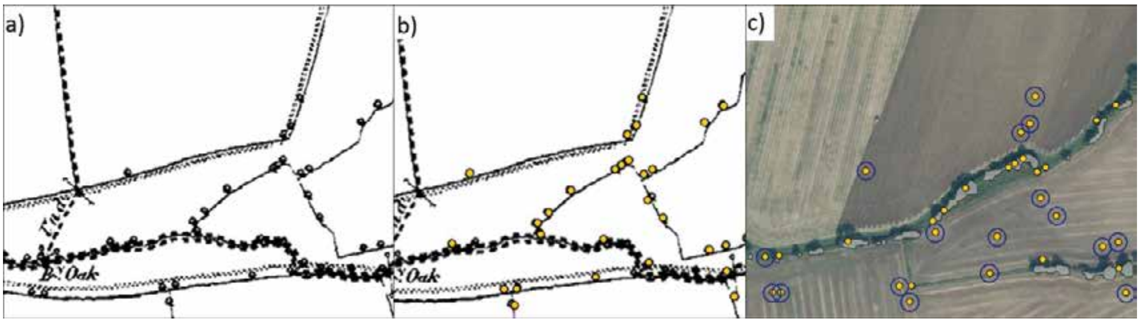


Figure 1.2.2. Following trees through time

In 350 randomly selected 1 km^2 squares the locations of >100,000 trees recorded on c. 1850 maps (see example in a) were digitised by volunteer citizen scientists (shown as yellow dots in b). A random sample of 500 trees was visually interrogated to determine TOW type and if tree cover was lost or remaining (c). Here all TOWs are boundary trees and circles denote those lost. TOWs and hedgerow loss are evident from visual comparison of c. 1850 maps and modern aerial imagery.

Source: the Woodland Trust

What does this tell us?

The Eastern Claylands landscape was estimated to contain 1.2 million mapped TOWs in c. 1850. Of these only 51% (0.6 million) were estimated to have survived to the present day. Boundary tree loss was 54% (from 0.86 to 0.40 million trees) and that of scattered trees

A mature roadside hedgerow ash felled – sadly happening across the UK as ash dieback spreads, leading to further losses of trees outside woods.

was even higher at 84% (from 0.12 to 0.02 million trees; Figure 1.2.3). This is particularly dramatic as scattered trees represented a small proportion of the TOW population even in c. 1850 (10%).

Grouped trees had a relatively low loss of 11% (Figure 1.2.3). We speculate that small groups of trees have relatively high survival because they have previously been perceived as small woods and as such valuable aspects of tree cover to protect. Additionally, these trees may be more easily replaced by naturally regenerating individuals, or the encroachment of neighbours into the area previously occupied by that tree's canopy.

The data does not tell us how many new TOWs have become established since c. 1850, which remains a significant uncertainty in our understanding of long-term TOW population dynamics. This requires more research, potentially incorporating mapping of contemporary trees using methods similar to those used in c. 1850 maps. Such work could also gather additional information on trees to assess how aspects such as species and structural complexity affect long-term survival. Additionally, while rates of TOW loss may be similar in some landscapes with similar land use history, application of the method developed here to other landscapes is required for robust direct comparison.

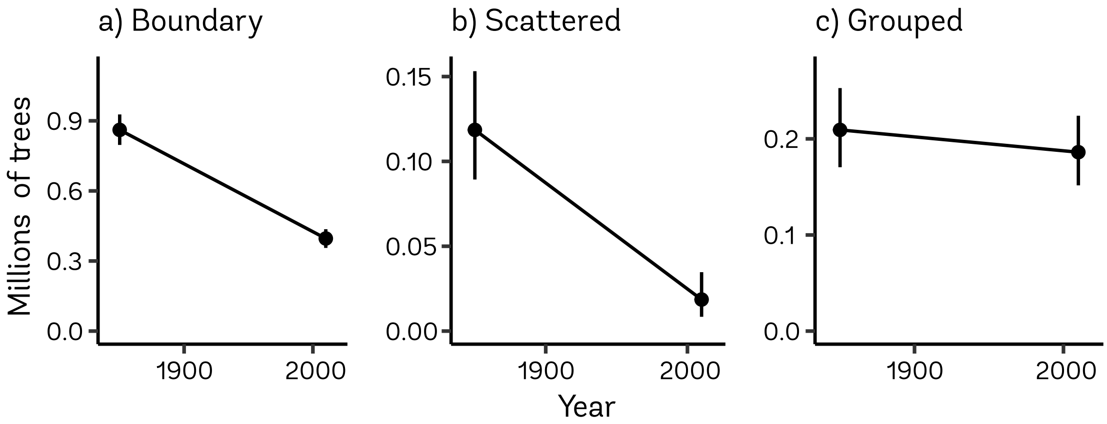


Figure 1.2.3. Estimated numbers of TOWs in c. 1850 and 2015 by type

Source: the Woodland Trust

Why does it matter?

Our study suggests a disappearance of half the TOWs recorded in the Eastern Claylands in 1850, and a trend that is likely replicated in other UK landscapes, particularly those with similar histories of agricultural intensification. The loss of these historic trees is concerning as they represent the loss of the particularly valuable veteran trees that they would have become had they survived. The high loss of boundary trees (54%) and particularly scattered trees (84%), which were rare even in c. 1850, highlights the risk faced by these types of TOWs and the specific habitats and benefits which they provide relative to those present in small groups. Concerted action is required if boundary and scattered TOWs are to be conserved.

By following individual tree canopies through time, we see that certain types of trees are more likely to be lost from our landscapes. Urgent conservation management is required to mitigate the loss of TOWs and the services they provide for people and wildlife. Assistance is needed to protect existing boundary and scattered trees and promote the establishment of future TOWs of these types and the specific benefits they provide, which are currently under-represented in the landscape relative to their state in c. 1850. The low rate of loss of grouped trees suggests that this TOW type is particularly resilient to change. Grouped TOWs may persist with relatively less attention and establishing TOWs in small groups may have greater success rates than individuals grown alone without specific management.

Urgent conservation management is required to mitigate the loss of TOWs and the services they provide for people and wildlife

Harnessing the skill, dedication and enthusiasm of volunteer citizen scientists, coupled with historical maps and state-of-the-art analytical methods makes evidencing this work achievable in a robust and repeatable way over huge landscapes.

What needs to happen?

Understanding and recognition: the variety of benefits provided by all types of TOWs to wildlife and people are myriad but not well understood or recognised. We need to achieve greater acknowledgement of their importance, separate to that of woodland cover, among landowners and businesses.

Protection: existing boundary trees, such as lines of trees and hedgerows, together with individual, scattered trees, require greater levels of protection. This can be achieved by grant support for their retention and good management. These trees can be perceived as challenging to owners and managers who currently bear the cost of their maintenance and may require greater advice and assistance.

Restoration: reconnect the landscape by taking action to restore the millions of TOWs lost and supporting the sustainable management of TOWs to conserve the wildlife and wider societal benefit they provide.

1.3 What is the state of ancient and veteran trees?

What do we already know?

We have a **deep-rooted connection** with ancient and veteran trees. We hug them, name them and recognise them as landmarks, and they feature in the memories and stories passed on through generations. They are iconic, natural monuments as significant as, and sometimes older than, cathedrals and stately homes. Ancient and veteran trees are of incredible importance for wildlife[1]; each tree is an ecosystem in its own right, providing a range of specialist habitats for animals, plants and fungi that depend on conditions found in the decaying wood, sap runs, cavities and crevices[2]. We are still learning about their biodiversity value and continue to discover new species in or within them. We are only beginning to reveal their vital role in long-term carbon stores, especially in the soil around and beneath them[3].

The UK's ancient and veteran tree population is of national and international conservation significance. Ancient and veteran trees are widely distributed and can be found throughout the UK where conditions have allowed them to remain rooted for hundreds of years. Often the landscapes in which they sit have dramatically changed – for example, from medieval deer park to modern housing estate.

Each ancient tree is an ecosystem in its own right

MARK ZYTYNSKI/WTML

Ancient or veteran?

The terms ancient and veteran are sometimes used interchangeably, but we also make a distinction between them. Veteran trees may be a great size or age, or display physical features such as trunk hollowing. By contrast, ancient trees are old in comparison with other trees of the same species[4]. Thus, all ancient trees are veteran, but not all veteran trees are ancient.

About the data

Ancient and veteran trees inspire projects and prompt further investigation. Record-breaking 'champion' trees are recorded on the Tree Register, while other specialist groups, such as the Ancient Yew Group[5], choose to document particular tree species and research them in detail.

The Ancient Tree Inventory (ATI)[6] gives us the most comprehensive picture of ancient and veteran trees across the UK. Established in 2003, the ATI is a tree-recording partnership between the Tree Register[7], the Ancient Tree Forum[8] and the Woodland Trust. Ancient and veteran trees are recorded, measured, photographed and made accessible on an interactive map. The ATI is a living database almost entirely populated by volunteers. It continues to grow each day as more trees are added by committed citizen scientists, trained volunteer verifiers and other tree-recording groups.

What does this tell us?

So far, 122,929 ancient and veteran trees have been recorded on the ATI, with 85% of these in England (Table 1.3.1). Some areas have significantly more trees recorded than others (Figure 1.3.2). This may be partly caused by the distribution of recording activity. A recent analysis of the ATI[9] found that a small number of 'super recorders' and active groups have made a high contribution to the dataset, resulting in localised and concentrated records in some regions. Thus, it is important to note that areas with fewer or no records are not necessarily less valuable for ancient and veteran trees: there are many trees yet to be recorded.

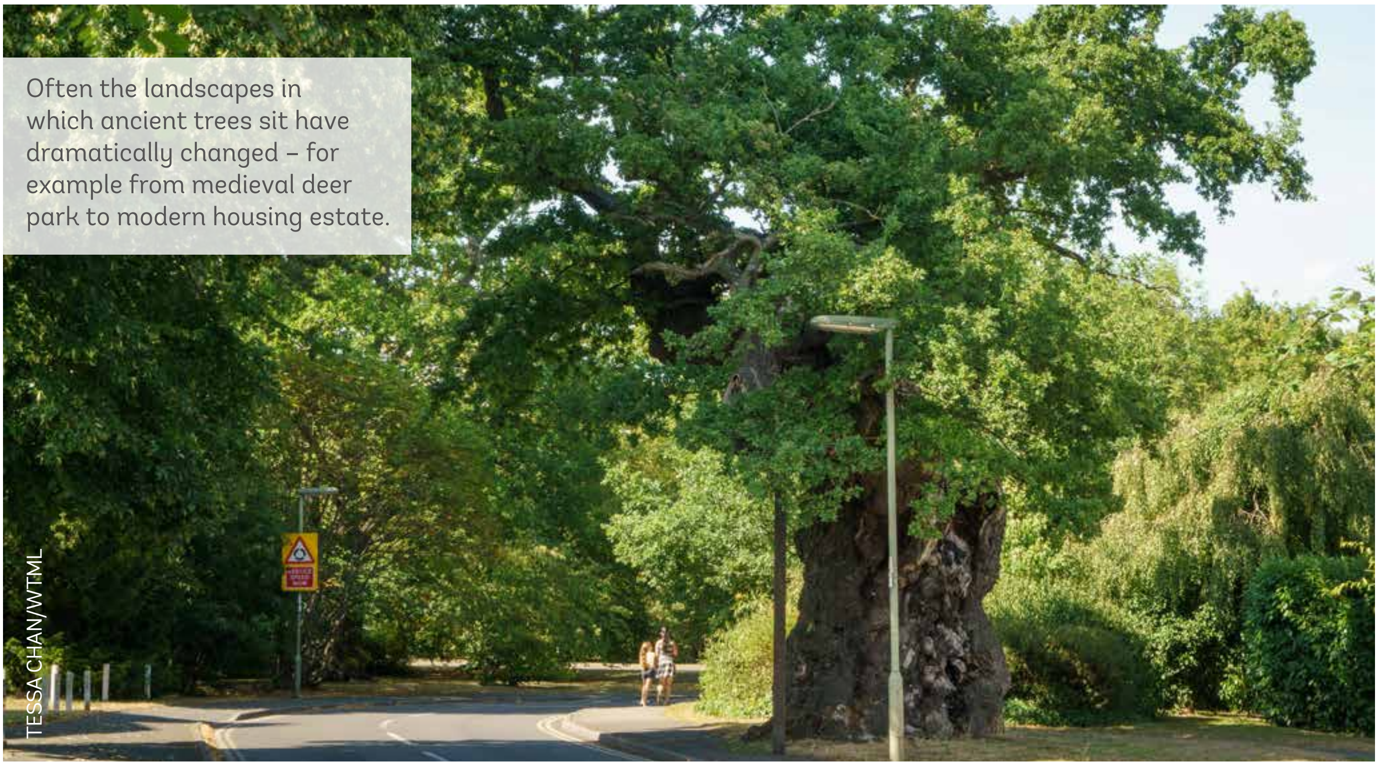
The ATI draws attention to **special sites** where there are high concentrations of ancient and veteran trees. These are often celebrated places in our national consciousness, such as Sherwood Forest and Richmond Park. Other approaches to identify quality habitats, such as the ecological continuity indices for saproxylic beetles[10] (species that rely on dead and decaying wood) tend also to identify these same sites, highlighting their national and international significance not only for the trees themselves, but the microhabitats they provide for other species.

Table 1.3.1. The total number of verified ancient and veteran tree records per country†

Source: Ancient Tree Inventory[6]

Category	England	Northern Ireland	Scotland	Wales	UK
Total ancient	11,683	134	1,783	964	14,564
Total veteran	92,869	2,449	7,861	5,187	108,366
Total ancient and veteran	**104,551**	**2,583**	**9,644**	**6,151**	**122,929**

† as of April 2020



Often the landscapes in which ancient trees sit have dramatically changed – for example from medieval deer park to modern housing estate.

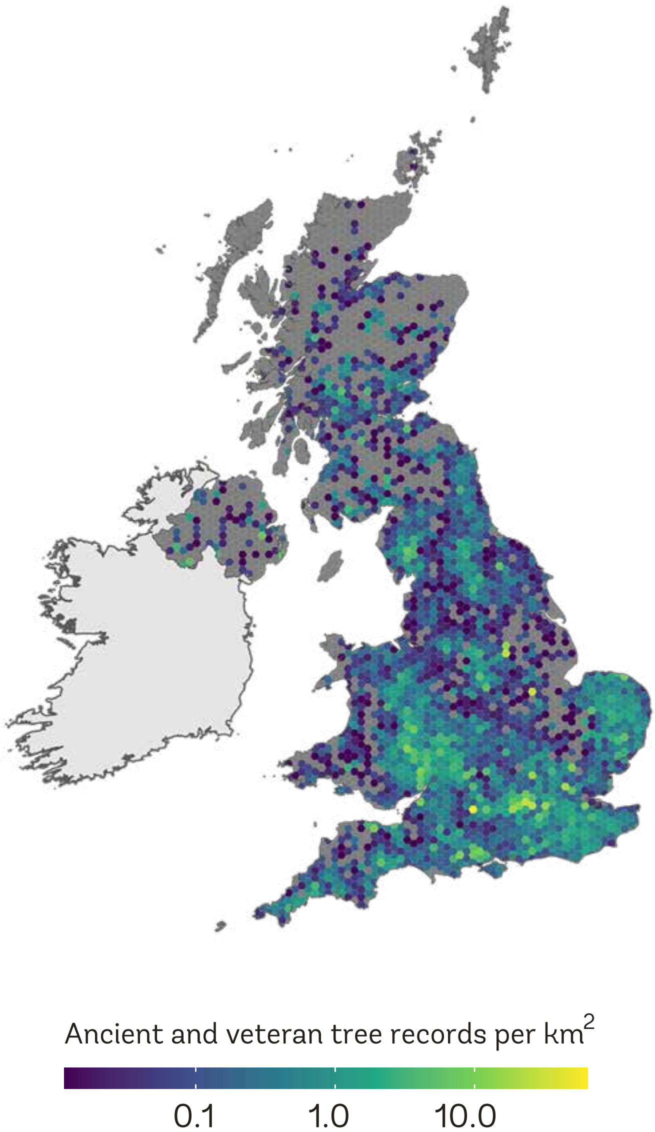


Figure 1.3.2. The number of recorded ancient and veteran trees (logarithmic scale). Grey hexagons indicate no records

Source: Ancient Tree Inventory[6]

Some trees show **interesting distributions:** ancient yews, for example, have been more frequently recorded in Wales and the south of England, whereas the majority of ancient Scots pine are recorded from Scotland. The distribution of ancient and veteran trees is diverse, existing in both concentrated populations and as scattered individual trees in a variety of land use settings (Table 1.3.3). Indeed, many old trees began their lives in circumstances very different to the challenging ones they find themselves in today. Compared with the National Forest Inventory (NFI)[11], 49% of ATI records occur in woodland, defined as areas with over 20% canopy cover, which thus includes many mosaic systems, including wood pasture and parklands.

Oaks are the most recorded trees (Table 1.3.4) and the majority of truly massive specimens are found in England. The 10 largest trees by girth include only oak and sweet chestnut (Table 1.3.5) and are among our finest examples of exceptionally old trees. The survival of a large number of ancient oaks in England is a remarkable story[12]. Of the living oak trees with trunks 9m or more in girth, 115 are known in England and just 85 in continental Europe. We believe there to be only nine such oaks in Wales and Scotland combined[6], but there are always undiscovered trees waiting to be found. Five oaks of 9m girth have been lost (through death, collapse or felling) since 2013[6].

Each tree counts, but there is currently little known about the rate of loss of ancient and veteran trees from our landscape and whether this loss is sustainable. Though we assume more losses occur than are reported, 73 ancient and 393 veteran trees were updated to 'lost' status on the ATI between 2010 and 2020. These were standing trees, but have since fallen, been felled or destroyed. One example is the Buttington Oak, which stood on Offas Dyke in Wales. This 11m girth tree collapsed in 2018 and was believed to be 1,000 years old, possibly planted to mark the Battle of Buttington (AD 893). After its collapse, a species of fungus new to science was discovered on it.

Table 1.3.3. The number of ancient and veteran trees in each surrounding habitat type (as a % of all ATI records in brackets)

Source: Ancient Tree Inventory[6]

Surrounding habitat	ATI Descriptors	Ancient trees	Veteran trees	Total
Woodland	Woodland, ancient woodland	4,174	33,694	37,868 (29%)
Wood pasture, parkland, common/ heath	Parkland, deer park, Tudor deer park, medieval deer park, historic park and garden, landscape garden, wood pasture, ancient wood pasture, common/ heath	4,912	29,337	34,249 (26%)
Field	Field	2,121	14,254	16,375 (13%)
Hedgerow and arable land	Hedgerow, arable	1,248	9,452	10,700 (8%)
Urban greenspace	Public or open space, domestic garden, school/ college ground, village green, urban tree, urban, churchyard, cemetery	920	7,086	8,006 (6%)
Roadside	Roadside	461	5,899	6,360 (5%)
Uplands and moorland	Upland, moorland	1,062	2,604	3,666 (3%)
Other	River/canal, SSSI/SAC, nature reserve, wetland, parish boundary, orchard, market garden, bridle path/ footpath, avenue, beside railway, other	1,591	11,895	13,486 (10%)

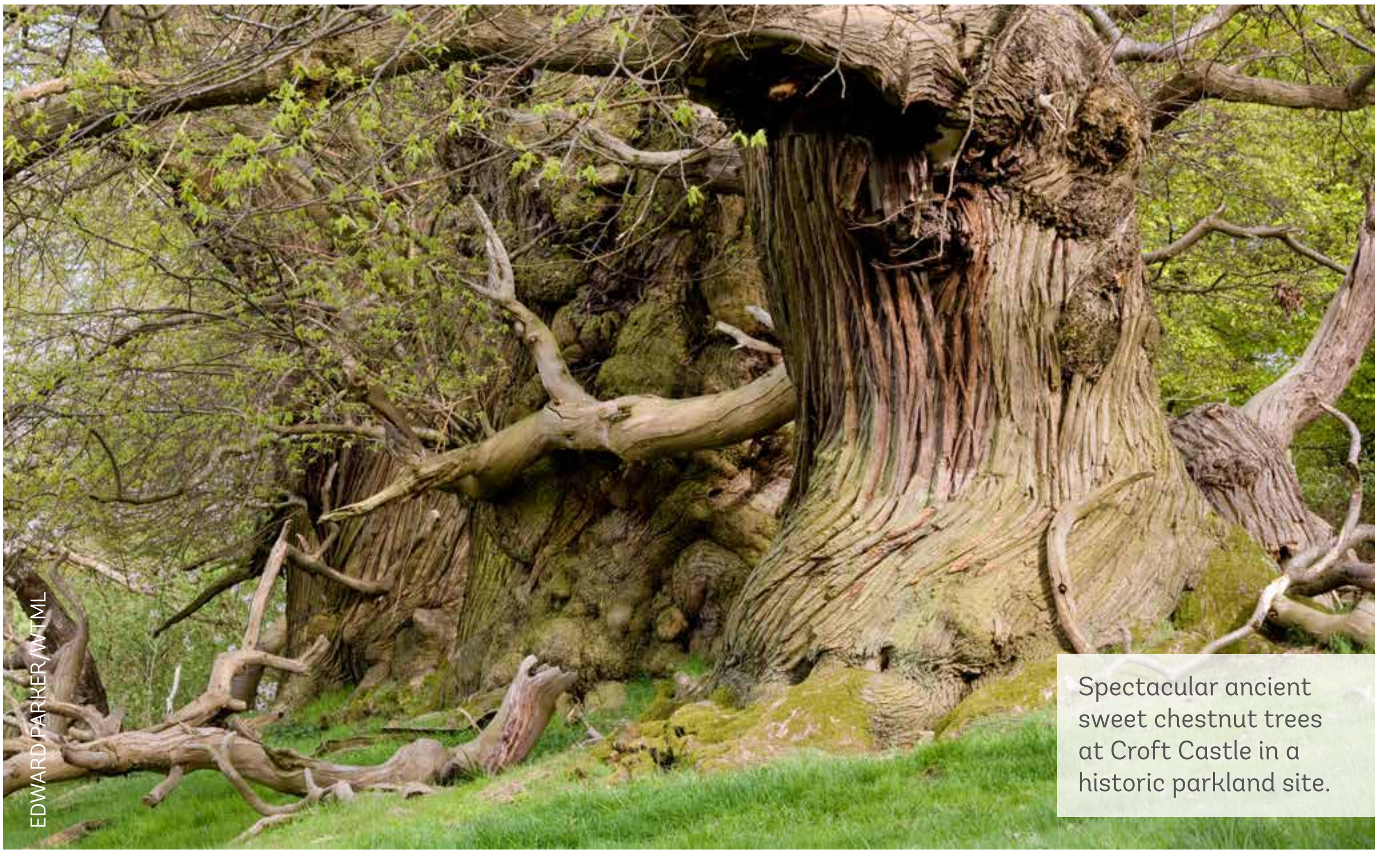
Table 1.3.4. The most frequently recorded ancient or veteran trees by species or genus, which comprise 87% of all ATI records (as a % of all ATI records in brackets)

Source: Ancient Tree Inventory[6]

Oak[a]	Beech	Ash	Sweet chestnut	Lime[b]
57,421 (46.7%)	16,087 (13%)	8,761 (7.1%)	6,491 (5.3%)	4,924 (4%)

Hawthorn	Yew	Scots pine	Alder	Field maple
2,991 (2.4%)	2,887 (2.4%)	2,655 (2.2%)	1,905 (1.6%)	1,774 (1.4%)

[a] Includes trees recorded as 'oak', 'pedunculate oak' and 'sessile oak'.
[b] Includes trees recorded as 'lime', 'common lime', 'small-leaved lime' and 'large-leaved lime'.



Spectacular ancient sweet chestnut trees at Croft Castle in a historic parkland site.

Table 1.3.5. The UK's top 10 largest-girthed single-stemmed trees

Source: Ancient Tree Inventory[6]

Local name	Girth (m)	Species	County
Marton Oak	14.02	Sessile oak	Cheshire
Canford Chestnut	14	Sweet chestnut	Dorset
Lydham Manor Oak	12.88	Pedunculate oak	Shropshire
Gospel Oak	12.8	Pedunculate oak	Herefordshire
Three Sisters	12.7	Sweet chestnut	Sir Ddinbych – Denbighshire
Queen Elizabeth Oak	12.67	Sessile oak	West Sussex
Bowthorpe Oak	12.3	Pedunculate oak	Lincolnshire
Majesty	12.16	Pedunculate oak	Kent
Melbury Park Oak "Billy Wilkins"	11.92	Pedunculate oak	Dorset
Cowdray Park Sweet Chestnut	11.8	Sweet chestnut	West Sussex

Why does it matter?

Ancient and veteran trees often require special consideration and care. Though they appear to be stalwarts of our landscapes, it is clear that their surroundings are continually altered by human pressures and wider environmental change. Measures must be taken to alleviate life-shortening impacts, as identified from a site management plan or individual tree assessment[13]. The predominant recorded issues for these trees are usually easily addressed; they most often include compaction of the soil in the rooting area, damage associated with grazing animals and over-shading by other younger trees.

Recent losses of our very largest ancient and veteran trees is something to be concerned about and no further avoidable losses should occur. However, protection or good management should not just be afforded to the oldest or most treasured specimens. We must ensure the perpetuation of tree populations with diverse age and size structures, and it is crucial that young and mature trees are able to become the next cohort of veterans.

Many ancient and veteran trees have survived in deer park habitats such as this.

BLICKWINKEL/ALAMY STOCK PHOTO

What needs to happen?

Identification: no further avoidable loss of ancient and veteran trees. This can be achieved by greater recognition, sensitive land management and legislation to protect them. We need better data on the rate of loss in order to track this. The ATI should be continuously added to, both as part of professional ecological and arboricultural survey and by the addition of new citizen science records.

Time and space: we must give trees the opportunity to become veterans and long-lived ancients of the future. Trees are long-term investments, as they are capable of living for hundreds of years. Our thinking, action and policies must apply over these long periods – in tree time[14].

The next generation: we must ensure a future ancient tree population that has trees of varying size, age and condition through land management options and incentives which care for existing mature trees and establish new ones.

Skills and awareness: ancient and veteran tree management is understood to be more complex, delicate and skill-demanding than standard arboricultural practice[15]. Investing in such specialist skills would help to deliver appropriate management and slow future losses.

Routine consideration: ancient and veteran trees are currently recognised by planning guidance across the UK as irreplaceable habitats or as having significant value. These trees should always be identified during planning so that their loss, damage or decline can be avoided. We recommend that the ATI is used as a starting point by local authorities, planners, developers, ecologists and tree officers when identifying hotspots for ancient trees.

Firmer protection: ancient and veteran trees currently have no legal protection. For example, there is no legislative equivalent to the Ancient Monuments and Archaeological Areas Act (1979) that safeguards special archaeological sites. Given that some ancient trees may be as old as some of our most treasured archaeological sites, we recommend exploring legal protection and more robust policies for better safeguarding of ancient and veteran trees.

Woodland condition is an indicator of the health of a woodland and its value for wildlife.

1.4 What condition are woodlands in?

What do we already know?

Wooded habitats, from young thicket copses to old growth woodlands with mature trees, present a wide range of ecological conditions and support different and complementary aspects of biodiversity. There are certain widely **agreed attributes** that are indicators of woods in 'good condition', for example woodlands that are free from browsing damage and invasive species, with a diversity of tree species and sizes and a range of other habitats. These attributes can be measured to understand woodland condition. This is crucial, because healthy ecological systems provide vital services for people and support woodland wildlife, and we need to understand what practical steps can be taken to improve those woods in poor ecological condition. In 2020 Forest Research published **the first Great Britain-wide assessment of woodland ecological condition** based on extensive field surveys. We explore the results here by woodland type and discuss the implications for people and wildlife.

About the data

As part of the National Forest Inventory for Great Britain, a field survey of woodland plots is undertaken on a five-year cycle, coordinated by Forest Research[1]. Various attributes are measured within 15,100 one-hectare sample squares that were chosen as a representative sample of British woodlands. The data reported here was collected between 2010 and 2015. The raw data was further processed to produce 15 indicators of woodland ecological condition, and thresholds were applied to categorise each plot as 'favourable', 'intermediate' or 'unfavourable' for each condition indicator. Here we report on eight of these indicators which focus on structural diversity and tree species composition. We present these indicators broken down into different woodland habitat types to highlight any issues specific to them.

What does this tell us?

Just 7% of native woodland in Britain is currently in good ecological condition overall[2]. Breaking this down into the nine priority habitat types (i.e. habitats that have been identified as being the most threatened and requiring conservation action) and two non-priority habitat types ('non-native conifer plantations' and 'other broadleaf') shows broadly similar results for most of the condition indicators (Figure 1.4.1). All woodland types are lacking in deadwood, veteran trees and open space. Despite the importance of wood pasture and parkland for veteran trees, the majority are unfavourable for this indicator, having less than one veteran tree per 20ha. But note that only a subset of wood pasture and parklands were surveyed, as the NFI excludes areas with less than 20% canopy cover, therefore the lack of veterans isn't necessarily representative.

All woodland types are mainly 'intermediate' for levels of regeneration, but this comes with a major caveat. The number of seedlings or saplings was not taken into consideration when assigning condition status – presence of just one of either seedlings (<50cm tall), saplings (≥50cm tall and <4cm in diameter) or other young trees (4-7cm in diameter) resulted in intermediate condition. It is therefore not possible to draw clear conclusions on the condition of woodlands for natural regeneration based on the published NFI analysis.

Native woodland types are mostly in favourable or intermediate condition for native tree species cover in the uppermost canopy (Figure 1.4.1). Non-native conifer plantations are poor in terms of native tree cover and number of native tree species. Including more native trees within conifer plantations would enhance their biodiversity value. It is important to know the nativeness (or otherwise) of plantations on ancient woodland sites and whether this is improving, but this information is lacking (see 4.6). Scots pine plantations and native pinewoods are also largely unfavourable for the number of native tree species, which means they only have up to two different tree species present. Non-native conifer plantations are also poor in terms of age distribution due to the presence of stands with uniform age – this should improve over time if a continuous cover forestry approach is used. Indeed, no woodland type exceeded 19% in favourable condition for age distribution, meaning that the majority have only one or two age classes present (out of young, intermediate or old). Trees of varying age provide structural diversity, which is important for good woodland ecological condition.

Lowland mixed broadleaved woods perform worst for the proportion of semi-natural habitat surrounding the wood, followed by lowland beech and yew woods, wood pasture and parkland, and wet woodlands. This indicates that these woods are more isolated from other semi-natural habitats – many are situated in relatively intensively managed agricultural landscapes – which will be reducing species dispersal and gene flow between woodland patches.


CTP PHOTOGRAPHY/WTML

Lowland broadleaved woods are more isolated from other semi-natural habitats.

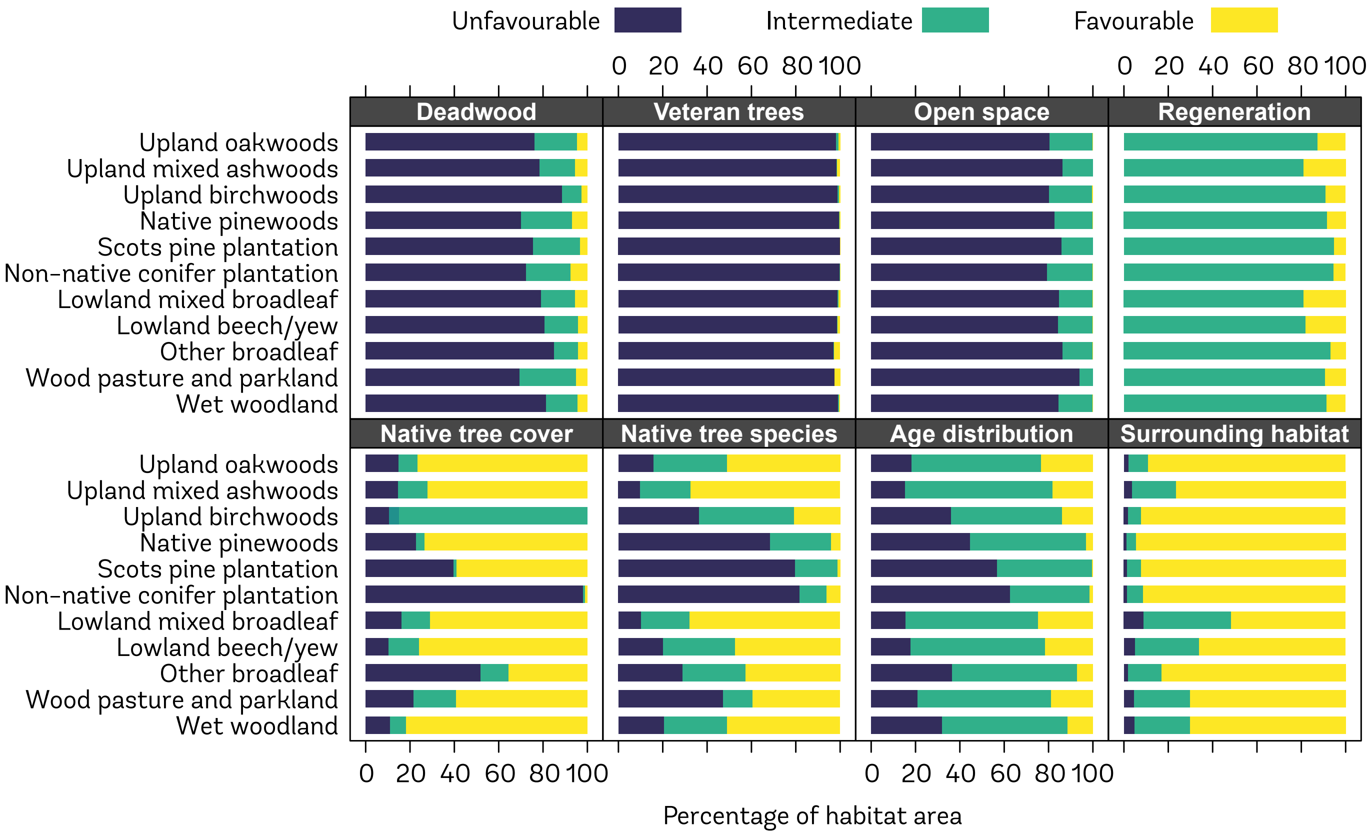


Figure 1.4.1. Woodland condition by type

Percentage of each woodland habitat type in unfavourable, intermediate or favourable condition for each of the following WEC indicators: deadwood volume (m^3 per ha), veteran trees, proportion of open space, regeneration (presence of seedlings and saplings), proportional cover of native tree species in the uppermost canopy, number of native tree and/or shrub species, age distribution of tree species and proportion of surrounding woodland or other semi-natural habitat.

Source: Forestry Commission (2020)[1]

Why does it matter?

The first ever comprehensive woodland ecological condition assessment for Great Britain revealed some stark findings which must stimulate urgent action. That so much of our woodlands do not contain sufficient deadwood, veteran trees or open space, or diversity of tree species, ages and structure, highlights major issues that impact on wider ecological functioning. Some of these indicators will be resulting in biodiversity loss, for example the lack of deadwood and veteran trees will be contributing to declines in saproxylic invertebrates and cavity nesting birds. Biodiversity trends and how they relate to woodland management are explored further in section 1.7.

The current condition of Britain's woodlands reflects a range of factors, including for some a lack of management and for others 'too much' management. And for yet others, simply a lack of time from their creation to produce complex ecological structures. But with the knowledge, technology and expertise that we have in the woodland sector today, and armed with such comprehensive data, we must work towards improving the ecological condition of our woodlands.

Some of the attributes of woodland in good condition:

Mix of tree sizes and ages

Standing and fallen large-diameter deadwood

Diverse ground flora

Abundant natural regeneration

Mix of tree species

Open habitats/glades and rides

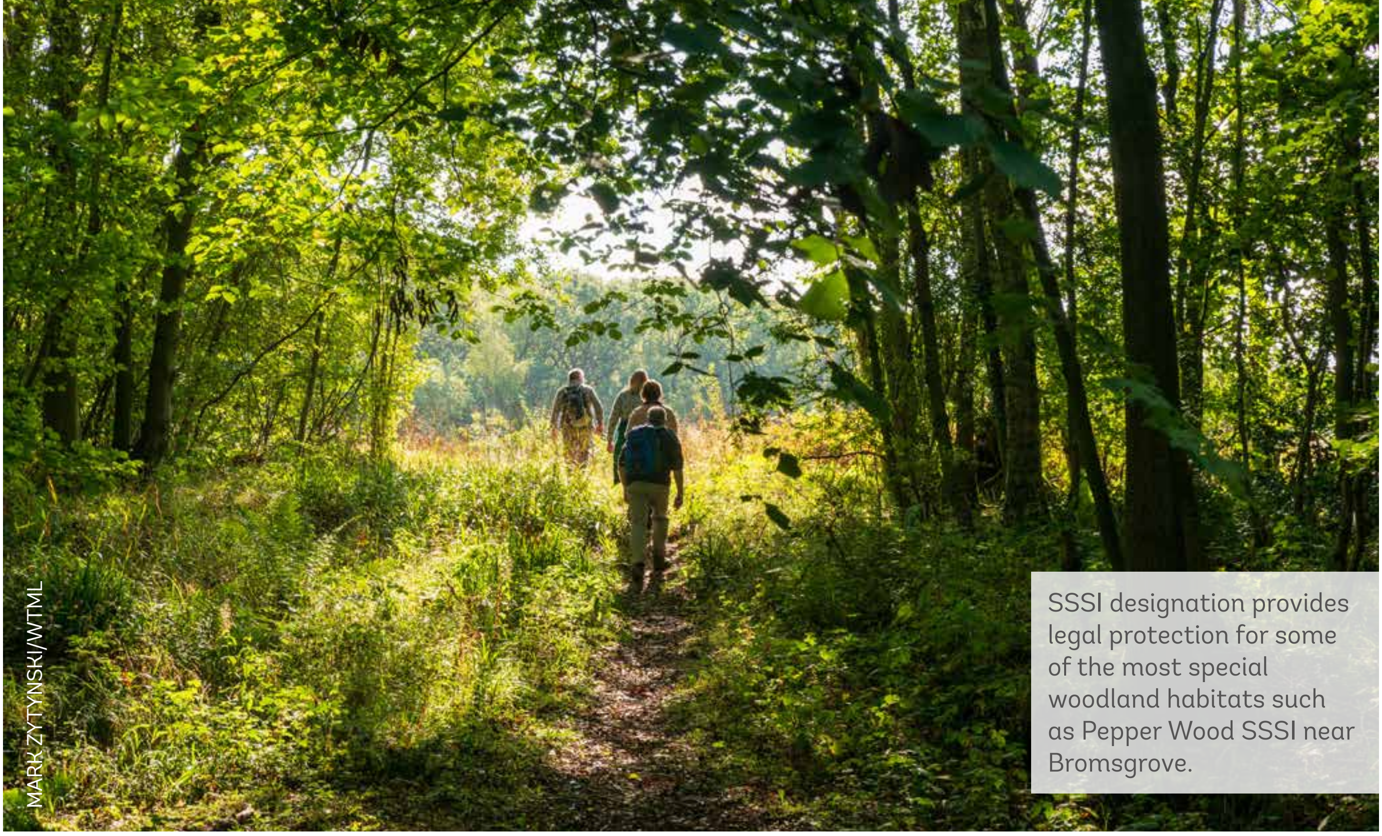
What needs to happen?

Appropriate management: there is an urgent need for woodland management plans which address the reasons for poor ecological condition. As a starting point, the UK Forestry Standard (UKFS)[3] provides guidance and legal requirements for woodland management.

Monitoring effectiveness of management interventions: management plans are only useful if progress and effectiveness against clear objectives is monitored to allow for adaptive management that improves woodland condition.

Improve non-native plantations: non-native conifer plantations in particular require management to improve their ecological condition, as they performed badly for all indicators except surrounding habitat.

Assess ancient woodlands: plantations on ancient woodland sites are not reported by the NFI separately, yet the nativeness of their canopy for example is critical for the restoration of ancient woodlands (see 3.7 and 4.6). These must be assessed and monitored for improvement.



SSSI designation provides legal protection for some of the most special woodland habitats such as Pepper Wood SSSI near Bromsgrove.

1.5 What is the condition of legally protected woodland wildlife sites?

What do we already know?

A representative sample of **our most special woodland habitats** are legally designated as protected conservation sites. In England, Scotland and Wales, protected sites are given the designation of Sites of Special Scientific Interest (SSSIs), and in Northern Ireland they are known as Areas of Special Scientific Interest (ASSIs). **Legislation** in the respective countries makes it an offence to intentionally or recklessly damage the protected natural features of an SSSI. Owners of these sites, many of which are private, have the legal responsibility to protect the interest of the site and are encouraged to undertake the management needed to conserve it. But this does not mean these sites are in good ecological condition.

