Wood Wise

TREES FOR GOOD

Tree & woodland conservation • Spring 2020

WOODLAND TRUST

ROLE OF TREES IN UK NET-ZERO EMISSIONS TARGET

NATIVE TREES ARE BEST FOR BIODIVERSITY

SPECIES' RESPONSES TO WOODLAND CREATION

MULTIPLE BENEFITS OF EXPANDING TREE COVER

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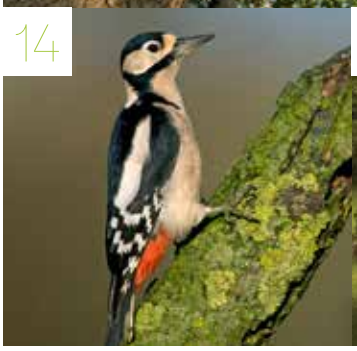

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WTML/Ben Lee

Our time is now

Darren Moorcroft

As 2020 began to unfold, never before had trees been so firmly in the thoughts of politicians and the public, and the urgency of the need to act so well-communicated and understood. Now, as we find ourselves in the midst of a public-health pandemic, attention is understandably elsewhere. But it has also highlighted that the work of the Woodland Trust is a crucial part of solutions to give hope today and tomorrow.

Our estate is enabling safe access for people to connect with nature for their physical and mental wellbeing at a time of lockdown, while also protecting and enhancing nature for future generations. And we will continue to campaign to protect the nation's ancient woodlands – nature's crown jewels. Our need to do so has never been greater. The number of ancient woodlands under threat has reached over 1,000 for the first time – not just from HS2 but across the UK.

Against a backdrop of the UK Government realising we must increase tree cover in the UK from 13% to 19%, we have the opportunity to engage landowners, schools, local communities and businesses, and inspire them to act. In February, Lloyds Banking Group formally announced its partnership with the Woodland Trust and a goal to plant 10 million trees with us over the next decade.

When the pandemic ends, the time will return for society as a whole to increase the scale of our ambition for the environment, and achieve greater impact. Society not only needs it, but is increasingly demanding it. The Woodland Trust will play its part. We will be raising our voice to protect the trees we have, which is crucial to tackle climate change and the nature crisis; we'll inspire and mobilise communities to stand up for trees in their area; and we'll ensure the Government recognises the value of native trees and natural regeneration.

Our recommendations for national and local governments are laid out in our recently released Emergency Tree Plan. In this, we challenge and inspire action to deliver effective and timely tree-based climate mitigation that is good for people and nature. We all need to make decisions about how and where we expand tree cover, and this issue of Wood Wise explains the science that can inform such decisions. Experts discuss how much more woodland cover we need, why native trees are best, and how to maximise the value of new woodland for biodiversity and society. In short: how to increase tree cover to address the nature and climate emergencies together.

Wherever you are when reading this, I hope that you are safe and well.

Dr Darren Moorcroft joined the Woodland Trust as director of estates and woodland outreach in 2017, and took over as chief executive in 2019.

Tree cover targets to tackle greenhouse gases

Piers Forster, Catherine Scott, Dominick Spracklen

Tree planting targets seem all the rage these days. From election manifestos to newspapers pledging to plant trees, everyone's at it. We discuss the climate science behind such targets. In particular, we look at how we use science to relate the international need to limit global warming, to the UK 2050 net-zero emissions target that includes strong UK action on woodland creation.

Prof Piers Forster (top), Dr Catherine Scott (centre) and Prof Dominick Spracklen (bottom) are researchers at the University of Leeds, researching aspects of climate and the role of forests. They contribute to Intergovernmental Panel on Climate Change (IPCC) reports on the state of the science. Piers additionally serves as science member on the UK Committee on Climate Change.

Climate targets in the Paris Agreement

After the successful Conference of the Parties (COP) meeting in Paris at the end of 2015, every country in the world, including North Korea and Syria, accepted the Paris agreement climate targets, detailed in Articles 2 and 4. Article 2 aims to limit warming to well below 2°C above pre-industrial levels and pursue efforts to limit it to 1.5°C. Article 4 tells us how: by achieving "a balance between anthropogenic emission by sources and removal by sinks of greenhouse gases"[1].

The Paris meeting also tasked scientists of the Intergovernmental Panel on Climate Change (IPCC) to look at the feasibility of the 1.5°C target, which is only around 0.5°C more warming than levels today, and the impacts that would be avoided if global society managed to achieve it. The IPCC published the Special Report on Global Warming of 1.5°C (IPCC SR1.5) in October 2018[2] and the nascent science was clear: 1.5°C was still within reach if countries around the world pulled out all the stops to halve carbon dioxide (CO_2) emissions in the next 10 years and reduce emissions to zero by the middle of the century. Further, it is well worth it – especially for biodiversity. For example, 2°C would wipe out virtually all warm-water corals, but at 1.5°C many would survive.

But how do we go zero? It is hard to get flying, farming and parts of heavy industry to zero emissions; therefore, the hypothetical pathways to limit warming to 1.5°C rely on increasing the capacity for CO_2 to be taken out of the air by enhancing 'carbon sinks', as well as reducing the emission sources. Hence, these imagined futures became known as net-zero CO_2 pathways, where residual emissions that could not be reduced further by the middle of the century are being offset by CO_2 removal.

John Oakley / Restoring Hardknott Forest

Natural regeneration can be an effective way of creating new native woodlands

The degree of this necessary removal of CO_2 is substantial – over 10 billion tonnes a year – equivalent to double the emissions from the USA in many global pathways. In these speculative future pathways, this need is met by a combination of woodland creation and growing energy crops for 'bioenergy with carbon capture and storage' (BECCS). In BECCS, CO_2 is captured from the flue gases of a bioenergy power station and stored in geological reservoirs. BECCS currently only exists in limited trials. One of these trials, the first of its kind, is happening at Drax, where a University of Leeds spin-out company (C-Capture) is capturing up to one tonne of CO_2 per day[3].

The global picture

The hypothetical global future pathways that successfully limit warming to below 1.5°C use tree planting, natural forest regeneration and BECCS in varying proportions to achieve substantial amounts of carbon removal. Stopping tropical deforestation is absolutely crucial: clearing tropical forests accounts for 10% of global CO_2 emissions, and every bit of cleared forest is land that can't remove CO_2 in the future. The amount of carbon removal needed depends upon how much reduction can be achieved across other sectors of the economy, but all the global pathways rely on taking CO_2 out of the air to some extent.

Achieving this level of CO_2 removal will require big changes to the way we use land. The scale is huge. In the future pathways laid out in the IPCC SR1.5 report, forest and energy-crop cover was increased by an area over three times the size of India, typically replacing one third of the world's pasture land. No mean feat. Is such a global large-scale change really feasible, and what would be the consequences for food production, biodiversity and water supplies?

A further IPCC Special Report, on climate change and land, was published in 2019[4]. This looked at the issue in more detail, examining how new forests, forest restoration, BECCS, biochar added to soils, and peatland restoration, could all contribute to removing CO_2. The report also examined the knock-on effects for food production, clean water, biodiversity and livelihoods, concluding that forest restoration and new forests were the most sustainable and scalable of all the CO_2 removal methods. But even for these methods, trying to remove more than 10 billion tonnes of CO_2 annually could increase food prices by up to 80%.

The IPCC reports tell us that trees are among the world's best bet for sustainably removing CO_2 from the atmosphere, but realistically there is a limit to their offsetting ability – around 20% of current emissions from energy production, transport and industry. However many trees we plant, to reach net-zero we must drastically and rapidly reduce our emissions from other sectors. The reports also show that creating woodland in a sustainable way, using native species, with community stakeholders and control over illegal logging, can improve food security, biodiversity, air quality and livelihoods.


Laurie Campbell/WTML

Woodland creation in the UK net-zero target

Following the IPCC reports, the UK Committee on Climate Change (CCC) updated its advice for UK-wide emission reductions, recommending the Government adopts a 2050 net-zero greenhouse gas emissions target. This was based on new evidence on climate impacts, on the capability of sectors to decarbonise and on cost estimates for the price of low-carbon transitions. Theresa May's government signed this target into law during her last days in office.

