DOCTOR OF PHILOSOPHY

Emerging opportunities for native woodland expansion in Britain's crowded future landscapes

Bodner, Theresa

Award date:
2023

Awarding institution:
Bangor University

Emerging opportunities for native woodland expansion in Britain's crowded future landscapes

Theresa Bodner

School of Natural Sciences
College of Environmental Sciences and Engineering
Prifysgol Bangor University

Submitted in partial fulfilment of the requirements for the Degree of Doctor of Philosophy in Forestry

DECLARATION

‘I hereby declare that this thesis is the results of my own investigations, except where otherwise stated. All other sources are acknowledged by bibliographic references. This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree unless, as agreed by the University, for approved dual awards.

I confirm that I am submitting this work with the agreement of my Supervisor(s).’

‘Yr wyf drwy hyn yn datgan mai canlyniad fy ymchwil fy hun yw’r thesis hwn, ac eithrio lle nodir yn wahanol. Caiff ffynonellau eraill eu cydnabod gan droednodiadau yn rhoi cyfeiriadau eglur. Nid yw sylwedd y gwaith hwn wedi cael ei dderbyn o’r blaen ar gyfer unrhyw radd, ac nid yw’n cael ei gyflwyno ar yr un pryd mewn ymgeisiaeth am unrhyw radd oni bai ei fod, fel y cytunwyd gan y Brifysgol, am gymwysterau deuol cymeradwy.

Rwy'n cadarnhau fy mod yn cyflwyno'r gwaith hwn gyda chytundeb fy Ngoruchwyliwr (Goruchwylwyr)

SUMMARY

British woodlands today provide a variety of ecosystem services, from carbon sequestration for climate change mitigation all the way to recreation and flood prevention. Given that the country only has 13% woodland cover, there is a pronounced drive for woodland cover increase; 30,000 ha and more annual woodland creation are planned until 2050, not least to meet the UK government's Net Zero targets. While Britain has over 100 years' worth of experience with woodland creation already, realised woodland creation in recent years has significantly fallen short of its targets. The British landscape is a cultural and crowded landscape, where most every piece of land already serves a range of land covers and land uses; integrating many thousand hectares of new (often native broadleaf) woodland into this complex landscape is difficult, as it may elicit undesirable trade-offs. As one potential solution, natural colonisation, i.e. the colonisation of trees on previously non-wooded land, is being introduced as a cheap and easy way to create structurally diverse woodlands (especially compared to active planting). Championed by the rewilding movement, natural colonisation is a relatively new approach to expanding woodlands and knowledge on its extent and how much it can really contribute to Britain's woodland expansion plans is limited to non-existent.

This thesis explored emerging opportunities for native woodland expansion in these crowded future landscapes to help shed light on potential ways forward. In doing so, it analysed historic drivers of woodland expansion in Britain, including afforestation targets and realised afforestation, to understand legacies of forestry history and valuable lessons to learn for the future. It also focussed on the approach of natural colonisation by using a landscape-scale case study area in North Wales as a basis for an investigation of existing spatial data and observational site visits, as well as a grounded theory approach and semi-structured interviews with farmers and other land managers on the extent and potential of natural colonisation in creating new native woodlands.

A key finding of this research is that woodlands today must provide more (diverse) benefits than ever before and must do so in a time with more competing interests than ever. Furthermore, this increased complexity is the main reason why realised afforestation has been falling short (compared to the targets) since the 1980s, and an overreliance on woodland creation targets remains ill-advised until there is a clear plan on what trade-offs will be accepted on a national, regional, and local level in the pursuit of native woodland expansion. Such considerations must also include a revision of the metrics used for these woodland expansion

targets, as the amount of land covered in trees has no linear relationship anymore with the provision of those ecosystem services new woodlands will be created for.

What the complexity of woodland expansion drivers also did, however, is offer new possibilities of creating native woodlands, specifically via natural colonisation. Unlike what might have been the case in the 20th century, natural colonisation can now provide a range of benefits 21st century woodland expansion in Britain is looking for. A key finding of this research is that natural colonisation can unlock areas of woodland expansion where active planting is not suitable; more so, unintended natural colonisation is able to circumvent land management barriers that hinder other options of woodland expansion. Natural colonisation cannot yet be found on any available spatial datasets on tree cover, but recent natural colonisation already exists, and a lot of it matches areas identified as woodland expansion opportunities.

Overall, natural colonisation should be emancipated as an equal and valid approach to 21st century native woodland expansion. It is an embrace of the crowdedness of the British landscape and its drivers, where no one ‘perfect’ woodland fits all, but the more options available for expanding woodlands, the more likely the targets and plans, whichever way they will look like, can be achieved.

ACKNOWLEDGEMENTS

ENGLISH

This thesis is the calumniation of not only one degree, but of over 10 years I spent in the academic world; and I regret nothing. I found some of my greatest friends, challenges, and opportunities during the making of this thesis, and I think it has made me both a better scientist and a better person.

To make it this far, and not drown in imposter syndrome, uninformed optimism, data limitations, Covid, bureaucracy, and my inability to use caffein as a stimulant drug because I just really don't like the taste of coffee, I will forever be indebted to a great many people.

Let's start with a minor character, although I'm sure he would think of himself as the most important one in this story. To my neighbour's cat, who loves to jump on my desk precisely whenever there is *no* space to do so – thanks for deleting that one paragraph, I guess my thesis will have to do without it.

Then, of course, two very important people; I was lucky to get two supervisors as supportive as Norman and Sophie. With a PhD that offered as much freedom to define my own project as this one did, Norman and Sophie are the reason why I was able to pursue the best possible research without getting lost in the details. I hope you will have other PhD students, as I am sure they will agree with me – you are awesome!

To my partner Josh, who regularly rolls his eyes at my geeking out over science – you may now call me *Dr* smartass, thank you very much.

To my brother, the true smartass in the family, and to my uncle, whose transcending coolness I could only dream of having. To my friends, especially the ones who kept me sane in those special PhD moments (looking at you, *ffrind*). I could not have survived without you.

And finally, the two people who shaped much of who I am today.

To my father, who has spent decades in the forest and probably knows more about them than all academic books put together – you will forever inspire me to be a knowledge junkie.

And to my mother, who still teaches me how to be my own person, and whose resemblance I wish to see every time I look in the mirror – I will always love you and give the dogs a kiss for me.

GERMAN

Meine Doktorarbeit ist nicht nur das Ergebnis von drei Jahren harter Arbeit, sondern auch von über zehn Jahren, die ich in der akademischen Welt verbracht habe. Und ich muss sagen, ich bereue nichts.

In meiner Zeit in der wissenschaftlichen Welt bin ich besten Freunden, großen Herausforderungen und noch größere Möglichkeiten begegnet, und ich glaube, dass mich diese Erfahrungen nicht nur eine bessere Wissenschaftlerin, sondern auch einen besseren Menschen gemacht haben.

Um es überhaupt so weit zu bringen, und nicht am Imposter Syndrome, uninformiertem Optimismus, unvollständigen Datensätzen, Covid, seltsamer Bürokratie oder meiner Abneigung von Kaffee als Aufputschmittel zu scheitern, brauchte es eine ganze Menge Leute, für deren Unterstützung ich ewig dankbar sein werde.

Am besten starten wir mit einem Nebendarsteller, obwohl er selbst wahrscheinlich davon überzeugt ist, der Wichtigste zu sein: Spencer, der Kater meiner Nachbarin. Vielen Dank dafür, dass du immer dann auf meinen Schreibtisch gesprungen bist, wenn der grade bis obenhin voll *geräumt war. Ich schätze, meine Doktorarbeit wird wohl ohne die halbe Seite auskommen müssen, die du gelöscht hast.*

Als nächstes muss ich natürlich meine zwei Professoren erwähnen: Norman und Sophie. Mein PhD Projekt hat es mir ermöglicht, vieles meiner Arbeit frei zu entscheiden, deshalb bin ich umso dankbarer für euren Rat und dafür, dass ihr mich davor bewahrt habt, mich in irgendwelche Nebenschauplätze zu verlaufen. Ich hoffe, ich werde nicht eure letzte PhD Studentin sein, denn ich seit ein Spitzenteam!

Vielen Dank geht an meinen Partner Josh, der es all die PhD Jahre mit mir aushalten musste – von jetzt an kannst du mich gerne ***Doktor*** *Klugscheißer nennen, herzlichen Dank.*

Dann ist da noch mein Bruder, der wahrhaftige Klugscheißer der Familie, und mein Onkel, von dessen Style zu haben ich nur träumen kann. Vielen Dank geht an meine Freunde, ganz speziell die, die mich in diesen ganz besonderen PhD Momenten davon abgehalten haben, meinen Verstand zu verlieren. Ohne euch hätte ich es nicht überlebt.

Und am Schluss, klarerweise, die beiden Menschen die in vielerlei Hinsicht dafür verantwortlich sind, dass ich heute so bin wie ich bin.

Vielen Dank an meinen Vater, der seinerseits Jahrzehnte im Wald verbracht hat und wahrscheinlich mehr über sie weiß als alle meine akademischen Bücher zusammengenommen – du wirst mich für immer dazu inspirieren, noch mehr lernen zu wollen.

Und, most importantly*, meine Mutter, die mir bis heute noch beibringt, ich selbst zu sein, und deren Ebenbild ich gerne sehe, wenn ich in den Spiegel schaue. Ich werde dich immer lieben und gib den Hunden einen Kuss von mir.*

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

AOI	Area of Interest
ALC	Agricultural Land Classification
APRS	Association for the Preservation of Rural Scotland
CAP	Common Agricultural Policy
CPRE	Council for the Preservation of Rural England
CPRW	Council for the Preservation of Rural Wales
FC	Forestry Commission
FLD	Friends of the Lake District
NFI	National Forest Inventory
NFM	Natural Flood Management
NFP	National Forest Park
NRW	Natural Resources Wales
NTM	National Tree Map™
SoNaR	State of Natural Resources
SSSI	Site of Special Scientific Interest
UK	United Kingdom
WEO	Woodland Expansion Opportunity
WEOM	Woodland Expansion Opportunity Map
WES	Woodland Ecosystem Service
WWNP	Working with Natural Processes

1 GENERAL INTRODUCTION

This thesis is an exploration of the emerging opportunities for native woodland[1] expansion in Britain's crowded future landscapes. Compared to a European Union (EU) average of 38% of national land cover as of 2018, woodland cover in the United Kingdom (UK) only extends to about 13% (FC, 2018a). Policy makers, practitioners, scientists, and other stakeholders make a strong case for a significant expansion of woodlands in the UK (Duckett *et al.*, 2016; The Scottish Government, 2016; DEFRA, 2018). The reasons for this are diverse, as woodlands provide a broad range of environmental, economic, and social benefits. These benefits are often conceptualised as ecosystem services (ES), linking ecosystem function to their impact on human wellbeing. According to Sing et al. (2018), the main woodland ecosystem services (WES) pursued as part of British woodland expansion are climate mitigation (carbon storage), biodiversity conservation, flood protection, timber supply (including fibre and biomass), recreation, and detoxification of water an air. As of the writing of this chapter in 2022, the UK government pledged to create 30,000 ha new woodland (or more) each year until 2050 (DEFRA, 2020b).

The British landscape, however, is a cultural and 'crowded' landscape. Crowdedness in this context is defined as the presence of a variety of land uses and derived benefits, which are all actively articulated and whose values are recognised by relevant policies. On a broad level agriculture already takes up 72% of the land, existing woodlands cover 13% and built-on environments cover 6% (Savillis, 2019). There are also large protection sites based on cultural and natural values that provide ecosystem services unrelated (or with limited relation) to woodland biomes. For example, many national parks in Britain showcase and preserve a naturally and culturally valued *open* landscape character, which puts large-scale woodland expansion at a disadvantage (Cox *et al.*, 2018; Gold, 2019).

Woodland expansion in the pursuit of ecosystem service delivery therefore must fit into a crowded landscape, where 'fitting in' is not only the provision of additional benefits but also the avoidance of disproportionately displacing those ecosystem services that were present already (Hardaker, 2018; Hardaker, Pagella and Rayment, 2021).

Calls for woodland expansion in Britain have been revived since the 2010s (DEFRA, 2013; Scottish Government, 2017; Welsh Government, 2018), but the country has been pursuing the expansion of its woodlands since the early 20th century. *The seasons in the past were different,*

[1] the term 'woodland' and 'forest' are used in different context in Britain, but generally describe an area bigger than 0.5 ha with more than 20% tree cover (see section **2.1.2** for more).

such as employment in rural areas, supply of timber in case of another war, or a renewed interest in native broadleaves, but the legacies of this history influence future plans (Tsouvalis, 2000; Oosthoek, 2013). The biggest historical impact on afforestation rates comes from large-scale conifer plantations, mostly in the upland regions of Britain. What was understood as appropriate acts of afforestation by responsible authorities at the time, fell into heavy disfavour later on (or immediately thereafter) due to the negative impact it had on other ecosystem services. An example of this is the Lake District in England, where afforestation was petitioned to a halt in the 1930s due to its negative impact on the highly valued small-scale and mosaic farming landscape of the area (Oosthoek, 2013). Another example is the afforestation of the 'Flow Country' in Scotland in the 1980s, which was seen as the cause for the "*most massive loss of wildlife habitat since the Second World War*" (Oosthoek, 2013, p. 157).

This history makes woodland expansion a topic potentially loaded with worries about not repeating past mistakes. Farmers, being important stakeholders for woodland creation due to the amount of land governed by agricultural land uses (Sing, Towers and Ellis, 2013; Graham *et al.*, 2017), express reservation about new conifer plantations (mostly using non-native trees), about (renewed) displacement of farming by forestry and the related loss of natural and cultural value derived from a farmed landscape (Lawrence and Dandy, 2014; Thomas *et al.*, 2015).

The discourse around woodland expansion in Britain today is not what it was in the 20th century. Due to the changed drivers for woodland expansion and past legacies, much greater emphasis is put on native woodland, and on alternatives to plantation woodlands. Natural colonisation of trees on previously non-wooded land is one of these proposed alternatives, seen as a cheap and easy way to produce native and structurally diverse woodlands (Rewilding Britain, 2020; Woodland Trust, 2020). We also need to consider Brexit, which is resulting in the cessation of high-level EU policies like the Common Agricultural Policy (CAP), thus creating space for new policies that will determine where new woodlands will be possible in Britain's future (Burton, Moseley, *et al.*, 2018). For example, the new Sustainable Farming Scheme in Wales and the Environmental Land Management Schemes in England all set out intentions for woodland creation (DEFRA, 2021a; Welsh Government, 2021c).

1.1 Research rationale

The amount of woodland created in Britain in recent years is merely one third of what is desired and far below what is planned going forward (Forest Research, 2020b). Furthermore, it is unevenly distributed between the countries, with most of the new woodland creation taking place in Scotland (Forest Research, 2020b). Questions remain around how different the plans for woodland expansion in Britain should be compared to its past, and why. Questions also remain around how future woodlands can be best integrated into a crowded landscape, and what role new approaches like natural colonisation will play.

Although the general history of woodland expansion in Britain is well known, a rigorous exploration is lacking of the changing drivers of woodland expansion that governed the 100-year increase from 4.8% in 1905 to 13.5% woodland cover in the new millennium (FC, 1921; Forest Research, 2020b), and what this legacy may say for the future of woodland expansion in Britain.

There is also no comprehensive collation of data of realised afforestation over these 100 years. The first national afforestation target of the 20th century in Britain was introduced in 1919 (FC, 1930), and many followed since, but there is little analysis of whether (and how much of) the targets were actually realised. Given that woodland expansion targets have once again become important pillars of planning future woodland – so much so that recent electoral candidates tried to outdo each other with the most ambitious targets (BBC, 2019; Lyon, 2019; Shrubsole, 2019) – this is vital information to understand what the future targets might say about how much new woodland there will really be.

Based on this history, plenty of research has gone into active planting for woodland creation, ranging from operational all the way to cultural considerations (Quine and Watts, 2009; Lawrence and Dandy, 2014; Hardaker, 2021b). Much less is known about natural colonisation, which is being increasingly widely advocated as a strategy for 'creating' new woodlands. It is unclear how much natural colonisation there is in Britain, and whether, despite it gaining much popularity in principle (Rewilding Britain, 2020; Woodland Trust, 2020), it really fits in with how and where future woodlands might be created in Britain.

More so, natural colonisation is based on a different, often more indirect approach to land management (Crouzeilles *et al.*, 2020; FC, 2021). Scientific and policy inquiries into land managers' perspectives on creating woodlands focus almost exclusively on active planting, especially when engaging with farmers. It is important to understand whether they think differently about using or facilitating natural colonisation, as this could uncover potential opportunities for native woodland expansion beyond what active planting might be (or has been) able to.

1.1.1 Aim and research questions

The overall aim of this thesis is to explore emerging opportunities for native woodland expansion in Britain, in order to contribute to the discourse around woodland expansion and the potential future of woodlands in Britain. The focus is hereby on the influence of historic legacies, and, to contrast it, natural colonisation as a novel approach to native woodland expansion in Britain.

Therefore, this research is focused around four research questions:

1. What were the main drivers of woodland expansion in Britain from 1919 to 2019 and what are the implications of this for Britain's future woodland expansion plans?
2. How much afforestation was achieved in Britain in the last 100 years, and how does this compare to future woodland expansion plans?
3. What is the coverage of natural colonisation in existing spatial data, and what does this say about its potential contribution to woodland expansion?
4. What do farmers and other land managers think about how natural colonisation could or could not be integrated into future land management?

1.1.1.1 Objectives

The overall objective of this thesis was to identify the impact of past legacies on future woodland expansion and contrast them with natural colonisation as a novel approach to native woodland expansion. Corresponding to the research aim and the four research questions, the research objectives were as follows:

1. Identify drivers of woodland expansion in Britain between 1919 and 2019 from historic accounts and compare them to future plans, in order to derive important lessons to learn from the past.
2. Compile afforestation targets and data in Britain between 1919 and 2019 from archived records and compare them to future targets, in order to understand how ambitious and realistic these targets really are.
3. Compile existing spatial maps of tree cover in Britain and combine them with observational data and site visits, in order to critically assess the spatial extent of and opportunities for natural colonisation.
4. Undertake interviews with farmers, other land managers and key informants about their view on natural colonisation, in order to critically assess whether and how natural colonisation could be integrated into future land management.

1.2 Chapter outline

The general introduction in **Chapter 1** and the final discussion and conclusion in Chapter 7 frame the whole thesis and synthesise the different research components.

Chapter 2 presents a literature review that details European trends and developments around woodland expansion, followed by a comprehensive view on contemporary woodland expansion in Britain, especially considering aspects unique to British woodland expansion, of which natural colonisation now makes up an important element.

Chapter 3 presents a comprehensive review of historic accounts of the history of British woodland expansion from 1919 to 2019 (research objective 1). It uses the DAPSI(W)R(M) framework to identify the main drivers for woodland expansion (Elliott *et al.*, 2017), how they changed over time, and what lessons can be drawn for woodland expansion in Britain's future.

Chapter 4 uses digitised archives to extract and compile 100 years' worth of officially recognised afforestation targets and afforestation data (research objective 2). The data is then critically assessed to understand what might be expected of the current woodland expansion targets and their potential translation to realised future woodlands.

Chapter 5 presents mixed-method research on the spatial extend of natural colonisation in Britain and its possible place in the country's spatial woodland expansion plans (research objective 3). An upland area in Wales (the Carneddau) is used as a case study for this, together with existing spatial data as well as primary data from observations and site visits.

Chapter 6 builds on chapter 5 and presents qualitative research from the same case study area on farmers' and other land managers' perspectives on natural colonisation and its potential integration into future land management (research objective 4). Semi-structured interviews with farmers, other land managers and key informants, as well as further site visits were used to understand the complex network of decision power and interests governing natural colonisation and its integration to woodland expansion.

Chapter 7 draws the research together in an integrated discussion and conclusion. It generates insights and recommendations, and seeks to synthesise knowledge that has been gained from the different chapters.

2 LITERATURE REVIEW

2.1 Woodland expansion as a trans-national agenda

The perceived importance of woodlands in delivering future ecosystem services is not a British feature alone. In September 2018 the Swiss newspaper NZZ published an article titled "*forests can be a huge contributor to climate change mitigation*" (Denzler, 2018, translated by Bodner). Two months later an article in the British Guardian read "*Tree planting in UK 'must double to tackle climate change'*" (Carrington, 2018); and just in the first months of 2019 students all around Europe were skipping school under the banner of 'Fridays for Future' and demonstrating for climate change agendas with slogans like "*less concrete & more woodland*" (Wieser, 2019 translated by Bodner), "*Plant a tree*" (ZUMA Press, 2019a), and "*Plant more trees, clean the seas, help the bees*" (ZUMA Press, 2019b).

As of 2019 the notion of woodlands being an integral part of climate change mitigation seems firmly embedded in public perception (Burton, Moseley, *et al.*, 2018). Climate change mitigation is, however, only one (if currently prominent) woodland ecosystem service (WES) which governments and the public have become interested in (UK NEA, 2011a). In 2018 Sing et al. (2018) identified the most commonly cited WES in British policy papers to argue in favour of woodlands and woodland expansion (e.g. Forestry Commission Wales, 2009; The Scottish Government, 2016; DEFRA, 2018); next to climate change mitigation these are "*timber and wood fuel supply, biodiversity, water quality, recreation, soil protection and flood prevention*" (Sing *et al.*, 2018, p. 153).

A comparison to other European countries, such as Germany or Switzerland, shows very similar lines of argument (apart from flood protection, Sing *et al.*, 2018); even more so, since the second half of the 20th century the influence of international policies on national forestry policies in Britain has grown steadily (Raum and Potter, 2015).

2.1.1 Large scale trends of woodland expansion in Europe

Land cover change from and to woodland has been an ongoing theme in many European countries during the last century and leading up to now, though different areas exhibit different patterns of change[2] (Gerard *et al.*, 2010).

One prominent spatial factor of land cover and land use change in many European countries is urbanisation. Its extent and the land cover type it transforms (mostly farmland or woodland) varies highly on national and local context (e.g. Lavalle *et al.*, 2001; EEA, 2002; Gerard *et al.*,

[2] Gerard et al. (2010) considered the whole geographical area of continental Europe, with the exclusion of Russia and Iceland.

2010). In a study by Lavalle et al. (2001) looking at the peri-urban zone of 27 large European cities the increase in urbanisation ranged from 25% (Ruhrgebiet, Germany) to 270% (Algarve, Portugal) between 1950s and 1990.

In turn it is often agriculturally less favourable areas that turns into woodland, either by active planting or passive natural colonisation (Gerard *et al.*, 2010; e.g. Alix-Garcia *et al.*, 2016). The EU-27 countries[3] (including Switzerland) lost around 19% of cropland and 6% of pastures and semi-natural grassland to other land uses between 1950 and 2010, a big part of which (though not exclusively) being grassland to woodland and cropland to woodland conversions (Fuchs *et al.*, 2013).

Farmland abandonment is also a common pattern of land cover and land use change, to the point where, for example, the impact of naturally colonised woodland on landscape aesthetics in popular Italian tourist destinations has made it into British newspaper ("Rapid rise of forests changes the landscape for Italians"; Squires, 2014). Specific numbers on the extent of abandonment are different between publications – Verburg and Overmars (2009b) talk about 10 to 29 million ha being released in the EU-27 countries[3] between 2000 and 2030, whereas the FAO (2008) estimates 20 million ha alone to have been abandoned after the end of Socialism in the countries of the former Soviet Union.

The question of what will happen with said abandoned farmland is similarly multifaceted. Many European policies try so slow or halt the process of abandonment and focus on retaining extensive agricultural systems (EEA, 2004; Ceausu *et al.*, 2015). These policies usually argue in favour of the fauna and flora biodiversity the current land use supports and the cultural attachment that is based on it (Fischer, Hartel and Kuemmerle, 2012; Navarro and Pereira, 2012). In fact, 31% of Natura 2000 sites in the EU-27 countries[3] result from agricultural land management (Rey Benayas and Bullock, 2012).

A study by Terres et al. (2013, p. 84) for the European Commission defined farmland abandonment as "*[...] a cessation of management which leads to* undesirable *changes in biodiversity and ecosystem services*". The transition to woodland is seen as negative for biodiversity conservation by creating "*species-poor and more homogenous vegetation types*" (Terres, Nisini Scacchiafichi and Anguiano, 2013, p. 84). Despite this and the measures that come with it, farmland abandonment is projected to continue in the future (Kuemmerle *et al.*, 2011; Alix-Garcia *et al.*, 2016; McGinlay, Gowing and Budds, 2017), mostly due to continued globalization of agricultural markets and reduced support for agriculture in Europe (Westhoek, van den Berg and Bakkes, 2006; Verburg and Overmars, 2009).

[3] The EU-27 countries refer to all EU member states between 2007 and 2013, when Croatia had not yet joined, and the United Kingdom had not yet left the European Union.

A different way of looking at the issue of agricultural land abandonment and land cover and land use change has been proposed by advocates of rewilding (Navarro and Pereira, 2012). A concept originating in North America, in Europe the idea of rewilding has focused on the "[…] *restoration of large, connected wilderness areas that support large, wide-ranging animals*" (Corlett, 2016, p. 455). Especially in Europe most rewilding projects are future oriented (compared to other approaches such as restoration or reintroduction), and to create a "*wildness (autonomy, spontaneity, self-organisation, absence of human control*)" (Corlett, 2016, p. 455). So, while rewilding does not exclude human intervention, to push an ecosystem in a desired direction, one goal may well be to "*embrace whatever non-interventions brings*" (Lorimer *et al.*, 2015, p. 45).[4] As this approach is also being discussed in Britain as a way to establish new woodlands, it is returned to in section **2.2.3**.

2.1.1.1 Woodland expansion as a tool for ecosystem service delivery

The Millennium Ecosystem Assessment (2005, p. 27), defined ecosystem services (ES) as "*benefits humans derive from ecosystems*", sub—categorizing them as supporting, provisioning, regulating or cultural services. Woodland ecosystem services (WES), therefore, cover all benefits derived from woodlands. In other European countries as well as Britain, WES mentioned most often in policy documents include climate mitigation (carbon storage), biodiversity conservation, flood protection, timber supply (including fibre and biomass), recreation, and detoxification of water an air (Sing *et al.*, 2018). The case for more woodlands (i.e. woodland expansion) builds on the desire to have more of these WES perceived as priority (UK NEA, 2011b), or to bring them into existence if they have not been present before (Thomas *et al.*, 2015; Sing *et al.*, 2018). This, as Thomas et al. (2015, p. 151) point out, is *"[...] contingent upon the implicit assumption that new woodlands are beneficial*" in the first place, i.e. that they will actually deliver the desired WES in a desired quality and quantity.

Various publications point out that the provision of a WES may vary highly depending on species composition, slope, soil characteristics, management regime, etc. (Ratcliffe, 2011; Mason and Connolly, 2014; e.g. Zanchi *et al.*, 2014). For example, Burton et al. (2018, p. 366) concluded in an extensive literature review that while there is good scientific evidence on the positive effect of reforestation on climate mitigation, further evidence is still needed on the "*effect of afforestation on multiple ecosystem services, cultural, and provisioning services*".

[4] Natural colonisation may be part of rewilding and succeed farmland abandonment, but while natural colonisation focuses on tree establishment, rewilding considers wider ecological processes including human intentionality, and farmland abandonment focuses on the retrospective loss of intentionality and management. More on this in section **2.2.4.1**.

Not all priority WES can be maximised at the same time either (Sing *et al.*, 2018), creating an internal trade-off where the maximisation of one WES might have to be ‘sacrificed’ in favour of another (e.g. maximisation of timber and wood fuel supply or maximisation of biodiversity). Additionally, the provision of ecosystem services from woodlands may differ significantly from those ES provided by other types of land cover or land use change, meaning that the increase in WES may come at the cost of those ecosystem services that had been delivered by the land before the afforestation or reforestation took place (Gimona and Van Der Horst, 2007; Ricketts Hein, Thomas Lane and Williams, 2017). These external trade-offs go far beyond the boundaries of woodlands alone, which demonstrates why the ecosystem service approach itself strives to be “*more accurately reflecting the multiscale and integrative nature of the environment*” (Quine, Bailey and Watts, 2013, p. 865).

2.1.2 Woodland expansion in a British context

British trends of land cover and land use change, especially in the ways they divert from those on a European level, will be discussed below. Firstly, however, a note on terminology is necessary.

In Britain, there are the terms ‘forest’ and ‘woodland’. In public documents they are often used interchangeably, and a common, official, definition is:

> *“Land under stands of trees with a canopy cover of at least 20% (25% in Northern Ireland), or having the potential to achieve this, including integral open space, and including felled areas that are to be restocked. Generally (including the UK) woodland is defined as having a minimum area of 0.5 ha.”*
> (FC, 2018c, p. 12)

The criteria of what constitutes a woodland/forest may be different in other countries; in Ireland, for example, a woodland/forest only needs to cover an area above 0.1 ha, not 0.5 ha (Forest Service, 2013).

Despite the shared official definition of the two terms in Britain, however, there is a slight nuance in how they are used in day-to-day life. Due to historical and cultural developments the term ‘forest’ today often tends to be about either “*large woodland areas (often conifers) or old Royal hunting preserves such as the New Forest or the Forest of Dean*” (FC, 2018a, p. 7). A ‘woodland’, on the other hand, tends to imply a lot of broadleaved tree cover and/or “*smaller elements of a landscape where open space is dominant*” (Scotland’s Environment, 2019).

For reasons of consistency this thesis will refer to all land fitting the current British definition of a forest/woodland as ‘woodland’, except for when the circumstances dictate otherwise (e.g. proper names or direct quotations using the term ‘forest’).

Given the focus of this research on the expansion of native woodlands, the term 'native' also needs to be discussed. The FC (2018c, p. 8) offers the following definition for a native species:

> *"Species that arrived and inhabited an area naturally, without deliberate assistance by man. For trees and shrubs in the United Kingdom usually taken to mean those present after post-glacial recolonisation and before historic times. Some species are only native in particular regions – hence locally native."*

The FC does not further define when historic times start in this context, but other publications mention the year 1500 AD as a threshold, after which newly introduced species would be classed 'non-native' (Goodenough, 2013; JNCC, 2021). The problem with this definition is that there is a lot of arbitrariness to it. For example, critics point out that trying to pinpoint the moment just before "*significant human civilization*" (Brown, 1997, p. 192) requires drawing a very subjective line on a spectrum of continuous historical development (Fall, 2017). Furthermore, given that ecosystems are in constant flux, especially in the fast-changing Anthropocene of the 21st century (Barnosky *et al.*, 2017), the implication that all (tree) species have a certain geographical space where they 'belong' seems difficult to maintain (Gibbs, Atchison and Macfarlane, 2015). Forces like climate change call key arguments of native species, such as them being "*optimally adapted to their location*", into question (Warren, 2021, p. 5).

Studies like Warren (2021) or Goodenough (2010) also criticise the value system attached to the 'native' vs. 'non-native' approach which seems to assume that in principle native species are 'good' and non-native species are 'bad'. Indeed, some non-native species turn out to be invasive, i.e. they "*expand their range vigorously, outcompeting others*" (Warren, 2021, p. 2). Proponents use this as a reason to reject any non-native species, while critics argue that would omit the myriad of non-native species which are not invasive and/or even beneficial (Chew, 2015; Vellend, 2017; Sagoff, 2020). Additionally, studies have shown that people value (tree) species based on a complex interplay of ecological, cultural, economic, and other factors which go far beyond the origin of a species in time and space (Kueffer and Kull, 2017).

The reasons why this present research still focuses on 'native' woodland expansion – i.e. woodlands comprised of species considered native to Britain as per the FC definition – is because the term is an important component of contemporary woodland expansion plans. Specifically, publications often insist on most of new woodlands being comprised of 'native' species (this is also often in conjunction with them being broadleaved species). For example, the England Trees Action Plan wants to continue planting trends "*for majority native broadleaved woodlands*" (UK Government, 2021, p. 3). In Scotland, the plans insist on 30-

50% of all new woodlands being native (Scottish Government, 2017, 2018), and in Wales the plans give priority to creating "*both native and mixed woodlands that can deliver multiple benefits*" (Welsh Government, 2018, p. 21).

Native, as the FC defined it above and despite all the arbitrariness that has been pointed out, is still the prevalent framing for a lot of woodland expansion plans. Nonetheless, when conducting the research in this thesis, specific issues around the concept emerged, which is why at certain points a critical reflection on the term will be picked up again.

Lastly, a short note on the definition of 'uplands' in a British context. There is no widespread consensus on where exactly the uplands start and end (e.g. when drawn on a map), but there are definitions based on climate, land use, topography, or vegetation character (BTO, 2020; Hardaker, 2021a). It is mainly an area *"where farming becomes marginal and profitability is constrained due to a variety of natural handicaps (including climate, altitude, slope, short growing season and poor soil fertility)"* (Hardaker, 2021a, p. 7). Orr et al. (2008) created a map that outlines a general presentation of upland areas in Britain (**Figure 2-1**), which will be used a reference in this thesis.

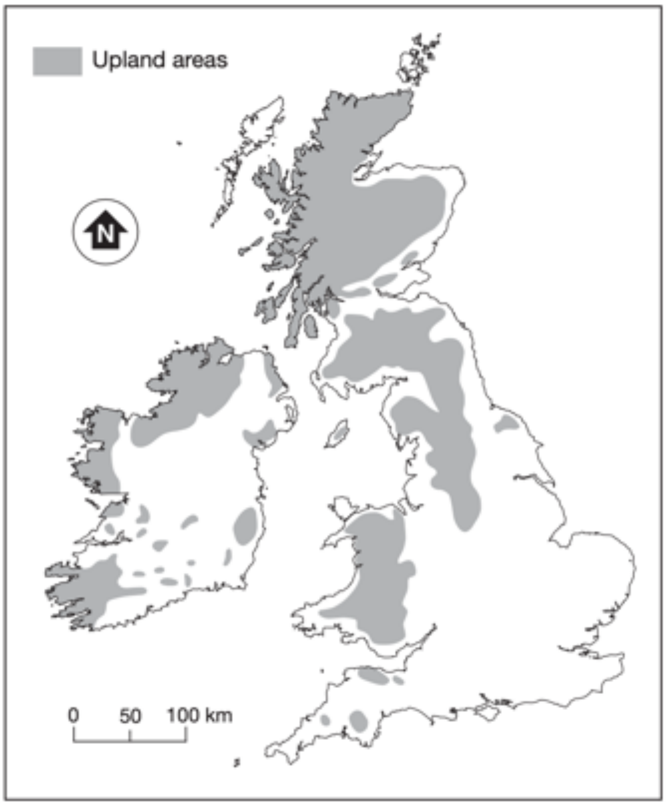

Figure 2-1. General representation of upland areas in Britain. Map taken from Orr et al. (2008).

2.1.2.1 Large scale trends of woodland expansion in Britain

According to Bibby (2009, p. 56), who looked at land use changes over a 25-year period, urbanisation taking land from agriculture was "*historically low*" in Britain, whereas there was a "*transfer from agriculture to forestry and woodland, especially woodland within agricultural holdings [...]*". Since 1981, the area of farm woodland in Britain more than tripled, with most of this expansion taking place in Scotland (FC, 2018a).

This small-scale woodland expansion interacts with another phenomenon prevailing within the British landscape, namely the issue of woodland fragmentation (Peterken, 2002; e.g. Watts, 2006). In 2006 75% of British woodland lots - a 'lot' being an area of woodland owned by an individual owner – were less than 2ha in size (Watts, 2006), though they only made up 5% of the national woodland area (and a small number of woodland lots with over 100 ha making up nearly 65% of the total woodland area). For comparison, in Germany 75% of woodland lots are bigger than 20ha (BMEL, 2015). Consequently, British woodlands have a significantly higher rate of edge to core ratio and more 'surface area' to communicate with other types of land uses and covers (Wade *et al.*, 2003; Watts, 2006).