Advice and assistance is provided to site owners by the relevant statutory nature conservation body (SNCB) for each country. It is also the role of the SNCBs to identify and protect SSSI/ASSIs. They have the objective to achieve **'favourable condition' status** for all SSSI/ASSIs, which means that the SSSI/ASSI habitats and features are in a healthy state and are being conserved by appropriate management.

About the data

While SSSI/ASSI designation applies to many different broad habitat types, we are focusing specifically on woodland SSSI/ASSIs for this report. Woodland SSSIs can be further broken down into priority habitat types, for example, native pinewoods, bog woodland, wood pasture and parkland, mixed ashwoods and acidic oak woodland. These contain unique species communities, and as such it is important to monitor the condition of each habitat type.

Data was obtained from the SNCBs by request on the condition of all woodland SSSIs in England, Northern Ireland and Scotland, including breakdowns by priority habitat type (habitat-specific data is incomplete for England). For Wales, data was only available for ancient woodland sites that are designated as Special Areas of Conservation (SAC) under the EC Habitats Directive. The number of SACs in each condition category was provided but not the area, which would be more representative of the state of protected woodlands in Wales. SACs only cover 63% (163,958 ha) of all SSSIs in Wales (not just woodland SSSIs), therefore the data presented here is not a comprehensive analysis of SSSI condition in Wales.

The **condition** of SSSI/ASSIs can be categorised as one of the following:

- favourable – habitats and features are in a healthy state and are being conserved by appropriate management
- unfavourable (recovering condition) – if current management measures are sustained the site will recover and achieve favourable status over time
- unfavourable (includes no change or declining) – special features are not being conserved or are being lost, so without appropriate management the site will never reach a favourable or recovering condition
- unassessed.

To **monitor progress** towards achieving favourable condition for all SSSI/ASSIs, the SNCBs undertake visits to assess the site's general condition and record the reason for adverse condition when there are any. Within this report, we summarise the condition status of woodland SSSI/ASSIs in the UK, and the main reasons for adverse condition (not available for Wales).

What does this tell us?

In England, 50% of SSSI woodland area is unfavourable (recovering) and 34% is in favourable condition. Just 4% of England's SSSI woodland area is unfavourable (no change or declining). In contrast, in Northern Ireland only 1% of woodland ASSI area is in favourable condition, with 61% in unfavourable condition. Scotland also has a large proportion of SSSI area in unfavourable condition (40%), with an equal area in favourable condition (40%). Two thirds of SACs in Wales are in unfavourable condition.

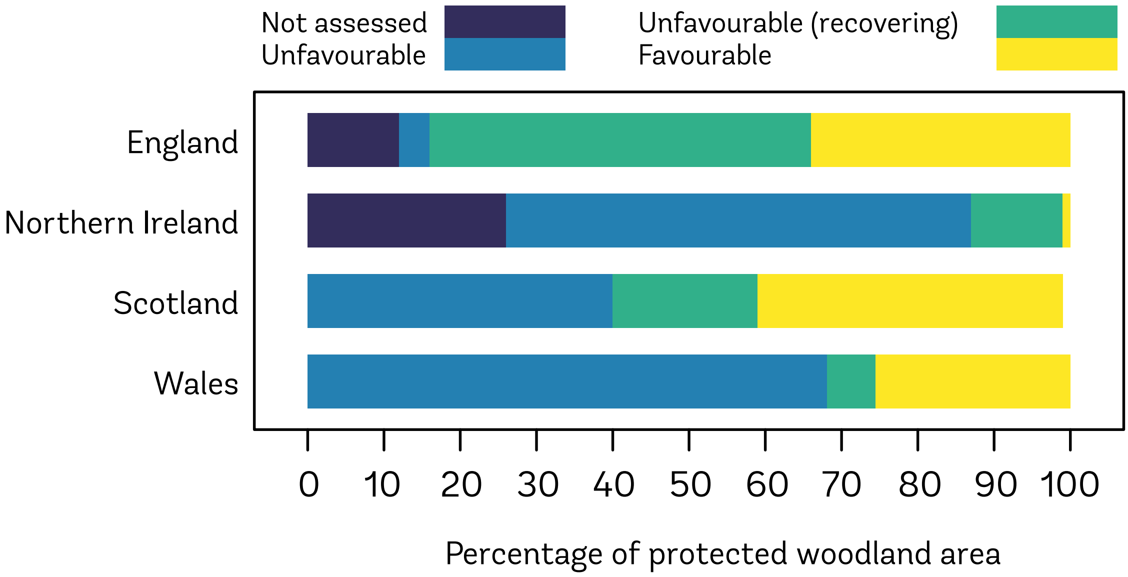


Figure 1.5.1. Percentage of woodland SSSI/ASSI area in each condition category for England, Northern Ireland and Scotland, and for Wales the percentage of woodland SACs (a subset of SSSIs) in each condition category (by number of sites as area data is not available)

Source: Natural England, Department of Agriculture, Environment and Rural Affairs, NatureScot and Natural Resources Wales (data not publicly available)

The **priority habitat types** in unfavourable condition – and therefore in urgent need of appropriate management – are different in each of the countries (Figure 1.5.2). In England, most priority habitat types are recovering due to management although large areas of some have not been assessed. Data is also not available to assess the condition of SSSI wood pasture and parkland.

In Northern Ireland, very little of the ASSI woodland area is in favourable or recovering condition. Furthermore a large area of ASSI oakwoods and mixed ashwoods require an assessment, therefore their condition is unknown.

In Scotland all SSSIs have been assessed. A large area of SSSI Caledonian forest and upland birch woodland are in unfavourable condition. In contrast the majority of Scotland's SSSI bog woodland is in favourable condition. Unfortunately this analysis was not possible for Wales as area data was unavailable.

There were differences in the way each country classifies habitat type, which makes it difficult to aggregate data and compare between countries. This is highlighted by Figure 1.5.2 as some habitat types are common to all three countries (e.g. acidic oak woodland) but some are unique (e.g. oakwood in Northern Ireland). This has resulted in five categories that include oak for example.

EDWARD PARKER/WTML

Ashenbank Wood, Kent is included in the Shorne and Ashenbank SSSI due to its deadwood habitat, veteran trees and open ground habitat.

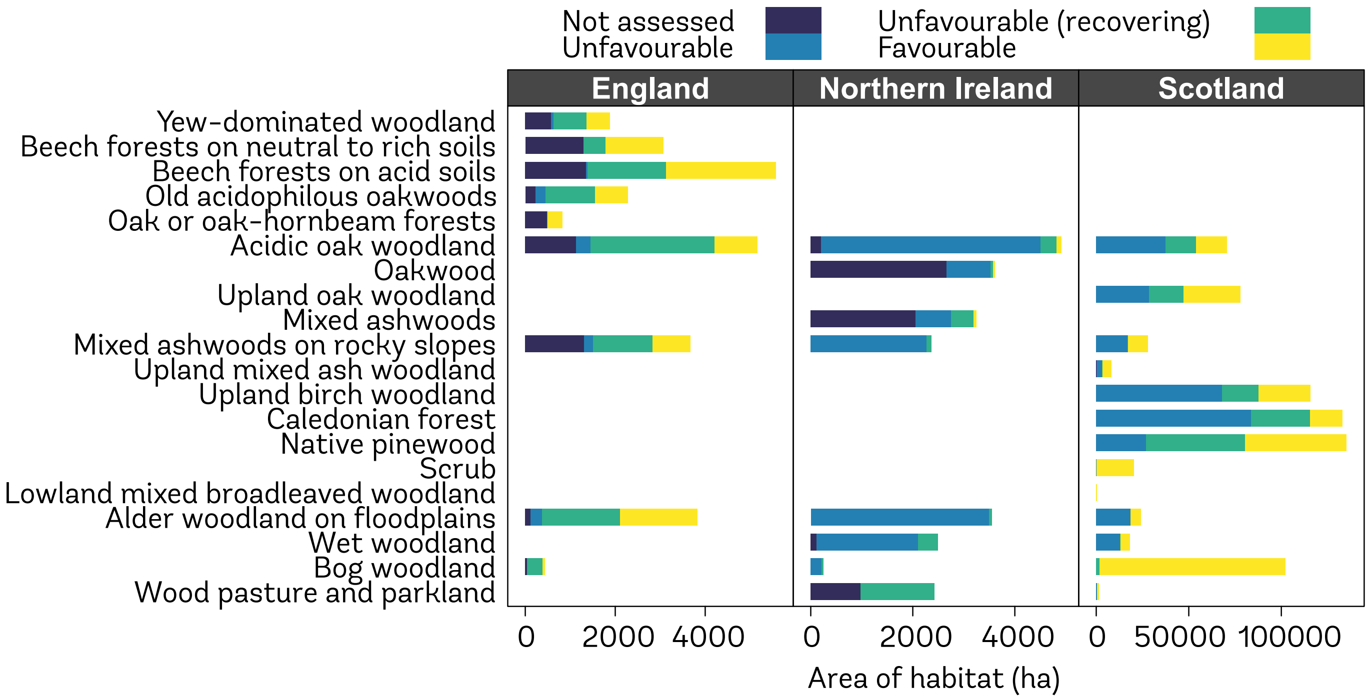


Figure 1.5.2. Condition of SSSI/ASSI woodland by priority habitat types (area in ha) in England, Northern Ireland and Scotland classed as not assessed, unfavourable, unfavourable (recovering) or favourable

Source: Natural England, Department of Agriculture, Environment and Rural Affairs and NatureScot (data not publicly available)

Reasons for adverse condition

The reasons for adverse condition of SSSI/ASSIs also vary by country (Table 1.5.1). Overgrazing (by livestock and wild herbivores) is in the top five for all three countries, and invasive species (both native and non-native) are having serious impacts in Northern Ireland and Scotland. Native species with the potential to become invasive include bracken and other scrubby species, while 'alien' non-native species cover a spectrum of plants such as rhododendron, Japanese knotweed, Himalayan balsam and cotoneaster. Inappropriate woodland management was the reason for adverse condition on a fifth of England's woodland SSSIs – by far the biggest threat.

Table 1.5.1. Top 5 reasons* for adverse condition of Sites/Areas of Special Scientific Interest in each country (percentage of all sites affected in brackets)

Source: Natural England, Department of Agriculture, Environment and Rural Affairs and Scottish Natural Heritage (data not publicly available)

England	Northern Ireland	Scotland
Inappropriate forestry and woodland management (20%)	Alien and problematic species (23%)	Overgrazing (57%)
Deer grazing/browsing (7%)	Intensive grazing or overgrazing by livestock (15%)	Presence/changing extent of non-native invasive species (41%)
Other (4%)	Invasive species (including bracken or scrub) (13%)	Presence/changing extent of native invasive species (9%)
Agriculture – overgrazing (4%)	Overgrazing (including deer browsing) (10%)	Recreation/ disturbance (3%)
Inappropriate scrub control (3%)	Other (1.3%)	Agricultural operations (3%)

*Sites may have more than one reason for adverse condition, and some sites with unfavourable condition have no reason recorded.

Why does it matter?

SSSI/ASSIs include priority woodland habitats that have been identified as most important and in need of urgent conservation action. Yet many of these woods have not even been assessed to determine what condition they are in and what management is required. Of those that have been assessed, large areas of these special, legally protected woodlands are in unfavourable condition. This means that they will not be able to provide suitable conditions to support the range of wildlife that depends on them. These are already rare habitats, so having only a proportion of these in favourable condition further reduces the area available to support woodland biodiversity. The main reasons for adverse condition differ in each of the countries of the UK, therefore each country must devise tailored conservation management approaches.

What needs to happen?

Joined-up approach: a common recording system with common habitat categories and adverse condition reasons is needed to better understand the condition of priority habitats across the whole of the UK.

Regular assessments: all SSSI/ASSIs should have a condition assessment at least every five years. Natural Resources Wales (NRW) does not have a comprehensive SSSI monitoring programme. However NRW aims to produce baseline condition assessments of SSSI habitats towards the end of 2020, so this should be available in the future.

Setting targets: all governments should adopt targets for reaching favourable condition of SSSI/ASSIs.

JOHN BRIDGES/WTML

The diverse woodland structure and habitats of the Ledmore & Migdale SSSIs support a thriving population of red squirrels among many other species.

Plant species richness is a fundamental component in assessing the state of woods and trees. Wood anemone *(Anemone nemorosa)* indicates long established woodland.

1.6 How is the richness of woodland plants influenced by woodland cover?

What do we already know?

The extent and character of woodlands within landscapes influences wider vegetation and the botanical richness of wooded ecosystems. The vegetation of wooded ecosystems includes a wide array of plants, from those of more shaded ancient groves to those that move with dynamic processes, disturbance and more open habitats. All plants support a wide diversity of associated fungi or fauna, and many also represent conditions or processes that other species depend on.

An assessment of the state of woods and trees must be informed by the state of the variety of species that make up wooded ecosystems, of which woodland plant diversity is a fundamental component. Plant distribution data can thus help inform the state of woodland ecosystems, and identify the processes or functions which are missing or being lost. Here we explore how woodland plant species richness varies with the extent and type of woodland cover.

About the data

As well as assessing regional trends in the diversity of woodland plant communities, our analysis describes the relationship between the number of woodland plant species recorded within landscapes and the cover of coniferous and broadleaf woodland. Data on the distributions of **192 native woodland vascular plant species** was provided by the Botanical Society for Britain and Ireland (BSBI), which identifies the 10km x 10km grid squares (hectads) across Britain that each species was recorded within from 2010 to 2019[1]. The plant species chosen represent a breadth of wooded or treed ecosystems and included both ancient woodland specialists, as well as those typical of more open semi-natural vegetation. They include many common and widespread species as well as some rarer specialists, covering a range of habitat requirements in terms of light, moisture and soil pH. The data on woodland cover comes from the CEH Land Cover Map 2019[2,3].

The analysis explores the effects of **landscape-scale broadleaf and coniferous woodland cover** on the number of woodland plant species recorded within hectads, and accounted for latitudinal gradients, underlying spatial processes, and the amount of hectads which were on land (further details available from the Woodland Trust on request). The predicted effect of broadleaf cover assumed constant conifer cover at its UK average (5%) and the predicted effect of conifer cover assumed average broadleaf cover of 7%. Both predicted effects assumed 100% land cover within hectads and average latitude (54.3°, that of North Yorkshire).

Some of the richest parts of the UK for woodland plants are also those where ancient woodland is most abundant

TIM GAINEY/ALAMY STOCK PHOTO

Ancient woodland indicator yellow archangel (*Lamium galeobdolon*).

What does this tell us?

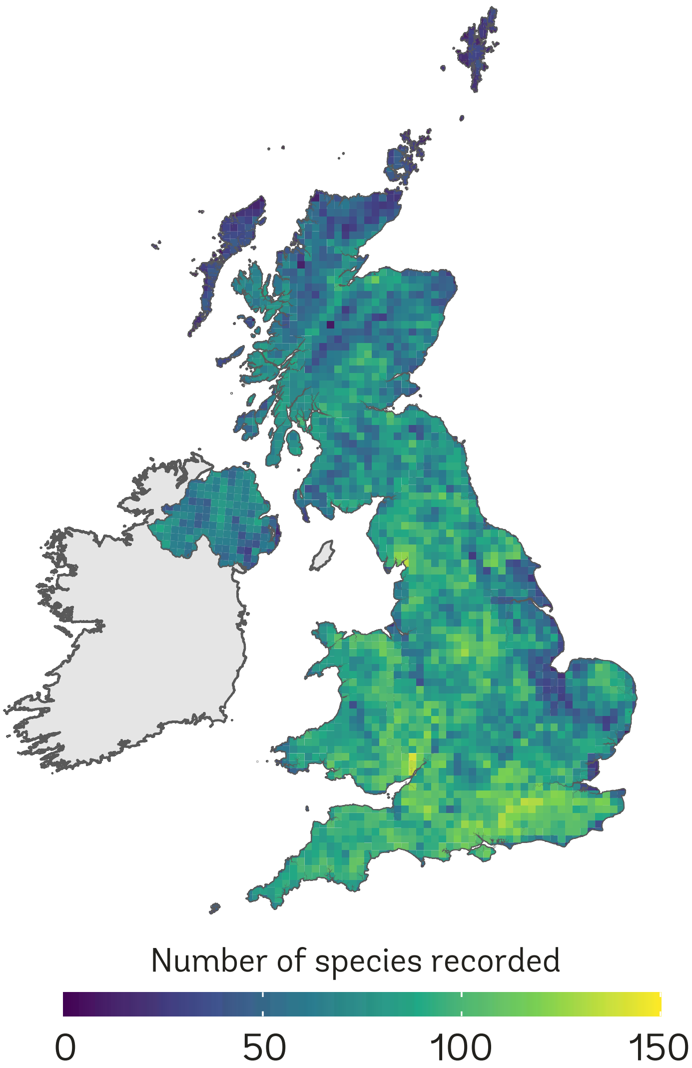


Figure 1.6.1. Woodland plant species richness per 10x10km hectad

Source: Botanical Society of Britain and Ireland[1]

Mapped woodland plant species richness strongly mirrors known hot spots of ancient woodlands (see Figure 1.1.1c), which are revealed as areas of highest importance for species-rich woodland plant communities (Figure 1.6.1). Examples include large parts of south-east England (Sussex Weald, South Downs, Surrey, Chilterns), south-east Wales and Welsh Marches. Species-rich parts of Scotland include areas like the Great Glen, Perthshire and parts of Argyll which also have relatively high ancient woodland cover. Some areas with high ancient woodland cover do not have high vascular plant species richness (e.g. parts of north-west Wales, and west coast of Scotland), but importantly, these areas are known to support an incredible richness of lower plants (mosses, liverworts and lichens) which are not considered in this analysis.

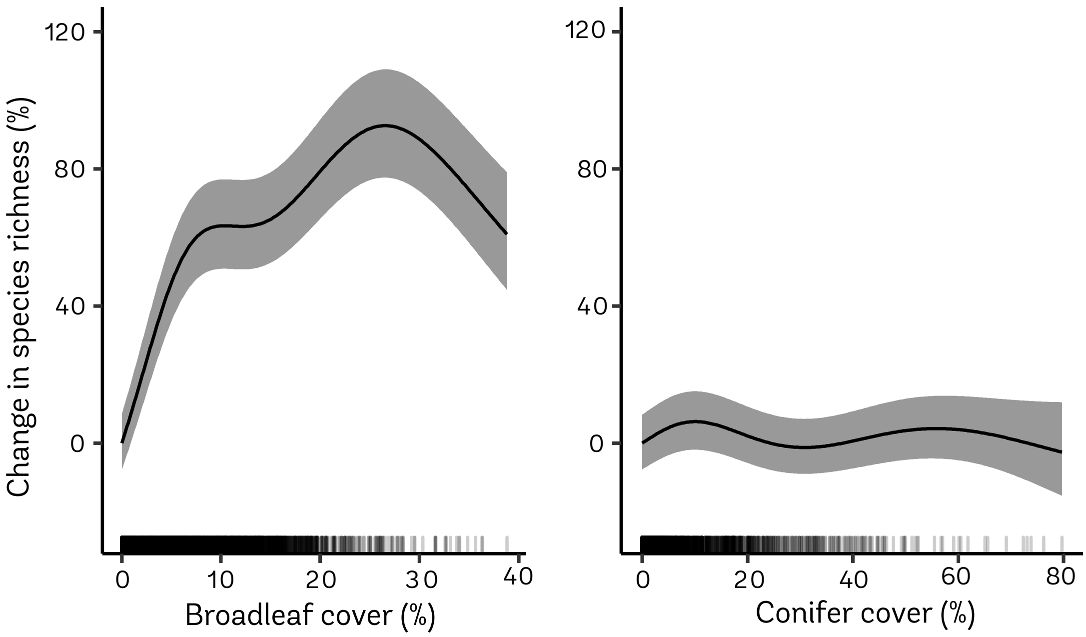


Figure 1.6.2. Percentage change in the average number of woodland vascular plant species recorded in hectads (10x10km²) with different broadleaf and conifer cover relative to landscapes with no cover of each type

Shading represents 95% confidence around the estimate, and the horizontal axis 'rugs' denote the data points informing descriptions.
Source: the Woodland Trust (unpublished)

The general relationship between the richness of woodland plants and cover of conifer and broadleaf woodland is also revealing. Woodland species richness varies greatly with differences in broadleaf cover, but is relatively constant regardless of changing conifer cover in hectads (Figure 1.6.2). The most dramatic difference occurred between broadleaf cover of 0 and 10%, whereby species richness increased by 63%. Thereafter, a more gradual increase in species richness was associated with increases up to 26% broadleaf cover. The downward trend suggested thereafter should be viewed with caution and is unlikely to be reliable, as it is informed by very few, highly influential data points (indicated by the small number of rug marks on the horizontal axis corresponding to broadleaf cover over c. 30%; Figure

1.6.2a). By contrast, there is no significant change in the average number of species recorded in landscapes with different proportions of conifer cover (Figure 1.6.2b).

It is important to note that those conifer woodlands with high vascular plant species richness likely include plantations on ancient woodland sites (see 3.7), where remnant plant communities persist from a site's history of native woodland cover. Additionally, the biodiversity of old-growth native conifer woodland may not be effectively highlighted by exploring vascular plant species richness, as the conservation value of these ecosystems may be more linked to their fungal, bryophyte, lichen and saproxylic communities.

CHRISTINE REID

New woodland located adjacent to ancient woods like this one, will help plants thrive and spread.

Why does it matter?

High species richness clearly corresponds with regions that have expansive ancient woodland cover and landscapes with high broadleaved cover more generally, which will be predominantly native tree species. This reaffirms that focus should be maintained on **protecting and restoring ancient woodland** sites as the most effective conservation action for associated woodland plants (see

4.6). Equally, the results suggest that **establishing new native woodland** in areas with currently impoverished woodland ecosystems could further support plant biodiversity.

It is important to acknowledge that this analysis does not show causation and is restricted by the selection of 192 vascular plant species as an indicator of biodiversity and the use of simple measures of woodland structure. Analyses of vascular plants also cannot highlight the important non-plant biodiversity values of some ecosystems (epiphytic lichens or insects that depend on decaying wood). It is therefore important to expand this analysis to consider other species groups and further nuances which contribute to woodland biodiversity at landscape scale.

The results suggest that an increase in richness of woodland vascular plant communities might be achieved by increasing the cover of native broadleaved woodland, but that this is not generally true for conifer woodland, which in the UK more typically exists as plantations dominated by non-native species. Many regions of particularly high woodland species richness feature abundant ancient woodland and much of the existing richness of woodland plants is likely driven by relic patterns of ancient woodland cover. It should, therefore, not be assumed that a rapid expansion of native broadleaf woodland would quickly achieve conservation aims. The natural limitations on the ability of many species to colonise new habitat suggests that locating new woodland adjacent to existing ancient woodland should take priority.

What needs to happen?

Ambitious targets: widespread native woodland cover – for example, of at least 10% native woodland cover in all appropriate hectads – will help the establishment of richer ecological communities across the UK. Currently only 28% of UK hectads have over 10% broadleaf woodland. Although the location of any new woodland is also key.

Landscape-scale management: it is vital that woodland conservation strategy is enacted at landscape scales and that management considers not only the importance and contribution of individual sites, but also how these can be combined to create ecologically rich wooded landscapes for people and wildlife.

Numbers of song thrush have declined by up to 47% since 1970.

1.7 How are woodland biodiversity indicators changing?

What do we already know?

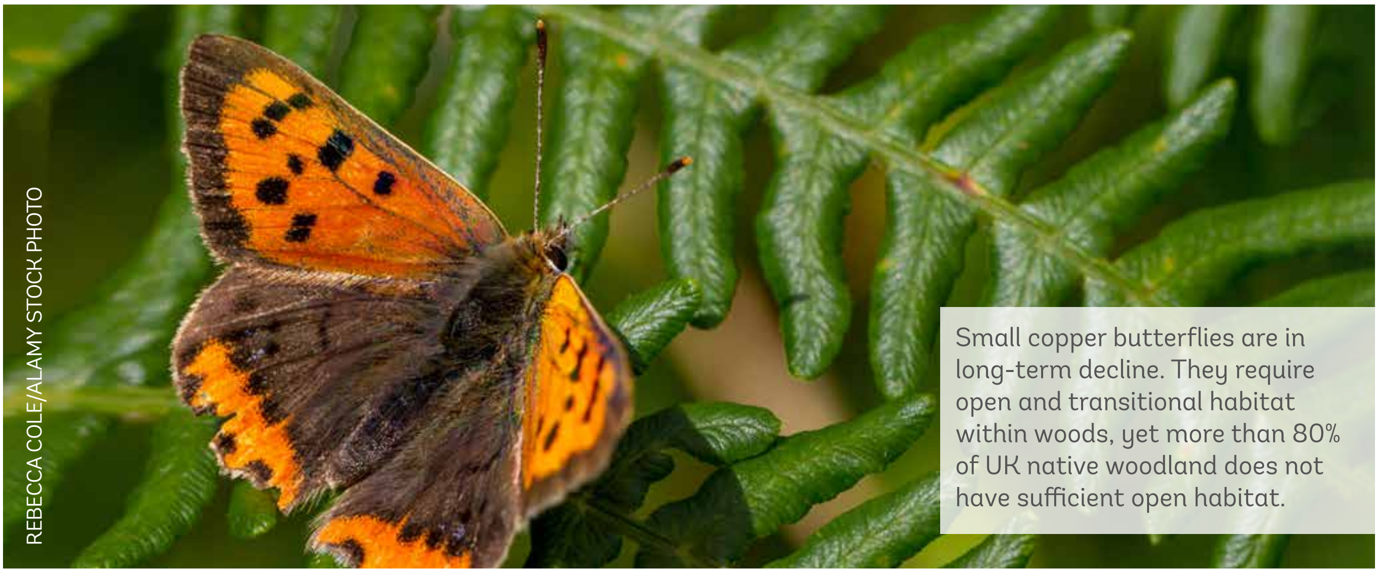
We are facing a **global biodiversity crisis** with species declines occurring at unprecedented levels. Understanding how flora and fauna are faring is core to understanding the state of our woods and trees. Despite an overall increase in the UK's canopy cover throughout the 20th century, woodland wildlife continues to decline. A key objective for woodland conservation action therefore, is to improve the biodiversity value of woodland habitats.

Biodiversity indices are a convenient approach to monitoring groups of populations such as birds, butterflies, bats and plants. These indicators can flag up underlying changes to habitats and track long-term progress of restoration and conservation activity. Here we focus on birds, butterflies and woodland plants. Work is ongoing to fill gaps in knowledge on woodland specialist bats[1].

Birds act as good indicators because they occupy a range of habitats and niches, and have well established monitoring programmes. They respond rapidly to environmental pressures that also affect many other species. Despite this, care should be taken when attempting to infer population fluctuations in other taxa.

Butterflies are also the subject of long-term monitoring programmes, and are good indicators due to their sensitivity to fine-scale changes to habitats. They are often highly specialised to a specific food source and may have limited dispersal ability, so population fluctuations can relate to local conditions – especially the degree of open habitats in woodland. To an extent, responses seen in butterflies may reflect changes among other insect species too.

Woodland biodiversity is often seen through the lens of animals; mammals, birds and insects such as butterflies often get a lot of attention. **Plants**, fungi, other insect groups and microorganisms are all vital components of biodiversity, but many of these groups lack structured monitoring programmes that can inform indices and trends. The Bunce Survey of Great Britain's woodlands is a rare large-scale, long-term survey to track changes in ancient woodland plant biodiversity over time. The survey is being repeated during 2018-2022 (see 1.8) after initial data was collected in 1971 and broadleaved sites were re-surveyed in 2001[2].



Small copper butterflies are in long-term decline. They require open and transitional habitat within woods, yet more than 80% of UK native woodland does not have sufficient open habitat.

What does this tell us?

Butterfly population trends

There has been a **41% decline in the woodland butterfly index** (which comprises 25 species) for the UK between 1990 and 2019, shown by the trend line in Figure 1.7.1. Longer-term trends are available for the habitat specialist index but the species included are not all associated with trees or wooded ecosystems. Some of the most serious long-term declines have been of butterfly species that specialise to a degree on dynamism within wooded ecosystems (for instance coppice rotation), and the important ecotones or transitions between denser wooded groves and more open habitat. Examples include pearl-bordered fritillary (*Boloria euphrosyne*), grizzled skipper (*Pyrgus malvae*) and small copper (*Lycaena phlaeas*). Some more generalist species appear to show long-term increases, for example speckled wood (*Pararge aegeria*) which has had a major range expansion, particularly in northern England. The persistence and state of many rare woodland butterflies like wood white (*Leptidea sinapis*) and heath fritillary (*Melitaea athalia*) is testament to much targeted effort from conservation and forestry organisations over recent decades.

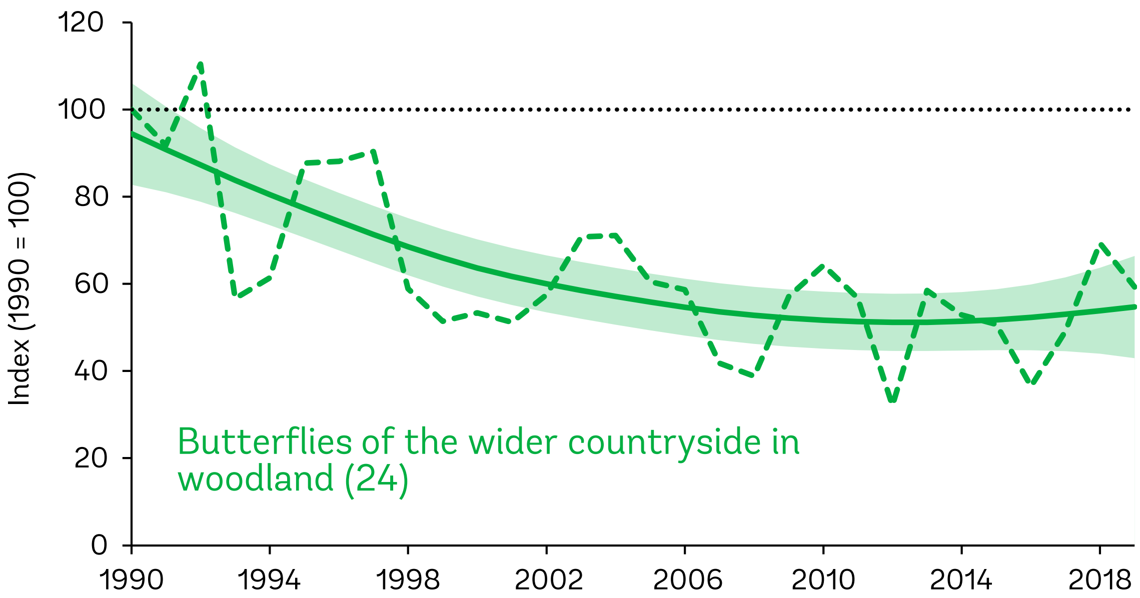


Figure 1.7.1. Trend for butterflies of the wider countryside in UK woodland, 1990 to 2019

Source: Defra (2020)[3] with permission from JNCC

Birds

The woodland bird index, comprising 37 species, was **29% less than its 1970 value** in 2018, shown by the trend line in Figure 1.7.2. Short term, between 2011 and 2017, the smoothed index decreased by 8%. However, combining 37 species into a single index hides some underlying trends. Bird species which are highly dependent on woodland habitats (woodland specialists) declined by 47%, whereas those that are found in a wide range of habitats including woodland (woodland generalists), increased by 3% in the same period. This highlights an inherent problem with grouping species into indices;

individual species trends get overlooked. Bullfinch, song thrush, dunnock and tawny owl are all 'woodland generalists' yet have declined by more than 30% since 1970 and by up to 47% for the song thrush.

Willow tit is the second-fastest declining bird species in the UK. It relies on younger wet woodland – an increasingly rare habitat across the UK.

More severe declines can also be masked by averaging, such as lesser spotted woodpecker, lesser redpoll, spotted flycatcher, capercaillie and willow tit – 'woodland specialists' that have all declined by over 80% relative to 1970 levels. In addition, UK-level data masks a more positive story for woodland birds in Scotland, which are increasing slightly.

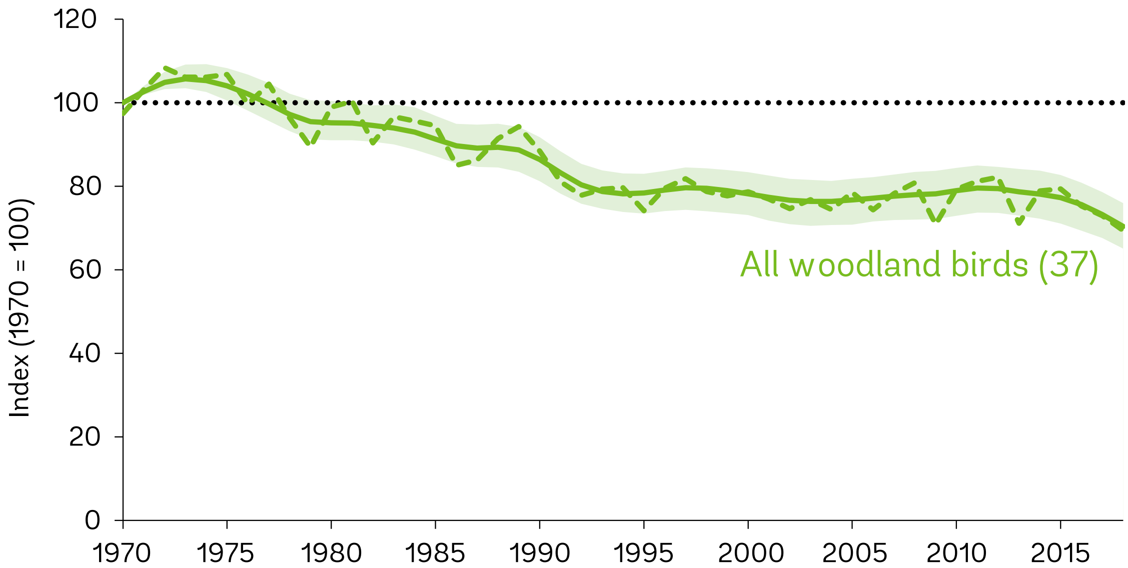


Figure 1.7.2. Trend for breeding woodland birds in the UK, 1970 to 2018

Source: Defra (2020)[4] with permission from JNCC

Since 2015 the plant index for broadleaved woodland and hedges has declined by 18%. Spreading bellflower *(Campanula patula)* is one of the plants in decline.

Plants

The National Plant Monitoring Scheme (NPMS) was launched in 2015 to monitor annual trends in the abundance of plants in habitats of conservation importance. Plants are a fundamental component of woodland habitats. Monitoring the state of woodland plants offers a glimpse into the health of the whole ecosystem and the biodiversity contained therein. A new experimental statistic has been introduced as an indicator to summarise the percentage cover (a measure of abundance) of a range of plant species at the broad habitat level. Within each habitat, plant species abundance trends indicative of good condition are averaged to provide an indication of the habitat's current state. The 'broadleaved woodlands and hedges' habitat type includes 64 species such as: foxglove (*Digitalis purpurea*), bluebell (*Hyacinthoides non-scripta*), hazel (*Corylus avellana*) and hawthorn (*Crataegus monogyna*). Since 2015 the **broadleaved woodland and hedges** index has declined by 18%, shown by the trend line in Figure 1.7.3. Use of this metric is still in its infancy so long-term trends cannot be inferred. However, this decline is also reflected in other habitat types which all remain below their 2015 levels.

Plants are a fundamental component of woodland habitats. Monitoring the state of woodland plants offers a glimpse into the health of the whole ecosystem and the biodiversity contained therein

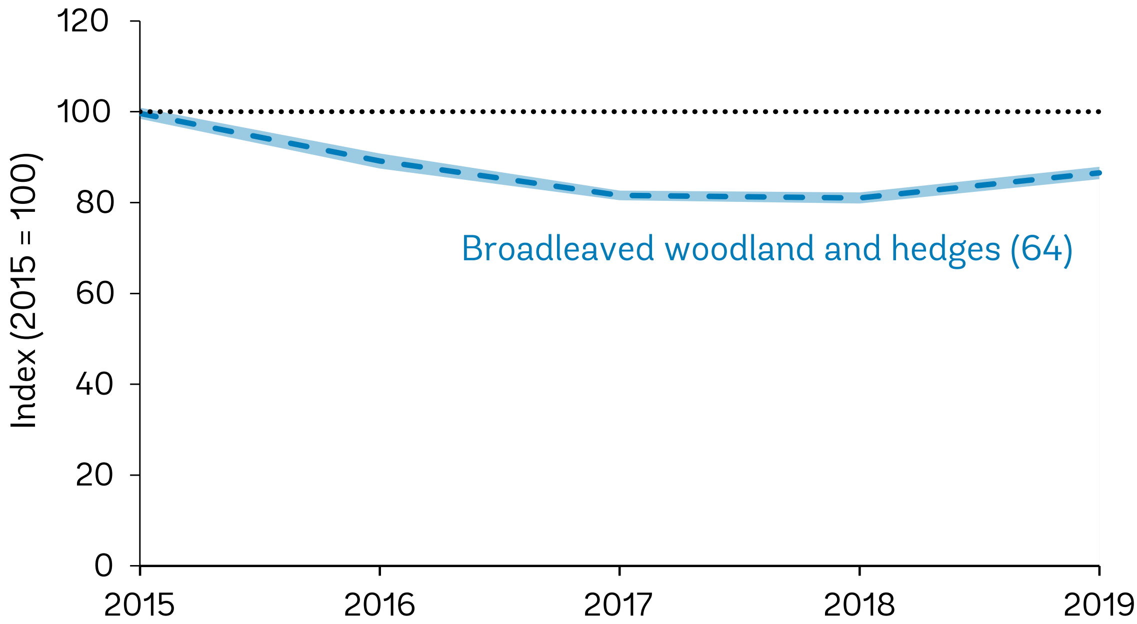


Figure 1.7.3. Trend in abundance of plant species in UK broadleaved woodland and hedges, 2015 to 2019

Source: Defra (2020)[5] with permission from JNCC

Other species indicators

Structured biodiversity monitoring data and woodland indices for other groups of species are lacking at the UK scale. However, other data collected by amateur naturalists, recording schemes and academic studies continue to reveal many important stories about species associated with woods and trees – and what they indicate.

Against the backdrop of a biodiversity crisis, it is useful to consider **which species are doing well**. Some species associated with wooded habitats and trees have seen range expansions during recent decades and have become more common. For example, a number of **moth species** have seen increases in recent decades[6], although the majority of these are generalists. Some woodland specialists are doing well, for example the northward range expansion seen by the slender brindle moth (*Apamea scolopacina*) which feeds on woodland grasses, including wood millet (*Milium effusum*) and wood-rushes (*Luzula spp.*). Unlike the slender brindle moth, which was already a resident species, some **insect species** such as the tree bumblebee (*Bombus hypnorum*) have naturally colonised from mainland Europe in recent years and are expanding northwards. However, with other rapid northward range expansions like the comma butterfly (*Polygonia c-album*) or nuthatch (*Sitta europaea*), these are likely to be linked to rapid changes in climate, and therefore need considering in terms of wider changes occurring (e.g. phenology, see 3.1).

Other species which were previously rarer or confined more or less to ancient woodland sites have also shown some recent increases. These include well-recorded tree-dwelling **lichens** like *Normandina pulchella, Dimerella lutea* and *Strigula taylorii*. Like some lichens, which have the potential to be quite mobile across landscapes, some increases have been seen by some tree-dwelling **bryophytes** like the tiny liverwort known as fingered cowlwort (*Colura calyptrifolia*). Conservation efforts and reintroduction or translocation programmes contribute other positive stories, including the recovery of goshawk (*Accipiter gentilis*) and red kite *(Milvus milvus*), as well as recent pine marten (*Martes martes*) releases in mid-Wales for example.

However, these individual success stories should not be overemphasised and some may be down to an increase in survey effort. Many species only further emphasise the **biodiversity decline**.

Some of the woodland species doing well

Tree bumblebee (*Bombus hypnorum*)

Slender brindle moth (*Apamea scolopacina*)

Elf-ear lichen *(Normandina pulchella*)

These can often suffer compounding impacts. For example the lichen *Anaptychia ciliaris* subsp. *ciliaris* was once formerly widespread and locally frequent across large parts of the UK where it occurred on well-lit roadside elm and ash trees in particular, but has decreased in many areas during the 20th century due to the combination of Dutch elm disease, sulphur dioxide pollution and the use of inorganic fertilisers. It is now largely extinct as an epiphyte in Scotland and northern England, with remaining populations now from Dorset to the Cotswolds where ash dieback is likely to exacerbate its decline. Other lichen declines (e.g. horsehair lichens *Bryoria* spp.) have occurred over the past few decades, and many are linked to nitrogen air pollution (see 3.3).