> **By 2050, woods and hedgerows could be capturing up to 20 million tonnes of CO_2 annually**

Every sector of the economy needs to try its best to reduce emissions. The CCC thought most could get to near-zero emissions by 2050, but farming and flying will always struggle, so new woodland will be needed to achieve an overall net-zero emission level. From interviewing organisations around the UK, a target of 30,000–50,000 hectares of new woodland per year until 2050 was settled on. This would increase UK woodland cover from 13% to over 19%. By 2050, these new woods and hedgerows, combined with better woodland management and agroforestry, could be capturing up to 20 million tonnes of CO_2 annually: around 5% of the UK's current greenhouse gas emissions. The committee has already suggested some approaches to achieve this uplift in woodland cover in its land use policy report[5], combining novel private-funding mechanisms to get large amounts of woodland creation, and direct government funding to support smaller areas of woodland creation.

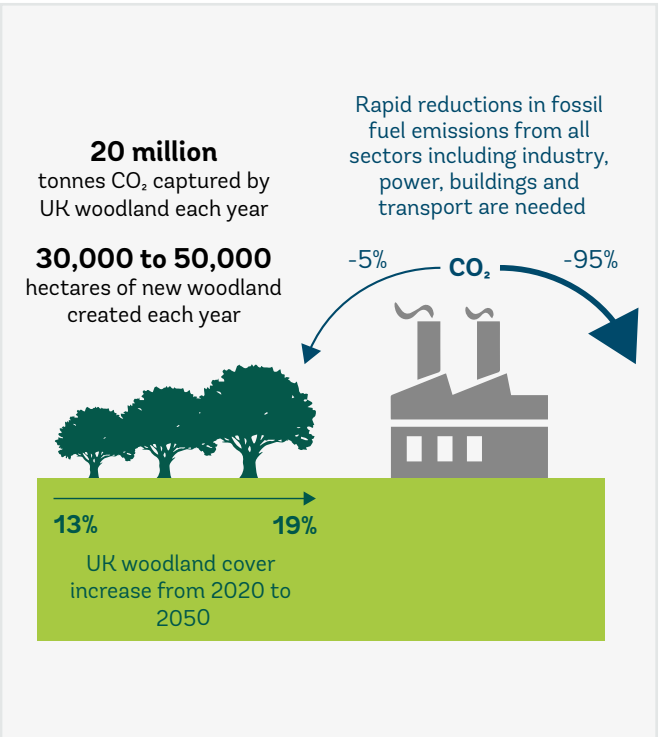
As presented very clearly in the Woodland Trust's Emergency Tree Plan[6], preserving existing large trees and encouraging woodland regeneration are among the best approaches to capturing carbon. The right sort of tree planting can also bring many co-benefits: trees in urban areas benefit air quality and our well-being; trees in the uplands help flood alleviation; native trees in particular support biodiversity.

Accounting and offsetting

The CCC is rightly cautious about using international offsetting to reduce our national emissions. Verifying the credibility of such trade is currently an issue. Further, in a world where every country is trying to reach net-zero emissions, few would be prepared to take its own forests out of its carbon accounting for the UK to use it in theirs, which would make offsetting an expensive option. Problems around double counting and verification abound with such schemes, and trying to negotiate a credible offset scheme as part of Article 6 of the Paris agreement led to the failure of the UN COP meeting in Madrid in December 2019; countries could simply not agree.

There is confusion about fast and slow-growing trees and their ability to draw carbon from the atmosphere. It is the forest as a whole, including its soil, which provides the long-term storage, and not necessarily individual trees. A slow-growing woodland can, in the long-term, provide more carbon storage in the trees and soil than fast-growing plantations. But there are nuances to this argument[7]. For example, using wood for building is a good example of semi-permanent carbon storage. We need to make sure that the rush to remove carbon doesn't bias future woodland creation plans to fast-growing plantations, which provide less public benefit. Ancient woodlands store the greatest amount of carbon, so protecting these special woodlands is crucial[8,9].

Reforesting and restoring woodland in the tropics, where the warm-year-round climate makes trees grow fast, removes carbon more quickly than growing trees in the UK. But until a robust, verifiable mechanism exists, we need to take care of our own domestic carbon account. There are many competing interests on every hectare of land in the UK, so a robust and verifiable domestic offset scheme could be a useful way to connect those with an ability to plant, to those with an ability to pay. For example, the CCC land-use policy report suggested that fossil fuel producers or airlines could be compelled to support woodland creation through a contract auction mechanism or emission trading scheme.



Potential contribution of UK woodlands towards achieving net-zero emissions by 2050

Ancient woodlands are large carbon stores and their protection is vital

Who claims the benefits provided by these extra trees is becoming a real issue and needs clarifying. Many organisations up and down the country are making use of what are effectively the same trees in their own net-zero targets. For example, the National Farmers' Union has adopted a net-zero 2040 target that implies extensive tree planting on agricultural land. The same trees are probably being used for the net-zero plans of the National Trust, our own University and many other organisations that are considering CO_2 removal as part of their net-zero emission plans.

The UK aviation sector could swallow up the offsetting potential of all this new woodland overnight and still need more. We have to ask ourselves as a society, should we let it? Or, is it better to put more pressure on the sector to decarbonise or reduce the demand for flying?

We need to start now

There are many important issues here that require a national conversation, but we also need to get started. The UK needs more tree cover to meet its net-zero 2050 target. To achieve this we must increase our native tree-nursery capability and plant and protect trees everywhere we can. Done the right way, increased tree cover will bring many benefits for biodiversity, health and wellbeing, air quality, and flood alleviation. While we work out who pays and who gets the credit, organisations such as the Woodland Trust are just getting on and doing. This is exactly what we need to make the UK's net-zero ambitions a reality.

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3. climate.leeds.ac.uk/news/innovative-technology-from-leeds-in-uk-carbon-capture-pilot/
4. ipcc.ch/srccl/
5. theccc.org.uk/publication/land-use-policies-for-a-net-zero-uk/
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Native trees for biodiversity

Jeanette Hall, Richard Ennos, Joan Cottrell and David O'Brien

Jeanette Hall is a woodland ecologist working at Scottish Natural Heritage. Her interests include conservation genetics and the control of invasive non-native species.

Prof Richard Ennos is an Honorary Professorial Fellow at the University of Edinburgh with research interests in both forest genetic resources and forest pathology.

Dr Joan Cottrell leads the Gene, Species and Habitat Conservation Programme at Forest Research. Her research focuses on the genetics of trees and associated woodland species.

David O'Brien is Biodiversity Evidence and Reporting Manager at Scottish Natural Heritage. His research includes work on conservation genetics and on the biodiversity of anthropogenic ecosystems.

Planting trees can only be a first step to creating a woodland ecosystem, which depends not only on planting – or not planting – trees, but on what those trees are and how they are established and managed in the future.

The first consideration should be whether to plant at all. Generally, where the aim is native woodland expansion for biodiversity conservation, natural regeneration should be the default option. It produces a more diverse structure, with better matching of species to soil and topography. It also benefits from the genetic adaptation to site conditions that has occurred in previous generations of trees grown in the area. Moreover, compared to the limited number of young trees used to establish a plantation, natural regeneration regularly offers large cohorts of seedlings which provide the raw material for adaptation to climate change. This approach also carries less risk of spreading diseases than moving planting stock around, which could potentially carry novel pests and diseases.

Planting is, however, essential to create new woodland far from a seed source, as natural regeneration is not a possibility. Planting may also be used to increase the diversity of existing woodlands (known as 'enrichment planting'). Naturally regenerated woodlands can benefit from enrichment planting as they are often dominated by only a few species, typically those with abundant seeds which are efficiently dispersed by wind (birch and willow) or birds (rowan and hawthorn), and which are able to


Lorne Gill/SNH

germinate and grow rapidly. Many species only produce seed during intermittent mast years (oak and beech), or regenerate largely by vegetative means (in different parts of the UK, this includes lime, elm and aspen). Additionally, past management or heavy grazing may have reduced the diversity of trees present in the area. When choosing 'missing' species, useful pointers come from species' inventories in areas of the woodland inaccessible to grazing animals or felling, such as rocky outcrops or steep streamsides. Data from nearby woods on similar soils, or the floristic tables in the National Vegetation Classification, can also be a useful guide.

Creating new, diverse woodlands and enrichment planting in existing woodlands is important, as biodiversity generally increases with greater tree and shrub diversity, and diverse woodlands are more resilient to disturbance and environmental change. Species-rich ecosystems are less vulnerable to damage because pressures, such as the introduction of a novel pest or pathogen or a discrete, extreme weather event, tend to affect species differently.

