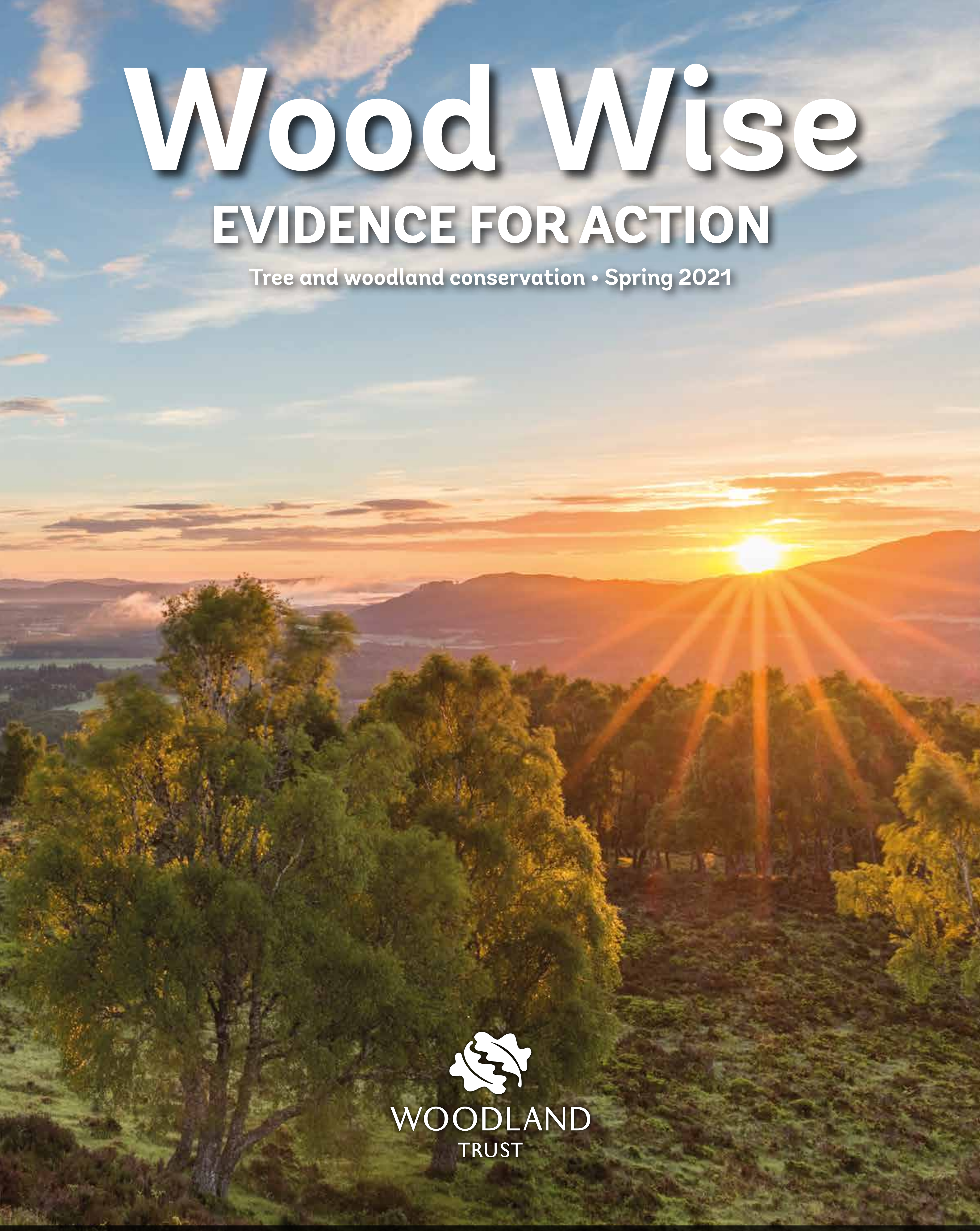

Wood Wise

EVIDENCE FOR ACTION

Tree and woodland conservation • Spring 2021

WOODLAND TRUST

THE NEED FOR STRONG SCIENCE IN GLOBAL CONSERVATION

CARBON STORAGE IN ANCIENT WOODLAND

ECOLOGICAL IMPACTS OF NITROGEN POLLUTION

PRESSING POLICY PRIORITIES

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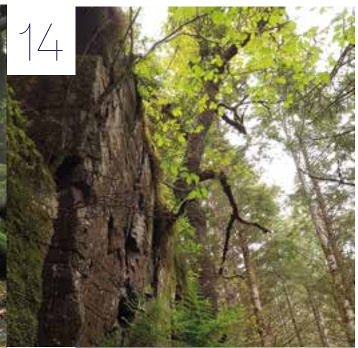
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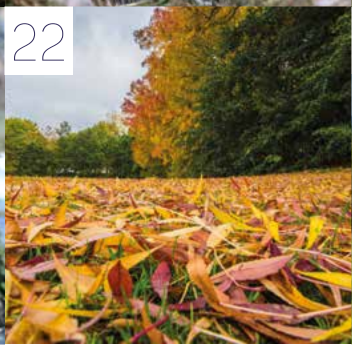
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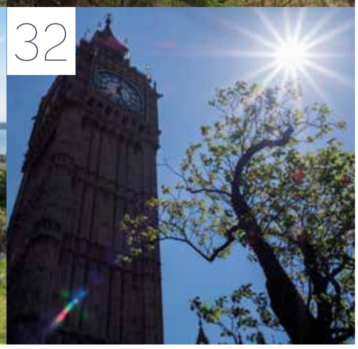

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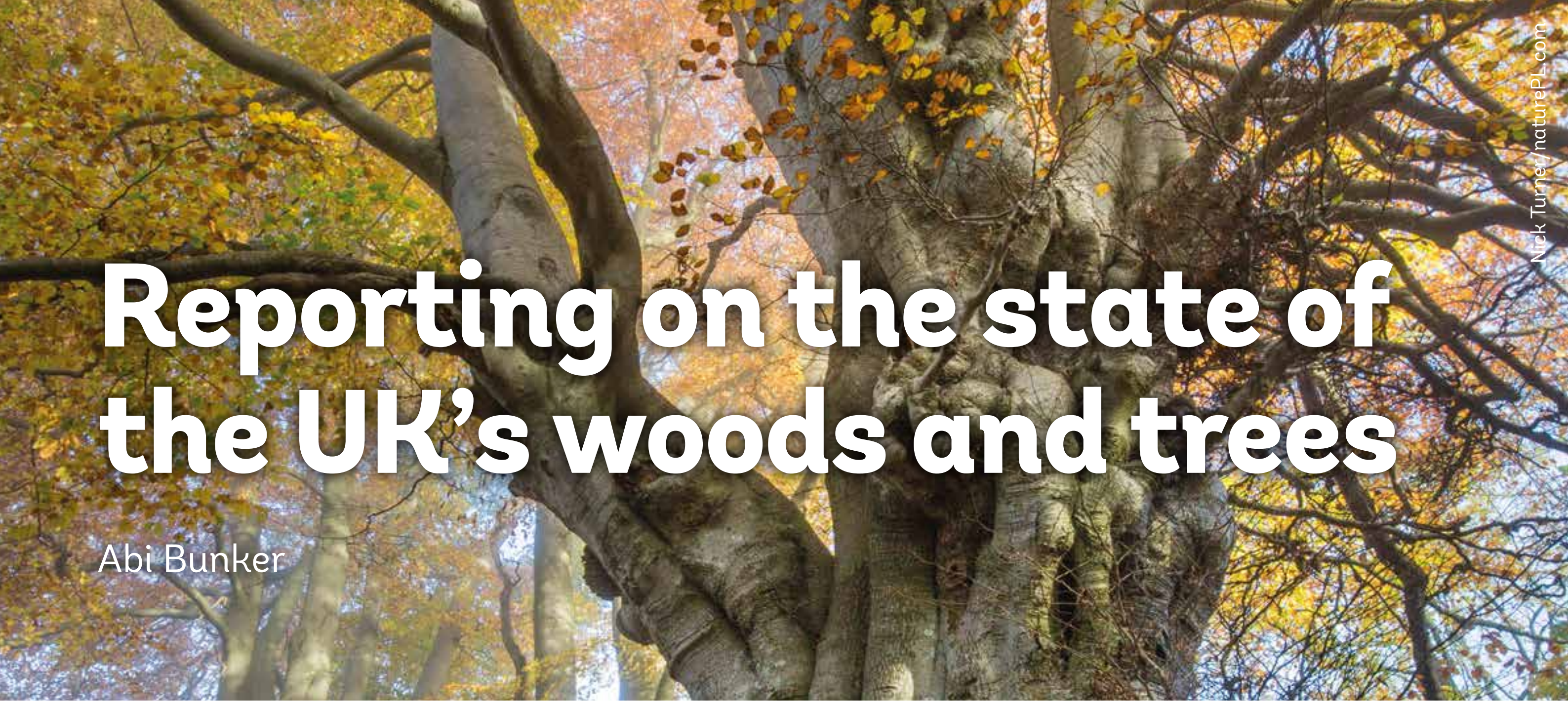


Nick Turner/naturePL.com

Reporting on the state of the UK's woods and trees

Abi Bunker

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.

To this end, the Woodland Trust has released the first ever *State of the UK's Woods and Trees* report. This not only presents important facts and trends about woods and trees, but also sets out what needs to happen to safeguard their future and enhance their benefits to people and wildlife.

In this edition of *Wood Wise*, academics and woodland conservation professionals delve deeper into some of the topics covered by the report. First off, Dr Hilary Allison explains the global context, highlighting the report's wider relevance beyond national biodiversity policy commitments. The articles that follow go into greater detail on some of the findings in the report. The storage and sequestration of carbon in ancient woodland is quantified for the first time, and research scientists from the University of Leeds explain how this can inform policies and targets around both ancient woodland protection and climate change mitigation.

Returning ancient woodlands currently planted with conifers back to native woodland is an urgent priority. Almost 40% of ancient woodland in the UK is currently damaged by plantation forestry, and progress with restoration has been slow. The Scottish uplands present particular challenges when it comes to ancient woodland restoration and require a unique approach, as described by Forestry and Land Scotland's native woodland ecologist Richard Thompson.

By bringing disparate sources of data together for the first time, the *State of the UK's Woods and Trees 2021* highlights the barrage of coinciding threats that the UK's woods and trees are being subjected to. These range from direct loss to more insidious influences such as climate impacts, imported diseases, invasive plants, mammal browsing and air pollutants. In this issue we expand on two of these: the serious but often undetected impacts of nitrogen pollution, and the knock-on effect of climate change on resource availability for wildlife.