Long-term declines of some **plant species** are also revealing. Spreading bellflower (*Campanula patula*) is an example of such a plant and has suffered considerable range contraction. It is strongly associated with the more wooded areas of England and Wales, particularly ancient woodland. Direct habitat loss and widespread cessation of coppicing over the last 120 years has contributed to its decline, but like some of the woodland butterflies, it is a species of more transitional habitats and relies on certain dynamic processes within wooded ecosystems. These ecotones or blurred edges are increasingly missing in our landscapes which juxtapose completely open agricultural or other land uses against dense closed-canopy woodlands.

Hazel pot beetle (*Cryptocephalus coryli*), one of the UK's rarest insects, reliant on scrubby woodland edge habitat.

WILDPICTURES/ALAMYSTOCK PHOTO

Some **insect species** tell similar stories, such as the hazel pot beetle (*Cryptocephalus coryli*), which occurs along wooded transitions to more open heath vegetation with scattered trees. Once widespread across southern counties, it declined greatly during the last century to become one of the UK's rarest insects. Such trends not only lead to a reduction in diversity of woodland ecosystems, they also add up to a general decline in sheer numbers of individuals or bioabundance (e.g. of insect biomass)[7]. Our perceptions of a 'normal' ecosystem change resulting in shifting baseline syndrome.

Why does it matter?

To reverse long-term population declines of indicator species, woodland condition must be improved (see 1.4). This requires managing woods for a range of structures and conditions including decaying wood and other old-growth characteristics, and encouraging structural diversity and allowing veteran features to develop on aging trees. Appropriate levels of **dynamism** are required with the resulting patterns of open habitats and disturbance. Many butterflies require open and transitional spaces within woods, such as open rides and coppice, and some birds depend on decaying wood and other old-growth characteristics for nesting or feeding opportunities. Sympathetic woodland management is however, only part of the solution and must be combined with addressing other key threats and drivers of biodiversity decline (see chapter three).

What needs to happen?

Sympathetic management: encouraging woodland owners via government grant schemes and other mechanisms to use existing toolkits and advice is essential to meet the specific management requirements for a range of species. The GB-relevant Woodland Wildlife Toolkit gives advice on managing woodlands for rare or declining species that are dependent on woodland habitats. The Niches for Species model is also available which maps out habitat requirements for a range of species and relates it to native woodland.

Grants, funding and licences: some grants are available to encourage sustainable management of existing woodland to deliver local biodiversity objectives. However, there is a need to raise the profile of biodiversity as a primary objective for both grants and felling licences. Grant payments should be linked to the genuine biodiversity value of woodland.

Woodland creation for biodiversity: new woodland creation schemes should consider the long-term objectives for the site and the wider landscape to achieve tangible biodiversity gains. Woodland habitats must be designed and developed over time to support the whole range of woodland species, often in mosaics with a range of other semi-natural habitats (see 4.5).

CASE STUDY

Loch Arkaig Pine Forest

1.8 Biodiversity changes in Loch Arkaig Pine Forest

Safeguarding the future of the UK's native woods is essential to conserve their incredible wildlife and maintain the vital ecosystem services they provide. For this we need accurate data about the state of their health and the changes occurring within them. An effective and important way to achieve this is through long-term biological monitoring conducted at a landscape scale.

Few robust, long-term datasets exist at this scale. However, the **woodland 'Bunce' survey** of Great Britain, first carried out in 1971 and repeated in 2001[1,2], is one exceptional example. It is based on sampling woodland soil and vegetation within a series of 200m^2 plots at 103 broadleaved woods across Britain and 26 pinewoods in Scotland. The Woodland Trust has formed a partnership to conduct a full resurvey of all the original woods, to be completed in 2022.

This will provide an invaluable 50-year dataset, which will allow us to detect the impacts of, for example, climate change, tree disease, browsing damage and pollution which have amplified over recent years.

Some preliminary results are in, including from Loch Arkaig Pine Forest, a 1,027ha Woodland Trust and Arkaig Community Forest site which was re-surveyed in 2018. An ancient Caledonian pinewood, Loch Arkaig is a prime example of Scotland's temperate rainforest, home to rare lichens, bryophytes and plants which were recorded as part of the survey.

A **major change in tree species composition** occurred in the period between the first survey in 1971 and the latest survey in 2018, from Japanese larch as the dominant species, to Sitka spruce. Both are non-native conifer species grown as a timber crop, and represent a major threat to the natural pinewood ecosystem. Consequently, the Woodland Trust is undertaking a massive restoration project over 2020 until 2026 to sensitively remove non-native trees. A key finding was also that the proportion of **native Scots pine** remained constant. This is the flagship canopy tree in this rare ecosystem and its persistence gives hope that numbers can be increased by careful management over the coming decades.


Surveyors being trained in the survey method prior to the Arkaig survey (Professor Bunce – seated).

WTML

In terms of **plant diversity**, a greater number of species were detected in 2018, while some species were equally common across both surveys, such as blaeberry, bracken, hard fern, heather, purple moor-grass and tormentil. But the 1971 plots otherwise had a degraded field layer, consisting of bare ground and rock, birch seedlings, leaf litter and wood. In contrast, in 2018, the plots had greater coverage by bog-moss species (*Sphagnum capillifolium* and *S. recurvum*) and the moss *Hylocomium splendens*, highlighting a marked change in ground flora community composition. These are key species of a pinewood's distinctive ground layer; therefore, this signifies a very positive change.

The changes in ground flora community composition and potential increase in overall number of flora species are likely to be **positively benefiting other species**. As with all woodland ecosystems, native pinewoods don't simply comprise trees; fungi, bryophytes, lichens and flowering plants are part of a healthy woodland. Birds, mammals and invertebrates all interact with, and are dependent on, these other parts of the ecosystem.

As well as these conservation gains, the larger size of the canopy trees and prominence of Sphagnum indicates an **increase in stored carbon** and carbon capture potential in 2018; essential services in light of the current climate crisis.

This is just one woodland site that has been resurveyed as part of the nationwide Bunce resurvey. Once all sites have been resurveyed by 2022, there will be a full analysis across all sites looking at changes over the past 50 years and the potential drivers of those changes such as tree diseases and climatic changes. The outputs will increase conservation knowledge, guide future woodland management, influence policymakers and contribute to further research.

JILL JENNINGS/WTML

Chapter two

Benefits for people

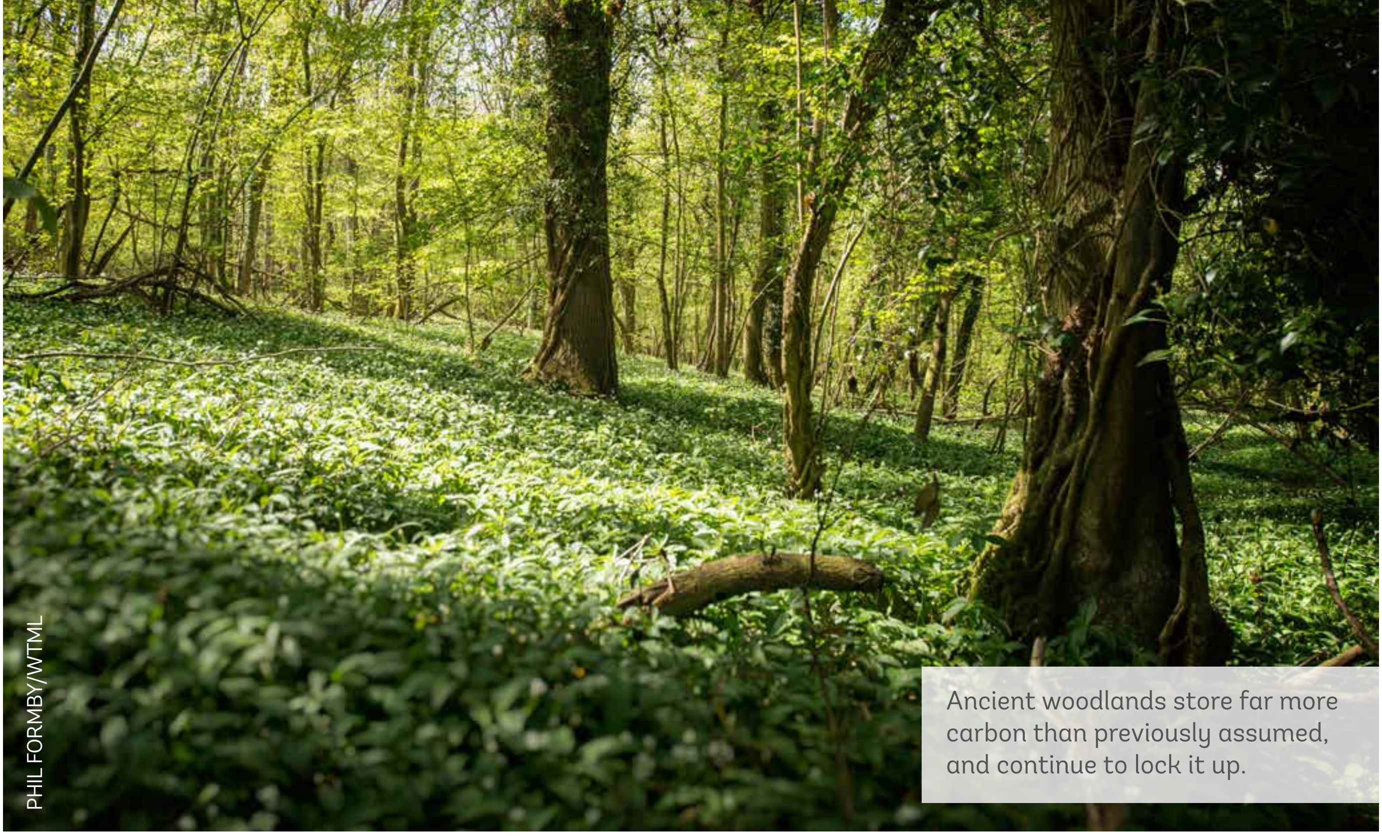
Contents

Introduction

Human life is made both possible and worth living thanks to the multitude of benefits provided by ecosystems, known as 'ecosystem services'[1]. These can be categorised as provisioning, regulating, supporting and cultural services.

Woodlands provide a unique recreational experience – an important cultural service. For almost two decades the Woodland Trust has been curating data on open access woodlands which enables an analysis of what proportion of the population has access to a wood. The Woodland Trust also has many years' experience of engaging people with woods and trees. Our work on these areas is summarised here. In future releases of this report it may be possible to include other measures of the cultural importance of woodlands, such as forest school activity and community management of woodland.

Provisioning services from woodlands, such as timber, wood fuel and food, have not been included in this first 'State of' report. Statistics on these are available from the governmental organisations for forestry and summarised as official national statistics[2, 3]. Governments also report on the regulating services of carbon storage and sequestration across all woodlands, so here we report on new data for this service specifically in the context of ancient woodlands. The various regulating services provided by urban trees (often a mix of native and non-native) are also presented along with economic valuations, which really bring home the incredible contributions that trees make to our lives.


PHIL FORMBY/WTML

Ancient woodlands store far more carbon than previously assumed, and continue to lock it up.

2.1 How much carbon is being stored and sequestered by ancient woodland?

What do we already know?

Woods and trees are one of the best ways to remove carbon dioxide from the atmosphere and store it for the long term. Creating new woodland has therefore been promoted as a tool for mitigating climate change[1].

There has been less focus on the important role of existing woodland. However, we do know how much carbon is currently stored in all of the UK's existing woodland[2], but until now we were unsighted on how much carbon is stored in *ancient* woodland and its potential for further carbon capture.

About the data

The **National Forest Inventory (NFI)** provides a record of the size, distribution and other key attributes of forests and woodlands in Great Britain. Here, we summarise the total carbon stored in living trees on sites classified as ancient woodland in Great Britain. The calculated estimations of carbon are broken down by country

(England, Scotland and Wales), and principal tree species. Further details can be found at the National Forest Inventory, including the NFI Survey Manual.

Information on the location and extent of ancient woodlands in Britain was obtained from the **Ancient Woodland Inventories (AWIs)** of England, Scotland and Wales. These open source datasets are maintained by Natural England, NatureScot and Natural Resources Wales, respectively (data.gov.uk). For this analysis, the Scotland ancient woodland dataset *included* the categories 'Long-Established (of plantation origin)' and 'Other (on Roy Map)'.

The AWIs include ancient semi-natural woodland (ASNW), plantations on ancient woodland sites (PAWS) and open habitat on ancient woodland sites. The Wales AWI includes the categories Restored Ancient Woodland Site (RAWS) and Ancient Woodland Site of Unknown Category (AWSU). Areas that are no longer woodland are removed.

There are various inaccuracies and caveats with the AWIs: only some regions include ancient woodland less than 2ha in size (thus creating an underestimate of carbon storage), and there is some erroneous classification of ASNW or PAWS, which could lead to small differences in carbon storage estimates compared with reality.

Estimating total carbon in woodlands requires information on both woodland area and woodland characteristics (number and size of trees). The NFI has access to this information from two databases: (1) the sub-compartment database (SCDB) for the public forest estate woodland and (2) the NFI database for the private sector woodland. The SCDB is updated annually and is maintained by the relevant public forest body for each country, i.e. Forestry England, Forestry and Land Scotland and Natural Resources Wales. The NFI database is maintained by Forest Research and is updated on a rolling five-year basis. Combining these two databases enables the estimates of total carbon to be split between two broad ownership categories (as described above). Estimates are given in millions of tonnes of carbon, which should not be confused with the alternative measure of carbon storage: megatonnes carbon dioxide equivalent ($MtCO_2e$).

Carbon is defined as carbon stored in *all living plant material* in both the above and below ground parts of trees that have a mean diameter (at breast height) of 7cm or more. This includes major roots, stumps, stems, branches, twigs and foliage. The estimates do not include carbon in young trees that have not grown to this minimum mean diameter, nor carbon in the stems of coppice that are harvested before reaching this minimum mean diameter. Also excluded is carbon in standing dead trees, growing saplings and seedlings, shrubs (except shrubs growing with the morphology of trees), other ground layer vegetation, lying deadwood, litter, soil, harvested wood products and substitution effects (e.g. avoided emissions by using timber in place of steel).

Estimating carbon sequestration potential is largely based upon the approach taken to harvesting. Typically, different harvesting strategies are used across different ownership types, to forecast future sequestration potential. However, in the current study, a single management scenario, zero intervention, is adopted to produce the forecasted estimates for ancient woodland under both public and private sector ownership. Zero intervention assumes no harvesting (felling or thinning) of any stand over the forecast period. This decision was made because ancient woodlands are unlikely to be managed as a productive forest; they may be located in areas assigned a formal conservation designation and they may have a legally protected status. Investigating numerous alternative management scenarios was beyond the scope of this report – although it is acknowledged that PAWS sites may undergo restoration, with owners of such sites encouraged to gradually transition from plantation forestry to more natural composition of native species. The forecast system uses Forestry Commission growth and yield models to predict future growth and consequent future standing volumes.

What does this tell us?

Carbon stores

The total amount of carbon (in living trees) in ancient and long-established woodland sites across Great Britain is estimated to be 77 million tonnes. This equates to 40 million tonnes in England, 27 million tonnes in Scotland and 10 million tonnes in Wales (Figure 2.1.1). This compares with total carbon in *all forests and woodlands* in Great Britain of 213 million tonnes. For England this is 105 million tonnes, for Scotland, 85 million tonnes and for Wales, 22 million tonnes.

Although ancient and long-established woodland in Britain makes up only 25% of all woodland, it holds 36% of all woodland carbon (in living trees)

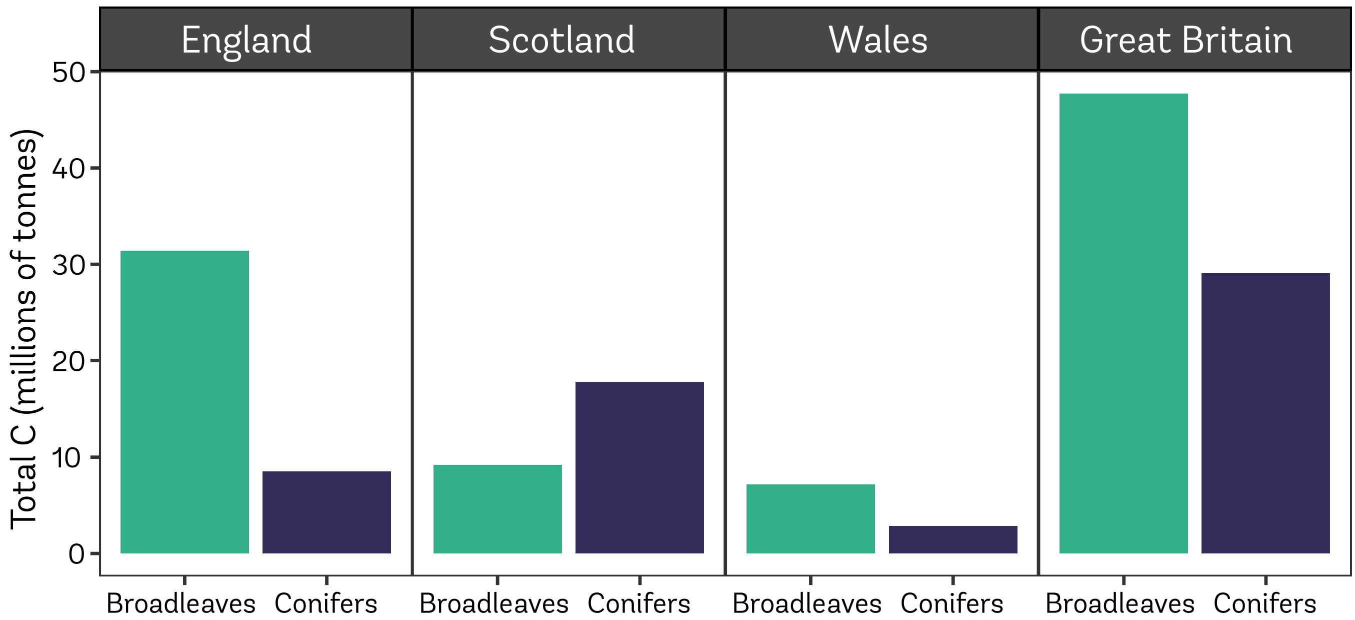


Figure 2.1.1. Comparison of the total carbon stocks in ancient and long-established woodland by broadleaves/conifers in Great Britain and the three countries

Source: Forest Research (in prep)

JILL JENNINGS/WTML

The total amount of carbon (in living trees) in ancient and long-established woodland across Great Britain is estimated to be 77 million tonnes

Carbon is defined as carbon stored in all living plant material in both the above and below ground parts of trees (including major roots, stumps, stems, branches, twigs and foliage), in trees with a mean diameter (at breast height) of 7cm or more.

The majority of ancient woodland carbon is stored within broadleaf tree species (62%) as compared to coniferous tree species (38%) (Figure 2.1.2). This is based on both the relative carbon storage of the different species of tree and the estimated amount of each species within ancient woodland in Britain.

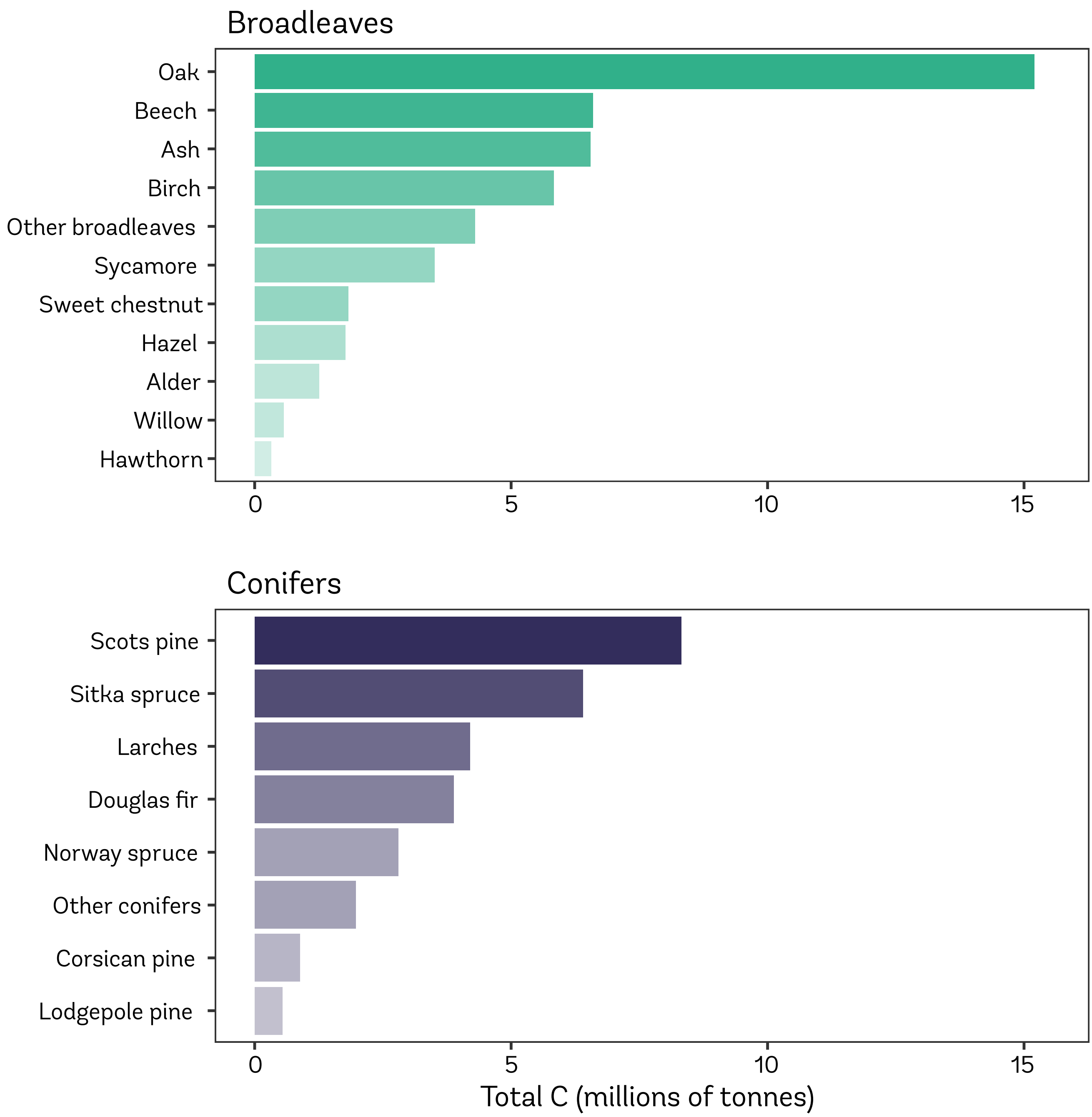


Figure 2.1.2. Total ancient and long-established woodland carbon stocks in Great Britain by broadleaved (top) and coniferous (bottom) tree species

Source: Forest Research (in prep)

Average carbon stocks per hectare in Britain's ancient woodland are 37% higher than the average for all woodland types (Table 2.1.1). Note this difference would rise considerably if ancient woodlands themselves were taken out of the national average for all woodland, which could be calculated with further analysis. Furthermore, the average carbon stock per hectare of Scotland's ancient woodland rises considerably (to 99 tonnes per hectare) if the LEPO sites are excluded from the amount of ancient woodland, primarily because LEPO sites contain more open unwooded areas. At a country level, the average carbon stocks per hectare are higher in ancient woodland than all woodland:

36% higher in England

31% higher in Scotland

47% higher in Wales

This reflects the relative maturity of the different woodland types and differences in current management practices.

Table 2.1.1. Average total carbon stock (tonnes per hectare) in ancient and long-established woodland and all woodland

Source: Forest Research (in prep)

Type	England	Scotland	Wales	Great Britain
Ancient and long-established woodland	110	76	105	95
All woodland (recent and ancient woodlands)	80	58	72	69

Sequestration potential

Carbon stocks in ancient woodland are set to double over the next 100 years from c. 77 million tonnes to c. 155 million tonnes (Figure 2.1.3). This scenario is based on a no-harvest approach (see 'about the data') and reflects the amount of ancient woodland containing younger trees that still have strong growth and sequestration ahead of them. Annual carbon sequestered by ancient woodland in Britain is circa 1.7 million tonnes per annum.

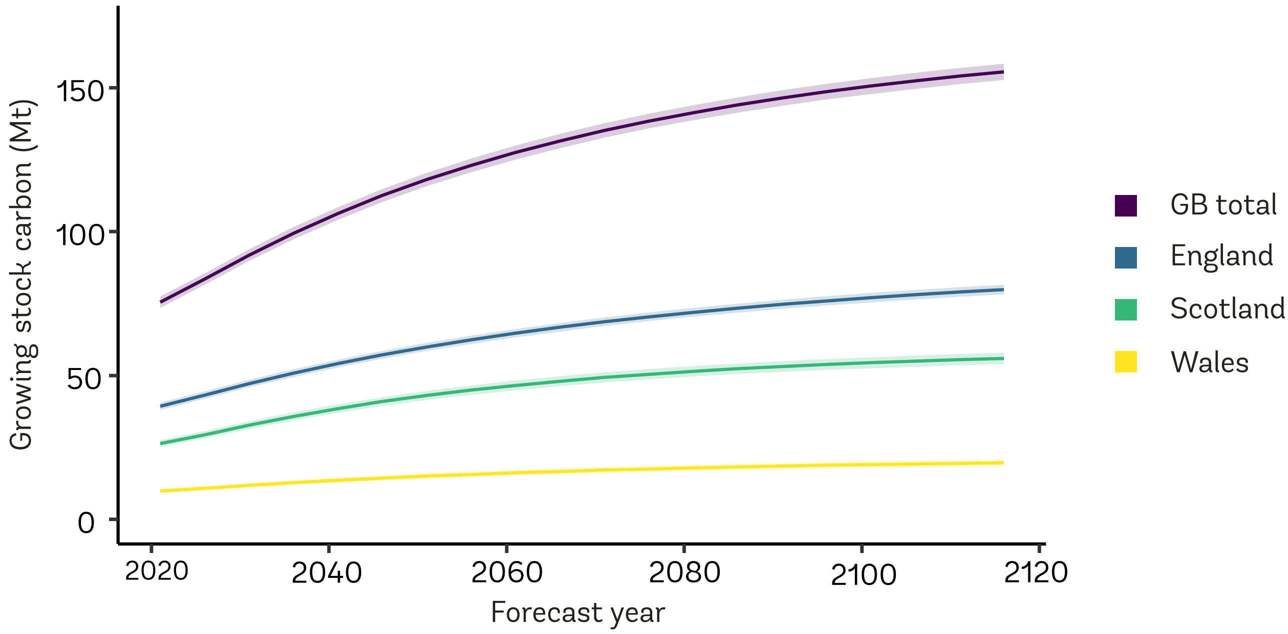


Figure 2.1.3. The 100-year forecasts for average annual growing stock volume in ancient and long-established woodlands in Great Britain, England, Scotland and Wales

Source: Forest Research (in prep)

Why does it matter?

The findings provide strong evidence of the **undervalued role that ancient woodland plays** in Britain's carbon balance (storage and sequestration). Ancient woodland has a disproportionately significant role compared to other woodland types, underlining the need to protect this irreplaceable resource, for its carbon as much as its wildlife.

The higher carbon storage per hectare in ancient woodland is principally due to ancient woodland having higher numbers of older and larger trees than other woodlands – with a higher component of broadleaved tree species.

Carbon stocks in ancient woodland are not static: they are projected to double over the next century as they continue to sequester carbon in both actively growing younger trees and larger older trees.

Soil is also a very important carbon store in its own right and it is hypothesised that undisturbed **ancient woodland soils**, on average, retain more carbon than more regularly disturbed soils, e.g. those used for commercial forestry, but more research is needed.

What needs to happen?

Recognition: in addition to wildlife and cultural values, ancient woodland needs to be recognised as a huge carbon store with great potential to lock up more carbon in future.

Protection: land use policies to mitigate climate change need to focus on protection of ancient woodland (from direct losses and more insidious threats like disease and browsing), not just creation of new woodland. These figures underline the irreplaceable nature of ancient woodland – one more reason there should be no further loss.

Soil carbon data: data on carbon stored and accumulated by soils in ancient woodland was not included in this analysis, but this would further increase the importance of ancient woodland as a carbon store.

In ancient woodland, oak holds almost twice the amount of carbon as any other tree species (see Figure 2.1.2).

CASE STUDY

These flumes are part of a Lancaster University project seeking to understand water run-off related to vegetation change in the uplands. The V-flumes capture rainfall data and map that against flow rates in the flume.

2.2 How are trees slowing the flow in Cumbria?

The UK is becoming wetter[1] and climate change has **increased the risk of floods**[2]. Extended periods of extreme winter rainfall in the UK are now about seven times more likely due to climate change[3]. Trees, hedges and woodland are **natural solutions** to reduce the risk of extreme flooding events as their leaves intercept water and their roots slow the flow through soil[4,5]. Nevertheless, there was much attention and debate around the efficacy of planting trees in Cumbria's upstream catchments after the devastating floods of December 2015, which was the wettest since 2010[6].

There is no comprehensive UK data on progress with natural solutions to flooding, but we present here collaborative initiatives in Cumbria which demonstrate that **working with natural processes** can benefit water, wildlife and people. In Cumbria, the Woodland Trust has partnered with Rivers Trusts, Cumbria Wildlife Trust, RSPB, Natural England, local communities, farmers and larger estates to demonstrate in practice the benefits of trees, alongside other landscape interventions, to reduce flood risk and create habitats for wildlife. Technical advice has been provided by Lancaster University and ecological support from South Lakes Ecology.

Approximately **250,000 trees were planted** across 400ha close to the village of Mallerstang and 60,000 trees across 126ha on Tebay Common. Simultaneously, the project invested in the local economy via the use of local contractors and in national biosecurity by using trees from UKISG accredited tree nurseries.

The tree-planting was complemented with **other interventions**, such as the exclusion of livestock to enable natural regeneration of vegetation, giving a rougher surface to intercept more water. Degraded peat bog habitats are being restored and around 70 small-scale woody dams have been placed on water courses. These measures will help slow the flow of water to areas prone to flooding by keeping it higher in the catchment for longer. The roots of the new trees and shrubs will help decrease compaction in the soil, which in turn will improve the permeability to water[7].

Similar to a beaver dam, these man-made leaky woody dams create temporary storage in high flow situations. In normal flows, water is allowed underneath the stream dam, but as flows increase, water is held back. Multiple small dams reduce peak flows.

Nature-based solutions such as these are an investment and it can take many years to reap the rewards. Despite this, after just eight years there is a marked decrease in speed of water flow. The ground within the sites is wetter and the overland flows in high rain events are slower, leading to less direct water transfer to watercourses. There has also been **a notable increase in biodiversity**. A range of native flora has returned – bird's-foot trefoil *(Lotus corniculatus)* and yarrow *(Achillea millefolium)* with heather (*Calluna vulgaris*) and bilberry (*Vaccinium myrtillus*), are early colonisers. Rare species such as black grouse *(Lyrurus tetrix)* have shown signs of flourishing, as have moths, voles and owl populations. Small birds including meadow pipits *(Anthus pratensis)*, whitethroat *(Sylvia communis)* and tree sparrow *(Passer montanus)* are increasing in abundance.

Rare species such as black grouse *(Lyrurus tetrix)* have shown signs of flourishing.

There are ongoing projects to **monitor the response** of biodiversity and water flow, using flumes and telemetry as part of a Natural Environment Research Council (NERC) funded project to quantify the impacts of natural flood management.

Nationally, there is a lack of monitoring or metrics for the benefits of trees, hedges and woodland on flood management. Measuring such multifaceted outcomes can be difficult due to the range of factors at play. However, without monitoring we will be unable to evaluate the impact of interventions over time, or assess which set of interventions deliver the highest impact for people, nature and hydrological landscapes.

What needs to happen?

Consistent monitoring: monitoring of the impact of different woodland creation and management measures on flood risk reduction and biodiversity improvement.

Incentives: nature-based solutions to reducing flood risk e.g. well-placed woodland creation in target catchments should be incentivised to encourage landowner collaboration.

NICK PATTERSON/WTML

Woods and trees are good for our health and wellbeing.

2.3 What access do people have to woods?

What do we already know?

Woods and trees are good for our health and wellbeing. Many of us feel this intuitively, but there is also a large body of research to back this up. It shows that access to woodland can make us physically healthier, improve mental wellbeing and increase quality of life[1]. The coronavirus pandemic and resulting lockdowns have brought into even sharper focus the importance of green space for recreation. Of 2,000 people polled in April 2020 for Natural England's People and Nature survey[2], 89% agreed or strongly agreed that green and natural spaces are good places for mental health and wellbeing, and 87% agreed that 'being in nature makes me happy'.

Moreover, the closer our homes are to green spaces, the more likely we are to use them. This is why the Woodland Trust is committed to making the case for **accessible woodland close to where people live**. We want people to enjoy and value woodland, not only for their own benefit, but for the benefit of our woods and wildlife too. A valued wood is more likely to be looked after. While a variety of accessible green space is important for people, woods provide unique opportunities. Their visual prominence can create a balance between the built and natural environment, especially in urban areas. They can welcome large numbers of visitors without detracting from the experience. And as they are such rich natural habitats, they make for exciting and inspiring places to visit. Trees outside woods in urban areas are also important for a variety of reasons and this is covered in section 2.4.

The Woodland Trust has lobbied for **better woodland access** for many years. By creating and caring for more woods near people's homes, we have provided many new opportunities to get out and explore woodland. But in many parts of the UK, significant numbers of people still do not have any nearby woodland they can visit. The reasons are twofold: many woods are under private ownership and have no permissive access, or there is insufficient woodland cover altogether. And to compound the issue, public funding through grants for provision of woodland access has been cut substantially in recent years.

To identify areas of deficit, the Woodland Trust has been gathering data on accessible woodland for more than a decade. Here we provide the results of our latest analysis on the amount of access people in the UK have to woodland close to their homes. It is of interest to a range of people, including policymakers, health professionals and planners.

About the data

The analysis uses accessible woodland data, along with data on overall woodland cover and population census data. Accessible woodland data comes from the **Woods for People project**, begun by the Woodland Trust in 2002 in partnership with the Forestry Commission. The aim was to produce a comprehensive inventory of accessible woodland across the UK. Since then, data has been updated regularly in a programme managed by the Woodland Trust, with the latest update in 2019-2020. The database includes both privately and publicly owned accessible woodland sites.

The first analysis of population-level access to woodlands was published in 2004 by the Woodland Trust in *Space for People*. The analysis was repeated using data from 2009, 2012 and 2016, and has now been repeated again using data from 2020, which is presented here. Results from previous analyses aren't directly comparable, as underlying datasets for UK woodland area and population have changed between analyses. Furthermore, the accessible woodland dataset has grown over time due to more landowners engaging with it rather than actual changes in their wood's access. Caution is therefore advised when looking at change over time.

The Woodland Trust's **Woodland Access Standard** forms the basis for the figures presented here on population-level access to woods, which essentially sets out performance against the standards by district, county and country. The Woodland Access Standard aspires that:

- no person should live more than 500m from at least one area of accessible woodland of no less than 2ha in size; and
- there should also be at least one area of accessible woodland of no less than 20ha, within 4km (8km round trip) of people's homes.

To assess the proportion of the population able to access woods within the aspirations of the Woodland Access Standard, 500m and 4km buffers were extended around accessible woods that met the respective size thresholds. The proportion of the population falling within these buffers was then calculated using census data, showing the percentage of population with access to a 2ha wood within 500m and a 20ha wood within 4km.

The Woods for People data was overlaid with data for total woodland area, and used to calculate the proportion of people who might have access to woods if those areas that are not currently deemed accessible were opened up. For the 2004 and 2009 analyses this was the National Inventory of Woodland and Trees (NIWT). This has been replaced with the more comprehensive National Forest Inventory (NFI), which was used for analyses in 2012 and after.

The remaining proportion of population is that which still would not have access to woodland, even if all woods were made accessible, due to lack of woodland cover. This percentage population figure, taken in conjunction with assessment of the spatial distribution of accessible woodland in any geographical area, can enable further work to assess the scale and location of further woodland creation that might be needed to provide access for all.

Full technical details of the processes used to derive these figures are not set out in this document but are available if required from the Woodland Trust.

What does this tell us?

The results of our latest analysis (Table 2.2.1), show that in 2020 16.2% of people in the UK had access to a wood of at least 2ha within 500m of their home, and 66.6% had access to a wood of at least 20ha within 4km of their home. This is down from 21.1% and 72.7% in 2016. These observed changes are due to removal of woods from our accessible woods database, including a large number of woods that were previously receiving grants to allow access. Although new woods have been added over this time, they have not balanced out these losses.

An additional 37% of the UK's population would have a local accessible wood if access rights were given to existing woods and 22.8% would gain access to a larger wood within driving or cycling distance. For a large proportion of the population (41.8%), there are no 2ha woods, accessible or otherwise, within 500m of their home. New woodlands with public access would therefore need to be created.

These figures are available at local authority level from the Woodland Trust, but see Figure 2.1.1 for an indication.

Only 16.2% of people in the UK have access to a wood of at least 2ha within 500m of their home

Table 2.3.1. Provision of woodland access and population requiring new woodland at country level across the UK

Source: the Woodland Trust

Region	% of population with accessible wood		% extra population if inaccessible woods included		% population requiring new woodland	
	2ha within 500m	20ha within 4km	2ha within 500m	20ha within 4km	2ha within 500m	20ha within 4km
England	16.0	65.5	35.8	23.0	42.8	6.0
Northern Ireland	10.3	59.2	25.5	19.5	58.5	15.7
Scotland	19.4	75.6	46.4	20.2	31.6	1.6
Wales	18.3	73.6	48.8	24.6	32.6	1.5
UK	16.2	66.6	37.0	22.8	41.8	5.7

MICHAEL HEFFERNAN/WTML

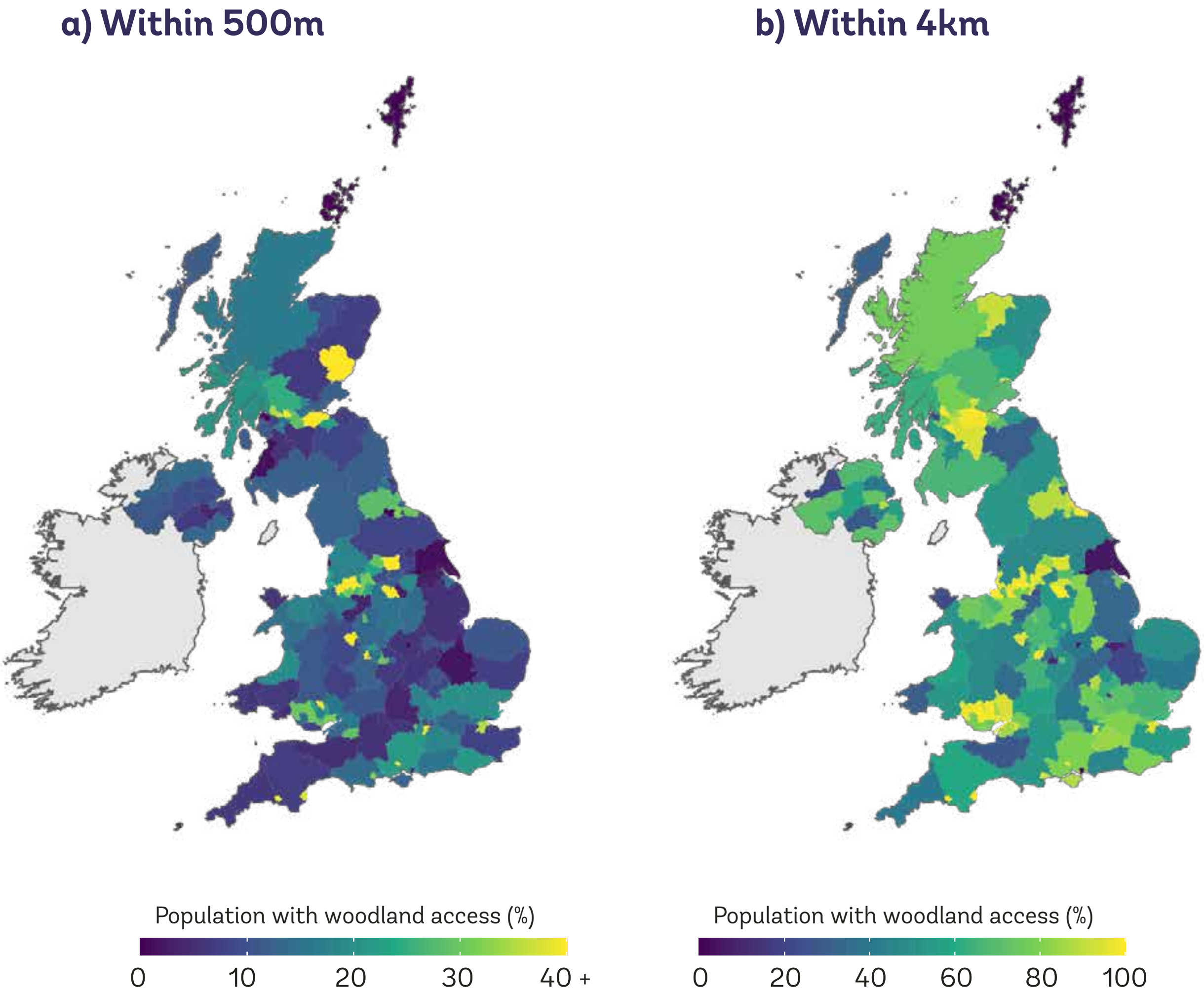


Figure 2.3.2. Percentage of population with access to (a) a wood of at least 2ha within 500m of home and (b) a wood of at least 20ha within 4km of home by administrative area

Source: the Woodland Trust

Why does it matter?