Implications of introducing non-native trees

Whilst woodland creation for biodiversity conservation has generally used native species appropriate to the site, it has recently been proposed that increasing diversity by adding non-native tree species might increase native woodland resilience[1]. The suggestion is that climate change, or pests and diseases, might lead to conditions becoming unsuitable for native species, and that the introduction of new species will ensure the survival of woodland in the future. Trees with characteristics similar to those of native species ('functional analogues') might insure against loss of associated biodiversity in the event that native species experience catastrophic population declines.


Paul Sterry/WTML

Haws, widely distributed by birds

The assumptions behind these ideas, and the possible implications for native trees and woodland biodiversity, are evaluated in our recent paper[2] and summarised over the page, with particular focus on the risks environmental change poses to native trees, and whether introducing new species is likely to reduce the impact.

Ash tree showing symptoms of ash dieback

Non-native lodgepole pine killed by *Dothistroma* needle blight

Climate change and native tree species

Some analyses have reported that conditions in the UK will be 'marginal' or 'unsuitable' for a number of native species by 2080[3,4]. However, this work used the ecological site classification (ESC) model, which uses these terms in relation to commercial performance rather than ecological status. For example, sessile and pedunculate oaks are classified as 'marginal' under present climatic conditions in northwest England, although they are dominant components of many native woodlands in that region, supporting substantial associated biodiversity and regenerating successfully. For conservation purposes, it is more important to know whether the climatic conditions trees might experience in the UK's future are within their climate envelope (the limits they currently deal with across their entire range).

For almost all of the UK's native tree species, the projected climates at their current sites in 2080 remain well within their present climate envelopes. Indeed, the potential ranges of some species currently limited by low temperatures in the UK – for example, small-leaved lime and hornbeam – are predicted to expand. This is because many tree species are at the northern edges of their distributions in the UK and all (except extreme boreal species such as dwarf birch) could accommodate climate changes projected for 2080.

Disease and native species

While new pests and pathogens are a major concern for our native tree species, there is room for cautious optimism. Few (if any) diseases have led to the complete loss of any tree species as some resistance is present in most populations. For example, a recent study on ash-dieback infected stands across Europe found a minimum recorded survival of 18% among naturally regenerated ash saplings[5]. Work by the John Innes Centre in Norfolk has found substantial healthy ash regeneration in areas where the inoculum load of the fungus is very high[6]. In addition, a recent Danish study[7] found that trees with low susceptibility to ash dieback had higher reproductive fitness than highly susceptible trees. Females with less crown damage produced more seeds, and males with less damage were more effective pollen donors. Rather than considering the replacement of ash, a better strategy is to manage woodlands to encourage ash to regenerate freely to promote the evolution of a resistant population.

Functional analogues

There are considerable difficulties with the concept of 'functionally equivalent' species that are not closely related to the target species. A distantly related species may appear to occupy the same physical niche as a native species but is highly unlikely to offer a similar combination

of traits, such as bark pH and roughness (essential to epiphytes like lichens and bryophytes), litter and nutrient cycling, or shade regime, which affect the ground flora. It is also unlikely to harbour the same community of co-adapted organisms, such as endophytes or epiphytes, or soil microbiota. This means it will not be an effective ecological substitute.

Impact of non-native species

Perhaps the most important consideration is the potential impact of non-native species on existing tree species and wider biodiversity. Four of the 18 worst invasive terrestrial plants in Europe are trees, which affect decomposition rates, plant community composition and a range of ecosystem functions. The UK has fewer native trees and shrubs than the nearby continent and fewer shade-tolerant species, especially further north. The UK's woodlands are therefore particularly prone to invasion and damage by shade-tolerant tree species whose presence can completely change the woodland's character – as demonstrated by the impacts of shade-tolerant beech, Douglas fir and western hemlock in Scottish broadleaved woodlands. Increased shade excludes much of the ground flora, and even relatively shade-tolerant native tree species (such as rowan and hazel) cannot regenerate under the canopy, with knock-on effects for other species such as epiphytic lichens.

Another potential threat from closely related species is hybridisation. For example, in Scotland and northern England, 25–30% of mature crab apple trees growing in the wild or planted in hedgerows are hybrids, with pure populations restricted to more isolated upland areas[8]. Since genetic variation can be related to wider biodiversity, this can have serious implications. For example, variation in aspen genotype affects lichen epiphyte community composition[9].

Non-native trees may also increase risks from pests and diseases. Overwhelming global evidence shows they are almost always colonised by pests and pathogens from their native range. If the non-native tree is closely related to a native, the new pathogen is likely to affect the native species too. In the UK, widespread planting of Corsican and lodgepole pine has led to the introduction of a new race of *Dothistroma* needle blight, which is now infecting native Scots pine. Fortunately, its impact seems to be low, except where Scots pine is growing with the introduced species. Lodgepole pine is now being removed from the vicinity of native pinewoods to reduce the inoculum load. Similarly, in the Ukraine and European Russia, emerald ash borer only infested European ash, ***Fraxinus excelsior***, when it was growing near introduced green ash, *F. pennsylvanica*[10]. If the non-native species is more resistant to a pathogen, the impact of the disease on natives might be exacerbated by competition and compromise their ability to develop resistance.

Key points

- Where biodiversity conservation is a significant objective, native tree species remain the best option.
- The productivity of native British tree species is likely to change over the next century in response to climate change, but it is very unlikely that the environment will become unsuitable for any of them.
- Although it has been suggested that introducing new species will increase the resilience of native woodlands in the face of environmental change, the evidence shows the opposite. Non-native tree species can decrease the resilience of native woodlands to pests and pathogens, may outcompete native tree species and are unlikely to support the same biodiversity.

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John MacPherson/WTML

Understanding the biodiversity benefits of woodland creation

Kirsty Park, Elisa Fuentes-Montemayor, Robin Whytock, Kevin Watts

Increasing tree cover is at the forefront of the environmental agenda to mitigate the current climate and biodiversity crises. In order to maximise the environmental benefits accrued by reforestation, planting policies must ensure quality as well as quantity of new tree cover. Planting 'the right tree in the right place' is vital to ensure sustained benefits. The WrEN project uses a natural experiment approach to assess the long-term effects of past woodland creation on current biodiversity to inform future reforestation actions.

Prof Kirsty Park is an applied ecologist interested in the effects of anthropogenic change on biodiversity and developing solutions to mitigate the impacts of humans on wildlife.

Dr Elisa Fuentes-Montemayor is an ecologist and conservation biologist investigating the impacts of anthropogenic disturbances and the effectiveness of conservation actions for biodiversity.

Dr Robin Whytock is an ecologist interested in understanding how forest biodiversity responds to environmental change and developing new technology for monitoring ecosystem health.

Dr Kevin Watts is an applied landscape ecologist focused on understanding the impacts of land use and climate change on the biodiversity and resilience of wooded landscapes.

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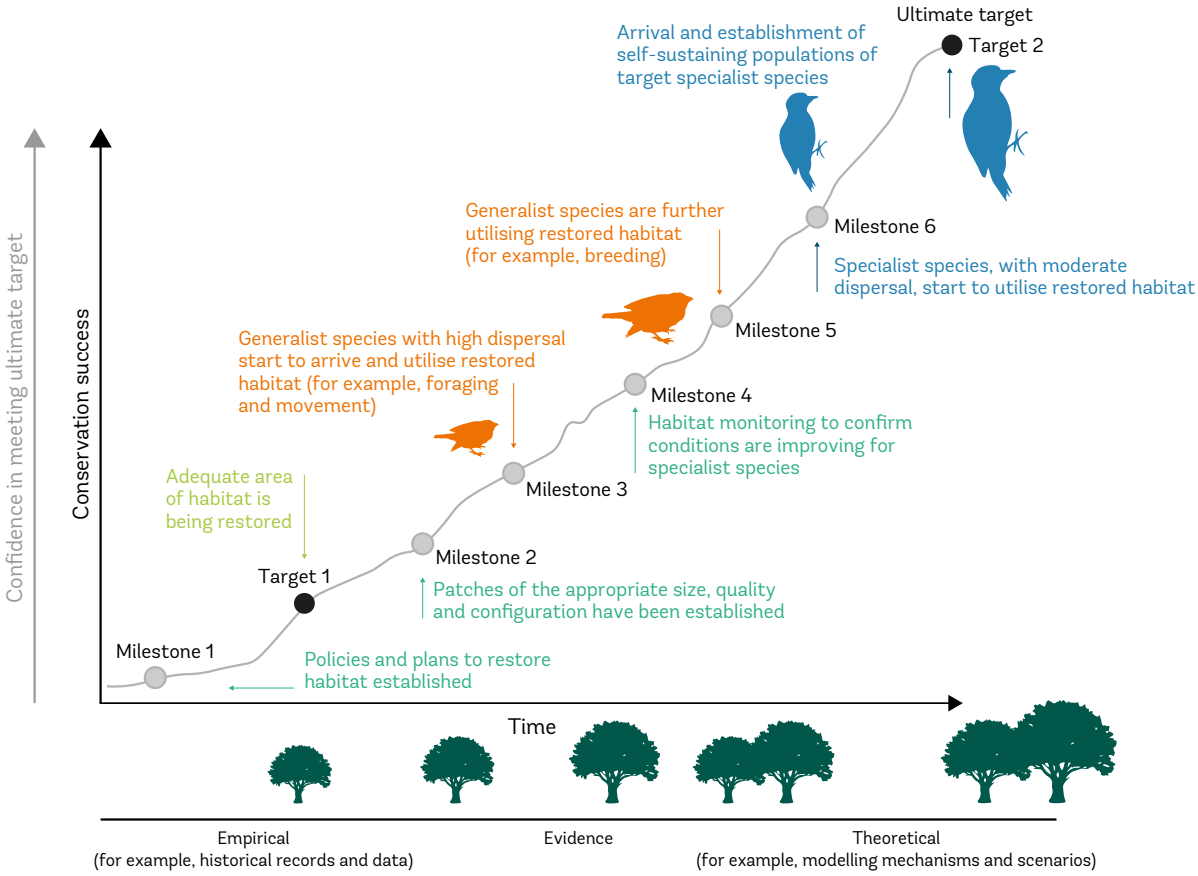