Humanity depends on healthy ecosystems for survival, and appreciation of this has grown in recent decades leading to the development of several frameworks to evaluate ecosystem service status and trends. Recent research by Professor Zoe Davies and Dr Phoebe Maund has found that such frameworks don't always represent how society values the environment.

We hope that the *State of the UK's Woods and Trees 2021* report is used over the coming years to inform policy discussions and shape plans for tree and woodland conservation across the UK. Our policy expert Andrew Allen wraps up this edition with a discussion of the four strategic themes that emerge from the report as pressing policy priorities – in other words, how we can use this evidence to inform action.

Read the full report at woodlandtrust.org.uk/report

Abi Bunker is director of conservation and external affairs at the Woodland Trust, providing strategic leadership across the Trust's conservation, campaigning and policy-influencing work.

The global context for the *State of the UK's Woods and Trees 2021* report

Hilary Allison

Forests are one of the richest habitats, both at a global and UK level. Our preoccupation with the modest level of woodland cover in the UK (just over 13% of total land area) means it is sometimes easy to forget the UK's wider obligations and contributions to global efforts to protect, restore and expand forest cover. The *State of the UK's Woods and Trees 2021* report is an important addition to the body of scientific assessment and monitoring required as a foundation for global forest biodiversity conservation.

Dr Hilary Allison was formerly head of ecosystem assessment and policy support at UN Environment Programme World Conservation Monitoring Centre. She is also a forestry commissioner and has a particular interest in how to communicate science to policy makers.

International commitments and contributions

As well as national biodiversity policy commitments made by each of its four nations, the UK has global commitments to many international environmental agreements on biodiversity. The Convention on Biological Diversity (CBD) requires countries (Parties) to prepare a national biodiversity strategy or action plan[1] and report regularly on national implementation of the convention's objectives, including actions relevant to forest conservation[2].

While there is no comparable global convention specifically on forests, over many years the UK has played an important global role in developing and supporting several forest policy mechanisms. These include the development of certification as a way of defining sustainable management, public procurement requirements for legally and sustainably sourced timber, and aid for forest projects overseas (for example, the UK's International Climate Finance programme and Darwin Initiative). The role of UK science in underpinning the role of forests in climate policy[3] has also been crucial in improving the evidence base and putting forests more centre stage in global and UK policy.

Biodiversity loss and its drivers

There is now global recognition of a nature and climate crisis. The UN Secretary General's State of the Planet speech in December 2020 unequivocally stated *"making peace with nature is the defining task of the 21st century. It must be the top, top priority for everyone, everywhere"*. To respond to this crisis there is an urgency to negotiate a strong post-2020 global biodiversity framework at the 2020 United Nations Biodiversity Conference in China in October, and to strengthen the commitments at the UN Climate Conference in the UK in November.

This recognition would probably not have been achieved without the comprehensive synthesis of the best available science in several hard-hitting global environmental assessments published over the past

Climate change has knock-on effects on the timing of seasonal events (phenology). In warmer springs, blue tit chicks hatch too late to make use of the earlier peak in caterpillar abundance.

two years[4]. All of these have identified the same direct drivers of global biodiversity loss – climate change, pollution, land use change, invasive alien species, exploitation and overconsumption – and all of these drivers are relevant to and connected with what is happening in the UK.

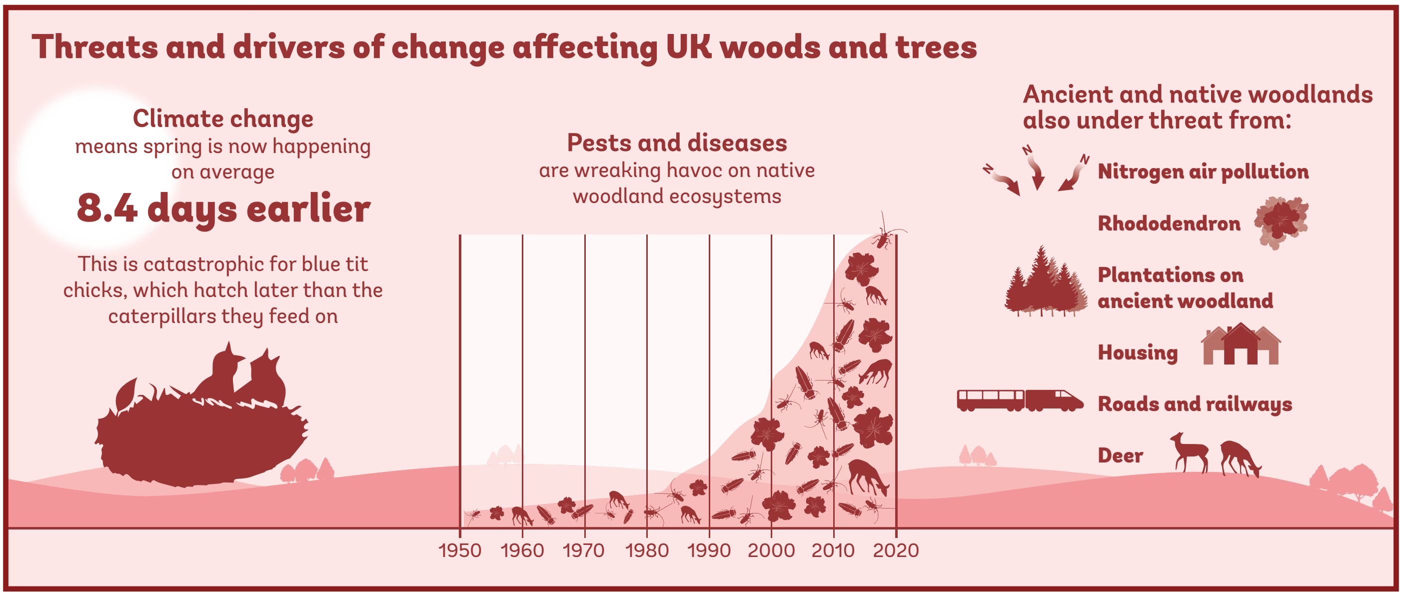
Climate change is both a direct and indirect driver of biodiversity loss. Rising temperatures and the increased frequency of extreme weather events, as well as rising sea levels, are having widespread direct impacts on species distributions, phenology, population dynamics, the structure of communities and the functioning of ecosystems. The Woodland Trust leads data-gathering efforts through its Nature's Calendar project, which has provided powerful evidence of phenological change[5], including indications that spring now starts on average 8.4 days earlier, which has knock-on effects on food chains.

Air, water and soil pollution arise from multiple sources, and the impact of plastics in both terrestrial and marine environments has received huge global attention in recent years. Pollution *per se* tends to receive less attention in the UK as a driver of woodland biodiversity loss, though studies on the impact of nitrogen loading and ammonia in woodland show that this is an important diffuse effect[6] and severe site-specific incidents affecting woodland still occur[7].

Land use change as a direct pressure is a consequence of several interrelated drivers, including competition for land for other uses, such as agriculture, houses, roads and railways. This is a particularly powerful driver in a country like the UK where population densities are high and where planning processes attempt to create checks and balances between national interests focused on expansion of infrastructure and urban areas and local concerns for quality of life and local environments. Moreover, demand within the UK for many agricultural commodities, such as soya, cocoa, coffee, palm oil, and beef, directly drives change of land use overseas as well as leading to deforestation[8]. This displacement of impact is a process known as telecoupling.

Plant and animal invasions affect nearly one fifth of the earth's surface, and can impact native species (as we know from the UK experience with grey squirrels) and ecosystem functions (such as water quality). Invasives include not only animals, insects and plants, but also pathogens, and act as sources of pests and diseases like ash dieback and *Phytophthora* which have significantly affected Europe's and the UK's forests and trees in recent years.

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.



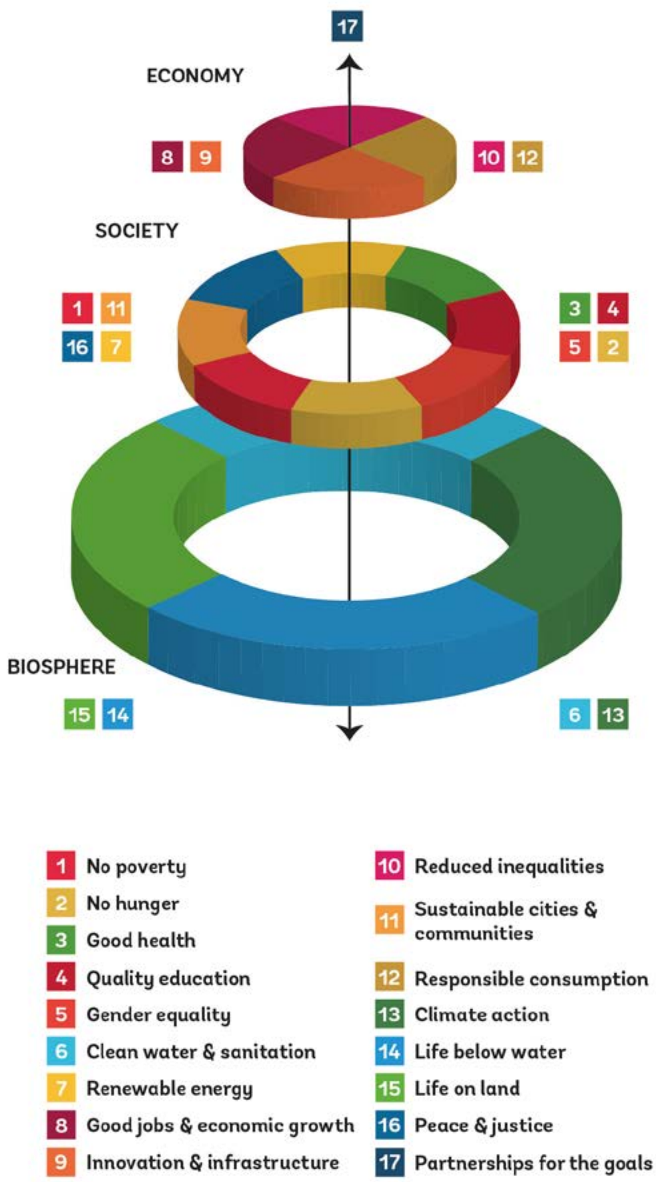
Direct overexploitation of biodiversity for the purposes of wildlife trade and subsistence is a serious driver of biodiversity decline in many parts of the world. In the past 50 years, global trade has grown tenfold which has driven unsustainable exploitation and overconsumption of resources in both developed and developing countries. The global timber trade is of significance in the UK context as the UK is the world's third largest importer of timber. This places responsibility on us to ensure that these imports come from legal and sustainable sources.