The more that people visit woods and are inspired to connect with nature, the better chance there is of protecting woodland habitats and the wonderful wildlife that depends on them – for example through increased membership of conservation organisations.

The benefits of outdoor access for both physical health and mental wellbeing are well recognised. People spending time in natural green spaces could deliver considerable cost savings for the health service. Suitable green space, including woodland, near to where people live, is necessary to provide such opportunities.

What needs to happen?

Targeted incentives: accessible woodland is needed in areas with the greatest deficit. These areas could be identified by using the Woodland Trust's accessible woodland data in combination with socio-economic data.

Requirements for planners: planning guidance should include requirements for the creation of new woodland within walking distance of residential areas.

Accessible woodland in local plans and strategies: new developments offer the opportunity for creation of appropriate green space, including woodland. The accessible woodland data should be used to underpin tree and woodland strategies and address the need for more accessible woodland in local plans and core strategies, green space strategies and green infrastructure implementation plans.

BEN LEE/WTML

2.4 What are the benefits provided by urban woods and trees?

What do we already know?

Over 80% of the UK population lives in urban areas, yet perhaps few of those people either notice or knowingly appreciate the many values of the trees and green spaces around them. The **urban forest** includes individual trees – from newly established to ancient – as street trees, riverine trees, hedgerows, copses and in parks and woods. The urban forest delivers a multitude of benefits to people's lives and the wider environment[1].

The growing scientific literature is increasing our understanding of how, when and why trees and urban greenspaces are good for us. Trees, thoughtfully **integrated with development**, can be positive elements of urban infrastructure[2], including through improvements to air quality, noise levels, temperature extremes and water management. Trees act as green barriers which disperse air pollutants and reduce exposure to them (but the relationship is not always straightforward)[3,4]. There is also substantial evidence of the **health benefits** of trees[5]. Overall, the potential rewards of greener towns and cities are tantalising, but how close are we to achieving them?

About the data

Measuring canopy cover is often recognised as a first step in understanding the urban forest and is used as a proxy for its benefits. An overall picture of UK urban trees is gained from the UK urban canopy map[6] led by Forest Research. This attempts to determine urban canopy cover at the electoral ward scale, through online assessments by volunteers. The project has been running since 2019 and is ongoing, providing freely downloadable data.

In addition to broad-scale canopy cover measures, the i-Tree Eco tool has been the most influential approach to assessing the state of the UK's urban forest, including structure and composition, while also quantifying benefits. **New surveys** are being completed at pace with around 21 towns and cities now assessed, with six (Manchester, Plymouth, Cambridge, Exeter, Cranbrook, Sheffield) either being undertaken or released in the past year; these can be monitored at Urban Tree Cover. In some areas of the country, local authorities have digitally mapped the trees in their care[7].

What does this tell us?

The UK canopy cover map indicates an **average urban canopy cover** of around 16%, with around 49% of electoral wards assessed so far. Canopy cover varies widely across the country; in some places as low as 2%, but occasionally 40%, and upwards to 80%. A recent analysis suggests uncertainty around current trends, with a mixed picture of canopy cover change between 10 towns and cities[8]. Also, trends are levelling out with a low chance of reaching existing targets; the recent two decades tending to show no statistically significant change, or slightly declining canopy cover.

Average urban canopy cover is around 16%

The **i-Tree Eco surveys** estimated that two thirds of all trees and shrubs were on private property[9], but in a review of 12 UK urban tree surveys[10], between 21% and 75% of the trees in each location were found to be growing on public land. The number growing as street trees varied between 0% and 16%.

The urban forest and the **ecosystem services** it provides can be measured at different scales, from whole metropolitan areas to university campuses. Some examples include Greater Manchester[11], Wrexham County Borough[12] and the University of Leeds[13]. Table 2.4.1 quantifies the assets and gives a replacement cost (a measure of value) for the urban forest. Table 2.4.2 gives economic values for some benefits of woods and trees that can be quantified. At these different scales, surveys of urban forests tell us different things. In Leeds, the campus-level survey highlighted, for example, which 'top' individual trees were contributing the most in terms of services, and also showed that most canopy cover was concentrated in one park.

Table 2.4.1. Headline figures from three i-Tree Eco surveys[11-13]

Factors measured	Greater Manchester	Wrexham (County Borough)	University of Leeds
Number of trees	11,320,000	364,000	1,450
Tree canopy cover	15.7%	17%	17.5%
Shrub canopy cover	7.8%	11%	-
Most common species	Hawthorn, sycamore and English oak	Sycamore, hawthorn, silver birch	Sycamore, common lime and ash
Replacement cost	£4,776,020,361	£900,000,000	-
Species recorded	192	54	137

Table 2.4.2. Economic values for four benefits of woods and trees in a range of urban settings.*[11-13]

Factors measured	Greater Manchester		Wrexham		University of Leeds	
Carbon storage[a]	1,573,013 t	£374,935,529	65,773 t	£14,000,000	540 t	£126,800
Carbon sequestration[b]	56,530 t	£13,474,180	1,329 t	£278,000	18 t	£4,200
Pollution removal	847 t	£17,331,207	60 t	£700,000	0.143 t	£3,798
Avoided runoff	1,644,415 m^3	£2,493,504	270,000 m^3	£460,000	550 m^3	-
Total annual benefits		£33,298,891		£1,440,000		£134,798

* Service amounts and economic valuations change all the time, so caution is advised when comparing surveys conducted in different places

[a] Carbon bound up in the above-ground and below-ground parts of woody vegetation

[b] Removal of carbon dioxide from the air by plants through photosynthesis

Why does it matter?

A holistic view of an urban forest is required to best address the needs of the local environment – via the right tree, in the right place, for the right reasons. We need to address location specific issues, for example increasing tree cover in areas of high social deprivation and locating trees where they can provide the most benefits.

The urban forest consists of lone trees through to urban woodlands, including those in private ownership, such as gardens. The rise in i-Tree surveys is improving our understanding of the state of the UK's urban forest, allowing comparisons between towns and cities.

Communities play an important role in standing up for urban trees

The Grantham oak, an ancient tree now in an urban setting, valued and cared for by the community.

TESSA CHAN/WTML

What needs to happen?

Increased canopy cover: trees and associated habitats should be a primary component of the green infrastructure of all urban areas. All urban areas should maintain and/or increase the urban tree canopy, where this will deliver benefits for people and wildlife. For example, the Woodland Trust encourages local authorities to commit to a minimum of 30% tree canopy cover for new development land.

Accessible knowledge: understanding the urban tree canopy is essential for a good urban tree strategy. The urban forest should be evaluated by several indicators, including size and age structure, and species diversity in addition to canopy cover. i-Tree surveys enable the benefits of urban trees to be quantified.

Resources for delivery: urban tree strategies need people to drive forward their implementation. Lost trees can take generations to replace, and the establishment and maintenance of trees in hard landscapes is technically challenging. We need tree officers and urban woodland managers who are well-resourced in terms of time, money and skills.

Empowerment: the public must be enabled to engage constructively with local planning from a good knowledge base about the benefits of trees.

CASE STUDY


PHIL FORMBY/WTML

2.5 How is the Woodland Trust engaging schools and communities with trees?

What do we already know?

Planting trees is a very tangible action and directly contributes to mitigating against climate change. It also engages people with nature, taking them on a practical learning journey to becoming more environmentally responsible citizens. As children and young people are our decision makers of the future, it is particularly important that they learn how to care for and protect the environment. There are several organisations involved with school engagement and some long standing initiatives, such as the Royal Forestry Society's Teaching Trees programme. The Woodland Trust's work to engage young people and communities with woods and trees includes[1]:

- the Green Tree Schools Award*
- free trees for school grounds and community projects**
- tree-planting and other events on our sites

*The Woodland Trust Green Tree Schools Award is generously supported by players of People's Postcode Lottery, who help us engage with schools across the UK.

**Current tree pack funders include Sainsbury's, Joules, players of People's Postcode Lottery, Lloyds Bank, Bank of Scotland and Sofology. Defra has funded 100,000 trees over four years (as well as funding Tree Tools for Schools) with a grant of £1.8 million.

About the data

The Woodland Trust maintains databases on tree pack orders and schools that have taken part in Woodland Trust activities or enrolled on our Green Tree Schools Award. These were consulted and are summarised here.

What does this tell us?

The Woodland Trust has been working with schools for over 15 years. During this time we have engaged a total of 23,033 schools – over 70% of all UK schools. This increases year on year, as more schools become engaged with woods and trees and their local environment. The total figure is derived from looking at all children's nurseries, pre-schools, primary, secondary and sixth form colleges who have worked with us on any of our school engagement projects.

As a result of the Woodland Trust's work, **over 40% of all UK schools are registered on the Green Tree Schools Award**, which inspires pupils about woods and trees. Schools are rewarded for completing environmental projects such as tree-planting, reducing CO_2 emissions and visiting woods. Schools collect points for each activity they complete, progressing through bronze, silver and gold levels up to the prestigious platinum award. Currently 12,830 schools have registered on the award, with 3,706 at bronze, 1,691 at silver, 1,466 at gold and 156 at platinum.

Around 23% of all UK schools have applied for one or more free tree packs from the Woodland Trust since 2017 (Table 2.5.1). Schools may plant trees on the school grounds or on nearby accessible land. The Woodland Trust also provides free tree packs to community groups for planting on publicly accessible land. The uptake of this scheme is a good demonstration of public engagement with trees and demand for accessible treed areas for outdoor enjoyment. Over the past three years the Woodland Trust has supplied around one million trees annually to more than 5,000 organisations. In 2019 the 1,100,850 trees planted by schools and community groups made up over a quarter (27%) of all the trees planted through the Woodland Trust that year.

Table 2.5.1. Number of community groups and schools that had successful applications for free tree packs in 2017-2019 and the total number of trees provided

Source: the Woodland Trust

Year	Number of community groups	Number of schools	Number of trees
Autumn 2017	1,000	2,182	557,805
Spring and autumn 2018	2,009	3,599	979,890
Spring and autumn 2019	2,543	3,876	1,100,850

Why does it matter?

People's lack of exposure to, and connection with, nature has massive repercussions for the environment. Connection to nature and environmental awareness are associated with positive behaviour and actions[3, 4]. In order to protect the world's natural habitats and wildlife from loss to development, intensive agriculture, climate change, pollution and other threats, the environmental movement needs to grow and strengthen. An important element of this is educating and inspiring the environmental guardians and conservationists of the future. Children who learn about woods and trees are much more likely to grow up to be environmentally responsible adults.

Children who learn about woods and trees are much more likely to grow up to be environmentally responsible adults

RICHARD FAULKS/WTML

What needs to happen?

Changes to curricula: core teaching curricula should incorporate learning about the UK's woods and trees, to better connect young people with the natural world and improve their physical, mental and social wellbeing.

Provision for outdoor learning: a six week (minimum) entitlement to an outdoor learning experience (for example the Green Tree Schools Award or Forest School[4]) for all primary-aged children across the UK.

Nature in school grounds: all new school builds should include an outdoor area with trees and woodland areas either in, or in close proximity to school, and accessible by the school and local community.

Funding: government and other funding is required to support the environmental education of the next generation.

Chapter three

Threats and drivers of change

JAMES READER

Contents

Introduction

Against the backdrop of global crises for climate and nature, our woods and trees are facing a huge array of threats. The Global Assessment Report on Biodiversity and Ecosystem Services identified the five key drivers of harmful change in ecosystems as: changes in land and sea use; direct exploitation of organisms; climate change; pollution; and invasive alien species[1]. UK woodlands are suffering from these same pressures. Built development and transport infrastructure are still resulting in loss of precious ancient woodlands and further fragmenting semi-natural habitats; climate change is impacting on the timing of nature's seasonal events; pollution from ammonia emissions is eroding woodland ecology; and invasive pests and diseases are killing trees and altering natural woodland composition. The list goes on.

Measuring threats (and their impacts) can be difficult. Climate change, for example, is complex, affecting ecosystems in a multitude of ways. It is also difficult to obtain a complete picture. For example, measuring the amount of nitrogen deposition in a wood does not show the effect that nitrogen deposition is having on the species community within it. We must, therefore, be pragmatic and make use of available data to draw inferences on the deeper impacts of the threats facing woods and trees. Where we don't have complete information, we must adopt a precautionary approach, aiming to reduce and remove threats wherever they occur to give our woodland ecosystems a fighting chance.

We have drawn upon data from a variety of sources to report on this range of threats, and present a new analysis of deer distribution to understand where impacts will be greatest and, therefore, where to target management. The legacy of non-native conifer plantations on ancient woodland sites (PAWS) remains a major threat to the wildlife and ecology of ancient woodlands, so figures are provided on the area of ancient woodland that is damaged by plantation forestry. Invasive non-native species are another serious threat to woods, as highlighted by condition assessments of legally protected woodland wildlife sites (see 1.6). But UK-wide data on invasive species in woodlands outside protected sites is not available. We discuss one such problematic species, *Rhododendron ponticum*, and a potential methodology to obtain accurate distribution data at a UK scale.

3.1 What does phenology tell us about climate change impacts?

What do we already know?

Accelerated climate change is widely recognised as one of the greatest threats to natural systems across the globe. There is substantial evidence that the UK climate is already warming[1] as well as projections of milder, wetter winters and hotter, drier summers during the 21st century[2]. Phenology – the study of the timing of seasonal events – is one of the simplest mechanisms for tracking changes in plant and animal behaviour due to climate change[3].

In the UK, the annual timing of seasonal events is recorded by volunteers contributing to the Nature's Calendar[4] citizen science project, also referred to as the UK Phenology Network. These records are stored in a phenology database. Currently, there are no professional national phenology networks in the UK, such as the one coordinated by the German Meteorological Service (Deutscher Wetterdienst).

This section only covers one element of known climate impacts on the state of woodland and trees. Shifts in climate space for species; increasing frequency of extreme weather events; increasing drought, fire risk, and the influence of climate on pest and pathogen threats are other major impacts, some of which are discussed elsewhere in this report.

About the data

Nature's Calendar has been run by the Woodland Trust in partnership with the UK Centre for Ecology & Hydrology (UKCEH) since 2000. The project has amassed nearly three million records, including historical phenology records from the UK, such as Robert Marsham's Indications of Spring dating back to 1736[5], and those from the Royal Meteorological Society National Recorder Network which ran from 1875–1948[6]. The records are of the timings of key seasonal events for a variety of common trees, shrubs, flowers, birds, insects, grasses, amphibians and a fungus. The data is made freely available for research purposes and is used to study the impact of climate change on UK wildlife.

Each phenology record consists of a location (latitude and longitude) and the date that a recorder first notices the seasonal event occurring. Data is available for a variety of tree species, many of which are common woodland species, although for the Nature's Calendar project they can be recorded in any environment (garden, urban, parkland, woodland, etc).

These phenology records are analysed alongside the Hadley Centre Central England Temperature (HadCET) dataset, which provides monthly temperatures representative of a roughly triangular area of the UK between Lancashire, London and Bristol, dating back to 1659[7].

What does this tell us?

Relationship between temperature and the timing of seasonal events

The **UK Spring Index** is calculated annually, using Nature's Calendar data, as one of the Joint Nature Conservation Committee (JNCC) UK Biodiversity Indicators[8]. Its specific purpose is to highlight a biological response to climate change.

The Spring Index is calculated as the annual mean UK observation date for the following species and events:

First flowering of hawthorn *(Crataegus monogyna)*

First flowering of horse chestnut *(Aesculus hippocastanum)*

First recorded flight of an orange-tip butterfly *(Anthocharis cardamines)*

First sighting of a swallow *(Hirundo rustica)*

These species were selected for the Spring Index because they are common and easily identified species, with a good UK distribution, for which a strong phenological response is observed. Data is also available for these species and events for the period 1891–1947, allowing a historic comparison to be drawn.

The UK Spring Index varies widely from year to year (Figure 3.1.1) but shows a strong relationship with average March–April temperatures: the index is earlier when the average temperature is higher. The index advances more rapidly when the average March–April temperature is equal to or exceeds 7°C. Despite the year-to-year variation in the Spring Index, when comparing the current 1998–2019 period to the historic 1891–1947 period, the Spring Index has become, on average, 8.4 days earlier[8].

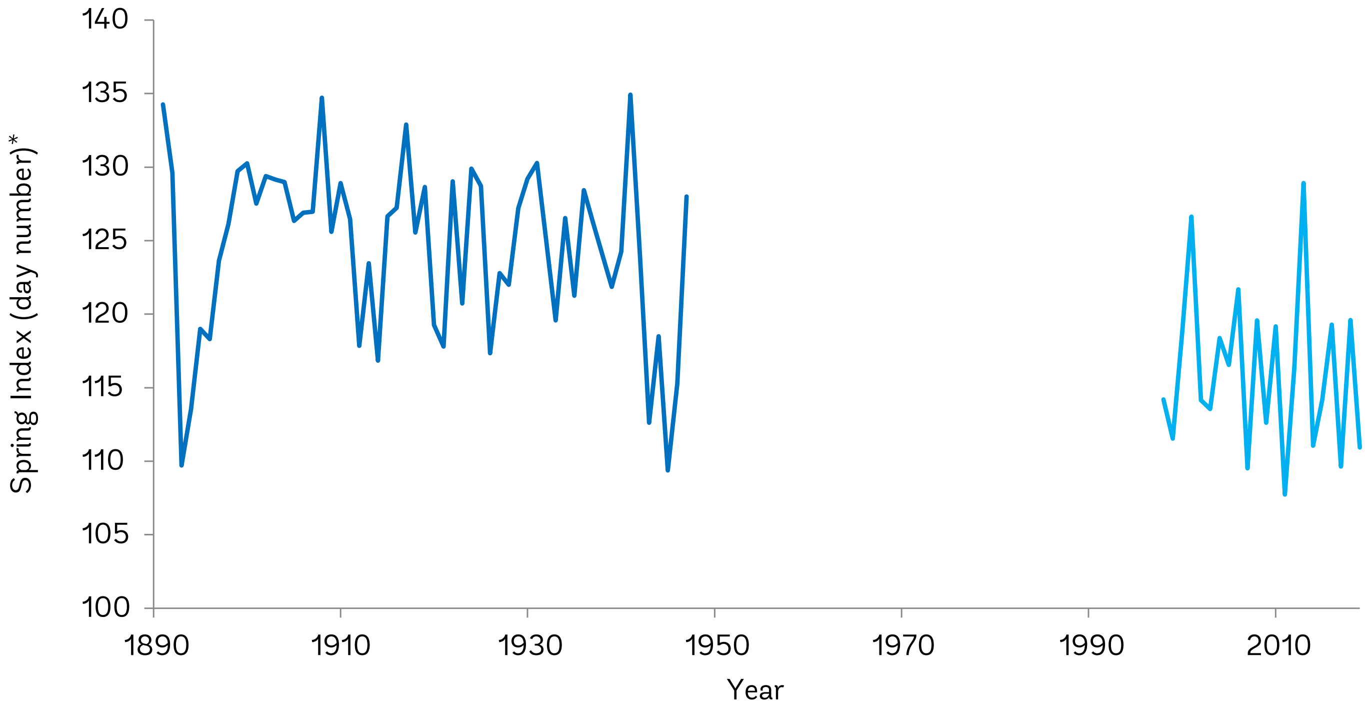


Figure 3.1.1. UK Spring Index 1891–1947 and 1999–2019. On average, the index is 8.4 days earlier during the more recent period

*Number of days after 31 December (e.g. day 121 = 1 May).

Source: Defra (2020)[8] with permission from JNCC

Similarly, a study using Nature's Calendar data to derive a **250-year index of UK first flowering dates** (for 405 plant species, including several tree species) found that the index was 2.2–12.7 days earlier in the most recent 25-year period of the study compared to any other consecutive 25-year period in the study, going back to 1760[9]. The index correlated with the February–April temperature, and was five days earlier for every 1°C increase in temperature.

Although these two indices include non-tree species, a similar response to spring temperatures was found in a recent analysis of

20 years (1999–2018) of **Nature's Calendar tree data**[10]. The date of first leaf for elder (*Sambucus nigra*), hawthorn (*Crataegus monogyna*), silver birch (*Betula pendula*) and pedunculate oak (*Quercus robur*) was on average six days earlier for every 1°C increase in mean temperature (for the temperature in the two months prior to the month of first leaf for each species).

Why does it matter?

The evidence presented illustrates that **climate change in the UK** is already having an impact on the timing of seasonal events for woods and trees, especially those in spring.

Climate change, through altering tree phenology, is having a negative effect on breeding success

In warmer springs, oaks leaf earlier, causing an earlier peak in caterpillar abundance. However, blue tit chicks hatch too late to take full advantage of peak caterpillar numbers.

KIM TAYLOR/NATUREPL.COM

Not all species respond to temperature changes to the same degree, which can **cause a 'mismatch'** in the timing of food availability between different levels of food chains[11]. Changes to the timing of tree leafing have been shown to have repercussions further along the food chain. Oak-leafing records used to investigate the impact of warmer springs on the tree-caterpillar-bird food chain showed that in warmer springs oaks leaf earlier, which correlates with an earlier peak in caterpillar abundance. This creates a mismatch with breeding birds, such as blue tits, great tits and pied flycatchers, where chicks hatch too late to take full advantage of peak caterpillar numbers. There was also variation in the extent of the mismatch between the three bird species as some were less able to adapt by shifting their breeding phenology[12]. The 'normal' timing of these events has been found to have a positive impact on both the quality and quantity of chicks produced[13].

This negative effect on breeding success is a clear example of how climate change altering tree phenology may lead to population decreases caused by mismatched timing higher up the tree food chain.

What needs to happen?

More climate impacts research: the Nature's Calendar dataset is a valuable tool for continued research on the impacts of climate change on phenology. The significance of climate change as a threat and driver of change to woods and trees warrants continued wider research which integrates climate and ecological sciences.

Action to tackle climate change: without concerted action to address climate impacts, mismatch in breeding success and higher prevalence of pests and diseases (see 3.4) spell bad news for woodland wildlife.

ROB CALLENDER

Many people feel strongly about activities which damage woodlands – such as the destruction of ancient woodland caused by building the High Speed 2 train line – and take action, such as this protest.

3.2 How is development threatening ancient woods?

What do we already know?

Ancient woodlands are rare, irreplaceable ecosystems (see 1.1). Yet they are still being destroyed.

By the mid-20th century, the majority of ancient woodlands had been cleared to make way for human development, agriculture, or commercial forestry. Those areas that are left urgently need protecting from any further loss. Developments, such as roads, railways, housing, agriculture and leisure activities, can destroy ancient woodland, both directly through conversion of land use and indirectly through damage to the woodland.

With each ancient woodland lost, we lose a part of our cultural heritage and the special wildlife that depends on it

Despite the importance of ancient woodland for biodiversity and our cultural heritage, and the small extent that remains, protection from human destruction is weak and poorly enforced. There is no blanket legislative protection covering all ancient woodland – only some are designated as Sites of Special Scientific Interest and protected under this system. Planning policy is devolved to the constituent countries of the UK, each of which include slightly different provisions for protecting ancient woodland from adverse impacts as a result of development (see box below). Large infrastructure projects, such as the High Speed 2 rail network, are considered as "wholly exceptional" under these policies on the basis that "the public benefit would outweigh the loss or deterioration of habitat". As well as those woods subject to the 'wholly exceptional' clause, there are still many ancient woodlands under threat from indirect impacts as well as poor application of national and strategic planning frameworks by local planning authorities.

Development can impact ancient woodland either directly or indirectly. Direct loss refers to actual removal of trees and vegetation and a change of land use. Indirect loss is much more insidious: pollution in the form of noise, light, dust or chemicals gradually alters the conditions of the wood, affecting its plants and other wildlife. Fragmentation is another form of indirect loss, as it can cut woods off from each other, thereby preventing the movement of species to and from the wood.

Planning policy in the UK

As with much of UK policy, planning issues are devolved to each of the four countries of the UK. They all recognise ancient woods and trees as important habitats warranting protection from development.

In **England**[1], **the National Planning Policy Framework** (NPPF), updated in 2018, includes a provision that "development resulting in the loss or deterioration of irreplaceable habitats (such as ancient woodland and ancient or veteran trees) should be refused, unless there are wholly exceptional reasons" (paragraph 175c).

The **Strategic Planning Policy Statement for Northern Ireland**[2] (SPPS), published in 2015, notes that "planning permission should only be granted for a development proposal which is not likely to result in the unacceptable adverse impact on, or damage to, known ancient and long established woodland…A development proposal which is likely to result in an unacceptable adverse impact on, or damage to, habitats, species or features listed above may only be permitted where the benefits of the proposed development outweigh the value of the habitat, species or feature" (paragraph 6.192 and 6.193).

Scottish Planning Policy, published in 2014, states that "ancient semi-natural woodland is an irreplaceable resource and ...should be protected from adverse impacts resulting from development". It also notes that "The Scottish Government's Control of Woodland Removal Policy includes a presumption in favour of protecting woodland. Removal should only be permitted where it would achieve significant and clearly defined additional public benefits" (paragraphs 216–218).

Planning Policy Wales, edition 10 published in 2018[3], also notes that ancient woodland and trees are irreplaceable and includes a proviso that "such trees and woodlands should be afforded protection from development which would result in their loss or deterioration unless there are significant and clearly defined public benefits" (paragraph 6.4.26).

About the data

Since 1999, the Woodland Trust has been recording cases of ancient **woods under threat from development.** The Woodland Trust is not a statutory consultee; therefore, data is based on specially trained volunteers who scour weekly planning lists for potential cases, as well as information shared by members of the public. The figures presented here, therefore, represent only the cases that were reported to the Woodland Trust, and the actual number of ancient woodlands impacted by development will inevitably be higher. Data is not available on the area of woodland lost to development, as this is sometimes part of a wood, not the whole wood, and the area isn't always reported. Trends in the number of cases over time are not looked at, but this could be done in the future.

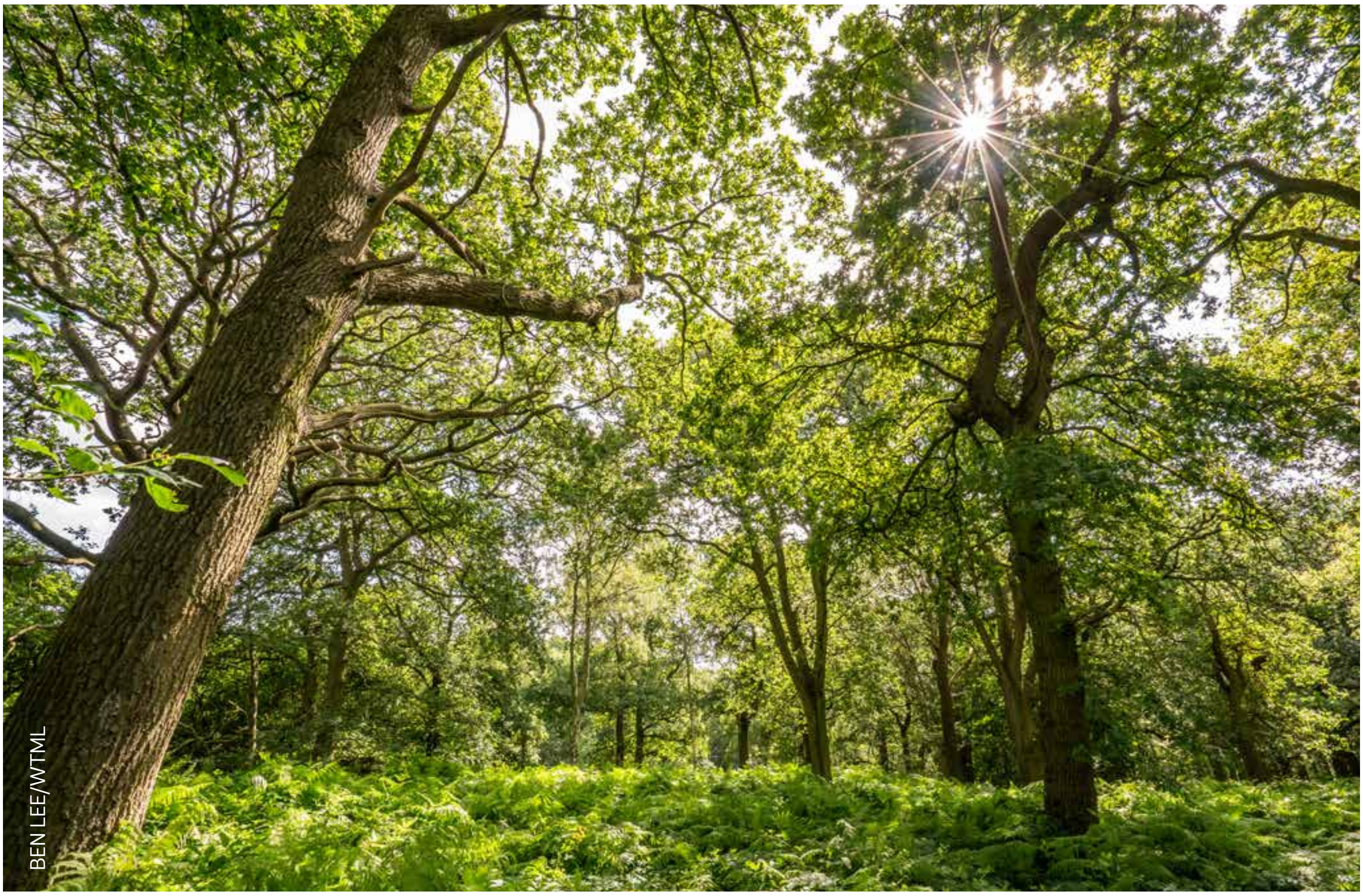
Cases are recorded under one of three categories: **saved, lost, or ongoing**, along with the type of threat. Woods are recorded as 'saved' if the planning application is withdrawn, which may be the result of campaigning effort by the Woodland Trust and local community (note that the same wood may come under threat again in the future) or the local authority refuses the application and this decision isn't appealed. If the development went ahead and the wood was destroyed or damaged, either wholly or partly, the wood is recorded as 'lost'. Ongoing threats refer to planning applications that the Woodland Trust is aware of that affect ancient woodlands, which are currently being considered or on hold awaiting further information.

What does this tell us?

Since the Woodland Trust began recording in 1999, as of July 2020, 1,225 ancient woods are currently under threat from development, while 981 are known to have been permanently lost or damaged. On a more positive note, over this period 1,186 woods are known to have been saved from development threats – at least for now.

Almost two thirds of all historic cases of woods under threat are from England (Table 3.2.1), and this is still the case with current woods under threat. This is despite the protection afforded to ancient woods in England since the National Planning Policy Framework was reformed in 2018. Anecdotal evidence suggests that this is because although the number of applications threatening direct loss of ancient woods has decreased, the number of developments adjacent to ancient woods, which would cause indirect impacts, has increased by a corresponding amount. In England, 12% of the woods currently under threat are threatened by High Speed 2. Wales has a higher proportion of woods saved than lost, while the opposite is true in Scotland (Table 3.2.1).

The biggest current threat to ancient woodlands is from *site allocations*, which are areas designated by local planning authorities for residential and industrial developments (Table 3.2.2). However, these are complex cases and this data requires updating. Planning applications for *housing, roads, agriculture, utilities* and *railways* pose the next biggest threats. Together, these six threats account for 80% of current woods-under-threat cases.



Irreplaceable ancient woodland (top image) remains under significant threat from direct loss due to road building (bottom image), which also results in indirect impacts to remaining habitat from noise, pollution and fragmentation.

Table 3.2.1. Country breakdown of ancient woodlands under threat from development that have either been saved, were lost, or are still currently under threat, since Woodland Trust records began in 1999

Source: the Woodland Trust

Country	Saved	Lost	Currently threatened
England	743	612	800
Scotland	102	270	274
Wales	337	98	149
Northern Ireland	4	1	2
Total	**1,186**	**981**	**1,225**

Table 3.2.2. Top six threats: number of ancient woodlands saved, lost or currently threatened by threat type, since Woodland Trust records began in 1999

Source: the Woodland Trust

Threat type	Saved	Lost	Currently threatened
Site allocations	369	108	362
Housing	267	345	178
Roads	146	61	144
Agriculture	29	49	143
Electricity / Gas / Water / Telecommunications	64	131	140
Railways	9	1	108

Saved: the development was either rejected or it was approved with suitable mitigation in place to ensure there would be no impacts on ancient woodland or veteran trees.

Lost: the development has been approved and will result in loss or damage to ancient woodland or a veteran tree.

CAMBRIDGE AERIAL PHOTOGRAPHY/ALAMY STOCK PHOTO

Once built, roads become a permanent barrier between fragments of ancient woodland and wildlife struggles to survive.

Why does it matter?

Any loss of, or damage to, ancient woodland by development destroys irreplaceable wildlife habitat that is also of huge importance to our culture and heritage. Only a small extent of ancient woodland remains – just 2.5% of the UK's land area.

Many species of plants, animals and fungi are highly dependent on ancient woodlands due to the stable conditions they provide and their sheer longevity, which has led to intricate relationships evolving. These species often have poor dispersal ability, so do not colonise new areas readily, and due to their very specific requirements, they may be easily outcompeted by more generalist species. Ancient woodlands are their stronghold and last refuge. Every ancient woodland impacted by human development reduces the area available for these species and threatens their survival. Add to this the importance of ancient woodland as a carbon store and its carbon sequestration potential (see 2.1), which will help mitigate climate change, and there should be no cause to destroy such a rare and valuable habitat.

Any loss of, or damage to, ancient woodland by development destroys irreplaceable wildlife habitat

Although our ancient woodlands have existed for thousands of years, they have very rarely been untouched by people. They are the very definition of **cultural landscapes**, influenced by nature and people throughout history. Our ancient landscapes, including woods and wood pastures, are irreplaceable artefacts of history, culture and ecology overlaid and interwoven.

What needs to happen?

No further loss: there should be no further loss of ancient woodlands. In order to achieve this, opportunities to strengthen their protection must be taken. Giving them full legal protection should be explored in recognition of their immense value that cannot be recreated or replaced.

Watertight national policy: government policy must be strong and clear on when development is acceptable or not, and well-enforced with support for local planning authorities. Action to enable the economy to recover from Covid-19 must not mean deregulation that further jeopardises existing protections.

Improved ancient woodland inventories: up-to-date/complete inventories of ancient woodlands across the whole of the UK are needed to be able to identify all ancient woodlands and protect them (including those under 2ha which have been excluded in the past).

Transparent monitoring: threats to ancient woodlands from planning applications, and loss or damage, should be reported by statutory nature conservation bodies to provide a full and clear picture across the UK. This is currently being undertaken by the Woodland Trust, a charity with limited resources, that is not a statutory consultee.

More research: developers often apply a 15-metre buffer around ancient woodlands, but more research is needed on what buffer sizes are best to protect ancient woodlands from nearby developments.

Ammonia (NH_3) is a form of nitrogen air pollution affecting woods. Agriculture accounts for 88% of ammonia emissions in the UK, with most emissions from livestock manures, particularly cattle and expanding poultry and pig industries.

TRACEY WHITEFOOT/ALAMY STOCK PHOTO

3.3 How is nitrogen air pollution affecting woods?

What do we already know?

Nitrogen (N_2) is everywhere; it is an essential part of life on earth, produced naturally and found in all living things. In its inert form, nitrogen is one of the main constituents of our atmosphere. But human activities, namely industrial and agricultural development, have resulted in immense changes to natural nitrogen cycling. As a result, other forms of nitrogen are created and dispersed with consequences for human health, ecosystems and climate change. Excess nitrogen has many impacts on the natural world and the recent global biodiversity assessment by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)[1] highlighted **reactive nitrogen in the environment** as one of the most significant threats to global biodiversity. Impacts on UK woodlands are widespread and directly affect many plants and fungi, with implications for wider ecosystem functioning, resilience and services[2–6]. Nitrogen pollution impacts are often hidden, complex or indirect, but are ubiquitous, and all result in the deterioration of UK woodlands.

The UK has made improvements in air quality since the 1970s, with the recent State of The Environment: Air Quality[7] reporting that nitrogen oxide (NO_x) emissions have reduced by 72%. NO_x mainly comes from industrial processes and vehicles. **However, emissions of ammonia (NH_3) continue to increase**. In 2016, agriculture accounted for 88% of all UK ammonia emissions, with the largest contributions from livestock farming, especially cattle and the expanding pig and poultry industries. Much of these agricultural emissions are unregulated.

About the data

Pollution loads and levels data was provided by the UK Centre for Ecology and Hydrology. The **critical load** relates to the quantity of pollutant deposited from air to the *ground* – in this case, total nitrogen deposition. It is a quantitative estimate of the amount below which significant harmful effects do not occur. Data is available to track trends of critical loads for different woodland types in different countries of the UK.

The **critical level** is the gaseous concentration of a pollutant in the *air* – in this case, ammonia (NH_3). This is the concentration of ammonia in the atmosphere above which direct adverse effects may occur. For ammonia concentration in air, the critical level for sites where lichens and bryophytes (mosses and liverworts) are an integral part of the ecosystem has been set at 1.0μg NH_3/m^3 (micrograms of ammonia per cubic metre of air) as an annual mean.

What does this tell us?

Total nitrogen deposition

Using established critical loads, it is clear that **nitrogen deposition is a significant and widespread issue for UK woodlands**. All woodlands in England exceed the critical load (Figure 3.3.1), and it is, therefore, assumed that these ecosystems have deteriorated as a result and their ecological integrity compromised. There has been no change to this between 1996 and 2017. Within Wales, just over 99% of all woods exceed the limit and 96% in Northern Ireland; there has been little change in the area affected in either country over the last 20 years. In comparison, large areas of Scotland still have relatively lower levels of nitrogen deposition (Figure 3.3.1). Although 60–70% of Scotland's woodland area exceeds the critical load, there are some specific exceptions: only 18.8% of native Scots pinewoods, which are found in more mountainous regions with less agricultural land use, currently exceed the critical load. Importantly, since 1996 there has been a 42% reduction of native pinewood area exceeding the critical load for nitrogen deposition. Other woodland types in Scotland have also seen reductions of between 15–40%.