Figure 1. Schematic representing the journey towards conservation success. Reproduced from Watts et al[3]

A move towards ecosystem restoration

As we enter the United Nations' decade on Ecosystem Restoration[1], which aims to massively scale up the restoration of degraded and destroyed ecosystems, woodland expansion is high on the political agenda. For example, in England, the Government's 25-Year Environment Plan outlines a commitment to plant 11 million trees from 2017 to 2022[2]. This provides an important opportunity to counter a long history of woodland loss and fragmentation in the UK and arrest associated wildlife declines. New woods and trees will provide habitats for wildlife and restore and enhance our biodiversity. The restoration of ecological functions and sequestration and storage of carbon to mitigate climate change are further benefits derived from woodlands.

However, it can be challenging to assess the effectiveness of habitat-creation approaches, especially for woodlands, as there is often a significant time lag between the habitat creation and the response of target species. This lag, where species gradually respond through time, is often referred to as a 'colonisation credit'. In contrast, an 'extinction debt' portrays the gradual decline of species after a negative disturbance such as habitat loss or degradation. Colonisation credits and extinction debts have been observed in a wide range of species (including plants, invertebrates, vertebrates, fungi and lichens) and habitats (such as grasslands, temperate forests, tropical forests and urban ecosystems) and operate on timescales from decades to millennia.

Ecological time lags and conservation success

Conservation scientists increasingly acknowledge time lags as important drivers of ecological communities, though these have not been explicitly translated into conservation policy and practice.

In the UK and other temperate countries, woodland extent has begun to increase over recent decades, partly as a result of large-scale planting schemes. However, it would appear that previous conservation efforts to reverse biodiversity declines are not meeting targets, despite decades of action. In fact, many woodland species, particularly those strongly dependent on this habitat, are still declining.

But, could it be that delays between woodland creation and species' responses – an 'ecological time lag' – are partly masking progress? We need to consider realistic timescales when setting targets and identify suitable milestones to monitor progress towards conservation success (see figure 1)[3]. However, urgent action is required to address the current biodiversity and climate crises, so time is not a luxury we have; we cannot simply 'wait and see' which conservation measures work and which ones fail. It's vitally important that we are able to distinguish between cases in which conservation actions are on track to achieve success but need more time for benefits to be realised, and those in which actions are simply insufficient or inappropriate.

Learning from the past

Woodland Creation and Ecological Networks, the WrEN project, aims to assess the effects of past landscape changes on the flora and fauna found in the woodlands today[4]. WrEN uses a 'natural experiment' approach, which has the potential to overcome some of the challenges of landscape-scale studies. Rather than carrying out direct experimental manipulation of a site or landscape, natural experiments overlay an experimental design on an ecosystem where change or active manipulation has occurred or is planned, beyond the control of the researcher.

The WrEN project makes use of woodland expansion in the UK that has occurred over the past 150 years from an all-time historical low. While much of this is non-native conifer plantations, a substantial amount consists of native woodlands. This has inadvertently produced test landscapes containing patches of woodland of varying age, size, shape and spatial configuration.

In addition, because the UK has very good historical land-cover maps, now available in digital format, we can usually estimate to within a few decades when a patch of woodland became established. This enables us to distinguish 'new' woodlands from fragments of older woodlands – an important consideration for studying the effects of creating habitat, as opposed to legacy effects following habitat loss and fragmentation.

These two ingredients – woodland habitat that has been created at various points in the past in a variety of configurations, and the ability to date when this happened – give us the starting point for our restoration 'experiment'. The WrEN project is using this opportunity to discover which attributes of newly created woodlands (and the landscapes around them) are associated with successful colonisation and establishment of a wide range of woodland species.

Woodland biodiversity making a comeback

There are now over 100 woodlands in the WrEN project network, ranging from 11 to 160 years old (at time of initial survey). Wildlife surveys started in 2013, and more than 2,000 species have been recorded so far, encompassing vascular plants, lichens and bryophytes, ground-dwelling and flying invertebrates, small mammals, bats and birds. Work is still ongoing; just last year camera traps began gathering information on mammals that use these sites, including badgers, foxes, red and grey squirrels, rabbits, hares and red and roe deer.

A key challenge is examining species' responses to the local and landscape-scale attributes of interest, such as the age of the woodland, vegetation structure and connectivity in the wider landscape. Results to date demonstrate how animals and plants respond differently to conservation actions depending on how specific their habitat requirements are and their ability to move through the landscape. For example, increasing the amount of

woodland in a landscape would be a valuable conservation strategy for highly mobile species, such as Natterer's bats, while less mobile species, such as brown long-eared bats, would benefit from targeted planting to improve woodland connectivity as they are less likely to cross open spaces[5].

At the local scale, increasing woodland patch size is a key priority action to enhance bird species richness[6], and woodland quality has the strongest influence on less mobile species. In particular, having trees of many different sizes benefits numerous taxa, including hoverflies and small mammals. There is also evidence that woodlands improve over time for some species: bank voles and wood mice are more abundant in older woodlands with larger amounts of deadwood for instance. Furthermore, livestock in woodlands can have a strong negative impact on small mammals and birds. Much more information is available on the WrEN website (wren-project.com), and there's a lot more to do.

Informing conservation action and policy

It is important that these findings are of practical use, thus WrEN is a collaboration of academics, policy makers and practitioners. Importantly, this project quantifies the relative importance of alternative management actions (for example increasing habitat quality at a local scale versus improving connectivity in the landscape), as this will enable recommendations to be made on priority actions for future planting schemes. Responses across taxa will also be examined to try to understand where the synergies might lie and where action for one group could be detrimental to another. In the current drive for increased woodland creation, it is more important than ever that the right mix of trees is planted (or natural regeneration facilitated) in the right places to ensure the multiple benefits we need from our landscapes in the future.

Conservation can and does work, but it often takes time. It is hoped that the WrEN approach – of learning from the past to predict the future – will provide much-needed evidence to inform current and future conservation actions. This is essential to meet international commitments to halt biodiversity declines and maximise the benefits of woodland creation.

M & J Bloomfield/ALAMY

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Taking a natural capital approach

Rebecca McIlhiney

In the current context of delivering net-zero greenhouse gas emissions and combating biodiversity declines, never has it been more important to focus on the overall objective of improving the environment. However, while biodiversity and carbon benefits will accompany environmental improvement, they should not be the only objective. Each natural capital asset should be maintained and enhanced to deliver multiple benefits.

Rebecca McIlhiney is the lead science adviser in the Natural Capital Committee Secretariat and a member of the Woodland Trust's conservation advisory committee.

The natural capital approach

Natural capital is that part of nature which directly or indirectly underpins value to people, including ecosystems, species, fresh water, soils, minerals, the air and oceans, as well as natural processes and functions. Natural capital forms part of our wealth; that is our ability to produce actual or potential goods and services into the future to support our wellbeing[1].