Forests and the Sustainable Development Goals

The adoption of Agenda 2030 and the Sustainable Development Goals (SDGs) in 2015 by UN Member States saw an enhanced recognition of the integrated nature of sustainable development ("people, planet, prosperity") and the dependencies between all goals[9] as illustrated in the diagram on the right. While there is no single SDG relating specifically to forests, the suite of biosphere-related goals (SDGs 6, 14 and 15 which encompasses forest protection in Target 15.2) is seen as underpinning social and economic wellbeing[10].

The annual State of the World's Forests report for 2020[11] focused particularly on biodiversity, and its

See right: Illustration of the economic, social and ecological aspects of the Sustainable Development Goals (SDGs). This new model, based on the iconic 'wedding cake' figure developed by Carl Folke and his team, aims to change our current approach where social, economic and ecological development are seen as separate parts. It is an effort towards making the economy serve society so that it evolves within the safe operating space of the planet. Credit: Azote Images for Stockholm Resilience Centre, Stockholm University



conclusions demonstrate the complex interlinkages and dependencies between forests and the implementation of the SDGs and the Aichi Biodiversity Targets. For example, there are strong positive associations between human health and wellbeing (SDG 3) and forests through many pathways, including medicinal plants and non-timber forest products supporting subsistence economies.

Forested watersheds protect water supplies and water quality (SDG 6), while strong governance (SDG 17) helps to tackle many threats to forests arising from illegal action and breaches of national and international law and conventions: responses to combating deforestation and illegal logging have gathered pace over the past decade to slow the rate of forest destruction.

Forest protection and conservation helps to secure SDG 15, especially through the role of protected areas where Aichi Biodiversity Target 11 (to protect at least 17 percent of terrestrial area by 2020) has been exceeded for forest ecosystems as a whole. Feeding humanity and conserving and sustainably using ecosystems, including forests, are complementary and closely interdependent goals (SDG 2), but transforming food systems is needed to halt deforestation and the loss of biodiversity. Indeed, large-scale forest restoration is needed more than ever to meet the SDGs and to prevent, halt and reverse the loss of biodiversity – a focus of the UN Decade of Ecosystem Restoration 2021–2030.

The need for strong science

Running through the story of explaining the global context of forest conservation and the UK's contribution to it is the role of strong science in helping everyone to understand the gravity of our situation and the urgency for action. Global assessments explore how data and information can inform and support analyses of what action is required to address the nature and climate crises. This is why the *State of the UK's Woods and Trees 2021* report is crucial in adding to the body of evidence in a UK context. In this globally connected world, where the Sustainable Development Goals provide a framework for integrated global to local action, the state of the UK's woods and trees is very much part of the global picture.

> "Strong science is crucial for understanding the gravity of our situation and the urgency for action."

Further reading

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Ancient woodland – carbon sink or source?

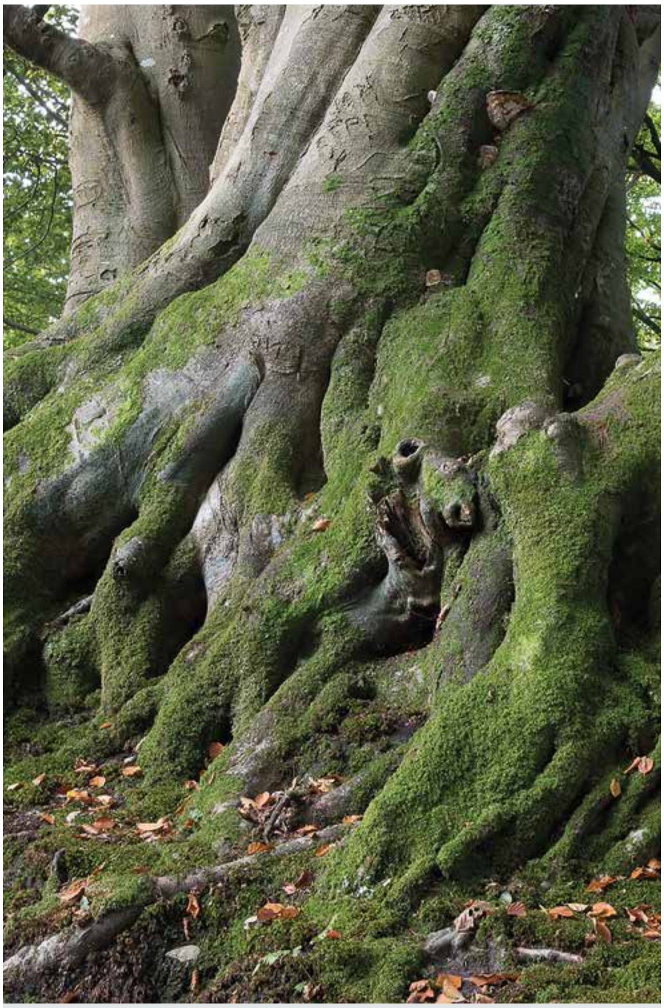
Dominick Spracklen and Cat Scott

Ancient woodland is one of the UK's oldest and rarest habitats. New analysis by Forest Research and the Woodland Trust shows that ancient woodlands store and sequester more carbon than previously thought. These new findings further highlight the importance of ancient woodland and emphasise the need to strengthen its protection.

Prof Dominick Spracklen is a professor, and **Dr Cat Scott** an independent research fellow, in the School of Earth and Environment at the University of Leeds.

Woods and trees remove carbon dioxide from the atmosphere and store it in vegetation and soils. Therefore, they have a major role to play in mitigating climate change, and the UK Government has ambitious targets to plant trees and create new woodland. Less emphasis, however, has been placed on the role of existing woodlands in the removal and storage of carbon. In particular, very little attention has been paid to the role of ancient woodlands.

Ancient woodlands are those that have existed since 1600 in England and Wales and 1750 in Scotland. These dates were chosen as the time when the first reliable maps of woodland cover became available and before large-scale planting of trees started. This means that an area classed as ancient woodland has been continuously wooded for centuries, perhaps even since the last ice age. Ancient woodland is rare, covering only 2.5% of the UK, yet is exceptional in terms of biodiversity value. There are a number of specialist species which rely on ancient woodland and are rarely found in younger woodland.



Carbon estimates are for the 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).

Carbon storage in ancient woodland

New analysis completed for the *State of the UK's Woods and Trees 2021* report makes the first estimate of the contribution of ancient woodland in Great Britain to the removal and storage of carbon. The analysis combined data on trees with a diameter greater than 7cm from the National Forest Inventory, with the location of ancient woodlands in the Ancient Woodland Inventory. Information on the size and species of trees was used to estimate the amount of carbon stored in the roots, stems, branches, twigs and foliage of living trees in ancient woodlands. In Scotland, the analysis also included long-established woodland.

It was estimated that ancient and long-established woodland stores 77 million tonnes of carbon, equivalent to 36% of the total carbon stored in all forests and woodlands in Great Britain. This means that while ancient and long-established woodlands only make up about one quarter of British woodlands, they lock up more than one third of the carbon stored in all woodlands. Ancient and long-established woodland stores on average 95 tonnes of carbon per hectare, 37% greater than the average carbon storage across all woodland types.

Old woodlands store more carbon than younger woodlands because they often contain bigger trees which store much more carbon than small, younger trees. One large tree with 100cm diameter can store as much as three tonnes of carbon – more than 100 times as much as a younger tree with 10cm diameter. So a few large trees contain more carbon than lots of densely packed, smaller trees.

Carbon sequestration in ancient woodland

As well as acting as a long-term store of carbon, woodlands also remove carbon dioxide from the air. Young and newly established woodlands sequester carbon dioxide at fast rates as they are rapidly growing. Older woodlands are often assumed to remove less carbon dioxide each year as they approach maturity. Very old and ancient woodlands are often considered to have stopped taking up carbon completely. If true, this would mean that although they continue to store carbon, they would not remove additional carbon dioxide from the atmosphere. However, numerous studies have found that contrary to the assumptions above, mature woodlands continue to remove carbon dioxide even when they are several hundred years old[1,2]. This suggests that ancient woodland could sequester more carbon in the future.

Existing forestry growth models were used by Forest Research to estimate that if ancient and long-established woodlands in Great Britain are not thinned or harvested (a no-intervention approach), the carbon stored in them will double over the next 100 years to 155 million tonnes. It was also estimated that ancient woodlands are currently sequestering about 1.7 million tonnes of carbon per year, equivalent to 6.2 million tonnes of carbon dioxide annually. To put this into perspective, ancient woodlands are sequestering the equivalent of around 2% of the nation's current annual greenhouse gas emissions.

These numbers, estimated from forestry yield models, suggest that on average, each hectare of ancient woodland in Great Britain is removing 7.7 tonnes of carbon dioxide every year. Data from models can be checked against detailed experimental measurements, known as eddy flux systems, that detect the movement of carbon dioxide into and out of a forest. An eddy flux system installed in an 80-year-old oak woodland in southeast England found that each hectare of the woodland was removing 17.8 tonnes of carbon dioxide each year[3], even more than estimated by the models. This provides further evidence that mature woodlands can continue to remove vast amounts of carbon dioxide.

Climate emergency and net zero

The UK Climate Change Committee (CCC) outlined the steps needed for the UK to reach net-zero carbon emissions by 2050. This will require rapid and deep cuts in fossil fuel carbon emissions, combined with changes in land use to sequester carbon dioxide. Increasing the area of woodland across the UK from 13% to 19%, combined with bringing 80% of existing woodland into active management, would remove an estimated 14 million tonnes of carbon dioxide per year by 2050.

The Woodland Trust's new report shows that ancient and long-established woodlands could provide 40% of the carbon sink that we need woods and forests to provide if the UK is to reach net zero. The carbon

Trees with a diameter greater than 7cm within ancient woodlands were measured and the species identified to estimate the amount of stored carbon.

sequestration of ancient woodland is worth £373 million annually to the UK[4], with each hectare of ancient woodland providing a service worth £420 each year. This demonstrates the vital role of ancient woodland in our efforts to address the climate emergency.

Deadwood and soils

Old woodlands contain more dead and decaying wood than younger woodlands. This is a valuable habitat for wildlife and also a carbon store: ancient woodlands can contain up to 150m^3 of deadwood per hectare, equivalent to about 20 tonnes of carbon per hectare[5]. The analysis completed for the *State of the UK's Woods and Trees 2021* report did not account for the carbon stored in deadwood, only that in living trees, so the carbon storage of ancient woodlands is actually even greater. Improper management and 'tidying' of mature woodlands can result in the removal of dead and dying trees, resulting in UK woodlands containing much less deadwood than they naturally would, thereby reducing their carbon storage potential.

