REFORESTING BRITAIN

Why natural regeneration should be our default approach to woodland expansion

REWILDING BRITAIN

CONTENTS

Natural regeneration:
The regeneration of trees and woodland through natural processes (e.g. seed dispersal) as opposed to planting by people. It may be assisted by human intervention, such as by scarification or fencing to protect against wildlife damage or domestic animal grazing.

Cover image: Rich Atlantic oakwood in summer, Taynish National Nature Reserve
Photography: Peter Cairns/scotlandbigpicture.com

EXECUTIVE SUMMARY

Trees should be abundant in the British landscape, interspersed with meadows, scrub, wetlands, bog and other habitats. Instead, remnants of our rich rainforests and oak woods lie scattered. A mere 13% of the UK's total land area is forested compared to 40% in the Europe Union area and 46% across Europe as a whole. France, Germany, Spain and Italy each have more than 30% forest cover. Sweden and Finland have 69% and 74% respectively.

We need to increase our tree cover for many reasons. We need urgent action to address climate change and biodiversity loss. Expanding our woodlands is a vital part of that. Woody vegetation, and the soils beneath, absorb and lock away atmospheric carbon. Forests also help to reduce flood risk, slowing the flow to streams and rivers.

People (and lots of wildlife) love the dappled shade of trees on a hot summer's day and the shelter they provide from wind and rain. Most of our biodiversity is associated with intricate mosaics of trees, shrubs, wetlands and open grasslands. Trees give us fresh air, food and medicines. Dead and alive they're a home and food source for an unimaginable range of plants, animals and insects.

The need for a rapid upscaling of woodland creation raises the question of how this expansion should be achieved. This report explores the contribution that natural regeneration can make to improving and expanding natural forest and woodland habitats in Britain, as part of a broader rewilding agenda that delivers both climate and biodiversity benefits.

Woodland expansion

The evidence suggests that natural regeneration could massively increase the scale of forest and woodland expansion in Britain. Given sufficient seed sources and suitable site conditions, trees will plant themselves in their millions for free over as large an area of land as we are willing to spare.

Natural regeneration is not straightforward, however. The speed and type of establishment is unpredictable and depends on the interaction of multiple factors.

The exact trajectory of re-vegetation (in terms of species mix, location and density) is difficult to predict in advance. In some cases natural regeneration may require assistance to boost the colonisation process.

This includes areas where ground conditions are unsuitable, seed sources too distant or grazing too intense. In these circumstances, natural regeneration can come through interventions including scarification, direct seeding, grazing control or selective enrichment planting.

Tackling ecological and climate emergencies

Natural regeneration increases habitat diversity and complexity. This in turn increases opportunities for wildlife and biodiversity. Examples of natural regeneration in Britain have shown that many species benefit, including nightingales, short-eared owls and Bechstein's bats and an astonishing array of invertebrates, plants and fungi.

Diverse scrub habitats are a vital part of natural dynamic succession, acting as protection for young seedlings and cover for wide range of species. Natural regeneration can support the expansion of precious and diverse habitat types such as Britain's native temperate rainforests.

Natural regeneration can also be seen as a tool for tackling the climate emergency. Trees that grow through natural regeneration can better adapt to rapid climate change through long-distance genetic exchange via pollen and seeds. Although the factors are complex, evidence suggests that expanding naturally regenerating forests can make a significant contribution to mitigating climate heating in the longer-term through increased carbon sequestration.

It is important to recognise that in many parts of the world large-scale natural regeneration has occurred as a result of rapid land use change and abandonment. This can bring significant social, cultural and economic impacts for local communities, both positive and negative. Natural regeneration cannot therefore be considered in isolation but must be part of a process of integrated land use change that supports resilient communities as well as ecosystems.

Based on this evidence, Rewilding Britain is calling for:

1.

Support for natural regeneration as the default approach to woodland expansion

We propose a Three Step Natural Regeneration Hierarchy as a practical model for decision making. This should be part of a broader rewilding approach where species-rich mosaics of woodland, scrub and grassland habitats are allowed to regenerate over large landscapes. The hierarchy starts with natural regeneration as the default approach with tree planting as a support option where the natural regeneration of diverse habitats will not happen without it (see p22 for more).

Allow natural regeneration as a default approach unless trees and shrubs are unable to establish or would take too long to arrive (e.g. due to distant seed sources, impenetrable sward, continued over-grazing).

Kick-start the process by assisting natural regeneration. For example, through ground preparation, direct seeding, and grazing control.

Plant locally sourced tree saplings ("whips") only where still considered necessary, particularly where this positively engages local people and communities.

2.

Double woodland cover by 2030 for the benefit of people, nature and climate

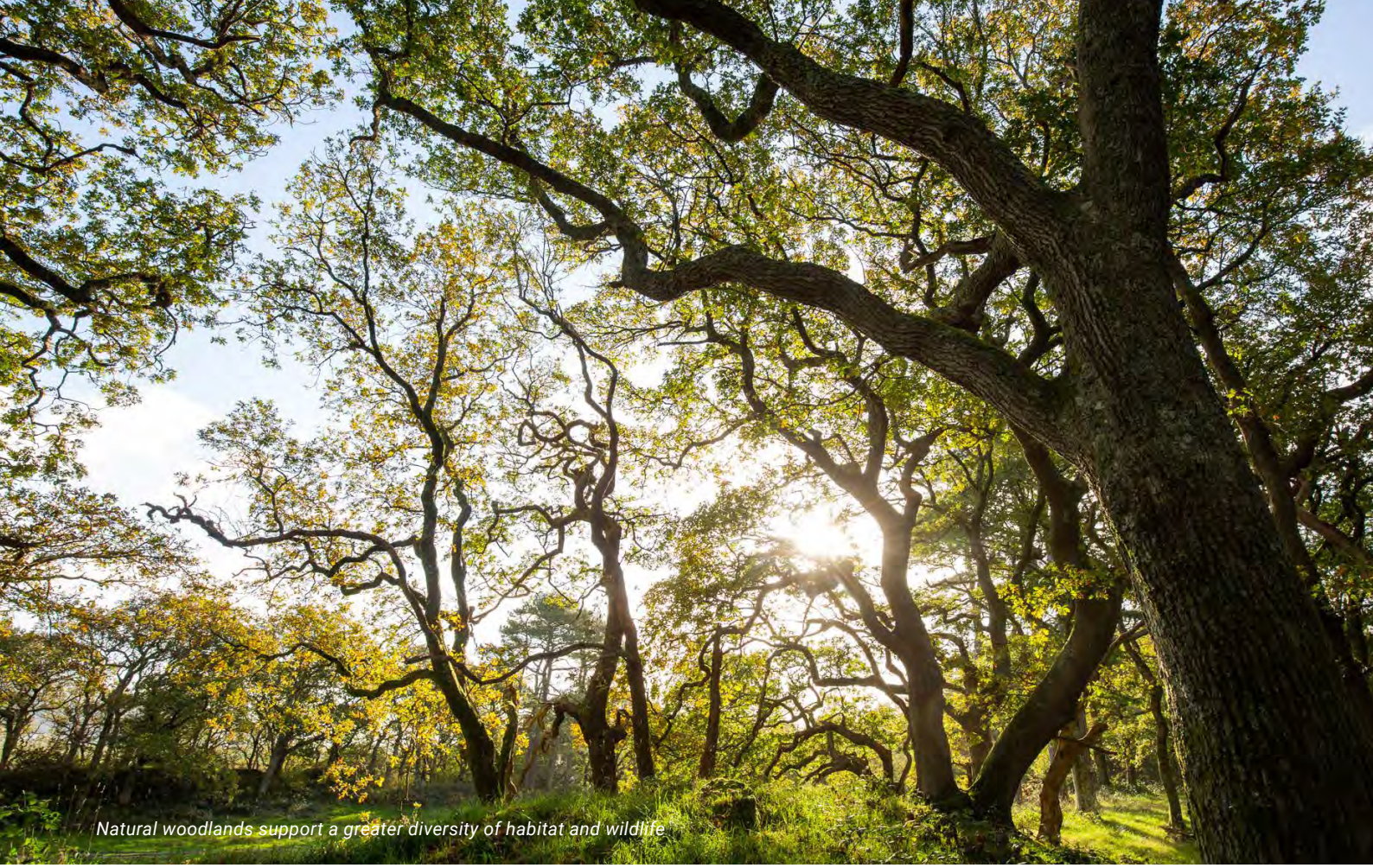
We urgently need to see an expansion of nature's recovery across Britain to match the scale of the threats from accelerating climate heating and species extinction. Doubling the cover of woodland and 'woodland in the making' from 13% to at least 26% by 2030 is achievable partly through a rapid expansion of the area where young woodlands are regenerating and growing into the natural forests and wildwoods of the future. Our National Parks and public lands should lead the way by establishing a mosaic of regenerating forest and woodland habitats at all scales alongside wetland, grassland, scrub and non-woodland trees.