Due to the fragmentation, there is also ample tree cover outside woodlands, i.e. single trees and groups of trees less than 0.5 ha in size (and thus not meeting the criteria to be termed 'woodland', see above), but data on this tree cover is limited. One study from 2017 suggests these trees cover an additional 3.2% of total Great Britain land area (Ditchburn and Brewer, 2017a). Despite not falling in the 'woodland' definition these (in parts newly planted) single trees and small groups of trees (< 0.5 ha) on farmland may, however, increase connectivity between existing and potential future woodland fragments.

Conversely, woodland has only lost minor areas to agriculture; the main contemporary reasons for woodland loss (in 2006-2015) have been mineral extraction and quarrying, residential developments, transport developments, industrial developments and wind farm developments (Ditchburn *et al.*, 2016).

As of 2019 in total 72% of the UK's land cover is in agricultural use (permanent grass, arable cropping, etc.), while 13% are covered in woodland and 5.9% are built-on (Savillis, 2019). The 13% of woodland (3.17 mha) break down to 45% of it in Scotland, 41% in England, 10% in Wales and 4% in Northern Ireland (FC, 2018a). Conifers as the principal species make up about 51% of the UK's woodland area, with a significantly higher percentage of 74% in Scotland (FC, 2018b).

2.1.2.2 The history of woodland expansion in Britain

After the last ice age, Britain is estimated to have been recolonized with woodland that covered almost its entire land area (Kaplan, Krumhardt and Zimmermann, 2009; Ditchburn *et al.*, 2016), and significant parts of Britain have been deforested long before the Industrial Revolution (Kaplan, Krumhardt and Zimmermann, 2009). At around AD 1850 England & Wales together where down to 1.9% of woodland cover on agriculturally suitable land (**Figure 2-2**); Scotland was down to 0.1% (Kaplan, Krumhardt and Zimmermann, 2009).

With the Napoleonic Wars in the 19th century and then even more by the turn of the 20th century British woodland was depleted. It was then after the First World War that the continuous shortage of softwood timber prompted the government to set up the Forestry Commission (FC) in 1919; a central and self-governing Forestry Authority whose goal it was to create a "*strategic reserve of timber*" (Aldhous, 1997; Tsouvalis, 2000, p. 35).

In the subsequent decades it was pure conifer plantations that were established, partly also because 'scientific forestry' as it had been understood at the turn of the 20th century had effectively labelled mixed or broadleaved forests as "*primitive*" and "*outdated*" (Aldhous, 1997; Tsouvalis, 2000, p. 39).

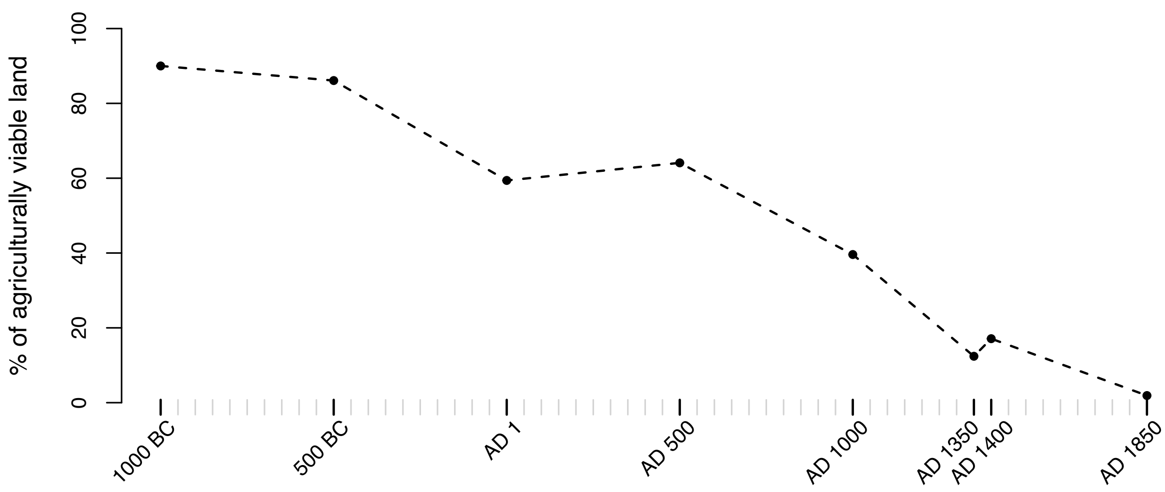

Figure 2-2. Woodland cover change on agriculturally viable land before the Industrial Revolution. Data is taken from Kaplan et al. (2009).

This approach to afforestation (creating big blocks of land planted with conifer plantations) was to become a key criticism of the FC's work (Aldhous, 1997; Tsouvalis, 2000; Thomas *et al.*, 2015). In England and Wales afforestation started to decline after the 1960s; public opposition became too strong and land prices too high (Tsouvalis, 2000). With the development of the tax avoidance potential of forestry in the latter half of the 20th century, however, vast areas of upland land were afforested as "*living tax sinks*" often for international investors who were more interested in tax benefits than in plantation management (Tsouvalis, 2000, p. 77).

Further criticism of conifer plantations in the latter half of the 20th century focused on hardwood woodland in England that, after having been through the value transformation from being 'the heart of England' (19th century) to 'outdated wasteland' (beginning of 20th century), was now relabelled as high value 'ancient woodland' (Tsouvalis, 2000).

Especially since the need for a 'strategic reserve of timber' subsided, the FC gradually adapted its goals and management objectives to suit the changing public interest – firstly towards employment in rural areas, then onwards to 'multifunctional' forest management, and eventually 'sustainable forest management' and landscape scale approaches (Tsouvalis, 2000). Raum and Potter (2015) who looked at changing forestry policies user the term forest 'policy paradigm' for this, i.e. "*a dominant belief structure that organises the way people perceive and interpret the functioning of the world around them*" (Milbrath, 1984, p. 7). Changes in these paradigms can be of different severity, with the most drastic one being a paradigm shift which entirely changes policies and underlying priorities (Raum and Potter, 2015).

As of 2018 the devolved units of the Forestry Commission (Scottish Forestry, Forestry and Land Scotland, Forestry England, Forestry Commission England and Natural Resources Wales) still have significant influence in active woodland expansion and management. While Forestry England and Forestry and Land Scotland manage these counties' public forest estate (Forestry and Land Scotland, 2022; Forestry England, 2022a), Forestry Commission England and Scottish Forestry deal with tree cover on private land via regulations, grants and licensing (Scottish Forestry, 2022b; UK Government, 2022a). In these two countries forest legislature and management of public forest estates is separated, while Natural Resource Wales covers both roles (NRW, 2022). Either structure is open to criticism; the two separate entities in England and Scotland can make things inefficient and confusing, whereas in Wales having one single organisation means that it is supposed to 'police' its own activities with much less oversight.

2.2 Contemporary woodland expansion in Britain

Since the 1990s the devolved governments in Britain have mostly used grants rather than tax schemes to incentivise woodland creation (Lawrence and Dandy, 2014). Contemporary examples include the Scottish Forestry Grant Scheme, the Woodland Creation Grant within the Countryside Stewardship for England and Glastir for Wales (Scottish Forestry, no date; NRW, 2020; Forestry Commission, 2021b) As explained below, however, several grants are in transitional phases due to Brexit.

Targeting specific groups of private landowners (or those landowners in a specific area) is hindered by the fact that there is no comprehensive ownership registry for Great Britain; indeed, "*only around one-half of rural land ownership is formally registered*" (Lawrence and Dandy, 2014, p. 352). Land tenure adds another layer of complexity. For example, Lobley et al (2012) estimate that 39% of land in England is either wholly tenanted or under mixed tenure.

For established woodland, other legal means like the requirement (within the licencing regime) to restock felled areas aim to keep current British woodland cover in place; between 2006 and 2009 most of those areas were being returned to coniferous woodland with Sitka spruce as the principal species (Ditchburn *et al.*, 2016).

Nevertheless, under special circumstances some woodland is being converted to other land uses, mainly mineral extraction, or urban development. Pest and diseases may also be a problem for established woodlands and require felling, such as ash dieback due to *Hymenoscyphus fraxineus* (Broome *et al.*, 2019; Forestry Commission, 2021a), or *Phytophthora ramorum* in larch (Scottish Forestry, 2022a).

To put the governmental plans for priority WES delivery into perspective, Read et al. (2009) estimated that for Britain to make a substantive contribution to climate change mitigation alone it would need to plant 23,000 ha of woodland per year for 40 years. As of the writing of this chapter in 2022, England's latest Action Plan foresees 12% woodland cover by mid-century, or over 5,000 ha of new woodland each year (UK Government, 2021). In 2018 the Scottish Government planned to create 15,000 ha new woodland per year until 2032 (Scottish Government, 2017, 2018), and the 2020 Agricultural White Paper for Wales speaks of 4,000 ha till 2049 (Welsh Government, 2020a). Furthermore, as already mentioned, the UK government has also pledged to create 30,000 ha of new woodland per year (minimum) until 2050. The problem with the targets is, however, that they "*have been repeatedly underachieved"* (Thomas *et al.*, 2015, p. 150). In fact, it seems internationally recognised that due to various challenges and barriers (some already mentioned above) these afforestation targets are much harder to reach than their straightforward appearance would suggest (Chazdon *et al.*, 2017; Burton, Moseley, *et al.*, 2018).

Another UK specific challenge that will further this complexity is the aftermath of Brexit. Since forest policy (and all its derived tools to support and enhance WES provision) in Britain has been significantly influenced by EU frameworks and subsidies (MCPFE, 2015; Raum and Potter, 2015), after Brexit, keystone elements of British forest and environmental policies need to be rewritten (e.g. with the end of the Common Agricultural Policy (CAP)). This could have significant knock-on effects on land cover and land use change, the outcomes of which might be hard to predict.

As of the writing of this chapter in 2022, certain subsidies and grants for woodland were secured for the time immediately following Brexit (such as the continued Scottish Forestry Grant scheme until 2020 or even 2024; Wright, 2018). Following this, new schemes are in development, such as the new Sustainable Farming Scheme in Wales and the Environmental Land Management Schemes in England, both of which set out woodland creation as an integral part of future sustainable land management (DEFRA, 2021a; Welsh Government, 2021c).

A different kind of effort to increase woodland cover in Britain comes in the form of more targeted (yet large-scale) approaches. In 2018 plans were unveiled to create a 'Northern Forest' stretching from Liverpool to Hull along the M62, by means of actively planting over 50 million trees over 25 years (Mash, 2018). The project focuses on many of the priority WES listed by Sing et al. (2018), such as flood risk mitigation, recreation and climate change mitigation, and adds an additional aspiration for better air quality. Improved connectivity of fragmented woodland areas and other woodland biodiversity benefits are also a desired outcomes of the project (Woodland Trust, 2017; Mash, 2018).

Other, more localised projects either follow these aspirations or have been preceding them. The Cambrian Wildwoods project targets the northern part of the Cambrian Mountains in West Wales and aims to replace the dominating purple moor grass with woodland cover (Ayres and Wynne-Jones, 2014); in this case through natural colonisation (after an active planting of 8000 trees as seed sources; (Cambrian Wildwood, 2018)). The Trees for Life project also aims to facilitate woodland resilience and expansion in the Scottish Caledonian Forest by fencing out deer, planting native trees (as seed sources) and removing non-native trees (e.g. *Rhododendron ponticum L.;* (Trees for Life, 2019)). Further expansion is again hoped to be achieved by natural colonisation.

It should be noted that compared to governmental facilitation of woodland expansion through subsidies the above-mentioned projects are mostly run by charities (e.g. Trees for Life, Wales Wild Land Foundation running Cambrian Wildwood) that rely significantly on voluntary work (Cambrian Wildwood, 2018; Trees for Life, 2019).

The increased public and political focus on woodland expansion goes hand in hand with a critical discussion around how, going forward, this expansion should be achieved, both by scientists and non-scientific stakeholders. These discussions are broadly themed around expansion scale, competing land uses, and establishment method.

2.2.1 Woodland expansion scale

The 30,000 ha of new woodland (annually) in the UK could be achieved on a spectrum of spatial scale from one large woodland site all the way to thousand hectares worth of individual trees scattered all over the country. For example, large-scale projects such as the Northern Forest or National Forest Wales are not intended as one closed forest biome, but an intertwined urban/rural landscape with a significantly increased tree cover (Woodland Trust, 2017), and a "*connected network of forests*" (Welsh Government, 2020b).

In workshops with stakeholders on what their vision of a future British landscape was, they identified a context dependent mix, with areas of large-scale woodland for designated habitat conservation all the way to individual urban trees for increased amenity (Brown *et al.*, 2018; Burton, Metzger, *et al.*, 2018). The configuration of woodlands and other habitats was based on what ecosystem services the woodlands would provide (e.g. more recreation or more conservation) and was a relative ranking of priorities that may also include the (relative) importance of ecosystem services from land uses other than woodlands (Barbier, Burgess and Grainger, 2010).

2.2.1.1 The special case of small-scale tree cover

A significant amount of existing tree cover in Britain exists outside woodlands, i.e. tree cover less than 0.5ha in size. As urban trees, shelterbelts, hedgerow trees, and other kinds, these trees are often not a primary focus in the woodland expansion debate.

Nonetheless, small-scale tree cover can provide a range of those ecosystem services that Britain's woodland expansion agenda is targeting. For example, as part of a semi-open landscape, it can increase the connectivity of existing woodlands (thereby enhancing habitats of woodland species), while retaining connectivity of surrounding habitats and their species (Boutaud *et al.*, 2019; Tiang *et al.*, 2021; Travers *et al.*, 2021). This is specifically useful where protected or targeted species are open-ground dependent and large-scale woodland creation is not a feasible option (Douglas, Groom and Scridel, 2020). Furthermore, when positioned as riparian tree cover, it can help boost biodiversity above and below the water surface (Bowler *et al.*, 2012; Kail *et al.*, 2021). This also relates to natural flood management, where small-scale tree cover can help reduce water run-off (Carroll *et al.*, 2004).

Small-scale tree cover (increase) may also provide collateral benefits beyond the above WES. While turning a pasture or arable field into a woodland requires a complete change in the use of the land, small scale tree cover provides complimentary benefits. For example, studies have shown that, along field margins, it can facilitate the presence of natural predators of pests on arable fields (Gavinelli *et al.*, 2020), it can decrease injurious feather-pecking amongst the free-range laying hens on chicken farms (Bright, Gill and Willings, 2016), it can provide shelter for lambing fields and the more extreme weather conditions climate change will bring (Arnell, Freeman and Gazzard, 2021; Pritchard *et al.*, 2021), and it can increase above ground carbon storage along field margins (Falloon *et al.*, 2004). Small-scale tree cover can offer some public benefits while also retaining benefits in situ for other land uses, such as farming (Hardaker, Pagella and Rayment, 2021). This is not only relevant in a cultural landscape where new tree cover must fit in with a variety of existing land uses (and all the ecosystem services they bring); it is particularly important in a country where a history of (upland) conifer afforestation and a presence on unfavourable economic conditions contributed to many farmers not being particularly fond of large-scale woodland expansion (Scambler, 1989; Ni Dhubhain and Gardiner, 1994; Lawrence, Dandy and Urquhart, 2010).

2.2.2 Making land use decisions in a crowded landscape

The idea of crowdedness has been mentioned above already, in the context of a British landscape being intricate mosaic of land uses, already providing a range of existing ecosystem services in which new woodland cover would have to be integrated. However, the concept of crowdedness goes beyond land use and also cover land users, i.e. the complex decisions land managers have to make with regards to woodland expansion, including the competing interests these decisions represent.

Given that 72% of the UK is used agriculturally in some way or form, agriculture is an essential land use to convert into or merge with woodland expansion. Biodiversity conservation advocates would like to use agriculturally improved grassland for woodland expansion because of grassland's comparatively low biodiversity value (Quine, Bailey and Watts, 2013; Graham *et al.*, 2017). Sing et al. (2013, p. 19) estimated that in Scotland about 89% of the land identified as "*most likely to have potential for woodland expansion*" is arable, rough gazing or improved grassland.

The problem is that British farmers themselves must weigh a range of factors when it comes to creating tree cover on their land. Firstly, the economic benefits of creating woodlands are relevant, especially in terms of balancing cost and addressing the lack of short-term financial reward (Church and Ravenscroft, 2008; Lawrence and Dandy, 2014). Governmental schemes try to encourage farmland tree planting through financial support and other resources (FC, 2020; e.g. NRW, 2020; Scottish Forestry, 2020b), but farmers often do not feel that the financial incentives are high enough to warrant a permanent change in land use (Wynne-Jones, 2013; Lawrence and Dandy, 2014). Unfavourable bureaucratic hurdles and administrative needs further complicate decision making (Urquhart, Courtney and Slee, 2010; Lawrence and Dandy, 2014).

Additionally, studies suggests that agri-environment schemes, many of which include incentives for tree planting, do not properly appreciate that economic benefits of woodlands are not necessarily the primary objective for many farmers (Burton, Kuczera and Schwarz, 2008; DEFRA, 2008; Burton, 2012). For example, farmers derive a sense of identity and social status from a certain aesthetic of their land – an aesthetic that embodies a productivist farming culture and complex local practices which are acknowledged by other farmers in that region (and beyond) as ‘good farming’ (Tsouvalis, 2000; Burton, 2004; Burton, Kuczera and Schwarz, 2008). Cusworth and Dodsworth (2021, p. 931) point out that practices considered ‘good farming’ are “*not necessarily those that deliver the highest economic returns*”, and similar studies on how farmers relate to and construct their farming identities exist in Germany (Schmitzberger et al., 2005; Burton, Kuczera and Schwarz, 2008), Finland (Silvasti, 2003), Austria (Schmitzberger *et al.*, 2005) or Ireland (Duesberg, O’Connor and Dhubháin, 2013; Ryan *et al.*, 2022).

The problem for woodland expansion in Britain is that while farmers’ decision making is not static, and identities do change over time (Cusworth and Dodsworth, 2021), a lot of farmers view the change from using land for crop or grazing to using it for growing trees as ‘abandonment’. Woodlands are seen as ‘unproductive’ and the land the ‘un-farmed’ (Lawrence and Dandy, 2014; Cusworth and Dodsworth, 2021), and because this is the case, the trees both do not offer much cultural or social capital, and may even affect it negatively (Bourdieu, 1983; Burton, Kuczera and Schwarz, 2008). Some studies even mention a “*long-standing cultural division between farming and forestry*” (Thomas *et al.*, 2015, p. 152), as “*farmers just are not prepared to be foresters*” (Wynne-Jones, 2013, p. 251).

Having said that, several studies found that it would be incorrect to assume British farmers have no interest at all in creating woodlands on their farms, even if those that do are a minority (Howley *et al.*, 2015; Fitzgerald, Collins and Potter, 2021; Iversen *et al.*, 2022). Farmers that share a positive attitude to woodland cover increase often already operate forestry, have a higher educational level, have a relatively high number of employees, are involved in environmental schemes, or are relatively recent entrants to holdings (Hopkins *et al.*, 2017; Barnes *et al.*, 2022). Eves et al. (2015) also found that large freehold farmers may be more likely to create woodland, and Morgan-Davies et al. (2008) conducted research in Scotland and found that positive attitudes in farmers are also more prevalent if their core farming practices (and thus, their cultural capital) could be maintained alongside new woodlands and/or small-scale tree cover. Considering the latter, trees outside woodlands are sometimes discussed as beneficial additions to farm systems themselves, most notably as hedgerow trees, shelterbelts and other linear features (Scholefield *et al.*, 2016; BW, 2018), or as part of emerging agroforestry systems (Stiles, 2017; Clarke, 2019; FFCC, 2021).

It should be noted that due to farmers' reluctance to specifically convert agriculturally valuable land to woodland, and a projected shortfall of farmland in the UK by 2030, a lot of modelling scenarios for woodland expansion exclude agriculturally valuable land as an option (grade 1,2 & 3a in the Agricultural Land Classification (ALC)). For example, Burke et al. (2021) and Benítez (2007) did so for their modelling of carbon sequestration, and even some of the woodland expansion opportunity maps which will be discussed in more detail below, list ALC grade 1-3a land as a restriction (Nauman *et al.*, 2018). This is an important reason why it is often marginal agricultural land in the uplands that is considered for woodland expansion.

Lastly, aesthetic and cultural values connected to farmland are not the only competing interest for woodland expansion. For example, conservation priorities call for the restoration of Britain's deep peat areas and active raised bogs, and the removal of any trees that had been previously planted on them (RSPB, 2012). The same is true for other 'priority' habitats with special conservation status that should not be converted to woodlands (FC, 2017). As mentioned above, many national parks in Britain showcase and preserve a both ecologically and culturally valued *open* landscape character, which puts large-scale woodland expansion at a disadvantage (Cox *et al.*, 2018; Gold, 2019).

2.2.2.1 Woodland expansion opportunity maps

A scientific way of formally conceptualising this crowdedness of land covers and land uses is the production of woodland expansion opportunity maps (WEOMs). WEOMs try to show where Britain's future woodlands could possibly be located when considering the land trees can biophysically grow on as well as restrictions or sensitivities based on other objectives and land uses (such as areas with special conservation status, high value agricultural land, deep peat areas, etc.). In Wales, for example, the Glastir woodland creation opportunity map is used to show land managers which areas are more likely to be approved for governmental woodland creation grants (**Figure 2-3**) (Welsh Government, 2014a); Friends of the Earth produced their own WEOM for England (Friends of the Earth, 2020), and there are also WEOMs specifically for natural flood management or nature conservation woodland (Jones, 2007; Hanking *et al.*, 2017a).

These WEOMs are decision support structures; their supplementary material, such as technical reports and user guides, emphasize that they not intended to be prescriptive (e.g. Hanking *et al.*, 2017a; Bell *et al.*, 2020b). The maps often depend on large collections of base datasets and work on a variety of assumptions, some of which are subjective in nature. Nonetheless, where there only used to be planting targets to conceptualise woodland expansion plans in the past, WEOMs now try to account for the complexity woodland expansion is facing today. As such, these maps and their underlying assumptions reveal a lot about priorities of present and future land use, and the potential ecosystem services that come with them.

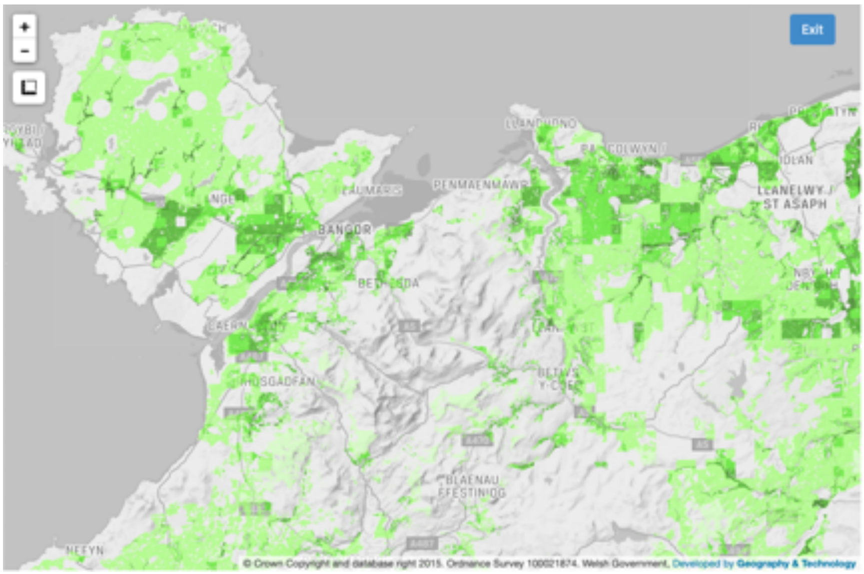

Figure 2-3. Glastir woodland opportunity map for North Wales. Woodland opportunity scoring in green: the darker, the better the opportunity for woodland creation. (Welsh Government, 2014b)

2.2.3 Establishment method

Questions around expansion scale and the intertwined competing land uses also relate to the third theme, the establishment method. A recent UK parliament POSTnote speaks of "*creating*" the 30,000 ha of new woodland (UK Parliament, 2021, p. 2), though this goes hand in hand with a primary emphasis on actively planting the trees, i.e. afforestation (hence also 'tree *planting* targets' and 'tree *planting* grants'). Today, however, this establishment method is not the only one being proposed.

Woodland expansion by means of natural regeneration – specifically the natural colonisation of trees on previously non-wooded land – has become a much-discussed topic in- and outside of science (Crouzeilles *et al.*, 2020; Rewilding Britain, 2020; Woodland Trust, 2020). This comes especially in the wake of land abandonment trends that have been recorded all over Europe in recent decades (Cramer, Hobbs and Standish, 2008; Kuemmerle *et al.*, 2011; Alix-Garcia *et al.*, 2016). Studies suggest this trend is strongest in Southern and Eastern Europe (Keenleyside and Tucker, 2010), but landscapes in the UK may follow suit, given the complex set of drivers underlying farmland abandonment (Hobbs and Cramer, 2007; McGinlay, Gowing and Budds, 2017).

There are two main responses to the threat of farmland abandonment. One approach argues in favour of halting the process of abandonment as current land uses support certain types of biodiversity and the cultural appreciation of the landscapes in question (Rey Benayas and Bullock, 2012; Ceauşu *et al.*, 2015). The other approach favours rewilding. In a country like Britain, where much of the land would likely be wooded were it not for many hundred years' worth of human intervention (Kaplan, Krumhardt and Zimmermann, 2009), one of the things rewilding can and does bring, is the natural colonisation of trees.

In this context, the rewilding approach identifies the opportunity for the land to evolve into (novel or restored) ecosystems other than farmland. In most cases, this would be woodland (Ceausu *et al.*, 2015), although it is not said that an area will automatically return to woodland just because it has been woodland several hundred (or thousand) years ago. Climate change, lack of seed banks, extensive pressure through herbivores etc. may hinder such a development (Cramer, Hobbs and Standish, 2008; Ratcliffe, 2011; Ceausu *et al.*, 2015). This is why some rewilders may suggest active intervention (especially at the beginning) such as the planting of tree islets with native trees, reintroduction of certain keystone species, removal of paths or an adjustment of protected area policies to allow for rewilding measures (Ceauşu *et al.*, 2015).

The UK Parliament POSTnote acknowledges natural colonisation has gained popularity: "*NGOs argue that natural processes [natural colonisation] should be the 'default' means of creating woodland, but current grant schemes are not well suited to this*" (UK Parliament, 2021, p. 2). Natural colonisation is arguably considered to be cheaper than active afforestation (Woodland Trust, 2020), though it is also a slow method, and its outcome still hard to predict (Thers, Bøcher and Svenning, 2019). Because of this uncertainty, "*current grant schemes are not well suited*" for it (UK Parliament, 2021, p. 2), but there are schemes, such as the England Woodland Creation Offer, that have defined criteria to include natural colonisation, such as 60% tree cover after 10 years and at least 100 stems per hectare (UK government, 2021). Furthermore, Forest Research is currently undertaking remote sensing research on sites that have been naturally colonised to further investigate how the success of natural colonisation might be conceptualised (Forest Research representative, pers. comm.).

2.2.4 Natural colonisation

The definition of natural colonisation – trees naturally colonising previously non-wooded land - suggests a general absence of human intervention (most notably planting), but it is not that simple. Natural colonisation is a process; its success rate depends on a variety of factors, and so does its potential usefulness for woodland expansion goals. It is because of this that ultimately, 'natural colonisation' and 'planting / afforestation' are not a dichotomy, but two general areas on a spectrum of human intervention.

2.2.4.1 The relationship between natural colonisation and the level of human intervention

Natural colonisation is not a single point in time, but a process. There are different stages of colonisation, and each of them may or may not limit the success rate of tree establishment. This could involve the presence of adequate seed sources (Thompson, 2004; e.g. Martínez and García, 2017), soil quality for germination and competition through existing vegetation, potential herbivory by grazing animals post germination (e.g. Tanentzap, Zou and Coomes, 2013; Turczański, Dyderski and Rutkowski, 2021), and a variety of additional factors such as pests and diseases. For example, a given plot of land will not automatically transition to woodland just because land management has been ceased; maybe the seed bank is lacking, the pressure from deer or sheep population is too high, or the abiotic conditions are (or have become) unsuitable (Cramer, Hobbs and Standish, 2008; Ratcliffe, 2011).

In a cultural landscape like Britain, only a very small proportion of naturally colonised trees will establish entirely without the influence of human intervention before or during colonisation. Per definition the trees germinate independently, but their existence (and colonisation success) may still be subjected to either (in)direct human intervention or at the very least intentionality. Two good examples of this have been mentioned above already: land abandonment and rewilding. If trees colonise an abandoned field where before they would have been eaten by grazing animals, their existence may be entirely unintentional – nobody planned/hoped for trees to appear on the site – but it is still a result of an abrupt change in human intervention. What if a rewilding project were to fence off the neighbouring field and plant some tree islets to promote a more diverse tree species colonisation? The trees that will follow still colonised 'naturally', but their existence was not left up to chance (Rey Benayas, Bullock and Newton, 2008; Ceausu *et al.*, 2015).

Another example is the concept of farmer managed natural regeneration (FMNR), practiced in various African countries. Here, trees on farms are managed in pollarding or coppicing systems to provide a range of benefits, such as shading of crops, availability of wood, production of fruits or nuts, or soil improvement (Moore *et al.*, 2020). These trees, however, colonised naturally. Before their inclusion in the FMNR system, their shoots would be cut or burnt periodically to make room for crops, halting any establishment success above ground. Therefore, while the trees were not planted, which also differentiates the system from agroforestry techniques (Tougiani, Guero and Rinaudo, 2009), the change in farmer's management and intentionality made the difference for their establishment, and they are now part of a closely managed farm system.

Ultimately, land abandonment, rewilding and natural colonisation can meet on the same stretch of land. Natural colonisation focuses on the ecological processes surrounding tree establishment itself, such as historical tree cover and subsequent establishment success of the new trees. Rewilding focuses both on ecological processes, which natural colonisation may be part of, and an intentionality governing whatever ecological changes no (or very little) intervention brings. Land abandonment in this context is the cessation of (intentional) agricultural land management, and may be succeeded by natural colonisation, with or without goals of rewilding.

The fluid spectrum of intervention and intentionality governing natural colonisation does not mean it is not a useful term; in fact, the term is gaining popularity over 'natural regeneration' when speaking about trees growing on previously non-wooded land (for example, according to Watts (2021) an area is colonising if it has not had tree cover in the 20 years prior). It will therefore be used in this sense within this research, but the complexity of the underlying processes should be kept in mind (and will be brought up again where appropriate).

2.2.4.2 How long does natural colonisation take?

Following from the above, the transition time from open habitat to woodland is highly dependent on local conditions, such as the size of the site, the soil properties of that site, the distance to surrounding woodland or tree cover as a seed source, and the tree species composition of the seed source tree cover.

For example, Martínez-Ruiz et al. (2021) studied the natural colonisation on grassland in Spain and found that the adjacent woodland was able to colonise an area extending over 60m into the grassland after 10 years with a seedling density that would likely result in a close canopy woodland. A meta-study by Wright and Fridley (2010) on secondary succession on 30 different North American studies found it took eight to 60 years for abandoned fields to reach 50% tree cover: the more suitable the temperature regime (i.e. available growing days per year), soil fertility (the higher the better), and plant traits, the faster natural colonisation could establish. It should be noted, however, that some of the factors are contested; Rebele (2013), for example, used a permanent plot study in Germany to test the influence of substrate types and soil nutrient levels on natural colonisation success. In their study, natural colonisation was much slower on the nutrient-rich site; while dominance of woody species on sand and ruderal soil was achieved after 10 years, the nutrient-rich site only had about half the number of woody species, which Rebele attributed to the increased competition (and dominance) of perennial herbs.

Verburg and Overmars (2009) took a different approach to estimating transition times by simulating land use dynamics for the whole of Europe, specifically addressing the transition of abandoned farmland to (semi) natural vegetation and woodland thereafter. **Figure 2-4** is an excerpt of this. In Britain, the modelled transition time from abandoned farmland to woodland varies considerably, most notably due to the time estimated for the first step: the transition of abandoned farmland to (semi) natural vegetation. What is interesting about this model is that when comparing **Figure 2-4** with the uplands map in **Figure 2-1**, those areas considered uplands in Britain generally exhibit a much lower transition time to (semi) natural vegetation (around 12 to 30 years), compared to certain lowland areas (> 40 years). Once (semi) natural vegetation has been achieved, the transition times to woodland seem very similar for the whole of Britain, at 15-40 years. This means natural colonisation in Britain may take between 25 to over 80 years to create close canopy woodland, depending on local conditions.

Fig. 5 Number of years needed for the transition of recently abandoned arable land into (semi-) natural vegetation (**a**) and for the transition of (semi-) natural vegetation into forest (**b**)

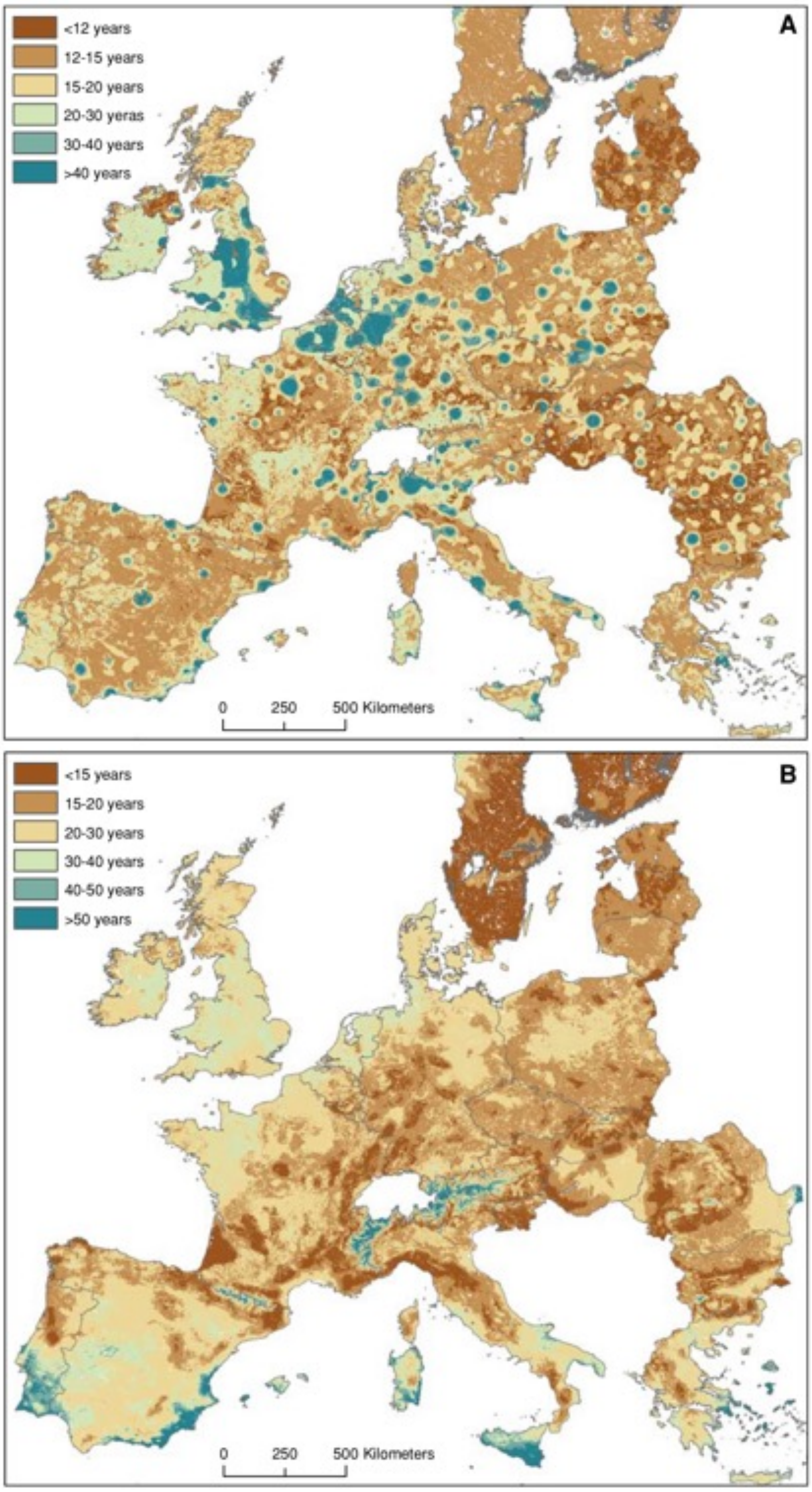

Figure 2-4. Transition times from abandoned farmland to naturally colonised woodland. Figure taken from (Verburg and Overmars, 2009, p. 1174)

2.2.4.3 Natural colonisation & the provision of ecosystem services

Just like with woodland expansion in general, as it has been discussed in section **2.1.1.1**, the opportunity for natural colonisation to contribute to British woodland expansion is also about whether it can provide the sort of WES that are desired (e.g. carbon sequestration or recreation). Here again, the relationships are not linear.