Woodland soils also store large amounts of carbon. Estimates for the UK are between 100 and 400 tonnes of soil organic carbon per hectare[6], often more than all the carbon stored in the stems, roots and branches of the trees themselves. Soil type plays a large role in the amount of carbon stored, with peat soils storing the largest amount of carbon. We know much less about how woodland management can impact soil carbon. However, undisturbed soils of ancient woodlands are likely to store more carbon than, for example, commercial forest soils that are more regularly disturbed by forest harvesting operations. Future analyses of the carbon stored in ancient woodland should include that stored in soils to give a more complete picture.

Conservation implications

This new work highlights the importance of ancient woodland for storage and sequestration of carbon, providing another reason to protect this vital habitat. Across the UK, around 1,225 ancient woodland sites are threatened by development, such as road and rail expansion and housing. To prevent further loss and damage to ancient woodland, UK policy must provide stronger protection.

The UK CCC suggests that 80% of existing UK woodlands should be brought under management to enhance carbon sinks. This new understanding of the ongoing removal of carbon by ancient woodland can be used to inform the management approach. In some cases, ancient and long-established woodlands will remove and store more carbon if a non-intervention approach is taken, where harvesting is minimised.

Old woodlands contain more dead and decaying wood than younger woodlands. This is a valuable habitat for wildlife and also a carbon store.

However, a balance must be struck between carbon and biodiversity management objectives. For example, the removal of non-native conifers from plantations on ancient woodland sites is essential for nature recovery. Equally, while a non-intervention approach might maximise carbon storage, it may risk losing diversity of trees and associated woodland biodiversity. Furthermore, active management can accelerate the development of old-growth characteristics, such as large trees, which are efficient and effective carbon stores and provide unique habitat not offered by younger, smaller trees. Retaining more old trees within productive forest plantations, either through continuous cover forestry or minimum intervention areas, will increase carbon storage.

The findings also have wider implications for forests outside the UK. Primary, old-growth and intact forests store and sequester vast amounts of carbon and play a crucial role in the global carbon cycle[7]. Despite this, they continue to be logged and degraded. Only 1.4% of European forests have never been logged[8], yet many are still lacking protection. At the global scale, logging and grazing have reduced forest carbon stocks by almost as much as deforestation[9]. Protecting the world's remaining primary and old-growth forests from logging, and reducing logging in mature woodlands to allow carbon stocks to recover, would greatly help to mitigate climate change.

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Managing for old-growth characteristics, as at Little Doward Woods, can accelerate the development of large trees, which are efficient and effective carbon stores and provide unique habitat.

Restoring planted ancient woodland in the Scottish uplands

Richard Thompson

The *State of the UK's Woods and Trees 2021* report summarises how much ancient woodland is currently damaged by plantation forestry. Restoration of these woodlands is an urgent priority; the longer remnant features remain in a critical condition the more likely they are to be permanently lost. While gradual restoration to a native canopy is usually recommended, the Scottish uplands present unique challenges and often require a different approach.

Richard Thompson is a native woodland ecologist at Forestry and Land Scotland.

By the early part of the 20th century, most ancient semi-natural woodlands in the uplands of Scotland were overgrazed and fragmented remnants on steep slopes and in gullies. Severe shortage of timber after the world wars, and an increasing drive to make economic returns from the land, led to large-scale afforestation. The best examples of our ancient Caledonian forest (be they pinewoods or oakwoods) were protected and celebrated. However, many other ancient woodland remnants were incorporated into these new plantations. This involved either under-planting with shade tolerant conifers or complete clearance of native trees to replant with non-natives. Where this occurred on ancient semi-natural woodlands, they became known as plantations on ancient woodland sites (PAWS).

In the northeast of Scotland, Scots pine was often planted as it is well suited to the free-draining soils and lower rainfall. However, in the west Highlands, the tree of choice has been Sitka spruce – a fast-growing, heavy-shade-casting conifer from the Pacific northwest of North America. There are 59,073 hectares of PAWS in Scotland, most of which were planted between the 1950s and 1970s. Forestry and Land Scotland is in the process of carrying out condition assessments on the ancient semi-natural woodlands and PAWS under their ownership and have begun restoration management on 18,000 hectares (62%) of their PAWS area.

The characteristics of most PAWS in the uplands of Scotland make gradual restoration – using thinning to retain continuous canopy cover – difficult to achieve. Clearfelling is, therefore, often the only means to remove non-native trees. This is counter to the gradual approach which aims to maintain woodland conditions. There are, however, ways to manage this abrupt transition, to safeguard ancient woodland remnants and develop a thriving native woodland ecosystem.

When is clearfell necessary?

Normal forestry practice would be to thin plantations

An upland plantation on an ancient woodland site on typically challenging terrain.

several times to promote the growth of dominant trees and increase stand stability. However, the steep, exposed and inaccessible nature of most PAWS in Scotland has often meant that little, if any, thinning has taken place. This has had two important consequences: 1) we are not presented with frequent, routine opportunities to free ancient woodland remnants from shade and root competition and 2) attempting to convert the plantation to native woodland through gradual means (i.e. continuous-cover forestry) would often lead to catastrophic wind-blow as each tree relies on a largely intact canopy for support. This pushes us down the road of clearfelling – an anathema for many who manage PAWS on more sheltered lowland sites.

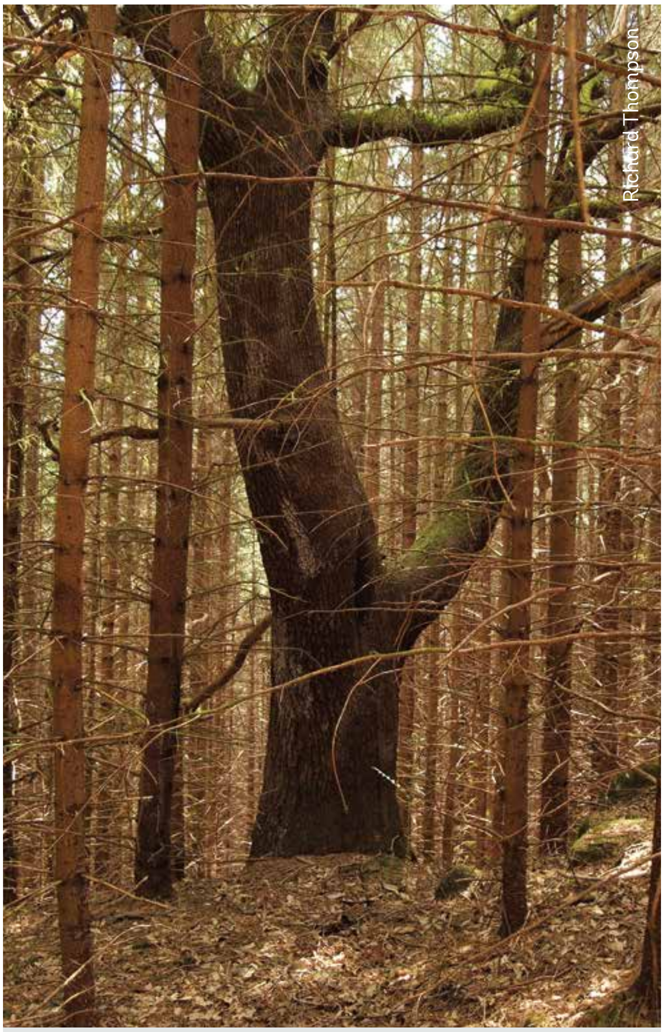
There are other drivers to clearfell too: extensive areas of lodgepole pine, another Pacific northwest species, were planted alongside our Caledonian pinewood remnants. Lodgepole pine harbours high levels of inoculum of the 'Dothistroma needle-blight' fungus which poses a serious threat to our precious native pinewoods. Clearance of large areas of lodgepole pine is underway to reduce this threat. Sitka spruce, western hemlock and lodgepole pine are species that typically produce prolific natural regeneration; therefore, gradual removal of such species would lead to a prolonged seed rain. While non-native regeneration is a problem on clearfells, it can become overwhelming in a frequently thinned stand.

Of course, it may be possible to gradually restore some upland PAWS, and those working on a small scale, with sufficient resources, may be able to deal with issues of tree instability and non-native regeneration through more regular interventions.

Clearfelling often results in competitive vegetation dominating more delicate flora typically associated with ancient semi-natural woodland, particularly on heavier mineral soils. Old native trees that survived within the plantation can suffer from sudden exposure, develop rank epicormics (shoots from the bole of the tree) at the expense of crown development and some may blow over. A newly felled site can appear like a wasteland. And yet, the characteristics of many of our upland PAWS can help to ameliorate these issues. Monitoring of old growth lichens on the Morvern peninsula in the west Highlands has shown that there is sufficient humidity in 'hyper-oceanic' sites to allow these lichens to recover and flourish. Indeed, in the rainforest zone on the west coast of Scotland, some lichenologists and bryologists have expressed a preference for rapid removal of the plantation to speed up the development of native woodland and create suitable habitat for colonisation of epiphytes from the adjacent ancient semi-natural woodland.

Reducing the impacts

There are several ways to reduce the impacts of clearfelling. Assessing the condition of ancient woodland remnants within PAWS will highlight where veteran native trees and patches of flora are suffering from shade and root competition due to being subsumed within the plantation. Other likely hotspots for ancient woodland remnants in upland PAWS are rock outcrops, boulder fields and gorges. If it is possible to thin the plantation, improving the condition of such remnants and topographic features is relatively straightforward by thinning more heavily in their proximity, while protecting the roots and crowns of native trees.



A veteran oak within an unthinned spruce plantation. Urgent action is needed to reduce shade and root competition.

Rock outcrops often occur in upland plantation on ancient woodland sites and typically support rich ancient woodland remnants.

In steep, exposed and remote upland sites where thinning has not taken place, such remnants should ideally be 'halo thinned' – that is, felling plantation trees around the remnant/topographic feature, pulling branches and logs back under the remaining plantation canopy and leaving the felled wood to rot. This promotes crown recovery on remnant trees and enhances remaining patches of vegetation along stream sides, under remnant trees and at the foot of rock outcrops. It also allows the 'seedbank' of woodland specialist flora in the soil to germinate and re-establish. In short, halo thinning makes remnants more robust and more able to tolerate the shock of the future clearfell.

To protect old oak trees at the time of clearfelling, we have tried the inverse of halo thinning by leaving a buffer of unfelled plantation trees around the oaks. This worked to some extent where the plantation trees were short, slow-growing Norway spruce, but not with much faster growing Sitka spruce that were much taller than the oaks. In this case, the plantation trees didn't offer any side protection to the oaks and mostly blew over or snapped. This illustrates the importance of working with the harvester operator, discussing the rationale for the treatment and agreeing parameters for when it is likely to be successful.