3.

Incentivise natural regeneration within an integrated approach to land use change

We would like to see a significant increase in investment in natural regeneration from public and private financing within a supportive regulatory framework. Current funding for trees, woodland creation and forestry is complicated and uncoordinated. And yet the multiple long-term benefits of natural forests and woodlands far outweigh the upfront costs. Integrated land management payments (for example, the future Environmental Land Management Scheme and devolved nation equivalents) should explicitly support and incentivise natural woodland regeneration and nature-enriching land uses that sustain rural livelihoods. This should be supported through a coordinated regulatory approach, enabling funding mechanisms and straightforward administrative requirements.

If the ambition is to create diverse, climate-resilient natural forests and woodlands, then natural regeneration is arguably the better way



Natural woodlands support a greater diversity of habitat and wildlife

Photography: Ben Porter

1. INTRODUCTION

A mere 13% of the UK's total land area is forested compared to 40% in the Europe Union area and 46% across Europe as a whole. There is a growing need for rapid upscaling of woodland creation in direct response to the ecological and climate emergencies and increasing demand for carbon sequestration is driving a new market for widespread tree planting. However, the manual establishment of trees by humans can be labour intensive, costly, and creates artificial woodland habitats. If the ambition is to create diverse, climate-resilient natural forests and woodlands, then natural regeneration can arguably be a better way.

Natural regeneration is the process by which plants and woodlands become established naturally – with seeds distributed by the wind, by birds and other animals, spreading root suckers and by other natural processes. Many organisations such as the Woodland Trust are now beginning to promote natural regeneration as an alternative or a complement to the manual planting of trees.

There are some key advantages to natural regeneration as compared to planting trees:

- **Greater complexity and diversity**
  Natural woodlands support greater structural complexity and diversity of habitats, which benefits plants, animals and humans.

- **Increased resiliency**
  Natural regeneration supports genetic mixing and the natural selection of trees best adapted to local circumstances and a changing climate. This assists the evolution of resistance to new diseases[3].

- **Reduced risk of pests and diseases**
  Less reliance on tree planting reduces the need to import tree saplings, and therefore the risk of introducing new pests and diseases[4].

- **Less management, more cost-effective**
  Natural regeneration requires less management and can be more cost effective than planting (although protection from grazing and browsing animals may be necessary in the establishment phase).

- **Better carbon storage**
  Naturally restored forests have a potentially higher carbon value thanks to reduced soil carbon loss and other factors. Helping forests and woodlands expand naturally could significantly increase net carbon gain in the longer term.

There are many positive reasons for planting trees, such as boosting local seed sources, enriching species diversity where it is lacking and engaging communities in their local environment. However, tree planting can leave a legacy of ground disturbance and loss of soil carbon, plastic tree guards that litter the landscape for decades, an artificial-looking mono-cultured appearance and the requirement for on-going management of weed and pest control for many years afterwards. It is also constrained in its ability to achieve the amount of woodland expansion that we need.

All forms of woodland creation take time, measured in decades rather than years. Where there are sufficient seed sources and suitable site conditions, as in most of Britain, the timeframe for natural regeneration is comparable with the 30-50 years required to establish broadleaf plantations. However, with natural regeneration the exact trajectory of re-vegetation (in terms of species mix, location and density) is very difficult to predict in advance.

The unpredictability of natural regeneration may be one reason why tree planting is often preferred with regards funding – it is easier to predict outcomes with tree planting and achieve numerical government targets, especially in relation to carbon credits. But natural regeneration can make a vital contribution to the expansion of forest and woodland habitats in Britain in a way that delivers both climate and biodiversity benefits.

At Rewilding Britain we recognise the important role that commercial forestry has in the sustainable production of timber. This report focuses on the expansion potential of natural and semi-natural forests and woodlands that are not primarily intended for commercial timber extraction. Woodland wildlife is dependent on native tree species and as the Woodland Trust points out: 'The UK does not have the time or resources to tackle the climate and biodiversity crises separately'[3].

We also recognise that the boundaries between commercial and naturally regenerating forests are not always distinct. For example, the harvesting and restructuring of 1970 and 1980s-era plantations across Britain is creating significant areas of land (around >10,000 hectares per annum) that is becoming suitable for natural regeneration[5]. In turn, natural regeneration is being used in the creation and management of woodlands of all types – from productive broadleaves to complex conifer Continuous Cover Forestry.

'The UK does not have the time or resources to tackle the climate and biodiversity crises separately'

Woodland Trust

Regenerating scots pine poking through flowering heather along the River Feshie in the Cairngorms National Park

Photography:James Shooter

2. NATURAL REGENERATION: LESSONS FROM AROUND THE WORLD

While there has been a relative lack of scientific attention given to the question of natural regeneration, the overall conclusion from our research is clear: natural woodland regeneration will happen on a large scale so long as it is not actively discouraged. Given enough time trees will plant themselves and former land uses will in most cases revert largely to highly heterogeneous, species-rich and species-diverse mosaic of woodland, scrub, wood pasture and open habitats.

More research is needed into the dynamics of natural regeneration in contrast to tree planting as a model for woodland expansion. A recent systematic review of the forestry literature found that 'the evidence base is dominated by research studying conifer plantations' whereas 'evidence for the effect of afforestation on ecosystem services... is severely lacking'[6]. However, there are profound lessons to be learned from research and experiences gained from around the world as well as some specific cases from the UK. These studies primarily suggest that:

- **Natural regeneration will happen on a large scale if we allow it**
- **The pace and process of natural regeneration are complex and unpredictable**
- **Natural regeneration brings additional biodiversity and climate benefits**

Natural regeneration will happen on a large scale if we allow it

In Eastern Europe and the former USSR a huge natural regeneration experiment has been taking place since the collapse of the Soviet Union. More than 58 million hectares of former croplands in Russia and Kazakhstan have been abandoned since the disintegration of the collective farming system. Virtually all of this area has been subject to 'spontaneous reforestation' without a stake or tree guard in sight. After just a couple of decades this reversion to pine and deciduous forest is absorbing huge quantities of carbon estimated to total nearly 50 million tonnes per year (equivalent to 150 million tonnes of carbon dioxide) in Russia alone[7].

Naturally regenerated forests on former agricultural land also comprise a large proportion of second-growth woodlands in the eastern United States and parts of Europe. The experience of these areas suggests that any failure for trees to appear would be highly unusual given enough time. One review summarises the situation in the following way: 'A dense thicket of shrubs and trees typically develops within 30–40 years, and a closed tree canopy in about 60–80 years'[8].