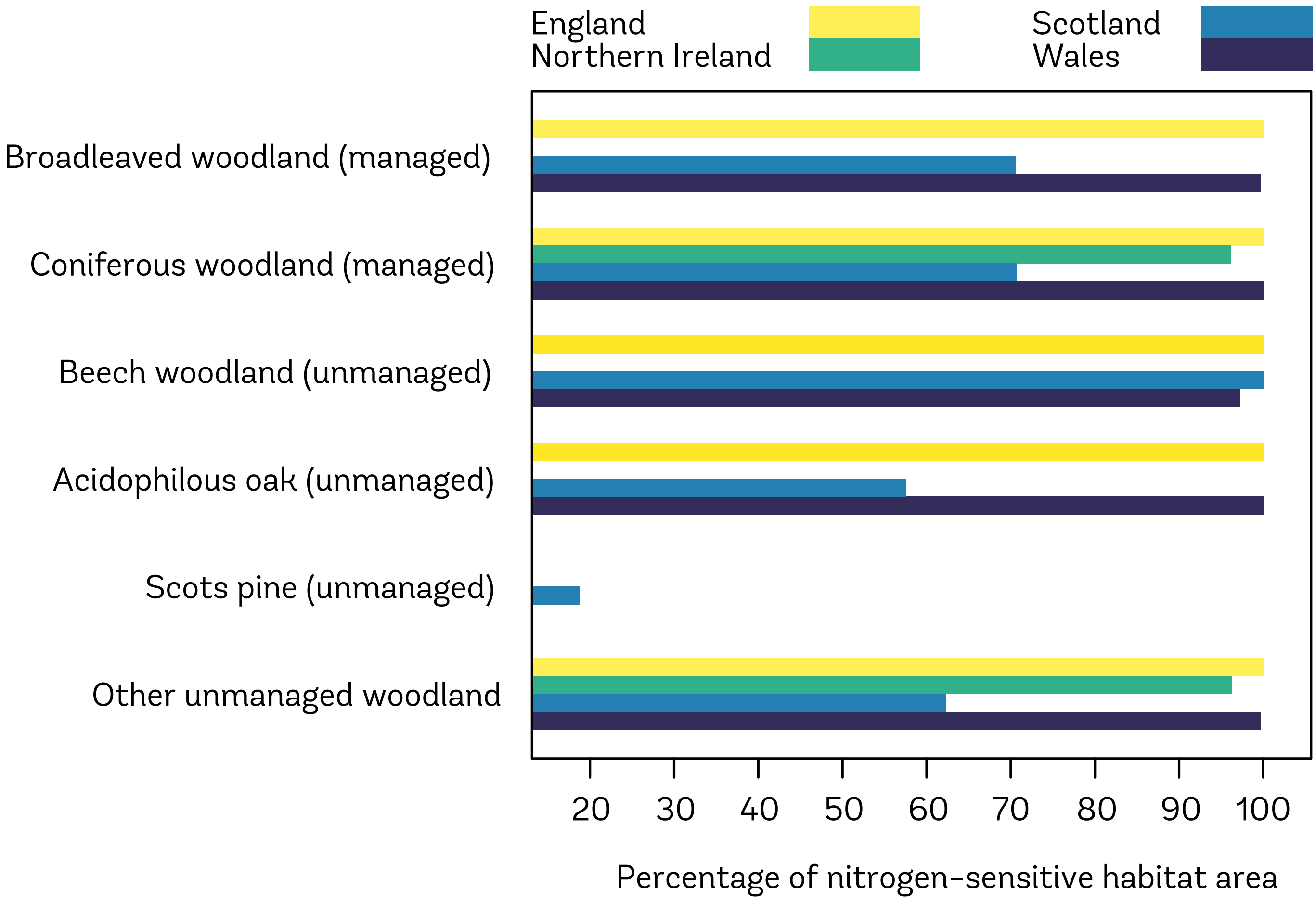


Figure 3.3.1. Percentage of woodland area exceeding critical loads of nutrient nitrogen by country

Source: Trends Report (2020)[8]

Ammonia impacts

Between 70 and 80% of **broadleaved woodland** habitat area across the UK exceeds the critical level of ammonia (1.0μg NH_3/m^3). The exception is acidophilous oak woodland, which is lower at around 40% (Table 3.3.2). Where critical levels are exceeded, lichen and bryophyte communities are altered, and ecological integrity is compromised.

For **coniferous woodland**, which includes commercial non-native conifer plantations, the current figure of 19.9% reflects an increase of 1.3% in the percentage of habitat exceeding the critical level between 2010 and 2016. This figure is still relatively low, probably attributable to the majority of commercial conifer plantations existing in upland regions with less intensive agricultural land uses. Importantly, woodland cover and forestry land uses produce fewer nitrogen emissions compared to agricultural land uses. So more extensively wooded landscapes tend to be those with lower ammonia levels.

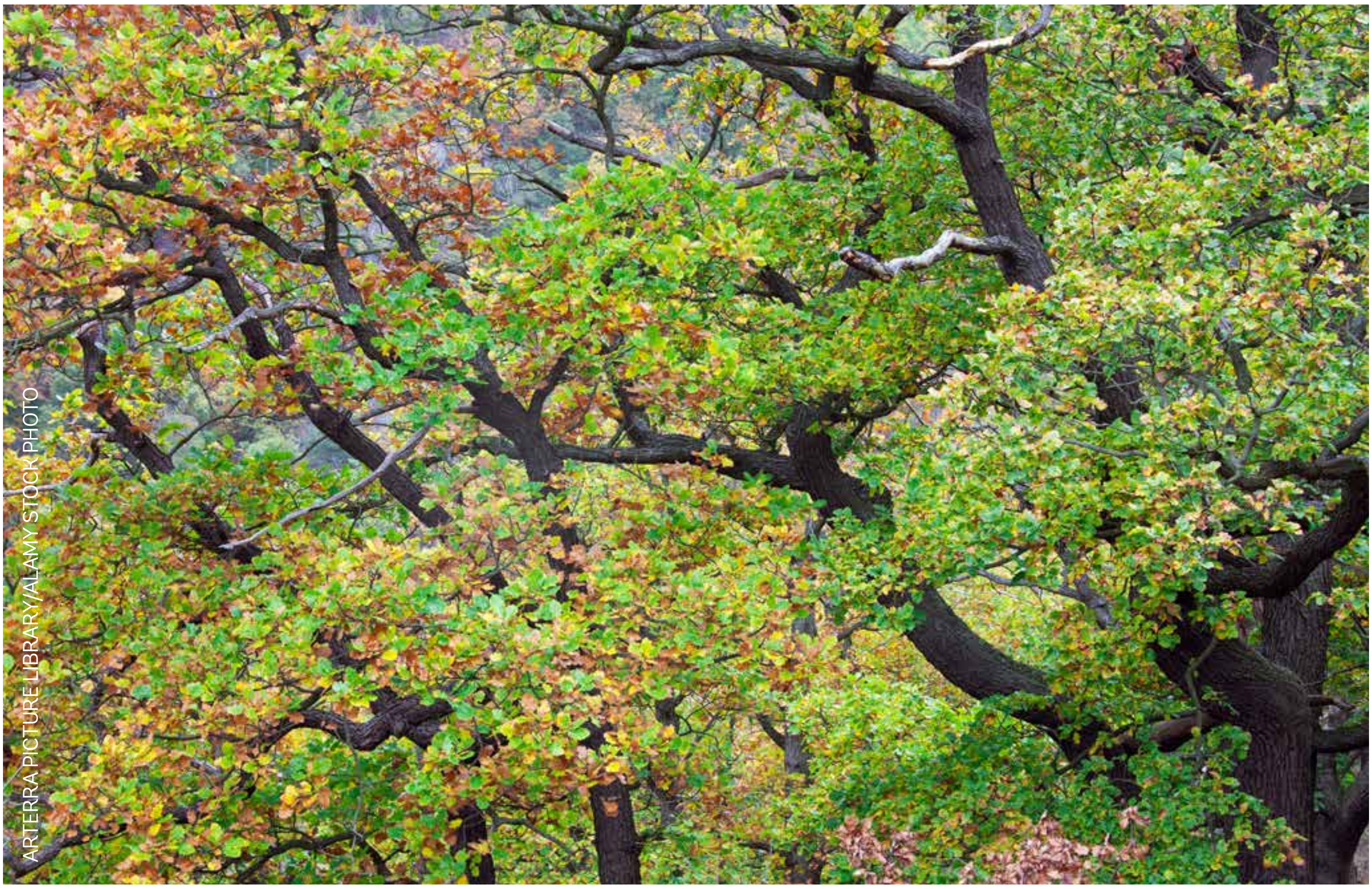
As with nitrogen deposition, native Scots pine woodland is doing best. Only 1.3% by area is exceeding the critical level for ammonia. These native woodlands are likely to have better ecological integrity where they have consistently had low levels of ammonia and nitrogen deposition.

Table 3.3.2. Percentages of, and change in, the area of nitrogen-sensitive habitats where ammonia critical levels of 1 μg/m^3 are exceeded in the UK, by habitat

Source: Trends Report (2020)[8]

Ammonia critical level	Coniferous woodland (managed)	Broadleaved woodland (managed)	Beech woodland (unmanaged)
1 μg/m^3	19.9	77	70.7
Change in % area exceeded from 2010 to 2016	1.3	-4.3	-5.2

Ammonia critical level	Acidophilous oak (unmanaged)	Scots pine (unmanaged)	Other unmanaged woodland
1 μg/m^3	40.1	1.3	81.4
Change in % area exceeded from 2010 to 2016	-3.8	-0.1	-0.6



Nitrogen pollution has shifted the public's image of what a wood should look like. Bare trunks free of lichen is the new normal (top image). Historically woodland would have been covered in a rich and diverse array of lichens – adding biodiversity value (bottom image).

Why does it matter?

The vast majority of UK woodland habitats are exceeding the level of nitrogen deposition at which the ecosystem is considered to deteriorate. This is one of the most widespread and significant impacts on woods and trees across the UK.

Shifting baselines

It is no coincidence that native pinewoods and **temperate rainforests of Scotland's west coast** are the remaining strongholds for many nitrogen-intolerant woodland lichens which otherwise would be more widespread in other parts of the UK. They emphasise an important shifting baseline about the presence of lichens. The richness of lichens in highly oceanic temperate rainforest woodlands is often attributed to climatic factors. While these are significant in determining the composition of lichen communities, the richness of lichens in these parts of the UK is also partly because the western extremities have been least affected by air pollution historically. For example, the tree lungwort (*Lobaria pulmonaria*) is often portrayed as a flagship for temperate rainforests, yet it occurred throughout most of Western Europe historically, including in much drier continental climates. This is illustrated by the presence of tree lungwort in the woodlands in the relatively dry Cairngorms.

In **other parts of the UK**, rapid declines in certain lichens in recent decades seem clearly linked to changes in air chemistry, with the impacts of ammonia and reactive nitrogen possibly compounded by decreases in sulphur dioxide (SO_2) which may have historically 'mopped-up' some reactive nitrogen through chemical reactions. The decline of species of horsehair lichen (*Bryoria* spp.) in Wales and parts of South West England is of particular concern.

The ecological integrity of most woodland in the UK has been impacted by the effects of historic and current air pollution

The historic impacts of sulphur dioxide from industrial pollution still persist and atmospheric nitrogen pollution is of significant concern today. Superficially, this has created a shifting baseline of what most people think trees and woods should look like, i.e. 'bare' tree trunks with very few lichens, or covered in bright yellow nitrophytic *Xanthoria* lichens, when in fact, in the past, most trees would have been covered with a greater diversity and structure of epiphytic lichens.

Most seriously, losses of species of lichens, or declines in certain woodland ground flora are probably an **early warning sign of pending ecosystem collapse**. For example, impoverished communities of tree root fungi as a result of nitrogen deposition are likely to be increasing trees' susceptibility to droughts or pathogens[9].

What needs to happen?

Reductions: considerably reduce nitrogen emissions from existing sources, which will likely require significant changes to existing land use practices.

Interim measures: in the interim, reduction attempts can be combined with habitat buffering and capturing emissions to reduce their dispersal into woodland ecosystems, particularly ancient woodlands.

Strategy: a strategic approach by governments is required to achieve the necessary levels of reductions for all ancient woodland across the UK, but localised actions can make a difference for individual ancient woodland sites.

Protect the best: the UK's rainforest on the west coast is one of the last remaining strongholds for many nitrogen-intolerant woodland lichens which otherwise would be more widespread in other parts of the UK. We need to keep it this way.


PHIL LOCKWOOD/WTML

Ash dieback disease is affecting the trees in the foreground which should be in full leaf during summer. This weakens the trees and they will eventually die.

3.4 What are the threats and impacts from pests and diseases?

What do we already know?

Trees and other plants, fungi, insect and bacterial species survive in a delicate ecological balance within woodlands. This balance can be significantly disturbed when a new species is introduced into this system. Non-native 'exotic' species can be a particular problem because the plants present in woodlands will not have co-evolved with these recently introduced species and will, therefore, not have any natural defence against them. The predators that keep these exotic species in check in their natural range may also not be present. In these circumstances, pest and disease outbreaks can have an extraordinarily severe impact.

Importantly, once a new pest or disease species becomes established, it can never be removed. **Detrimental changes are often at a landscape scale** as we have seen with Dutch elm disease, ash dieback and *Phytophthora ramorum*. These changes have wide-ranging impacts on species that rely on the host tree species and so impacts are often under-acknowledged. In addition, many of the diseases that have become established over the last 30 years that are attacking native tree species are poorly studied so their wider impact is uncertain; for example, *Phytophthora* diseases of alder, juniper and oak.

There are many more global pests and diseases which would cause devastation if they reached the UK, so there is a **perpetual risk**. A small number of problematic species could potentially blow into the south of England from the continent, but most introductions are a result of the trade of plants, timber and wood products. For example, Dutch elm disease was introduced on logs imported from the US in the early 1970s; ash saplings infected with ash dieback were traded across Europe through the 2000s; and imports have been implicated in the introduction of a number of disease-causing *Phytophthora* species.

About the data

Information on the pests and diseases that are of concern to UK forestry and trees were taken from Forest Research[1] and The UK Plant Health Risk Register[2]. Detailed information on the distribution, lifecycle and environmental impact of specific pests was also sourced from the Invasive Species Compendium hosted by Centre for Agriculture and Bioscience International (CABI)[3].

The increase in tree diseases has mirrored the growth in tree imports since 1992.

What does this tell us?

The available data shows a significant rise in the incidence of serious pest and disease introductions into the UK since 1990 (Figure 3.4.1).

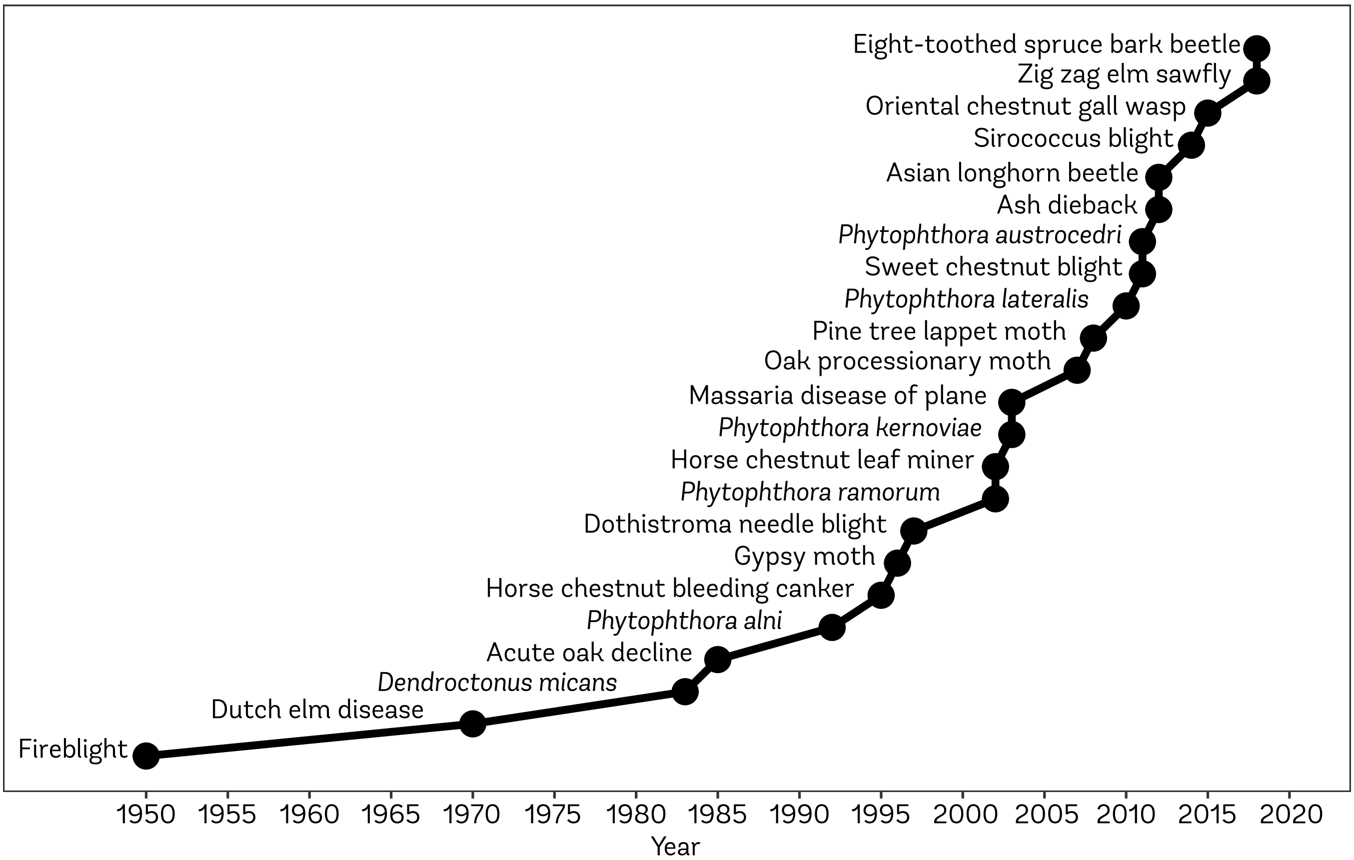


Figure 3.4.1. Timeline of when pests and diseases were first reported as causing serious issues with particular host species in the UK (1950–2018)

Source: Forest Research[1] and The UK Plant Health Risk Register[2]

This increase in incidence has occurred alongside a significant increase in plant and tree imports from the EU and beyond (Figure 3.4.2).

There are many more global pests and diseases which would cause devastation if they reached the UK

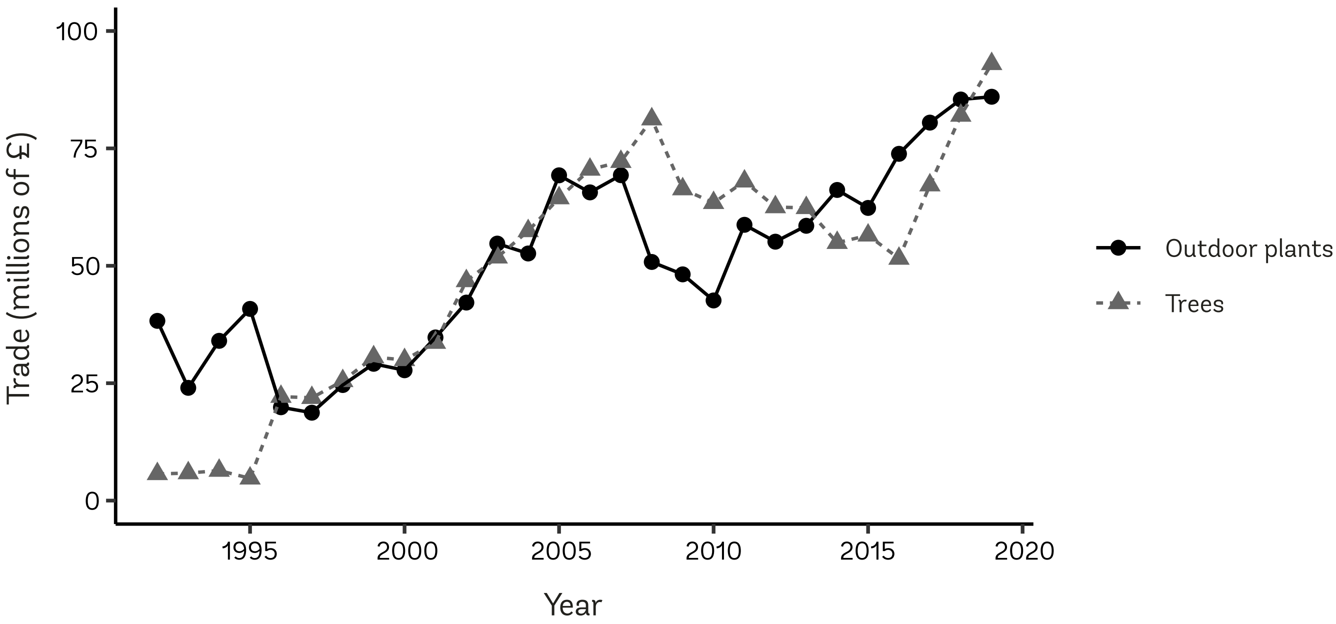


Figure 3.4.2. Trade value of imports of trees and outdoor plants (in millions of pounds) between 1992 and 2019

(2019 numbers are provisional)

Source: Defra 2020[4]

Figure 3.4.2 shows that imports of tree saplings and standard trees rose from £6 million in 1992 to £93 million in 2019, over a tenfold increase. There has also been a significant increase very recently, from £52 million in 2016 to £93 million in 2019, a 79% increase. Imports of outdoor plants, which are often alternate hosts for tree diseases, have also significantly increased from a low point of £19 million in the 1990s to £86 million in 2019.

This clearly shows an increased reliance on imported stock to fulfil trade orders. Free trade within the EU has increased reliance on imports over time, with the nursery industry generating more profit from importing trees rather than growing them in the UK. It is also clear that **lessons have not been learned** from previous devastating introductions, as there has been a huge spike in tree imports since 2016.

The apathy over the risks and consequent impacts from imports is exemplified by **oak processionary moth (OPM)**. The caterpillars can defoliate oak trees, but most serious is the severe allergic reaction that contact with their hairs can cause in people and animals. This

Oak processionary moth, *Thaumetopoea processionea*, is a non-native species which can cause severe defoliation of oak trees. The main concern, however, is to human health. After being inadvertently introduced on imported oak, lack of swift action to eradicate means that it's likely here to stay.

pest started causing issues on oak trees in northern Europe in the early 2000s. Despite this, the UK continued to import oak, and inadvertently OPM, many times, with 1.1 million oak trees (*Quercus* species) imported between 2013 and 2015[5]. A nest was even discovered at the Chelsea Flower Show in 2016[6], and the OPM is now widespread throughout London.

Despite its known impact, considerable financial investment to manage OPM, as well as new legislation, the pest was once again imported in 2018/19, this time to more than 70 sites across the UK, from southern England to northern Scotland. Most of these trees were traced by plant health authorities and destroyed, but some were not. For such a well-known pest to be repeatedly imported demonstrates that **border controls** for plant pests and diseases (particularly those that are hard to identify) are not sufficient to keep out known threats, let alone unknown pests and diseases. This is particularly concerning because oak is a native species and could be grown within UK tree nurseries if investment was made in the production process.

In addition to pests and diseases that have already been intercepted, the UK Plant Health Risk Register indicates there are a further 127 high risk pests and diseases that would have a big impact on the UK's woods and trees if they managed to enter the country.

The impact of pests and diseases is predicted to become more severe under climate change conditions. This area of research is in its infancy; however, forest ecosystems will undoubtedly be affected by the combination of climate change and pest and disease introductions[7].

Market values versus clean-up costs

A recent study calculated that the long-term economic, cultural and environmental cost of just one disease, **ash dieback**, is £15 billion[8]. That is 50 times larger than the annual market value of trade in live plants to and from Britain (£179 million in 2019), but note this does not include non-economic benefits. In addition, the paper points out that there are a further 47 other known tree pests and diseases that could arrive in Britain and which could cost an additional £1 billion or more each to manage. Unfortunately, a significant proportion of this cost is carried by landowners who are liable for managing diseased trees as they become increasingly unsafe. It is clear that it is far more cost effective and beneficial to the environment to keep these species out of the country in the first instance than to deal with the clean-up costs.

Why does it matter?

Wildlife impacts

The scientific community is only recently starting to elucidate the full effects of tree disease outbreaks on the wider environment. Species such as ash and elm host many hundreds of species of insects, fungi, mosses, lichens, birds and mammals, many of which only survive on these specific tree species. Mitchell *et al.* (2014)[9] found that 953 species are associated with ash trees: 12 birds, 28 mammals, 58 bryophytes, 68 fungi, 239 invertebrates and 548 lichens. Forty-four of these species were identified as 'obligate' species (these are only found on ash and cannot survive on another tree species): 11 fungi, 29 invertebrates and four lichens; while another 62 species were found to be 'highly associated' with ash.

As a result of the dependency of these species on ash it is becoming increasingly clear that there is a real **risk of an extinction cascade** event due to ash dieback. A recent Swedish study found that 56 species of ash obligate species in Sweden are already threatened with extinction, a situation that is only going to worsen as the disease progresses[10]. In addition to this, 115 species were deemed at high risk of regional extinction. The populations of many species dually associated with ash and wych elm are also expected to decline due to the combination of Dutch elm disease and ash dieback, especially those that are associated with coarse bark on older trees (i.e. lichens and mosses).

People impacts

The ramifications for people are also often not fully appreciated. For example, unlike animal diseases such as foot and mouth where farmers are helped logistically and financially with disease management, with plant diseases it is generally the landowners who bear the costs of disease management and clean-up. Knock on effects are likely if, say, local authorities pay for a severe tree disease outbreak by diverting funds from other areas.

Perhaps even more seriously, land managers could come to the conclusion that planting trees brings unwanted future risks and costs. Given the climate crisis we are currently facing and the central role trees play in mitigating the impacts, it is more important than ever that landowners are encouraged to plant trees and encourage natural regeneration on their land.

What needs to happen?

Investment in biosecurity: importing plants is very high risk because of the potential for the inadvertent introduction of new pests and diseases on the plants or within the compost. Therefore, investment in UK and Irish nurseries is needed so we can move away from importing trees. Plant buyers can be more responsible by specifying plants grown within the UK and Ireland (see 4.2). Plants should be sourced from within the UK and Ireland using established assurance schemes such as UKISG. In all circumstances the origin of the plants should be known and UK and Irish grown plants preferred. Importing trees should be a last resort rather than the default.

CASE STUDY

DAVID SLAWSON

3.5 How is citizen science helping to tackle tree pests and diseases?

The threat from tree pests and diseases is increasing and early detection is vital[1]. This indicates a need for a UK-wide network of people detecting pests and diseases and submitting accurate, quality reports to tree health professionals. In response to this, Observatree[2], a multi-partner project led by Forest Research, was initiated in 2013. The Woodland Trust recruits and manages the network of **skilled volunteer citizen scientists**, situated across the UK, to act as an 'early warning system' for pests and diseases. Observatree is highly regarded by UK and international governments as a model for engaging citizens in tree health monitoring and raising tree health awareness. In this novel approach, volunteers receive training from government scientists who support them to carry out tree health surveys. Their site reports and occasional associated samples are fed straight back to tree health teams who then take appropriate action.

Between the start of the project and July 2020, the network had contributed 10,500 tree health reports and 22,000 hours of survey time, demonstrating the value of citizen scientists for monitoring pests and diseases. The number of both pest and disease reports and healthy tree reports increases each year as confidence in the network and volunteer expertise grows (Figure 3.5.1). The large increase in healthy tree reports demonstrates an increased interest from volunteers in submitting negative data and is best practice in citizen science.

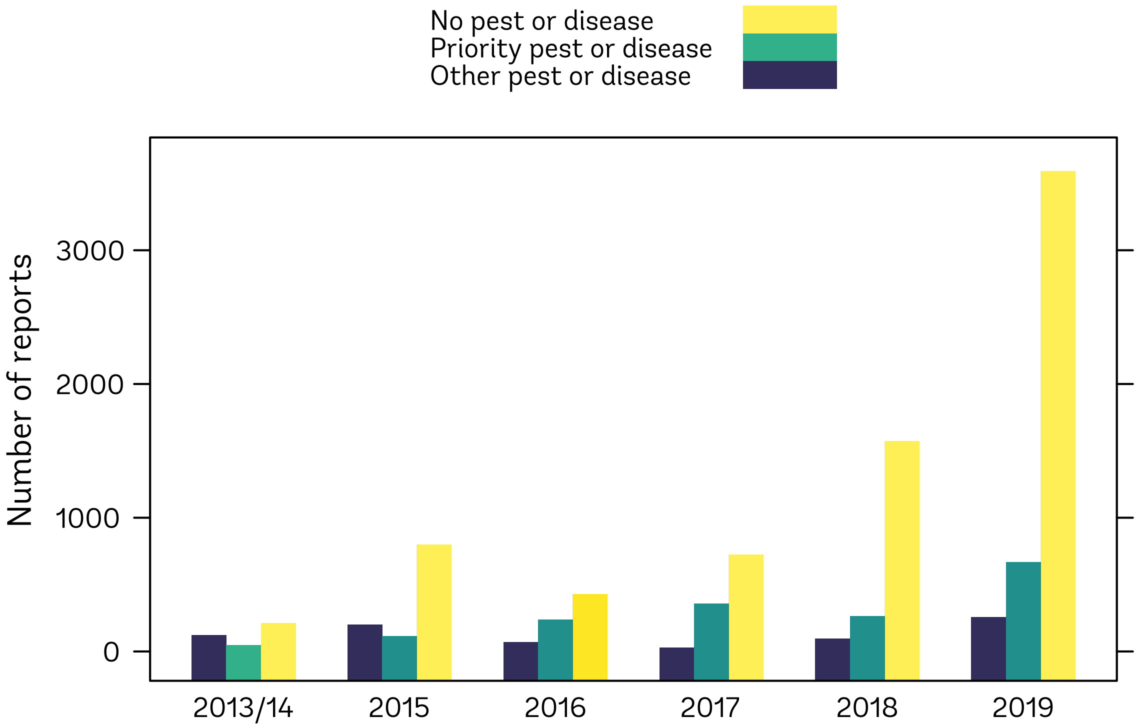


Figure 3.5.1. The number of tree health reports from Observatree volunteers by year

Source: the Woodland Trust

The network has been called upon by professionals for rapid, UK-wide surveying in outbreak situations. For example, the network provided data on the spread of **oriental chestnut gall wasp** and oak processionary moth. The most significant finding to date by the network was the second UK report of the oriental chestnut gall wasp, more than 100 miles from the first, which dramatically changed how the authorities dealt with this pest by widening the search area. The fast detection of new pests and diseases through the project allowed faster action from the authorities to prevent further spread. Ongoing government support for such volunteer networks is crucial to maintain this critical link in the tree-defence armoury.

Populations of all six of the UK's deer species are growing.

3.6 What are the impacts of deer on woodlands?

What do we already know?

Deer are an important part of the UK's woodland ecology and can have a vital role to play in diverse woodland and wood pasture ecosystems. The UK has six species of deer: native red and roe deer; fallow deer – present since Norman times; and sika, Reeves muntjac and Chinese water deer – introduced in the past 150 years.

Populations of all deer species are growing and spreading through the landscape. Numbers are likely to be higher than at any time in the last 1,000 years, and in many parts of the UK they have reached levels where they seriously threaten the habitats that they and other wildlife depend on[1–4]. With no predators, deer numbers have increased substantially in recent decades due to expanding woodland cover, more opportunities for food because of changes in agriculture, such as more winter cereals, milder winters and improved access to urban green space. Understanding how this impacts woodland ecology and condition is key to identifying appropriate deer and woodland management strategies.

Impacts of deer on woodland ecosystems

High deer numbers negatively impact the structure and biodiversity of many of our most valued woodlands[1, 2, 5, 6]. Pressure from deer browsing causes declines in characteristic herbaceous plants, birds, invertebrates and mammals like the dormouse because it removes the structural complexity of woodland by limiting the growth of many shrub and tree species, and preventing their regeneration (including coppice regrowth). One extensive study[1] found the reduction in low shrub cover due to deer resulted in reduced numbers of willow warbler, garden warbler, song thrush, nightingale, dunnock and bullfinch.

Woodlands are becoming less diverse in their tree and shrub species composition over time, with deer browsing even influencing the composition of the canopy layer. In addition, tougher species like grasses and sedges are thriving at the expense of more delicate woodland flowers. Of course, some important habitats like wood pasture and temperate rainforest rely on moderate browsing pressure to retain their characteristic features, such as open-grown 'parkland' trees, many of which can reach a great age, and for the wealth of biodiversity such as lichens and deadwood invertebrates that they support in their complex structures.

Signs of deer impacts in woodland:

Fallow buck damage to tree tubes

Deer browse line on woodland edge

Difference in deer browsing inside and outside a deer fence

Heavily browsed coppice stools

Stem frayed by fallow buck

The geographic distribution, impact and behaviour vary with each deer species[5]. Better understanding of deer impacts on woodland vegetation and young trees is vital to successfully protect, create and manage woodlands. Recent work has identified that deer damage extent varies between different habitat types[6]. New analysis of National Forest Inventory survey data has allowed us to investigate the relationships between woodland cover, habitat quality and deer impacts.

About the data

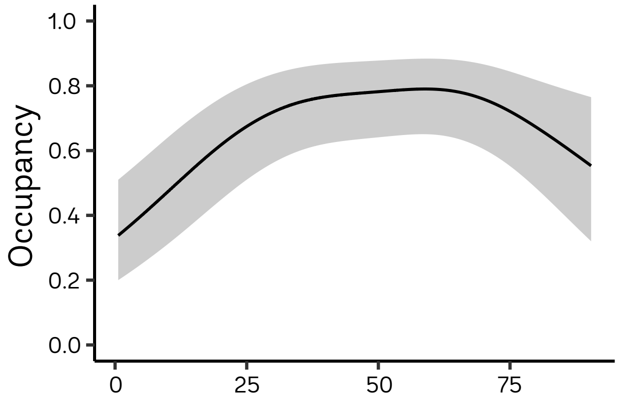
The aim is to predict how the occupancy of different deer species varies between woodlands to inform management approaches for different woodland situations[7]. The following habitat effects were investigated: woodland type, age of trees, woodland origin (natural, semi-natural or plantation), vertical complexity, shrub cover, and the presence and quantity of seedlings, saplings and young trees. Data on woodland habitat was obtained from the National Forest Inventory (NFI) field survey, undertaken by Forest Research. The NFI survey of ~15,000 1ha grid squares throughout Britain began in 2010 and is repeated on a five-year cycle. Information is recorded on woodland type, tree structures, vegetation health and browsing impacts.
Data from the first cycle (2010–2015) only was used. Independently estimated predictions of deer occupancy for each species was also derived from data by Croft *et al.*[8].

What does this tell us?

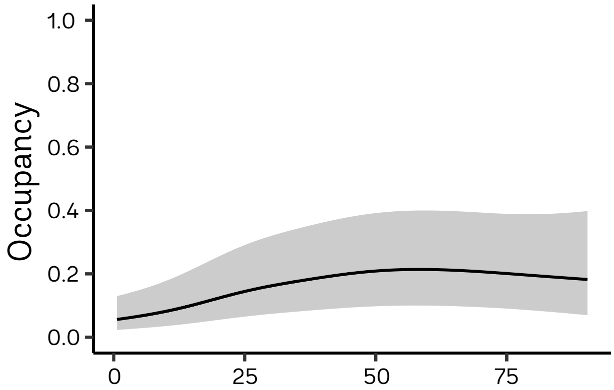
Surprising results?

The results of the analysis are initially surprising: increased deer occupancy/browsing occurrence within survey plots does not correlate with poorer woodland condition. Conversely, woodlands in better condition have higher levels of browsing. While this appears counterintuitive, it is ecologically reasonable that deer would be attracted to the 'better' areas of woodland for feeding. Measuring the impact of deer on longer term woodland condition requires an examination of woodland change over time. The NFI is currently completing its second five-year cycle of field surveys, which will allow future trend analysis.

(a) Roe



(b) Red



(c) Fallow

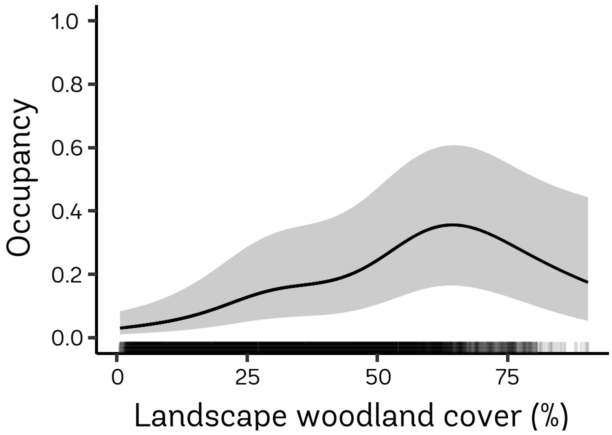


Figure 3.6.1. Change in site deer occupancy as woodland cover within the surrounding 100km² landscape changes for (a) roe deer, (b) red deer, (c) fallow deer

Shading represents 95% confidence around the estimate, and the horizontal axis 'rugs' denote the data points informing descriptions.

Source: Forest Research (in prep.)

The independently estimated predictions of deer occupancy confirmed that browsing intensity in each survey plot increased linearly with the occupancy of red, roe and fallow deer. Exploring the habitat characteristics that impact this relationship reveals that there is significantly less browsing damage in coniferous woodlands compared to broadleaved and mixed woodlands. Browsing was also lower in woodlands where all trees were over 20 years old.

The habitat variables predicting the occupancy of red, roe and fallow deer each vary in their importance and effect between species. However, woodland cover within 5.6km radius is the most important variable for all three deer species (Figure 3.6.1).

The Goldilocks zone

Occupancy for red deer increases with increasing woodland cover in the surrounding landscape. The analysis suggests the existence of an optimum woodland cover for fallow deer and for roe deer (Figures 3.6.1c and a). Occupancy for these species increases with increasing landscape woodland cover up to an optimum, but decreases thereafter. This suggests a **threshold of landscape woodland cover** which is most suitable for deer species – neither too little nor too much (the 'Goldilocks zone'). Woodland type is important for describing the distributions of all species, with these results suggesting that roe deer are more likely to occupy mixed woodland over coniferous and mixed, while red and fallow deer are more often found in coniferous woodlands. Whether woodland is plantation or natural does not affect roe or red deer occupancy, but fallow deer are more likely to occupy ancient semi-natural woodland than plantations. Woodlands of mixed age trees are possibly more likely to be occupied by roe deer; however, this effect is uncertain.

Why does it matter?

Deer gravitate towards certain types of landscapes, with roe deer particularly preferring a 'Goldilocks zone' of neither too little nor too much woodland cover in the landscape. This varies between deer species, and its effect is much less apparent for red deer. Understanding this allows deer management to be targeted to the landscapes where it will have most benefit.

Expanding deer populations may negatively impact woodland ecological condition. Deer prefer woods with 'rich pickings', and so will target healthier woods and ancient and native woods for browsing. This suggests that our best quality woods for wildlife are those which are most at risk and require the most protection.

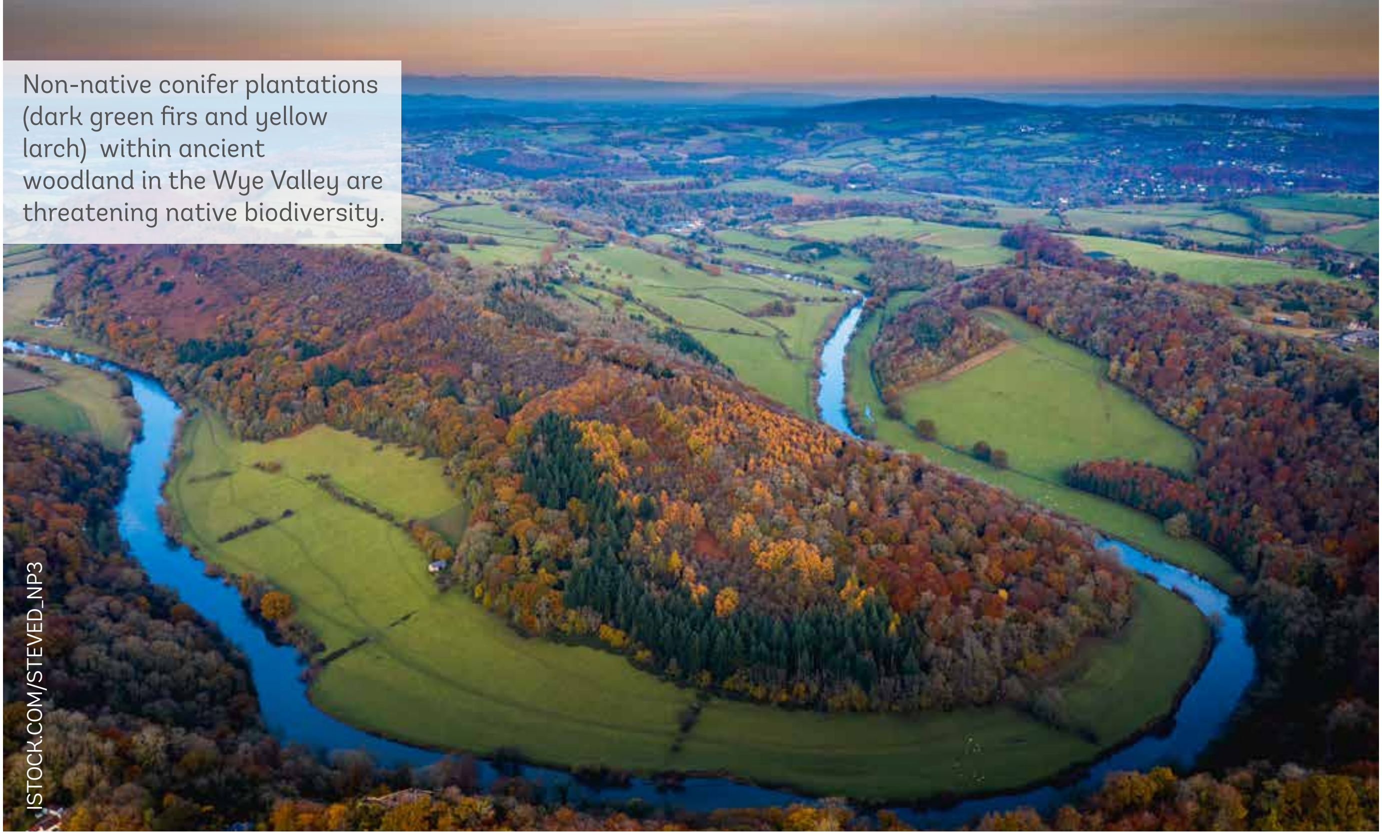
Changes to woodland cover are likely to affect deer populations and their impacts. Increasing woodland cover at scale will push more landscapes into the Goldilocks zone for species such as roe deer, potentially increasing their impact. This has serious implications for woodland creation activity, which should consider the changes to landscape-scale deer management which will be required to mitigate potential negative impacts on wildlife resulting from increased deer browsing pressure.