Each forest manager in the uplands is typically responsible for many thousands of hectares. When a PAWS must be clearfelled, everyone involved in the planning and implementation of the felling needs to be fully aware of what is special on the site. This informs what management is required to protect important features and enhance the prospects for recovery and development of the future native woodland. Protection of the ancient woodland remnants must be the primary objective. Where creation of access would cause substantial damage, more innovative methods should be used; for example, barge extraction on lochs, or a cable crane. Younger native trees must be protected too – these are the building blocks to regenerate the future native woodland.

Halo thinning of oak and birch trees to promote crown recovery prior to future clearfelling of remaining conifers.

Native woodland regenerating through heather-dominant vegetation several years after clearfelling.

In extensive upland landscapes where neighbouring landowners have different objectives, it may be difficult to get deer numbers low enough to allow natural regeneration of palatable trees such as oak, hazel, holly or aspen to successfully establish. A small number of such trees in a birch-dominated woodland will vastly improve its biodiversity value. Localised protection of at least a proportion of these palatable species (using guards of an open net structure, for example) is recommended where sufficient reduction in deer pressure is unachievable. The impacts of deer on woodlands is discussed in more detail in the *State of the UK's Woods and Trees 2021* report.

It is often necessary to do two or three sweeps through felled PAWS to clear non-native regeneration. This is an expensive process. The duration of non-native regeneration can be reduced by encouraging canopy closure of the native woodland (i.e. through suppressing deer numbers) and developing a native woodland buffer around the PAWS – or at least, one composed of more benign species such as Norway spruce.

Restoring PAWS in the Scottish uplands is challenging, and clearfelling is often necessary. However, if the protection and enhancement of ancient woodland remnants remains the focus of all operations and a long-term view is taken, successful restoration is achievable.

Ammonia-emitting developments such as intensive poultry and livestock units can impact on nearby ancient woodlands.

Nitrogen – an insidious threat

Alastair Hotchkiss

Alastair Hotchkiss is a conservation adviser on woodland for the Woodland Trust.

One of the most insidious and widespread threats facing the UK's woods and trees is the excess of reactive nitrogen in the environment as a result of human activities. This strips trees of characteristic lichens and causes a fertiliser effect to the detriment of sensitive woodland plants and their associated insects, disrupting woodland ecosystems in ways we are only beginning to understand.

Bryophytes and lichens form significant communities of epiphytes – organisms that grow on tree trunks, branches and twigs. The ground vegetation of ancient woodlands is also strongly characterised by bryophytes. Healthy communities of lichens and bryophytes are a fundamental component of ancient woodland ecology. Unfortunately, there is substantial and wide-ranging evidence of the harmful effects of nitrogen deposition on woodland ecosystems. Impacts are widespread and directly affect many woodland epiphytes as well as plants and fungi, with implications for wider ecosystem functioning, resilience and services.

Worrying trends

The latest data on trends in nitrogen deposited to the ground and nitrogen in the air is reported in the *State of the UK's Woods and Trees 2021* report. The vast majority of UK woodland habitats are exceeding the threshold amount of nitrogen deposition at which the ecosystem is considered to deteriorate. Additionally, between 70 and 80% of broadleaved woodland habitat area across the UK exceeds the set threshold of ammonia in the air, meaning that lichen communities will be altered and ecological integrity compromised.

Worryingly, there is increasing evidence that ecologically significant impacts occur at lower nitrogen concentrations, suggesting that current thresholds are not robust enough. The nitrogen deposition threshold for key components of woodland ecosystems such as the life-support fungi associated with tree roots (ectomycorrhizae) has recently been proposed to be nearer to 5–6kg of nitrogen per hectare per year (N/ha/y), whereas the current threshold for most woodland in the UK (last revised in 2010) is 10kg N/ha/y.

Similarly, the current threshold for the concentration of ammonia in the air is insufficient to avoid impacts on the most sensitive species. It is set at 1μg NH_3/m^3, but ecologically significant changes occur at levels as low as 0.5μg NH_3/m^3. There is also growing concern about the impacts of acute toxicity on woodland species arising from spikes in ammonia concentrations during, for example, slurry/manure spreading, so annual mean ammonia concentrations may not be the most robust way of assessing impacts.

Ecological impacts

Nitrogen deposition is increasingly leading to a greater abundance of nitrogen-tolerant plant species which outcompete and impact on many characteristic ancient woodland plants[1,2] and mosses[3,4], degrading the ecological integrity of ancient woodland sites. The knock-on effects for all animal species associated with nitrogen-sensitive components will be significant; for example, where essential larval food plants of woodland butterflies, moths and other insects are impacted[5].

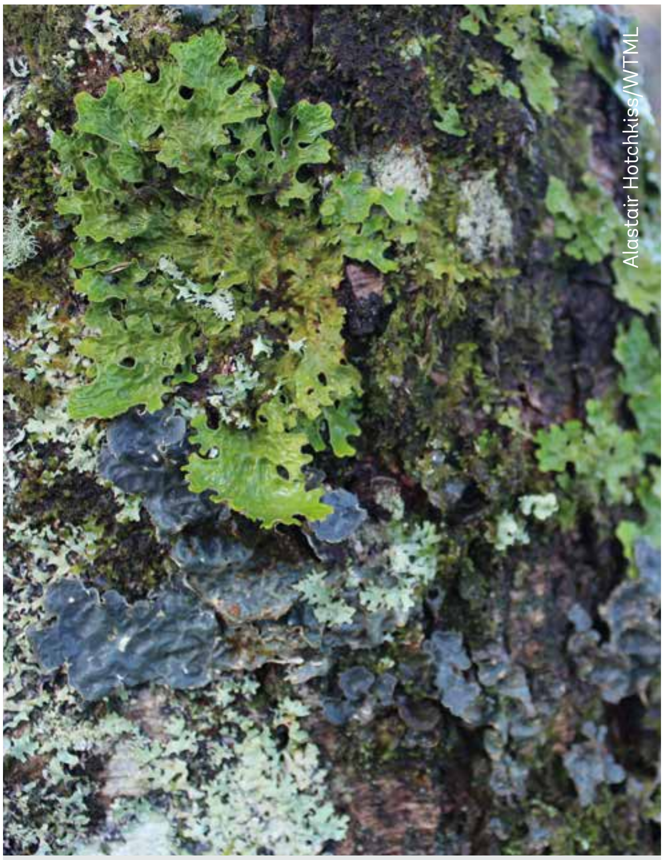
Trees can be directly impacted and, at very high gaseous concentrations, can suffer bleaching, leaf discoloration and increased susceptibility to damage from drought, frost and diseases, reducing overall health and vigour[6]. The deteriorating mineral nutrition of trees (e.g. foliar phosphorous) is linked to nitrogen deposition, with consequences for ecosystem functioning and climate-change response[7]. Wood density of some tree species (e.g. beech, sessile oak, Scots pine) has decreased significantly since 1900 due to increases in carbon dioxide and reactive nitrogen combined[8], which makes them more susceptible to disturbance events, such as high winds. There are also links being made between nitrogen pollution and tree diseases like acute oak decline[9].

Many woodland fungi have been shown to be sensitive to nitrogen deposition, and there is particular concern about impacts on ectomycorrhizal species (those associated with tree roots), and the subsequent impacts on tree health[10,11]. If these fungi are suffering, then our trees will be having a harder time getting all they need from the soil and dealing with stresses like drought. The loss of these woodland fungi also results in soil carbon release to the atmosphere, with climate change implications[12]. This important group of life-supporting fungi has been shown to recover in parts of the Netherlands, where the Government actively put measures into place to reduce ammonia and nitrogen deposition over the past decade or more[13].

Lichens are powerful indicators for the biological monitoring of air pollution impacts. Many woodland lichen species and communities evolved and developed in naturally low levels of atmospheric nitrogen and are highly sensitive to change (e.g. lungworts, *Lobaria* spp. and beard lichens, *Usnea* spp.). Lichens on trees provide shelter, food, and vital microhabitats for invertebrates, and are considered to contribute to wider ecosystem services; for example, in carbon cycling, water retention[14], and medicine[15].

Shifting baselines

Reactive nitrogen pollution is an immediate issue. Without looking carefully, the insidious impacts are perhaps not always striking. But this itself is a strong case of shifting baseline syndrome – people's perceptions of what a tree or wood should look like has settled on the acceptance of what they see around them. Bare trunks and branches are the new normal. Even the ecologists get it wrong, as many conservationists still think trees in the far west are covered in big, bushy beard lichens, oak moss and


Alastair Hotchkiss/WTML

A healthy community of lichens growing on trees in the relatively clean air of Loch Sunart in Scotland.

Nitrogen pollution has shifted the public's image of what a wood should look like. Bare trunks free of lichen is the new normal.

Historically, woodland would have been covered in a rich and diverse array of lichens – adding biodiversity value.

lungworts because of the wetter climate. These areas have also been least affected by air pollution. Species such as the tree lungwort lichens (*Lobaria pulmonaria* and *Lobaria scrobiculata*) are often portrayed as a flagship for UK rainforests, yet they occurred throughout most of Western Europe historically, including in much drier climates in central and southeast England.

The more you learn to spot the signs and the more you read about the complexity of the issue, the more you realise that this is one of the biggest and most widespread threats facing the UK's woods and trees. Everyone recognises the need to address carbon for the climate crisis, but we absolutely must be talking about the need to deal with nitrogen with the same degree of urgency, to address the nature crisis.

A call to action

Where ammonia concentrations and total nitrogen deposition exceed the thresholds for woodland ecosystems, action must aim to reduce emissions from existing sources. This is not about avoiding any further increases, it is about the need to reduce emissions. In many parts of the UK, the reductions required are considerable and may require significant changes to existing land use practices. In the interim, reduction efforts can be combined with attempts to buffer or capture emissions to reduce their dispersal into woodland ecosystems, particularly ancient woodlands.

It will require a strategic approach by governments to achieve the necessary levels of reductions for all ancient woodland across the UK as most air pollution issues arise from sources outside the boundary of woods themselves. But localised actions can make a difference for individual ancient woodland sites.

A number of actions can be considered by individual landowners and managers:

Buffer ancient woods and ancient and veteran trees to reduce, capture or intercept emissions[16]. Create zones around woodland and important individual trees where there are no nitrogen inputs (e.g. no spreading of manure or fertiliser). Edge effects of 200m can be detected in woods adjacent to land uses with high nitrogen deposition levels[17].

Use trees to intercept and capture ammonia emissions. Localised planting of tree belts may protect ancient woodlands from existing sources of pollution[18], such as intensive livestock units. At the landscape scale, parts of the UK with high woodland cover and other semi-natural habitat emit less ammonia, compared to agricultural land uses which have high nitrogen inputs. So, increasing woodland cover will also help reduce reactive nitrogen input to the atmosphere.