For example, a woodland established through natural colonisation creates levels of structure and bio-diversity that are highly dependent on local biophysical conditions and land use legacies (Navarro and Pereira, 2012). It is incredibly hard to predict how such a future woodland may look like. Their high structural diversity may be well suited for biodiversity conservation (assuming it was primarily native species that colonised), but less so for timber production, or even recreation. Studies on the carbon sequestration potential of managed vs. unmanaged woodlands (and different types thereof) do not suggest a simple relationship; a woodland's carbon stock depends highly on the amount of biomass in the woodland, below ground carbon stock, growth rates over time, use of any timber extracted from the woodland, treatment of dead wood, etc. (Deng *et al.*, 2011; Noormets *et al.*, 2014; Hale *et al.*, 2019). A woodland created via natural colonisation does not necessarily store more carbon than a planted and/or managed woodland. Conversely, a woodland created through planting may have a delayed net carbon sequestration, as the first decades are spent sequestering the carbon emitted during the site disturbances while planting (Matthews, 2020).

2.2.4.4 The spatial scale of natural colonisation

While the paragraphs above explore the complexity of natural colonisation, its success and its relevance in the discourse around woodland expansion, one of the most important aspects is still missing: how much natural colonisation is there already in Britain – if there is any? Answering this question is decidedly difficult, most notably because of limitation of existing spatial data.

For example, the National Forest Inventory (NFI) is a publicly available spatial dataset and report that maps and describes the extent and state of woodlands in Britain. In 2020 the UK had a woodland area of 3.2 million hectares (Forest Research, 2020). This is 13% of its total land area.

Trees outside those woodlands, naturally colonising trees often being amongst them, are not captured NFI. There is no publicly available spatial dataset that tries to map the extent of trees outside woodlands in Britain. However, there is a privately owned map of tree cover outside woodlands – it is called the National Tree Map^{TM} (NTM) and is owned by Bluesky International Ltd (Bluesky, 2021). This map captures all individual trees above 3m in height and was the basis for a governmental report in 2017, stating that there is an additional 3.3% or 740,000 ha of tree cover in Britain (Ditchburn and Brewer, 2017b), solely made up by small woods, groups of trees or lone trees that do not appear on the NFI map. This dataset on 'trees outside woodlands' says nothing about tree age, or species, but it is one step closer to capturing the full extent of existing and emerging tree cover in Britain, natural colonisation included.

Furthermore, natural colonisation can't easily be identified with a single map of a single year. An area needs to be monitored over time to see whether net tree cover increases, decreases, or doesn't change at all. Even then, how could one tell which young trees might have actually been planted? Currently, there is no map that captures any trees smaller than 3m in height, much less one that would monitor them long-term. Right now, a hiker who frequently revisits their favourite spots in the uplands and observes the slow emergence of young trees on the hillsides may well know more about the spatial distribution of recent natural colonisation in the country than most scientists.

With the advent of high-resolution (and more low cost) Lidar applications, high-resolution aerial photography and other technological advancements, this might soon change (Thers, Bøcher and Svenning, 2019; Broughton *et al.*, 2021). The better the change of tree cover can be monitored, the better trees outside woodlands – planted or colonised, young or old – can be integrated into landscape scale assessments around woodland expansion. If trees outside woodlands above 3m in height add another 3.3% of tree cover to the 13% of existing woodland in Britain, the question is how much more tree cover (to-be) below the 3m mark is already out there.

2.3 Conclusion

Britain's interest in woodland expansion is not unique; on a European level, WES such as timber and wood fuel supply, biodiversity, or recreation underpin the pursuit of creating (and managing) more woodlands (Sing *et al.*, 2018). Many European countries shares trends of land cover and land use change, especially (farm)land abandonment (Verburg and Overmars, 2009). The responses are equally diverse; to either halt it and preserve a cultural landscape (EEA, 2004; Terres, Nisini Scacchiafichi and Anguiano, 2013; Ceausu *et al.*, 2015), or to embrace new directions, such as rewilding (Navarro and Pereira, 2012; Corlett, 2016). Britain is no exception in this, with discussions centring around how woodland expansion can be achieved while also acknowledging its already crowded landscape, full of other land covers and land uses and the benefits that are derived from them.

There are, however, some things that are unique about the way woodland expansion is being pursued in Britain. The country already has 100 years' worth of history with woodland expansion. After many centuries of deforestation (Kaplan, Krumhardt and Zimmermann, 2009), the country almost tripled its woodland cover within the span of a century (FC, 1921; Forest Research, 2020). During that time the large-scale interests in woodland expansion changed (Tsouvalis, 2000; Raum and Potter, 2015), conflict arose, and legacies remain that still influence the British landscape and stakeholders' opinions on new woodland expansion going forward. In this way, the country's forestry history serves as an important baseline for where, how and by whom woodlands can be created in Britain's future.

More so, new approaches to woodland expansion that decidedly deviate from past legacies are also being pursued. Natural colonisation is considered a potential alternative to active planting in creating new British woodlands, but knowledge gaps remain on how effective it can be in creating woodlands (Thompson, 2004; Ceausu *et al.*, 2015), how much of it there really is, and how its indirect management (or lack of management) could possibly be integrated in an otherwise highly management landscape like Britain.

3 THE MAIN DRIVERS OF WOODLAND EXPANSION IN BRITAIN FROM 1919 to 2019

3.1 Introduction

During the next decades, various plans have been laid out to increase woodland cover in Britain significantly. As has been mentioned in section **2.1.2**, both England and Wales give native woodland a priority (Welsh Government, 2018; UK Government, 2021), though an explicit split of native vs. non-native woodland expansion in numbers is not provided.

The current arguments for woodland expansion are manifold and are reflected in the management goals of these new woodlands: climate change mitigation, timber and wood fuel supply, water quality, recreation, soil protection and flood prevention (Sing *et al.*, 2018). Various stakeholders in the country, including the public itself, are (or are becoming more) aware of and interesting in woodland expansion (BBC, 2019; Shrubsole, 2019), so much so that woodland expansion goals have become part of electoral campaigns, and latest research is regularly reported on in media outlets (Barkham, 2019; Carrington, 2019; England, 2019; Sherwood, 2019).

How this increase in woodland cover will be achieved, however, is still very much up for debate. The complexity of British landscapes creates a lot of potential trade-offs that need to be considered, Brexit is significantly changing the design of new agri-environment schemes and other tree related initiatives, and the progression of climate change will further impact what future resilient woodlands in Britain can and will really look like.

In order to find opportunities for woodland expansion in the future, these new drivers and the scenarios they may create need to be considered, but similarly those drivers that already exist today are the result of the evolution of past drivers.

3.1.1 The rich history of British woodland expansion

The overall objective to expand woodlands in Britain is not new; all throughout the 20th century woodland cover in Britain has increased, from 4.8% in 1905 to 12.3% in 1999 and eventually 13.2% in 2019 (Locke, 1987; Aldhous, 1997), influenced by changing sets of drivers, activities, mechanisms, and external pressures. Many historical accounts discuss parts of these developments and use different perspectives (and timeframes) to do so. For example Linnard (1982) draws a clear picture of the drivers and activities for and *zeitgeist* around woodland expansion in the 19th century (and gives a Welsh perspective on the beginning of the 20th); James (1981) focuses on England and on the private sector's involvement (and how those might have differed from the public sector), while Oosthoek (2013) focuses on Scotland and explains in detail how the environmental conditions of the uplands shaped the face of British woodlands as they exist today. Tsouvalis (2000) writes in detail about the involvement (or lack thereof) of the public and NGOs, and about changing attitudes in the Forestry Commission (FC), given the FC was the only governmental forest authority in the 20th century and therefore represented the public sector of woodland expansion. Raum and Potter (2015) discuss the changes in forest policies and the ever-increasing influence of international debates and obligations. Some publications also focus on individual events within the timeline, such as the events in the Lake District in the 1930s (Joint Comittee FC & CPRE, 1936), or the events in the Flow Country in the 1980s (Warren, 2000).

So, while the future of woodland expansion in Britain may not rest solely on the already existing set of drivers from the past, they are an important part of it and the way they shaped British woodlands to what they are today needs to be understood. The historical accounts with their varying timeframes and perspectives all contribute different insights to this, but a full synthesis is necessary to explore the changing drivers that governed woodland expansion since the creation of the FC in 1919.

The following research is an attempt at this synthesis. Using the DAPSI(W)R(M) framework, an extension of the DPSIR framework, a comprehensive literature review of scientific and grey literature was undertaken to identify the main drivers of woodland expansion in Britain between 1919 and 2019. The research question was:

What were the main drivers of woodland expansion in Britain from 1919 to 2019 and what might that say about Britain's future woodland expansion plans?

It should be noted that Chapter 5 will revisit and expand on the findings in this chapter by considering the knowledge gained during Chapter 4.

3.2 Methodology

To understand complex environmental problems or developments, such as resource scarcity, climate change or woodland expansion, an integrative and interdisciplinary approach is necessary that considers the interactions and feedback loops between various components of the system (Binder *et al.*, 2013).

A variety of frameworks are already available to work with, such as the Driver – Pressure – State Change – Impact and Response (DPSIR) framework (Eurostat, 1999), the Human-Environment System (HES) framework (Scholz and Binder, 2003), or the Natural Step (TNS) framework (Burns, 1999). Binder et al. (2013) compiled a comprehensive list of frameworks in use and concluded that no framework is perfect and the choice of the most appropriate one depends highly on the research question (and relevant context).

Considering the research questions in this present research, the DPSIR framework appeared to be very suitable, given it is geared towards action-oriented research questions regarding the impact of humans on the ecological system (Binder *et al.*, 2013).

3.2.1 The DPSIR framework

The DPSIR framework was introduced just before the turn of the new millennia and has since been used broadly in Integrated Environmental Assessments such as coastal zones (Eurostat, 1999; de Jonge, Pinto and Turner, 2012), but also water, pollution, and in some regards forestry (see e.g. Sarmin *et al.*, 2016; Scriban *et al.*, 2019) . Especially in Europe the framework has been used quite often (Binder *et al.*, 2013), with the idea to "*assess the causes, consequences and responses to change*" in a holistic way (Binder *et al.*, 2013; Elliott *et al.*, 2017, p. 27). In this anthropocentric framework, societal drivers lead to pressures on the environment. These pressures change the state of the ecological system, which lead to negative (or positive) impacts on humans. These impacts then lead to a response of the social system, which closes the cycle (Binder *et al.*, 2013).

Often, the framework is applied to find sustainable (policy) responses to certain environmental impacts of human induced pressures, but it can be used generally to understand complex environmental developments, regardless of whether their impact may be perceived as good or bad, or both (Atkins *et al.*, 2011; Patrício *et al.*, 2016).

During the 20 years of its existence, however, the DPSIR framework has also faced criticism, mostly concerning the actual application of the different terms/categories in real-life (Binder *et al.*, 2013; e.g. Gregory *et al.*, 2013).

For example, some publications define DPSIR 'drivers' as certain activities (see e.g. Halpern *et al.*, 2008), others define them as whole sectors like 'agriculture', 'transport', or 'population' (see e.g. Kristensen, 2004), or hybrids of both, such as 'forest holdings' or 'forest sector workforce' in Wolfslehner and Vacik (2011). Similarly, DPSIR 'pressures' sometimes are activities (e.g. 'use of resources' or 'production of waste' in Kristensen (2004)), or they are mechanisms of change resulting from these activities (e.g. 'radiation' in Kristensen (2004) or 'water flow change' in Scharin (2016)). In the same spirit, changes to the environment are often seen as 'state changes', but sometimes also as 'impacts' (Sarmin *et al.*, 2016; for the latter see e.g. Scriban *et al.*, 2019).

This is also true for those cases where the DPSIR framework was used in forestry research; similar to other publications, some of these forestry related papers state their definitions of the DPSIR components (e.g. Scriban *et al.*, 2019), while others only mention the framework in passing and don't offer further clarifications (Thees and Olschewski, 2017).

Specifically, the ambiguous definition of what a 'driver' is or is not constitutes a problem for this present research. To address these issues, a variety of adaptations and derivatives of the DPSIR framework have been developed. Patrício et al. (2016) gathered all 'offspring' of the DPSIR framework in a 'family tree' and found the latest step in this evolution to be the DAPSI(W)R(M) framework, whose terminology – with special emphasis on the definition of 'drivers' - has subsequently been chosen for this present research.

3.2.1.1 The DAPSI(W)R(M) terminology

The goal of the DAPSI(W)R(M) framework (pronounced *dap-see-worm*) is specifically to overcome the confusion around the DPSIR terminology, in addition to the oversimplification and one-dimensionality problem (Elliott *et al.*, 2017). This is not a completely new framework but an extension of the DPSIR framework and its original goal to "*assess causes, consequences and responses to change in a holistic way*" (Patrício *et al.*, 2015; Elliott *et al.*, 2017, p. 27).

3.2.1.1.1 DAPSI(W)R(M) terminology

The new terms within the framework are drivers, activities, pressures, state change, impact (on welfare) and responses (through measures). The following definitions are based on Elliot et al. (2017):

- **Drivers [D]:**

Drivers are basic human needs (food, drink and shelter, but also psychological needs such as friendship, acceptance & respect from others, etc.). Aesthetic needs, cognitive needs and transcendence needs, as defined in Maslow (1987), may also be considered drivers.

During the conduct of this research, it has become evident that these drivers rarely present themselves in such a pure and distinct form, i.e. people do many things because of an ambiguous mix of basic interests/needs, and not all of them are always known. However, an essential reason why historical accounts did or did not differentiate some 'driving forces' from others is based on whether they did or did not result in broadly similar types of activities, state changes, impacts (on welfare) and responses. This is why 'drivers' in this research are defined as:

- impacting the state change of woodland expansion on a large scale (either positively or negatively, see below),
- relating to basic human needs as per the DAPSI(W)R(M) framework, and
- resulting in broadly similar types of activities, impacts (on welfare) and responses.

Furthermore, as this research focuses on those drivers that influence the state change of woodland expansion, there are two more distinctions:

- **Facilitating driver**: a driver that facilitated the state change of woodland expansion at the time, i.e. that caused large-scale woodland expansion, such as a national need for timber.
- **Inhibiting driver**: a driver that inhibited the state Change of woodland expansion at the time, mostly by means of driving activities on behalf of competing impacts (on welfare), such as food production.

This distinction of facilitating and inhibiting drivers helps understand the history of woodland expansion, especially through the lens of a crowded British landscape with competing land uses.

- **Activities [A]:**

Activities (to satisfy the drivers) can be grouped either based on sectors, or based on types of action. This is because different actions may result in the same pressures, and it might be easier for corresponding actions to be grouped together, even if they are being carried out by different sectors. Examples: Aquaculture, agriculture and extraction of living resources are sectors; benthic trawling, coastal farming and shellfishery are more specific actions/activities.

- **Pressures [P]:**

Pressures are a result of the activities and represent "*mechanisms of change*" (Elliott *et al.*, 2017, p. 29). They can be separated into exogenic unmanaged pressures (ExUP), which stem from outside the system and whose causes cannot be managed within the system (e.g. climate change as an ExUP to coastal environments), and endogenic managed pressures (EnMP) which stem from inside the system in question and can be managed within its boundaries (e.g. impacts of commercial fisheries within the coastal environment). This means that the state change and impact of ExUPs can be managed within the system (e.g. future proofing environments for a changing climate), but their origin can't (i.e. changing climate change itself).

- **State Change [SC]:**

State changes are those changes that happen in the (environmental) system as a result of one or several pressures. Often, this refers directly to physio-chemical variables (i.e. organic matter, dissolved oxygen), but state changes can also regard general (large scale) changes in ecosystems, such as land cover change. For the DAPSI(W)R(M) framework, those ctate changes (positive or negative) are relevant that produce an impact (on human welfare), i.e. state changes that relate to the provision of ecosystem services (with reference to Fisher, Turner and Morling, 2009)).

In this research, woodland expansion is the central state change in question, as well as all drivers with relation to it.

- **Impacts (on Welfare) [IW]:**

Impacts (on welfare) result from state changes that have an impact on societal welfare. This depends highly on what exactly societies value (again, referring to the goods/benefits relating to ecosystem services); some state change may not create any noteworthy impact (on welfare), just as some pressure may not result in any notable state change.

- **Responses (through measures) [RM]:**

Depending on the impacts (on welfare) different responses (as measures) might become necessary, often directed at drivers, activities or pressures. For example, a governmental response to overfished coastal areas (state change), which created negative impact on tourism and local food sources (negative impacts on welfare) might be to lower fishing quotas (measure directed at the fishing activity).

An illustration of the DAPSI(W)R(M) components can be seen in **Figure 3-1**. As mentioned before, it was not the intention of this present research to use (or test) the full DAPSI(W)R(M) framework, with its nested cycles and other innovations, but to use its terminology, especially regarding drivers, as a sensible baseline of standardisation. For more information on other DAPSI(W)R(M) parts, see Elliott et al. (2017) or Scharin et al. (2016).

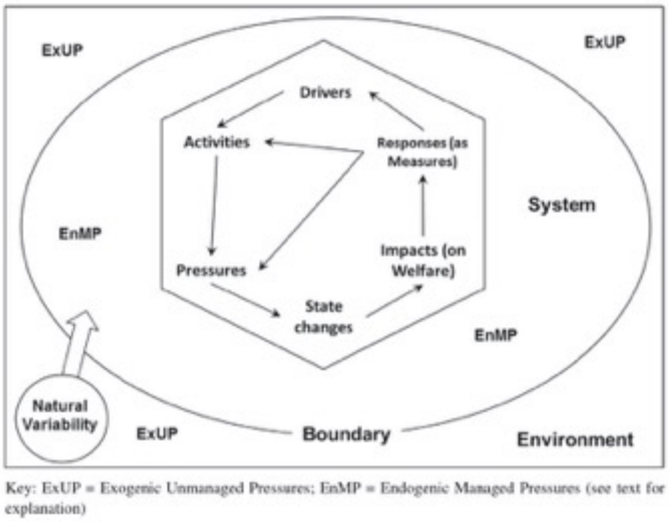

Figure 3-1. Components of the DAPSI(W)R(M) framework. Illustration taken from Elliott et al. (2017).

3.2.2 Qualitative data: historical accounts and synthesis

Historical accounts were found through a literature review using Google, Ecosia, Mendeley Desktop, Web of Science and other search engines, for either parts or the total timeframe of this research. Search terms that yielded the most relevant results included "*forest history Britain*", "*forestry history Scotland*", "*woodland history*"; publications found under these terms often covered large timeframes within forestry history, sometimes reaching back in time beyond 1919. Terms like "*history of plantations Wales*" or "*broadleaved woodland history England*" uncovered more localised publications, both in time and place. Because of the nature of the data in question both scientific and non-scientific publications were assessed. This included annual reports, newspaper articles, scientific papers, books, policy reports, civil estimates and others.

The publications that were found were preliminarily assessed on whether they yielded information on historical aspects of woodland expansion, regardless of whether over a long-term period or only specific to certain events within the time period.

Because many publications were grey literature (i.e. mostly not peer reviewed), care was taken to find several accounts for the same events and timeframe to make sure all relevant developments at the time could be identified, since not all information was present in all publications (even if they were dealing with the same events). Wherever possible, further care was given to use grey literatures sources that nevertheless offered traceable references for fact-checking.

3.2.2.1 Synthesis

The preliminary literature review showed that most of the historical accounts (in)directly mention developments that can be classified with DAPSI(W)R(M), but they do not focus on them and do not trace them long-term.

The synthesis used the historical accounts found above to extract this information. The main criteria for the synthesis was to focus on the state change of woodland expansion, not on specific stakeholders or events.

Because the historical accounts have different perspectives on the same developments, they often overlap in parts of their content. This means that it would have been possible to obtain information on certain drivers from different sources. To limit the possibility of reaching a different result if different sources would have been employed, care was taken again to find several historical accounts for the same developments to build a reliable synthesis.

3.2.3 Limitations

As mentioned in the introduction, the drivers of woodland expansion in Britain could only be identified if they were mentioned in the historical accounts. Furthermore, using non-scientific publications as sources generally holds the risk for bias on behalf of the authors. This may be less of a problem if it is known, e.g. the authors admit to depicting a certain perspective.

To mitigate this, wherever possible several accounts on the same developments were gathered to limit possible bias. This was possible for almost all developments, providing confidence in the data gathered.

Accessibility of the accounts only proved a minor problem in this research. Most accounts were either freely available (online or offline) or accessible due to university subscriptions (or correspondence with the authors). Some very old original documents (e.g. the original Acland Report that heralded the birth of the FC) could not be accessed, but the historical accounts reported on them extensively and in agreement, so it is likely that tracking down the original would not have added much additional value.

3.3 Drivers of woodland expansion in Britain, 1919-2019

The historical accounts of woodland expansion in Britain, 1919-2019, have identified various drivers, activities and pressures that influenced relevant political and land use decision. They differ in scale, the timeframe within which they were relevant and the mechanisms they used. Given the 100-year timespan, these components are also connected and altered by responses (through measures), which are relevant as well.

3.3.1 The synthesis of historical accounts

3.3.1.1 The forestry scene in Britain leading up to 1919

In the 19th century and up until the Forestry Act 1919 Britain did not have a very clear forestry policy; Linnard (Linnard, 1982, p. 146) called it a very "*laissez-faire*" approach, especially in the second half of that century, but that does not mean that before 1919 forestry was irrelevant.

3.3.1.1.1 18th century and 1st half of the 19th century

At the turn of the 18th century those woodlands that were still present in Britain had mostly remained because either they were seen to have some use, or because of their inaccessibility (Aldhous, 1997). Then and during the 19th century forestry was mostly in the hands of private individuals, since before the existence of the Forestry Commission the woodlands were almost exclusively in private ownership (Linnard, 1982; Aldhous, 1997). The only exception were Crown woodlands that by 1914 only made up 3% of the total woodland cover (House of Commons Hansard, 1943a).

In the first half of the 19th century woodlands on private estates were used mostly for timber. The main facilitating driver of managing these forests at the time was the interest in financial revenue from such commercial forestry (and personal usage of timber on the estate). This was the case all over Britain, but it was often Scotsmen skilled in (plantation) forestry that were employed as foresters (and gamekeepers) on the big estates in all three countries, since in Scotland skilled men had already been nourished during the 18th century (Forbes, 1904; Linnard, 1982). Linnard (1982) points out this is also one of the reasons why in Wales many forestry terms did not exist in Welsh for a long time, since the working orders were mostly given in English.

Even when the land was let for rent (often to local farmers), the woodland on it and all the revenue from it remained in the hands of the estate owners (Linnard, 1982). Killing big trees or even small new seedlings on the land leased by the farmer was illegal and prosecuted. Winter (1996) supports this and says the British landlord-tenant system overall supported the (strict) dichotomy of forestry versus agriculture that would be retained well into the 20th (and possibly 21st) century.

3.3.1.1.2 2nd half of the 19th century

In some examples gathered by Linnard (1982) forestry made up about 10% of private estates' total income, so up until the mid 19th century forestry was generally considered a "*sound investment*" by private landowners, making the financial revenue form commercial forestry the main facilitating driver for woodland management and expansion. However, by the 1860s this driver started to be weakened; the advent of iron ships replaced the need for naval oak timber, and the advent of a Free Trade policy made imports of cheap softwood timber possible (Linnard, 1982), both of which significantly reduced the need for commercial forestry in Britain. It was also this Free Trade policy that led to the adoption of the aforementioned '*laissez-faire*' approach, i.e. the response of private estates was to change their activities (and drivers) and manage woodlands based on whatever alternative would bring beneficial impacts on their welfare. For example, in some cases this was game shooting; woodlands became managed as "*pheasant coverts*" (i.e. for game preservation) with timber production being next to irrelevant (Tsouvalis, 2000, p. 50). Especially in the south of England this practice continued well into the 20th century until the Forestry Act 1947 was tailored to (further) encourage woodland management for timber on private estates (for more details see below; James, 1981).

By 1900 woodlands were generally regarded as an "*economic liability*" (Linnard, 1982, p. 191) and private woodland owners found that "*forestry does not pay*". This was specifically important for broadleaved woodlands and especially oak which, according to Schama (1996,

p. 155) having been known as "*the heart of England*" for centuries due to being essential for ship building (and thus imperial expansion, Tsouvalis, 2000), subsequently lost its spiritual value, too; by 1900 it had transformed from being the "*symbol of Englishness*" to "*outdated waste land*" (Tsouvalis, 2000, pp. 17, 32).

On the other hand, this change in attitude opened the field for other interests, one of them being silvicultural experimentation. Arboricultural experiments were already fashionable in the gardens and parklands of estates, especially regarding exotic tree species imported from all over the world, and by the end of the 19th century new tree species had been identified that either could grow faster than native counterparts in Britain, or that would grow feasibly on marginal land where native counterparts would not. Exemplary species are Douglas fir (*Pseudotsuga menziesii*), Sitka spruce (*Picea sitchensis*), and Japanese larch (*Larix kaempferi*) (Miles, 1967).

3.3.1.1.3 Start of the 20th century & the Acland Committee

Towards the turn of the 19th century this increasing import of timber and the absence of financial revenue from commercial forestry as a driver (and therefore no unifying management approach) for British woodland resulted in a response in the form of governmental involvement. The idea was to find new (unified) activities to create positive impacts on welfare from woodlands, so the response pushed not only for a national forest policy, but also for professional training and education, along with the establishment of a state forest service. Amongst others, the consequential surge in employment all this would bring became an important desired impact on welfare (James, 1981; Linnard, 1982; Tsouvalis, 2000).

The Board of Agriculture appointed a Departmental Committee in 1902 (House of Commons Hansard, 1943a) to look into the matter of a forest policy and again in 1909 another Committee recommended the adoption of a national forest policy, but no action was taken at either time (Robertson, 1943; Oosthoek, 2013). In fact, many historical accounts suggest that while the push for a national forest policy (and interest in a state forest service) was present already by the turn of the 19th century, it was World War I that put the implementation on the public and policy agenda (Linnard, 1982; Aldhous, 1997; e.g. Oosthoek, 2013). During WWI the German naval blockade prevented Britain from importing timber, thus spreading the realisation that inland Britain itself had no adequate resource (or management) of timber to meet the national demand (Linnard, 1982; Oosthoek, 2013). Tsouvalis (2000) notes that in 1914 93% of Britain's timber requirements had been met through imports.

As a result, the Reconstruction Committee after WWI included a Forestry Subcommittee, also known as the Acland Committee (Tsouvalis, 2000; Oosthoek, 2013). The recommendations of the Acland Committee were to (1) establish a "*strategic reserve of timber*" as quickly as possible in case of another emergency, and to (2) use woodlands for rural employment (Ryle, 1969, p. 35; Aldhous, 1997; especially the Highlands; Oosthoek, 2013). By doing so the Committee responded to the loss of the financial revenue driver (from commercial forestry) during the 19th century and the loss of a secured replacement of timber through imports during WWI.

In the context of this research, there is an important distinction between financial revenue from commercial forestry, and a strategic reserve of timber. The primary goal of commercial forestry was to use timber and other related operations (including tax breaks and grants, more below) to derive revenue. With the driver for a strategic reserve of timber, however, the government was primarily interested in the timber itself (and a significant increase thereof). Economic viability in this case came only third, after employment in rural areas, a ranking of priorities which would, in fact, be held against the government a few decades later.

A new forestry policy was to create the desired reserve of timber, to put the already present (but "*uncultivated and derelict*") woodlands back into use and to use all of this to (re-)establish woodlands as a means of employment (James, 1981; Oosthoek, 2013, p. 52). James (1981) also points out that especially after WWI there had also already been a shift in forestry practice to (gradually) replace broadleaved stands (and afforest the stands felled in the war) with conifers.

Several historical accounts say this "*rekindling of interest*" in forestry at the start of the 20th century in Britain was also nourished and influenced by continental forestry practice, mostly Germany (James, 1981, p. 45; Oosthoek, 2013); many important guides and field manuals at the time, including yield tables and other statistics, were imported German work until British literature and statistics were developed (towards the 1920s). This was accompanied with a change in attitude towards forestry practice itself, now understood as 'scientific forestry' that looked at trees as a crop to be cultivated and farmed (James, 1981).

3.3.1.2 Establishment of the Forestry Commission (FC) and the 1920s

The new set of drivers and the resulting involvement of the state set the scene for the Forestry Act 1919. It established the Forestry Commission (FC) as the state authority to realise the objectives proposed by the Acland Committee (HoL Library, 2019); specifically, to create a substantial increase in woodland cover for a strategic reserve of timber, and to provide rural employment in the process.

3.3.1.2.1 Amenity: recreation, landscape aesthetics and wildlife & nature conservation

It is important to note that "*considerations such as amenity, wildlife and nature conservation were not mentioned in the report*" of the Acland Committee (Oosthoek, 2013, p. 53), and they were not an objective of the FC at the time of establishment. Recreation and landscape aesthetics, as well as wildlife and nature conservation were mostly bundled in the broad term 'amenity' at the time (Linnard, 1982; Oosthoek, 2013), and according to Oosthoek (2013) the FC believed that their work would provide this amenity (as a positive 'side-impact' to welfare) in and of itself. When the FC was established the Welsh and Scottish uplands were seen as 'derelict land' that had been turned into 'wastelands' or 'wet deserts' by a combination of wet climate and bad agricultural practice (Alan and Macdońald, 1945; Darling, 1955; Oosthoek, 2013). This could explain why the FC thought no additional considerations of 'amenity' were necessary; its work would intrinsically bring value to this 'wasteland', no matter what type of landscape the result would be. It is true that there was an amenity stipulation formulated in 1921 that was meant to keep scenic hilltops from being planted (Oosthoek, 2013), but it was only voluntary and did not prevent later conflicts in the Lake District and elsewhere (Aldhous, 1997; Tsouvalis, 2000).

3.3.1.2.2 The uplands

The uplands were relevant for the FC from the time of its establishment. As already pointed out above agriculturally viable land (i.e. prime agricultural land) had been cleared from woodland already and continued to be reserved for food production (House of Commons Hansard, 1943a; Kaplan, Krumhardt and Zimmermann, 2009). In fact, the increase of food production in the interwar (and later post war) years further pushed this inhibiting driver (Winter, 1996; Oosthoek, 2013). On the other hand, the FC needed to create large scale woodlands to satisfy its objective, and consequently it was the uplands where (a) large stretches of land were owned by the same individual(s) and (b) land was affordable enough for the FC to buy on a large scale (House of Commons Hansard, 1943a; Aldhous, 1997).

3.3.1.2.3 Accessibility to the countryside

At the same time as the FC started its work during the 1920s there was an increase in public interest in access to the countryside (different reasons are named for this, such as positive impacts on welfare from increased mobility, widespread industrialization or negative impacts on welfare by the ongoing enclosure of land by landowners; Maxwell, 1930; National Parks UK, 2019). Consequently, it was the time of the establishment of the Council for the Preservation of Rural England (CPRE) in 1926, the Association for the Preservation of Rural

Scotland (APRS) in 1927 and the Council for the Preservation of Rural Wales (CPRW) in 1928. They all concerned themselves with protecting the landscape and amenity of their respective countryside (so also but not exclusively with matters of woodland expansion; CPRE, 1937; Oosthoek, 2013).

With the Forestry (Transfer of Woods) Act 1923 the FC took over the Crown woodlands to manage and thereby became the sole forest authority in Britain, and with the Forestry Act 1927 the FC acquired powers to regulate the access to state woodlands (Forbes, 1932; James, 1981; Oosthoek, 2013). The driver for access to the countryside and 'amenity' also underpinned the establishment of the National Parks Committee in 1930, on which the FC was represented (Maxwell, 1930; House of Commons Hansard, 1943a).

The committee concluded that National Parks should be established to (1) safeguard areas of outstanding natural beauty, (2) create access for tourism (to enjoy said beauty) and (3) for conservation of 'vulnerable fauna and flora' (Oosthoek, 2013). According to Maxwell (1930) the FC supported this action as long as the FC's plantations are not endangered by this admnission of the public. Based on this account it seems the FC sought to outsource accessibility in a way so that it would not interfere with its activity of timber production. Because of the international recession in the 1930s and later World War II there was no National Park set up until 1951 (Oosthoek, 2013).

3.3.1.3 The 1930s and the Second World War

Many historical accounts cite the 1930s as a crucial time for the drivers of woodland expansion in Britain, mainly because of events in the Lake District.

3.3.1.3.1 Lake District events

By the early 1930s the FC had purchased a substantial amount of land in the Lake District in the North of England with plans for afforestation. During the 19th century the landscape of the Lake District had already become a national asset and attraction for many visitors (Tsouvalis, 2000; Oosthoek, 2013); but this value was derived of the landscape being free of woodlands (Wordsworth, 1835), thus creating a typical 'Englishness': fields, hedgerows, hills and lakes (Newby, 1999). In 1934 the charity Friends of the Lake District (FLD) was established to represent the drive to keep the landscape as it was at the time (and to do so establish a National Park in the Lake District; FLD, 2019). The CPRE (and the National Trust) sided with the FLD in this conflict with the FC over land use (and cover) in the Lake District, though according to Oosthoek (2013) the FLD acted a lot more radically with a nationwide petition against the FC's afforestation plans, while the CPRE tried to use tactics of reconciliation and negotiation. Eventually, the compromise was that central parts of the Lake District (roughly 77,700 ha) would not be purchased for planting (Joint Comittee FC & CPRE, 1936).

These events in the Lake District show that the impact on welfare of drivers and activities surrounding woodland expansion depend on how the alternative land covers (and land uses) are valued. In the Lake District the landscape was valued intrinsically in the (seemingly) undisturbed way it existed (Wordsworth, 1835; Jones and Thomas, 2006); the idea of changing them for a driver like timber production created less positive impact on welfare than keeping them for an (inhibiting) driver like non-woodland amenity. In comparison (and as noted in section **3.3.1.2)**, the uplands were seen as 'wasteland', with rather little positive impact on welfare. This was especially the case with Scotland, where in the 18th and 19th century they became seen as valuable *if* they were utilised (Wordsworth, 1835; Watson and Smout, 2007). In contrast to the Lake District where woodlands would have inhibited the value of the landscape, in Scotland in the 1930s they were mostly seen as an opportunity to put the land to good use. According to Oosthoek (2013b) this is one of the reasons why there was little resistance to afforestation in the Scottish uplands during the 1930s. Another reason may be the fact that in the Lake District the negative feedback to the FC came from outsiders (tourists, general public), while big influencers in Scottish afforestation matters and conservation groups were the landowners themselves (Oosthoek, 2013). Especially in the post-depression years employment in the uplands was an important facilitating driver, too.