The Natural Capital Committee (NCC) focuses on securing the stock of assets (species, ecological communities, soils, fresh waters, land, atmosphere, minerals, sub-soil, oceans and coasts) so they can provide sustainable 'flows' or benefits (pollination, carbon sequestration, protection from flooding, etc.). It's important to recognise that degraded assets can still deliver a multitude of flows/benefits; therefore, focusing on flows will not illustrate when assets are being used unsustainably or when they are reaching a critical threshold where they move from being a renewable to non-renewable resource.

To use woods and trees as an example, values have been placed on various benefits, such as timber, carbon stock and recreation opportunities[2]. However, there are other benefits of trees that have unknown values – they provide habitats that support complex systems of species, clean the air, hold back water flows, improve soil structure and much more.

A natural capital approach is fundamentally about considering all of the system-wide benefits and trade-offs when planning and delivering environmental improvements. The NCC advocates moving beyond what can be given a monetary value and into considering the whole system to decide what needs to be done. Considerations when creating a new woodland include the impacts on recreation, fresh water (flooding, filtration, flows), soil, wildlife, air, etc.

How to do it

The NCC has created a framework which sets out four steps needed for a natural capital approach[3]. This was developed in response to the Government's 2011 commitment *"to be the first generation to leave the environment in a better state than it inherited it[4]."* Achieving this bold ambition is going to require both the maintenance of natural capital assets and major efforts to improve them.

Step 1. Create a plan

The Government's 25-Year Environment Plan[5] (25-YEP) is the result of NCC advice and delivers step one of the framework. A natural capital approach is critical to ensuring this plan is carried out in a way which maximises the benefits while minimising costs and properly considering the trade-offs. To deliver this plan effectively, firstly, the plan must be placed on a statutory footing with legally binding targets in the upcoming Environment Bill[6]. A suite of targets will be required to ensure that each asset is being used sustainably. Secondly, delivery of the plan and targets needs overall coordination – the current approach involving several departments and agencies will fail to deliver, possibly leading to even further degradation of the environment.

Step 2. Set a baseline

An environmental baseline census is essential to report the extent and condition of all natural capital assets; the NCC has provided detailed advice on how to deliver this[7]. Without this baseline, reporting progress against the plan (assessing whether the natural environment is improving) is not possible. This was highlighted by the Government's 25-Year Environment Plan Progress Report[8] which provided a very limited assessment and demonstrated that the existing metrics and Defra's Indicator Framework[9] do not provide a baseline against which progress can be measured[10]. Much of the existing environmental monitoring data could be used to create a baseline, as shown by the 25-YEP pioneer projects and the Ox-Cambs Arc.

Steps 3 and 4. Build the evidence and weigh up the options

These two steps involve using the baseline data to carry out mapping and modelling to identify the options for environmental/asset improvement. Models should consider all land uses and outcomes – for example, infrastructure and food production – as well as information on trade-offs and benefits. This analysis has yet to be carried out for the 25-YEP due to the lack of a baseline, but important lessons could be learnt from the natural capital pioneer projects.

Corporate natural capital accounts can be created at this point and valuations of natural capital conducted. This can be particularly useful for companies who own, manage or depend on natural capital, so the value gained from their assets is properly accounted for and they are maintained. However, much more work needs to be done on how to value natural capital before valuation can be used more effectively. For example, the Office for National Statistics (ONS) UK Environmental Accounts estimated in 2016 that the partial value of UK natural capital was £951 billion[11], which - when compared to the housing stock (at £7.3 trillion in 2019[12]) - is disappointingly small.

Luke Moseley/WTML

A natural capital approach to trees

To follow a natural capital approach, plans to increase tree cover should not be viewed in isolation. The latest advice from the Climate Change Committee recommends that 30,000ha of new woodland is created every year until 2050 (that's 90–120 million trees per year, depending on planting density)[13]. However, increasing tree cover solely for carbon benefit is a siloed approach and fails to consider the whole system, risking trading-off functioning ecosystems to achieve a single objective. Consider, for example, a scenario where lower carbon habitats such as species-rich grasslands are lost through conversion to woodland in favour of carbon capture.

There are multiple pressures and uses for land which must be considered before deciding on local planting targets. Without such an approach, food production, environmental improvement (including specific species' requirements), infrastructure and biofuel production will come into conflict. Failure to recognise the benefits, costs and co-dependencies is likely to repeat past failures of land-use policy, especially agricultural policy.

Any plan for trees should also consider the maintenance of the existing stock. Without serious investment, the stock of the asset (trees) and flows (such as carbon storage) are at risk. Losses of trees can occur due to disturbance events, such as pest and disease outbreaks or forest fires, and climate change is likely to exacerbate these.

Better data is needed for natural capital assets to undertake spatially aware decision making which considers all of the trade-offs and benefits to increasing tree cover. These benefits are numerous, including habitats for wildlife, places for recreation, improvements to people's wellbeing, carbon storage, flood protection, urban cooling, capturing pollutants and water filtration. However, there are many unknowns about how to optimise these benefits at various scales, in addition to meeting the landowners' objectives for increasing tree cover.

The spatial scale at which to assess the landscape and make decisions is one of the biggest challenges. The capacity and need of different farms, landscapes, counties, catchments and regions will be different. And the creation and delivery of national targets need to take this into account. For example, counties worst affected by the loss of ash trees outside woodlands to ash dieback (such as Leicestershire, Northamptonshire and Devon) would require more investment to maintain tree cover than counties with less ash.

Using a natural capital approach to increasing tree cover in light of the current biodiversity declines and changing climate has both benefits and drawbacks. It is not in doubt that both more trees and maintenance of existing trees is required, but where, how many and which species, are complicated questions to answer at a national level. The natural capital approach should be viewed as a framework to provide a decision-making tool on how to maximise benefits and limit trade-offs when expanding tree cover.

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For further advice from the Natural Capital Committee on using nature-based interventions to reach net-zero greenhouse gas emissions see: https://gov.uk/government/publications/a-natural-capital-approach-to-attaining-net-zero-nature-based-interventions

Alan Belton/WTML

Trees, please!

Christine Reid

Trees are in big demand as a nature-based solution to the climate crisis. The Woodland Trust's tree shop, community tree packs and MOREwoods scheme have never been more popular as all sorts of people want to do their bit to increase the UK's carbon suction power and help ailing wildlife. How we fit more trees in, and which ones are best, are the issues I explore here through the lens of the Woodland Trust's Emergency Tree Plan, which aims to challenge and inspire others to help address the climate and nature emergencies.

Are trees a good response?

Other articles in this issue demonstrate that – if 'done well' – an increase in woods and trees can benefit both people and wildlife by helping to tackle two of the most significant and related challenges of our time. These are the rapid and seemingly unrelenting declines in some of our best-loved wildlife and essential biodiversity[1], combined with the 'climate chaos' already in evidence.

Woodland creation can lock up carbon and provide renewable fuels and building materials, with slow growing trees under sustainably managed forest systems fixing more carbon over time than fast-growing plantations (*Tree cover targets to tackle greenhouse gases*, page 4).

Christine Reid is the principal conservation adviser for the Woodland Trust, and is keen to ensure woodland expansion for carbon also delivers great habitat for woodland wildlife and many benefits for people.

Paul Glendell/WTML

The Woodland Trust's free tree packs for local communities have never been more popular

Native trees for biodiversity explains the critical importance of native trees and shrubs for nature recovery, and the likely fortitude of our native trees in the face of climate change (page 8). The WrEN project outlined in *Understanding the biodiversity benefits of woodland creation*, on page 14, is informing woodland creation design by revealing which local and landscape-scale attributes of woods and trees are most beneficial for wildlife. And, finally, we mustn't forget the value of well-planned woods and trees for human livelihoods in cities and in the countryside, and the inextricable links between the two (*Taking a natural capital approach*, page 18).

So yes, trees are a great response to these twin crises; but, how many we need, what type they should be, and where they go, are key questions subject to much current debate, and tackled head on in our Emergency Tree Plan[2].

How much is enough?

The increase in the UK's woodland canopy cover from 13% to 19% required to achieve the Government's target of net zero emissions by 2050, equates to roughly 1.5 million hectares of additional woodland. Despite the undisputed evidence that trees have a major role to play in capturing unavoidable carbon emissions, last year just 13,390ha of new woodland was created in the UK, with only 1,420ha in England (see figure 1) – falling woefully short of the Government's target in 2018/19 of 5,000ha for England. At least a threefold increase in annual planting rates is urgently needed, and we propose how this can be shared among the devolved UK nations.