Be aware of new developments in the local area, and mindful of the impacts from air pollutants. New developments should not lead to further degradation of ancient woodland sites because of increases in atmospheric nitrogen[18]. This can include nearby developments like intensive agricultural units. Although localised, game bird releases can also have significant impacts from localised nitrogen emissions[19].

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Changes in the timing of autumn – the neglected season

Tim Sparks

Phenology is the study of the timing of naturally recurring events; for example, leafing dates. In the UK, our oldest known phenology records date from the end of the 17th century. Originally seen as a branch of natural history, phenology now has a much more important role in helping to understand our changing world.

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It is important to understand how much change may occur in the timing of autumn as a result of climate change.

Phenology can be used to track changes in plant and animal behaviour due to climate change. For example, the UK Spring Index is an indicator derived from combining the annual mean UK observation date for first flowering of hawthorn, first flowering of horse chestnut, first recorded flight of an orange-tip butterfly and first sighting of a swallow. When comparing the current 1998–2019 period to the historic 1891–1947 period, the Spring Index has become on average 8.4 days earlier. Other research from across the globe also shows recent advances in the timing of spring. The *State of the UK's Woods and Trees 2021* report highlights evidence of earlier springs in the UK and the serious repercussions along the food chain.

Recording of spring events has always been popular, perhaps because they mark the passing of the dark and dreary days of winter and a return to new life. In contrast, autumn is the poor cousin in terms of recording phenology, both historically and currently, and has been described as the neglected season[1]. It is important, however, to also understand how much change may occur in the timing of autumn.

The evidence for limited change in autumn

A recent paper by Zani et al. in the leading journal *Science*[2], based on data from Central Europe, predicts earlier autumns as a result of the advances in spring. This could potentially have serious consequences for the amount of carbon that would be captured by trees under future warming, since they will experience a shorter autumn. These findings would suggest that the leaves of trees have a fixed lifetime, or 'shelf-life', with early springs leading to, all other things being equal, early autumns. If carbon capture by trees in autumn is going to be more limited than previously thought, then this may have serious consequences for plans to deal with the planet's excess of carbon.

In the UK there is relatively little longer-term data on autumn phenology. Some data is available, however, covering more recent time periods, including from Nature's Calendar. This is a UK network of citizen scientists recording common phenological events throughout the year. Founded in 1998 and populated with historical records, it has been coordinated by the

The annual mean UK observation dates for first flowering of hawthorn, first flowering of horse chestnut, first recorded flight of an orange-tip butterfly and first sighting of a swallow are combined to calculate the spring Index.

Woodland Trust for the past 20 years. This database is used to calculate the Spring Index and is widely used for research. Evidence from Nature's Calendar and other available data regarding the timing of autumn are discussed below to evaluate Zani et al.'s 'shelf-life' hypothesis.

Data from the bank

In the 1901 Phenological Report[3], 14 years of data were collected of dates of the "Appearance of the first speck of green" [budburst in spring] and "Trees quite bare of leaves" [an indication of autumn] of lime trees in the garden of the Bank of England "recorded with great care" by a Mr Pike. These trees were evidently a feature of this garden[4]. Two further years of records were reported in the next two phenological reports, but this is where the records end.

The 16 years of both the 'Green Speck' and 'Bare' records show temperature responses; the former advancing by four days for every 1°C warmer in March, and the latter delaying by two days for every 1°C warmer in September. However, in the case of the latter, bare dates advanced by 1.2 days with a 1°C increase in March temperature, thus corroborating the prediction of early springs influencing the timing of autumn.

Frederick Lowe's unique dataset

Frederick Lowe was employed at the English Choir School at St Michael's, Tenbury Wells. He kept a unique record of the dates of year-round events of 90 woody species, which extended to 17 years by the time of his death in 1931. His records included first leafing dates on all 90 species, and bare dates on 69 (for example, being absent for evergreen species). This dataset clearly confirms a greater variability in the timing of first leaf in spring than in the timing of bare dates in autumn (shown by the spread of the bars in Figure 1).

A broad-brush analysis of Frederick Lowe's data, simply regressing all first-leaf dates on mean January–March temperatures and all bare dates on mean August–October temperatures, is equally revealing. A 1°C increase in average temperature across January–March would advance first leafing, on average, by nine days, while in contrast, a 1°C increase across August–October would delay autumn bare dates, on average, by 2.5 days. Thus the effects of climate change would be expected to have a disproportionate effect on spring, with a greater advance in leafing, than the delay in autumn. In terms of bare dates being also influenced by either first leaf dates or spring temperatures, there is only limited evidence from these data.

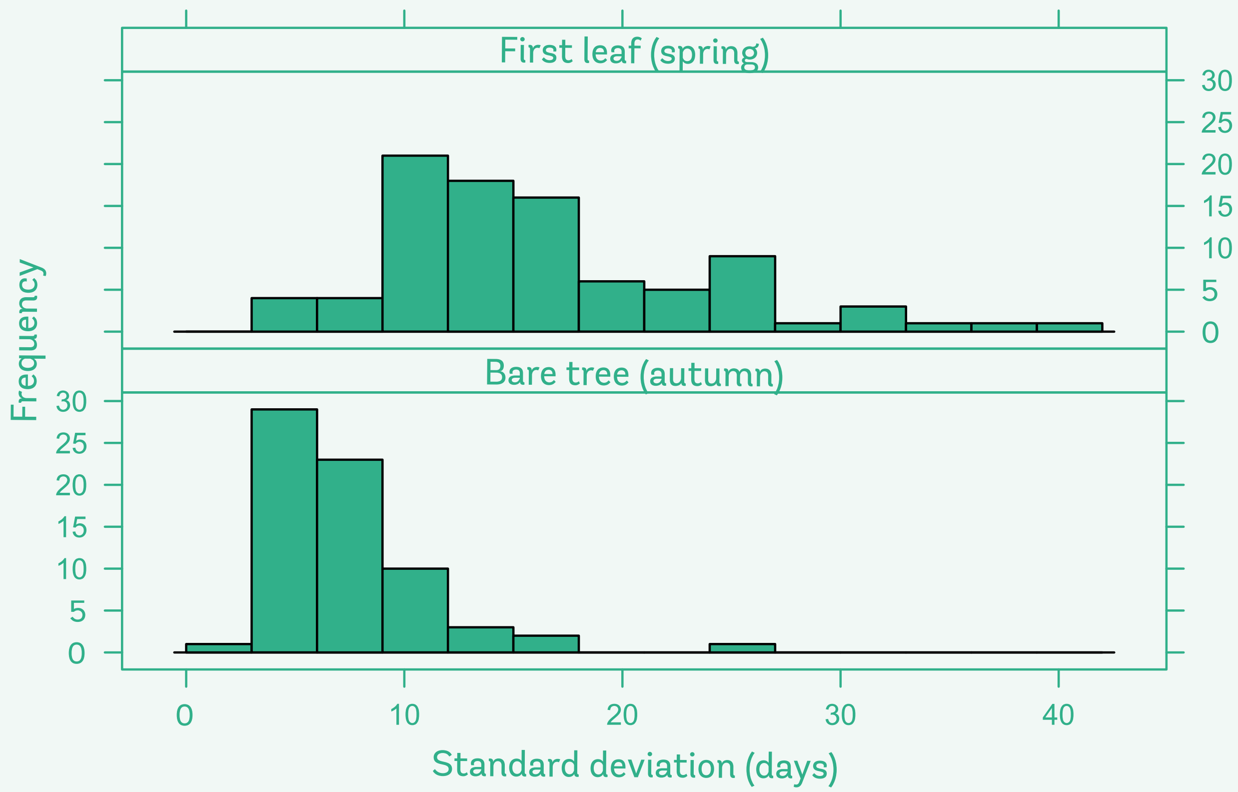

Figure 1. The variability in the first leaf dates of 90 woody species (upper) and in the bare dates of 69 woody species (lower). The mean variability in spring is twice as great as that in autumn, implying a range in first leaf dates of about two months for the average species, but only a range of about one month in bare dates of the average species.


Rob Grange/WTML

Nature's Calendar data

The two previous examples both show clear temperature responses, despite being a relatively short series of 16–17 years from single locations. Sadly, the main national network that existed between 1875 and 1947 collected only limited data on tree leafing in spring (preferring to focus on flowering dates), and no autumn tree data.

The more recent Woodland Trust scheme is rectifying that shortcoming by collecting tree phenology data throughout the year across the UK. The mean dates of UK-wide data collected through the Nature's Calendar programme for 1999–2020 also show strong temperature relationships. Dates for pedunculate oak first leafing were approximately six days earlier for every 1°C warmer in February–April, while bare dates were two to three days later for every 1°C increase in October temperature. However, and once again, the latter relationship is moderated by temperatures in spring, reducing by about a day for every 1°C increase in March temperature.

Thus, there is evidence from a variety of current and historical sources that delays in autumn caused by higher temperatures may in fact be limited by higher temperatures in spring. Whether this influence of spring temperatures on autumn phenology is sufficient to advance autumn phenology, as suggested by Zani et al., is not confirmed by the data investigated here. Their data was of a much longer duration than is currently available in the UK. However, the data collected by Nature's Calendar in the UK is now of a duration that is useful for a wide range of investigations. It is, for example, used in both the Global and UK Annual State of the Climate reports[5,6], and in government biodiversity indicators[7]. Thus it is vital to maintain the recording impetus in order to inform policy and demonstrate change. Furthermore, we are currently developing an Autumn Index, as a complement to the Spring Index, to help monitor changes in this key season.

Oak first leafing is recorded by Nature's Calendar as a sign of spring.

A visual record

As an alternative way to demonstrate the variability in the timing of autumn, photographs taken of oak trees at the beginning of December each year for the past 20 years are plotted along a timeline (Figure 2). This visual representation conveys a very strong message about the variability of our seasons from year to year. This sequence clearly shows some years where trees remained very green and others where the trees were bare, but no obvious trend between October temperature and the progression of autumn. While hugely valuable as an historical record, a single location like this is not sufficient to provide an efficient monitoring programme and the UK-wide recording scheme of Nature's Calendar is, therefore, vital to provide monitoring of our seasons, and the data necessary for more in-depth scientific investigations.

Figure 2. Over the page: photos of the same oak tree taken at the beginning of December every year from 2001 to 2020, taken at Monks Wood in Cambridgeshire, plotted against mean October temperature.
Credit: Phil Croxton and Tim Sparks

Nature's Calendar is supported by players of People's Postcode Lottery, encouraging people to get involved in helping us better understand the impacts of weather and climate change on our wildlife.