Similar evidence comes from coastal southern Norway which a century ago was as deforested and bare as many upland parts of Britain. Now flourishing broadleaved forests clothe the lower slopes of mountains. Norway illustrates how natural regeneration might proceed in Scotland and northern England if sheep and deer grazing pressure is reduced and other forms of detrimental management such as the deliberate burning of hillsides is halted. However, any process of land use change at this scale can have wider social, cultural and economic impacts – both positive and negative – that need to be taken into consideration (see Case Study 1).

A recent meta-analysis also looked specifically at the question of whether an 'active' (including tree-planting) or 'passive' (simply ending a destructive land use) approach was more successful in promoting forest restoration[9]. This included 166 studies from around the world. Most of them were from tropical regions so not directly applicable to the geography and climate of the United Kingdom but the evidence was strong enough for the authors to draw a clear conclusion:

'Actively restoring former agricultural land, primarily by planting trees, did not result in consistently faster or more complete recovery than passively restored sites.' In other words, viewed at the global level, there is little evidence that planting trees is any more successful in restoring natural forests than simply letting the trees regenerate naturally. 'Our results suggest that simply ending the land use is sufficient for forests to recover in many cases,' they write.

This is supported by one of the few well-studied long-term succession sites in Britain. After being cultivated for centuries, a small four-hectare site at Monks Wood in Cambridgeshire was ploughed one last time in 1961 before being abandoned to natural succession. With abundant local seed sources the process of colonisation began almost immediately.

The majority of the area had reverted to oak-ash woodland by the time of the first comprehensive flora survey in 1998 when many trees were reaching 10m tall[10]. As well as the two dominant broadleaved tree species, smaller numbers of field maple and downy birch were present, with dogwood, hawthorn, elder and blackthorn as the shrub layer. 'The survey work on the [Monks Wood] Wilderness has shown that natural regeneration of native woods can be relatively rapid (< 50 years) on abandoned arable sites which are adjacent to native seed sources,' concludes one researcher[11].

IN SUMMARY

The evidence suggests that natural regeneration could massively increase the scale of natural forest and woodland expansion in Britain. Given sufficient seed sources and suitable site conditions, trees will plant themselves in their millions for free and over as large an area of land as we are willing to spare.

However, it is important to consider that in Europe and the US, at least, this process has happened as a result of rapid land use change and abandonment. This can bring significant social, cultural and economic impacts for local communities, both positive and negative. Natural regeneration cannot therefore be considered in isolation, it must be part of a wider discussion about integrated land use change that supports both resilient ecosystems and communities.

Natural regeneration: process and pace are complex and unpredictable

The circumstances at a site can play a big part in whether trees and shrubs take hold. The type and intensity of land use activities prior to colonisation can profoundly affect the regeneration process. In many cases trees and shrubs readily colonise land when free to do so. Some species colonise consistently. Some take much longer.

For example, many upland areas of Britain will struggle to see rapid natural regeneration of trees due to the absence of nearby seed sources over large areas of treeless landscape (see Case Study 2)[12]. In addition, thick vegetation swards established by tough grasses, such as purple moor grass (*Molinia cerulea*), can prevent seeds penetrating to the soil and germinating[13]. This is even the case when areas are fenced off from sheep grazing and other browsing animals. Where seed sources are available, grazing pressure (wild and domestic) is the most important determinant of whether natural regeneration can proceed[13].

In the lowlands, the experience of the Knepp Estate is especially interesting because the differing starting conditions of the farmland and the management that preceded natural regeneration show differing results (see Case Study 4). Isabella Tree reported in her book *Wilding* that within four years of arable land being abandoned, thousands of oak saplings had begun to appear. It was presumed that these were almost all planted by jays which had buried acorns as a future food store in among the new thorny scrub that appeared. This was probably aided by ample seed sources since Sussex already has higher levels of tree cover than almost anywhere else in England.

The reaction of many across Britain to scrub is likely to be a primary reason natural regeneration fails (see Case Study 5). Whole generations of conservation volunteers have been brought up on weekends spent on local nature reserves 'scrub-bashing'. In some rare circumstances removing scrub can safeguard specific species of conservation concern but in general scrub is a key transition phase of regenerating woodland. It is also an important habitat in its own right. Some studies indicate that bramble plays an essential role as a nursery for both oak and alder buckthorn by protecting

Photography: www.jameswarwick.co.uk

At Knepp, jays have planted thousands of acorns in among thorny scrub that are now growing as oak saplings

it from browsing herbivores. Indeed, in one study 'all saplings taller than 100cm (oak) or 200cm (buckthorn) were associated with bramble scrub... the establishment of bramble on the former arable fields seemed essential for oak wood regeneration'[14]. If we can learn to embrace scrub, many more trees will plant themselves and establish successfully.

Two long-term succession studies of small sites in England also illustrate the importance that the initial site conditions, soil type and vegetation have on the process and outcome of natural regeneration.

Broadbalk and Geescroft Wildernesses

These two small plots in Hertfordshire were allowed to revert to woodland in the 1880s after having been continuously cultivated for centuries before that[15]. They 'now provide the only examples of a natural succession from farmland to woodland which have been recorded for more than a century in the UK'[16]. At Broadbalk, trees and shrubs colonised within a decade and formed a dense thicket within 30 years of abandonment.

It was concluded that 'natural regeneration of woodland on farmland can take at least 20-30 years to achieve a complete canopy cover'. However, the process was slower at Geescroft where only a few tree and shrub species were present even after 30 years. This was possibly due the more acidic soil type and because it began as established grassland rather than disturbed, cultivated ground when it was abandoned.

The Roughs, Northamptonshire

During World War II, part of the Ashton Estate in Northamptonshire was requisitioned for the building of an airfield. While much of the area was returned to agriculture after the war, a 30-hectare area (including the airfield buildings) was allowed to return to nature. Having been abandoned in 1948, it was 56 years old at the time it was studied in 2005[17].

It had not returned to closed-canopy woodland in the half-century since abandonment, rather it was a mix of scrub and woodland. Hawthorn, blackthorn, thick grass sward, rose and numerous other bushes were present, as well as some ash-dominated woodland, which had established in a few areas. Notably, ten species of 'conservation importance' were found in the overall survey, and all ten were found in the scrubland of the Roughs.

The natural regeneration of complex wood-pasture ecosystems can take many decades, as in south-west Norway (see Case Study 1), so the question arises of whether the process can be accelerated in suitable parts of the UK. According to leading expert Duncan Halley who has researched this issue in detail:

'The way to speed things up, compared to south west Norway, is to provide seed sources, since that very definitely is the main proximate factor observed to influence regeneration in south-west Norway. Most regeneration takes place within a couple of hundred metres of existing trees, even for highly mobile seeds like birch. If you got grazing down durably, it would all happen in a snowballing trajectory of speed and scale, over about a century. That's what happened here with no planned intervention apart from commercial plantations. But on scales of human lifetimes, if you want to get it going quickly, providing seed source is primary.'[18]

IN SUMMARY

Natural regeneration is not always straightforward. The speed and type of establishment is unpredictable and depends on the interaction of multiple factors. The exact trajectory of re-vegetation (in terms of species mix, location and density) is virtually impossible to predict in advance. Within this complexity, our diverse scrub habitats should be embraced as a vital part of natural dynamic succession. Assistance can be given to boost natural regeneration where ground conditions are unsuitable, seed sources too distant or grazing too high. For example, scarification, direct seeding, grazing control or selective enrichment planting can all help the successional process.

The brown hairstreak butterfly thrives in natural woodland where scrub, such as blackthorn, is present

Photography: Iain Leach

Natural regeneration brings biodiversity and climate benefits

Most of the biodiversity in Britain is associated with intricate mix of trees, shrubs and open grasslands. One advantage of natural woodland regeneration is the resulting habitat complexity and diversity. As one study highlighted 'trees will be patchily distributed across the site and thus the woodlands may be more natural looking with greater structural diversity; the species will be matched to the site and be of the local genetic stock'[19].