Crucially, any new targets and policies for woodland cover must take into account losses of existing trees. For example, ash dieback could cause the loss of approximately 150 million mature ash trees and two billion saplings and seedlings in the UK over the next 10 - 20 years. To avoid importing any more pests or diseases, UK nurseries will need time to build up stocks of trees sourced and grown in the UK.

Alongside new woodland, trees outside woods are an essential component of increasing tree cover. This includes trees in hedgerows, fields, river banks and roadsides. The UK needs dedicated separate targets for the additional expansion of tree cover outside woodlands to meet the needs of people and wildlife.

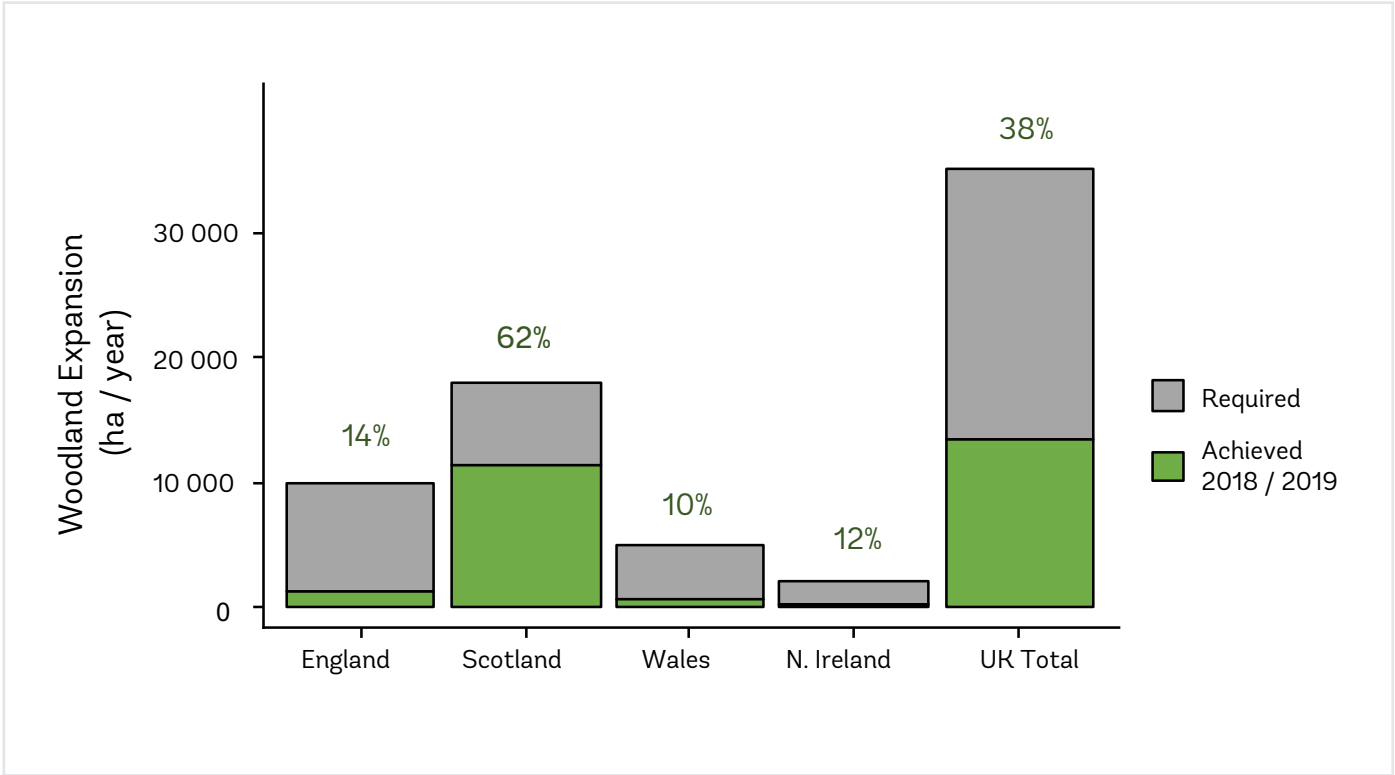


Figure 1. Average woodland expansion required each year until 2025 (grey), and that achieved through planting in 2018/2019 (green) for each region. Percentages represent the proportion of the requirement achieved in last year's planting season

Ash-dieback affected trees felled for safety reasons will require additional replacements

What mix do we need?

The majority of woodland and tree-cover expansion should be delivered with native woods and trees, due to the importance of tackling the nature and climate crises together. However, the UK needs significantly higher levels of all types of tree cover, including sustainable production-focused plantations, which will often be a mix of native and non-native tree species.

All trees capture carbon while they are growing. However, carbon also needs to be stored for long periods to avoid passing the climate change problem on to the next generation. The longevity of trees and woodland ecosystems is therefore vital. Some of the UK's native species, such as oak and yew, can live for over 1,000 years, effectively capturing and storing carbon for a millennium. There is also evidence that large, old trees and ancient forests fix significantly larger levels of carbon compared to smaller trees and younger forests. This is one of many reasons to protect and restore existing trees and ancient woodland alongside expansion plans.

Designing new woods solely for carbon capture is something we cannot afford to do. Much of the UK's woodland wildlife is entirely dependent on native woods and trees. For example, there are 2,300 species dependent on the two native oaks for at least part of their life, 326 of which are only found on oak, and a further 229 species rarely found on any tree species other than oak[3].

We need to ensure trees and woodlands are resilient to future projected local climate conditions. The evidence shows that the majority of native tree species hold a high proportion of genetic diversity[4]. If trees are supported to self-seed and spread, this can allow genetic mixing and the natural selection of the fittest, so each successive generation of trees become better adapted to changing climatic conditions. Natural regeneration, therefore, needs to play a much more central role in woodland expansion plans.

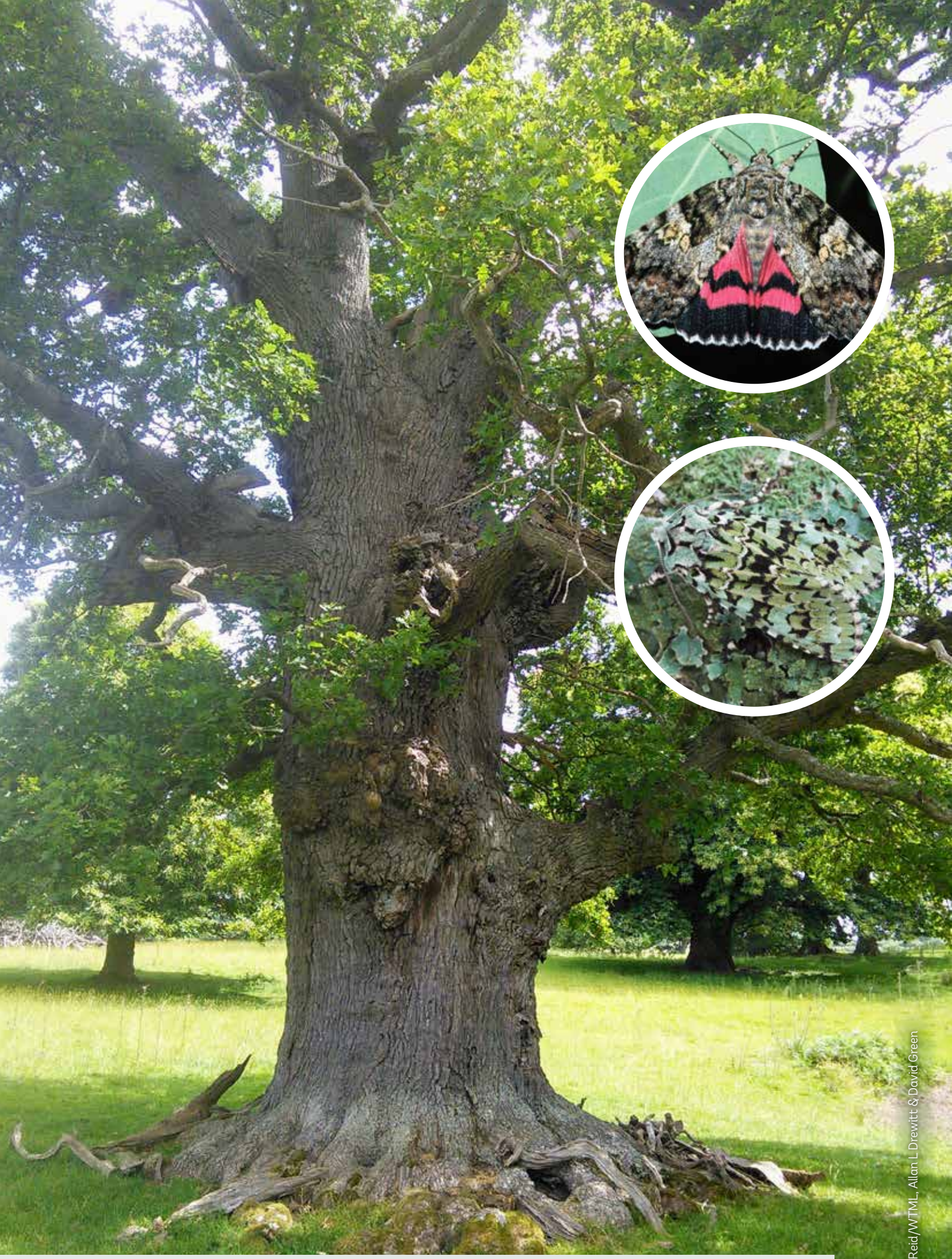
Extending the uses of native woodland (and other woodland types) through innovative products and market development will also help drive sustainable management and motivate expansion. These uses can lock carbon into long-lived construction materials, such as timber framing for housing and even cellulose products as a plastics alternative.