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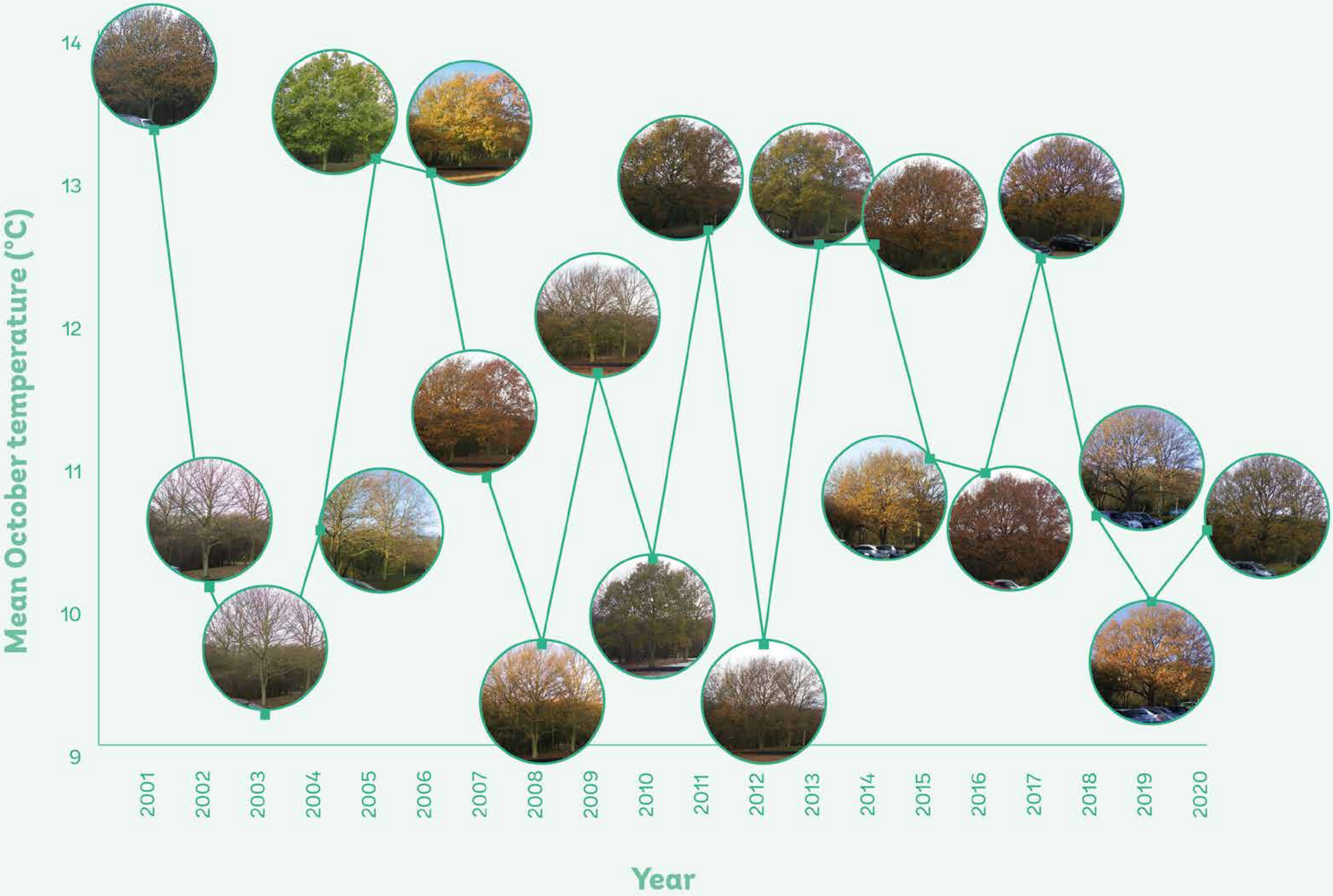
Figure 2:



Mean October temperature (°C)
14
13
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11
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9
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Do expert-developed ecosystem service frameworks mirror public values?

Zoe Davies and Phoebe Maund

Nature supports human wellbeing in a multitude of ways. Making sure that these economic, cultural and social values are fully incorporated into policy and management decision making is difficult. Expert-developed ecosystem service frameworks are therefore increasingly being used to explicitly account for these complexities, translating the benefits nature provides for a variety of audiences. But do these frameworks accurately reflect the wants and needs of society? Here we explore this question for British woodlands.

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The countless benefits that people gain from ecosystems are now well recognised. As highlighted in the *State of the UK's Woods and Trees 2021* report, woodlands support human wellbeing through the provision of a diverse array of ecosystem services, such as carbon storage, temperature regulation in our cities and providing a space for people to relax or exercise. Since the Millennium Ecosystem Assessment (MA) was published in 2005, a plethora of frameworks have been developed to explicitly account for, and value, the benefits derived from nature in land-use decision making. These standardised frameworks can be used to systematically evaluate and examine potential trade-offs between ecosystems and the services they provide, in a fair and transparent manner.

The challenges

The existence of different ecosystem service frameworks is perhaps not surprising, given the growing urgency to curtail the loss and degradation of biodiversity, as well as the inherent complexity of human-nature interactions. Yet the widespread use of multiple frameworks throws up a number of challenges, not least because it limits the ability of decision makers to make meaningful comparisons across assessments and grapple with the associated uncertainties. In turn, this reduces their usefulness. While this warrants debate and attention in the academic, policy and practice communities, another substantial issue has been overlooked. The one thing that all the ecosystem service frameworks have in common is that they have been created based on expert opinions and views of how ecosystem services are structured, rather than that of the beneficiaries: the public.

Ecosystem service frameworks need to accurately reflect the wants and needs of society, not just the standpoints of experts with their specialist knowledge.

This is particularly true for cultural ecosystem services, which are the non-material benefits gained primarily from people's interactions with biodiversity and nature, such as recreation or aesthetic enjoyment. We decided to explore the extent to which these frameworks actually represent the values held by the wider public and variability across different sectors of society, using British woodlands as our focus[1].

Our research

We used the Common International Classification of Ecosystem Services (CICES) framework as it was developed by the European Environment Agency with commonality and harmonisation in mind. Essentially, it aims to be a one-stop-shop for ecosystem service assessments, as it is a flexible and nested tool that can be adapted to operate across a diversity of geographic scales and tailored to specific groups/ resolutions of service.

CICES is constructed as a five-level hierarchy:

- Section
- Division
- Group
- Class
- Class type.

At the highest level, 'Section' includes three broad ecosystem service categories (provisioning; regulation and maintenance; cultural). Subsequent levels become increasingly more specific and detailed. For instance, 'Section' – 'Provisioning'; 'Division' – 'Biomass'; 'Group' – 'Cultivated plants'; 'Class' – 'Cultivated plants for nutrition'; and 'Class type' – 'Cereals'. CICES includes ecosystem services that are experienced through direct use (*"in-situ and outdoor interactions with living systems that depend on presence in the environmental setting"*) and indirect use (*"remote, often ex-situ interactions*

Questionnaires distributed to a good representation of the British public showed that physical activities were the main way that they interacted directly with woodlands.

with living systems that do not require presence in the environmental setting").

We developed a questionnaire that was distributed to participants across England, Wales and Scotland that represented the diversity of the British public, including sectors of society who are often underrepresented in research (e.g. elderly, ethnic minorities, lower income households). The public principally valued British woodlands for the 'cultural' services they provide. The strongest values were for woodlands to be conserved for future generations and that they are important ecosystems even if no-one visits them. People were also aware of, and prized, the symbolic, cultural and historical meanings associated with woodlands, as well as their aesthetic value. Physical activities were the main way that the public interacted directly with woodlands. Importantly, the public also valued woodlands highly for the 'regulation and maintenance' services they deliver. These included helping to: reduce soil erosion, floods, storm surges, wind damage and landslides; maintain soil quality; break down and filter waste and pollutants in the soil, water or air; regulate the global climate; maintain water quality; and reduce the smells, noises and visual appearance of industry, buildings and roads.

At the other end of the spectrum, people did not value direct 'provisioning' services, such as collecting woodland species for consumption, decoration, crafting or enjoyment. Similarly, they did not use woodlands directly for spiritual, sacred or religious activities.

Discrepancies between experts and the public

Our findings highlighted some stark disparities between how the experts and public perceive the values associated with British woodlands. People did not relate to any of the more detailed CICES subcategories within the 'provisioning' or 'regulation and maintenance' service categories. For instance, the public did not discern between woodlands helping to regulate the global climate or maintaining local water quality. So, while these aspects of CICES might be useful for decision makers who are required to report on ecosystem service provision, people do not conceive the services woodlands provide with that level of refinement.

In contrast, a different picture emerged for some 'cultural' ecosystem services, with people's values aligning relatively well to the expert-developed framework. There were some notable exceptions, however, where public perceptions were far more complex than how they are captured by CICES. A prime example of this was the myriad of physical activities people may do in woodlands, such as walking, running, cycling and horse riding, which all fall within a single CICES category. So, although many experts believe physical activity is a relatively straightforward service to assess, people view it as far more multifaceted. This is probably because there is significant variation in the likelihood of people undertaking these activities, how long they might do them for and how intense they are.

Peter Dench/WTML

The spiritual, sacred or religious significance that people place on British woodlands was found to differ according to ethnic background.

Ecosystem service frameworks translate the importance of nature and the services it provides. However, they do not currently account for the intricacies of people's values.

This discrepancy is a potential concern, as the need to account for the values associated with physical activity is important to a range of stakeholders and is a critical consideration in decision making. Indeed, it is particularly key when evaluating trade-offs with other services; for example, whether to prioritise conservation or recreation.

Different values across society

We also discovered some interesting distinctions between different sectors of society, mostly in relation to ethnicity. This was most striking for the spiritual, sacred or religious significance that people place on British woodlands, with individuals from a white ethnic background valuing this ecosystem service far less than those from other ethnicities. Quite often, ecosystem service assessments fail to really engage with a representative cross section of the public, which could lead to inaccurate evaluations. Given the diversity of the British population, our work serves to highlight the importance of making sure that the views of harder-to-reach sectors of society are fully incorporated into environmental decision making, so the choices being made are appropriate and effective.

Final thoughts

Expert-generated ecosystem service frameworks are clearly valuable tools, as the complexities of economic, cultural and social values are seldom fully incorporated into policy and management decision-making processes. The classic example of this was the proposed sell-off of publicly owned forests in the UK back in 2013, which revealed that people's values for the environment had been largely ignored by those responsible for the aborted plan. In the same way, private woodland owners often hold views regarding the provision of public goods by their property which are at odds with those of wider society, leading to mismatches between how the public might want woodlands to be managed, and their actual management.