While it should be recognised that there can sometimes be negative impacts on specific species, in general this habitat complexity, in the words of Isabella Tree, provides 'rocket fuel for biodiversity'[20]. At the Knepp Estate regeneration has supported the return of many long-vanished and increasingly rare wildlife species including nightingales, purple emperor butterflies and an explosion of invertebrates, vascular plants and fungi (see Case Studies 4 and 5).

Getting the right balance between natural disturbance and vegetation succession increases habitat complexity even further. It favours important successional habitats such as scrub – 'one of the richest natural habitats on the planet' which gives 'protective cover for invertebrates, birds and small mammals, and a cornucopia of berries for over-wintering birds'[21]. It can also avoid perverse tree establishment in native grasslands[22]. Reintroducing ecosystem engineer species, including beaver, wild boar[23], bison (or proxy species such cattle and ponies), as well as predators such as lynx, can additionally enhance natural disturbance and improve ecological, structural and species diversity.

Evidence also suggests that our image of bare hills in national parks as being natural and appropriate needs to be challenged. Our heavily grazed uplands and highlands are ecologically impoverished. Without intensive grazing these there would be much more tree cover and habitat diversity. The widespread forest regeneration in southwest Norway, with its diverse flora and fauna, offers a demonstration of what might be possible (see Case Study 1).

Protecting existing fragments of Britain's precious woodland habitats, with their rich biodiversity and allowing them to regenerate and expand naturally also has the potential to significantly extend their range. Rainforests, including oaks festooned with epiphytes like ferns, mosses and lichens, were once extensive on Britain's maritime slopes of westward-facing uplands, thanks to a climate that delivers moderate to extreme precipitation frequently throughout the year[24]. With help and encouragement our temperate rainforest could gain a wider hold once again (see Case Study 3).

In the context of climate heating, natural regeneration also demonstrates benefits in terms of both climate adaptation and mitigation. Natural regeneration can support genetic variation and natural selection of trees best adapted to local circumstances in a changing climate. Many of our trees are wind-pollinated and genetic adaptations to the changing climate could spread surprisingly rapidly if natural regeneration is allowed.

There is also potential for this process to be assisted through the strategic mixing of selected seed sources from other climate zones or elevations with local seeds to increase diversity and adaptability to a range of future climates[25]. In addition, restoring and connecting species-rich habitats can help save up to a fifth of species from climate-driven habitat loss, species decline or extinction by enhancing their ability to adapt and adjust their ranges[26].

Naturally regenerating woodlands can also bring significant carbon benefits. Whilst there is limited research specifically focused on temperate zones a study of tropical areas concluded that 'natural forests are six times better than agroforestry and 40 times better than plantations at storing carbon'[27]. So much so that the authors issued the following plea: 'We call on the restoration community, forestry experts and policymakers to prioritise the regeneration of natural forests over other types of tree planting — by allowing disturbed lands to recover to their previous high-carbon state.'

Globally the amount of carbon that could be stored by regenerating former agricultural land is immense. One recent meta-study concluded that restoring ecosystems on just 15% of the world's farmland could spare 60% of species otherwise expected to go extinct, and sequester nearly 300 gigatonnes of CO2 – equivalent to a third of the total CO2 increase in the atmosphere since the Industrial Revolution[28]. This could be achieved with little impact on food availability.

It should be recognised that the measurement of net change in carbon is hugely complex and dependant on a wide range of factors. Notably, very few studies have specifically looked at natural regeneration as opposed to afforestation through tree planting.

In Britain, in the short to medium term, naturally regenerating woodland may sequester less carbon than a densely packed and rapidly growing sitka spruce plantation[29]. But there's little to no biodiversity in a sitka spruce forest and carbon gains are higher in natural forests over the long term. In addition, planting trees does not always lead to carbon boosts, especially on deep peat soils[30], and net change in carbon (above ground and soil) varies considerably depending on the planting options used[31].

One very recent study that does map and quantify the potential above ground carbon accumulation of naturally re-growing forests, including temperate zones, concludes that it can 'strongly contribute towards stabilising global warming'[32].

Natural regeneration has largely been omitted from much of the modelling undertaken of afforestation scenarios in Britain. For example, to help deliver the UK's 2050 Net Zero target, the Committee on Climate Change (CCC) has called for 'an increase in tree planting to at least 30,000 hectares per year', which it suggests 'equates to the planting of between 90-120 million trees per year'[33]. However, under the CCC's scenarios most of this would be Sitka spruce and natural regeneration isn't factored in at all. This is a major omission as the potential carbon benefits of natural regeneration (through longer-term biomass gains, combined with the expanded area that can be regenerated, at minimal cost, with negligible loss of soil carbon[34]) could be significant.

IN SUMMARY

There are many projected biodiversity gains from the increased habitat complexity that results from natural regeneration. Natural regeneration can also support the expansion of precious and diverse habitat types such as Britain's native temperate rainforests.

Natural regeneration can allow trees to better adapt to rapid climate change through long-distance genetic exchange via pollen and seeds, potentially assisted through mixing seed sources to increase resilience.

Although the factors are complex, evidence also suggests that expanding naturally regenerating forests can make a significant contribution to mitigating climate heating in the longer-term through increased carbon sequestration.

3. CASE STUDIES OF NATURAL REGENERATION

CASE STUDY 1
LEARNING FROM SOUTH-WEST NORWAY

South-west Norway and the Scottish Highlands are very similar in climate, geology and landforms but very different in modern land-use patterns and resulting landscapes. While much of Scotland is still largely bare and treeless, trees have returned widely to Norway thanks to a process of natural regeneration that has been taking place, largely unmanaged, for the past 80 years. Before and after photos illustrate clearly how much of this part of Norway used to resemble current-day Scotland, and how it has changed.

In Norway, woodland regeneration resulted from a period of very low grazing in the late 19th and early 20th centuries and a further period in the 1950s. Low grazing levels were due to cultural and societal changes such as the widespread abandonment of sheep farms due to emigration to North America and later economic prosperity reducing subsistence-level farming. This resulted in a dramatic increase in woodland cover which still continues today.

Almost all this reforestation occurred through natural regeneration. Norway challenges our perceptions of where forest should be: grasslands and woodlands are integrated (rather than being fenced off from each other). Treelines are also much higher than most people suppose. Given the chance, mountain birch could establish and thrive in Scotland at 600-900m, as would montane willow and other broadleaved shrub species[35]. The reason these montane ecosystems are nearly extinct in Scotland is because of centuries of continued grazing pressure, not climatic unsuitability. Tiny remnants of dwarf willow, and alpine herbs, hang on only in a few inaccessible cliffs, where they can escape the nibbling mouths of sheep and deer.

Norway suggests that the forests of Scotland could regenerate if grazing pressure (wild and domestic) were reduced and if land wasn't burned to favour shooting birds. This does not mean the total cessation of management. In Norway, there is an active hunting culture and deer are generally in better condition (with heavier carcass weights) than in Scotland. Overall, the same amount of deer meat is harvested.

What it does demonstrate is that any process of land use change happens within a wider social, cultural and economic context and can have significant impacts on local communities, both positive and negative. South-west Norway has an overall population density higher than the Scottish Highlands. However, working rural properties are much smaller than the typical holding in Scotland. They are usually owner occupied. Land use in Norway is diverse, with each property typically gaining income from a mix of activities such as agriculture, grazing, forestry, hunting and fishing sales, fuel wood production and cabin sales/rentals. It's therefore vital that local communities are at the heart of discussions and decision-making about future land use change.