What needs to happen?

Think big: landscape-scale woodland planning, creation and management is required – focusing on site-level actions is not enough. Consideration should be given to how altering the woodland cover and composition in a landscape may alter the deer population and in turn the levels of browsing in existing woods.

Assess risks: if a wood is in a Goldilocks zone for deer then damage is likely to be higher and more management action is required. In zones of very low or high woodland cover, the risk of damage to trees may be lower, thus vigilance, rather than action, is required.

More research and monitoring: we need to understand at what point, and over what timescales, deer impacts adversely affect aspects of woodland condition. It is critical that governments continue to support regular monitoring such as via the NFI, bolstered by 'reports from the field' (e.g. via systems like the Deer Manager) to understand change over time and most effective responses.



Non-native conifer plantations (dark green firs and yellow larch) within ancient woodland in the Wye Valley are threatening native biodiversity.

ISTOCK.COM/STEVED_NP3

3.7 How are ancient woodlands threatened by plantation forestry and invasive plants like rhododendron?

What do we already know?

Non-native conifer plantation species, and some broadleaf plantation species, cause a direct change to the composition and structure of ancient woodland by replacing native trees and shrubs and their unique functions[1]. These **plantations on ancient woodland sites** (PAWS), many of which originated in the 20th century, often have considerably reduced light levels reaching the woodland floor, with further changes in leaf litter, soil chemistry and decaying wood all affecting the wildlife and ecology associated with semi-natural ancient woodlands[2]. Any remaining pre-plantation native trees – some of which may be ancient or veteran – are usually quickly 'over-topped' by faster-growing conifers.

These effects are particularly acute in dense plantations of **evergreen conifer species** and where evergreen non-native invasive species such as **rhododendron** (*Rhododendron ponticum*) have colonised[3]. The year-round shade, coupled with the leaf and needle litter, critically threatens any remnants of the ancient woodland ecosystem and prevents regeneration of native trees and other plants. The threats posed are almost always progressive in nature; they become greater over time when not addressed, and the chance of recovery diminishes[4]. There is a compounding threat with rhododendron, as it is also a host plant for the killer fungus *Phytopthora ramorum*, which attacks beech, oak and larch trees. Unless urgent action is taken, there will be direct loss of biodiversity and degradation of irreplaceable habitat. Rhododendron and other invasive non-native species (such as Himalayan balsam *Impatiens glandulifera*, Japanese knotweed *Fallopia japonica*, shallon *Gaultheria shallon*, and bidi-bidi *Acena* spp.) affect all types of woodland and/or other semi-natural habitats, and due to their invasive nature need to be managed at a landscape scale.

Examples of the invasive non-native species affecting native woodland:

Rhododendron
Rhododendron ponticum

Himalayan balsam
Impatiens glandulifera

Japanese knotweed
Fallopia japonica

Restoration of the most critical or threatened PAWS and rhododendron-damaged woodland is an urgent priority, as the longer these woods remain under a dark conifer or rhododendron canopy the more likely they are to lose any remnant ancient woodland features. A second rotation of conifer following harvesting of the initial plantation trees is particularly damaging. Progress with PAWS restoration is discussed in 4.6.

To address these threats adequately it is necessary to act strategically and collaboratively at a landscape scale over many years. In some parts of the UK there have been concerted **rhododendron eradication programmes** (see 3.8), while in others the control has been more piecemeal or non-existent. In order to achieve a fully effective landscape scale eradication programme, it is necessary to be able to map the extent and location of the rhododendron bushes so that the eradication can be planned and adequately resourced. **Mapping** by surveying on the ground is possible, but it is time-consuming and can be inaccurate. Airborne surveys or satellite remote sensing data have the advantage that surveying is rapid and reliable and can be repeated periodically using the same methodology. The use of remote sensing to map ground cover and distinguish between different vegetation is now possible, especially for evergreen species.

About the data

UK-wide data on conifer PAWS is available from the country Ancient Woodland Inventories (see 1.1), which classify ancient woodlands into ancient semi-natural woodland (ASNW) or plantations on ancient woodland sites (PAWS). The data is in some places 30–40 years old; however, on the **public forest estate** (around 34% of all PAWS), more accurate and recent mapping of threats and progress with restoration is available (see 4.6). The estimated amount of PAWS on private land has been updated in some areas (e.g. the south-east of England and in Wales).

Accurate distribution data for rhododendron does not currently exist at a UK scale. Forest Research released a report in 2016 with preliminary estimates of the presence and extent of rhododendron in British woodlands[5]. The mapping was an estimate based upon National Forestry Inventory sampling from November 2009 to August 2013. At a regional scale this identifies priority areas, but detailed mapping is required to identify 'fronts' of invasion to prioritise control.

Scoping work by the Woodland Trust indicates that the use of hyperspectral cameras coupled with high resolution LIDAR mounted on an aircraft, or drone, will be able to accurately map rhododendron, and be able to discern it among other vegetation types. This methodology, once established, can, and should, be repeated at regular intervals, but it will take some upfront investment to establish.

What does this tell us?

A total of 20% of all ancient woodland is owned by the national forestry agencies across the UK, and is predominantly made up of plantations on ancient woodland sites (c. 91,000ha; 34% of all PAWS); see Figure 3.7.1. The 80% majority of ancient woodland is owned by private land owners, charitable organisations and other public bodies such as the Crown Estate. Of this, approximately two thirds is ancient semi-natural woodland (c. 313,000ha) and one third is plantations on ancient woodland sites (c. 177,000ha; 66% of all PAWS).

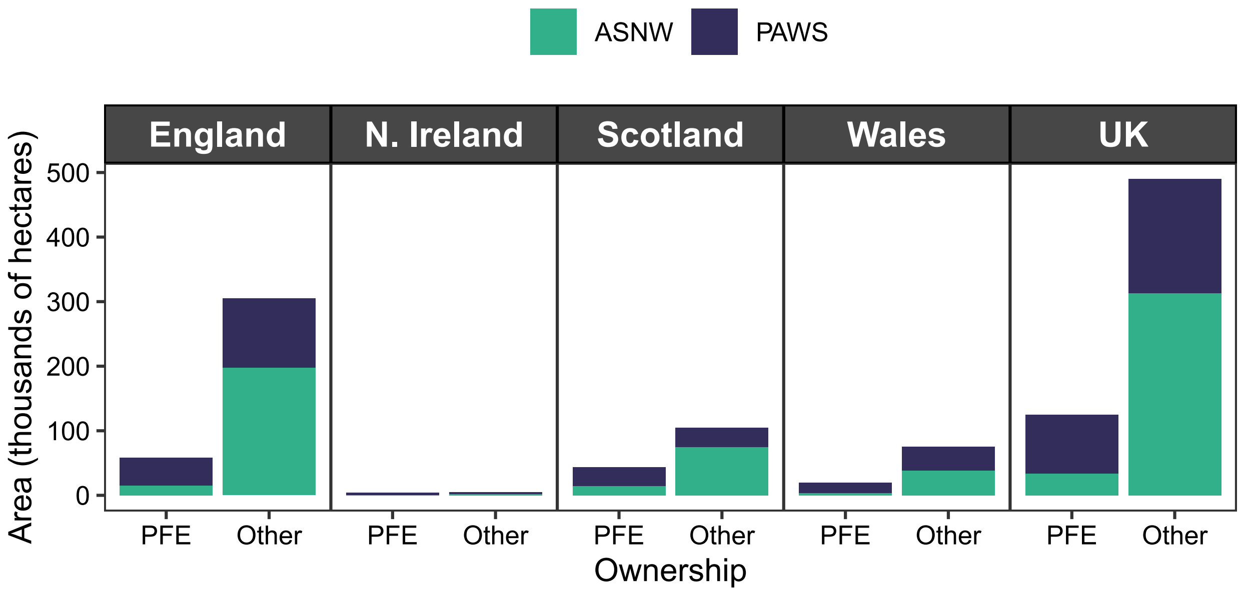


Figure 3.7.1. Estimates of ancient woodland area in the UK countries by type and ownership

Type = ancient semi-natural woodland (ASNW) or plantation on ancient woodland site (PAWS); ownership = public forest estate (PFE) i.e. national forestry agencies or other, includes private, non-governmental organisations and other public land. Figures for Northern Ireland include LEPO and Wales' PAWS area includes the categories RAWS (c. 21,960ha) and AWI-Unknown (c. 5,440ha).

Source: Ancient Woodland Inventories

Why does it matter?

Ancient woodland is an irreplaceable resource of immense historic, cultural and wildlife value (see 2.1 and 3.2). We cannot create more of it, but we can work to restore that which has been damaged by forestry planting and invasive species. The restoration of ancient

Rhododendron removal needs to be tackled strategically at a landscape scale, otherwise it continues to spread.

woods damaged by conifer PAWS is discussed in 4.6, and it is hoped that by the next iteration of this report we can present some positive findings about tackling the rhododendron threat too.

What needs to happen?

Restoring damaged ancient woodland: see 4.6.

Tackling rhododendron threat: an effective long-term rhododendron eradication programme needs to be informed by accurate density mapping that is repeatable and reproducible. If this is in place then it can be tackled in a planned, strategic, and cost-effective manner. See case study 3.8.

Adequate public funding: financial support is needed to support willing landowners to deal with invasive non-native species at landscape scale in areas of priority habitat that are highly damaged and with long-term legacy management.

CASE STUDY

3.8 Scotland's rainforest under threat

Scotland's temperate rainforest is one of our most precious habitats – as important as tropical rainforest, but even rarer. Yet few people know it exists and fewer still know how globally significant it is.

Sometimes known as Atlantic woodland, Scotland's rainforest is made up of the native oak, ash, birch, pine and hazel woodlands found on the west coast in the 'hyper-oceanic' zone. Here, high levels of rainfall and relatively mild, year-round temperatures provide just the right conditions for some of the world's rarest bryophytes and lichens. It is the sheer abundance and diversity of species found in Scotland's rainforest that make it internationally important. Its climatic conditions are rare too - hyper-oceanic climates cover less than 1% of the planet. Whilst rainforest habitat can be found in other parts of the UK (Cumbria, North Wales and south west England), Scotland has the greatest amount of it and some of the best remaining sites in Europe.

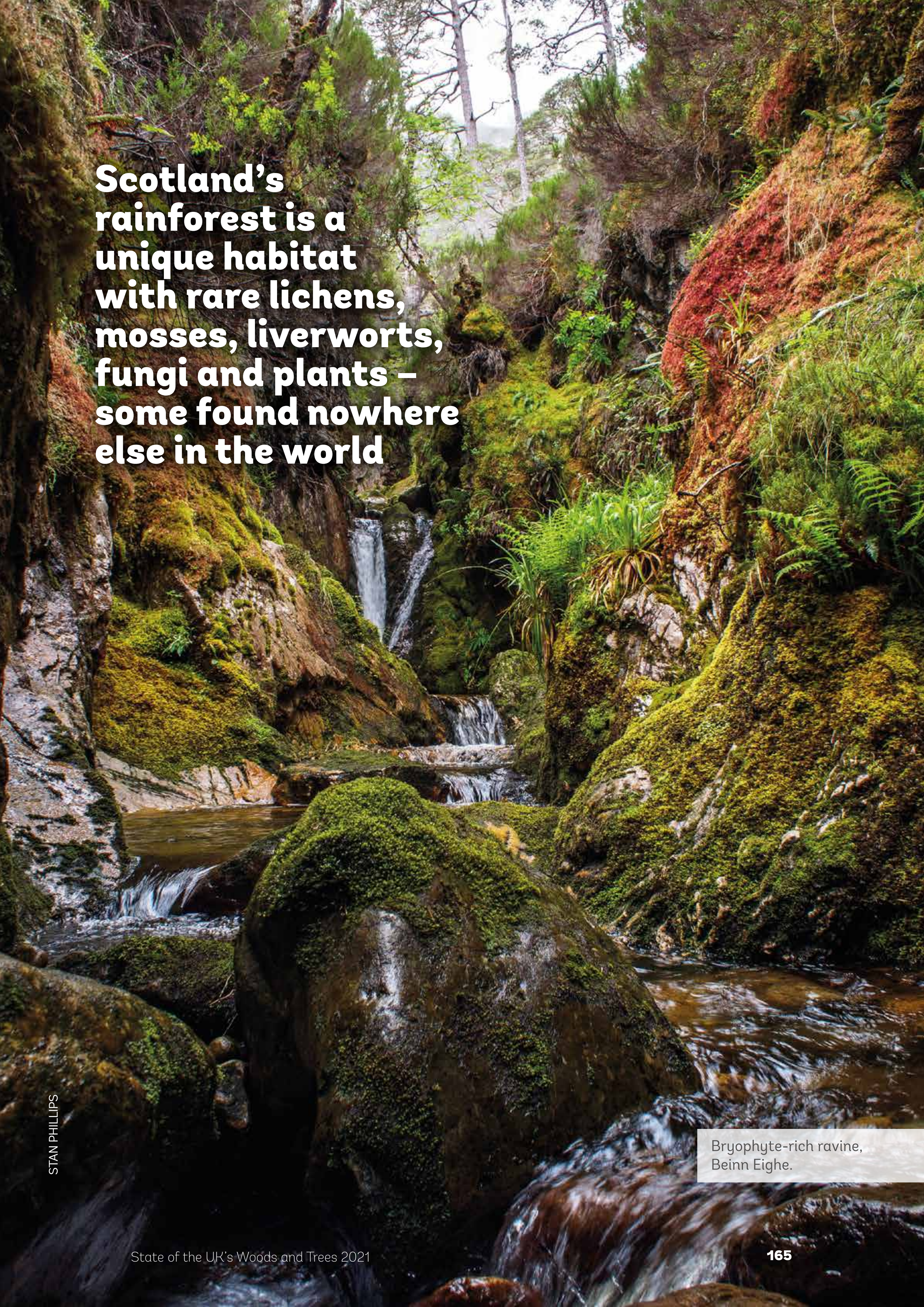
But Scotland's rainforest is in trouble. As little as 30,325ha of Scotland's rainforest remains – a mere 2% of Scotland's woodland cover and only one fifth of the area that has climatic conditions suitable for rainforest. Surviving remnants are often small and isolated from each other, 'over-mature', showing little or no regeneration and impeded by overgrazing and invasive non-native species (INNS). According to the Native Woodland Survey of Scotland, only 30% (9,217ha) of Scotland's rainforest area is in satisfactory condition.

The **biggest threats** are inappropriate levels of grazing, invasive rhododendron and plantation forestry (as described in 3.7), as well as tree disease, especially ash dieback. Around 41% (c. 12,000ha) is suffering from high or very high levels of grazing, largely due to deer, impeding its long-term survival[1]. Undergrazing can be an issue too. Rhododendron is a problem in at least 40% (12,290ha) of the rainforest area where it threatens to choke the woodlands and prevent the distinctive rainforest flora from surviving, while 21% (6,500ha) have been planted with non-native conifers[1].

The lichens and bryophytes that inhabit Scotland's rainforest are non-vascular, which means that they absorb water from the atmosphere across their surfaces rather than from the soil through roots. Because of this they are highly sensitive to atmospheric pollution, such as nitrogen deposition, as well as to changes in environmental conditions. Rainforest species are, therefore, also under threat from nitrogen air pollution (see 3.3).

Tree lungwort is a lichen found on tree bark and is highly sensitive to atmospheric pollution and low light levels caused by evergreen conifers and invasive rhododendron.

Scotland's rainforest is a unique habitat with rare lichens, mosses, liverworts, fungi and plants – some found nowhere else in the world



STAN PHILLIPS

Bryophyte-rich ravine, Beinn Eighe.

What needs to happen?

The Alliance for Scotland's Rainforest, a voluntary partnership of organisations led by the Woodland Trust and Plantlife, has identified the following actions as priorities to save Scotland's rainforest:

Tackle threats: secure policy support and resources to address invasive rhododendron, tree disease, and deer and livestock grazing impacts to ensure the long-term ecological health of the rainforest.

Build restoration capability: increase knowledge, skills and capacity in ancient woodland restoration and monitoring effectiveness of actions.

Deliver landscape-scale projects: enable landowner collaborations to restore and expand rainforest sites.

Communicate values and opportunities: widely engage the public, landowners and businesses to engender appreciation of healthy rainforests as motivation for their long-term recovery.

JUDITH PARRY/WTML

Chapter four

What is being done? Creation, restoration and management

Contents

Introduction

The other chapters in this report describe the state, threats and drivers of change facing woods, trees and their wildlife, and show what we stand to lose if the valued benefits for people are eroded. This chapter assesses what is being done to tackle the challenges faced by woods and trees and make the most of the opportunities presented.

We know that new woods and trees are vital components for nature recovery on a large scale and can offer a wide range of benefits to people. We assess whether the UK countries are rising to their own aspirations to increase canopy cover, using disease-free and well-adapted tree saplings. Trees outside woods have been gradually lost from fields, hedges and river banks yet they are the arteries of landscape connectivity – we showcase two inspiring community led efforts to get these arteries pulsing with life again; and we identify the potential in agroforestry to restore healthy soils, water and wildlife to farms across the UK. We developed and present a new method to assess the landscape-scale impact for wildlife of the flagship Northern Forest, a method which could be applied to other large-scale nature recovery projects over time.

Looking after existing woods and trees is imperative to increase their resilience and habitat quality. It will also ensure a source of nature to colonise newly created woods and will reduce the risk of threats spreading to new woodland and trees. Woodland management approaches that address these issues and deliver a host of other benefits (e.g. from timber to outdoor recreation), will be key to the successful long-term future of our woods and trees. Currently 43% of woodland area is certified as sustainably managed under a recognised assurance scheme, though this mainly comprises commercial forestry[1]. This is only a proxy for how these woods are meeting their objectives for nature, climate and resilience, and should be considered along with condition information (see 1.4) to get a full picture. In one survey, the number of woodland owners following a management plan that complied with the UK Forestry Standard was around 52%[2], and the standard itself is under review to bolster its requirements for nature, climate and resilience. Here, we draw together available data on progress with a more specific aspect of woodland management – restoring damaged ancient woodland, on both the public estate and on private land (see 4.6). Finally, we present the results of the 2020 British Woodland Survey which explores how woodland owners, agents and advisers are responding to environmental change.

Wildlife in small woodland fragments is vulnerable to local extinctions, and will struggle to adapt to climate change and other pressures.

4.1 What is being done to create new woodland for wildlife and people?

What do we already know?

Historic and continued losses of woods and trees to development and other land uses, and to threats such as disease, result in habitat fragmentation and compound the creation challenge. A large portion of the UK's woodland now exists as small and scattered patches, often surrounded by land uses that are inhospitable to wildlife. In England for instance, around 75% of all woods are less than 10ha in size[1]. Wildlife in small woodland fragments is vulnerable to local extinctions and will struggle to adapt to climate change and other pressures. There is an urgent need to make small woodlands bigger and connect them within networks of other nature-friendly habitats, as highlighted in the Making Space for Nature report[2]. We can then begin to reverse the collapse of biodiversity and create opportunities for species to adapt.

Trees and woods also perform a range of 'services' for people, the need for which is growing. They capture carbon (see 2.1), mitigate the impacts of increased summer temperatures (see 2.4) and help manage the increased risk of flooding (see 2.2). Additionally, they are a vital part of our social and cultural landscape, providing opportunities for recreation and improved wellbeing (see 2.3), are treasured for their beauty, and fundamental to making our towns and cities liveable (see 2.4).

About the data

Commitments and targets

The UK Government and national governments have all committed to increasing woodland cover, prompted by various reports and recommendations. Most recently the **Committee on Climate Change** (CCC) has called for an increase as part of achieving 'net zero' carbon emissions[3].

The Woodland Trust's Emergency Tree Plan[4] has supported the target proposed by the CCC for an increase in woodland from 13% to 19% by 2050 to tackle the UK's biodiversity and climate crises.

Reporting on action

Tracking the *quantity* and *quality* of woodland creation is a good proxy for the benefits being achieved. However, mechanisms to track change have flaws.

A key issue is that the annual reporting is based only on the split between broadleaved and conifer, not between native and non-native (see 1.1). We have had to assume this figure, by using broadleaved woodland as a proxy for native (which of course it is not in all cases, e.g. non-native broadleaves, outside-native-range broadleaves and native conifers). This makes it more challenging to assess the impact for woodland wildlife.

There is also a question about the extent to which the annual creation figures are accurate – mostly they are based on Government woodland grant scheme data. They do not systematically include private or NGO woodland creation activity, or areas which naturally regenerate without grant support, so may be an under-representation of change on the ground.

Records of losses, of both woodland and trees, are inconsistent, and are not presented alongside woodland creation figures. Therefore it is not possible to identify what the *net* rate of creation is.

What does this tell us?

A summary of the average area of annual woodland expansion from 2016-2020 and national aspirations for this expansion is shown in Figure 4.1.1.

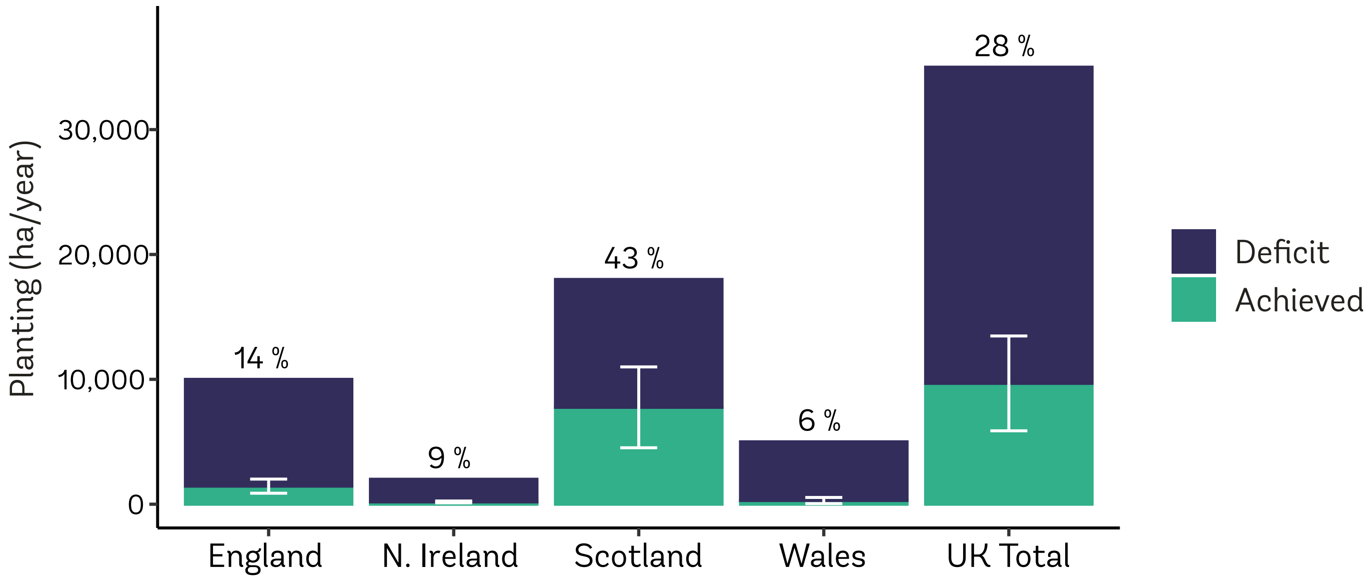


Figure 4.1.1. Average area of woodland planting achieved (2016-2020) (green), and deficit relative to CCC minimum recommendations (dark blue), by country

Percentage labels show the average proportion of the recommendations achieved. Whiskers indicate standard annual deviation in woodland planting.

Source: Forest Research 2020[5]

The recommendations to the UK Government from the CCC for increased woodland cover to between 17-19%* by 2050 would require an average of around 33,000 – 50,000ha of new woodland each year. The average rate for the UK for the last five years (broadleaved and conifer combined) is under 10,000ha, just over a quarter of that required. Scotland is contributing the most to the UK's ambitions.

*Depending on emission reductions in other sectors.

Both planting and natural regeneration will be needed to reach aspirations for new woodland cover

LAURIE CAMPBELL/WTML

Hillside with naturally regenerated trees. Suitable policies and funding to support the right tree, in the right place, for the right reason and by the right method are required, alongside consistent ways of measuring progress.

Assessing the quality and benefits of newly created woodland

It is challenging to assess the quality and potential of newly established woodland. Grant schemes have an application process which assesses applicants' objectives and their fit with the grant-giving body's priorities. The UK Forestry Standard has basic parameters for the design of new woodland. Independent assessments of quality and delivery against objectives are harder to come by, certainly in any comprehensive way. An assessment for wildlife value or adaptive potential, for example, could be based on spatial distribution (i.e. is it contributing to making existing fragments larger or adding to habitat networks – see 4.5), species composition, establishment techniques, protection from browsing, and design. It will also be important to ensure that other semi-natural habitats are not damaged by unsuitable woodland creation. Correlations with the presence of indicator species may also be useful, although it will take time to demonstrate results[6].

Replacing trees outside woods (TOWs)

The majority of TOWs have little protection from loss, either as a result of deliberate removal or gradual attrition. Individual trees will generally fall below the threshold for the protection offered by a felling licence. From one study in this report, estimates suggest 30-50% of all countryside TOWs have been lost in the last 150 years (see 1.2). Trees lost due to age or disease are not usually replaced and often do not have the opportunity to regenerate naturally.

The majority of trees outside woods have little protection from loss, either as a result of deliberate removal or gradual attrition

There are no specific commitments from UK governments for maintaining, replacing or increasing TOWs and few grant schemes which support them. Given the importance of ash (*Fraxinus excelsior*) as a TOWs species, this could be significant in the face of losses due to ash dieback (*Hymenoscyphus fraxineus*), particularly following on from the massive losses of TOWs 50 years ago to Dutch elm disease.

Why does it matter?

The failure to meet targets for tree and woodland creation has important implications across a range of issues. For woodland wildlife, increasing woodland size and creating habitat networks are critical to reduce local extinctions and create the opportunity for adaptation to climate change (see 4.5). A lack of new native woodland and trees will, over time, lead to species extinctions and loss of adaptive capacity for woodland wildlife.

Increased woodland is a key element of the CCC recommendations for the UK to achieve net zero carbon emissions and is one of only a few options identified as available for rapid implementation. Lack of new woodland and trees will result in a failure to meet a proportion of carbon mitigation targets and ultimately increase the impacts of climate change for people and wildlife.

What needs to happen?

Support for expansion: governments across the UK, along with landowners, businesses and civil society, must urgently increase support for woodland creation and for maintaining and expanding tree cover outside woods (including in urban areas). Our exit from the European Union and the need for a green recovery in light of the Covid-19 pandemic, offer the opportunity for the governments to take a lead in significantly increasing the area of woodland to benefit communities, the economy and nature.

More native woodland and trees: we urgently need more woodland and trees to meet a range of objectives. A high proportion of native woods and trees is important for native wildlife (see e.g. 1.6, 4.5).

Reporting on quality: systematic methods need to be developed for tracking changes in the quality of and outcomes from, newly created woods and trees.

Mechanisms for trees outside woods: trees outside woods have few mechanisms to protect and replace them. This urgently needs addressing.

CASE STUDY

Working with a nursery manager on a UKISG audit.

4.2 What progress is being made with improving biosecurity in tree planting?

What do we already know?

Home-grown tree saplings for planting schemes avoid the need to import plants and any harmful diseases they may harbour. Locally collected seeds are also more likely to produce trees adapted to locally prevalent pressures such as tree disease or drought and they will flower and fruit in season with local pollinators and other wildlife – unlike many imported plants.

UK and Ireland Sourced and Grown (or UKISG) is currently the only biosecurity assurance scheme that tackles the significant pest and disease risk posed by the importation of plants. There is a clear link between the increased use of imported plants since the early 1990s and the rise in new tree pests and diseases (see 3.4). When it became clear that ash dieback had been imported into the UK on infected ash saplings that were planted out into the wider environment in 2012, the Woodland Trust decided that none of the trees it planted would be imported.

Local seed collections avoid the need for imports

Hazelnuts

Hawthorn berries

Acorns

The plant production industry is in the process of introducing a new plant health standard, Plant Healthy. This voluntary standard aims to raise awareness of biosecurity issues across the industry through the introduction of new checks on production processes. Plant Healthy does not prevent the importation of plants but it does check the plant health chain of custody (plant passports and phytosanitary certificates). As the standard develops it is hoped that it will provide a more biosecure plant supply chain.

About the data

This data is drawn from Woodland Trust contracts covering the period from 2014 to 2024. They are indicative figures which show how the volume of trees the Woodland Trust places under contract are increasing – and demonstrate a commitment to plant health. Nursery partners across the UK have enthusiastically embraced UKISG to deliver increasing numbers of healthy and risk-free stock to thousands of woodland creation sites.

Woodland Trust procurement of UKISG has eliminated the risk of introducing pests and diseases from what could otherwise have been 27 million imported trees

What does this tell us?

Twenty-six UK tree nurseries have now adopted the Woodland Trust-initiated assurance standard, UKISG, for some or all of their tree stock. To date the Woodland Trust has procured 12.5 million UKISG trees and has contracts in place for a further 14.5 million trees until 2024 (see Figure 4.2.1). This has eliminated the risk of introducing pests and diseases to the UK from what could otherwise have been 27 million imported trees. In addition, the three-year contracts provide security and confidence to those nurseries awarded a tender and the Woodland Trust provides business to other nurseries on an opportunistic basis, where they meet the UKISG assurance standard. Given the success of UKISG and the willingness of nurseries to be involved, it is estimated that the current 26 assured nurseries could produce 70-100 million UKISG trees per year. The Woodland Trust uses UKISG to procure native trees, however, any tree/shrub species could be brought into the assurance scheme as long as it satisfies the audit criteria.

Experience of UKISG has flagged that **native tree seed supply** is a potential bottle-neck in the process. For some of both the common as well as the rarer native trees and shrubs, there are very few recognised seed stands or seed orchards[1].

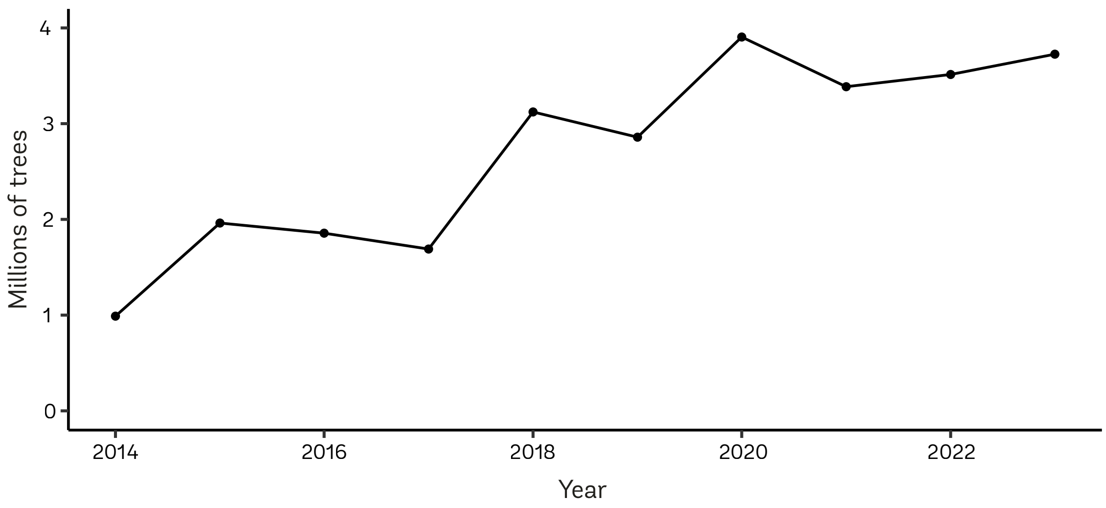


Figure 4.2.1. Numbers of trees produced and under contract to the UKISG scheme

Source: the Woodland Trust

UKISG trees being grown at one of the UKISG nurseries.

Why does it matter?

Widespread uptake of the UKISG assurance scheme with UK nurseries demonstrates the demand for biosecure and well-adapted tree stock in planting schemes, while supporting UK business and creating jobs.

What needs to happen?

Greater uptake of UKISG: biosecurity and resilience of UK trees depends on all planting schemes having access to disease-free and well-adapted planting stock i.e. UKISG or similar assurance standards. This should include all procurement of trees by governments, e.g. for large transport infrastructure schemes.

Reduce imports: reduce the demand for, and use of, imported stock, including tighter regulations and a major education programme for those buying and selling young trees, including within the horticultural sector.

Sustainable supply chains: develop sustainable seed stands, collections, storage and supply chains as a matter of urgency to meet forecasted need for tree-planting material. This should include support for community tree nurseries to ensure availability of tree stock close to where the planting is planned.

Promote natural regeneration where appropriate: managing trees to self-seed and naturally spread can be a suitable way of creating new woodland in many circumstances, avoiding the need for planting altogether.

CASE STUDY

Welsh landscape with hedgerows, tree lines and scattered trees.

4.3 Are trees outside woods being replaced?

We know trees outside woods continue to suffer untold losses (see 1.2). These case studies demonstrate that local action to replace them is possible if there's a will.

Saving Devon's Treescapes

Saving Devon's Treescapes is supporting local communities throughout Devon to plant and nurture over 250,000 trees. The project will enable people to care for and celebrate treasured treescapes, achieving local action for wildlife and climate change.

Saving Devon's Treescapes is led by Devon Wildlife Trust on behalf of the Devon Ash Dieback Resilience Forum and is supported by the National Lottery Heritage Fund, as well as other funders, including the Woodland Trust.

Unprecedented threats to Devon's treescapes

Devon's spectacular landscape of rolling hills, picturesque river valleys and open moorland derives much of its distinctive character from trees outside woods (TOWs).

These trees are the unsung heroes that create small copses, orchards, parklands and wood pastures, and enhance fields and the remarkable 53,000km of Devon hedgerows that bind the whole patchwork together. Equally important are the street, garden and park trees that make towns and villages attractive and enjoyable places to live.

Traditional hedge-laying skills are being revived to ensure longevity of these important landscape features.

But right now, Devon's TOWs – and hence its treasured treescapes that provide a sense of place and belonging – face unprecedented threats. Surveys show that a high proportion of hedge trees are nearing the end of their life due to old age. Without concerted, sustained efforts to replace them, there will be profound impacts on the many other species that they support.

Furthermore, TOWs face a wave of threats to their health, most imminently ash dieback. Ash is Devon's second most common tree, after oak. Outside woods there are an estimated 1.9 million ash trees in Devon's hedges and along its footpaths, roads, riverbanks and coastlines – and an estimated 90% of these trees will be killed by ash dieback over the coming years.

Plans for the future

To combat the decline in Devon's TOWs, Saving Devon's Treescapes will be working to establish new trees across Devon to safeguard the future of the treescapes and their wildlife. The project will be planting 250,000 new urban and rural trees through:

- three new community tree nurseries which will empower local people and generate tree stock for a free tree scheme
- outdoor learning, workshops and events with schools with communities, farmers and landowners
- treescape advisory visits for farmers and landowners
- sustainable management regimes to enhance existing hedges
- 50ha of new trees in field corners and copses
- 20km of exemplar flagship hedgerows.

Hedges – the 'long-forests' of Wales

Collecting hawthorn berries to grow in a community tree nursery and use to 'gap-up' hedges in Wales.

Increasing the amount of UK hedgerows by 40% has been identified as a strategy to contribute to locking up carbon on a big scale[1], while delivering a plethora of other benefits for wildlife and people. This would require the creation of 200,000km of new hedges across rural and urban landscapes – which equates to about the half the length of Britain's road network.

UK data on what is being done to create new hedges is lacking. This community case study shows what can be achieved by people power.

In Wales, a quarter of all hedgerows were removed between 1984 and

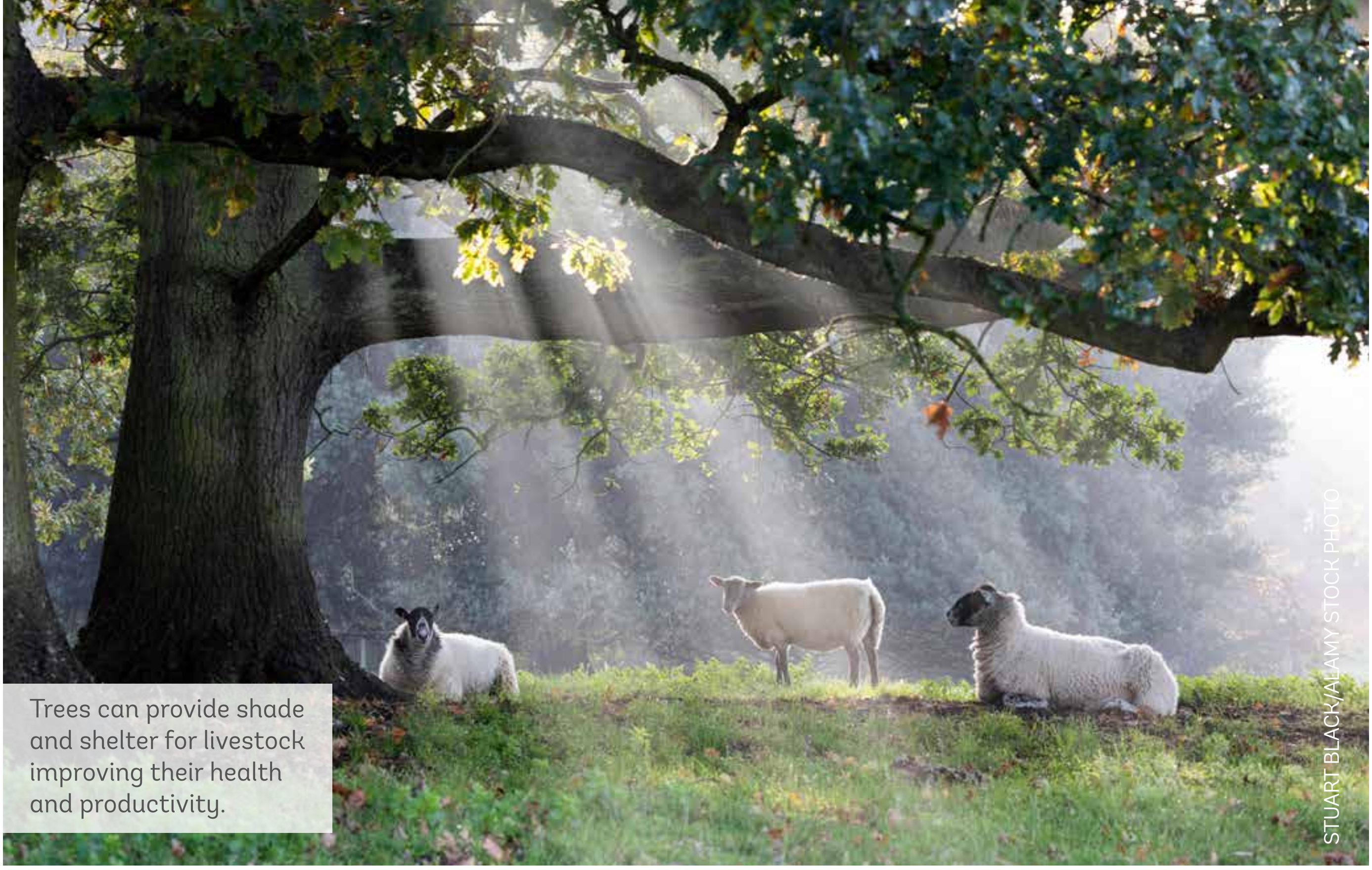
1990[2] and 78% of remaining Welsh hedgerows are in 'unfavourable condition'[3].