Where should new canopy cover go?

In short, new canopy cover should go in the places where it will deliver the most benefits – ideally multiple benefits for people and wildlife. A core principle for all expansion is that it should seek to maximise future wildlife value and not detrimentally affect any important local wildlife. The Woodland Trust is working with others to make best use of the plethora of botanical surveys and other wildlife records that are available for much of the UK.

Trees need space and on a small crowded island, this can be a challenge. We therefore need to integrate and overlap trees with other land uses. A promising option is agroforestry, where trees are integrated into productive farming systems to the benefit of crops, livestock, soils, water retention and wildlife.

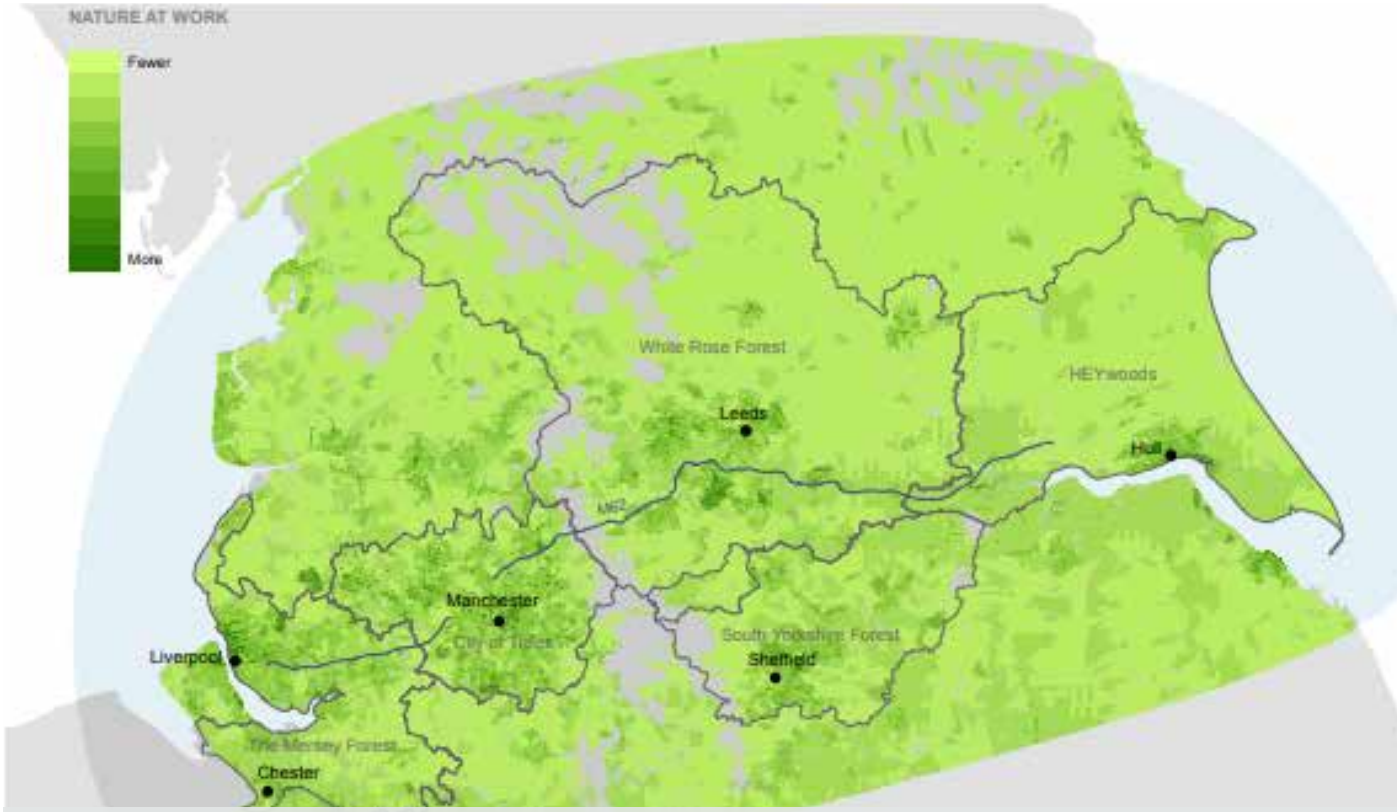
If we are going to make greater use of natural regeneration, then it follows that existing woodland will need to be able to spread outwards, buffering and extending surviving patches. This type of native woodland expansion follows the principles of landscape ecology set out in *Making Space for Nature*[5].



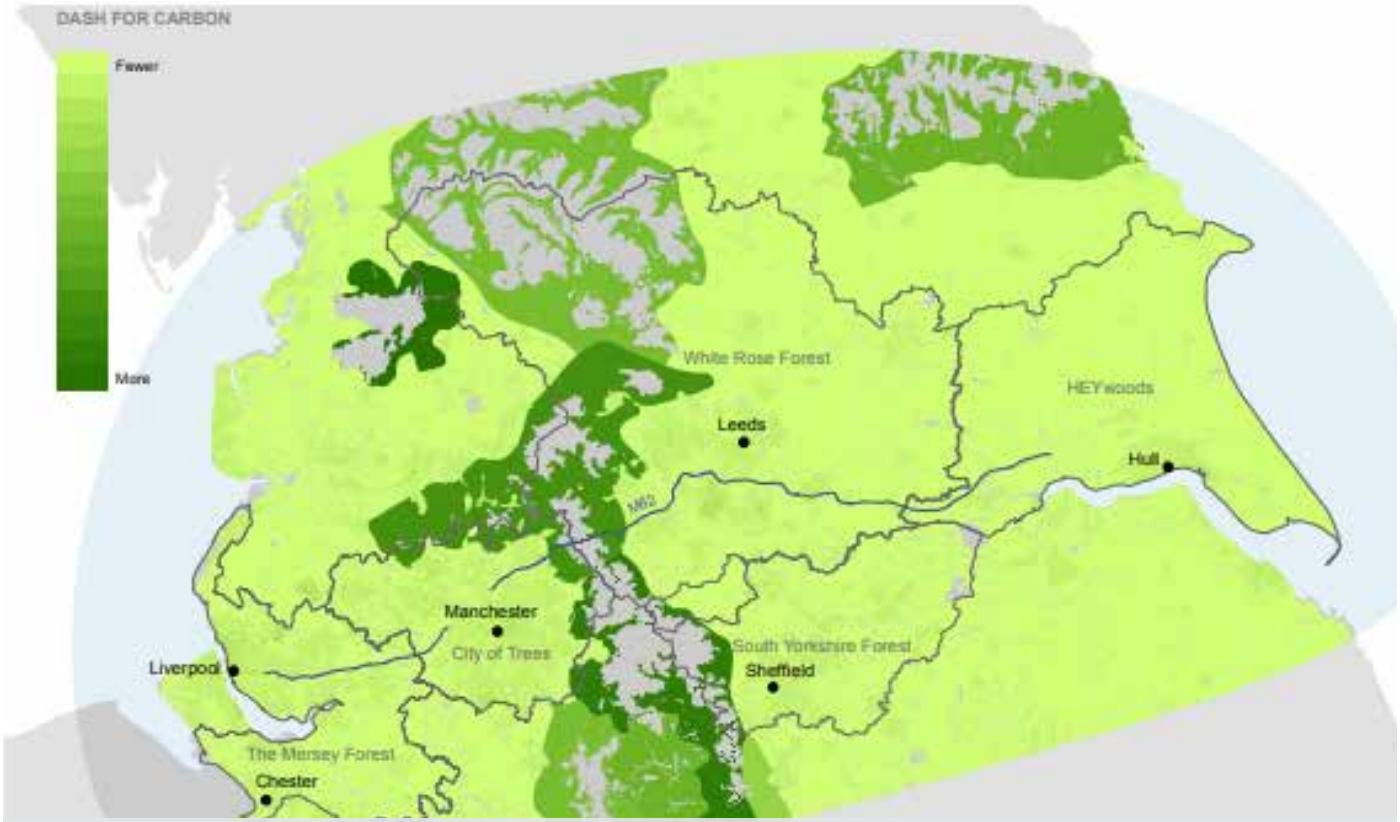
Spreading open grown oaks store carbon for hundreds of years as well as providing quality habitat for many species such as the dark-crimson underwing, ***Catocala sponsa*** (top), and scarce merveille du jour, ***Moma alpium*** (bottom)