Fidgadalen 1927


Fidgadalen 2007

CASE STUDY 2
NATURAL REGENERATION IN THE UPLANDS AND HIGHLANDS

Evidence suggests that some upland areas will struggle to see rapid natural regeneration of trees due to the absence of nearby seed sources over large areas of treeless landscape[36]. In addition, thick vegetation swards established by tough grasses such as purple moor grass (*Molinia cerulea*) prevent seeds penetrating to the soil and germinating[37]. This is even the case when areas are fenced off from sheep grazing and other browsing animals.

Where seed sources are available, grazing pressure is the most important determinant of whether natural regeneration can proceed. Creag Meagaidh National Nature Reserve in Scotland provides a good example of this. Red deer densities in the reserve were reduced ten-fold between 1986 and 2008, down to 1.7 deer per km2 while sheep and other deer species populations are also now kept very low. Researchers report that grazing pressure from deer is by far the most important factor in whether birch can regenerate. Ground vegetation, such as heather and *Molinia*, comes second[38].

'By reducing the grazing pressure small seedlings, held in check for years, have been able to grow up into saplings. Birch, willow and rowan are the most abundantly regenerating trees on the Reserve, but other species, such as aspen, oak and hazel, are returning too, as well as alder along the burn [stream] sides. Natural regeneration from seed is also occurring further supplementing the woodland development,' reports NatureScot (formerly Scottish Natural Heritage) which manages Creag Meagaidh[39].

For the future, the managers of Creag Meagaidh plan to expand the use of cattle which 'are beneficial in breaking up the surface, enriching with dung and controlling the purple moor grass [*Molinia*]. Cattle also break up areas of bracken, opening up the ground layer and allowing other species to establish[40].' Elsewhere it has been suggested that wild boar could play the same role. These important ecosystem engineers break up bracken as well as graze thick grass through rooting behaviour[41].

Reduced grazing pressure is allowing new woodland to thrive at Creag Meagaidh

Photography: Mark Hamblin/scotlandbigpicture.com

CASE STUDY 3
NATURAL REGENERATION IN THE LOWLANDS

The Knepp rewilding project began in 2001 when landowners, Charlie Burrell and Isabella Tree, began to abandon conventional farming across large blocks of the estate. The farm had previously been mixed arable and dairy on low-grade clay soils and had not been profitable in conventional production.

The first block, the 277 ha 'Middle Block', was seeded with wildflowers and native grasses and populated with large herbivores from the outset: Exmoor ponies, Tamworth pigs and English longhorn cattle. The aim was to prevent the quick succession of species-poor closed canopy woodland on the abandoned grassland and create a more diverse mosaic of habitats. The 235 ha 'Northern Block' was also seeded with native grasses before being left to longhorn cattle. Isabella Tree reports that: 'Because this whole area was either pasture already or re-seeded with grass, vegetation is, however, taking a long time to get away. Thorny scrub is only just beginning to break out of the hedgerows and colonise the thick, thatchy sward[42].'

Browsing and grazing is working with natural regeneration at the Knepp Estate (Image courtesy of knepp.co.uk)

Photography: Mark Hamblin/scotlandbigpicture.com

The larger 450 ha Southern Block was left as abandoned arable land rather than being seeded with grass and this cessation of management has allowed a spectacular vegetation pulse to happen over 4-6 years. Because the vegetation succession had proceeded a long way before the introduction of large herbivores, this area now supports populations of deer, cattle, ponies and pigs. This area is probably the most useful in terms of analysing the likely progression of natural succession on a different type of abandoned farmland from those mentioned above.

By [2010], unhindered by the kind of impenetrable grassy sward established in the Middle and Northern Blocks, thorny scrub had begun to take off, providing a nursery for jay-planted oak saplings and the spontaneous germination of crab apples and wild service, as well as protective cover for invertebrates, birds and small mammals, and a cornucopia of berries for over-wintering birds. Eruptions of sallow (hybrid willow) germinating in the damp, open soil, has given rise to the largest colony of purple emperor butterflies in the UK. By the time free-roaming animals were introduced there was plenty of browsing as well as grazing available to them, providing them with a richer food supply. The ensuing battle between animal disturbance and vegetation succession has increased habitat complexity even further. This is now by far the wildest area of the rewilding project and source of most of our headline wildlife successes – the part that looks like Africa. **Isabella Tree, Knepp Estate** [43]

CASE STUDY 4
EXTENDING BRITAIN'S RARE RAINFORESTS

Britain is a natural home for native rainforest[44]. Our islands are squarely located in the temperate rainforest biome and fragments of this extremely rare habitat still exist in the west of England, Scotland and Wales, the so-called Celtic Rainforest. Temperate rainforests, which exhibit a high richness of epiphytes like mosses, ferns and lichens, were once common on the maritime slopes of westward-facing uplands thanks to a climate that delivers moderate to extreme precipitation frequently throughout the year[40]. All are now considered critically endangered due to extensive deforestation.

In Scotland, less than 1% of the original temperate rainforests remains, scattered in isolated fragments in the northwest. One of the largest fragments is at Coille na Glas Leitir in the Ben Eighe Nature Reserve in Wester Ross which sees around two metres of rainfall annually. These oak woodlands, some of the most northerly in Europe, with areas believed to have stood uncut for 8,000 years[45], are one of the best places in Britain for moisture-loving mosses and liverworts.

Some of Wales' Celtic rainforest fragments are considered to be among the best examples of natural oak woodland in Europe. But even these tiny fragments are threatened by grazing pressure, the introduction of non-native conifer plantations and invasive species like rhododendron. Their value is now recognised by the Celtic Rainforests LIFE Project[46], which Snowdonia National Park Authority, the Woodland Trust, RSPB and National Resources Wales manage jointly with other partners. One very specific sub-category of the Celtic Rainforest biome is the stunted coastal hazel and oak woodlands, such as Gallt y Bwlch on the north coast of the Lleyn Peninsula in North Wales.

However, it is notable how timid existing management plans currently are. They typically seek to add only tens of hectares of regeneration to a biome that would once have covered hundreds of thousands of hectares across all of the UK's Celtic fringe, from Dartmoor to Loch Torridon. Properly protecting what tiny fragments are left, and allowing these to expand through natural regeneration, is surely the first step towards bringing our lost rainforests back. This has been largely impeded by overgrazing of sheep and deer.

Temperate rainforest zones in Britain
Source https://www.sciencedirect.com/science/article/abs/pii/S1470160X16303016

While some level of herbivory can be beneficial for the development of mosaic wood-pastures, deer numbers remain above carrying capacity in virtually all of Scotland, and sheep in other UK upland areas prevent any substantial natural regeneration. However, the exclusion of all grazing may be undesirable if it allows too much heavy growth of the lower shrub layer (especially bracken and brambles) which can impede regeneration of small saplings and shade out lichens and bryophytes characteristic of Celtic Rainforest habitat[47].

Despite their global importance, nearly half of the 22 coastal slope woodlands in Wales have no statutory protection and are increasingly degraded. According to one 2015 study, Gallt y Bwlch is unfenced and 'exposed to uncontrolled sheep numbers and a large population of feral goats' which kill any regenerating saplings and even strip the bark from larger trees in winter[48]. It seems perverse for so many people in Britain to be concerned about threatened rainforest overseas when our own rainforest fragments are still being destroyed.

Thorny scrub offers protection for growing trees and supports a diverse mix of other wildlife

CASE STUDY 5
LEARNING TO LOVE SCRUB

Spiny shrubs like bramble and blackthorn can be important nurse species which protect regenerating broadleaved tree saplings from being eaten by herbivores as they grow [49]. One study in southern England found that 'bramble facilitates the establishment of birch and willow with seedling heights and diameters being positively related to bramble height and cover'[50].

Anecdotal evidence around the UK suggests that it is not just bramble that provides this service of nursemaiding saplings: gorse, bracken, blackthorn and even thistles will do the same job.