In order to mend the negative impression the FC (and their conifer plantations) had earned at the start of the 1930s, it set up National Forest Parks (NFP) with the first one in Argyll in 1935. The NFPs aimed to serve the public's growing need for recreation and be on land unsuitable for forestry so it would not interfere with the FC's main activity of timber production. A significant difference to the National Parks established later in the century was that the NFP had no obligation for nature conservation (FC, 1935), which might be a direct sign that at the time the FC simply did not consider itself responsible for conservation (Oosthoek, 2013). Argyll turned out to be quite popular and in the Post-War Forest Policy Report in 1943 the FC planned to establish further forest parks (FC, 1943b).

3.3.1.3.2 World War II

For the time of World War II not much is being said in the historical accounts about the drivers of woodland expansion, despite a further exploitation of British forests for timber and a slump in progress for the FC.

James (1981) comments that since many of the FC's woodlands were still too young to be harvested, it was private woodlands that had to give most; during WWII roughly 200,000 ha of private woodland was felled or 'devastated' (James, 1981), compared to 12,000 ha of FC woodland during the same timespan (FC, 1949, 1952a).

3.3.1.4 Post WWII forest policy and the 1950s

3.3.1.4.1 Engagement of the private sector

In 1943 a FC report on Post-War forest policy was published (FC, 1943a), which was identified by many historical accounts as an important signpost of the following years and decades (Robertson, 1943; Aldhous, 1997; Tsouvalis, 2000). It identified a very low rate of private plantings compared to FC activities between 1919 and 1939 (Robertson, 1943). This was mostly attributed to the "*not conducive general environment*" at the time (socially, economically as well as politically; Robertson, 1943, p. 1). For example, as it has been mentioned above, up until this point the overriding activity of woodland management on many private estates had been game shooting (for related positive impacts on welfare), with only little interest in actual timber production (James, 1981).

This became important in post-war forest policy through the Forestry Act 1945 (and the Forestry Act 1947) which empowered the FC to offer grant aid to private owners (through what was called the 'Dedication Scheme') if they managed their forests more appropriately (FC, 1949; Tsouvalis, 2000). 'Appropriate management' was synonym with timber production; the FC concluded that while enticing financial revenue from commercial forestry as a driver for the private sector would create an entirely different impact on welfare for them (financial revenue), their activities were also the same activities that would provide a strategic reserve of timber; namely planting forests and growing trees (see illustration of DAPSI(W)R(M) components in **Figure 2-2**). However, grant aid might not have been the only reason private landowners started to see a financial advantage in expanding forest cover; at the time landowners had a possibility "*to offset expenditures on new forest plantations against income before tax*" (Aldhous, 1997, p. 288). These tax advantages would become significantly relevant 40 years later.

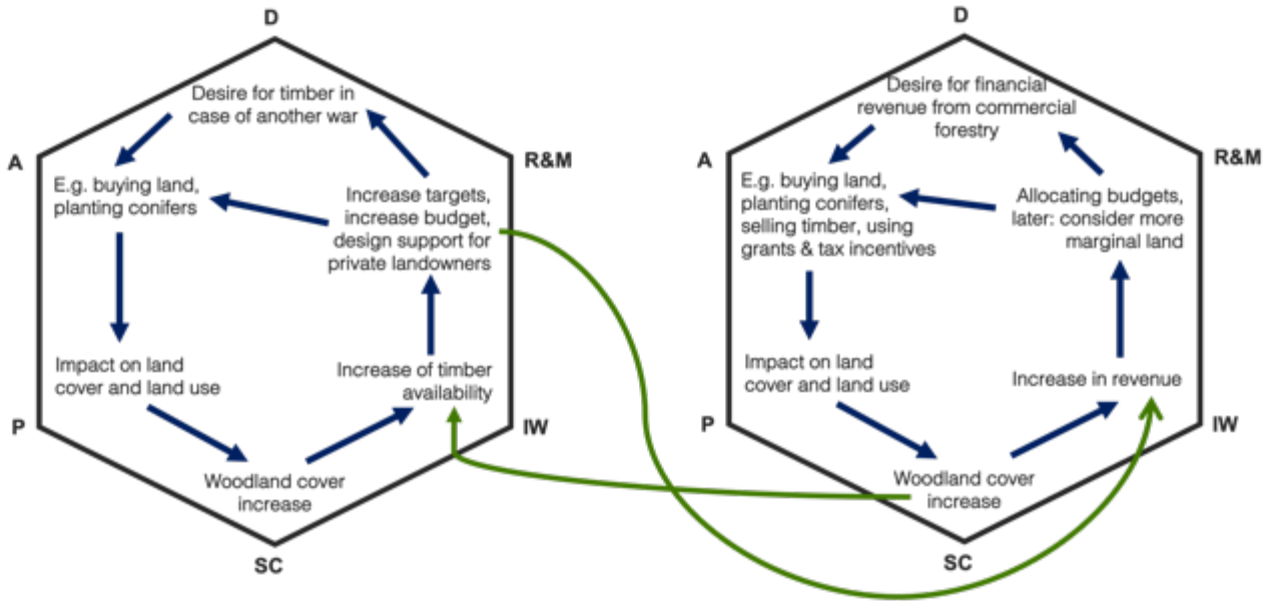

Figure 3-2. DAPSI(W)R(M) components for the driver for a strategic reserve of timber and commercial forestry during the early 1950s. The government designed grants and financial incentives to make commercial forestry attractive for the private sector. In return, the private sector increased woodland cover, aiding the increase in timber availability in case of another war.

Overall, the historical accounts report that after WWII the driver for a strategic reserve of timber continued and intensified (Robertson, 1943; Oosthoek, 2000), while private landowners became involved through growing trees (and timber) for financial revenue.

3.3.1.4.2 Technological innovation

The 1940s and 50s also saw important innovations to increase afforestation success in upland areas. On the uplands, generally, broadleaves were not compatible with timber production since they did not grow fast enough (Oosthoek, 2013). Native Scots pine was suitable for dry and sandy areas but would not grow well enough on poorly drained peat soils. As mentioned before, however arboricultural experiments in the 19th century and leading up to the 1940s had identified non-native conifers as a potential solution. Sitka spruce (and Norway spruce) could withstand the wet climate and grow well enough, and yet they did not do well on waterlogged soil. It is here where the technical innovations of the 1940s and 50s mark the difference to the decades before, with better ploughing techniques, mechanical drainage and aerial application of fertiliser, thus paving the way for more intensive and mechanical woodland expansion (Wood, 1974; Davies, 1979). Oosthoek (2000, p. 8) concludes on the matter that the environmental conditions of the uplands paired with technological innovation and the subsequent emphasis on mechanisation and efficiency by the FC "*defined to a large extent the appearance of Britain's forests*", given that the most efficient way to work was with long straight plough lines on large scales, subsequently planted with non-native conifers.

The inhibiting driver for landscape aesthetics also played a role in these decades, albeit to a much lesser extent. In the 1940s and 50s the FC declared efforts to match the species to site to not only have the trees grow better (as pointed out above) but also increase landscape design and aesthetics (Barrington, 1957). However, some critics seemed to have labelled this a mere cosmetic action, since it did not halt afforestation (Oosthoek, 2000, 2013).

3.3.1.4.3 The Zuckerman report

Towards the end of the 1950s the constellation of drivers around woodland expansion changed when a new report was published in 1957, the *Enquiry into Forestry, Agriculture and Marginal Land*, also known as the Zuckerman Report. It was concerned with the "*proper use of marginal land*" and concluded that the self-sufficiency of Britain in terms of timber had become obsolete with the advent of nuclear power, thereby denying the FC the main facilitating driver for its afforestation programme (House of Commons Hansard, 1957; James, 1981). In response a working party by the Treasury concluded that if not for strategic reasons forestry had to pay off commercially and socially, including a new measure to set up a domestic wood processing industry to support this shift to financial revenue (House of Commons Hansard, 1973; Tsouvalis, 2000). Oosthoek (2000, p. 3) identified this as further positive feedback for uniform "*single-species planting*" to grow consistent quantities of timber in short rotation. Following the working party's arguments there was also specific mention of broadleaves as "*the growing of hardwoods on a large scale is commercially unattractive [...] because the main species mature slowly and yield little revenue*", so hardwoods were not deemed "*of major importance in the future*" of British woodlands (CWP, 1963, p. 4; as cited in Oosthoek, 2013, p. 76). The only exception of the commercial viability was private forestry, where the grants for dedicated woodlands were not reduced but increased.

The sentiment about the facilitating drivers for commercial and social viability was later reiterated by another working party in 1963 (Oosthoek, 2013). Social viability, in this case, was interpreted as a facilitating driver for recreation from and accessibility to woodlands, as well as a facilitating driver for employment (Pringle, 1994), the latter of which was deemed significantly important for upland areas both in Scotland and Wales (see details below).

The Nature Conservancy, a government body which would later become Natural England, had reported to the working party in 1958 that the FC was not taking nature conservation into consideration enough (Oosthoek, 2013). They introduced the concept of multiple use management systems from the United States as an approach to give the drivers of recreation and nature conservation a more equal footing with timber production within the FCs woodlands. This led to the creation of a Wildlife Officer post within the FC in 1964 to "*develop* *methods of control to harmonise the conservation of wildlife with the need for timber production*" (FC, 1964; Oosthoek, 2013, p. 119).

It should be noted here that in this research the drivers of recreation and nature conservation are understood as inhibiting drivers, as they inhibited the type of woodland expansion that was prevalent at the time, i.e. large-scale conifer plantations. Hence, they are classified as inhibiting drivers of 'non-conifer plantation recreation' and 'non-conifer plantation biodiversity conservation'.

3.3.1.5 The 1960s and 70s

3.3.1.5.1 Employment in rural areas

It is the increasing mechanisation of forestry operations by the FC that is attributed to the decline in workforce employed by the FC during the 1960s (Oosthoek, 2000), while the afforestation rates reached new heights. To illustrate this **Figure 3-3** compiles data from the FC archives and shows that since the peak of 13,200 ppl as technical staff in 1953 the numbers of technical staff decreased continuously, down to 7,695 ppl in 1970 and 5,950 ppl in 1980. In several annual reports during the 1970s (and later 80s) the FC directly points out "*the number of staff fell [...] as a result of further improvements in efficiency and the wider employment of contractors*" (FC, 1980, p. 10). It should be noted that labour started to be outsourced to contractors which possibly skews the impression of total labour employed in the forestry sector over time (1,400 contractors were employed in 1987; FC, 1987). The same applies to the wider wood processing industry that started in the 1960s for which consistent data to build a timeline was not available.

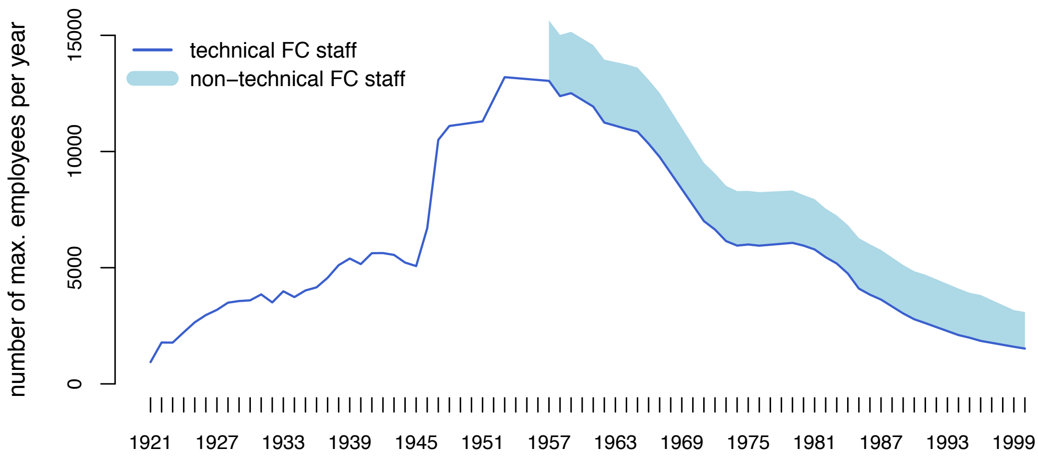

Figure 3-3. Employment data for the FC from 1921 to 2000. Data may include part time workers. Distinction between technical staff and non-technical staff (Divisional and District officers and office staff).

As mentioned throughout the synthesis above the creation of employment in rural areas through its activities was a core facilitating driver of the FC ever since 1919, so the number of staff employed by the FC (and the wider forestry sector) is an important supporting element surrounding woodland expansion. According to Oosthoek (2013) after WWII the population in many rural areas had started to decline much more rapidly than before. This might explain why by the start of the 1960s the argument of promoting forestry as a supplier of employment "*had become one of the main objectives to justify public money spent on forestry*" (Oosthoek, 2013, p. 78). In fact, it hadn't been until 1957 when employment had been formally introduced as forest policy objective (Tsouvalis, 2000).

Later, in 1972, the Treasury concluded in a cost-benefit study that forestry was overall an uneconomic enterprise and the only reason for the continued investment of public money was employment in rural areas (Tsouvalis, 2000). Tsouvalis (2000) also describes the other side of this coin and says critics of woodland expansion and/or the FC's work in particular had started to reject the employment argument as valid ever since the numbers of FC staff had clearly started to decline by the start of the 1960s.

3.3.1.5.2 Shift of woodland expansion to Scotland

It is also the later 1960s when new land acquired by the FC became primarily located in Scotland. Oosthoek (Oosthoek, 2013) attributes this to a more and more limited availability of land in England and Wales. James (1981) details here that there was an increase in demand for agricultural land and improvements in hill farming that competed with making land available for forestry in England and Wales (i.e. an inhibiting driver for food production), and Tsouvalis (2000) adds that in both countries public opposition to conifer plantations had become very high. By 1969 the British government also gained the green light to negotiate its entry into the EU and its Common Market, and British landowners at the time were reluctant to make decisions until the implications of this transition were known (James, 1981; UKandEU, 2019).

3.3.1.6 The 1980s: tax breaks and conservation in the Flow Country

With the start of the Thatcher government in 1979 further woodland expansion was advocated for the driver of employment from forestry and a reduced reliance on imported timber (Tsouvalis, 2000). Now, however, new afforestation should be delivered almost exclusively by the private sector, therefore fully redirecting the focus back on private forestry after 60 years of emphasis on active governmental involvement in afforestation (though the FC would still provide guidance and grants). To promote this shift, the FC was to make part of its land planned for afforestation (and some woodland) available for sale; this push for privatisation had begun years earlier when for the government economic viability as a driver to invest in forestry had started losing momentum (Miller, 1981).

3.3.1.6.1 The broadleaf policy

In 1982, the Forestry Commission had organised a conference on broadleaves (Oosthoek, 2013). With the drivers of landscape aesthetics, nature conservation (of non-conifer woodlands) and recreation gaining traction, broadleaves were in the midst of being rediscovered as sources of value for these new drivers; this was not least due to their perceived nativeness and its contrast to non-native conifer plantations (see also section **4.4.3.2.2**). The FC, as the only state authority responsible for forestry in Britain, was seen as negligent towards broadleaved trees and woodlands (Warren, 2000). Ultimately, after several years of consultations with NGOs, governmental agencies, and private sector representatives (Watkins, 1986), the government issued a broadleaf policy in 1985 in which the FC committed itself "*to the protection of broadleaved woodlands and trees, especially the so-called ancient woodlands and hardwood trees of high landscape valu*e" (FC, 1985; Oosthoek, 2013, p. 154).

What is important about this is that while the FC now officially became responsible for protecting and enhancing broadleaved woodlands, it did not change its heavy involvement with the private sector in facilitating large-scale non-native conifer plantations. The seeming incompatibility of this two-track policy would become particularly relevant in the events that were already taking place in the north of Scotland, as will be discussed below.

3.3.1.6.2 Tax breaks for private forestry

Several historical accounts come to the conclusion that for the private sector in the end it was financial reasons that sent the rates of afforestation during the 1980s on a steep climb. A system of tax concessions for woodland expansion was exploited whereby high-income investors could "*offset any losses incurred on forestry operations to be set against other income for tax purposes"* (Tsouvalis, 2000; Oosthoek, 2013, p. 151). The creation of the plantations increased the value of the land, which the investors (private parties or forestry agencies on behalf of private parties) would sell off long before revenue from logging would play a role and move on to the next piece of land to repeat the procedure (Mather, 1987; Hart, 1991). Oosthoek (2013) estimates that by the mid 1980s over 90% of afforestation in Scotland was utilising this scheme. The forest management companies eventually started to compete with each other and further increased land prices and "*the FC, because of its strictly controlled budget, was often left with the worst land*" (Tompkins, 1989; Tsouvalis, 2000, p. 80).

Eventually, the afforestation cycles arrived in the Flow Country, a region in the very North of Scotland, with sparked a controversy with the inhibiting driver of non-woodland nature conservation that had gained significant traction at the time.

3.3.1.6.3 The developments in the Flow Country

The Flow Country is an area of blanket peat and wetlands in the North of Scotland; it is home to various endangered species, most notably birds, and according to the Flow Country Partnership in 2022, it is "*the most intact and extensive blanket bog system in the world*" (Flow Country Partnership, 2022). Back in the 1980s, however, the area had not yet become such as synonym for rare and high-value biodiversity, and instead was the setting of "*the showdown between conservation and forest interests*" (Warren, 2000, p. 315).

In the continuation of tax-break afforestation, the Flow Country became attractive for three reasons: land there was cheap; improvements in ploughing technology made it possible to unlock deep, wet peats for planting; and combinations of non-native conifers were found that would grow well on this type of soil (Avery and Lesley, 1990; Warren, 2000). Additionally, when asked why the FC would support this type of afforestation in the wake of the broadleaf policy, the FC argued that the Flow Country was an "*unproductive*" area anyway (Warren, 2000, p. 318), and that afforestation would bring employment in an otherwise rather limited local job market, as well as potentially opening further opportunities in the sector, for example by building a pulp mill (Mackay, 1995). Additionally, the FC felt itself only following the governmentally issued afforestation targets, which were at 33,000 ha at the time (more on this in Chapter 4; Oosthoek, 2013).

Unlike areas that had successfully been afforested elsewhere, however, stakeholders representing the driver for non-woodland nature conservation rallied against the afforestation plans (see illustration of DAPSI(W)R(M) components in **Figure 3-4**). According to historical accounts, one of their most successful tools for doing so was a "*sophisticated*", "*high-profile*" (Warren, 2000, p. 316), and widely executed publicity campaign that resulted in all eyes turning to the developments in the Flow Country (Avery and Lesley, 1990; Tsouvalis, 2000).

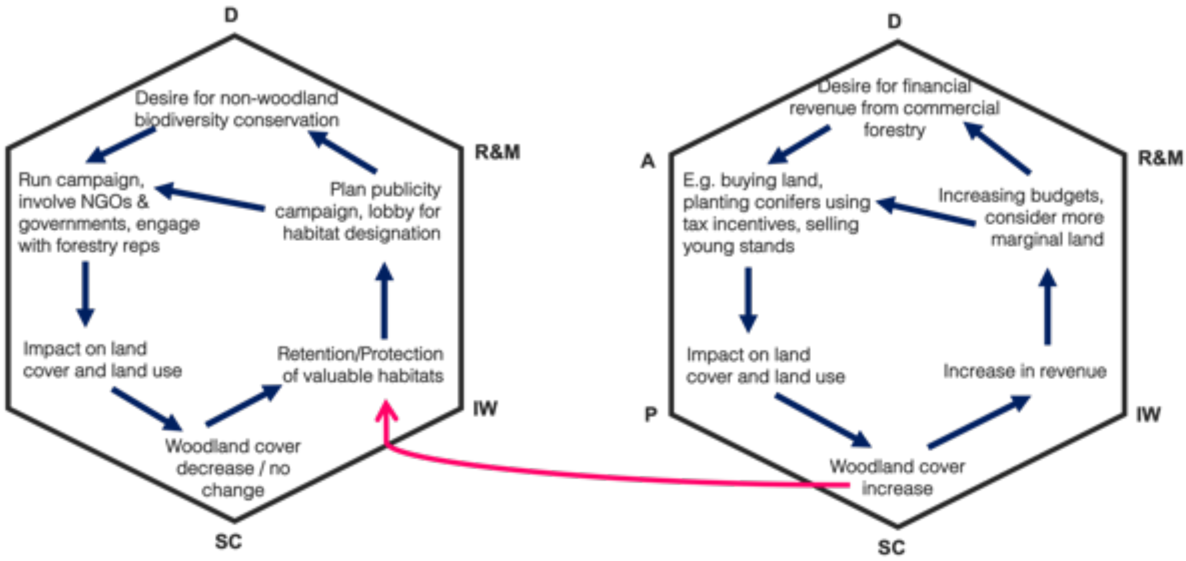

Figure 3-4. DAPSI(W)R(M) components for the driver for non-woodland biodiversity and commercial forestry in the Flow Country during the 1980s. The increase of woodland cover in the area negatively affected the perceived nature conservation value of those areas, causing efforts to halt the increase (and/or cause a decrease in woodland cover).

The arguments brough forward against afforestation were that the blanket peatlands had both immense (international) biodiversity value via the endangered fauna and flora, as well as significant scientific value due to the peat's ability of archaeological preservation (Avery and Lesley, 1990; Warren, 2000). Afforesting even part of the area may have significant (detrimental) knock-on effects on the whole ecosystem (Warren, 2000). Conservationists also specifically questioned the economic and social efficacy of forestry in the region, claiming that the trees would not grow well on this type of soil anyway, meaning the only real return to be had was from the grants and tax benefits (NCC, 1986), and the employment argument was not much use to locals since forestry operations only employ sporadically and often outside contractors at that (Warren, 2000). It should be noted, however, that while the locals themselves generally held unfavourable views of afforestation in their area, they did not side with conservationists either, as they perceived them as single-minded urban dwellers who had little interest in actually engaging with local communities (Mather, 1993).

Warren (Warren, 2000, p. 317) concludes that while parts of the Flow Country did indeed get afforested, ultimately, non-woodland nature conservation "*prevailed*", which is most apparent in the legacy of the Flow Country events for the whole of woodland expansion in Britain. For example, several publications agree that the Flow Country events were the main reason why in the budget 1988 any further tax incentives from forestry were suddenly removed (Mackay, 1995; Wigan, 1998). The events were also the leading reason why in subsequent years, applications for FC afforestation grants needed to consider environmental (and social) impacts in much more detail and thus, became harder to obtain (Warren, 2000). By the 1990s, the FC had switched from considering trees as crops to pursuing a sustainable management of forest ecosystems (Worrell, 1996); this included a swing from conifers to broadleaves and non-native to native species (MacKenzie, 1999). Also by the 1990s, trees in the Flow Country started to get removed, by 2000 the FC disapproved of afforesting deep blanket bog (Warren, 2000), and even in recent years, there is support for the further removal of trees on deep peat all over Britain (RSPB, 2012; FC, 2017).

Despite all this, the "*high-profile anti-forestry campaign of the late 1980s*" significantly tainted the public's image of forestry (Warren, 2000, p. 329); and because trees take long to grow and the legacy of afforestation would be visible in the countryside for decades to come, that image would take very long to remedy (Avery and Lesley, 1990; Mackay, 1995).

Lastly, nature conservation also changed because of the Flow Country events. Most notably, more emphasis was put on a more holistic approach to conservation that included local communities in the process (Mather, 1993). Furthermore, at the end of the 1990s, the NCC, having been responsible for the whole of Britain, announced its devolution into English Nature, Natural Heritage Scotland and Countryside Council for Wales; this was done to further facilitate a diverse and regionally sensible approach to conservation (Mackay, 1995).

3.3.1.6.4 Forestry as an employer

In addition to everything else that had been going on in the 1980s with regards to woodland expansion, in 1986 the National Audit Office concluded that the facilitating driver for rural employment was not an adequate justification for continued governmental support of forestry anymore (reasons include better job offers in other branches, and the fact that in Scotland most jobs in forestry were created at felling times, so 40-50 years after plantation establishment; NAO, 1986). Tsouvalis (2000) writes it was this final report that prompted the FC to abandon the facilitating driver for employment in favour of new ones; as mentioned above at the backend of the Flow Country events and the broadleaf policy, in 1992 the FC wrote in its annual report forestry in Britain had "*evolved*" and was now to contribute "*in terms of wood supply, the environment and other public benefits*" (FC, 1992, p. 11).

All this means is that by the end of the 1980s, the driver for financial revenue from commercial forestry took a big hit due to the removal of tax breaks (although the private sector may have still pursued forestry and timber production); the governmental driver for rural employment was abandoned; the inhibiting driver for non-woodland nature conservation was strengthened, as was the facilitating driver for non-conifer woodland nature conservation via the broadleaf policy. Additionally, Oosthoek (2013) also identifies an expansion in stakeholders with regards to the new constellation of drivers; most notably community forests emerged as evidence of the increased engagement of the public (see more below).

3.3.1.7 Policy changes in the 1990s

Continuing the development of drivers around woodland expansion into the 1990s explains a new type of involvement; for once from an international level, and also from local stakeholders.

3.3.1.7.1 International agreements and climate change

As mentioned above, community woodlands gained traction at the beginning of the 1990s, and this increased involvement of local stakeholder groups coincided with the United Nations Earth Summit in Rio de Janeiro in 1992, which put emphasis on a more bottom-up approach to sustainable development (Jounis, 1997). The UK's interpretation of these international goals was "*sustainable management of existing forests, enhancing their economic value as well as seeking other gains in terms of biodiversity, to combat climate change, recreation and landscape, and for the expansion of the area of woodland in pursuit of these multiple objectives*" (Wynne, 1993; Department for the Environment, 1994; Oosthoek, 2013, p. 162).

This was the first time climate change was mentioned as an facilitating driver of woodland management and expansion in Britain (Oosthoek, 2013), and other sources agree that it was the 1990s when climate change reached the British forestry agenda (Winter, 1996). The historical accounts also conclude that it was these international developments that prompted the conservative government not to privatise the FC at the start of the 1990s, and by doing so there was a continuation of subsidies for the community woodland initiatives (Barclay and Hughes, 1995; Oosthoek, 2013). Even more so, after the Rio Summit the FC was made responsible for the full range of woodland benefits (as listed above) and to explicitly help local stakeholders to get involved (Reid, 1997). In 1999/2000 the FC made two publications[5] that formerly acknowledged the importance of offering involvement to local communities (Oosthoek, 2013): 'Forests for people working with communities – our commitment' and 'Forests for people working with communities – our approach'.

With the rearranged set of facilitating drivers, emphasis was now as much on adequate woodland management as it was on woodland expansion. Compared to the times when the facilitating driver for a strategic reserve of timber produced a very uniform vision of woodlands and the main factor was expansion, facilitating drivers such as woodland recreation, woodland

[5] While publications like Oosthoek (2013) and Fowler and Stiven (2005) agree on the importance of these two documents, they do not give a full reference for them, and neither the Forest Research online archive nor an extensive google search provided the original reports.

biodiversity or climate change mitigation in the 1990s involved the handling of existing woodlands, too.

3.3.1.7.2 Multi-purpose forestry and Sustainable Forest Management

It is important that none of the historical accounts offer a ranking of these facilitating drivers by (political) importance, which is quite different from earlier decades when either the driver for a strategic reserve of timber or the driver for financial revenue were explicitly stated as the 'overriding goal'. Indeed, a governmental paper of forest policy in 1994 looked into whether "*such mixed [driver] use is really feasible, or whether the various interests are really incompatible, linked only by the use of trees*" (Barclay and Hughes, 1995, p. 6). The authors conclude that "*the dilemma remains that commercial timber production will rely upon conifers, because they provide a return in the medium-term rather than the long-term*" and owners *"cannot be expected to care for either the environment or for public access in the same way*" that the FC can (Barclay and Hughes, 1995, p. 7). At the time the solution was seen as (1) the FC taking on the so-called 'multi-use' forestry on its estates, and (2) community forests and projects such as the National Forest which are mostly intended to be multi-use (FC, 1992; Barclay and Hughes, 1995; Tsouvalis, 2000). More examples of community forest projects can be found below.

It was also this time when the term 'sustainability' had become a key forest policy objective (Tsouvalis, 2000), with the idea of 'Sustainable Forest Management' (SFM) being introduced in 1992. In fact, Raum and Potter (2015) note that SFM replaced multi-purpose forestry as a management approach towards the end of the 1990s. It should be emphasised that both these approaches are not new woodland expansion drivers as much as they are activities that tried to accommodate the more diversified set of drivers as they had developed in the 1980s (woodland nature conservation, woodland recreation, carbon sequestration, financial revenue).

3.3.1.7.3 Community woodlands

The local communities getting involved in woodland management and expansion in the 1990s were looking for "*multi-purpose woodland in which community participation, economic regeneration, countryside access, recreation, and heritage conservation*" all played a role (Oosthoek, 2013, p. 160).

For example, the National Forest "*pioneered [...] a forested landscape that would bring all the benefits of woodlands near to where people live and work*" (The National Forest, 2020). In fact, a competition was held to find the best location for the project, and the local communities around Leicestershire and Staffordshire in the English midlands brought in a "*passionate*" bid for their area (The National Forest, 2020). This is an interesting contrast to the Flow Country just a few years earlier, where locals felt (conifer) afforestation had nothing to offer to them or their landscape (Mather, 1993). As of 2022, the project increased woodland cover in its area from 6% (below national average) to more than 20% (well above national average); 80% of the new woodlands are publicly accessible (The National Forest, 2020), the majority of which being comprised of native broadleaved species, and local councils today praise the project for its environmental and touristic value to the region (e.g. ESBC, 2020; NWLEICS, 2022).

Other projects include the Thames Chase Community Forest in East London and South Essex, established in 1990, with an aim the cover 30% of the area in woodland by 2030 (Thames Chase, 2020); the Mersey Forest, a community forest set up in the early 1990s and in Merseyside and North Cheshire, which has by now planted over 9 million trees (The Mersey Forest, 2020); or the White Rose Forest in North and West Yorkshire, established in 2000 (White Rose Forest, 2020). Scientific literature has since followed in critically assessing the success of community forest projects in delivering on their many objectives (Mell, 2011), identifying further barriers to doing so (Dowson and Hill, 1998), and suggesting ways forward using interdisciplinary approaches that can adequately appreciate the diversity of social, cultural, economic, and environmental benefits community forests seek to provide (Jerome, 2017; Nolan, 2019).

During the 1990s, and according to the above examples still today, many community forest projects express a preference for broadleaved and native woodlands (Tsouvalis, 2000). Only Scots Pine was recognised as an exception, being a conifer species and native. For example, the conservation charity Trees for Life has been working since the early 1990s on restoring the Caledonian Forest in the Highlands of Scotland, by purchasing land, fencing out deer to support natural colonisation/regeneration, and liaising with local land managers and other stakeholders to gradually expand the woodlands (Scotland's Nature, 2015). A critical reflection on the comparison of broadleaves and nativeness can be found in section **4.4.3.2.2**.

Further support for these developments came from an international level with the Convention on Biological Diversity in the wake of the Rio Earth Summit (Oosthoek, 2013). The interest in restoring (and expanding) Britain's 'ancient' woodlands was also supported by external economic influences; at the time the pound was strong and the price of softwood timber fell due to the collapse of communist Eastern Europe and a surge in timber supplies from some of the states in the process (Pearce, 2006).

3.3.1.7.4 Farm woodland

While for the decades earlier woodland expansion was focused on the upland regions in Scotland and Wales, Hemery (2006, p. 1) notes that it was the end of the 1980s and start of the 1990s when the "*farm-woodland trend*" started, meaning a focus on expanding woodlands as part of farm systems. Indeed, by the start of the 1990s the FC had also developed a Farm Woodland Scheme for financial support (FC, 1999), a development that reflects both the more and more limited availability of further land in the upland regions (Oosthoek, 2013) and an increased important in satisfying the drivers other than commercial forestry.

3.3.1.7.5 Devolution of the Forestry Commission

The international developments and bottom-up approaches to British woodland management and expansion led to an increasing emphasis on 'social forestry' by the end of the 1990s (Tsouvalis, 2000). It was also the time of devolution of governments in Scotland and Wales, so the interest of delivering the sub-national forestry strategies in England, Scotland and Wales lead to a subsequent devolution of the Forestry Commission into an individual branch for each country (FC, 2004; and a national part for finance, research and grant administration; Oosthoek, 2013).

At this point different stakeholders involved in woodland expansion in Britain followed distinctively different drivers. The private sector had split into those still primarily interested in financial revenue from their woodlands (while trying to comply with other drivers where mandatory and/or possible) and those who were involved in NGOs and community woodlands (and similar projects) to serve recreation and conservation (with 'ancient' woodlands being one aspect), as well as community benefits. While the first group can be defined by one driver (financial revenue from timber), the latter is mostly defined by all the other facilitating drivers together since they based their management on 'multi-use' (or 'sustainable') forestry. This is similar to the third entity, the FC (and its devolved branches) which by the turn of the 20th century also officially had to cater to all facilitating drivers. Subsequently, activities in line with sustainable forest management were developed to try and do so.

Nevertheless, at the turn of the 20th century the overall interest in the expansion of woodlands was still present. For example, in 1999 the FC wrote its mission was "*to protect and* expand *Britain's forests and woodlands and increase their value to society and the environment*" (FC, 1999, p. 9).

3.3.1.8 The 21st century

The new millennium up until 2019 was marked by both an introduction of new drivers, as well as a gradual shift in how they were prioritised (most notably towards carbon sequestration for climate change mitigation).

It is also a time when the devolution of state forestry continued to evolve. Since 2013 Natural Resources Wales has taken over most of the Forestry Commission's functions in Wales, and with 2018 forestry functions in Scotland were transferred completely to the Scottish Ministers (while in England and Wales the Forestry Act of 1967, as amended, remains key statute on forestry matters; HLL, 2019). This is important because it means that after the 20th century where the FC could be seen as equivalent to the public forestry sector (given it was the only governmental authority on forestry matters), it is now differently devolved agencies/departments responsible for part or all of each country's woodland management and expansion agendas (FLS, 2019; e.g. Scottish Forestry, 2019).

The question of how to satisfy the varied set of facilitating drivers in woodland management and expansion continued into the 2000s, with sustainable forest management passing over to the Ecosystem Service approach which put emphasis on the equality in (monetary) valuation of the multitude of services British woodlands provide (Raum and Potter, 2015). This was (and is) an international development (e.g. with the Millennium Ecosystem Assessment in 2005; MEA, 2005), and the UK put it into national context in the early 2010s (FC, 2011, and later 2017; UK NEA, 2011b). However, till today there is open discussion about how exactly the ecosystem service approach should service woodland management and expansion drivers in Britain (Quine, Bailey and Watts, 2013; Raum and Potter, 2015).

3.3.1.8.1 Continuation of community engagement & cohesion

The creation of community forest projects continued in the 21st century, not only with regards to creating new woodland cover, but also buying existing woodlands by local communities. For example, Aigas Community Forest near Inverness in Scotland is a "*community run social enterprise*" that has been established by purchasing existing woodland off of Forestry Commission Scotland in 2015 (Aigas Community Forest, 2020). Additionally, the grassroot network Llais y Goedwig provides a map of all Welsh community woodlands within their membership (Llais y Goedwig, 2022), and survey from 2010 identified 138 active community woodlands in the country, covering about 1795 ha of woodland (Griffiths, 2010).

There is evidence that the impact on welfare from these projects goes beyond the woodland expansion drivers that have been mentioned already. Most notably, interests like 'social interaction', 'inclusion', 'community confidence' and 'community cohesion' are quite unique to community woodlands (Tsouvalis, 2000; Woodland Trust, 2011; Goodeney, 2015), which is why within this research, they will be classified as a new driver for community benefits from woodlands.

Possibly as a spin-out of community benefits, urban areas have also come in focus for tree cover expansion, with Rutley (2019) stating the parliament was committed to not only plant 11 million trees in the countryside, but also "*one million trees in our towns and cities*". This means that the new drivers, such as community benefits and farm woodland, also changed the scale at which woodland expansion was pursued: individual trees in the city and small groups of trees on farmland do not qualify as a woodland (for being below 0.5 ha in size), yet they have also now become tools in expanding British tree cover.