Ecosystem service frameworks therefore have a vital role to play in translating the importance of nature and the services it provides to a variety of different audiences. Nevertheless, while they provide a great starting point, they do not currently account for the intricacies of people's values. Overlooking these issues risks incorrectly valuing services, which could result in poor decision making and outcomes for our ecosystems. Arguably, it is perhaps most important that these wrinkles are ironed out for cultural ecosystem services as these are the services that inspire deep attachments within human communities. They are critical entry points to engage the public in environmental matters and grow support for conservation.

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The *State of the UK's Woods and Trees 2021* report presents a clear and urgent task for policy makers at all levels of government.

What next? Public policy imperatives

Andrew Allen

Andrew Allen is the Woodland Trust's lead policy advocate on land use.

The *State of the UK's Woods and Trees 2021* report is more than a series of data sets – it is a call to arms. In setting out in detail the condition of the country's trees and woods, it illuminates the multifaceted nature of our interaction and reliance on trees, and the urgent need for action to protect and enhance this essential resource.

This new report has ramifications for public policy makers across government and its agencies at local, country and UK level. Although the need for targeted policy interventions can be explicated from information throughout the report, four strategic themes emerge as pressing policy priorities:

1. Ancient woodland must be protected as a key part of the UK's climate change strategies
2. To deliver for nature, native trees must be a major part of woodland expansion
3. More trees are needed to create healthier, happier and more secure places to live
4. Trees and woods must be protected from the import of pests and diseases

Ancient woodland must be protected as a key part of the UK's climate change strategies

The debate around trees and the response to climate change is dominated by plans to establish large areas of new woodland. The role of existing trees and woods is equally important but attracts far less attention from policy makers. New research included in the *State of the UK's Woods and Trees 2021* report highlights how ancient and long-established woodland is both an exceptional carbon store and has the potential to sequester large amounts of additional carbon in the coming decades. Ancient woodland is more carbon-rich than other woodland types, holding over a third of all woodland carbon even though it only makes up a quarter of all woodlands; i.e. it holds 77 million tonnes of carbon out of a total of 213 million. So, rather than being carbon neutral, ancient woodland continues to absorb large amounts of carbon, with stocks set to double over the next 100 years to over 150 million tonnes.

The protection afforded ancient woodland is currently too weak. Ancient and long-established woodlands which are of most ecological value now represent only a quarter of remaining woodland cover and continue to be fragmented, damaged and destroyed. Development pressures resulted in nearly 1,000 ancient woods being damaged or destroyed since 1999 with another 1,225 currently under threat. Of what remains, 50% is being damaged by a combination of conifer plantations and rhododendron.

Together, ancient woodland's status as both a valuable and growing carbon store and an important wildlife habitat clearly justifies a higher level of protection and a proactive approach to management and enforcement. In land-use planning, there is a strong case for giving the ancient woodland designation a status akin to that afforded Sites of Special Scientific Interest in England. Additional measures are required to protect ecological integrity, such as buffering around ancient woodland boundaries as a formal requirement. Increased grant funding and better guidance is required for landowners through the replacements for the Common Agricultural Policy.

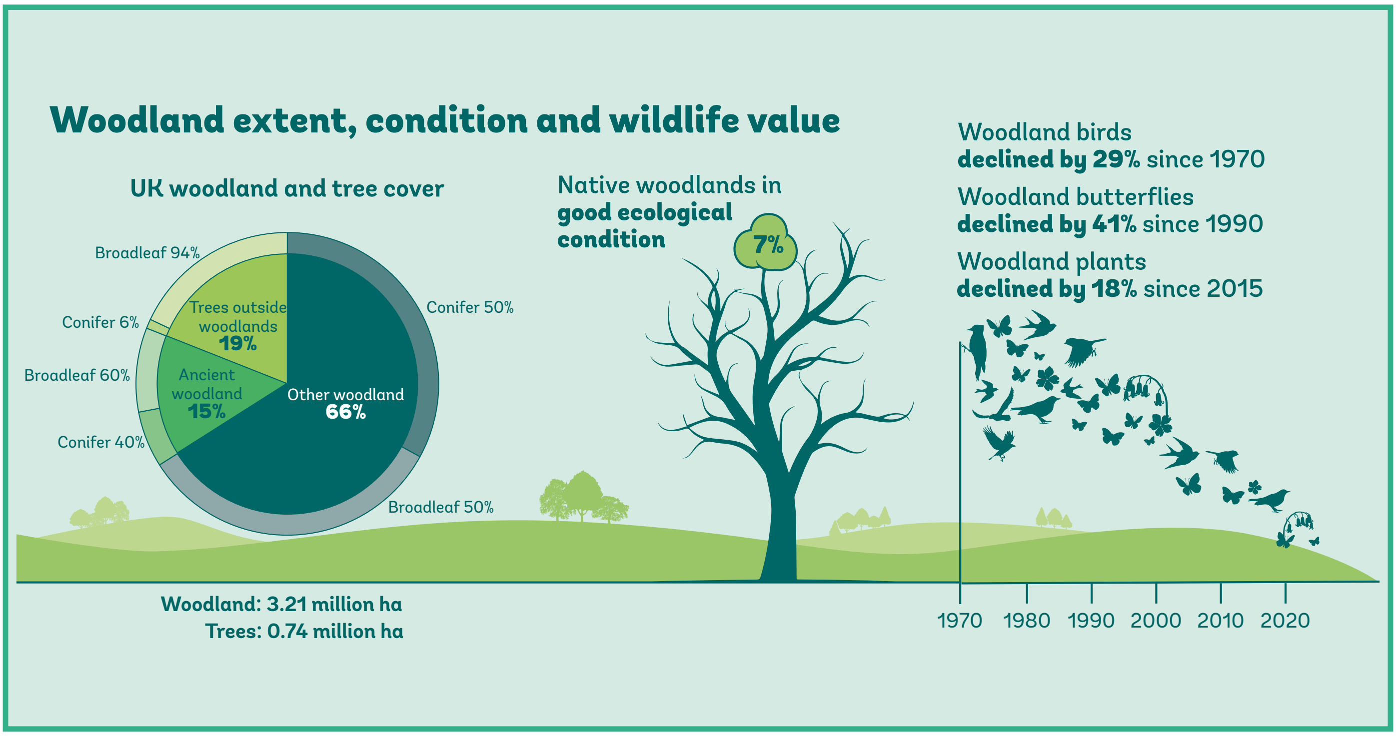
To deliver for nature, native trees must be a major part of woodland expansion

The UK's national governments have targets in place for significant increases in tree and woodland cover over the next 30 years. To ensure this delivers for nature and climate together, native trees must be a major part of the expansion.

UK woodland cover has nearly tripled since the beginning of the last century. But, what should have been a boon for nature has coincided with a decline in overall woodland condition and population declines of many species dependent on them. Only 7% of Britain's native woods are in good ecological condition, with many woodland-dependent species showing sharp declines in recent decades, including birds by 29% since 1970, butterflies by 41% since 1990 and plants by 18% since 2015.

The picture is just as stark for native trees outside of woods: the individual trees scattered across our towns, parks and countryside. In one part of the country, an investigation revealed that only half of such trees recorded in the mid-1800s still remain. What is more, there are insufficient new trees outside woods currently being established. In farmed landscapes, only 3% of UK agricultural land practises agroforestry. In urban areas, despite encouraging overtures about 'tree-lined streets', average tree cover is only 16%, and as low as 2% in some locations.

Action is needed to ensure the tens of thousands of hectares of planned new trees and woods deliver for nature and climate. Each UK government should put in place targets for native trees to be a major



Each UK government should put in place targets for native trees to be a major part of expanding tree cover.

part of expanding tree cover. Replacing the Common Agricultural Policy is an early opportunity to support new targets through clear, consistent and well-resourced grants which are simple to apply for and offer long-term support. Wherever possible, tree and woodland expansion should consider the wider landscape to maximise benefits, combining ecological goals such as buffering and connecting existing woods with other objectives, including water management and carbon sequestration. Particular importance should be given to allowing woodland to regenerate and expand naturally, helping trees and the ecosystems they support to adapt naturally to climate change. These challenging objectives require programmes of high-quality outreach, advice and support for landowners.

More trees are needed to create healthier, happier and more secure places to live

Trees and woods make the places we live better. Their cultural, ecological and social value has been brought into sharp relief this year by Covid lockdowns and the increased attention many people have paid to their local green space.

In sum, the value of the UK's woodlands has been estimated at £130bn. This includes value for recreation (£22.5bn), pollution removal (£31.7bn), and urban shading and cooling (£4.6bn) – many times their value as timber. Research in England found 89% of people agreeing that trees, woods and other green space are important for physical and mental health. Despite this, only one-in-six of us has access to a good size wood within walking distance of home.

National and local policy interventions are needed to support trees and woods in and around our towns and cities. Building on the example of the Northern Forest, public investment is needed to create new, large, accessible woodlands near to where people live. Every local authority should be guided and encouraged to create and deliver a local tree plan. This should include a commitment to a minimum of 30% tree canopy cover in new developments and an assessment of council landholdings to identify suitable sites for new woods. Care for existing trees should be enhanced through reform of the Tree Protection Order system, with clearer guidance on identifying trees that require special protection, a standardised approach to data collection and presentation, and a firm approach to enforcement.

Trees and woods must be protected from the import of pests and diseases

The UK's trees face growing pressures from imported diseases. A coordinated overhaul of policy is needed to address these risks, support the country's tree nursery sector, and protect trees and woods for the future.

Between 1992 and 2019, tree imports to the UK increased by nearly 1,500%. This coincided with the import of at least 19 serious new tree pests and diseases including ash dieback which is expected to kill the large majority of ash trees at a financial cost of £15bn. Others, such as the oak processionary moth, were repeatedly imported, eradicated and reimported. Other damaging diseases are spreading across continental Europe with the potential to seriously impact on common UK tree species.

Tough and well-resourced biosecurity protocols at UK borders is an important policy priority that would greatly reduce the risk of importing pests and diseases. The current reliance on imported trees, coupled with plans for increasing tree planting rates and changes to trade and border arrangements resulting from Brexit, could easily heighten the risk of importing tree diseases. There should also be a commitment to using UK and Ireland Sourced-and-Grown stock for any trees planted with public money. Such a move would come with the bonus of creating jobs and offering long-term security to the UK tree nursery sector.

Trees are an extraordinary resource. The evidence in the *State of the UK's Woods and Trees 2021* report shows clearly the role they play in helping maintain our climate, supporting biodiversity and contributing to our collective quality of life. But it also reveals the threats and pressures they face from disease, development and much more. This presents a clear and urgent task for policy makers at all levels of government. In legislation and in practice, we must better protect the trees we have, plan for increased tree cover so that it can deliver for nature and climate, and invest to establish more trees in our towns and countryside.