In Belgium, scientists found that in a regime of low-intensity grazing of cattle and horses, 'increasing cover of unpalatable/spiny vegetation in the herb layer and low shrub layer increased tree frequencies' and allowed young trees to 'grow out' above the browse line[51]. The authors reported that 'succession to pioneer forests is a rapid process' on former arable land and that bramble scrub 'interacts with this process and facilitates' woody species to grow out.

A similar process has been reported at Knepp Estate in southern England: "The reason [natural regeneration] doesn't happen nowadays is our demonisation of thorny scrub. Hawthorn, blackthorn, dog rose, gorse and bramble are nature's barbed wire. These species provide saplings with protection from browsing by deer and rabbits; shelter from the wind; a buffer against drought and excessive rain; and nutrients via mutual mycorrhizal connections underground. 'The thorn is the mother of the oak' is an ancient forestry saying[52]."

However, the relationship is complicated. The positive results may be because bramble and trees were established at the same time on new ground. Tree seedlings may be unlikely to establish in the middle of existing dense bramble thickets. Bramble is an understorey species, however. Sooner or later it will be outcompeted by woody trees and shaded out, and this battle for ecological succession is one of the main drivers of scrub dynamics. In turn, encouraging tree growth in problem areas dominated by a single species, such as bracken, in time, can result in effective control[53].

After centuries of sheep grazing, tree planting was needed in the Carrifran Valley to assist natural regeneration

Photography: Borders Forest Trust

4. KEY FACTORS INFLUENCING NATURAL REGENERATION

If we let them, trees will plant themselves in their many millions over much of Britain. Closing the gate on a field and walking away will in many cases mean a rapid reversion to scrub and then to patchy woodland. However, this is not guaranteed and the speed and type of establishment depends on the interaction of multiple factors.

While the course of succession and recolonisation is complex and difficult to predict, it is the interaction of seed availability, and the suitability of the site for the seed's germination and establishment, that is of primary importance.

At least five factors can be identified which we will explore in this section:

1. **Seed source** – including the frequency of seed production and forms of dispersal

2. **Soil and ground conditions** – including soil type as well as past and current land use

3. **Grazing pressure** – including the intensity and selectivity of grazing by wild and domestic herbivores

4. **Vegetation cover** – including density and composition and associated competition for light, nutrients and moisture

5. **Weather and micro-climate** – including warmth and moisture as well as events such as flooding

1. Seed source

Tree seedlings have to germinate from seeds that have either come in as 'seed rain' (spread by wind or brought by animals) or exist already in the soil seed bank. Different species spread seeds over different distances. For birch, one upland study found that 63% of regeneration occurred within 20 metres of a seed source while no significant relationship was found for oak and rowan (both of which are dispersed more widely by animals)[54]. Colonisation is most concentrated within the first 30-50 metres and limited mainly to within 150 metres of the seed source.

In Monks Wood, oak was seen to be evenly distributed throughout the site, with some of the largest trees in the middle of the field[55]. Ash, on the other hand, was largely concentrated in dense clusters around the edge. This is likely to be because ash has wind-dispersed seeds which tend to fall relatively close to the parent tree. Oak has large seeds that are dispersed over long distances by birds and other mammals. Single jays, for example, have been known to plant 7,500 acorns in four weeks. Squirrels can assist in regeneration by burying seeds (but are also known to predate/destroy them). Fruit-eating carnivores, such as foxes and badgers, also play a role.

One study of regeneration on former industrial sites found that if a parent tree was visible from the site, there was a 58% chance of finding the corresponding seedlings

Other bird-spread seed sources, such as berry-producing shrubs (for example, hawthorn and elder), can also disperse over larger distances. One study of regeneration on former industrial sites found that if a parent tree was visible from the site there was a 58% chance of finding the corresponding seedlings. Goat willow was an exception because its fluffy wind-blown seeds can travel great distances. Over 85% of colonisation came from ash, hawthorn, birch and goat willow, with the majority of sites having been abandoned for 10-20 years at the time of the survey[56].

The availability of seeds from different seeding trees varies in different years. This is because many trees have 'mast years' where most seeding is done and may produce little seed in between. If seed sources are not available in the immediate vicinity then one option is direct seeding to mimic the natural 'seed rain' that would take place in a more healthy and diverse system. Successful establishment can be achieved at lower cost and with reduced herbicide input[57]. In some parts of the world drones are now being developed which can fire seeds into the ground over large areas. However, ground conditions are important in whether direct seeding succeeds or not. Seed collection can also be difficult and expensive or there may be a limited amount or diversity of species available locally. In these cases enrichment tree planting can be used in conjunction with, and to assist, natural regeneration.

2. Soil and ground conditions

Ground disturbance can be essential for many seeds to germinate and grow. Infertile, stony soils (even bare gravel) are easier for trees to colonise because some seeds need to be able to germinate in contact with the mineral layer in order for roots to penetrate the ground. Birch prefers disturbed open ground because its small seeds struggle to establish through thick vegetation. Some evidence suggests that fertile soils, with the denser grass and herbaceous layers they support, are therefore more likely to inhibit colonisation by trees[58].

Bare seedbeds on former arable land can benefit oaks, for example, which are mostly planted by birds like jays, which prefer to cache seeds in bare soils. However, ash regenerates well in the established sward of thick grasslands. One study from Germany found that on former arable land (irrespective of the initial starting condition) grasses and annuals dominated for the first few years, giving way to shrubland by year 10 and then fully-established pioneer forest after two decades[59].

Current and past land use including the history of each field can also be a factor. For example, previous use of persistent herbicides like atrazine and others, as well as soil compaction from heavy machinery in past agriculture, can inhibit regeneration[60]. However, natural regeneration of native tree species can happen successfully after clear felling conifer plantations.

One study surveyed 15 upland sites, from 120m to 380m above sea level in Scotland and the Lake District[61]. While some non-native conifers also regenerated (from seeds left in the soil before felling) most regeneration successfully came from native species like birch, oak, rowan, willow, alder, ash, holly and hazel, with new trees sometimes forming quite dense stands of up to 5,000 stems per hectare.

3. Grazing pressure

Even if trees and shrubs get to a given site and germinate successfully, they have to contend with the hungry mouths of herbivores, both wild and domestic. With no natural predators in the ecosystem, larger herbivores like deer can all-but curtail any tree and shrub growth[62]. At lower densities, they tend to sculpt the growth of trees and shrubs, not prevent it. Red deer density is a particular problem in the Scottish Highlands. Roe, fallow and muntjac deer are also an increasing issue in many lowland areas.

In addition, large areas of our uplands are heavily grazed by sheep which prevent any natural regeneration of woodland or woody shrubs. Grazing pressure can be a problem even within established forest, as herbivores prevent the regeneration of trees as older mature trees gradually die off. One study of a patch of the New Forest found that unrestricted grazing by ponies, deer and cattle effectively prevented any regeneration of young trees[63].

In all cases the evidence is clear: grazing (domestic and wild) must be reduced dramatically at least in the initial establishment phase for most tree species to colonise quickly and successfully. In most upland areas grazing may need to be eliminated completely, at least for a period of time, before a new balance can be struck between established regenerating trees and browsing herbivores. This brings potential consequences for many communities where there is already widespread concern about possible impacts of on livelihoods, culture and language. Decisions, therefore, need to be made with local people and communities as part of a wider discussion on strategic land use change. This is not to say that browsing is always a negative influence: animals can break up heavy sward and encourage further regeneration, and in lowland areas prevent species-poor closed-canopy woodland establishing too quickly. It is the dynamic balance between vegetation succession and grazing that enhances habitat complexity within naturally regenerating systems. This balance becomes even more complex and diverse where predators also play a part, not least in influencing the numbers and behaviour of herbivores.