3.3.1.8.2 Rewilding

Another potentially new driver of woodland expansion is the desire for an intrinsic appreciation of natural processes via the rewilding movement. The term rewilding originated in America in the 1990s, but according to Rewilding Britain (2019a) the idea gained a wide audience in Britain in the 2010s. It is based on the concept of achieving nature conservation and related WES not by active management, but through reducing intervention wherever possible (Corlett, 2016).

Rewilding does not entirely exclude human intervention, for example planting tree islets to facilitate future natural colonisation, but a goal may well be to "*embrace whatever non-interventions brings*" (Corlett, 2016). An example for rewilding projects the Cambrian Wildwoods in Mid Wales, founded in 2007, "*to preserve wild land or restore land to a wilder state*" (Cambrian Wildwood, 2018); the Affric Highlands in Scotland, a project that was started in 2020 as a collaboration between Rewilding Europe and the local landowners (Trees for Life, 2021); or Knepp Castle Estate in West Sussex, which was ahead of its time by having started already in 2001 (Knepp Wildland, 2020). It should be noted that in all three of these projects, some management is being undertaken, such as selective grazing or tree planting, and in all three projects woodland cover increase is, amongst others, a welcome outcome (Cambrian Wildwood, 2018; Knepp Wildland, 2020; Trees for Life, 2021).

Studies using these projects often discuss the conceptualisation surrounding rewilding, e.g. what is 'wild', whether and when 'wild' is considered good, and for what/whom (Ayres and Wynne-Jones, 2014; Wynne-Jones, Strouts and Holmes, 2018). While the concept of rewilding includes an interest in biodiversity conservation, as well as possibly community cohesion, it is much more open-ended and adds a desire for an intrinsic appreciate of natural processes and their sometimes unpredictable outcomes.

Within rewilding, natural colonisation is for the first time the primary tool for woodland expansion (over active planting), and a minimisation of any active management is the goal. This is why the desire for an intrinsic appreciation of natural processes is considered as a new driver for woodland expansion, though more time may have to pass to see how much large-scale influence it will have.

3.3.1.8.3 Climate change

In 2006 Prime Minister Tony Blair called the science of climate change "*the moon landing of our day*" (as cited in Hemery, 2006, p. 1), thus emphasising the importance of climate change and its impact on human welfare. Trees here are used as a means to sequester carbon, and the mitigation of climate change as a facilitating driver significantly increased in importance not only in other areas, but also in terms of woodland management and expansion.

As mentioned in the Introduction, in 2019 the Committee on Climate Change (CCC) concluded that for the UK to reach a net-zero Greenhouse Gas Emissions (GHG) target for 2050 (and therefore uphold the commitment it made at the Paris Agreement in 2015), 30,000 hectares of land should be afforested annually (Carrington, 2018; CCC, 2019). If other carbon reduction targets (most notably changes in consumption habits) would not be achieved the afforestation should rise to 50,000 hectares annually.

3.3.2 The main drivers of woodland expansion in Britain, 1919-2019

Following the synthesis above, a total of ten facilitating drivers (**Figure 3-5**) and eight inhibiting drivers (**Figure 3-6**) influenced the history of woodland expansion in Britain between 1919 and 2019. They are a representation of wide-spread societal and subsequent political demands put on British woodlands throughout these hundred years. In that, these drivers also relate to woodland ecosystem services (WES) and, in case of inhibiting drivers, non-woodland ecosystem services, as those demands in turn represent expected benefits and impacts on human wellbeing.

The ten **facilitating drivers** were based on:

1. The desire for timber, in case of another war
2. The desire for rural employment
3. The desire for woodland amenity
4. The desire for financial revenue from commercial forestry
5. The desire for woodland recreation
6. The desire for biodiversity conservation of non-conifer plantation woodlands

7. The desire for farm benefits from woodlands
8. The desire for carbon sequestration from woodlands to combat climate change
9. The desire for community benefits from woodlands
10. The desire for an intrinsic appreciation of natural processes value via rewilding

The **inhibiting drivers** were based on:

1. The desire for food production
2. The desire for non-woodland amenity, for example regarding (open) landscape aesthetics, nature conservation and recreation in the Lake District
3. The desire for avoided loss of financial revenue from commercial forestry, for example via tax changes
4. The desire for non-woodland landscape aesthetics, specifically regarding open landscapes with low levels of woodland cover
5. The desire for non-conifer plantation biodiversity conservation
6. The desire for non-conifer plantation recreation
7. The desire for cultural landscape conservation
8. The desire for non-woodland climate change mitigation

Figure 3-5 and **Figure 3-6** show the times when the individual drivers exerted the biggest influence on woodland expansion, according to historical accounts. It is important to note that the drivers may have been present locally or regionally outside these time spans as well (e.g. financial revenue from commercial forestry), but were less important on shaping the state change of woodland expansion on a national level.

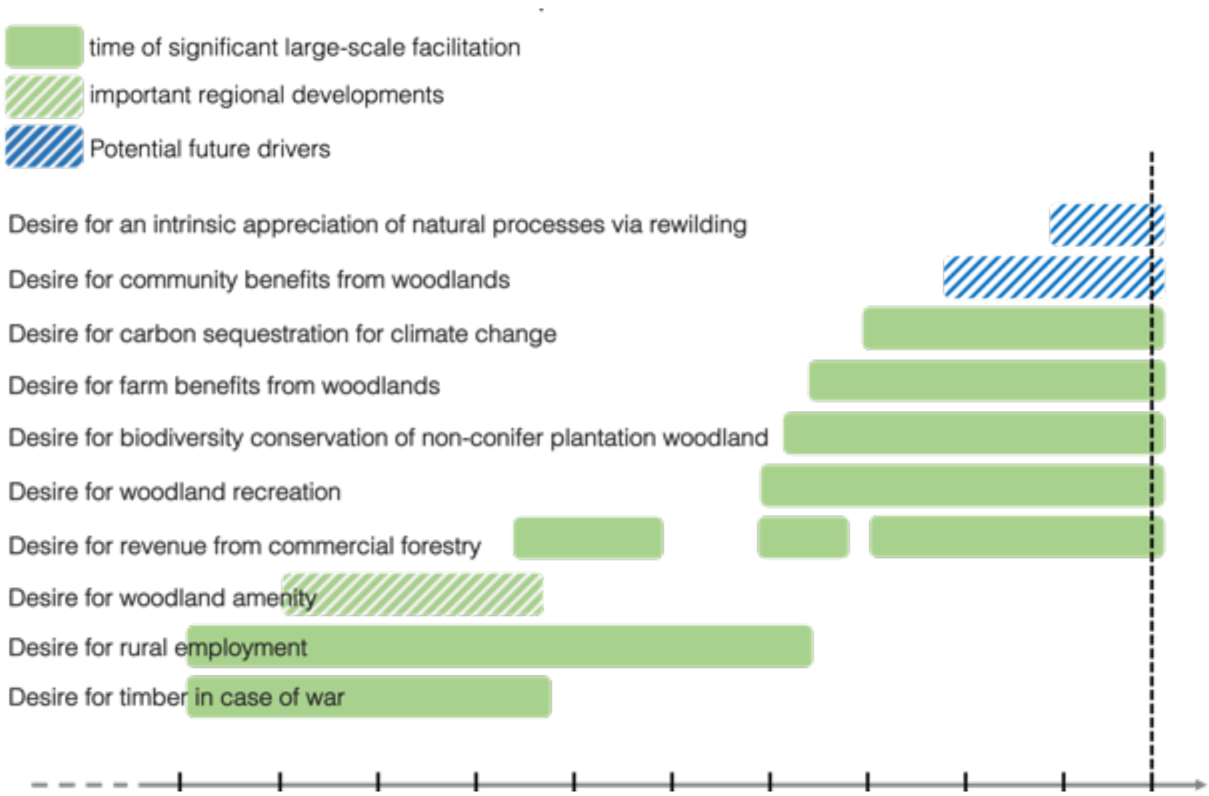

Figure 3-5. Facilitating drivers of woodland expansion in Britain between 1919 and 2019. The desire for community benefits and an intrinsic appreciation of natural process are a very recent trends, so their large-scale influence is still unclear.

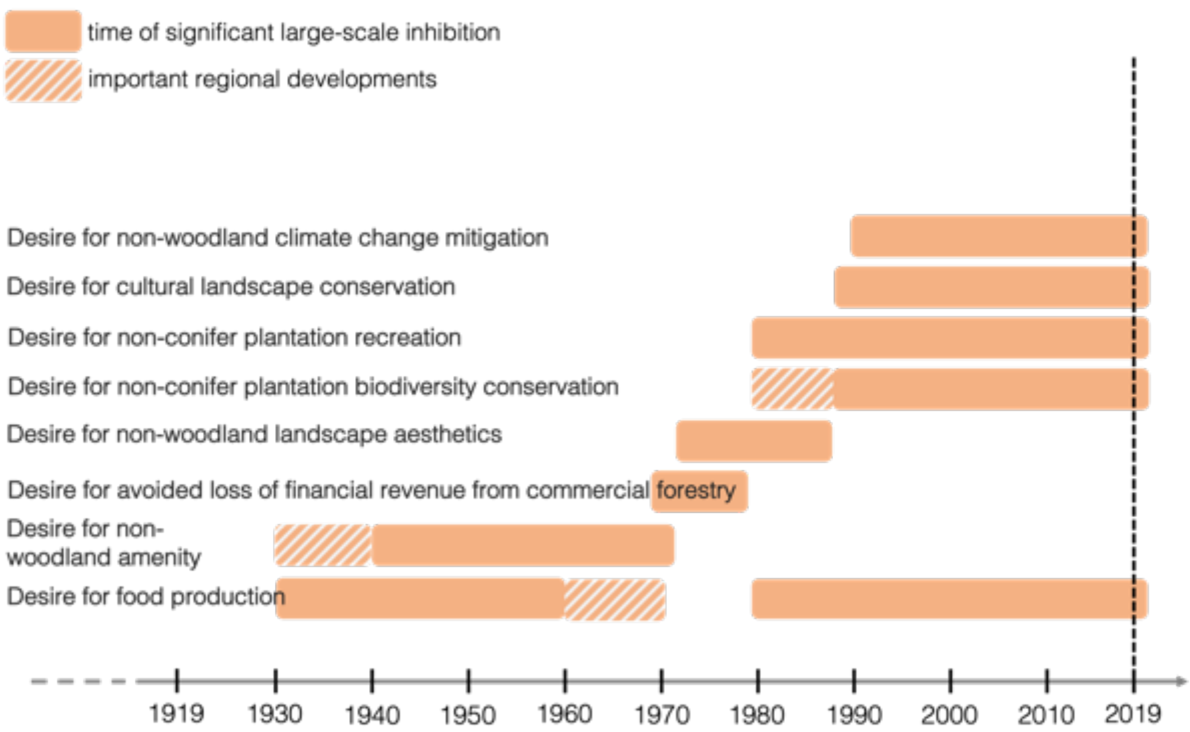

Figure 3-6. Inhibiting drivers of woodland expansion in Britain between 1919 and 2019. As of 2019, many facilitating drivers have an inhibiting counterpart, such as the desire for biodiversity conservation and recreation.

The **desire for a large-scale timber reserve** was introduced after WWI (Ryle, 1969; e.g. Aldhous, 1997). WWI and WWII are said to have been important events to 'jump start' woodland expansion in Britain (Oosthoek, 2013). The scarcity of woodland in Britain had been pointed out before 1919, but not acted upon to the degree it was called for (House of Commons Hansard, 1943a; Robertson, 1943). The driver declined in importance in 1957 when it was concluded that the advent of nuclear power had made it obsolete (House of Commons Hansard, 1957; James, 1981).

Rural employment from forestry was a **facilitating driver** from the beginning of the timeframe in question and continued as a strong reasoning for further woodland expansion (especially in remote areas) far beyond the driver of a strategic reserve of timber (Ryle, 1969; Aldhous, 1997; e.g. Oosthoek, 2013). Even though technical staff started to decline at the start of the 1950s, due to increased mechanisation and technological advancement, employment remained relevant as a driver especially for the FC (FC, 1980; Tsouvalis, 2000). It was only considered insignificant in the mid 1980s with the conclusion that other sectors offered better jobs and forestry as it had become practiced by then did not justify employment as a driver anymore (NAO, 1986; Tsouvalis, 2000).

The desire for **food production** first inhibited woodland expansion from the two world wars until the 1960s, and then emerged again during and after the 1980s. Especially after WWII a secured supply of food was considered more important than timber for another war, so prime agricultural land was not (and would continue not to be) available for afforestation (House of Commons Hansard, 1943a; Kaplan, Krumhardt and Zimmermann, 2009; Oosthoek, 2013). In the 1960s higher values of food production made land available for woodland expansion in England and Wales scarce and/or too expensive for the FC to buy, which pushed the afforestation further into the Scottish uplands (James, 1981). Food production as an inhibiting driver once again gained influence from the 1980s onward, when the remaining upland areas had become hard to afforest and focus shifted towards trying to bring woodlands onto farms (FC, 1999; Hemery, 2006). Conversely, this also resulted in the facilitating driver of farm woodland creation, which supports woodland creation for shelter belts, flood mitigation, reduction of sediment runoff and other farm related benefits.

The desire for non-woodland amenity as an **inhibiting driver** became relevant almost with the creation of the FC in the late 1920s and was essential as a regional, inhibiting factor in the developments in the Lake District in the 1930s (Joint Comittee FC & CPRE, 1936; Tsouvalis, 2000). For a long time thereafter, it encompassed all those interests that would later branch out into the drivers for non-conifer plantation biodiversity conservation, open landscape aesthetics, non-conifer plantation recreation, and cultural landscape conservation (Alan and

Macdońald, 1945; Linnard, 1982). Amenity was mostly understood as an argument against woodland expansion, especially against the expansion of conifer plantations: for example, in England and Wales of the 1960s it was not only food production inhibiting woodland expansion, but also rising concerns about the negative impact of these woodlands on the landscape (and people's enjoyment of it; Tsouvalis, 2000). It should be noted, however, that **amenity** had a regionally **facilitating** counterpart in Scotland, where during the 1930s-50s planting the hills with woods was seen as a productivist increase in the beauty of the landscape (Oosthoek, 2013).

The desire for **financial revenue from commercial forestry** as a facilitating driver of woodland expansion had been relevant in the first half of the 19th century already, specifically regarding hardwood (Linnard, 1982), but then faded in relevance on a large scale roughly until the 1950s (Linnard, 1982; Tsouvalis, 2000; Oosthoek, 2013). Then, the government started offering grants and other incentives to entice the private sector into taking up commercial forestry once more; this would strategically also serve the strategic reserve of timber, as in both cases forests would be planted and timber would be grown (FC, 1949; Aldhous, 1997). Later on, the government also had to measure its own activities against this driver, as the strategic reserve of timber lost relevance in the advent of nuclear power (House of Commons Hansard, 1957), and employment was concluded to have become an insufficient argument for governmental expenditures on woodland expansion as well (NAO, 1986). In the 1970s potential wealth and capital transfer taxes temporarily introduced the **inhibiting driver** of **financial loss from commercial forestry**, as at that point financial revenue from commercial forestry was mostly running via beneficial tax exemptions (Linnard, 1982). Ultimately, inhibiting changes to the tax system for woodland expansion were averted, and in the 1980s the tax breaks again facilitated financial revenue from commercial forestry and woodland expansion in the process until the budget 1988, when they were removed (Mather, 1987; Hart, 1991; Oosthoek, 2013). Since then, financial revenue from forestry for landowners may be less of a focus in terms of large-scale woodland expansion, but on a local level is likely still relevant (Burton, Metzger, *et al.*, 2018).

The desire for **non-woodland landscape aesthetics** as an inhibiting driver is what amenity rolled over in to during the early 1970s, when especially the FC had to concede the way new woodlands changed the face of the landscape (Tsouvalis, 2000; especially at a time when the trees once planted turned into large, high stands of mostly conifers; Oosthoek, 2013). During the 1980s and later early 1990s, however, a lot of interest was already put into the inhibiting drivers non-confer plantation recreation and non-conifer plantation biodiversity conservation, so that landscape aesthetics was eventually replaced by the **inhibiting driver** of a desire for

cultural landscape conservation. Given that a historical Britain, at least in recent centuries, has been primarily characterised as a mosaic and *open* landscape with low levels of woodland cover, conserving this cultural landscape has primarily been seen as inhibiting woodland expansion (Roberts and Kelly, 1994).

As **inhibiting drivers**, both **recreation** and **biodiversity conservation** (or nature conservation) were often used as arguments specifically against the large-scale conifer plantations that made up the vast majority of woodland expansion at the time. This was especially the case in the 1980s in the Flow Country, where non-woodland biodiversity conservation inhibited woodland expansion to retain the blanket bog habitat (Oosthoek, 2013). This specification to 'non-conifer' woodland is important because it explains the existence of their facilitating counterparts – the desire for **woodland recreation** and **biodiversity conservation of non-conifer plantation woodland**. It was not that no one was interested in spending recreational time in woodlands, or in conserving biodiversity in woodlands, but that conifer plantations specifically were not seen as beneficial to either. Especially the rise of the broadleaves policy and the appreciation of native woodlands in the 1980s offered plenty of facilitation for non-conifer woodland expansion (Barclay and Hughes, 1995; Tsouvalis, 2000).

The desire for **carbon sequestration for climate change** is one of the younger additions to the main facilitating drivers of woodland expansion in Britain, reaching forestry agendas in the 1990s (Wynne, 1993; Department for the Environment, 1994), though it is gaining continued importance (CCC, 2019). One of the biggest factors supporting woodland expansion is the ability of trees to sequester carbon (CCC, 2019), but they may also help with managing changing weather conditions (flood prevention, wind shelter). Adversely, the desire for **non-woodland climate change mitigation** can be an **inhibiting driver**, especially on a regional level. A good example for this are land covers or land uses that already retain or sequester high amounts of carbon, such as deep peat (FC, 2017).

The desire for **community benefits from woodlands** is one of the two last additions to woodland expansion drivers. It has been shaded in **Figure 3-5**, because it's likely that not enough time has passed yet to decide whether community benefits were a significant influencing factor of woodland expansion since the 2000s on a large scale or not. What is true is that there are certain interests, such as 'community cohesion', 'social interaction', 'inclusion', or other aspect of community woodland projects that do not belong within any of the other drivers (Tsouvalis, 2000; Oosthoek, 2013). With the Community Forests Programme in England, established in 1990 (Community Forest Trust, 2020), and large-scale support and/or grassroot developments since then (Griffiths, 2010; Aigas Community Forest, 2020), Britain now houses a wide variety of community woodland projects pursuing woodland expansion.

Finally, there **is the desire for an intrinsic appreciation of natural processes via rewilding** as another tentative facilitating driver of woodland expansion, especially from the 2010s onwards, when it became more widely introduced in Britain (Rewilding Britain, 2019b). Rewilding has a more open-ended approach to its potential impact on welfare (Corlett, 2016), as it primarily pursues a reduced management level (and with it prioritises natural colonisation over tree planting); this differentiates it from other drivers. Much like community woodlands above, since the 2010s, a range of rewilding projects have been introduced, many of which welcome the increase of woodland cover (Cambrian Wildwood, 2018; Knepp Wildland, 2020; Trees for Life, 2021).

3.4 Discussion

This research has identified an evolving and expanding set of drivers that shaped woodland expansion in Britain from 1919 to 2019. It also showed that overall, the general objective of woodland expansion (as a state change) was rarely contested. Davidson and Wibberley (1977, p. 37) report of one such rare incidence when The Ramblers Association, in its criticism of the FC's limited nature conservation efforts toward the 1980s, noted *"[...] there is nothing inherently bad about having a smaller area under trees than in most other countries*". Nonetheless, even after that and up until now the objective of woodland expansion remains.

Furthermore, this research has shown that the DAPSI(W)R(M) framework and its terminology, originally introduced for marine environmental management (Elliott *et al.*, 2017), can be used as a sensible baseline for standardising large-scale trends of woodland expansion, their impacts, and developments over time. These drivers all represent societal and subsequent political demands put on woodlands, thereby also making them comparable to other frameworks, such as the ecosystem service framework (Millennium Ecosystem Assessment, 2005). However, even with the DAPSI(W)R(M), some subjectivity in deciding what is or isn't a driver, desire or trend remains; a different researcher using a different framework for this work might have identified a similar but not necessarily identical set of trends.

3.4.1 A changing future

As mentioned above, in many ways woodland expansion in the 2010s is very different from 100 years ago. The number and variety of drivers significantly increased, from 4 drivers in 1919 (two facilitating and two inhibiting) to 12 drivers in 2018 (seven facilitating and five inhibiting).

The number and nature of these drivers directly corresponds to an increase in responsibilities that are attributed to British woodlands**.** For example, it used to be that the FC did not see its woodlands needing to deliver things like conservation, or recreation, or native broadleaved trees (Maxwell, 1930; Linnard, 1982), but this has changed; woodlands now need to provide more large-scale benefits than ever before.

Because of this diversification, activities involving woodland expansion have changed, too. The introduction of natural colonisation is a prominent example. Active planting has governed almost all facilitating drivers of woodland expansion during the last 100 years, and in many ways the history of British woodland expansion *is* a history of active planting. With the introduction of rewilding, however, alternatives such as natural colonisation (and the active planting of native broadleaved species) are being proposed, so the future of activities surrounding woodland expansion may be much more diverse.

Stakeholder involvement has also diversified significantly. For example, citizens of a community gathering to plant trees and socialise in the process is a long way from the 20th century government setting out to create a strategic reserve of timber. Today's stakeholders that directly interact with woodland expansion (i.e. managing land to create tree cover) may be private individuals (Woodland Trust, 2021b), communities (Community Forest Trust, 2020; Llais y Goedwig, 2022), NGOs (Rewilding Britain, 2019a; Woodland Trust, 2020), companies (BrewDog, 2020; Carnell, 2022), international investors (Garside and Wyn, 2021; Investment Property, 2022), or the government (Forestry England, 2022b); each with their own sets of drivers. In fact, historic accounts point out that after the 1970s the government had stepped back to a supporting role of woodland creation, while not directly being responsible for any afforestation anymore (FC, 1992; Tsouvalis, 2000); Chapter 4 will look at the corresponding afforestation data for this. There is evidence, however, that the devolved governments are once again planning to participate more actively in securing land and creating woodlands (Forestry England, 2022b). Due to Brexit and the increasing importance of climate change, the government is also pursuing new agri-environment schemes and policies to support the private sector (DEFRA, 2021a; Welsh Government, 2021c), though it remains to be seen how successful these measures will be given the complexity of land manager decision making (DEFRA, 2008; Wynne-Jones, 2013; Lawrence and Dandy, 2014).

This range of drivers and stakeholders also diversified the size, location and character of tree cover that is being pursued. For much of the 20th century there was a heavy emphasis on even aged conifer stands of a certain size (for commercial forestry, employment or a strategic reserve of timber), and especially after the 1950s the location of these woodlands was primary in the uplands (and the Scottish uplands at that). Today, there is also evidence of the uplands being a primary area of interest for further woodlands creation (Helm, 2017; Cosby *et al.*, 2020), and interest in (non-)conifer woodland still remains (The Scottish Government, 2017; Forster *et al.*, 2021), but there is much more now. The management of small woods has become interesting (Small Woods, 2021), as well as trees outside woodlands on farms on uplands and lowlands (NFU, 2019; Soil Association Scotland, 2019; Wheeler, 2019), and even individual urban trees (UK Government, 2019; BBC, 2020; LUFP, 2020). Woodlands may now also be native broadleaves (Welsh Government, 2018; UK Government, 2021), and instead of (single-species) even-aged stands stakeholders may pursue structurally diverse mixed woodlands (Rewilding Britain, 2019b; CEH, 2021).

Yet, there may still be more. When comparing the drivers of woodland expansion, as they were identified from historical accounts, to the list by Sing et al. (2018) of Britain's priority WES (see section **2.1.1.1**), there is one more driver that may be relevant on a large-scale soon: flood prevention. Damage from floods costs billions of pounds in Britain each year (Taylor, Goodley and Syal Rajeev, 2015; Hughes, 2020), and with climate change increasing the likelihood of extreme rainfall events, the numbers will likely increase. In recent years, woodland creation is often proposed as an alternative to conventional hard engineering solutions (Hanking et al., 2017c; Woodland Trust, 2021a). In fact, the Northern Forest project, introduced in Section **2.2**, mentions flood risk mitigation as one of its prime interests (Woodland Trust, 2017; Mash, 2018). It should be noted, however, systematic reviews of existing literature suggest that there is a lack of primary evidence and further research is needed on the impact of tree cover on flood risk (Carrick *et al.*, 2019; Tembata *et al.*, 2020).

In comparison to these developments, the inhibiting drivers of woodland expansion also show that woodlands today (and woodland expansion) are much more intertwined with other land covers and land uses**.** By being so, they very much demonstrate the *crowdedness* of the British landscape, as it was introduced in section **2.2.2**. Almost every facilitating driver today has a large-scale inhibiting counterpart. For example, carbon storage for climate change mitigation may result in afforestation and woodland expansion, while carbon storage from deep peat may result in deforestation of past plantations and woodland cover decrease (FC, 2017). Recreation may also facilitate woodland expansion, or inhibit it, depending on what is seen as most important. Biodiversity conservation encourages woodland expansion, mostly *if* it is native broadleaves, but discouraged it in the Flow Country in the 1980s, favouring local habitats over conifer plantations (Tsouvalis, 2000). This pairing of drivers ultimately creates a spectrum of trade-offs, where there may never be a single 'best' version of future British woodlands, only scenarios based on national, regional and local priority setting.

3.4.1.1 Balancing Britain's woodland expansion drivers

To balance Britain's woodland expansion drivers, different approaches could be taken, from trying to equally integrate all drivers on a national scale all the way to prioritising one driver nationally and pursuing collateral benefits for other drivers only on a local level.

There is evidence, for example, that carbon sequestration for climate change is becoming prioritised over other reasons to expand British woodlands. A lot of current woodland creation targets have become directly related to carbon sequestration (Cuff, 2020; RFS, 2020; Seabrook, 2021), so much so that in a POSTnote from early 2021 the UK government describes any other (collateral) benefits derived from woodland as "*non-carbon reasons for woodland creation*" (UK Parliament, 2021, p. 1).

It seems that, given the urgency of climate change, the driver is taking over the centre stage of large-scale woodland expansion in Britain, but this approach is being criticised, not least due to its perceived historic precedence. For example, historic accounts classified the pursuit of a strategic reserve of timber a very single-minded one, in which other drivers such as amenity and later landscape aesthetics and biodiversity conservation suffered collateral damage. Indeed, the very definition of prioritising one driver over all others means accepting whatever negative trade-offs may occur. While back then people were afraid of the Lake District losing its scenic English landscape to woodland cover (Joint Comittee FC & CPRE, 1936; FLD, 2019), by 2019 a variety of stakeholders are afraid of the farmed landscape losing its historical and cultural value to renewed woodland expansion (Greenhill, 2019; Stanley, 2019).

In another example, Mather (1987) and Hart (1991) write that during the 1980s tax breaks for wealthy investors where responsible for over 98% of all woodland creation. Many of these stakeholders had little to no interest in trees of woodland management at all, and considerations other than selling the stands at the earliest opportunity were not relevant. In the Flow Country of the 1980s, it was this very singular pursuit that would become the turning point for woodland expansion in Britain as a whole (Warren, 2000). Today, a similar worry exists around climate change; that some large corporations see tree planting as a means of 'greenwashing' their operations, caring little about the future state of these woodlands or their wider impact (Garside and Wyn, 2021; Owen, 2021; Williams, 2022). This is not least paired with the criticism that carbon sequestration can only be successful in addressing climate change if large industries follow suit in cutting down their carbon emissions (Sene, 2020; Temple, 2020).

Many of these past developments and their level of collateral damage are now perceived as mistakes (Tsouvalis, 2000; Oosthoek, 2013). The alternative would be to pursue all drivers of woodland expansion on a more equal footing, as it was introduced in the 1980s. Community woodlands seem to do this, many of which listing a range of environmental and social benefits the projects seek to provide (Thames Chase, 2020; The Mersey Forest, 2020; The National Forest, 2020). Rewilding projects, similarly, suggest that a ‘wild’ landscape may provide intrinsic and utilitarian value (Cambrian Wildwood, 2018; Knepp Wildland, 2020). Whether these projects manage to deliver on all their objectives equally or not, they certainly seem to seek a level of balance. On a much larger scale, woodland expansion opportunity maps (WEOMs), introduced in section **2.2.2.1**, support this idea by spatially categorising where woodlands could be used for carbon sequestration, for financial revenue, for community cohesion, or biodiversity conservation (Jones, 2007; Hanking et al., 2017c; e.g. Friends of the Earth, 2020). Some of the woodlands may serve more than one facilitating driver, others do not. Some priority setting does, however, also occur. Many WEOMs, for example, class agriculturally land (1-3a on the agricultural land classification) as a constraint for woodland expansion (Nauman *et al.*, 2018; Burke *et al.*, 2021), thereby ranking food production on this land above any other drivers of woodland expansion. Similarly, deep peat is usually also classified as a constraint, putting emphasis on non-woodland nature conservation (and possibly carbon retention) in these areas (Nauman *et al.*, 2018).

Indeed, in many ways the question is less whether to prioritise or not, but how much to prioritise, and on what level. Balancing a lot of drivers takes careful planning and extensive stakeholder involvement, which is time consuming and not necessarily in line with the urgency of climate change (or species extinction). Neither should it the goal to deny the British landscape the complexity it already exhibits, including the diverse values and benefits that are derived from it. The future of woodland expansion in Britain will have to be one of continuous conversations on priority setting, and thus on what stakeholders are willing to do or to accept to make future woodlands a reality – on a national, regional and local level.

Such a deliberation should also include one last point, about creating woodlands for only one or several purposes; more so, about the idea of growing trees *deliberately* for any anthropocentric purpose. Woodlands operate on timescales much longer than humans: native tree species to Britain often take at least 50 years to mature, and they can outlive human generations several times over. Deliberately designing future woodlands based on present drivers is taking the risk that by the time these woodlands mature, the world has already moved on. The narrower the set of drivers for the original design, the higher the risk that the mature woodlands will not be fit for a new world order. The conifer plantations from the 1930s, designed for a strategic reserve of (conifer) timber, matured in the 1980s and the age of multi-purpose broadleaved woodland. In turn, the multi-purpose broadleaved woodlands planted in the 1980s are now slowly maturing in the 2020s in the midst of arguments about whether conifer plantations may not be better suited for carbon sequestration (Forster *et al.*, 2021). The timescales of woodlands match neither five-year policy cycles, nor drivers of woodland expansion that span a few decades. What foresters have long known – that they only ever reap their predecessors' work and sow their successors' woodlands – is an important lesson for the whole discourse around woodland expansion.

This research has identified a range of facilitating and inhibiting drivers that govern large-scale woodland expansion as of 2019 (and the early 2020s). Consolidating these drivers is proving hard enough (Thomas *et al.*, 2015; Burton, Metzger, *et al.*, 2018; Sing *et al.*, 2018). Creating thriving and beneficial woodlands *now* for the *future* is also about leaving enough room for growing woodlands to respond to a rebalancing of priorities in those drivers that are already known *and* include some of those that haven't even made it on the list yet. Though this would take careful deliberation and negotiation, it may be a way to (albeit slowly) adapt for a changing future with lessons learned from the past.

3.5 Conclusion

This research has shown that the last 100 years of forestry history in Britain were most notably a time of diversification; woodlands now must provide benefits for a much wider range of interests and stakeholders than they ever did before. It has also become clear, however, that most of this history was governed by active planting, and alternatives such as natural colonisation are a very recent and entirely new way of engaging with woodlands.

The future of woodland expansion in Britain will hinge upon the balance that can be struck between all these new interests; between how much carbon sequestration can be prioritised without repeating the types of collateral damage 20th century afforestation is now judged for; and between how much the diverse interests can be balanced, using stakeholder engagement and models like the WEOMs, without losing sight of the urgency some of them require.

Lastly, whatever trade-offs may be deemed acceptable in the pursuit of woodland expansion – on a national, regional, or local level – this research has also shown that in all this anthropocentric planning the timescales on which woodlands operate should be considered. The drivers of woodlands expansion continuously changed over the last 100 years, and will likely do so in the future, which bears the risk that the woodlands designed with the objectives of today may not be fit for the future in which they mature into. However focused or broad the purpose for Britain's new woodlands will be, it may be prudent to include some flexibility to this, so that these woodlands may be resilient (and diverse) enough for a potential repurposing, depending on what changes the future may hold.

4 ONE HUNDRED YEARS OF PLANTING TARGETS AND AFFORESTATION IN BRITAIN

4.1 Introduction

Chapter 3 demonstrated that Britain has a long history of woodland expansion. It is also clear that there is a renewed ambition in creating new woodlands of the future. This is not least due to the urgency of climate change and the ability of woodlands to sequester carbon.

The ideal vision of these new woodlands (and by extension their success) is quantitatively most often expressed as total area (in hectares) of woodland 'created'. As of the writing of this chapter in 2022, England's latest Action Plan foresees 12% woodland cover by mid-century, or over 5,000 ha of new woodland each year (UK Government, 2021). In 2018 the Scottish Government planned to create 15,000 ha new woodland per year until 2032 (Scottish Government, 2017, 2018), and the 2020 Agricultural White Paper for Wales speaks of 4,000 ha till 2049 (Welsh Government, 2020a). The UK government has also backed the Climate Change Committee's call for the UK to create 30,000 ha new woodland per year (minimum) until 2050 (DEFRA, 2020b).

Apart from those woodland creation programmes that either originated with or have been backed by government(s), private sector and NGOs have also proposed targets. In 2018 and 2019 Confor, Friends of the Earth and the WWF all independently proposed to create 40,000 ha of new woodland per year in the UK until 2050 to reach net-zero GHG emissions as per the Paris Agreement (WWF, 2018; Bennett, 2019; Confor, 2019b, 2019a). Some, such as the National Farmers' Union, also support the expansion of woodlands, though they do not name a specific target (NFU, 2019).

Using hectares as the main quantitative approach to large scale woodland creation makes the data easily comparable and scalable (and measurable), but the approach has limits. It omits information on the management status of the new woodlands, their stand health, and which location may deliver what type of benefit. For example, different types of woodlands deliver different (and not always known) levels of carbon sequestration (e.g. Lal, 2005; Nair, Kumar and Nair, 2009), flood prevention potential depends on a lot of factors (Carroll *et al.*, 2004; Carrick *et al.*, 2019; Dittrich *et al.*, 2019), and the delivery of recreation is similarly dependent on context (e.g. Moseley *et al.*, 2018). Measuring and even anticipating the level of success in these objectives is highly complex, which is not least why WEOMs were introduced as a way to account for this complexity (more on this in chapter 5).

As it has been alluded to in Chapter 3, designing/monitoring woodland creation programmes with area-based targets are not a new methodology for British woodland expansion, but their efficacy is not entirely clear. For example, Chazdon et al. (2017) outline in their review of a range of international forest restoration programs that targets must be backed with comprehensive plans to address potential barriers, trade-offs and other aspects of national, regional and local complexity.

Currently, there is a significant knowledge gap in relation to the relationship between afforestation targets in Britain and realised afforestation over the past 100 years. Since its creation in 1919, the Forestry Commission (FC) and later its devolved agencies, have been documenting both afforestation targets and data on realised afforestation. The problem is that most of this data is not digitised, dispersed and has never been collated and presented rigorously.

In this chapter I report analysis of archived statistical reports and related grey literature from the last 100 years of British forestry history to collate a comprehensive picture of both afforestation targets and realised annual afforestation between 1919 and 2019. It is the first time these numbers have been extracted and unified to such a degree of detail and over such a long time-span. This dataset has then been compared to the levels of woodland creation that are planned for the future, in order to reflect on how realistic or achievable current targets may in fact be.

Therefore, the research question is:

How much afforestation was achieved in Britain in the last 100 years, and how does this compare to future woodland expansion plans?