Increasing the amount of UK hedgerows by 40% has been identified as a strategy to contribute to locking up carbon on a big scale

Protecting, extending and connecting the hedgerows or 'long forests' of Wales has inspired the Long Forest project, developed by Keep Wales Tidy in partnership with the Woodland Trust and supported by the Heritage Fund and Esmée Fairbairn Foundation. This project has been able to:

- plant 119,711 trees as new hedges, restore 'gappy' hedgerows and reconnect fragmented hedgerow networks
- progressively restore 15km of dilapidated hedges using traditional techniques
- establish four community tree nurseries which are raising young tree stock from locally-collected native seed and run training events for those wishing to establish their own community nurseries
- involve more than 3,000 volunteers across Wales in practical hedging activities
- train 1,100 landowners and volunteers on how to plant, care for and restore hedgerows
- produce informative guides on planting and managing hedges
- survey 48km of field, wayside and garden hedgerow across the length and breadth of Wales using the 'Long Forest app'.

More initiatives of this type are vital to connect people with nature recovery ambitions and tackle climate change. As a next step, the Woodland Trust is developing a **'Hedges and Edges' proposal** for Wales to support farmers in retaining and increasing tree and hedge cover on their land. This recognises that hedges are part of an ancient agroforestry tradition. Together with hedgerow trees and field edge habitats they form the extensive habitat network that is crucial to wildlife and defines our landscapes. They provide lots of practical benefits including protecting livestock from weather extremes, aiding biosecurity, mitigating flooding, and enhancing soil, carbon and water resources.



Trees can provide shade and shelter for livestock improving their health and productivity.

4.4 What is the uptake and effectiveness of agroforestry?

What do we already know?

Most trees outside woods occur on farmland. The practice of deliberately integrating woody vegetation (trees or shrubs) with crop and/or animal systems to benefit from the resulting ecological and economic interactions is termed **agroforestry**. This land management approach has multiple benefits. It can be designed in a way that enhances soils, water, carbon storage and wildlife alongside food production in modern farming systems[1].

There are five distinct types:

1. Silvopastoral: trees and livestock
2. Silvoarable: trees and field crops
3. Hedgerows and buffer strips
4. Forest farming: cultivation within a forest environment
5. Home gardens: small-scale, mixed or urban settings

In the UK, agriculture and forestry are often treated as separate and distinct disciplines in terms of practice, policy, education and training, resulting in a lack of knowledge and practical guidance on agroforestry. If trees and small woodlands on farms are valued through integrating them into farming systems, they will be protected and looked after and farmers will want to have more of them – increasing space for nature in often intensively managed countryside.

About the data

There is no comprehensive assessment of the amount or quality of agroforestry in the UK, nor of trends in expansion or loss. The figures that do exist only give a partial picture and do not include the more traditional forms of agroforestry such as hedgerows and wood pasture systems.

What does this tell us?

Farming is the dominant land use in the UK. Utilisable Agricultural Area covers 72%[2] of the total UK land area. It is estimated that 3.3%[3] of the utilisable UK farming area is in agroforestry (excluding more traditional boundary hedgerows, parkland and wood pasture; Table 4.4.1).

Table 4.4.1. Area* (ha) of agroforestry in the UK

Source: adapted from den Herder *et al.* (2017)[3]

Utilised Agricultural Area (UAA)	High value tree agroforestry e.g. orchards	Silvopastural	Silvoarable	All agroforestry	Est. proportion of farmland
16,882,000	14,200	547,600	2,000	551,700	3.3 %

*Some overlap between categories hence subtotals add up to more than total.

Why does it matter?

The current low level of agroforestry (particularly compared to other European countries) is a concern because the threats to wildlife, landscape and ecosystem services are not being tackled at scale on farmland, which covers 72% of our countryside.

Wildlife plus

Agroforestry can benefit wildlife, with the potential to more than double average farm biodiversity levels[4]. Crop pollinators and the predators of insect pests also increase[5]. Agroforestry can also reduce soil degradation, water runoff and pollution. Thoughtfully designed schemes will act as buffers to valuable habitats such as ancient woodland and provide connectivity across farmed landscapes.

Crop pollinators have been shown to increase in agroforestry systems.

Carbon

Integrating trees into farms at a significant scale could dramatically increase the amount of carbon sequestered on farms compared to monocultures of crop or pasture land. Silvopasture (trees with livestock) has been ranked as the ninth most powerful of 80 climate mitigation solutions and as the most powerful of all agricultural strategies[6]. Carbon sequestration of 1-4 tonnes of carbon per hectare per year from agroforestry densities of between 50 and 100 trees per hectare have been achieved[7].

Furthermore, to support the UK's net zero carbon emissions target, the Climate Change Committee (CCC) recommended 10% of agricultural land should be used for agroforestry by 2050. This could deliver 6MtCO_2e savings by 2050 and would require 39,000ha of additional agricultural land to be used for agroforestry each year.

Resilience and sustainability

Practising agroforestry can help a farm business be resilient, diverse and produce a combination of marketable goods as well as public benefits. Growing two crops on the same area of land, such as an apple/cereal alley cropping system, can increase total productivity by up to 40% compared to mono cropping[8].

There is great potential for agroforestry to expand to become a mainstream land use delivering multiple benefits for nature, climate and productivity. Government support for agroforestry is minimal within the UK. The lack of current government support is a major barrier to realising the full potential.

Farms can diversify by planting fruit trees interspersed with arable crops, which also extends employment over a longer season.

What needs to happen?

Targets and support: stretching governmental agroforestry targets and support – including training – is a vital next step.

Investment: investment in supply chains and processing capability for tree products to make agroforestry viable to more landowners.

Better evidence and monitoring: a UK-wide assessment of the scale and quality of agroforestry should be undertaken, with consistent categories. Agroforestry should be included in government statistics. It is currently not part of the Utilisable Agricultural Area.

CASE STUDY

The noctule bat (*Nyctalus noctula*) feeds on insects above the tree canopy. It is one of many species that would benefit from a better connected wooded landscape in the Northern Forest area.

4.5 How do we measure the wildlife benefits of new woodland at a landscape scale?

What do we already know?

Despite site-based conservation measures, the fragmentation of native woodland at a landscape scale threatens many of the wildlife species relying on it. Fragmentation decreases the amount and quality of habitat and increases the isolation between different habitat patches. A patch is an area of habitat of suitable size and quality for a species to successfully reproduce. Wildlife populations in different patches in a landscape are connected by dispersal, when individuals leave the patch in which they are born, travel to another (often through habitat unsuitable for reproduction) and settle there, contributing to that new patch's future population.

Wildlife population sizes and growth rates are lower in small and poor quality patches and so populations produce fewer dispersers and are more likely to go extinct. This is because dispersal becomes more difficult with distance between patches and greater 'hostility' of the surrounding landscape. Connections between wildlife populations through successful dispersal are vital in fragmented landscapes to ensure the genetic health of populations, the recolonisation of empty patches, species range shifts in response to climate change and other ecological processes integral to biodiversity conservation.

Methods for quantifying the **functional connectivity** between populations in fragmented landscapes have been a topic for development and application in recent years[1,2]. These aim to measure the total contribution of a landscape's isolated patches to the viability of vulnerable wildlife populations. By combining all of the **Lawton principles** for the conservation of ecological networks of "Bigger, better, more and joined up"[3], such methods provide a toolset with which to monitor progress and target action to improve the ecological connectivity of landscapes.

Establishing a baseline

Launched in 2018, the 'Northern Forest' project (Figure 4.5.1) is a 25 year, transformative, landscape-scale plan to increase woodland cover from a current dearth of 7.6%, by planting at least 50 million trees and through natural regeneration of unwooded areas. This case study, presenting an assessment of the connectivity of broadleaf woodland across this landscape, can act as a baseline to assess the conservation success of the project. It can also be used to help target future woodland creation and landscape conservation management to areas where it will be most beneficial for the resilience of wildlife populations vulnerable to fragmentation.

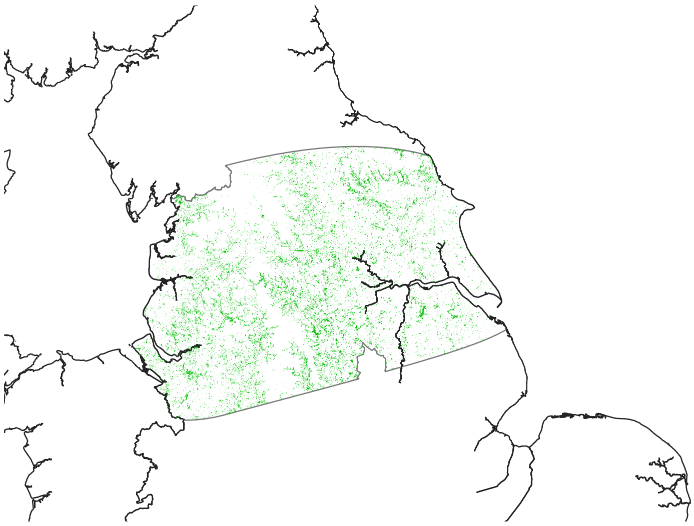


Figure 4.5.1. Northern Forest boundary area showing broadleaf woodland cover in 2019

Source: CEH (2020)[6]

About the data

Calculating equivalent connected area

The habitat types represented in the Northern Forest were identified in comparable land cover maps for 1990 and 2019[4-7], which describe land cover type throughout the UK at 25m resolution. The **Equivalent Connected Area (Probability of Connectivity)** or ECA(PC) was calculated for broadleaf habitat across the landscape in both years for two 'generic' woodland species: one highly sensitive to fragmentation and one with moderate sensitivity. Following Watts *et al.*[8], the highly sensitive species required habitat patches of >10ha and was able to disperse 1km with 95% probability, whilst the moderately sensitive species required habitat patches of >2ha and was able to disperse 5km with 95% probability. The method could be applied using the attributes of any species, but the generic species approach has the strength of concisely revealing general trends applicable to a wide range of species.

The ECA(PC) metric is defined as "the size that a single habitat patch would need to be, to produce the same probability of connectivity as the actual habitat pattern in the landscape"[9]. ECA(PC) is reported as an area, and thus simple to communicate relative to other connectivity metrics. Higher ECA(PC) values indicate greater functional connectivity, and a landscape's ECA(PC) value will always be greater than the area of the largest patch in the landscape, but smaller than the total area of habitat.

Incorporating functional connectivity

The methods of Saura and Rubio[9] were adapted to incorporate components of **functional connectivity** highlighted by Watts and Handley[1]; namely the varying negative impact of different habitat types bordering woodland on a patch's quality, and the variation in the permeability of the landscape between woodland patches to the isolation of patches. Using published estimates the impacts of each different habitat type on the bordering patch quality and landscape permeability is described[10].

The contribution of individual broadleaf woodland patches to connectivity increases with their area and quality, and decreases with isolation from other patches of suitable size in the landscape. Edge effects on patch quality were considered by decreasing patch area by the area of edge habitat, which extended into patches to different extents depending on the bordering habitat type (see example in Figure 4.5.2). Isolation increases both with increasing distance between suitable patches and with increasing cost of movement through the landscape. The 'least-cost' distance was calculated between woodland patches to measure the chance of successful dispersal between them. Least cost distance describes the shortest equivalent distance between patches, considering that movement costs vary with the habitat type that is moved through (e.g. moving 100m through urban habitat was equivalent to moving 500m through broadleaf woodland).

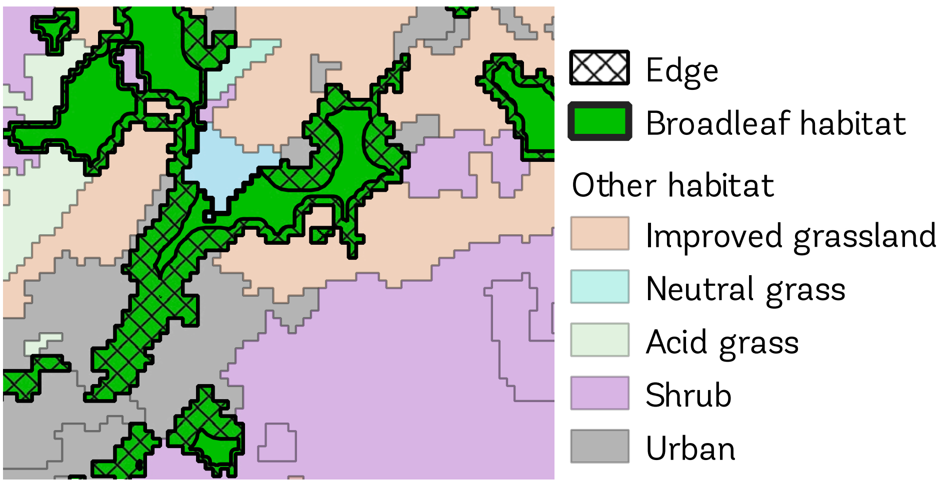


Figure 4.5.2. Illustration of varying negative edge impact of different habitat types

Varying edge impacts on patch quality are evident, as 'hostile' habitat types (such as urban) encroach to a much larger extent into broadleaf habitat than others, such as neutral grassland.

Source: the Woodland Trust

What does this tell us?

Table 4.5.1. Changes in equivalent connected area 1990 to 2019

Source: the Woodland Trust

Year	Number of patches	Total habitat area (ha)	Mean patch area (ha)	Mean movement cost	Equivalent connected area (ha)	
					Highly sensitive	Moderately sensitive
1990	23,085	139,830	6.1	7.85	2,091	2,137
2019	28,381	160,404	5.7	7.65	2,373	2,410
Change	23%	15%	-7%	-3%	13%	13%

Between 1990 and 2019 there has been a 15% increase in the area of broadleaf woodland in the Northern Forest, which has been accompanied by similar increases in the equivalent connected area for woodland species both highly and moderately sensitive to fragmentation (13% for both; Table 4.5.1). There were marked differences in connectivity in different regions, with areas of particularly low connectivity evident in both the North West and South East (Figure 4.5.3). Plotting changes in connectivity in space also highlights where the biggest contributions to increased connectivity have been made.

Young native woodland helping to connect isolated woodland patches and increase wildlife habitat.

PHIL FORMBY/WTML

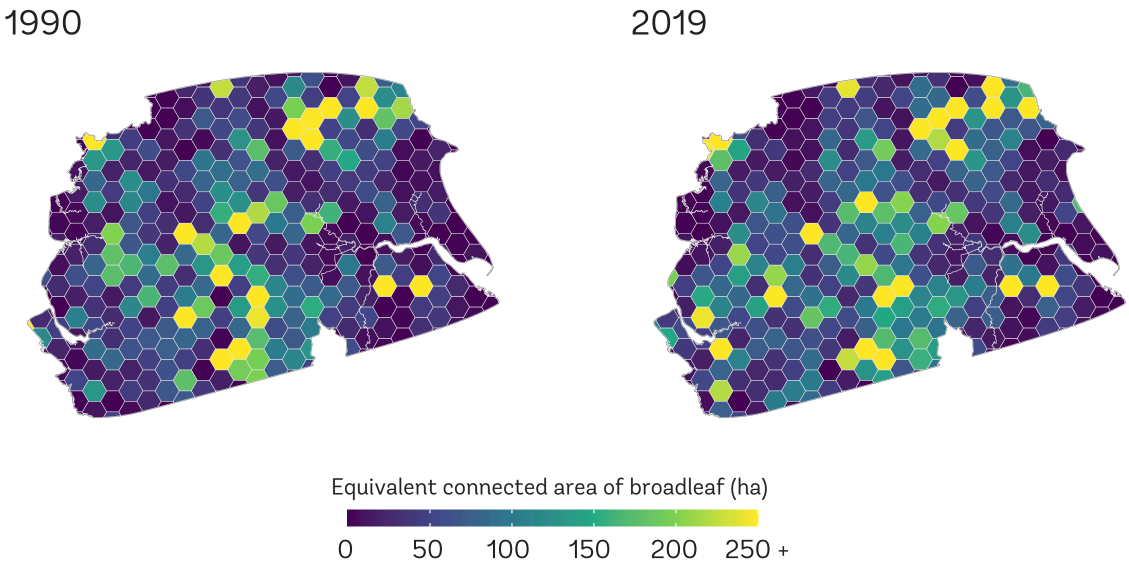


Figure 4.5.3. Broadleaf habitat connectivity

Equivalent connected area (probability of connectivity) of broadleaf woodland habitat for a highly fragmentation sensitive generic species in the Northern Forest within 10km wide hexagonal grid cells in 1990 and 2019.

Source: the Woodland Trust

Why does it matter?

The area, quality and spatial configuration of native woodland habitat are all important for the viability of woodland species populations. **Functional connectivity** between woodland patches should be pursued as an explicit objective for woodland creation. Quantifying functional connectivity allows the effectiveness of woodland creation for landscape scale conservation to be monitored and to guide decision making between alternative strategies. Edge effects of hostile neighbouring habitats can be particularly costly for functional connectivity, thus targeting woodland creation to buffer pre-existing woodland is an effective way to reduce this cost. While connectivity can most effectively be enhanced by increasing the size and quality of woodland habitat, ensuring the permeability of the surrounding landscape – i.e. improving the quality of other semi-natural habitats, farmland and urban areas – is also important to allow populations in otherwise isolated patches to be linked by frequent dispersal of individuals.

PHOTO COURTESY OF FORESTRY ENGLAND

From former colliery to thriving woodland for people and wildlife in the Mersey Forest area.

MAP DATA: GOOGLE EARTH

More woodland creation like this is needed to increase wildlife survival and benefit people.

Even prior to the instigation of the plan to create a Northern Forest, the region has undergone a marginal increase in broadleaf woodland cover and connectivity. This is reassuring and **sets a baseline** from which the success of the Northern Forest project can be measured. The analysis also highlights areas with poor functional connectivity. The reason for poor connectivity may differ between these areas, and further investigation is required to identify which management actions are most appropriate to improve connectivity in different areas. Some areas may have comparative broadleaf habitat to areas of higher connectivity but be highly impacted by the negative effects of a hostile landscape between forest patches, or high edge effects.

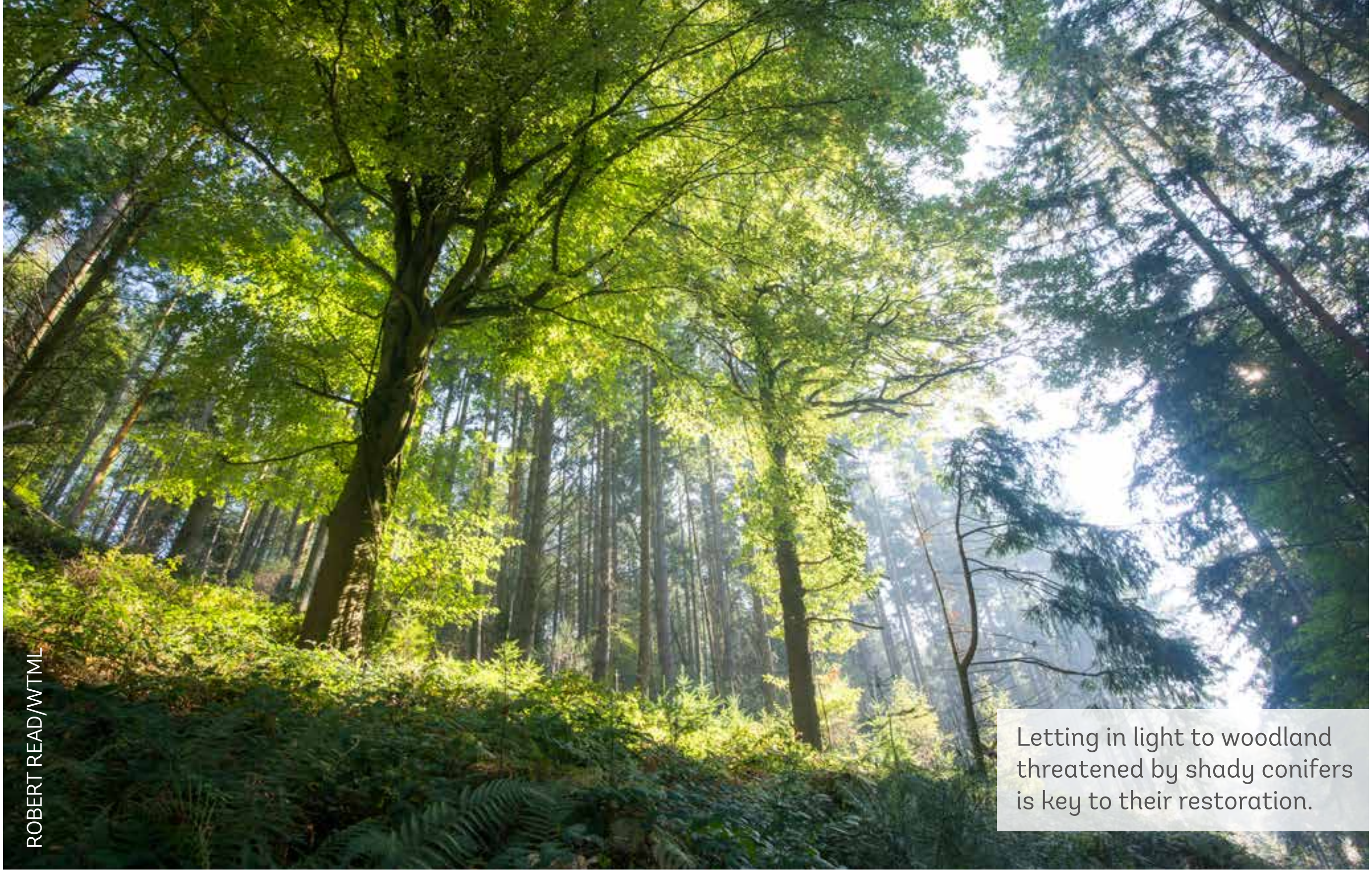
Creating resilient wooded landscapes requires careful consideration of where woodland creation is best suited to enhance the functional connectivity of populations vulnerable to fragmentation. Mapping connectivity and comparing changes over time, and integrating this data with information on species' responses, allows woodland creation to be targeted to where it will most benefit these populations. Estimates of the potential benefit of new native woodland to functional connectivity can be combined with the likely costs associated with native woodland establishment in different areas to highlight where the greatest potential opportunities are present.

What needs to happen?

Targeting for connectivity: native woodland creation should be pursued, with the explicit objective of optimising the functional connectivity between existing native woodland patches across landscapes. This will likely be best achieved by increasing the size and quality of existing native woodland patches, as well as improving the permeability of the surrounding landscape for wildlife dispersal.

Prioritise native woodland: native woodland will be the most beneficial to native woodland wildlife, relative to non-native conifer plantations, which can act as a hindrance to, rather than promote, the functional connectivity of native woodland wildlife. The condition of existing woodland and other semi-natural habitats should also be improved to ensure breeding success of wildlife populations.

Repeated monitoring and measurement: the analysis presented here should be repeated as future data becomes available to monitor the response of the landscape to the woodland creation being undertaken. The results should be integrated with monitoring of species responses and used to guide management decision making through an adaptive process. This would refine both the effectiveness of woodland creation for conservation, and the utility of these tools to estimate functional connectivity in the landscape.



Letting in light to woodland threatened by shady conifers is key to their restoration.

4.6 What is being done to improve the condition of damaged ancient woodland?

What do we already know?

Ancient woodland is irreplaceable and where degraded (see 3.7), must be restored. Restoration of ancient woodland in the most critical or threatened condition is an urgent priority. The longer remnant features remain in a critical condition the more likely they are to be permanently lost. While urgent, restoration also takes time. Gradual restoration of Plantations on Ancient Woodland Sites (PAWS) through thinning and continuous cover transformations requires regular and ongoing management interventions to achieve the desired regeneration and wider recovery. A series of guides on ancient woodland restoration are available from the Woodland Trust[1-5].

Restoration aims to develop **future ecosystems** with greater ecological integrity and resilience, and not return woodland to some previous composition. It is important that the current state of most ancient semi-natural woodlands (ASNW) is not seen as the pinnacle of ecological condition. Restoration is not complete when tree species composition becomes native; ancient woodland restoration goes beyond addressing threats such as non-native conifers, and includes other positive steps towards maximising the ecological integrity of all ancient woodland sites. It is vital to track progress with the restoration of the most critical and threatened ancient woodland ecosystems, to avoid the deterioration or loss of remnant ancient woodland features from inaction or inappropriate management.

Gradually felling the non-native trees will enable native species to grow, such as here at Brede High Woods in Sussex.

Restoration of degraded ancient woodland has been supported by **government policy** since the Broadleaves Policy (1985). Various devolved government policies have continued to support PAWS restoration (e.g. Keepers of Time, Woodlands for Wales). For example, in England, Keepers of Time (2005)[6] had the target that 'by 2020, the majority of planted ancient woodland sites are either being improved or under gradual restoration to native woodland'. Despite 35 years of public policy, a considerable amount of the UK's ancient woodland remains as PAWS, (see 3.7) and much of this is still likely to be in a critical or threatened condition.

The **UK Forestry Standard (UKFS)** is the Government's approach to sustainable forestry, and adherence to this standard should be ensured through forestry regulation (i.e. felling licences, grant schemes and other approved management plans). However, the minimum required by current UKFS is that any remnant features are retained or protected, with only 'consideration' to restoration of the wider stand and progressive transformation to native woodland. Outside statutory protected sites (see 1.5) there are no legislative powers to ensure restoration of PAWS. Only the Forestry Act in Northern Ireland (amended in 2010) includes a specific provision relating to ensuring the special character of ancient woodland is regarded in determining felling management plans.

The **UK Woodland Assurance Standard (UKWAS)** outlines the requirements which must be met as part of global certification schemes for forestry and forest products, the Forest Stewardship Council® and the Programme for the Endorsement of Forest Certification. For certified forests, this requires owners/managers to maintain, enhance or restore features and areas of high conservation interest within PAWS. It also requires that owners/managers identify and evaluate remnant features, the threats they face, and to implement targeted actions. This precautionary approach, prioritises action based on the level of threat and value of remnant features. All ancient woodland on the Government-owned public forest estate (PFE) is managed under UKWAS, but the proportion of privately owned ancient woodland that is certified is unknown.

About the data

The focus here is on progress with restoring PAWS to a more secure condition. Limited data is available on aspects of management. Each country of the UK reports on their progress with ancient woodland restoration on the public forest estate separately, and each monitors this differently; this data is drawn together for this report. In addition, we draw on available data from the Woodland Trust's work with private landowners – advising managers and private owners on restoring their ancient woodlands.

What does this tell us?

Ancient woodland restoration on the public forest estate (PFE)

England

Between 2014 and 2018/19, there has been some progress with restoration. For example, the area of PAWS category 1 (over 80% native tree species in the canopy) increased by 19.1% (just over 1500ha; Table 4.6.1). There was a corresponding 18% decrease in the amount of PAWS with under 20% native trees (category 4), but in terms of total area this category still forms over half of the PAWS on England's public forest estate. It is important to acknowledge that it is possible to rapidly increase nativeness scores through a clear-fell and restock approach, but this does not necessarily safeguard the condition of remnant features or maintain wider woodland functioning. It is for this reason that progress with restoration is best understood through a more detailed assessment of condition, rather than canopy composition alone. Restoration is not complete with canopy cover transformation to native trees.

Table 4.6.1. Extent of PAWS in England by semi-naturalness score

Source: Forestry England (2019)[7]

Category*	Area in 2014 (ha)	Area in 2018/19 (ha)	Change in area (ha)	% change
1 – Over 80% native	8,261	9,835	1,574	19.1
2 – Between 50-80% native	3,332	3,739	407	12.2
3 – Between 20-50% native	5,765	5,831	66	1.1
4 – Under 20% native	27,252	22,349	-4,903	-18.0
0 – No trees	993	942	-51	-5.1
Total area	**44,610**	**41,754**	**-2,856**	**-6.4**

*This is based on 'nativeness' of canopy composition only. No information is given on the condition of remnant features or management approaches.

Northern Ireland

Approximately 50% of the PAWS in Northern Ireland is on the Public Forest Estate, managed by Northern Ireland Forest Service. All ancient woodland sites (including PAWS and ASNW) were surveyed in 2013-14. 709ha were considered 'secure'; not under any widespread threat from impacts such as invasive plant species or shade from non-native tree canopy. A work programme was drawn up for the 302ha of ancient woodland in a threatened or critical condition.

The areas identified as threatened or critical in 2013 were assessed again in 2019. The area classified as threatened had decreased by 99ha, and the area classified as secure had increased from 709ha to 809ha. Whilst 194ha remained in a threatened condition, only 9ha was considered to be critical.

Scotland

Accurate figures on the condition of PAWS are not currently available, but Forestry and Land Scotland is in the process of carrying out condition assessments on ASNW and PAWS on the public forest estate and should have results for the whole ASNW area by the end of May 2021 (pers. comm. Forestry and Land Scotland, 2020). Over the coming 2-3 years, Forestry and Land Scotland will report on the area of PAWS in different conditions (critical, threatened or secure).

Forestry and Land Scotland reports it has begun restoration management by halo thinning, silvicultural thinning, or clear-felling over approximately 18,000ha (62% of PAWS on PFE in Scotland, equating to 30% of the total PAWS in Scotland).

Wales

In 2012 the condition of the entire c. 19,500ha of ancient woodland on the PFE in Wales was assessed using a combination of field-based sampling and desk-based analyses of both threats and ecological potential. Of this, 34% was considered secure, 36% threatened and 30% critical (pers. comm. Natural Resources Wales, 2020). Approximately 3,250ha of PAWS consisted of larch, the majority of which will have been, or will be, felled in the future due to infection with the pathogen *Phytophthora ramorum*. Natural Resources Wales intends to carry out a full repeat ancient woodland condition assessment in 2025. This will be the first opportunity to fully assess trends against the 2011/12 ancient woodland baseline survey.

In 2020, areas that were mainly clear-felled in 2011, and could therefore not be classified in the inventory, were re-assessed. Of the 2,790ha (14% of PFE ancient woodland in Wales) assessed, 49% now had more than 50% native canopy cover (classified as Restored Ancient Woodland Site in the Welsh inventory), whilst 45% was classified as PAWS (>50% non-native canopy cover), with 6% remaining unclassified.

Natural Resources Wales' target for thinning of PAWS (removal of selected non-native trees) in 2018/19 was not met. The total area

Huge areas of ancient woodland remain in a critical or threatened condition. Remnant ancient woodland wildlife is at risk of being lost without urgent action. Here, sanicle (*Sanicula europaea*) an ancient woodland indicator hangs on under a shady canopy.

CHRISTINE REID

thinned was 92ha, against a target of 350ha, which is just 0.76% of the PAWS on the PFE in Wales. The target for the management of invasive non-native plants in ancient woodland was also missed in 2018/19, with only 95ha actively managed against a target of 581ha.

The principal approach to PAWS restoration is through thinning, but clear-fell targets are included for issues such as unstable crops or disease compliance needs. The target for 2018/19 clear-fell programme on PAWS was 223ha. The reported figure for completed PAWS clear-fell and restocking in 2018/19 is 108ha (0.9% of PAWS on PFE in Wales).

Ancient woodland restoration under other ownership

Sixty-six per cent of PAWS in the UK are owned by private land owners, charitable organisations and other public bodies (see 3.7). Yet, there is no complete data on progress with restoration across these ancient woodlands. Since 2015, the Woodland Trust has assessed the condition of 21,547ha (c. 7.2%) of PAWS on privately owned land, of which 1,636ha was classed as critical, 17,399ha threatened, and 2,512ha secure.

As a result of the Woodland Trust's work since 2008, nearly 31,000ha of ancient woodland was committed to restoration, with areas increasing every year. This includes land for which management actions have been agreed and the land manager has confirmed that they intend to carry out the work, but the work may not have started yet – with lack of funding often quoted as a reason. Follow up is required to monitor the progress of the work and track areas where active restoration takes place. Incomplete data on this is available from 2014, which shows that active restoration management involving Woodland Trust support has taken place on more than 3,700ha. This data is now being collected in a systematic way for better reporting in the future.

The Woodland Trust estate

The Woodland Trust estate has 497 sites that contain ancient woodland, covering 8,629ha (1.5% of UK ancient woodland). Of this, 163 Woodland Trust sites contain PAWS, covering 3,959ha (1.5% of all UK PAWS).

CHRISTINE REID

Wider paths and rides, with their higher light levels, are often where woodland flowers survive and provide a source of colonisation into stands formerly dominated by shady conifers

All the Woodland Trust's PAWS are in a program of active restoration and more PAWS are being acquired. As a snapshot, in the past five years 182 ancient woodland sites have received restoration management, including 145 where invasive non-native plants have been controlled, and 37 where non-native trees have been thinned or felled as part of restoration management, the latter over an area of nearly 1,000ha.

Why does it matter?

Although it has been public policy to restore PAWS since the Broadleaves Policy (1985), three decades later – while there has been some progress with restoration on the public forest estate – huge areas of ancient woodland remain in a critical or threatened condition. Conservation charities make up the minority of the 'privately owned' PAWS category, yet it is often these charities that are leading the way for demonstrating active restoration.

Complete data on the condition of ancient woodland is not available. This prevents us from tracking trends and puts a huge swathe of the UK's ancient woods at risk of deterioration. Remnant flora, fungi and fauna within the most threatened ancient woodland ecosystems will continue to struggle, and unless critical sites are urgently managed, are at risk of being lost. Woodland Trust support for restoration on private land illustrates that around two thirds is considered to be 'threatened'. Although the area assessed only represents a small proportion of the total ancient woodland and PAWS in the UK, it covers a large geographical spread in all parts of the UK, and could be considered to be representative of the entire resource.

No data is available on the uptake of Government grant schemes, which would provide important information on attempts at restoration in privately owned woodland. In recent years there has been limited Government grant support for PAWS restoration, and what little has been available has largely supported restocking on clear-fell sites, which does not incentivise best practice through more gradual transformations. In some instances, for example in the Welsh Government's Glastir scheme for *Phytophthora ramorum*-infected larch clear-fell sites, public funding has even funded the restocking of non-native conifers back onto PAWS clear-fell sites.

Long-term vision

Ancient woodland restoration requires a long-term vision. It is vital that restoration is not just seen as addressing the negative impacts, or considered complete when tree species composition becomes native – further action is required to improve ecological integrity. This requires positive steps to develop other aspects of woodland structure and composition (see 1.4 and 1.5). For example, the need to develop more decaying wood and veteran trees, and to reduce the impacts from nitrogen air pollution (see 3.3), and the vital contribution of new woodland (see 4.1 and 4.5).

What needs to happen?

Policies and targets: forestry and biodiversity policies must be strengthened, with specific commitments and quantified targets for ancient woodland restoration across the UK. Progress should be informed by assessments of condition rather than canopy cover composition alone.

Regulation and standards: consideration should be given to a legal requirement to ensure ancient woodland restoration. Within existing standards (e.g. UKWAS), requirements must be better verified through clearer mapping and monitoring of remnant features in particular.

Public forest estate in active restoration: government bodies manage a large percentage of the UK's PAWS and have a duty to lead restoration and demonstrate exemplary practice. This requires better understanding of progress with restoration and the management approaches used.

Privately owned PAWS: much greater engagement and reporting on privately owned ancient woodland is required. More effective incentives for private ancient woodland restoration, including more Government support to secure the benefits of sensitive PAWS restoration. Alternative funding mechanisms could be developed e.g. Payments for Ecosystem Services, and the wider adoption of UKWAS could be encouraged.


MICHAEL HEFFERNAN/WTML

4.7 How are woodland owners responding to environmental change?

What do we already know?

Seventy-three per cent of the UK's woodland area is in private, charitable or other ownership i.e. outside the public forest estate. Understanding the motivations and actions of this disparate group of woodland owners, their agents and advisers, and supporting businesses, is key to enabling positive policy and practice change.

The British Woodlands Survey[1] (BWS) is the biggest regular survey of private woodland owners' attitudes and actions, gathering evidence about Britain's woodlands, and those who care for them, since 2012. It builds upon older surveys running since 1963. The British Woodlands Survey is coordinated by Sylva Foundation and run in partnership with other woodland sector organisations.

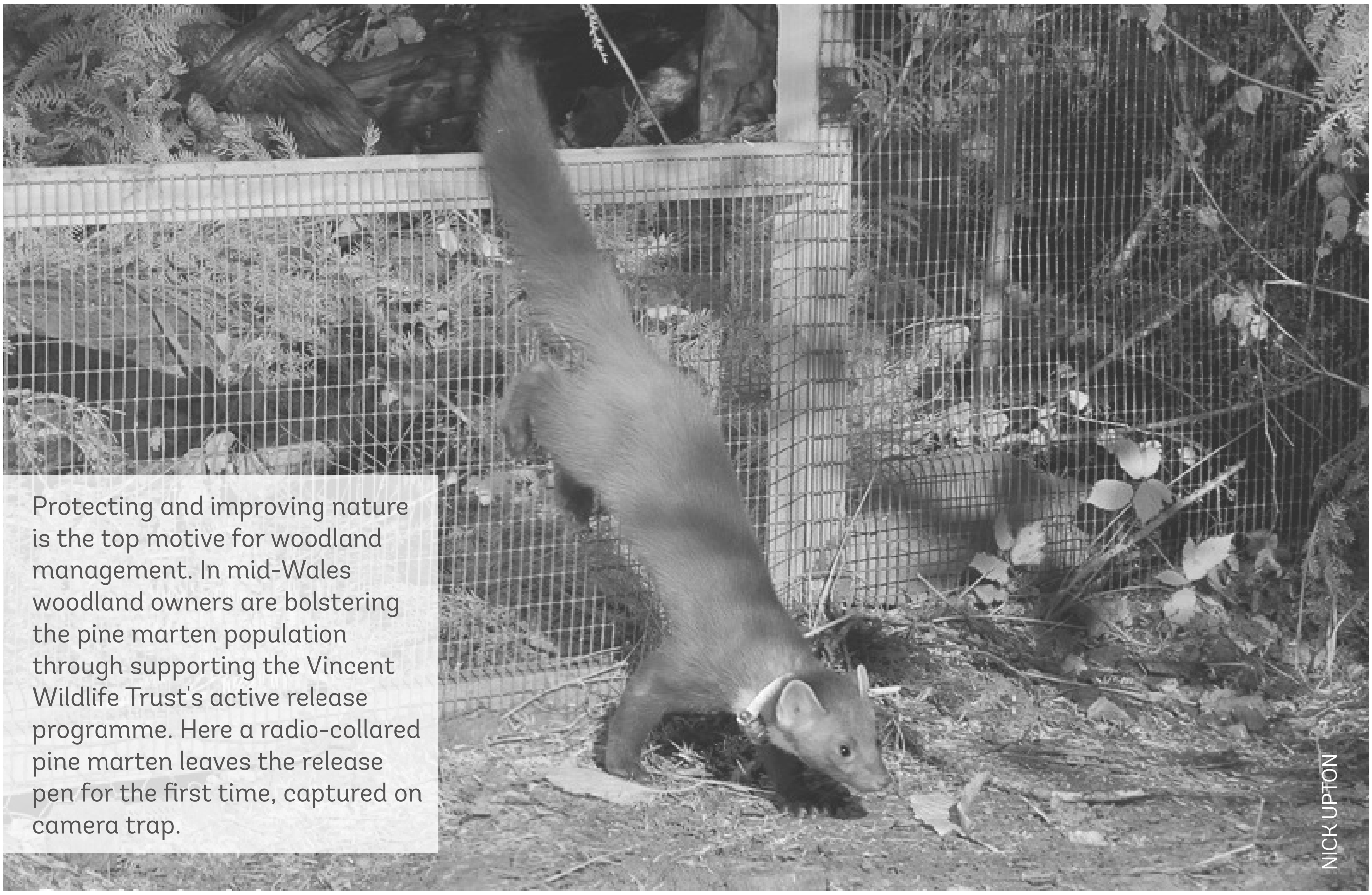
About the data

Two surveys (2015 and 2020) have gathered information specifically on the theme of environmental change. Of 1,055 respondents (owners, agents, other sector professionals and businesses) in 2020, the majority were from England (79%), the remainder distributed between Scotland and Wales. We summarise some of the key results, and the full methods and results are available from the Sylva foundation[2]. These results give a partial indication of wider trends, covering about 4% of Britain's privately owned woodland area.

What does this tell us?

What is motivating woodland owners?

Woodland owners were asked to indicate the relative importance of their aims for their woodland(s), each scored between 0-10. Protecting/improving nature or biological diversity (mean 8.1) was ranked as the most important motive, followed by personal pleasure (mean 7.5) (Figure 4.7.1). Wood products (timber, bioenergy, woodfuel, etc.) scored a mean of 5.5, while the motivations ranked lowest in importance were non-timber forest products (mean 2.0) and hunting/shooting (mean 1.8).