Natural regeneration of native tree species can happen successfully after clear felling conifer plantations

4. Vegetation cover

Where vegetation and grass sward is very thick it can provide a formidable barrier to seeds germinating and growing. Wild boar can break up the thatch and give seedlings a toe-hold[64]. Cattle can serve a similar role, pulling apart the thatch and creating bare soil into which seeds fall and germinate.

Where animals are not appropriate, the need to promote seed germination raises the question of whether mechanical site preparation methods such as discing or other forms of ground scarification might help accelerate the establishment of native species, particularly in upland areas with a thick grass sward. Mechanical 'scarification' can kick-start recolonisation by exposing ground to pioneer species like willow and birch[65]. There is some evidence from Sweden that birch seedling germination is enhanced when the ground is disturbed with mechanical preparation to expose some bare soil[66]. Different species have different requirements: willow seeds, for example, can blow long distances but require bare, damp ground in early summer to germinate. Another study in Norway looked at the effects of

different degrees of soil scarification (in terms of how much mineral soil was exposed) on the regeneration of Scots pine and birch in boreal forests[67]. The study, which was carried out on clear-felled land, found more exposed soil allowed more pine seedlings to germinate, leading to denser stands of saplings, but there was no positive association found for birch.

Moreover, scarification was associated with poorer growth in later years. The authors also warn that intense mechanical scarification (which is akin to ploughing) can have a negative effect on landscape appearance, can harm groundcover shrubs like bilberry and also releases carbon and leaches nutrients.

There are clearly trade-offs in the extent to which scarification can give naturally regenerating trees a headstart. In arable-to-forest lowland situations it can be fine to scarify and temporarily leave bare soil but in upland areas with semi-natural ground vegetation scarification can be damaging or too mild to be effective. Hand screefing (manual scarifying) and planting can be a low-impact compromise in some circumstances.

5. Weather and micro-climate

Microclimates have a big effect on whether seeds can germinate and establish. Seeds obviously cannot germinate without some moisture but too much means they may die from waterlogging. Weather events such as flooding, drought and even frequency of snow can all impact on seed dispersal and germination.

There are clearly trade-offs to the extent to which scarification can give naturally regenerating trees a headstart

Photography: Alastair Driver

Natural regeneration on the Eastern Moors in Derbyshire

Pine martens love the diverse woodland habitat associated with natural regeneration

Photography: James Roddie

5. NATURAL REGENERATION HIERARCHY: A PRACTICAL THREE-STEP MODEL

Evidence suggests that natural regeneration could make a significant contribution to woodland expansion in Britain at a fraction of the cost of tree-planting alone. It is clear that in many places the planting of tree saplings ("whips") is unnecessary in Britain. This raises a significant challenge to existing conservation and land management practices. Do we simply stand back and allow nature the space to work its woodland-creating wonders? Do we kick-start the process then stand back? Or do we get stuck in and act as nature's guiding hand?

We propose a Three-Step Natural Regeneration Hierarchy[68] as a practical model for decision-making as part of a broader rewilding approach where a species-rich mosaics of woodland, scrub and grassland habitats are allowed to regenerate over large landscapes. This starts with natural regeneration as the default approach with tree planting as a support option where the natural regeneration of diverse habitats will not happen without it.

STEP 1
LET NATURE LEAD

Allow natural regeneration as a default approach unless trees and shrubs are unable to establish or would take too long to arrive (e.g. due to distant seed sources, impenetrable sward, continued over-grazing).

STEP 2
GIVE NATURE A HAND

Kick-start the process by assisting natural regeneration. For example, through ground preparation, direct seeding and grazing control.

STEP 3
PLANT TREES

Plant locally sourced tree saplings ("whips") only where still considered necessary, particularly where this positively engages local people and communities.

There may well be landscapes where the use of all three approaches is appropriate. In some highly modified landscapes, the state of the ground vegetation and grazing at abandonment may mean that little further assistance is needed. In others using natural or assisted regeneration could simply lock in past damage, leading to the dominance of just a few pioneer species.

In these circumstances planting missing species, while relying on natural regeneration for those already present, could lead to the faster establishment of more diverse, resilient forests. Over time some levels of grazing and other disturbance can be permitted but for the first few years most regenerating woodlands will need strong protection from herbivores. This means land managers will need to make decisions about which approach or mixture of approaches, is most appropriate for each site guided by the following questions:

- **Can all desired species get to the site without intervention in a 'reasonable' time frame?**
- **Can the desired species germinate within the site?**
- **Can the desired species establish themselves and grow on to become integral to the ecology of the site?**

In the following table we summarise some of the key considerations in this decision-making process for each of the three steps. It is recognised that these decisions cannot be made in isolation however and need to be part of a more integrated approach to land management. This in turn depends on a clear and well-enforced regulatory framework, well-coordinated funding mechanisms and straightforward administrative requirements. For example, current woodland creation is regulated through the UK Forestry Standard (UKFS) and its requirements should ensure that natural regeneration as well as natural and 'naturalistic' forestry aims are supported.

APPROACH	STEP 1 LET NATURE LEAD	STEP 2 GIVE NATURE A HAND	STEP 3 PLANT TREES
Description	This uses natural regeneration as the default approach unless trees and shrubs are unable to establish or would take too long to arrive. **This may include:** ▪ Natural encroachment from woodland or hedgerows on to surrounding land; ▪ Abandonment of intensive land use/activities ▪ Colonisation of brownfield or derelict post-industrial sites; ▪ Colonisation of land disturbed through erosion, flooding or fire	This approach kick-starts the process by assisting natural regeneration where there are modest constraints on the arrival, germination and establishment of some or all shrub and tree species at the site.	Applicable only where the site is so remote that seed rain, natural vectors or a modest degree of human intervention isn't feasible or where planting positively engages local people and communities.
Can *all desired* species **get to the site** without intervention in a 'reasonable' time frame?	**Consider the following:** ▪ Are the given species already present in the seed bank or as seedlings? ▪ Are desired species available as seed sources in the immediate vicinity, and close enough to arrive by natural means (wind, animal vector, seed rain)? ▪ Can woodland establishment proceed within a 'reasonable timescale' e.g. given carbon or biodiversity targets (most woodland in the UK will regenerate within 50 yrs, but a single decade is a different matter). **If yes,** proceed with natural regeneration. **If no,** consider assisted natural regeneration.	**Consider the following:** ▪ Collect seed of desired species from as close to the site as possible and sow to mimic seed rain. ▪ Establish pioneer trees to facilitate seed distribution in surrounding area. ▪ f insufficient amount and diversity of seeds available some enrichment planting through Step 3 can boost the process. ▪ Strategic mixing of selected seed sources (e.g. from other climate zones or elevations) with local sources to may increase climate adaptability.	**If no** to all Step 1+2 options on all or part of land area: ▪ Introduce some or all desired tree and shrub species through planting nursery "whips" ▪ Collect or source seeds, cuttings or wild seedlings of those species from as close to the site as possible and grow on in on-site/local nursery. ▪ Consider creating 'dispersed' nursery to grow-on seedlings/ cuttings from the local area. This could involve asking schools, households etc to grow on seeds like acorns.