4.2 Methodology

4.2.1 Afforestation programmes

For this present research, all those national afforestation targets were identified that had been either issued by the FC or any other body representing the government between 1919 and 2019, or that had been issued by bodies whose targets had subsequently been backed by the government (such as the CCC targets). As has been introduced above, other targets may have been suggested during that time, but without official endorsement by the government they were not seen as official, national afforestation targets.

Most of the afforestation targets were found in FC annual reports that had been digitised in the Forest Research online archive (Forest Research, 2022). Sometimes, the annual reports referenced other grey literature in connection with the introduction of new targets, such as new policies or separate publications focussing on the future of woodland expansion. In these cases, attempts were made to also find those original publications for more context. Most of the reports had to be read manually and in full; since they had been scanned from copies, automated text search was not always possible, and the format in which afforestation targets were reported changed over time, making it easy for them to be overlooked.

4.2.1.1 Data extraction and processing

During the data collection phase, it became evident to differentiate between an 'afforestation programme' and 'afforestation target'. An afforestation programme in this research is defined as several (potentially changing) afforestation targets that share the same overall rationale. Though this definition is not clear-cut, it is important because over time, the yearly planting targets often where adjusted (downwards), but remained part of the same overall afforestation programme. The programmes and targets were reported in changing units and changing levels of detail, so care was taken to unify their data as much as possible.

Some of the afforestation programmes spanned decades, and at various points in time programmes overlapped. Therefore, an 'average annual afforestation target' was created as the most realistic reflection of which target was pursued in any given year. The methodology for this was:

- For every year, the planting target of the latest governmentally endorsed programme at the time was taken as the target of that year.
- If a programme included a higher and lower target (e.g. the 1950s Programme, see **Table 2**) and no clarification was made whether either of them was pursued primarily, the average was taken as the target of that year.
- In two cases, the 1940s and 1990s, the annual reports and grey literature do not explicitly mention an afforestation programme or annual targets. However, in both case certain evidence in text suggests that the aspirations of the respective previous targets remained, which is why the data was not interrupted (more detail can be found in section **4.3.1.1**).

All data was gathered manually from the online archives and figures were produced using R (R Core Team, 2013).

4.2.2 Realised afforestation

A preliminary literature review suggested that five dimensions are generally used to describe woodland expansion in Britain:

- **Ownership**: Private sector compared to Forestry Commission (FC)
- **Tree species**: Conifers compared to broadleaves

- **Planting type**: Afforestation compared to restocking
- **Country**: The three countries England, Scotland and Wales compared to each other
- **Management**: Managed woodland compared to unmanaged woodlands

To facilitate comparability this research intended to use these dimensions. This also includes **restocking** - i.e. the planting of areas of woodland that have been felled or otherwise deforested (e.g. after a windfall). With this thesis' focus on native woodlands, restocking of previously non-native stands is a potentially relevant opportunity, which is why it has been included. Furthermore, historical accounts have mentioned that a lot of established woodlands were felled during WWI and WWII, and restocking was the modus operandi to 'rehabilitate' these 'derelict' woodlands (Alan and Macdońald, 1945; FC, 1955).

Most data for the first four dimensions was available in the same FC annual reports that also reported on afforestation targets (see **Table 1** for details). Similarly, data collection of realised afforestation also had to be done manually, as the format of the annual reports changed over time, both with regards to which figures were reported (e.g. only Britain as a whole, or broken down to country level), what unit they were reported in (acres or hectares), and in what order they were reported in (e.g. as figures, or within text, or within the appendix). A comparison of managed vs. unmanaged woodland was not possible due to the scarcity and incompatibility of the data.

Table 1. Data sources for quantitative data. Relevant details on coverage are noted as comments.

Data	Source(s)	Date accessed	Comments
Woodland cover change data SCT, ENG & WAL	(Aldhous, 1997; FC, 2018a; Forest Research, 2019)	Feb 2019	Total woodland cover data (with conifer/broadleaved distinction)
Afforestation & restocking data 1971 – 2018	(Forest Research, 2019)	April 2019	Includes data for total UK and ENG, SCT and WAL separately (with public/private + conifer/broadleaves distinction)
Afforestation & restocking data 1920 – 1971	(FC, 1921, 1924, 1930, 1936, 1939, 1943b, 1945a, 1946, 1947, 1949, 1952b, 1954, 1956, 1958, 1960, 1962, 1964, 1966, 1968)	Dec 2018 – April 2019	Includes data for total UK and in parts ENG, SCT and WALES separately (in parts also with public/private + conifer/broadleaves distinction)

4.2.2.1 Data extraction and processing

Based on the available data 'conifer' and 'broadleaved' woodland in this research are defined by whether the principal species is a conifer or broadleaved tree (e.g. FC, 2018a).

It is also important to note what the FC, being the primary source of quantitative data, defined as 'private sector' versus FC woodland. According to the FC (2018a, 2018c) 'FC woodland' includes woodland owned either directly by the FC or by the devolved agencies (e.g. Natural Resources Wales, Forestry Commission England). 'Private sector' woodland describes "*all other woodland. Includes woodland previously owned/managed by the Countryside Council for Wales and the Environment Agency in Wales, other publicly owned woodland (e.g. owned by local authorities), woodland owned by non-government organisations (e.g. Woodland Trust) and privately owned woodland*" (FC, 2018a, p. 5). The same is true for the FC's definition of 'private sector' during the 20th century; the category simply constituted all woodland that was not directly in ownership and/or management by the Forestry Commission (FC, 1949, 1950, 1968, 1972). For consistency the term will be used in the same way within this research, though it should be noted that other publications may define the 'private sector' differently.

Another important definition is that of what constitutes a woodland, which is defined in this research as it was introduced in section **2.1.2**:

> *"Land under stands of trees with a canopy cover of at least 20% (25% in Northern Ireland), or having the potential to achieve this, including integral open space, and including felled areas that are to be restocked. Generally (including the UK) woodland is defined as having a minimum area of 0.5 ha."*
> (FC, 2018c, p. 12)

During the examination of the archived records and related grey literature it became evident that there was also some information on changing woodland cover over the years. To complement this research, that data was collected as well (**Table 1**). Data on net woodland cover loss was not added due to how difficult it would have been to obtain it.

Data was compiled for the timeframe between 1919 and 2019, and figures were produced using R (R Core Team, 2013). Older records in acres were converted to hectares, and for part of the analysis the data was divided by the country areas (20,933,100 ha for Great Britain with 13,039,500 ha, 8,007,700 ha and 2,073,500 ha for England, Scotland and Wales respectively), in order to compare woodland expansion as a fraction of overall land area. Additional comments on individual data points will be given as appropriate.

4.2.3 Limitations

As mentioned above some limitations exist based on the availability and accessibility of data. Managed versus unmanaged woodland as a dimension did not provide enough (reliable) data, and net woodland loss would have been difficult and too time consuming to assess.

The data that was available also had limitations. Over the span of 100 years, forest surveying methodologies changed and were refined. Consequently, certain changes in the data (on realised afforestation) may not be due to actual changes in land cover, but due to more precise estimation methods (James (1981) provides detail on the accuracy of some of the estimations, especially regarding the early 20th century). Further information on changing methods can be found for example in FC (2018c, p. 19). Additionally, 'years' in this dataset do not end in December, but either in September of the same year or on 31st March of the following year (forest year vs. financial year for the FC) – see also FC (1960). However, this slight shift in timing does not constitute a significant change in the developments over 100 years' time.

The data in this research gives no spatial indication (other than country level), i.e. where the woodlands were created, and which other types of land cover or land use they replaced. This could only be inferred on a broad scale with the synthesis of the historical accounts.

4.3 Results

The results section is split into two parts. First, the afforestation programmes will be presented, as far as they were evident from archived records. This will be accompanied by a short summary of any rationale that was given as to what the goal of the afforestation programmes was (or is).

After this, the realised afforestation will be presented, including figure of woodland cover increase during that time.

4.3.1 Afforestation programmes and targets in Britain, 1919-2019

Over the span of the last 100 years and including the current programmes that cover the coming decades until 2050, eight distinct afforestation programmes could be identified (**Table 2** and **Figure 4-1a**). Some of the programmes had unique names given in the reports (which are used here), while others did not, in which case they are named after the approximate time period they cover. They spanned the whole 100 years between 1919 and 2019 (and up to 2050). The resulting average annual afforestation target can be found in **Figure 4-1b**.

Below is a summary of the rationale behind the afforestation programmes, as far as they were stated. This summary also includes some contextual information on other relevant developments at the time, as they have already been discussed in Chapter 3. **Figure 4-5** further down also draws the average annual afforestation targets against realised afforestation.

Table 2. Planting programmes for the whole of Britain between 1919 and 2019 (going to 2050).

ID	Name & sources	Timeframe	Planting targets [ha]
1	**Acland Committee's Programme** (FC, 1930)	1920 – 2000	1920-1929: increase from 0 to 12,000 ha annually 1920 onwards: 12,000 ha annually
2	**Desired Programme** (House of Commons Hansard, 1943b; FC, 1944)	1947 – 1995	Intermediate: from 14,000 to 45,000 annually

			Desired: 20,000 annually till 1955 and then 25,000
3	**1950s Programme** (FC, 1956)	1956 – 1965	High estimate at 14,000 and low estimate at 10,000 annually
4	**1960s Programme** (FC, 1959, 1964)	1959 – 1973	24,000 till 1964 and then 18,000
5	**Wood Production Outlook Programme** (FC, 1977)	1980 – 2024	Low estimate at 35,000 till 2001 and 12,000 after, and high estimate at 50,000 till 2001 and 32,000 after
6	**Alternative Land Use Programme** (FC, 1987)	1988 – 2009	30,000 ha annually until further notice
7	**21st century Programme[1]** (FC Scotland, 2009b; Welsh Assembly Government, 2010; DEFRA, 2013; The Scottish Government, 2017; Welsh Government, 2018)	2014 – 2049	23,000 till 2021, then 23,000 (original) or 21,000 (revision) till 2032, and then 20,000 annually
8	**CCC Programme[2]** (CCC, 2019; DEFRA, 2020b)	2020 – 2049	High estimate at 47,000 and low estimate at 28,000 annually

[1] this programme is based on the average sum of the woodland creation programmes in England, Scotland and Wales;

[2] the Climate Change Committee is not a governmental body, but the planting programme has been endorsed by the government; this programme has been proposed for the whole of the UK, so targets have been reduced to the relative size of Great Britain;

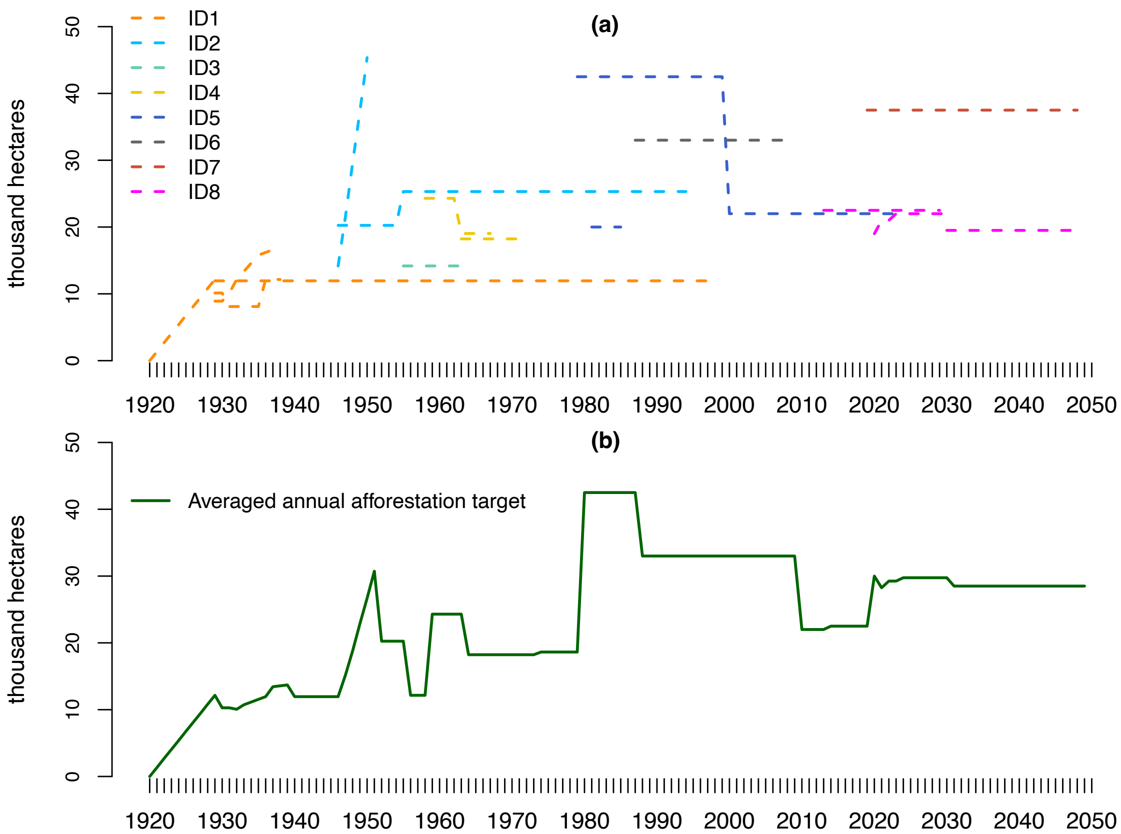

Figure 4-1. Annual afforestation targets over the last 100 years. (a) Individual target within the seven programmes as per **Table 2**, and (b) average annual afforestation target.

4.3.1.1 Afforestation programme rationales

Many of the afforestation programmes were accompanied by a short rationale as to why they were put in place, and what the ultimate goal of that planned afforestation was. Following the knowledge gained on the changing drivers of woodland expansion in Chapter 3, some further contextual information is added below as well.

At the turn of the 19th century (in 1895) Britain's woodland cover was at 4.7% and by 1914 93% of the country's timber requirement were met thought imports (Tsouvalis, 2000; Kaplan, Krumhardt and Zimmermann, 2009). Subsequently, during WWI the German naval blockade prevented timber shipments from reaching Britain, which spread the awareness that inland Britain had no adequate resource (or management) of timber to meet the national demand (Linnard, 1982; Aldhous, 1997; Oosthoek, 2013).

As a result, the Acland Committee, a part of the post-WWI Reconstruction Committee, proposed the first afforestation programme of the 20th century (**ID1**), to plant 715,000 ha in Britain by the year 2000, with much of this happening in the first 40 years of the programme (FC, 1930). In the wake of this, the Forestry Act 1919 established the FC as the governmental authority to realise this "*strategic reserve of timber*" and generate the associated rural employment (especially in the Highlands; Ryle, 1969; Aldhous, 1997; Oosthoek, 2013).

During WWII, the tables on afforestation programmes omit any official targets for the years 1940 to 1945 (see for example **Figure 4-2**). However, it does not seem that afforestation targets were abandoned. In text, the reports of that time state that priority had to be given to maintaining existing stands and helping with war efforts, but land for afforestation continued to be purchased and afforestation and seedling preparation to "*meet the assured planting programme*" continued to take place (FC, 1943b, p. 2, 1945b). In another example, it is reported that "*it was also necessary to reduce the planting programme*", which means that despite everything, and aspiration to stick to the targets remained (FC, 1945b, p. 1). Furthermore, roughly 212,000 ha of woodland predating the Acland Committee's programme (ID1) were felled for the war (James, 1981), because the new stands were still too young for the timber to be used. These felled woodlands were later restocked, most likely with confers (Winter, 1996).

Year Ending 30th September	Proposed to be Planted	ACTUALLY PLANTED			Excess (+) Deficit (-) on Decade or Annual Programme
		New Planting	Replacements	Total	
First Decade:	Acres	Acres	Acres	Acres	Acres
1920-29:					
Conifers	150,000	126,444	4,316	130,760	-19,240
Hardwoods	Unspecified	6,365	1,146	7,511	
				138,271	
Second Decade:					
1930-39:	*	218,064	12,543	230,607	
Third Decade:					
1940		26,411	877	27,288	
1941		25,644	1,223	26,867	
1942		16,045	701	16,746	
		418,973	20,806	439,779	

Figure 4-2. Lack of explicit afforestation targets during WWII. The table includes past afforestation targets, but the years 1940, 1941 and 1942 are left blank. Taken from (FC, 1943b, p. 7).

Towards the end of WWII, two White Papers were prepared on how to proceed with forestry after the war (FC, 1943a, 1945a) which concluded that by the end of 50 years post-war there should be 1.2 mha of new afforested woodland, to create a strategic reserve of timber and offer employment in rural areas (FC, 1944; Ryle, 1969; Oosthoek, 2013). There were two suggestions; an Intermediate Programme which would start out more slowly at 14,000 ha, and a Desired (and more ambitious) Programme, planning to afforest 200,000 ha of "*bare land*" within 10 years post-war (House of Commons Hansard, 1943b, p. 890). According to the FC annual report in 1952, the Desired Programme (**ID2**) was chosen as the primary target (FC, 1952b).

In 1955, a new programme was proposed (**ID3**) with the aim to afforest between 10,000 ha (low estimate) and 14,000 ha (high estimate) annually, for the subsequent ten years (FC, 1956). This programme emerged from a review of the previous programme and its achievements had not been realised to the degree desired. Looking back on the Desired Programme (ID2) in 1951, problems were identified to do with a "*shortage of plantable land, and, in the more remote areas, lack of labour*" (FC, 1952b, p. 11). The FC was not able to acquire enough land to meet to the annual afforestation targets, but confidence in the revised programme (1950s Programme – ID3) remained (FC, 1956). Since it was not specified whether the high or low estimate would be taken as primary goal, the target in this research was set at 12,000 ha annually.

A new programme begun in the late 1950s (1960s Programme – **ID4**), with a target of 24,000 ha annual afforestation at first and then reducing it to 18,000 ha (FC, 1959, 1964). It should be noted, however, that there is evidence that this programme (and possibly also the previous one), might have primarily targeted FC afforestation. For example, in 1964, the government's new programme "*provided for the Commission to plant 450,000 acres during the ten years…*" (FC, 1966, p. 8), which does not include the private sector. Additionally, the FC reports later state in retrospect that the organisation had been underperforming (FC, 1956, 1959, 1964); section **4.3.2.1.1** will show that total realised afforestation (including private sector) by far exceeded the targets at the time, so this statement is only correct if FC afforestation was considered without the contributions from the private sector.

In the later 1960s the land acquired by the FC for afforestation became primarily located in Scotland (Oosthoek, 2013). In England and Wales land was less and less available; possibly due improvements in hill farming and an increased demand in agricultural land (James, 1981), and possibly due to an ever-growing public opposition to conifer plantations in England and Wales (Tsouvalis, 2000).

In 1978 the FC was tasked to produce a Wood Production Outlook report into the future of national forestry and woodland expansion (FC, 1977). As part of this they created 3 scenarios: (a) no planting in the future; (b) 700,000 ha afforested in total till 2000 and another 300,000 ha till 2025, or (c) 1,000,000 ha afforested in total till 2000 and another 800,000 ha till 2025. The report heavily discouraged option (a), so the Wood Production Outlook Programme (**ID5**) is between (b) and (c). The average annual afforestation targets based on this programme were 42,000 ha till 2000 and 22,000 ha thereafter; **Figure 4-1** shows that especially the first part of this programme by far exceeds most of what had been proposed before.

In 1987, the Alternative Land Use Programme (**ID6**) was introduced. Along with new policies to support farm woodland expansion, a national target of 33,000 ha annual afforestation was set (FC, 1987). In the annual reports till 1995, the programme is still mentioned, albeit not in as much prominence as programmes like ID3 or ID5 were at their time (e.g. FC, 1991, 1992). After 1995, the explicit mention of annual targets, in numbers, disappears. However, the programme is never officially abandoned, and comments in text still mention the "*steady expansion of forestry*" as one of forestry's main aims (FC, 1996, p. 89). Therefore, the average annual afforestation target of the Alternative Land Use Programme (ID6) was continued till the 2010s, when new afforestation programmes were issued.

In the 2010s, new afforestation programmes were issued by England, Scotland and Wales individually. The annual targets have seen several revisions already. In 2013 England planned to create 5,000 ha each year till 2060 (DEFRA, 2013). In 2009 Scotland planned to create between 10,000 ha (low estimate) and 15,000 ha (high estimate) of new woodland till 2049 (Scottish Government, 2011), in 2011 a short revision proposed 10,000 ha annually till 2021, and the latest proposal suggests to increase woodland creation to 18,000 ha by 2023 and continue with it until 2030 (The Scottish Government, 2017). In 2010 Wales proposed to create

5,000 ha annually till 2030 (Forestry Commission Wales, 2009), and a 2018 proposal was for 2,000 ha till 2049 (Welsh Government, 2018). Most of these targets are set to tackle climate change and sequester carbon, though additional benefits such as biodiversity conservation or recreation are mentioned. Furthermore, as has been mentioned in the introduction, since 2019, the end of the time period in this research, the targets for England and Wales have already been revised again.

Put together, this 21st century Programme (**ID7**) plans between 20,000 and 23,000 ha for the whole of Britain. Even higher rates are proposed by the Climate Change Committee (**ID8**), with 28,000 ha as a low estimate and 47,000 ha as a high estimate (CCC, 2019). This programme has been endorsed by the UK government as well (DEFRA, 2020b).

4.3.2 Realised afforestation in Britain, 1919-2019

Below is a representation of 100 years' worth of realised afforestation (and restocking) in Britain. It follows the dimensions that the data was available in: afforestation vs. restocking, broadleaves vs. conifers, FC vs. private sector, and the three countries England, Scotland and Wales compared to each other. A critical reflection on these dimensions can be found in section **4.4.3.2**.

Gaps in the data are primarily from before 1971, after which the archives provide a lot of continuous data (see **Table 1**). Information on private sector afforestation was most difficult to find. Archived reports mention that estimating private sector data was very difficult (FC, 1937, 1950), and to this day the devolved agencies of the original FC acknowledge that in certain aspects, private sector data may be underrepresented (e.g. such as with the level of restocking; Forest Research, 2020b).

4.3.2.1 Realised afforestation & restocking – Great Britain

An afforestation rate of around 15,000 ha annually was reached in Britain in the 1920s, and afforestation rates increased further to 30,000 ha all throughout the 1950s and 1960s. Since the 1970s, total afforestation has decreased steadily, which is not least due to the FC stopping to directly buy and lease land for trees.

During the early existence of the FC, its afforestation rates increased significantly as time went on, as well as after 1944, whereas there is an overall decrease in plantings after 1971, with a shift from afforestation to restocking (compare **Figure 4-3** to **Figure 4-4**). Private sector afforestation shows a significant decrease in the latter half of the 1970s (from 19,800 ha in 1974 to 6,700 ha in 1978), then a significant increase till 1989 (to 25,300 ha), and towards the end of the timeframe an overall decrease with an increase in restocking rates.

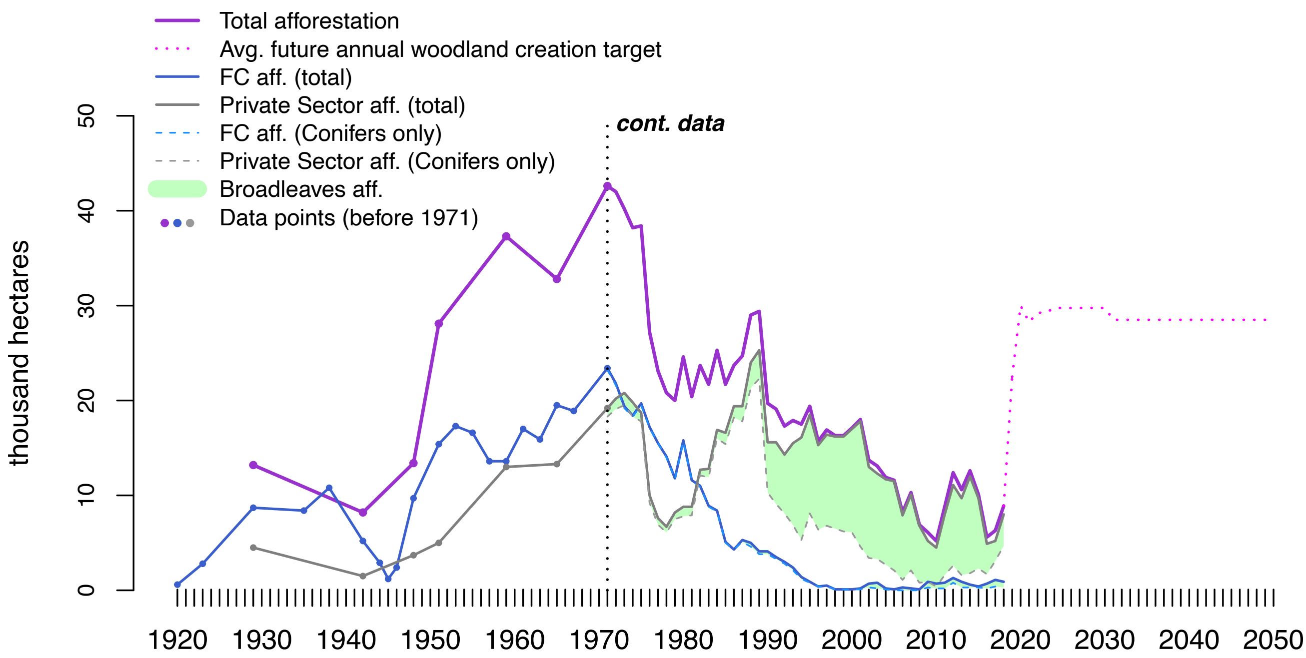

Figure 4-3. Afforestation rates in Britain from 1919 to 2019. Before 1971, limited data was available. Includes woodland creation targets till 2050.

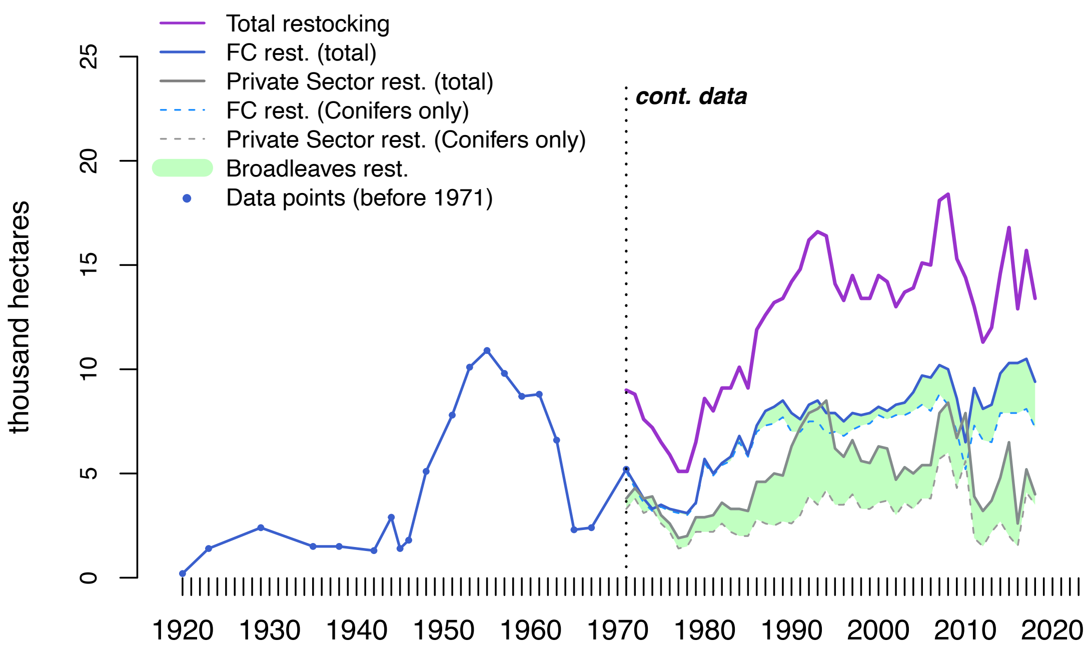

Figure 4-4. Restocking rates in Britain from 1919 to 2019. Before 1971, only individual datapoints for the FC were available.

The FC has, since data availability in 1971, mostly afforested conifers, though by the end of the 1990s FC afforestation decreased to a minimum. The private sector on the other hand significantly increased its afforestation of broadleaves after 1990, and though the exact ratio of broadleaves to conifer afforestation fluctuated since then, broadleaves made up at least half of all new afforestation.

Looking at restocking rates (**Figure 4-4**), the FC achieved significant rates of restocking during the 1950s and early 1960s (over 10,000 ha at some point, likely due to restocking of those woodlands that had been depleted during the wars). After a slump in the 1960s, restocking rates for the FC have been on a rising trend since; the majority of that being covered by conifers.

The private sector restocked with more broadleaves than the FC, especially during the 1990s. Since then, restocking rates have been below those of the FC, and conifers make up a significant proportion of it.

4.3.2.1.1 Total afforestation compared to average annual afforestation targets

The total rate of afforestation between 1919 and 2019 drawn against the average annual afforestation rate can be found in **Figure 4-5**.

It seems that during the 1920s and 1930s, afforestation rates somewhat matched the afforestation targets at the time, at least until WWII, when FC afforestation took a hit. In the 1950s, 1960s and early 1970s, both FC and private sector afforestation picked up significantly and together outperformed the afforestation targets – sometimes even reaching more than the target, such as in 1957 with around 12,000 ha planned and over 37,000 ha achieved. However, as pointed out in section **4.3.1.1**, there are indicators that programmes of the 1950s and 1960s (ID3 & ID4) might have been only intended for the FC, in which case they fell short at times – in 1951 the FC only achieved 15,000 ha compared to a target of 30,000 ha.

At the end of the 1970s, the total afforestation rates (FC and private sector together) fell back to the level of the afforestation targets – meeting at around 20,000 ha in 1980. Since the start of the 1970s the FC had a slowly decreasing rate of annual afforestation; arguments are that land cost too much and the state investment into afforestation was put into question (Tsouvalis, 2000; Oosthoek, 2013). Not much is known about why the private sector went from 18,700 ha afforestation in 1975 to 7,600 ha in 1977, but those sources that comment on it seem to agree it was a sudden change in taxes that had undesirable knock-on effects on private landowners (FC, 1976; James, 1981; Winter, 1996).

Ever since the 1980s, the afforestation rates did not meet the targets of their time. In the 1980s, this was despite advantageous tax breaks facilitating a significant increase in private sector afforestation (Tsouvalis, 2000; Oosthoek, 2013), and the shortfall continued in the 2010s when new afforestation targets were introduced. In 2018, realised afforestation was at 8,900 ha, making less than half of the 22,000 ha that were targeted.

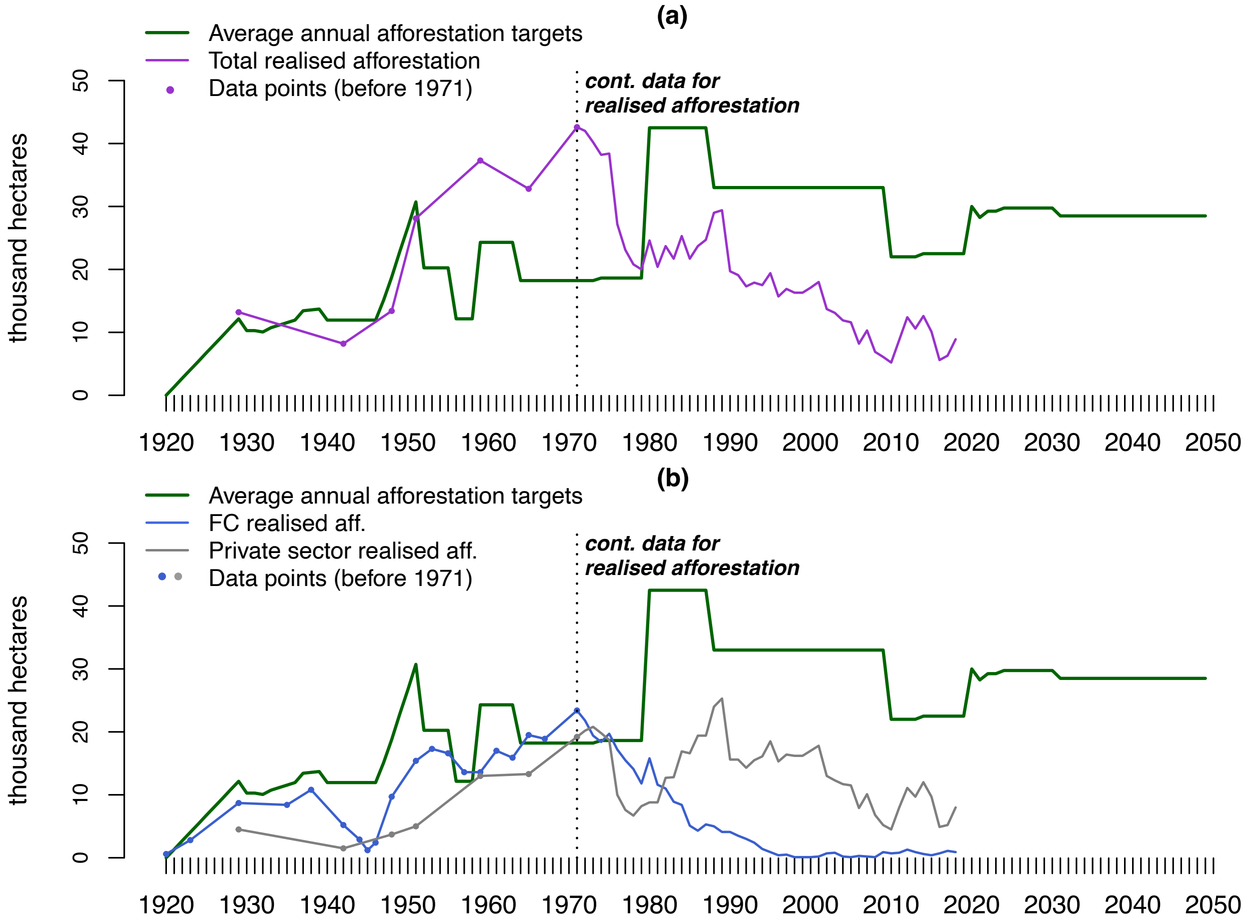

Figure 4-5. Average annual afforestation target drawn against realised afforestation. The comparison is both with (a) total realised afforestation (FC and private sector together) and (b) realised afforestation of FC and private sector separately.

4.3.2.2 Realised afforestation & restocking – England, Scotland and Wales

Compared to **Figure 4-3** in the previous section looking at total afforestation in Britain, **Figure 4-6** does so for England, Scotland and Wales separately, and **Figure 4-7** converts the hectares of total afforestation per country into a percentage of that country's land area. This was done to appreciate the significantly different sizes of the three countries.

In total area the largest amount of afforestation happened in Scotland, both under FC and private sector management (**Figure 4-6b**), followed by England (with a relatively strong private sector in the 1990s and the 2000s) and Wales. Considering afforestation as a percentage of individual country area, the picture for Wales changes significantly (compare **Figure 4-6c** and **Figure 4-7c**). Between 1944 and 1965 FC afforestation in Wales outperformed that in Scotland, and after 1971 afforestation in Wales is much closer to that of England than the representation in hectares alone would suggest.

In the last 100 years conifer afforestation was highest in Scotland, although the private sector both in Scotland and England significantly increased its afforestation of broadleaves since the start of the 1990s.

The data for restocking, both as total numbers in **Figure 4-8** and as percentages of country area in **Figure 4-9**, shows a somewhat different trend. In Scotland afforestation rates gradually increased since the 1980s (**Figure 4-8b**), except for a temporary ditch in private sector afforestation between 2010 and 2016. Also, FC afforestation in all countries, but especially Scotland, still consists largely of conifers, not broadleaves. The rates of restocking in Wales as a percentage of country area (**Figure 4-9c**) significantly outperform those of England, and even those of Scotland over long stretches of time.