Christine Reid/WTML, Allan L Drewitt & David Green

Two different models for tree cover expansion



The 'Nature@Work' scenario creates the same area of tree cover as the 'Dash for Carbon' but over a wider area, delivering both carbon sequestration and wider environmental and social benefits.



The 'Dash for Carbon' scenario creates a narrow corridor of fast-growing plantation in the Pennines to sequester carbon.

The Northern Forest: more trees, more benefits

The flagship Northern Forest partnership project provides a live illustration of decisions about where new trees and woodland can be established to realise multiple benefits. The project is aiming for a major expansion in tree-canopy cover over the next 25 years. Our research shows that the M62 corridor, urbanisation and the lack of woodland in the Pennines, will all act as significant barriers to the movement of wildlife in a changing climate. With 13 million people living in an area with a mere 7.6% woodland cover, the Trust wants to show how well-placed woods and trees can help wildlife, absorb millions of tonnes of carbon, reduce the risk of flooding, make people happier and healthier, and create thousands of new green jobs.

Modelling has shown the consequences of different approaches to delivering woodland creation targets in the Northern Forest (see illustrations). The two maps show how different priorities deliver quite different models of expansion. The 'Dash for Carbon' scenario prioritises establishing fast-growing plantations in the Pennines for rapid carbon sequestration. The 'Nature@ Work' scenario models how the same area of tree cover (created through planting at variable scales and densities of native woodland, trees outside woods, and commercial forestry) can deliver a far greater range of urgently needed outcomes, including carbon sequestration, a reduction in flood risk, improved health and wellbeing, and restoration of ecological networks for wildlife.

The tree panacea?

Trees have much to offer to help address the climate and nature crises. However, the detail really matters in terms of quantity, quality and geographical location. In themselves, they are not a panacea but should be seen as part of a more holistic approach to land use and management, which puts nature and people at its heart. The recommendations we propose in the Emergency Tree Plan focus on how trees can be better integrated into the diverse needs of society today and for the long term.

Download our Emergency Tree Plan at woodlandtrust.org.uk/publications/2020/01/emergency-tree-plan/

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Research update

Dr Christopher Nichols,
Conservation Evidence Manager

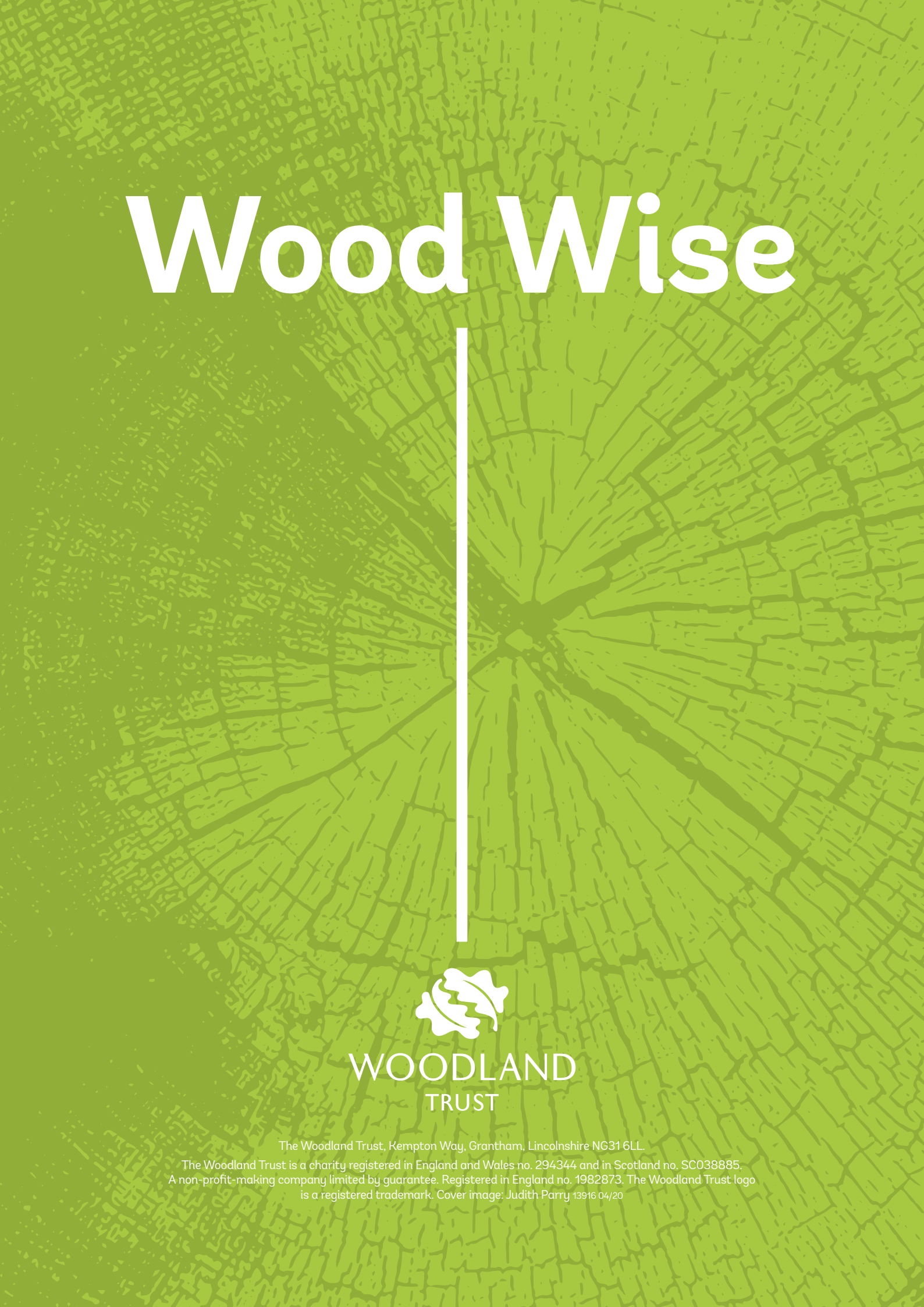
We're excited to welcome a number of new PhD students part-funded by the Woodland Trust.

Sam Hollick has recently started an agroforestry PhD at Bangor University. Sam will be investigating how best to use trees and hedges as shelterbelts to sustainably increase farm livestock productivity. Data will be collected using life-size model sheep containing sensors, and the results will be used to help plan where to put shelterbelts. Good news for landscape connectivity, wildlife, farmers and of course… the sheep.

Staying in Wales, Rebekah Bristow has recently started a PhD at Aberystwyth University. Rebekah will be researching the vulnerability of Welsh sessile oak woodland to insect outbreaks and herbivores under projected climate change through the 21st century.

We are also looking forward to the start of a new PhD project on the ecology and conservation of the blue ground beetle. An important species in ancient woodland ecosystems, it is the largest and one of the rarest species of ground beetle in the UK. It has a very restricted distribution, mostly in the south-west of England, and relatively little is known about its biology. The project is in collaboration with the University of Exeter, Natural England and Dartmoor National Parks Authority. We can't wait for it to get off the ground (beetle).

Wood Wise



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