APPROACH	STEP 1 LET NATURE LEAD	STEP 2 GIVE NATURE A HAND	STEP 3 PLANT TREES
Can the species **germinate within the site?**	▪ This depends on availability of germination niches ▪ Arable land, which has been recently disturbed, mostly allows easier germination ▪ Thatched grasses are harder - these appear to delay germination for species other than oak and ash ▪ Disturbed grassland: what is the ground impact of wild boar, ground poaching by bison, cattle etc? **If yes,** proceed with natural regeneration. **If no,** consider assisted natural regeneration.	**Consider the following:** ▪ Ground preparation, e.g. using animals or scarification, to disturb soils especially where seeds don't establish well through thick sward. ▪ Direct seeding using locally sourced seed where necessary ▪ If disturbing natural ground vegetation scarification too damaging or too mild to be effective consider some enrichment planting through Step 3.	▪ Engage local communities in tree planting activities. ▪ Make decisions about: - age of plant material: seedlings/ nursery whips/ standards. - sequencing of planting, e.g. starting with species birds can perch on to roost and spread seeds of other species in droppings, or thorny species that can allow others cover to establish. - how much planting across the whole site, in clumps, at what density? - planting without protection or within protective bramble, blackthorn etc and accepting associated losses - only using tree guards (biodegradable wherever possible) if losses are unacceptable. - using fencing and/or deer management practices.
Can desired species **establish themselves and grow on** to become integral to the ecology of the site?	▪ Assuming desired species/mix has been able to arrive at and germinate within the site in sufficient numbers, are they then able to grow on and perform their role within an ecological community (some species may be early but short-lived colonists, others (such as bramble) might deplete through time; others, such as oak, might take a lot longer to achieve old-growth roles). ▪ This will need to consider density and species mix, as certain levels of grazing/ browsing sculpt succession rather than halting it. Some grazing can help establish more biodiverse mosaic habitats rather than closed-canopy woodland: herbivory is an established feature of natural ecosystems. **If yes**, proceed with natural regeneration. **If no,** consider assisted natural regeneration.	**Consider the following:** ▪ Remove or reduce the density or frequency of grazing (wild and domestic) to support initial establishment, e.g.: complete exclusion for limited or extended period; deer management; trial introduction of predator species, e.g. lynx to control deer numbers. ▪ Ground preparation prior to colonisation to reduce competition with ground flora; ▪ Weed control during initial colonisation stages to reduce competition with ground flora; ▪ Re-introduce herbivores (wild and proxy/domestic) to reduce or produce selective vegetation competition.	

We propose a Three-Step Natural Regeneration Hierarchy as a practical model for decision-making as part of a broader rewilding approach where a species-rich mosaics of woodland, scrub and grassland habitats are allowed to regenerate over large landscapes

The decisions we make today will affect the lives of generations to come

Photography: Paul Harris/2020VISION

6. CONCLUSION: IMPLICATIONS FOR FUTURE POLICY AND PRACTICE

Urgent action is needed to address the climate emergency and extinction crisis and trees can help mitigate both as part of a species-rich mosaic of natural forests, woodland, scrub and open habitats. Evidence suggests that allowing woodlands to regenerate naturally could massively increase the scale of woodland creation across Britain at a fraction of the cost of tree planting.

If we let them, trees will plant themselves in their many millions over much of Britain – aided by small mammals, the wind and birds. This will create natural forests and woodlands better able to soak up carbon dioxide, support wildlife and adapt to a changing climate. Imported tree diseases, plastic tree guards, management costs and soil carbon loss would all be reduced. Britain's precious native woodland habitats, such as our temperate rainforests, would also be able to expand naturally across their range.

We recognise that natural regeneration is not a panacea. It may be decades in most places before a mosaic of forest, scrub and open habitats results but the transition can be surprisingly rapid once it gets underway. We recognise too that the exact trajectory of revegetation (in terms of species mix, location and density) is virtually impossible to predict in advance and that this unpredictability is a key barrier to natural regeneration becoming the preferred policy for woodland establishment in Britain.

However, natural regeneration surely has an important role to play in the expansion of Britain's natural forests and woodlands alongside tree planting. With its ability to enhance ecological function and complexity, natural regeneration is perhaps best understood as part of a broader rewilding agenda where natural processes are restored over large landscapes with assistance being provided only where needed. However, natural regeneration cannot be considered in isolation of broader social, cultural and economic issues. It must be part of a wider discussion about integrated landscapes, resilient communities and flourishing ecosystems.

WHAT REWILDING BRITAIN IS CALLING FOR:

- **Support natural regeneration as the default approach woodland expansion**

  We propose a Three-Step Natural Regeneration Hierarchy as a practical model for decision-making. This starts with natural regeneration as the default approach with tree planting as a support option where the natural regeneration of diverse habitats will not happen without it (see page 22):

- **Double woodland cover by 2030 for the benefit of people, nature and climate**

  We urgently need to see an expansion of nature's recovery across Britain to match the scale of the threats from accelerating climate heating and species extinction. We would like to see ambitious new targets for doubling woodland cover across Britain by 2030, from 13% now to at least 26%. We know we have more than enough suitable land[69] without impacting on peat, other precious habitats or valuable farmland.

  With natural and assisted regeneration as the default approach doubling woodland cover becomes highly achievable through a rapid expansion in the area of 'woodland in the making' where young woodlands are regenerating and growing into the natural forests and wildwoods of the future. Our National Parks and public lands should lead the way by establishing a mosaic of regenerating forest and woodland habitats at all scales alongside wetland, grassland, scrub and non-woodland trees.

- **Incentivise natural regeneration within an integrated approach to land use change**

  We would like to see a significant increase in investment in natural regeneration from public and private financing within a supportive regulatory framework. The current funding landscape for trees, woodland creation and forestry is complicated and uncoordinated. And yet the multiple benefits of natural forests and woodlands in terms of carbon drawdown and storage, flood mitigation, improved soil and water quality, habitat for wild species, nature-based livelihoods and well-being far outweigh the upfront costs. Faced with the combined climate and nature emergency, we can't afford not to spend more money on natural forest/woodland creation.

  This requires an integrated approach to land use that: protects existing natural forest; massively expands natural woodland regeneration; and incentivises high nature value land uses that maximise species diversity and sustain rural livelihoods. The future Environmental Land Management Scheme, and devolved government equivalents, should explicitly provide funding for the natural regeneration of forests and woodlands as well as the integration of trees and woodlands into farming systems via agroforestry, woodlots, woodland pasture, low impact silviculture etc. Rewilding Britain has proposed a rural payments mechanism that could help deliver this outcome in an earlier report[70].

  This should be supported through; a coordinated regulatory approach across agriculture, environment, forestry and planning; enabling funding mechanisms; and straightforward administrative requirements. And as a matter of priority we should also invest in addressing the evidence gaps in scientific research and carrying out opportunity mapping of the potential for natural regeneration across a range of scenarios.

APPENDIX 1: GLOSSARY OF TERMS

Afforestation: The process of establishing trees or woodland in an area where there was no previous tree cover.

Forest expansion: Expansion of forest on land that, until then, was under a different land use, implies a transformation of land use from non-forest to forest.

Natural forest and woodland: A forest or woodland that has reproduced naturally, consisting of non-native or indigenous tree species and strains.

Natural forest expansion: Expansion of forest through natural succession on land that was under a different land use. Implies a transformation of land use form non-forest to forest (e.g. forest succession on land previously used for agriculture).

Natural regeneration enhanced by planting: Natural regeneration that has been combined with artificial planting or seeding, either to ensure satisfactory restocking with the naturally regenerated species or to increase species diversity.

Natural regeneration: The regeneration of trees and woodland through natural processes (e.g. seed dispersal), as opposed to planting by people. It may be assisted by human intervention e.g. by scarification or fencing to protect against wildlife damage or domestic animal grazing.

Naturally regenerating forest: Forest predominantly composed of trees established through natural regeneration.

Planted forest: Forest predominantly composed of trees established through planting and/or deliberate seeding.

Regeneration: Re-establishment of a forest stand by natural or artificial means following the removal of the previous stand by felling or as a result of natural causes, e.g. fire or storm.

Scarification: A silvicultural technique used to help regenerating native trees. It involves different methods of disturbing the ground in a controlled way – for example, light digging, dragging, harrowing or trampling. Scarification also happens naturally – for example, through trees falling, wild boar rootling and flood waters scouring

Wildwood: An uncultivated wood or forest that has been allowed to grow naturally.

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