Looking into the future (**Figure 4-6**), woodland creation targets are different for England, Scotland and Wales; the goal in England is to reach a rate it has had last in the 1990s, in Scotland the goal is to return to rates of the 1960s or 1980s, and the woodland creation targets for Wales are to match those rates from the 1950s and 1960s. Considering how much land is available to each country (**Figure 4-7**), target in Wales and Scotland are similarly ambitious, while England's woodland expansion targets remain more conservative.

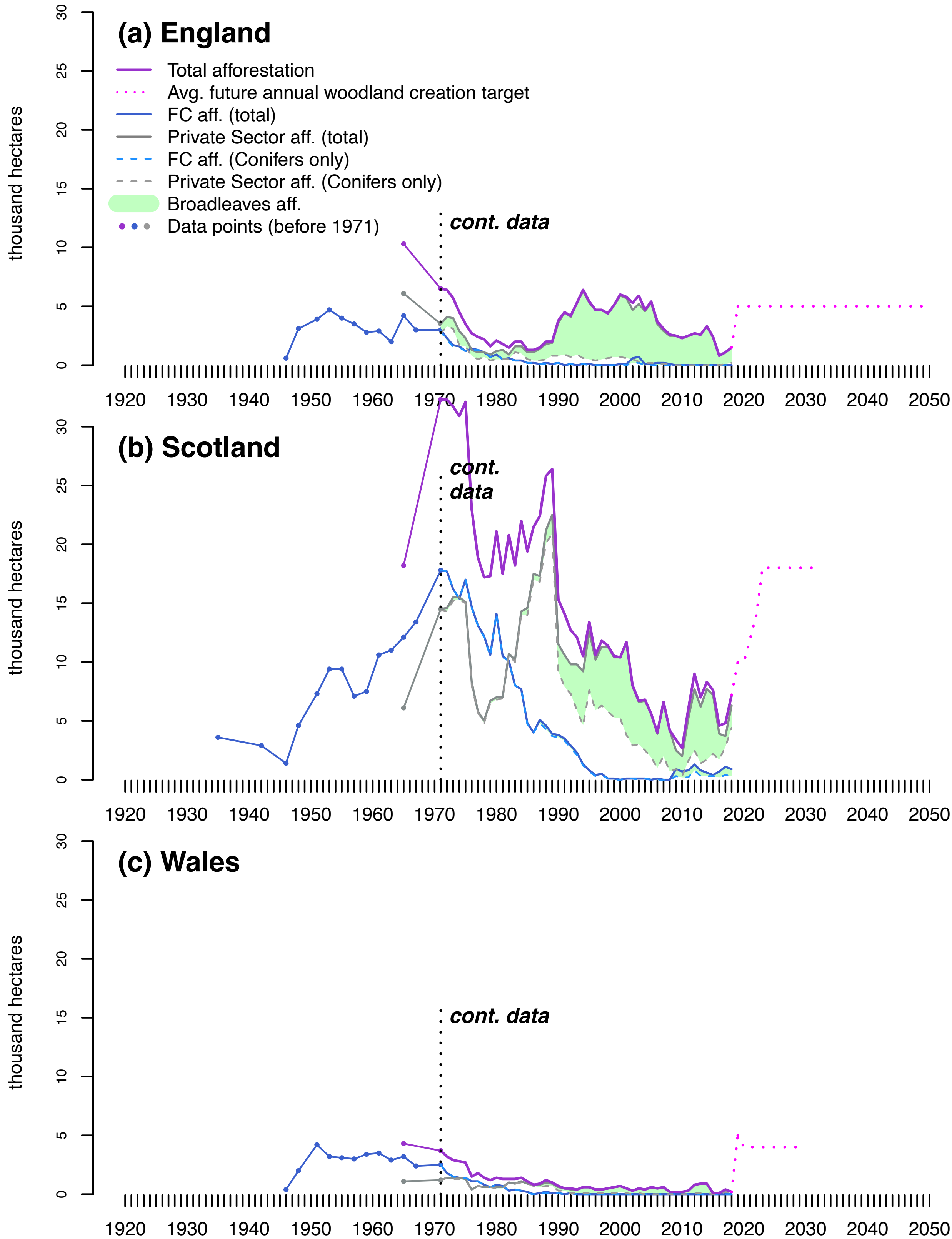

Figure 4-6. Afforestation rates for England, Scotland and Wales between 1919 and 2019, given in hectares. Limited data was available before 1971. Included each country's woodland expansion target.

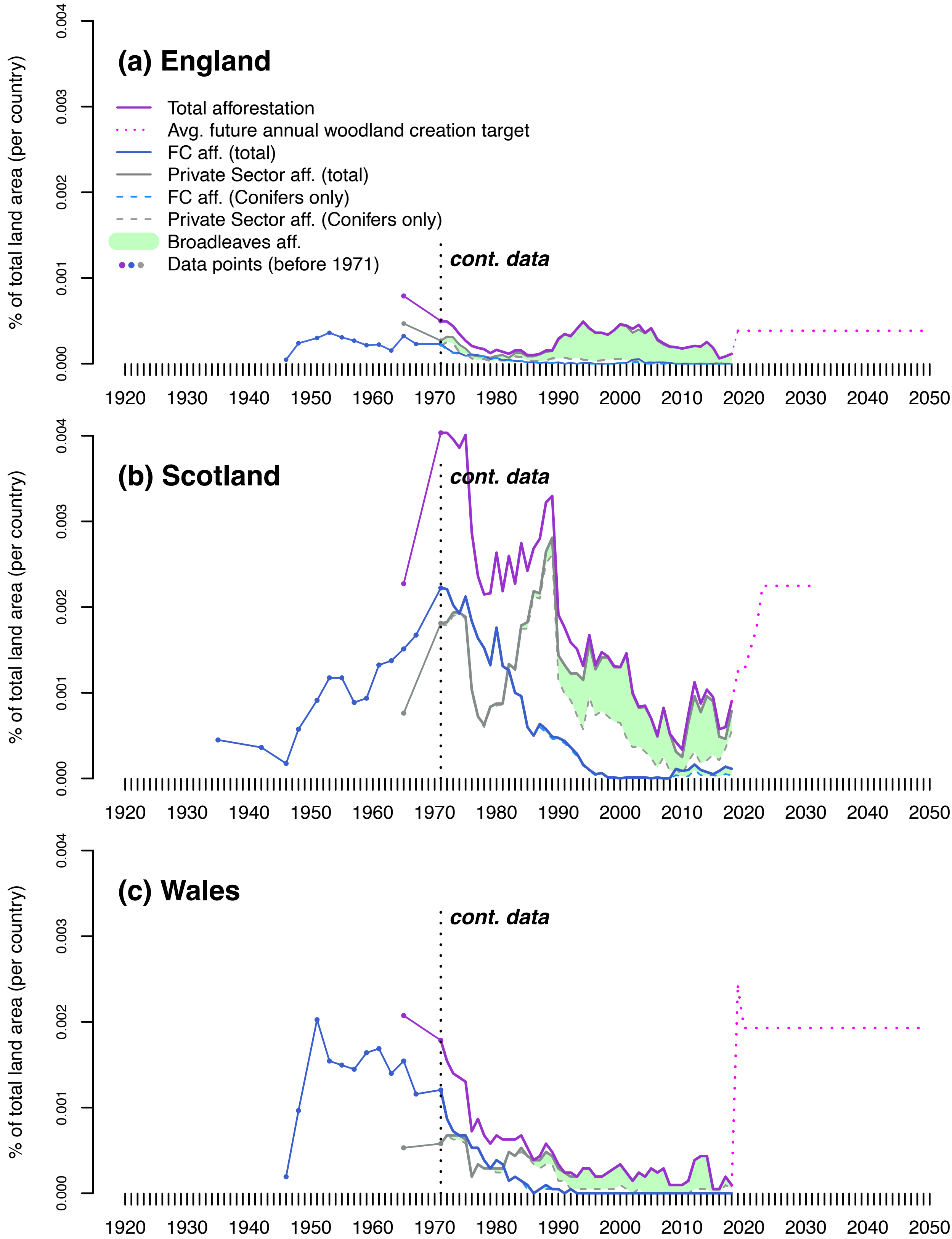

Figure 4-7. Afforestation rates for England, Scotland and Wales, based on percentage of land area. Limited data was available before 1971. Includes each country's woodland expansion targets for the future.

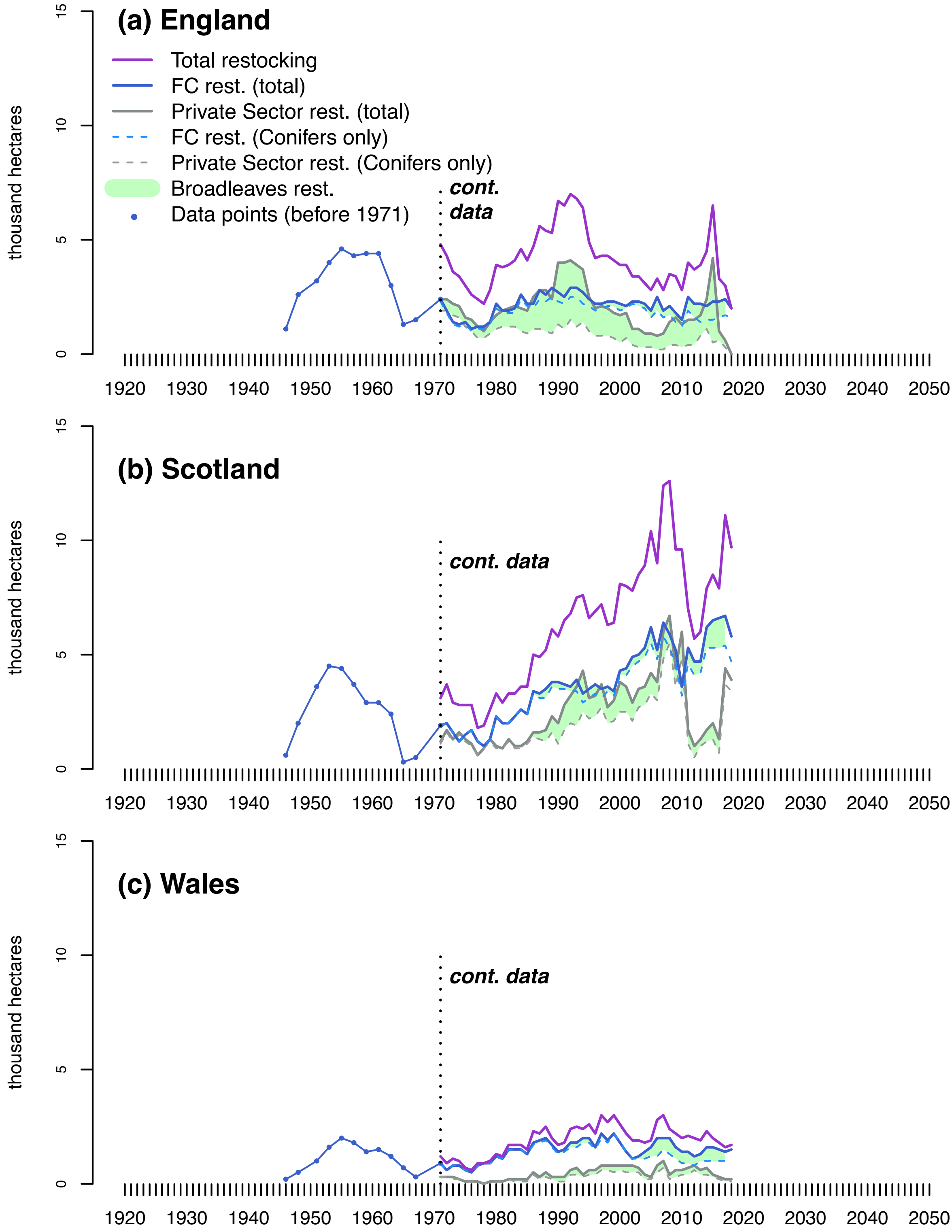

Figure 4-8. Restocking rates in England, Scotland and Wales between 1919 and 2019, given in hectares. Limited data was available before 1971.

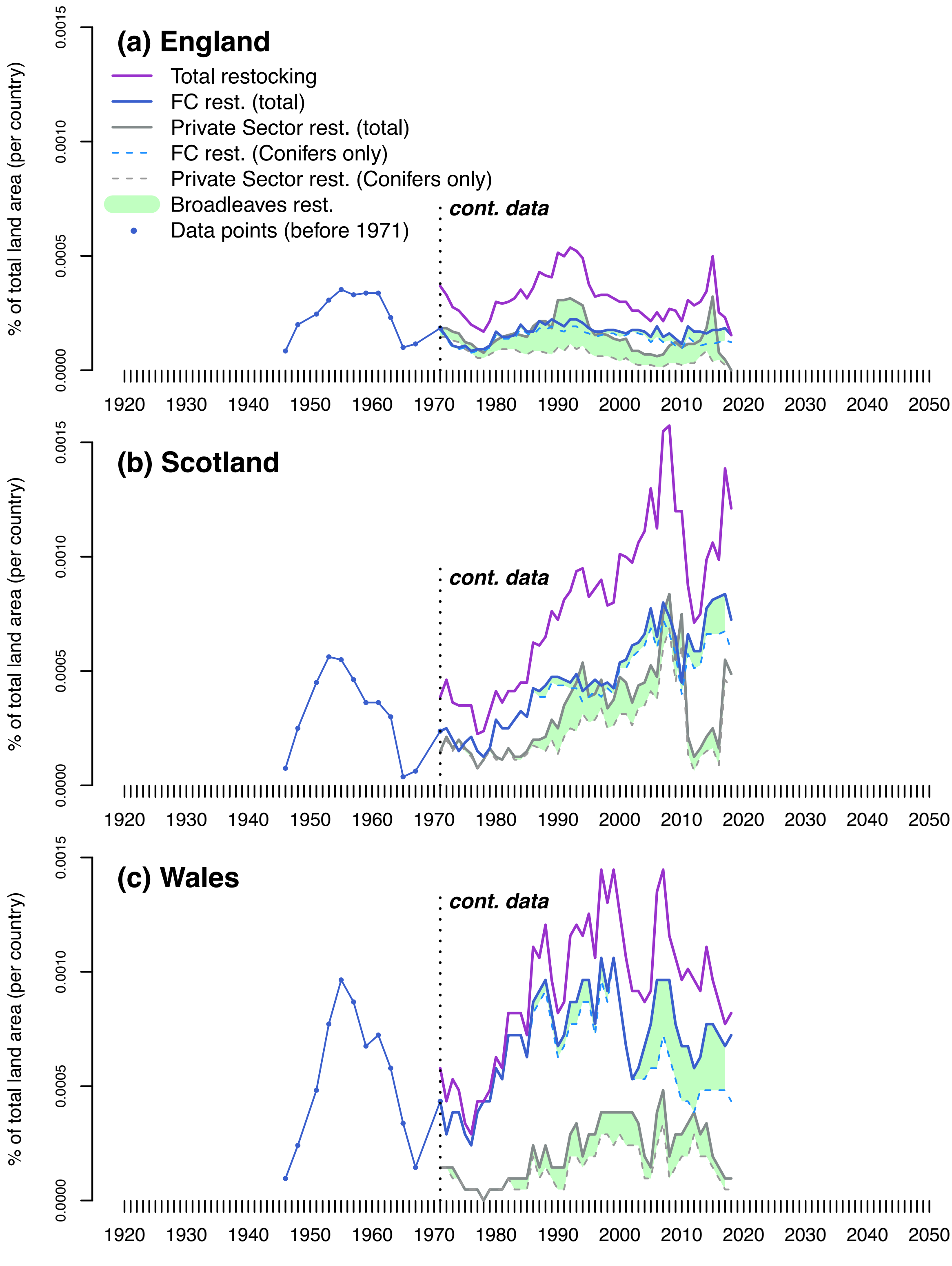

Figure 4-9. Restocking rates in England, Scotland and Wales from 1919 to 2019, as percentage of land area. Limited data was available before 1971.

4.3.2.3 Changes in total woodland cover

Given that this is the first time that afforestation data and average annual afforestation targets were extracted and unified to such a degree of detail, an opportunity presented itself to calculate how much woodland cover Britain would now have, if all targets during the last 100 years had been met and compare it to how much woodland cover was actually achieved. **Figure 4-10** does so, by taking a starting point of 1.16 mha of existing woodland in 1920 (Aldhous, 1997), and either adding annual targets or realised annual afforestation up until 2018. In addition to this, woodland censuses have been carried out at various points during this time span, some of which were added as well (Locke, 1987; Aldhous, 1997). The methodology of these censuses often involved entirely different sets of data, such as interviews, or sample site visits (Locke, 1987), which makes them an interesting backdrop to add to this figure.

Up until 1945, woodland cover data from censuses, afforestation targets and realised afforestation matches very well. However, from 1956 all the way to 2003, woodland cover increased faster that the target would have predicted. A review of **Figure 4-5** shows that this was due to the exceptionally successful decades during the 1950s and 1960s, after which woodland cover based on annual targets only caught up by the early 2000s. In 1979, at the height of this mismatch, there was 365,000 ha more woodland than planned. It is interesting to mention that during this time, the censuses are very close to the theoretical woodland cover, not realised one. The censuses were carried out by sampling different woodlands around the country (Locke, 1987), which means the datasets are mostly unrelated, so the close fit with the theoretical woodland cover is surprising.

By 2003, theoretical and realised woodland cover met at 2.95 mha, and since then, realised woodland cover has fallen below of what it should have been. In 2018, British woodlands were 268,000 ha short – realised woodland cover was at 3.06 mha, whereas theoretical woodland cover was at 3.34 mha. In comparison, the difference is about 40% of what the 21st Century Programme (**ID6**) says is needed to meet Britain's 2050 Net Zero agenda.

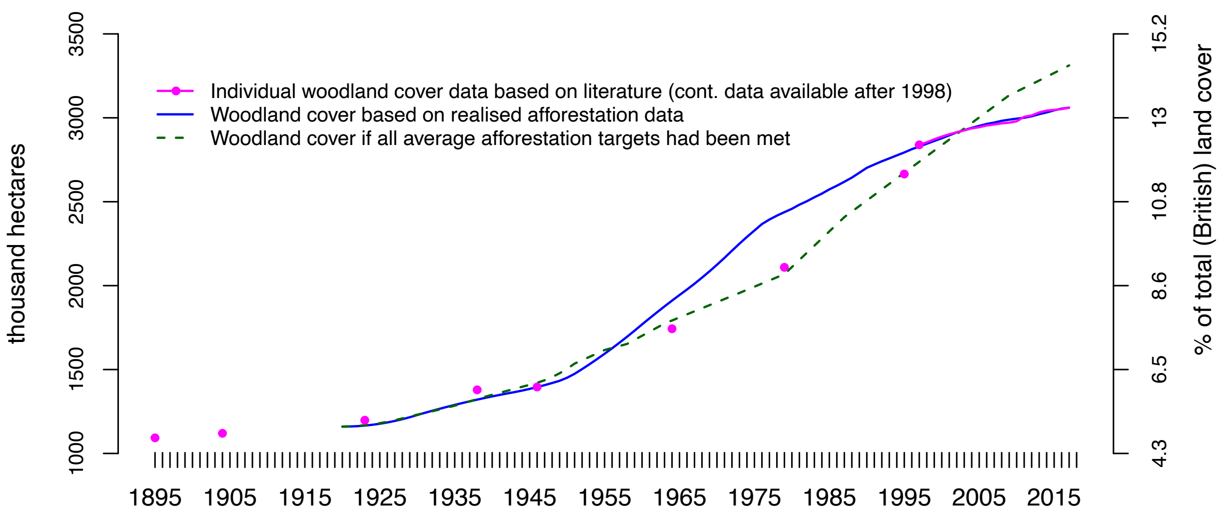

Figure 4-10. Woodland cover changes based on realised afforestation versus afforestation targets. Additional data points were included from woodland censuses found in literature.

4.4 Discussion

The discussion is split into three parts. Firstly, the results will be discussed using the contextual knowledge gained in Chapter 3, to compare realised afforestation with the historical narrative. From this, lessons are drawn on the potential future of woodland expansion targets in Britain. Lastly, a methodological reflection will discuss how the way woodland expansion is measured may not be sufficient anymore to account for the diversity of woodland expansion drivers in the 21st century.

4.4.1 Afforestation data as a reflection of history

Although historical accounts, as they were discussed in chapter 3, rarely mentioned actual data on realised afforestation, a lot of the large-scale trends they identified are reflected in the synthesis of data in this chapter.

For example, there is an evident rapid increase of afforestation after the wars, specifically mentioned in the statistical reports as being for the drivers of a strategic reserve of timber and rural employment (FC, 1930; Linnard, 1982). Restocking rates also rose significantly during that time, at least as far as the available data of the FC is concerned. The most likely explanation of this is what the historical accounts mentioned; that over 200,000 ha of woodland had been 'depleted' in WWII alone (FC, 1952b; James, 1981), and these woodlands were swiftly restocked – most likely with conifers.

There is also the decrease in afforestation rates in Wales and England in the 1960s, due to a strong driver of food production, a growing opposition to conifer plantations and the driver of non-woodland amenity. Afforestation instead shifts towards Scotland, where the tax break afforestation by the private sector in the 1980s is clear (as is the rapid decrease after the Budget 1988; Oosthoek, 2013).

Broadleaved woodlands also reveal an interesting pattern. During the 1990s, a time when the Alternative Land Use Programme (ID6) was still in place but hardly mentioned in the annual reports, broadleaves suddenly became the principal species of more than half of all new afforestation (**Figure 4-3**). Especially in England broadleaves seemed to have made a strong impression, revitalising afforestation rates that during the early 1980s had decreased to a minimum (**Figure 4-6**).

Overall, even the changing involvement of the state can be traced in the data, with the strong rates of afforestation in the early 20th century and until the 1970s, when the state was seen as responsible for progressing woodland expansion, and the subsequent decline and abandonment of afforestation by the state in later years, in favour of leaving further woodland expansion to the private sector (James, 1981; Tsouvalis, 2000).

4.4.1.1 Mismatches between data and historical accounts

Not all trends in the data were quite as expected, given the contextual knowledge gained in Chapter 3.

A key issue is the problem of large-scale data obscuring important regional developments. For example, on a national level, the opposition against afforestation in the Lake District during the 1930s did not result in significant reductions in FC afforestation rates of that time (**Figure 4-3**). Sadly, no data was available for England only (see missing timeframe in **Figure 4-6**), so it is not clear whether a trend would have been evident there.

The same problem also applies to comparing national data for the whole of Britain (**Figure 4-3**) to the data available for each of the three countries (**Figure 4-6**). Especially since the 1960s, England, Scotland and Wales clearly followed different, sometimes even opposite trends. Considering them together obscures a lot of the nuance that is discussed in historical accounts. One example for this has already been mentioned – the shift away from England and Wales and towards Scotland in the 1960s is clear in **Figure 4-6**, but is lost in **Figure 4-3**.

Wales takes an additional, special place in the comparison between the three countries. As the events in the Lake District during the 1930s happened in England, and much of the afforestation later on takes place in Scotland (as do the events in the Flow Country), Wales often seems the least featured country in historical accounts. Wales, however, also has much less land area available for afforestation, compared to the two other countries. When considering afforestation as a percentage of land area (**Figure 4-7** and **Figure 4-9**), afforestation Wales is on much more equal footing to the two other countries, sometimes even outperforming them. Wales still has a higher percentage of woodland cover (15%) than both England (10%) and the national average (13%), and its future woodland expansion targets are equally ambitious to those of Scotland (**Figure 4-7**). This shows that when discussing woodland expansion, it is important to remember that the various governments' pledges in hectares alone may not be the best way to compare their efforts.

Sometimes, the data also showed trends that seem much more significant to the large-scale trends of woodland expansion than their very limited coverage in historical accounts would suggest. The developments of the private sector in the 1970s is a good example for this; within seven years private sector afforestation dipped from 42,000 ha to 20,000 ha (**Figure 4-3**). This trend was not specific to any country, as it can be seen in the analysis for England, Scotland, and Wales (**Figure 4-6**). It is at the end of this significant reduction in afforestation rates when the average annual afforestation target starts to deviate significantly from realised afforestation (**Figure 4-5**). Yet the historical accounts barely mention the 1970s; only the FC (1976) and

James (1981) discussed a threat of wealth tax and capital transfer tax connected to forestry, which scared off the private sector. The fate of these taxes is only alluded to; Winter (1996) shares some insight in that a lot of lobbying helped to introduce "*enough changes*" towards the end of the 1970s to appease private landowners (Tompkins, 1989).

This mismatch between emphasis given in historical accounts and realised woodland cover change also extends to restocking. For example, much emphasis is given in the historical accounts on the FC becoming responsible for much more than just the expansion of conifer plantations for forestry purposes. During the 1980s the importance of (native) broadleaved trees was established as central to future woodland management and woodland expansion. Native broadleaved trees in many ways were seen as representative of the new facilitating drivers of woodland expansion, such as biodiversity conservation, recreation, and later community cohesion. In 1992 the FC annual report stated that forestry in Britain had "*evolved*" and was now to contribute "*in terms of wood supply, the environment and other public benefits*" (FC, 1992, p. 11).

It is therefore surprising that to this day, most of the restocking by the FC (now as devolved agencies), in all three countries, is with conifers (**Figure 4-4** and **Figure 4-8**). By 2019, restocking was the only direct planting activity the devolved agencies of the FC were still doing, as they had ceased afforestation activities over a decade prior, so the main way the state directly interacted with trees was via conifers and, to a majority, non-native ones at that (FC, 2018a). It should be notes, however, that there is some evidence that this relationship is once again changing; for example, as of 2022 Forestry England is seeking to lease land long term to actively afforest new woodlands once again (Forestry England, 2022b). Furthermore, guidance material on the initiative suggests most new trees will be broadleaves, and natural colonisation will be considered on sites that are deemed suitable (Forestry England, 2021).

Overall, the comparison of data from Chapter 3 and Chapter 4 suggests that the relationship between woodland expansion drivers and realised afforestation is very complex. Neither historical accounts nor afforestation data alone seem to be able to tell the full story. For example, the developments in the Lake District indeed set an important precedence for the opposition to woodland expansion, even if the afforestation data may not show much impact. Conversely, the 1970s likely deserve more consideration in historical accounts, given how significant the change in afforestation rates was at the time. It seems that the best view on the complex relationship between woodland expansion drivers and realised woodland expansion is by synthesising historical accounts *and* statistical data.

4.4.2 The success and future of woodland creation targets

This research identified eight afforestation programmes within the last 100 years (and leading up to 2050). With every programme, the annual targets were forecast decades in advance, and often revised (downwards) as the years went on. What is interesting is the slight upwards trend of the average annual afforestation targets in **Figure 4-1**; it seems that the more woodland was created in Britain, the more new woodland was desired.

When looking at the matches and mismatches of averaged annual afforestation targets and realised afforestation, as has been done in section **4.3.2.1.1**, it is important to remember that original afforestation programmes and targets may be idealistic aspirations of the future, but averaged annual afforestation targets may also be a result of certain 'corrections' of previously envisioned targets to reflect more 'realistic' goals. Consider **Figure 4-1** for this; as afforestation programmes went on, annual targets were often revised; this could have been because it turned out the original goals were not attainable. A recent example could be Wales in the 21st Century Programme. When the data was collected for at the end of 2018, Wales' ambition was to create 5,000 ha of woodland annually (Forestry Commission Wales, 2009), but at the time of writing this chapter (in 2022), the target had been corrected two more times; once downward to 2,000 ha (Welsh Government, 2018), and then back up to 4,000 ha (Welsh Government, 2020a).

Woodland creation targets (and past afforestation targets) may start out as detached aspirations of an ideal future, but as time goes on their revisions are likely based on a more realistic interplay of woodland creation drivers (and surrounding circumstances). This means that the current targets for the future may only be temporary, no matter how many decades they claim to cover, and new target (higher, or lower) are just around the corner.

4.4.2.1 Lessons to learn

For the first five decades of this research's time period, afforestation targets seemed to have been reasonable predictors of the amount of realised afforestation that was to come. Since then, realised afforestation has not been able to keep up, and because of that, as has been shown in **Figure 4-10**, by 2018 woodland was missing over 250,000 ha compared to its theoretical aspiration.

One of the important differences between the two time periods has been discussed in Chapter 3 (section **3.3.2**) – in the 1980s a significant list of new drivers of woodland expansion was introduced, as a way of dealing with the complexity of creating woodlands in an already crowded landscape. It has also been outlined that the appreciation of diverse, 'multi-use' woodlands take effort and time, which may well explain why the woodland creation rates in recent decades have been lower, despite the aspirational targets.

Area based woodland expansion targets are expressions of intent; they are one way to measure the success of woodland expansion plans and hold the issuers of these targets accountable (especially with regards to any involvement of the government). Unlike the 1920s, it is today's complex environment of woodland expansion drivers that needs solving. How can a country's government act swiftly and triple its afforestation rates, while also protecting existing land uses, and also creating diverse woodlands, and also involving all relevant stakeholders?

Woodland expansion targets are only ever as good as the plans to get there. The last 50 years have shown that they are no prophecies, and creating woodlands in Britain's future will take much more than simply pledging them on paper.

4.4.3 A critical reflection on methodology

This research focused on afforestation programmes and realised afforestation of the past, because woodland creation targets, expressed in hectares of land covered in trees, are once again used to facilitate the new drivers of woodland expansion. This research has also shown, however, that the way woodland expansion is measured may not be sufficient anymore to account for the diversity of woodland expansion today.

4.4.3.1 Data limitations

Most of the data presented in this research is from FC archives. By its own admission, the FC (and its devolved agencies) can only report on the type and numbers of afforestation that is available to them. The private sector is a problem here; there is only limited information on private sector afforestation in the early 20th century, because the FC had little means of estimating it. Since then, the source of data is often successful applications for grants connected to woodland creation and/or restocking. If no grants are applied for, then nothing is recorded, and the new woodlands will only be known once they are established enough to feature on the National Forest Inventory (NFI – introduced in section 2.2.4.4 and discussed further in section **5.1.1**).

This problem may intensify in the coming years and decades. Today's diverse set of stakeholders in woodland expansion may pursue means such as rewilding or natural colonisation (Dandy and Wynne-Jones, 2019; Rewilding Britain, 2019b; FC, 2021). This may not involve applying for grants, or leaving other traces by purchasing from tree nurseries – indeed, it has been established in section **2.2.3** that due to the nature of natural colonisation the government is having difficulties offering grants for it. There might be types of woodland expansion that will go significantly underreported, unless new ways are developed to keep track of the multitude of efforts stakeholders are putting into creating new woodlands.

4.4.3.2 Data dimensions as remnants of the 20th century

Four broad dimensions have been used to describe the progression of woodland expansion in Britain, both in archived reports of the FC and in historical accounts:

- afforestation compared to restocking,
- conifers compared to broadleaves,
- FC compared to the private sector, and
- the three countries England, Scotland and Wales compared to each other.

A fifth dimension, management status of those woodlands, only offered very limited data and could not be used for this research.

It stands to reason that these dimensions were introduced to describe changes in woodland expansion as they related to large-scale woodland expansion drivers (James, 1981; Aldhous, 1997). For example, for a strategic reserve of timber, the annual afforestation rates were seen as valuable approximations of how ‘successful’ this driver was (e.g. James (1981) and Tsouvalis (2000) highlight certain annual afforestation numbers as part of their historical accounts). Restocking rates were used to note ‘success’ on ‘rehabilitating’ the ‘derelict’ felled woodlands after WWI and WWII (Alan and Macdońald, 1945; FC, 1955). In another example, afforestation (and restocking) rates of broadleaves were often used as proxies for ‘nativeness’ with regards to the drivers of natural colonisation and recreation (and generally for facilitating drivers other than financial revenue from forestry (Tsouvalis, 2000)).

The problem is, that while these might have been sufficient dimensions to describe woodland expansion in Britain as it happened in the first half of the 20th century and up until the late 1970s, they do not seem well suited anymore in defining woodland expansion ‘success’ since then. This is most evident in three prominent examples: using tree planting as the exclusive measure of woodland expansion, equating broadleaves with nativeness, and using realised afforestation as an exclusive measure for woodland expansion ‘success’.

4.4.3.2.1 Using tree planting as the exclusive measure of woodland expansion

Chapter 3 outlined that with the facilitating drivers of woodland expansion in the 20th century (especially earlier on), tree planting was the default *modus operandi* for woodland expansion. Chapter 4 contributed to this by showing that the main way woodland expansion was measured was (and in many ways still is) by collecting data on afforestation, which implies active planting. Especially at the beginning of the timeframe, the two big stakeholder groups, the FC and the private forestry sector, engaged with woodland expansion via tree planting. At the time, woodland expansion realistically meant tree planting.

Times have changed and with it the types of stakeholders involved in woodland expansion. The drivers of woodland expansion have changed, and they in turn introduced a whole new range of possibilities of how to interact with and realise woodland expansion.

One of the most prominent examples of this has been mentioned already, natural colonisation. Natural colonisation is a very different approach of 'doing things', and in many cases may not require any active ground preparation or tree planting to take place. It is a more indirect approach, achieved through the management of trees at the level of a whole site, or a whole valley, including the non-wooded habitats that coinhabit it (Tanentzap, Zou and Coomes, 2013; Turczański, Dyderski and Rutkowski, 2021). It is an approach that may not even be intended and simply be the result of windows of opportunity that arise in an otherwise crowded and changing landscape.

The terms 'afforestation targets', and even just 'planting targets', are still used in today's debate around woodland expansion (National Trust, 2021b; UK Parliament, 2021). With rewilding and natural colonisation (Rewilding Britain, 2020; FC, 2021), however, Britain has entered the age of 'woodland expansion targets', and the future data on realised woodland expansion will have to account for trees that have never been touched, recorded, or even managed by any human, even in a crowded landscape like Britain.

4.4.3.2.2 Broadleaved woodland afforestation and the concept of nativeness

Another problem in conceptualising woodland expansion is the equation between broadleaves and nativeness, which doesn't always work due to the existence of the native conifer species Juniper (*Juniperus communis*), Yew (*Taxus baccata*), and especially Scots Pine (*Pinus Sylvestris*) (Countrysideinfo, 2019; Trust, 2019).

As the 1980s were preceded by several decades or primarily non-native conifer plantations, the driver for nature conservation in the 1980s was combined with the 'rediscovery' of broadleaved trees and woodlands (as introduced in section **3.3.1.6**). This way, broadleaves became to be seen as a representation of nativeness, while conifers, especially commercial species, were seen as non-native (Tsouvalis, 2000; Oosthoek, 2013). Till this day, documentation on woodland expansion plans often mentions not only a focus of native trees, but native broadleaves at that (Welsh Government, 2018; UK Government, 2021).

While most species considered native to Britain indeed are broadleaved species, Scots Pine is a good example for why the comparison does not work, as it is both a native conifer species (evident in the now highly valued Caledonian forests in Scotland) *and* a commercial species.

Even back in 1945, 1955 and 1963 the percentage of native Scots Pine was 18.9%, 18% and 16.4% of total annual afforestation, respectively (FC, 1947, 1956, 1964). In 2018, Scots Pine still makes up about 17% of all conifer woodland in Britain, topped only by non-native Sitka Spruce with 50% (FC, 2018a).

Of course, this distinction is particularly relevant in Scotland with its Caledonian forests, but it should generally be understood that even if the comparison often works out, nativeness is not the same as broadleaves, and tree species used for commercial purposes have not always been and still are not always non-native.

4.4.3.2.3 Using realised afforestation as an exclusive measure for woodland expansion 'success'

In the current discussion around woodland expansion, targets are the most prominent excerpts being taken from governmental (and other) reports; they are easy to understand, easy to compare and easy to summarise in news articles and social media posts (Carrington, 2018; Lyon, 2019; Scottish Forestry, 2020a). However, when considering the historical context, a methodological question arises about whether woodland expansion targets, expressed in number of hectares covered in trees, are a sufficient measure for woodland expansion 'success'.