Protecting and improving nature is the top motive for woodland management. In mid-Wales woodland owners are bolstering the pine marten population through supporting the Vincent Wildlife Trust's active release programme. Here a radio-collared pine marten leaves the release pen for the first time, captured on camera trap.

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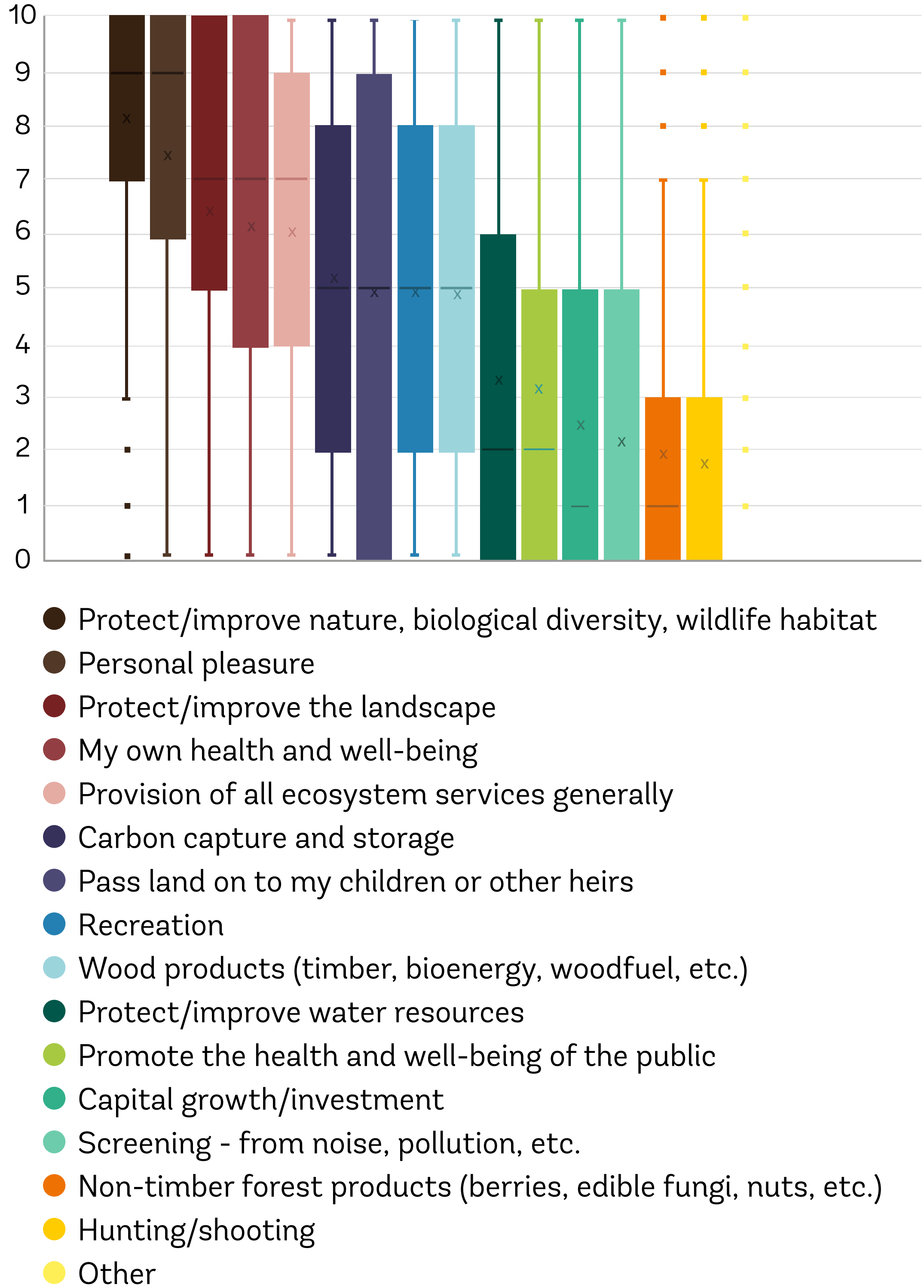

Figure 4.7.1. Management aims for woodlands among woodland owners (n=634) from not important (0) to important (10)

The coloured boxes indicate 1st and 3rd quartiles, the line within indicates the median value, and x shows the mean. The whiskers indicate minimum and maximum values, and dots, any outliers.

Source: Hemery *et al.* (2020)[2]

Shifts between 2015 and 2020 were option-specific, but there was a trend for reduced scores in the 2020 survey. For some aims (*carbon stocks, landscape, nature, personal pleasure* and *water resources*) this was somewhat offset by an increase in scores of 10 in 2020 versus 2015. Generally, 2020 scores tended to be more extreme (more 0 and 10 scores) than 2015 scores.

Woodland management standards

Among woodland owners who answered questions about management plans (612), 34% of respondents did not have a woodland management plan in place, while 7% were unsure. Among those who did have a plan in place (59%), 52% were UKFS-compliant, 21% were not, and 27% were unsure. Overall, this means that most respondents (69% of 612 respondents) did not have a UKFS-compliant woodland management plan in place. Between 2015 and 2020 there were no significant differences, either for the presence of a management plan or UKFS compliance.

The majority (91%) of woodland owners did not have independent certification for woodland management, for example under the UK Woodland Assurance Scheme. For those who did (9%; 51), 14 were registered with the FSC®, 4 with PEFC, and 10 with the Grown in Britain standard.

Observations of environmental damage

Woodland owners were asked about their own observations of environmental damage in woodlands in the last five years, and whether they believed there had been an increase, decrease or no change (figure 4.7.2). The number of respondents varied between 742 and 773. The greatest change observed by 611 respondents (79%) was an increase in *pathogen damage*, followed by *pests (vertebrate) damage* (55%; 423), *pests (invertebrate) damage* (45%; 338), and *wind damage* (43%; 329). *Pollution damage* was the factor most thought to have stayed the same (84%; 621) or decreased (5%; 40).

In terms of a comparison with the 2015 survey, respondents in 2020 were more likely to score the threat of *drought* with an increase over 25%. Similarly, *fire* and *pathogens* also increased since 2015, with the threat of *vertebrate* and *wind* damage more likely to be the same, and the threat of *pollution* having declined.

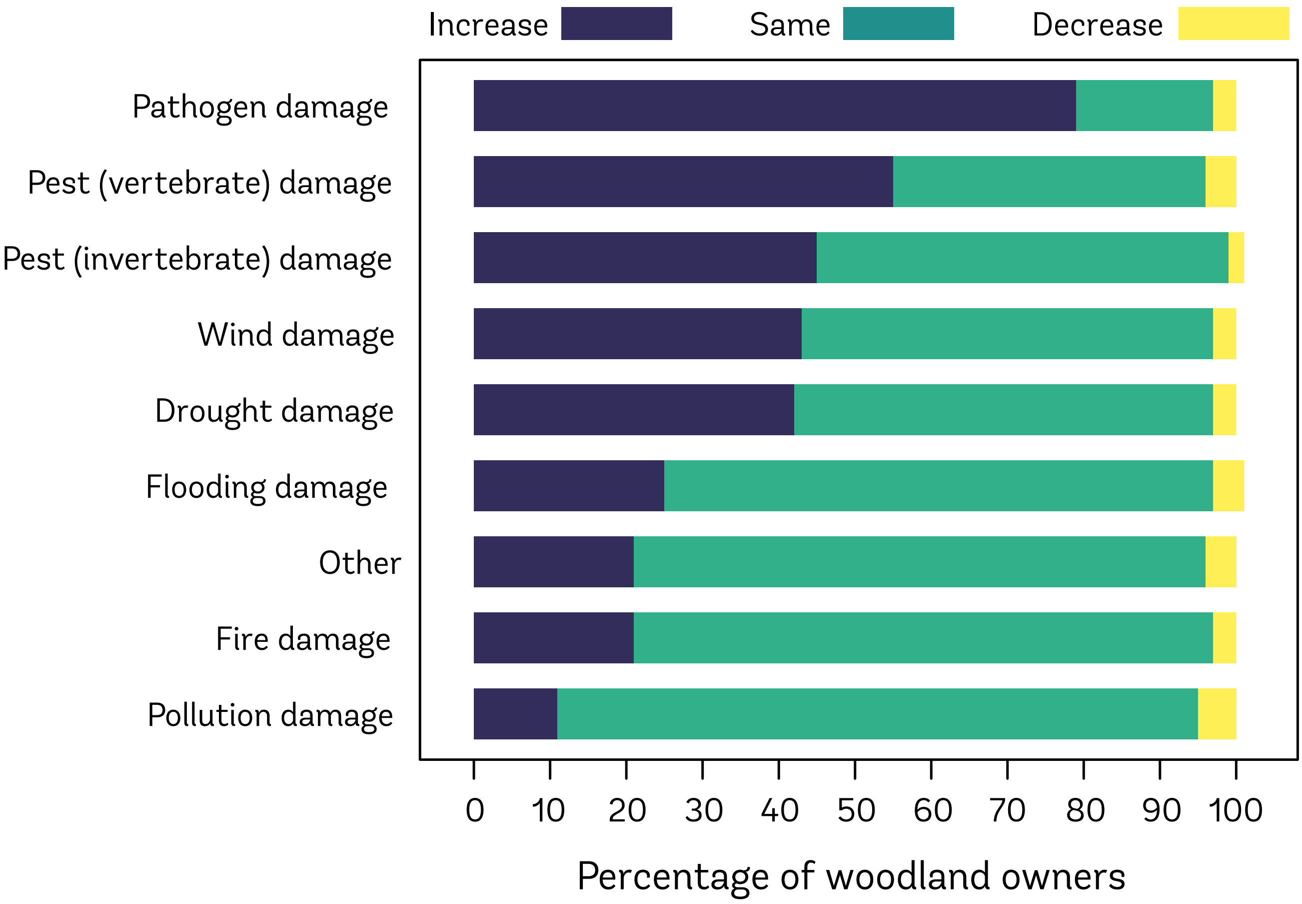

Figure 4.7.2. Observations by woodland owners across Britain of changes in environmental damage

Source: Hemery *et al.* (2020)[2]

Managing for resilience

Woodland owners were asked about four management activities thought to support forest resilience (Table 4.7.1). Just over half had continuous cover management in place and were assessing tree species suitability, but 70% of respondents were unaware of climate change projections for their region, although 57% said that they would explore them in the future.

Table 4.7.1. Counts of woodland owners and agents showing whether they do or do not currently undertake a range of four management activities

Source: Hemery *et al.* (2020)[2]

	Survey of soil types	Continuous cover management	Climate change projections	Tree species suitability assessment
Yes	157	306	164	339
No	410	252	382	225
Total	567	558	546	564

Native or non-native

Respondents were asked what they consider might be the ideal balance between native and non-native tree species to improve future resilience of UK forests. Among 755 respondents, the mean ideal proportion of native trees was 65%, this represents a substantial increase from the current UK level which is around 50% native species and 50% non-native.

Carbon

For the first time in the British Woodland Survey series, respondents were asked a range of carbon-related questions. As reported above, carbon capture and storage ranked 6 out of 16 woodland management aims.

For woodland owners who said they intended to create new woodland in the next five years (536), the largest proportion said they were unsure (47%), or that they would not (33%) consider registering it with the Woodland Carbon Code, due to lack of understanding of the system.

Protecting carbon stocks and carbon sequestration were important woodland management objectives. Of 361 woodland owners who responded to a question about whether their management plan included actions to minimise carbon/greenhouse gas emissions, 40% (144) said *yes*, 26% (93) answered *no* and 34% (124) were unsure.

Species diversification

Among a range of considerations that had influenced a decision to diversify the range of tree species in their woodland, woodland owners ranked biodiversity considerations and forest health as the primary reasons (85% and 79%). Carbon capture and storage was fourth out of five choices (with 38% indicating that it did influence them); timber yield ranked lower (33%).

Increasing tree cover

Among 518 woodland owners, 46% (237) had expanded their tree cover in the previous five years. Of these, the mean increase in area was 12.5ha (median 1ha; max 500ha). Woodland owners were asked if they were considering expanding tree cover in the next five years, by how much, and by what method. *Tree planting* was most favoured (192) with a mean expansion of 28.7ha. *Natural regeneration* was next most popular (130, mean expansion of 5.8ha). Expansion through *Agroforestry* was an aspiration of 73 respondents with a potential for over 2,000ha (total).

Reasons given (by 281 respondents) for not expanding woodland: Other than those stating that *all existing land was already planted* or *they have enough woodland*, the factor most discouraging woodland creation was *lack of grant aid* (43), *complexities of regulations relating to grant aid* (38), and the fact that *expenditure comes from taxed income* (37).

Planting stock

Seventy nine percent of woodland owners (out of 417) said that they knew which species were suitable for their land. A small proportion (25%) had accessed online tools such as the Ecological Site Classification (ESC) online tool for information on species suitability.

The survey asked woodland owners how likely they were to specify different categories of tree planting material. The choices offered included all combinations of *UK-sourced material, UK-grown material,* and *improved material.* The largest proportion (29%; 281) would specify *UK-sourced and UK-grown. UK-grown material only* was second most-popular at 21% (205), followed by *UK-sourced material only* at 14%. *Improved material only* was least popular at 4%.

Natural regeneration

Very clear support came for the concept that *natural regeneration is important to drive site-based adaptation to change*, with 74% agreeing with this statement.

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46% of woodland owners surveyed had expanded their tree cover in the last 5 years by an average of 12.5ha

Collaboration

The majority (59%; 512) of woodland owners indicated that they currently collaborated with other woodland owners to *share knowledge and information*, but otherwise only a minority collaborated to achieve a range of outcomes, including *control pests and diseases* (21%), to *achieve economies of scale* (17%), *increase landscape (e.g. catchment scale) tree planting* (12%), and to *share profits* (1%). In terms of the likelihood of collaborating in future, woodland owners responded similarly to current levels of activity, with only *control pests and diseases* being an activity showing notable change with 45% likely to collaborate in future compared to 21% currently doing so.

Why does it matter?

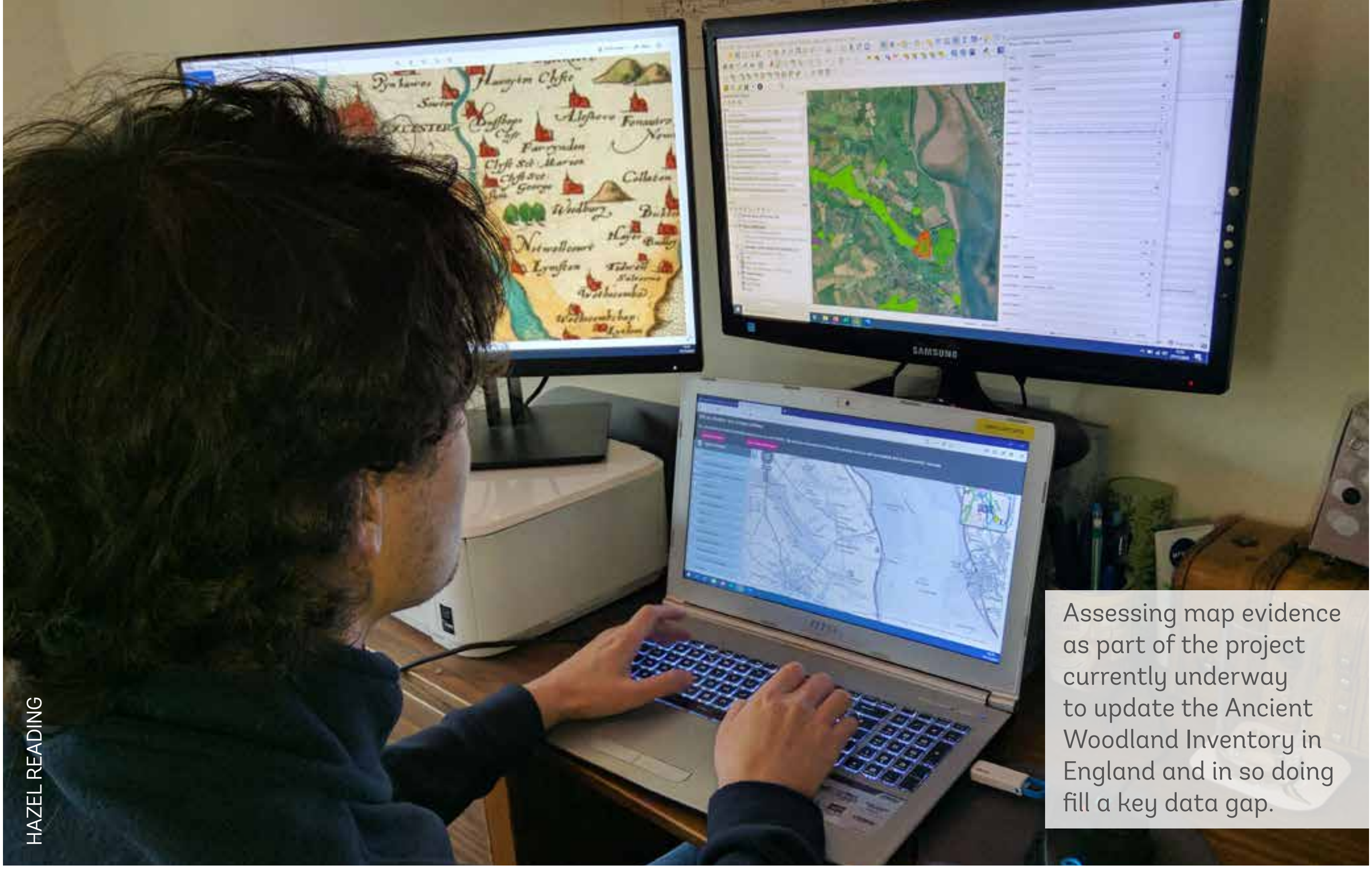
A shortage of available land is the chief barrier to woodland creation. This is compounded by a lack of suitable funding. There is also low awareness of local climate change projections, tree species suitability and the influence of soils. This highlights a need for better planning for resilient woodlands, and a need for clarity on suitable adaptation measures.

Not enough woodlands have UKFS-compliant management plans in place. Without such plans, it is unlikely that issues of concern to woodland owners – such as the damage caused by deer, grey squirrels or disease – will be addressed effectively at a landscape scale in accordance with the UK standard.

There is a general trend towards a desire for more coverage by native species. UK-grown trees are favoured for planting, perhaps reflecting increasing concerns about biosecurity.

What needs to happen?

Collaboration is key: many issues can't be tackled at a single site level, so woodland managers need to increasingly work together to share knowledge and information on how best to respond to environmental change. Enhanced support for cooperation and collaboration would help to drive landscape-scale resilience and adaptation. At a policy level, greater collaboration between the devolved administrations to address challenges that cross borders such as climate change and disease would be extremely beneficial.



HAZEL READING

Assessing map evidence as part of the project currently underway to update the Ancient Woodland Inventory in England and in so doing fill a key data gap.

The state of the evidence: data gaps and opportunities

Identifying trends and putting them in context is instrumental to our long-term understanding of the changing state of woods and trees. We rely on available data to interpret trends. The majority of data for this report comes from government or government-affiliated organisations, supplemented by NGOs and charities.

In the past, public bodies have tended to view woods and trees around the priorities of timber production and rural development. Biodiversity, ecological condition, social wellbeing and carbon storage are relatively recent concerns. Today these issues are much higher in the collective minds of UK forestry and environmental organisations, as well as the public. Despite this, in some cases data to allow monitoring and an assessment of the state of UK woods and trees is lacking or not readily available.

Data provides the tools for viewing past trends but we should be cautious about how it is being used. There is the temptation to only compare data with the time at which 'records began'. This may miss the unrecorded degradation that occurred up to this point – that likely triggered the collection of the dataset in the first place. We must be careful to avoid this **'shifting baseline' syndrome** whereby an arbitrary point in time is put on a pedestal as pristine and something to be strived towards. For example, many biodiversity records date from 1970 as the baseline year, yet in ecological timescales huge biodiversity loss and degradation had occurred before this point.

Central to data relating to woods and trees is the geographic and spatial context. While the four nations that make up the United Kingdom each have their own ecological character, divergence in methodology and approach in collecting data is often not conducive to whole landscape-scale thinking. Data may also be collected at a local level linked to individual projects which are not easily scaled up to gain a bigger picture.

There is a need to be pragmatic and work with the available data, keeping in mind the limitations of that data. An important part of gathering information for this report was to identify where data gaps exist, and where filling these will help provide context and understanding to the trends we see today.

Extent, condition and wildlife value

- **Net change** – accurate recording of losses as well as gains in canopy cover would enable reporting on net change in woodland and tree cover. For example, there has been an alarming loss of trees outside woods across the countryside, yet there is currently no data to answer if these are being replaced and where.
- **Ancient woodland and ancient trees** – completing the UK's Ancient Tree Inventory and updating the Ancient Woodland Inventories in the different UK countries are imperative.
- **Tree species distribution** – mapping the distribution of different tree species will enable targeted management responses – for example to tree disease outbreaks. Whilst we broadly know the relative abundance of tree species across the UK, technology is rapidly evolving to enable us to go beyond this. Developments in remote sensing and earth observation data could enable us to identify species composition and distribution more accurately. Investment and innovation are needed.
- **Quality as well as quantity** – further monitoring of the effectiveness of management interventions on addressing key aspects of condition is necessary to ensure actions produce

desired outcomes

- **Woodland wildlife** – improving biodiversity should be an overarching principle when considering woods and trees. Biodiversity can be extremely sensitive to woodland type, age, tree species and change in land use. A lot of information can be gained from close, long-term monitoring of key sites and species: warnings, trends, stories of success and lessons to be learnt.
- **Trees outside woods** – more data is needed on the extent, condition, biodiversity value and contribution of trees outside woods to ecological networks.

Benefits for people

- **Health and wellbeing** – the mental health and wellbeing benefits of woods and trees are being increasingly recognised. More research is required to further quantify benefits for people and rectify inequalities for people of different socio-economic backgrounds.
- **Urban forest** – information on the urban forest is an evolving science. More i-Tree surveys would better enable the benefits of urban trees to be quantified. This would support management plans to look after them and help determine where an increase in the urban canopy would make the most difference.
- **Ecosystem services and values** – trees should not be considered in isolation. They influence all UK ecosystems. Comprehensive monitoring of services provided by all other natural spaces should be a priority, including: flood risk, water quality and carbon storage.

Threats and drivers of change

- **Climate impacts on wildlife** – impact of climate change on climate space for woodland species and on the frequency of damage by extreme weather events, including storm, drought and fire would help plan for adaptation.
- **Agriculture** – greater knowledge of the impacts of agriculture on semi-natural habitats would help to devise solutions for nature recovery at landscape scale.
- **Tree health** – geographical and genetic data is needed for both diseased and healthy trees to monitor their levels of tolerance

and resistance to current and emerging threats. There is also no information available on how statutory plant health notices (e.g. to clear-fell *Phytophthora* infected larch) are impacting plantations on ancient woodland sites.

- **Pest control** – accurate time series data on deer impacts and the spread of invasive non-native species (INNS) using new technology would allow enhanced monitoring of these threats to target management interventions.

What's being done? Creation, restoration and management

- **Creation** – distribution data for non-woodland habitats needs to be integrated into decision support tools when planning for new woodland creation. This will help avoid inappropriate woodland creation on other valuable habitats. Data on how much woodland creation is happening is incomplete, for example new areas of natural regeneration are not consistently recorded. More evidence of the impacts of new woods and trees on biodiversity and connectivity at a landscape scale would help with designing nature recovery networks.
- **Restoration** – consistent data is lacking on the status of PAWS on the Public Forest Estate and on uptake of government incentives for private landowners.
- **Management** – there is little information about how effective different management interventions are to achieve a whole range of objectives. Tracking and improving this will offer great gains for biodiversity and carbon storage.
- **Landscape-scale metrics** – to be effective, large scale nature recovery proposals need to assess contribution to ecological connectivity and landscape resilience. Feasible metrics to assess progress with delivery of outcomes must be developed.

Summary and Conclusions

Woodland cover sits at 13.2% of UK land area, which excludes trees outside woods – important contributors to overall canopy cover. Twenty-two years ago woodland canopy cover was 12% of the UK land area. To meet aspirations for increasing woodland area for climate and nature we will need to quadruple the recent rate of woodland creation across the UK. This is a huge challenge, and we need to ensure each woodland created, or tree planted, is done with due consideration for nature and people.

Native woods and trees make up around 50% of UK canopy cover, yet punch well above their weight. For example we know that:

- They provide essential habitat and refuges for native wildlife in a rapidly changing environment. Sections 1.6 and 1.7 underline the value of native woodlands for plants, butterflies and birds, and some of our rarest invertebrates.
- An estimated 94% of trees outside woods are native broadleaved species (see 1.1), which is one reason why their expansion, alongside that of new native woodland, is crucial to improving ecological connectivity of landscapes (see 4.5).
- They are hugely valued by people, for example, since 2017, 23% of schools have planted native trees in their grounds; and over the last 15 years volunteer citizen scientists have added nearly 123,000 records to the Ancient Tree Inventory.

The more we discover about ancient woodland and ancient trees the more significant they become in the story we are writing for our future; for example, to provide the seed source for the woods of tomorrow and to continue to store and lock up more carbon to mitigate climate change (e.g. ancient woodland stores on average 37% more carbon than other woodland, see 2.1). Yet, we still have no comprehensive record of where all ancient woodlands and ancient trees are, so cannot adequately protect and look after them.

Woods, trees and their wildlife are barometers of environmental change. We know from the National Forest Inventory's recently published study on woodland ecological condition, that woods across the UK have a lack of dead and decaying wood, very little 'open habitat', a low diversity of tree species and limited growth of young

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trees (see 1.4). These are troubling signs which are fuelling declines in much-loved woodland wildlife such as butterflies and birds. The condition of our nationally designated woodland wildlife sites has been improving in recent decades (see 1.5), but only very slowly, with many challenging threats – often beyond the woodland boundaries – to resolve before wildlife will be on a firm footing to recovery.

The Nature's Calendar phenology studies over many decades are setting alarm bells ringing (see 3.1). In some years the first flush of tree leaves in spring has become mismatched with the insects and birds that feed on them. This is one small example of a cascade of change being repeated at different levels in the woodland ecosystem due to weather and climate fluctuations.

Global trade has shifted the goal posts on tree health. In the last 30 years our woods and trees have been bombarded with an accelerating influx of exotic pests and diseases, arriving on our shores with the horticultural goods, food and packaging we desire (see 3.4). Once established and free of their natural predators, such pests and diseases have little to hold them back, causing havoc with our ecosystems and our economy.

The 'immune system' of the UK's woods and trees is being pushed to its limits, as newer threats such as disease (see 3.4) and climate change (see 3.1) exploit existing weaknesses caused by long-standing ones. For example, damage by browsing deer (see 3.6), conifer plantations on ancient woodland sites and invasive plants like rhododendron (see 3.7) have all taken their toll. Unseen nitrogen pollution has stealthily distorted the ecology of the vast majority of woods in the UK today (see 3.3). Direct loss of our most precious ancient woodland and ancient trees to development of housing and transport infrastructure is still happening (see 3.2). As well as the immediate destruction, such losses further fragment woods and create barriers to wildlife movement across landscapes (see 4.5).

We know that woods and trees are good for us in so many ways. Access to woods and trees is a key factor determining 'a good place to live' (see 2.3); trees in towns and cities are known to reduce stress levels and bring pollution down (see 2.4); trees are tools to tackle our large-scale problems like mitigating climate change and reducing flooding (see 2.2). Yet current trajectories of many of the key factors

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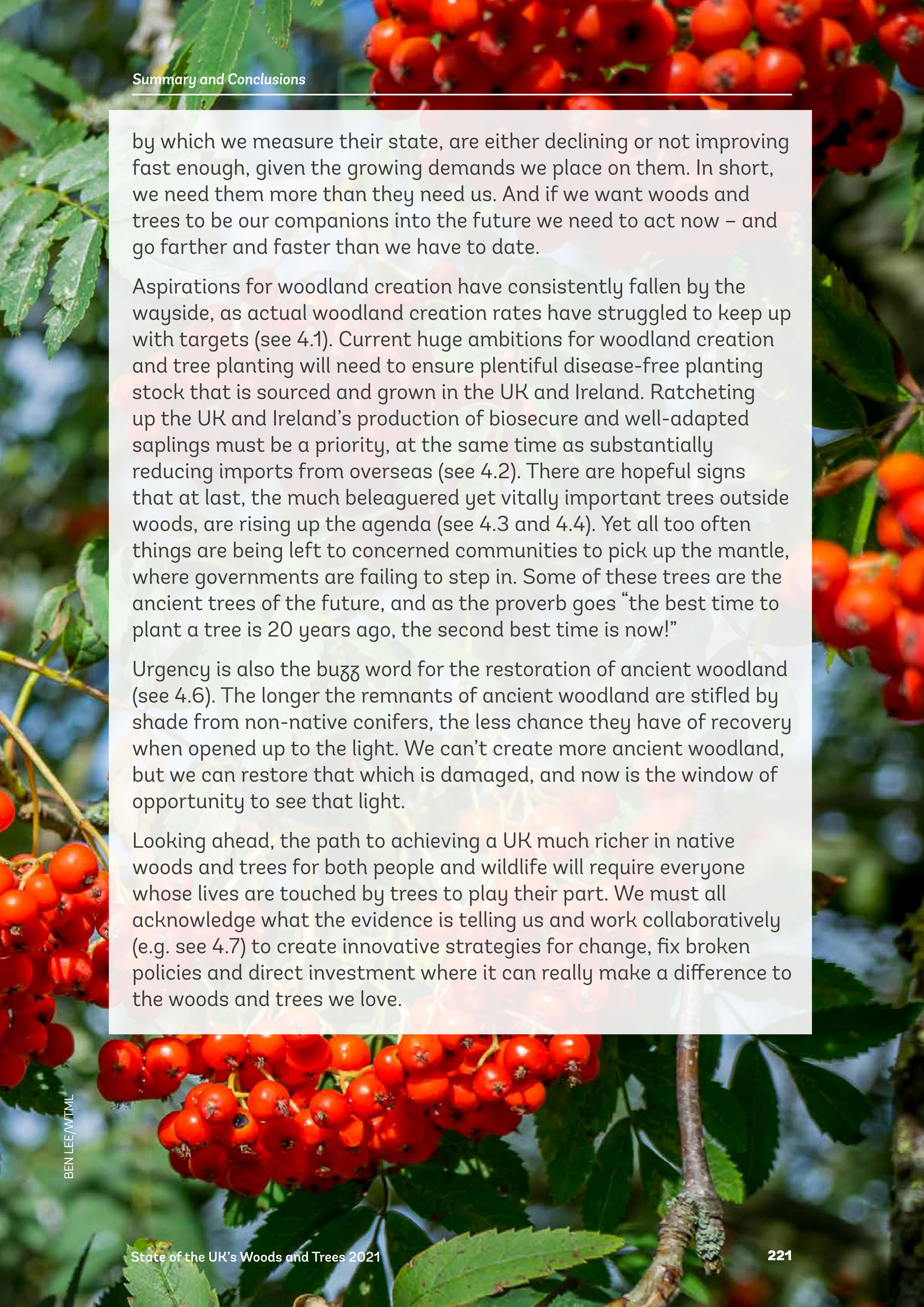
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by which we measure their state, are either declining or not improving fast enough, given the growing demands we place on them. In short, we need them more than they need us. And if we want woods and trees to be our companions into the future we need to act now – and go farther and faster than we have to date.

Aspirations for woodland creation have consistently fallen by the wayside, as actual woodland creation rates have struggled to keep up with targets (see 4.1). Current huge ambitions for woodland creation and tree planting will need to ensure plentiful disease-free planting stock that is sourced and grown in the UK and Ireland. Ratcheting up the UK and Ireland's production of biosecure and well-adapted saplings must be a priority, at the same time as substantially reducing imports from overseas (see 4.2). There are hopeful signs that at last, the much beleaguered yet vitally important trees outside woods, are rising up the agenda (see 4.3 and 4.4). Yet all too often things are being left to concerned communities to pick up the mantle, where governments are failing to step in. Some of these trees are the ancient trees of the future, and as the proverb goes "the best time to plant a tree is 20 years ago, the second best time is now!"

Urgency is also the buzz word for the restoration of ancient woodland (see 4.6). The longer the remnants of ancient woodland are stifled by shade from non-native conifers, the less chance they have of recovery when opened up to the light. We can't create more ancient woodland, but we can restore that which is damaged, and now is the window of opportunity to see that light.

Looking ahead, the path to achieving a UK much richer in native woods and trees for both people and wildlife will require everyone whose lives are touched by trees to play their part. We must all acknowledge what the evidence is telling us and work collaboratively (e.g. see 4.7) to create innovative strategies for change, fix broken policies and direct investment where it can really make a difference to the woods and trees we love.

Glossary

Term	Definition
Agroforestry	The practice of deliberately integrating woody vegetation (trees or shrubs) with crop and/or animal systems to benefit from the resulting ecological and economic interactions.
Ancient semi-natural woodland	Ancient woodland comprising native tree and shrub species which has not obviously arisen by planting. Semi-natural in character.
Ancient tree	A tree which is exceptionally old (and often very large) in comparison with other trees of the same species. Often of great biodiversity and cultural importance.
Ancient woodland	Woodland believed to have been in continuous existence for centuries (officially since 1600 in England, Wales and Northern Ireland, and 1750 in Scotland). Often of great biodiversity and cultural importance.
Ancient Woodland Inventories (AWI)	Database(s) of digitised records of the boundaries of ancient woodland, with information about reasons for inclusion. The Inventories are owned by the statutory nature conservation bodies (Natural England, NatureScot, Natural Resources Wales), with the exception of Northern Ireland inventory available from the Woodland Trust.
Arboriculturist/ arborist	A professional with expertise in the establishment, care and management of individual trees, particularly in amenity settings.
Area of Special Scientific Interest	See Site of Special Scientific Interest (SSSI).
Baseline	The time when records began. Used to establish trends over time.
Bioabundance	The overall amount of nature, as distinct from biodiversity describing the diversity of life in a given habitat, ecosystem or location.

Continuous cover forestry	A forest management practice which aims to achieve a forest with trees of irregular age and structure, often providing a wider variety of habitat 'niches' in comparison to a clear-fell forestry system.
Condition/ ecological condition/ condition assessment	Refers to the state of ecological systems, which includes their physical, chemical, and biological characteristics and the processes and interactions that connect them. Condition assessment takes easily assessed indicators – such as habitat structure, species composition, level of invasive species, etc. and scores them against established criteria to determine condition status. Repeating assessments over time can indicate how condition is changing in response to management or external threats.
Canopy cover	From above, the area of land beneath the tree canopy. Distinct from 'woodland cover' as it includes trees outside woodland and excludes the open space in woodland.
Dynamism	Refers to the processes which drive change (positively or negatively) in ecosystems e.g. storms/ disease/ tree felling create tree canopy gaps and deadwood allowing light to reach the forest floor for new tree regeneration and provide decaying wood as habitat.
Ecosystem services	The benefits provided by ecosystems that contribute to making human life both possible and worth living. Examples of ecosystem services include products such as food and water, regulation of floods, soil erosion and disease outbreaks, and non-material benefits such as recreational and spiritual benefits of natural areas.
Felling licence	A felling licence is required by UK law to cut down more than a small amount of trees/ timber in any calendar quarter. This applies to trees in hedges as well as woodlands. It is a means of protecting woodland/ trees from inappropriate felling.

Fragmentation	Occurs when large areas of habitat are divided into smaller areas by habitat loss, both decreasing habitat availability and increasing isolation between habitat patches – can drive species dependent on large habitat areas to local extinction.
Functional connectivity	The connectivity between different habitat patches that allows species to successfully disperse between them, linking populations. Typically larger, better quality habitat patches produce more disperses, and dispersal is more successful between spatially close patches separated by other, permeable habitat types.
Hectad	A 10 km x 10 km grid square.
Indicator species	A species which can be used to infer suitability of conditions in a habitat, and may also indicate trends in other species requiring similar conditions.
Lawton Principles	The summary principles of *more, better, bigger and joined-up* identify what is needed to create a coherent ecological network of wildlife sites across England, from a review chaired by Sir John Lawton (Making Space for Nature in 2010).
LEPO (Scotland, and also used in Northern Ireland)	Long established woodland of plantation origin. Interpreted as plantation from maps of 1750 or 1860 and continuously wooded since. Many of these sites have developed semi-natural characteristics, especially the oldest ones, which may be as rich as ancient woodland.
National Forest Inventory (NFI)	Official statistics on Great Britain's forests, trees and woods, run by Forest Research.
Native range	Area of the UK to which native species have colonised naturally (without human assistance).
Native species	Species which have naturally colonised regions of the UK since the last ice-age.
Native Woodland Survey of Scotland (NWSS)	Survey of Scotland's native woodlands – extent and condition – undertaken by the then Forestry Commission Scotland (2008-2013).

Natural regeneration	Natural establishment of trees and shrubs from seed, layering or suckering.
Near-native	May refer to native tree species outside their natural range, or species long-established or 'naturalised' in the UK which are sometimes thought of as native.
Non-native species	Species introduced to the UK (or regions of it) which would not naturally be present.
Open habitat	Semi-natural habitat without a tree canopy (e.g. grassland, heathland, ponds, lakes etc).
Phenology	The study of the timing of nature's seasonal events.
Plantations on ancient woodland sites (PAWS)	Ancient woodland sites that have been clear-felled and replanted with tree species not native to the site (often conifers plantations for timber production).
Precautionary approach	Proceeding with caution where there is incomplete information to make a decision about the effects of environmental management, so as to not have inadvertent consequences on habitats and species.
Priority habitats	UK BAP priority habitats cover a wide range of semi-natural habitat types, and are those identified as being the most threatened and requiring conservation action under the UK Biodiversity Action Plan (UK BAP). Notwithstanding devolution, the UK list of priority habitats, remains an important reference source and has been used to help draw up statutory lists of priority habitats under countryside and nature acts.
Public Forest Estate (PFE)	In this report we've used this to mean land owned by the government departments and agencies responsible for forests.
Recent woodlands	Woods not classified as ancient which have been planted or grown up naturally on previously open ground.

Refugia	An area or habitat in which a population of organisms can survive through a period of unfavourable conditions, especially glaciation or climate change.
Remnant features	Ancient woodland specialist features (such as plants, veteran trees, soil seed bank, archaeology etc.) surviving within an ancient woodland site damaged by plantation forestry or invasive species.
Saproxylic	Any species dependent for part of its life cycle on decaying wood in living or dead trees.
Site of Special Scientific Interest (SSSI)	A Site of Special Scientific Interest (SSSI) in Great Britain or an Area of Special Scientific Interest (ASSI) in the Isle of Man and Northern Ireland is a statutory conservation designation denoting a protected area. They underpin most other legal nature/geological conservation designations in the United Kingdom.
Shifting baseline syndrome	Shifting baseline syndrome is perpetuated when each new generation of people perceives the environmental conditions in which they grew up as 'normal'. It also describes how people's standards for acceptable environmental conditions are steadily declining.
Special Area of Conservation (SAC)	Defined in the EU's Habitats Directive (92/43/EEC), to protect the 220 habitats and approximately 1000 species listed in annex I and II of the directive which are considered to be of European interest following criteria given in the directive. They must be chosen by the State Members and designated SAC by an act assuring the conservation measures of the natural habitat.
Stand of trees	A forestry term for an identifiable group of trees within a bigger woodland, forest or site.
Trees outside woods (TOWs)	TOWSs include small copses, hedgerows, street trees, trees on farms and along rivers, and in wood pastures and parklands.

Urban forest	An overarching term for urban tree and woodland cover including individual trees – from newly established to ancient – as street trees, riverine trees, hedgerows, copses, and in parks and woods.
Veteran tree	The terms ancient and veteran are sometimes used interchangeably, but we also make a distinction between them. Veteran trees may be a great size or age, or display physical features such as trunk hollowing. By contrast, ancient trees are old in comparison with other trees of the same species3. Thus, all ancient trees are veteran, but not all veteran trees are ancient.
Woodland	An ecosystem/ habitat with a significant proportion of woody vegetation (trees/ shrubs), and a canopy cover of over 20%.
Woodland condition	See condition.
Woodland cover	The amount of land covered in woodland and wooded habitats (usually includes open habitats within woodland). [See also Canopy cover].
Wooded habitats	Habitats with woodland, copses, individual trees, shrubs interspersed with other habitats such as grassland, heath, bog and farmland.
Wood pasture	Mosaic systems which typically include the following features: grazing animals, an open ground layer of grassland or heath, shrubs and scrub, veteran trees and decaying wood.
UK Forestry Standard (UKFS)	The reference standard for sustainable forest management across the UK, it applies to all woodland, regardless of who owns or manages it. Set and updated by the UK Government.

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Extent, condition and wildlife value

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