In the 1920s, the Acland Committee's Programme (ID1) large-scale afforestation programme, was created for very specific reasons – to create a strategic reserve of timber, and increase employment in the process (Tsouvalis, 2000; Oosthoek, 2013). Using afforestation targets as a measure for the programme's success was simple but reasonably straightforward; if more land were to be covered in trees, more timber would be available and, as forestry at the time required much labour, more employment would be needed in the sector.

The difference is that today's complex drivers of woodland expansion have no straightforward relationship anymore with the mere amount of land covered in trees. For example, whether trees can contribute to natural flood management depends highly on local context (Carrick *et al.*, 2019; Dittrich *et al.*, 2019); whether trees can increase and area's recreational value largely depends on what landscape features people value and for what reason (Tengberg *et al.*, 2012; McGinlay, Gowing and Budds, 2017), and just like it has been pointed out when discussing the data on past woodland expansion in Britain above, the amount of land covered in trees says little about these woodlands' state and biodiversity value (also in comparison to other habitats that could have existed in their place; Barbier, Burgess and Grainger, 2010; Veldman *et al.*, 2015). Simply put, an afforestation target "*says nothing about how planting is done and ongoing management*" (Churchill, 2011, p. 20).

Indeed, it seems that carbon sequestration was the main driving force in the 2010s to reintroduce national woodland expansion targets. Even there, however, a lot of nuance remains about which woodlands, woodland soils and management techniques yield the best carbon sequestration (Falloon *et al.*, 2004; Noormets *et al.*, 2014), and indeed, whether they really do so better than the habitats they are meant to replace.

Woodland expansion targets have 100 years of history in Britain, and to measure the success of new woodland creation the amount of land covered in trees is certainly one aspect to consider, but it is by far not the only one.

4.5 Conclusion

This research was able to fill a significant knowledge gap on the relationship between afforestation targets and realised afforestation in Britain between 1919 and 2019. This is the first time this data has been extracted and unified to such as degree of detail and over such a long time-span.

Until the 1970s, average annual afforestation targets can be considered successful, in that they were met or exceeded by realised afforestation. Since then, however, realised afforestation has not been able to keep up, and today over 250,000 ha of woodland are missing from its theoretical goal; this compares to 40% of what is needed to meet the new targets for the Paris Agreement in 2050.

The comparison of data from Chapter 3 and Chapter 4 has also shown that the relationship between targets and realised afforestation is complex; not least due to the diversification of woodland expansion drivers. Neither historical nor statistical data alone was able to represent the full picture of woodland expansion history in Britain. In fact, afforestation targets were continuously revised to account for this complexity, and even today the targets keep changing as governments and other stakeholders try to anticipate how much afforestation will be achievable in a crowded British future landscape.

Lastly, with the complexity of today's woodland expansion drivers, certain methodological questions remain. This specifically regards the dimensions in which we choose to measure the success of future woodland expansion, what the state of these woodlands will be, and whether they will be measured not only on their existence, but also on their delivery of those very benefits they were created for.

5 THE ROLE OF NATURAL COLONISATION IN BRITAIN'S WOODLAND EXPANSION

5.1 Introduction

It is clear now that there is a distinct difference in what type of woodland expansion was desired in Britain in 1920, compared to 2020. Drivers have diversified, stakeholders have diversified, and so have the approaches of engaging in woodland expansion.

As has been introduced in section **2.2.4**, natural colonisation, in the wake of rewilding, is part of this diversification, proposed as a way of achieving an expansion of tree cover without (or a more indirect) level of human intervention compared to active planting (Ceausu *et al.*, 2015).

Natural colonisation of trees on previously non-wooded land – natural colonisation in short – mainly defines the process of trees germinating and establishing without being planted (Watts, 2021). Human intervention, often indirect, may still be involved (review section **2.2.4.1**), especially in a crowded landscape like Britain with its many intertwined land uses and land use legacies (Thompson, 2004; Cramer, Hobbs and Standish, 2008; Tanentzap, Zou and Coomes, 2013).

Because of these primarily indirect influence, naturally colonised trees are harder to predict than their planted and directly managed counterparts. A naturally colonised woodland may establish within 20-30 years (Cramer, Hobbs and Standish, 2008; Verburg and Overmars, 2009), but exact estimations are often hard to make (Lambin and Meyfroidt, 2010). Studies suggest that these woodlands may offer higher structural and bio-diversity and a significant potential for carbon sequestration, but these effects vary and depend highly on local site conditions (Deng *et al.*, 2011; Navarro and Pereira, 2012; Noormets *et al.*, 2014). In fact, a 2021 UK Parliament POSTnote says "*current grant schemes are not well suited*" for natural colonisation, and this uncertainty of outcome is likely one of the reasons (UK Parliament, 2021, p. 2). A policy scheme would have to pre-determine the amount of time allowed for natural colonisation to occur (e.g. 10 years, 20 years or 50 years) to judge the woodland expansion success of a particular site, and a similar pre-determination would be required for the dimension used for measurement, be it stems per hectare, biodiversity indicators, number of people visiting, or else.

Another important problem is that despite this gain in popularity, and even with these uncertainties around how to conceptualise natural colonisation within the confines of environmental policy making, there is no large-scale spatial map capturing natural colonisation in Britain. Mapping young trees of various height/canopy cover colonising non-wooded habitats would require datasets (such as aerial photography or Lidar data) with a resolution high enough to distinguish the trees from surrounding vegetation (Wallace *et al.*, 2012; Thers, Bøcher and Svenning, 2019). Especially for young trees in a highly structured surrounding habitat, this is still very difficult.

Furthermore, given that natural colonisation is not a moment in time, but a process, governed by many potential factors that may facilitate or inhibit establishment success over the first few years/decades (Thompson, 2004; Tanentzap, Zou and Coomes, 2013; Martínez and García, 2017), spatial assessments would have to be repeated over those consecutive years to tell whether an area is, in fact, net-transitioning to woodland (however slowly) or not.

5.1.1 Spatial tree cover maps

Currently, the most comprehensive large-scale spatial maps of tree cover in Britain are the publicly accessible National Forest Inventory and the commercially available National Tree Map™ (**Figure 5-1**). Both maps may offer some clues as to the extent of natural colonisation.

As part of its regular iterations, the National Forest Inventory (NFI) integrates all newly wooded areas if they qualify as woodlands (over 0.5ha in size and generally above 20% canopy cover; Forest Research, 2020). If new areas get added, they are mostly planted and often are part of a grant application, which is being recorded as well. A lot of natural colonisation may happen in small patches, especially if it is an unintentional occurrence. This means that in addition to small groups of trees and singular trees outside woodlands, at least for some time a lot of natural colonisation falls outside of NFI records.

In 2010/11, however, a new map was created by Bluesky International Ltd, called the National Tree Map™ (NTM -Figure 5-1). This map for the first time records the number and cover of trees outside woodlands (of at least 3 m in height) on a national basis for England, Scotland and Wales (Bluesky, 2021). Originally produced for urban areas and used by insurance companies, it became the basis for the governmental report on trees outside woodlands in 2017 and identified 3.3% or 740,000 ha additional tree cover in Britain (Ditchburn and Brewer, 2017b). In the report, the tree cover is split into small woods, groups of trees and singular trees. The NTM data does not give details on how old the trees are (or their species), so natural colonisation will be mixed in with long-established singular trees in fields, large hedgerow trees, or small groups of trees that have been intentionally planted. It also has varied resolution, with some areas being easier to map (i.e. trees being clearly distinguishable from surrounding vegetation) and some areas being based on more high resolution (and up to date) datasets.

It is possible that other spatial maps of large- and small-scale tree cover exist. Especially for smaller areas and/or research projects more comprehensive maps of tree cover, including natural colonisation, may have been produced (e.g. by adding field work or localised, privately available high-resolution datasets). The problem with these maps is that they are local only and mostly remain in private hand, so they cannot be used by anyone else on a national scale. The NTM, while not public (i.e. available for free), is a comprehensive national-scale map of trees outside British woodlands available to buy for anyone, and it may, despite its methodological limitations, be the best large scale spatial indicator of natural colonisation currently available.

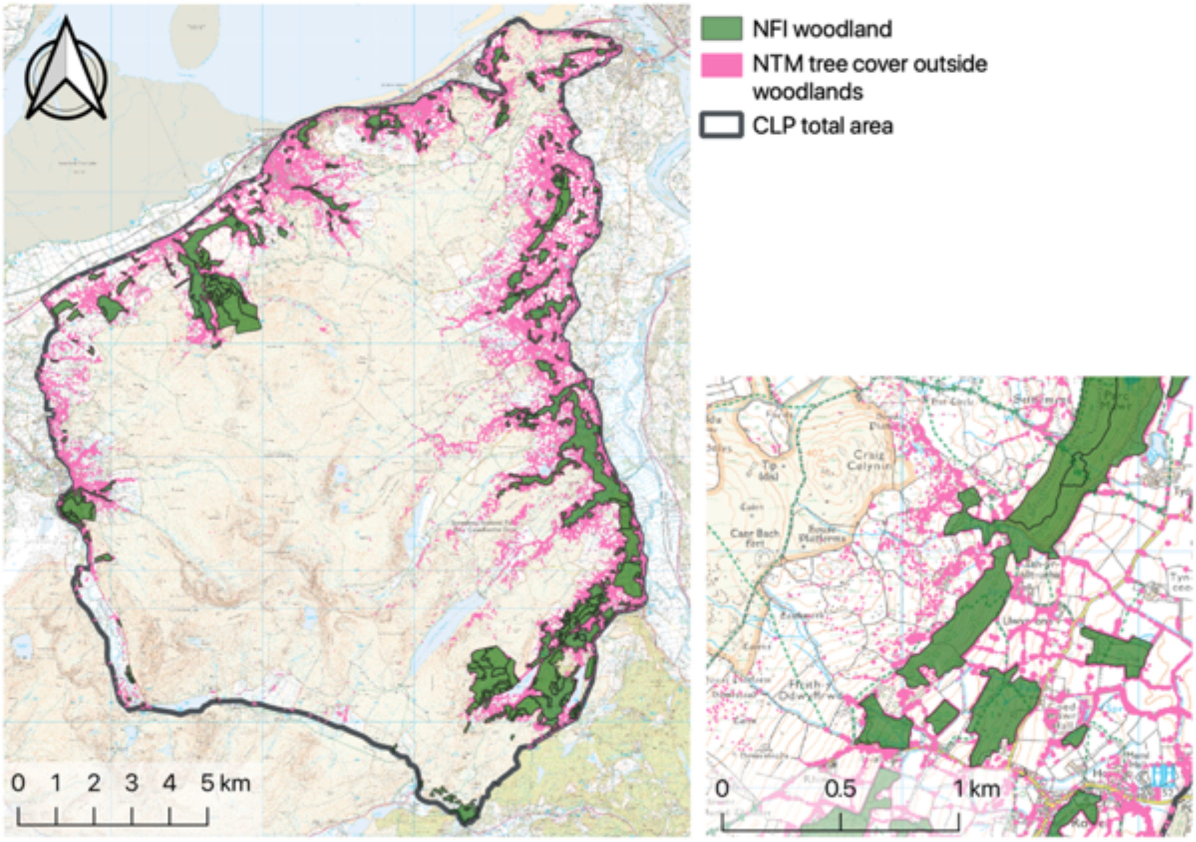

Figure 5-1 National Forest Inventory (NFI) and National Tree Map (NTM) for the Carneddau. NTM includes small groups of trees and singular trees if they are 3m in height.

5.1.2 Natural colonisation as part of national woodland expansion plans

To understand whether natural colonisation could be integrated in current and future woodland expansion plans, its scale and location also needs to be assessed against a conceptualisation of where future woodlands are indeed desired.

The woodland expansion opportunity maps (WEOMs), introduced in section **2.2.2.1**, offer exactly this opportunity. WEOMs try to show where future woodlands possibly could be created by marrying a representation of the present landscape with certain assumptions on how the landscape ought to look like in the future. In Wales, WEOMs are currently used as part of payment schemes for land managers to plant woodlands (NRW, 2020), to aid landscape scale considerations of natural flood management (Hanking et al., 2017c), to suggest improved conservation of important habitats in protected areas (Jones, 2007; Turner, 2018b), and other areas (Bateman *et al.*, 2014; e.g. Cosby *et al.*, 2020). As such, they are important decision support structures and tools, and they often are part of a wider governance structure around woodland expansion.

The maps themselves are, however, not as objective and neutral a product of science as they may seem. In recent decades geographers and cartographers have put more emphasis on maps being a product of their time and thus the knowledge culture they were created in, rather than simply a universal representation of reality (Crampton, 2001; Kitchin and Dodge, 2007). Almost all maps are created with a certain end user in mind or at the very least a (subjective) predetermination at the hands of the cartographer of which datasets to omit and which to show, thus avoiding a map so packed with details that it becomes illegible and useless (Pickle and Monmonier, 1997). In fact, this is in line with recent scientific arguments that for highly complex environments, there likely is not one single "*best*" map (Crampton, 2001); there are instead various types/sets of data to look at, at various levels of interactivity, and various levels of scale.

When it comes to WEOMs, the kind of 'opportunity' they show and the 'constraints' they are based on equally requires a predetermination on (a) what it is users of the map will want to see, and (b) what other interests in land use are in perceived competition with new woodlands and inform the choice of constraint datasets. This directly corresponds with the drivers of woodland expansion that were identified in Chapter 3; they changed over time and therefore now shape the 'reality' of what is considered important, as an 'opportunity' or 'constraint', for woodland expansion.

5.1.3 Research rationale and question

Given the available data and its limitations on the current extent of tree cover, as well as the time and resources within this research, it was not feasible to create a large-scale spatial assessment of natural colonisation for the whole of Britain. Nonetheless, this research intends to provide a steppingstone towards doing so, by using a mixed-method approach of existing quantitative data (NFI & NTM) and primary qualitative data (site visits), as well as a landscape-scale case study area (Carneddau), to qualitatively profile the location and state of natural colonisation. Most importantly, it also compares the results of this with WEOMs, in order to provide insight how natural colonisation might be integrated into future woodland creation.

In this way, the following investigation into natural colonisation is meant as much as an independent piece of research as it is as an inspiration to future studies conducted in this field; to get one step closer to understanding the exact contribution natural colonisation may offer for Britain's woodland expansion plans.

The research question for this chapter is:

What is the coverage of natural colonisation in existing spatial data, and what does this say about its potential contribution to woodland expansion?

5.2 Methodology

To qualitatively profile the spatial extent of natural colonisation and assess its potential contribution in creating future woodlands, the methodology of this research comprised four steps (see **Figure 5-2**).

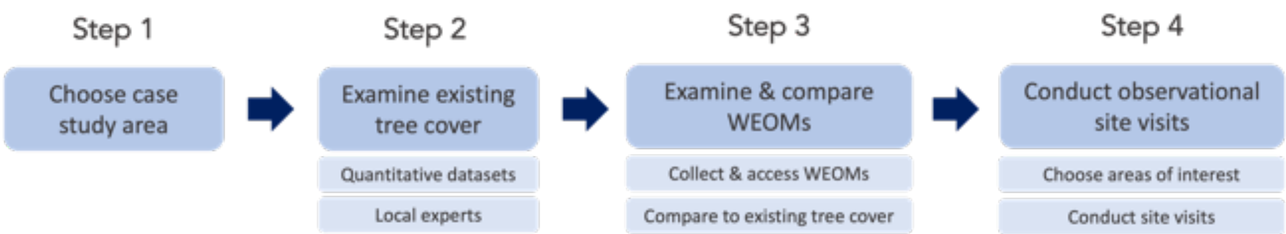

Figure 5-2. Methodological research structure for Chapter 5.

First, the area of the Carneddau Landscape Partnership Project (CLP) in North Wales was chosen as a case study area. Details for this choice will be explain in section **5.2.1**.

Then the NTM and NFI were purchased and downloaded, respectively, to investigate existing tree cover in the Carneddau. More on this can be found in section **5.2.2**. Additionally, four ecologists with long experience in the Carneddau were interviewed on where they have witnessed recent natural colonisation in the area. This was done to enrich information gained with the NTM and NFI with additional information on recent natural colonisation, whether it was marked on a map or not. Details on this can be found in section **5.2.3.**

Existing tree cover was then compared to 12 different WEOMs. This was to understand how tree cover outside woodlands already relates to spatial woodland expansion opportunities (WEOs), and what areas would be interesting for further investigation. More on the WEOMs can be found in section **5.2.4.**

Lastly, the data from above was analysed to identify sites for observational field visits. These field visits were conducted to gain local, in-depth understanding of natural colonisation, including species, location within surrounding habitats and land uses, common characteristics, and other relevant information. More on this can be found in section **5.2.5**.

All this was then taken to discuss the profile and potential spatial extent of natural colonisation in the Carneddau and Britain, as well as its potential place in Britain's woodland expansion plans.

5.2.1 Case study area

A range of areas could have hosted the research in this chapter. Ongoing rewilding projects, for example, would likely already be in the process of facilitating natural colonisation, so they could have been an interesting choice for spatially mapping it (Knepp Wildland, 2020; Trees for Life, 2021). Community projects, as it has been pointed out in section **3.3.1.7.3**, also host a wide range of stakeholders and woodland expansion drivers, so natural colonisation could have been investigated in this intricate network of collaboration (Thames Chase, 2020; Llais y Goedwig, 2022; NWLEICS, 2022). WEOMs also exist for other areas of Britain, covering the same of different types of potential WEOs (e.g. Friends of the Earth, 2020). In fact, as the discussion of this chapter will emphasise, it would be very beneficial to replicate the research in this chapter in other areas around the country, to see how the results would compare.

Ultimately, the area of the Carneddau Landscape Partnership Project (CLP) – hereafter referred to as 'Carneddau' – in the north of Snowdonia National Park, Wales, was chosen as the case study area, for several reasons. Firstly, the Carneddau is rich in different land uses that reflect the various drivers of woodland expansion, including (see also **Figure 5-3**):

- several areas with special conservation protection status of different kind;
- several areas of common land, and privately owned land, including a lot of land owned by the National Trust and the Crown Estate;
- fenced and open land;
- various catchments of different sizes;
- various slopes, ridges, watercourses, lakes and other topographic features.

Secondly, at about 22,000 ha in size the area is both big enough for landscape-scale considerations and small enough to investigate local factor influencing natural colonisation. It covers both lowlands and uplands, including land above the tree line. A lot of the land is used as rough grazing for sheep and *ffridd* pasture, though there are also some woodlands, heath and lowland grassland. Only 8.5% or roughly 1,900 ha are officially (as per the NFI) covered in woodland; 53% and 28% of that being broadleaved and conifer woodland, respectively (**Figure 5-1**). This means the area's woodland cover is significantly below the national average of 15%, offering an interesting perspective on woodland expansion. Extensive information on climate, soil, topography and other biophysical features of the area can also be found in Turner (2018a).

Thirdly, the Carneddau offers an additional advantage in that its uplands make up a significant part of it. In the discourse around woodland expansion, it is primarily marginal agricultural land – itself often in the uplands – that comes in to focus for various economic and political reasons (Helm, 2017; Dwyer, 2018; Cosby *et al.*, 2020). This means that the Carneddau is a relevant case study to see how natural colonisation would fare in Britain's woodland expansion plans.

Furthermore, it should be noted that while rewilding projects, or other projects integrating natural colonisation into their land management, would certainly be an interesting case study, the absence of any focus on natural colonisation in the Carneddau was seen as an advantage in this research. Most areas in Britain do not (yet) host projects involving natural colonisation, so the Carneddau is a representative case study for them; this includes the engagement with farmers and other land managers of the Carneddau in Chapter 6, neither of whom had yet had any exposure to natural colonisation related projects or initiatives. It should be noted, however, that some organisations are undertaking tree planting activities in the Carneddau, such as the Snowdonia Society (representative, pers. comm.), as well as the National Trust together with the Carneddau Landscape Partnership project (CLP, 2018b, 2018a). The location and desired future benefit of these planting sites were noted down wherever possible for additional contextual information.

Finally, conducting most of the field work in times with significant Covid restrictions inadvertently made the Carneddau the best possible case study area. The research for Chapter 5 and Chapter 6 were designed early 2020. By the end of March 2020, the first Covid lockdown happened, which delayed field work for several months. The new regulations thereafter (including those during 2021) offered just enough room to conduct this type of research in the Carneddau: working from home (based in Conwy at the northern border of the Carneddau), using a rental car for daytime solo trips, and conducting interviews outside (for Chapter 6). Week-long travels to and extended overnight stays in other areas of Britain would have been extremely difficult or impossible considering the Covid regulations at the time.

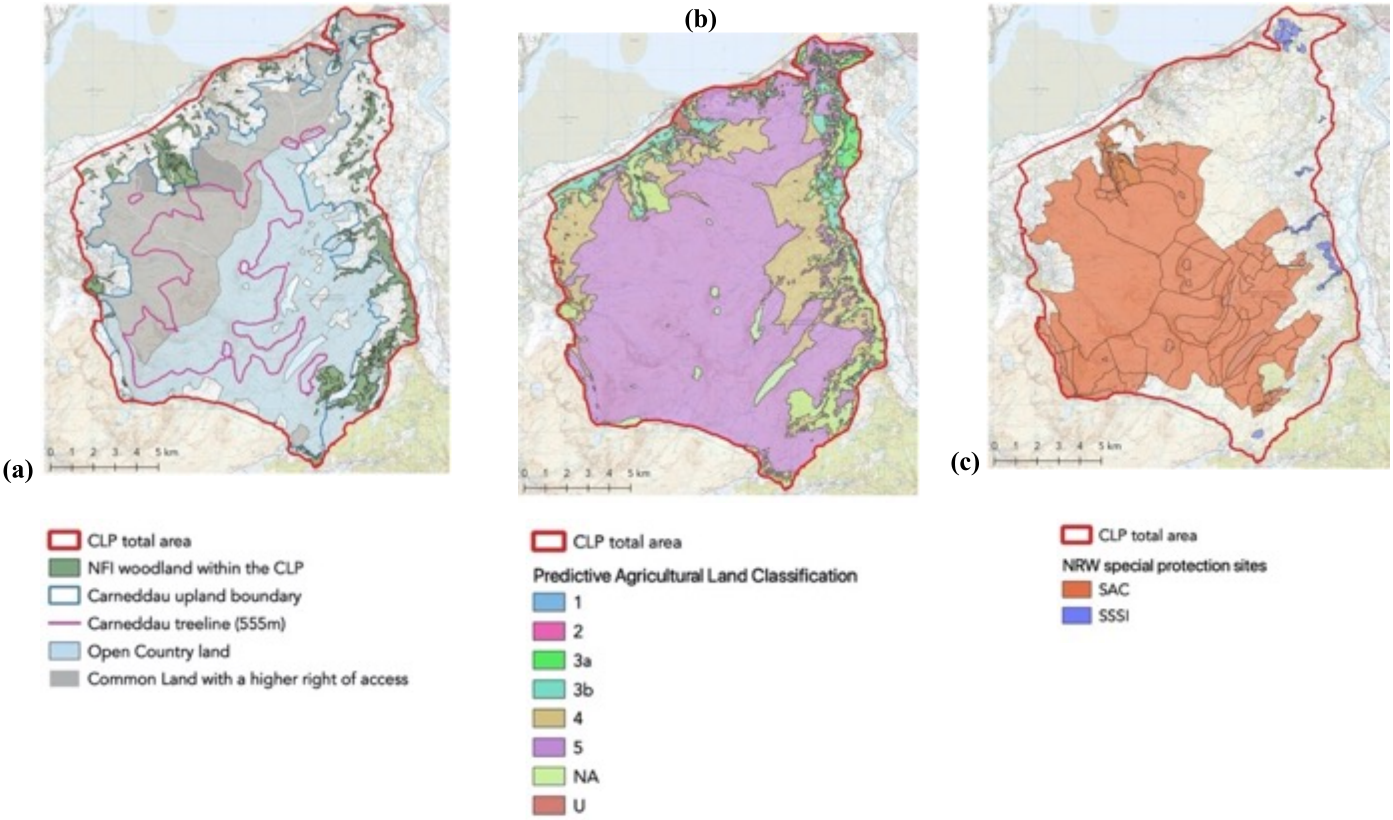

Figure 5-3 (a) general topographic and public land use features, (b) predictive agricultural land classification and (c) NRW special protection sites in the Carneddau. The whole area comprises roughly 22,000 ha land, 8.5% of which is (NFI classified) forest.

5.2.2 National Tree Map^{TM} (NTM) & NFI

The National Tree Map^{TM} for the Carneddau was purchased from Bluesky International Ltd in January 2021 (Eddy, 2020). It shows individual tree crowns, idealised circular shaped crowns and height points (Bluesky, 2021). Technical reports and other grey literature were used to understand the map's purpose and limitations, and a representative of BlueSky International Ltd with in-depth knowledge of the NTM was communicated with via email to fill in knowledge gaps.

The NFI dataset was downloaded from Forest Research (2020a). It shows general types of woodland (e.g. conifers, broadleaves, felled areas) and some additional habitats (e.g. shrub).

5.2.3 Ecologist data on recent natural colonisation

To identify areas where there has been confirmed natural colonisation in the last 10-20 years, four ecologists with long-term experience in the Carneddau were interviewed (identified and contacted through Bangor University links). They were given a map of the case study area and asked to circle areas where they have witnessed natural colonisation in recent years (or decades). In some cases, they volunteered additional information on what type of natural colonisation they witnessed, or where to look for it specifically, given the often-patchy nature of natural colonisation.

5.2.4 Woodland Expansion Opportunity Maps (WEOMs)

Four large-scale WEOM collections (with 12 maps in total) were compiled that cover the Carneddau (see **Table 3**). It should be noted that additional WEOMs are in use for land use decision making in Wales (e.g. Bateman *et al.*, 2014; Cosby *et al.*, 2020), but their spatial data (and technical details) was not available at the time of this research.

Spatial analysis was done in QGIS (QGIS.org, 2021). A representation of the maps can be found in **Figure 5-4**, **Figure 5-5**, **Figure 5-6**, **Figure 5-7**, **Figure 5-8**, and **Figure 5-9**. A more detailed description of each individual map can be found in the appendix (section **9.1.1**).

Table 3 WEOMs and sources.

Map ID	Map collection	WEOM opportunity	Source
ID1	CLP Upland Framework	conservation	Alex Turner & NRW (for the CLP)
ID2	Glastir scoring map	for grant support	Welsh government
ID3	WWNP NFP maps collection[1]	catchment woodland	Natural Resources Wales
ID4		riparian woodland	
ID5		floodplain woodland	
ID6	SoNaR[2] map collection	carbon sequestration	Environment Systems (for NRW)
ID7		rapid turnover forest	
ID8		community woodland	
ID9		land ownership patterns	
ID10		catchment woodland	
ID11		riparian woodland	
ID12		floodplain woodland	

[1] Working With Natural Processes (WWNP) Natural Flood Prevention (NFP) maps

[2] State of Natural Resources (SoNaR)

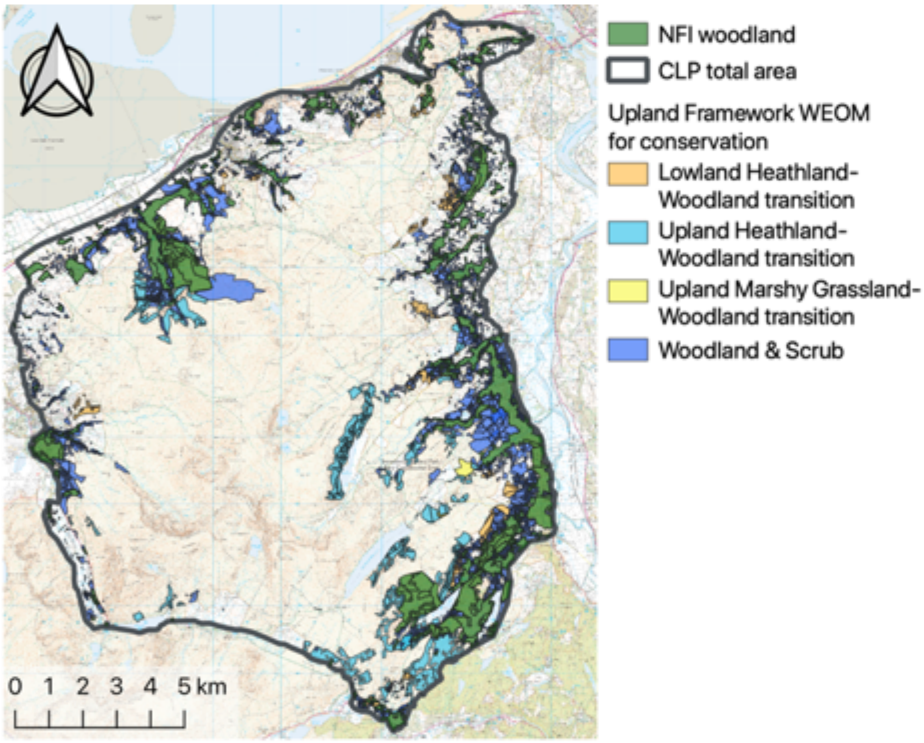

Figure 5-4 WEOM for the Carneddau - Upland Framework for conservation.

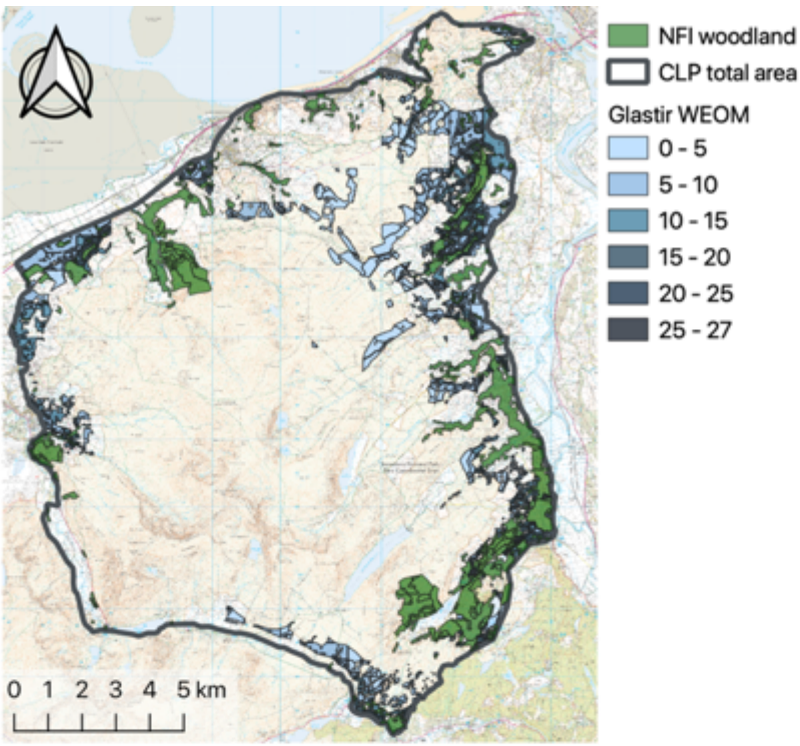

Figure 5-5 WEOM for the Carneddau - Glastir scoring map for overall planting grants

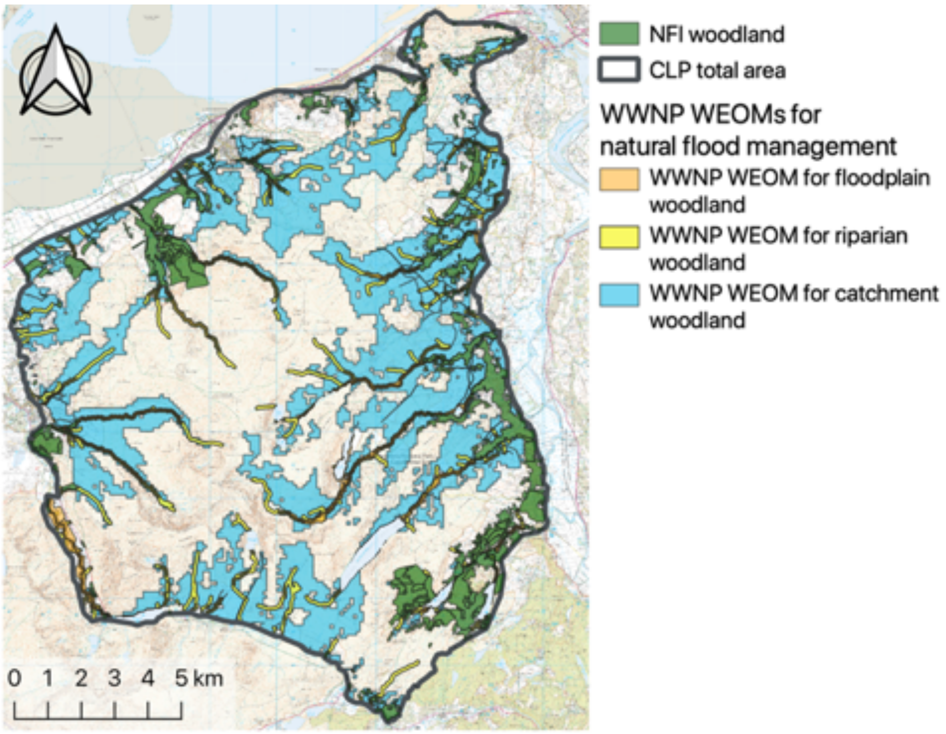

Figure 5-6 WEOM for the Carneddau - WWNP for natural flood management.

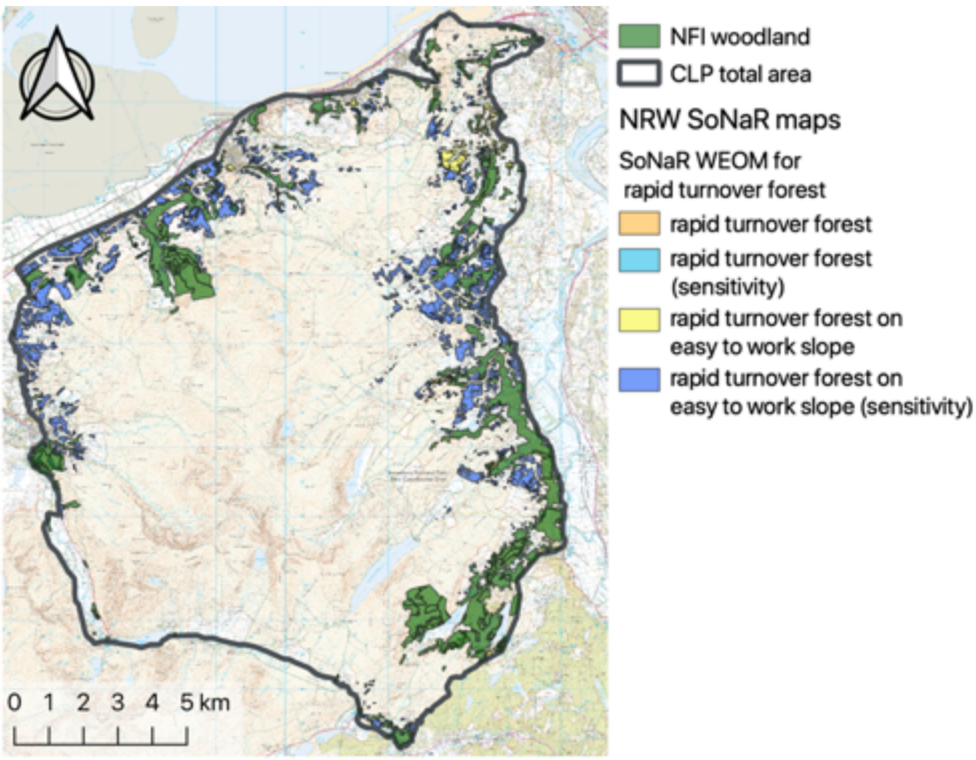

Figure 5-7 WEOM for the Carneddau - SoNaR map for rapid turnover forest.

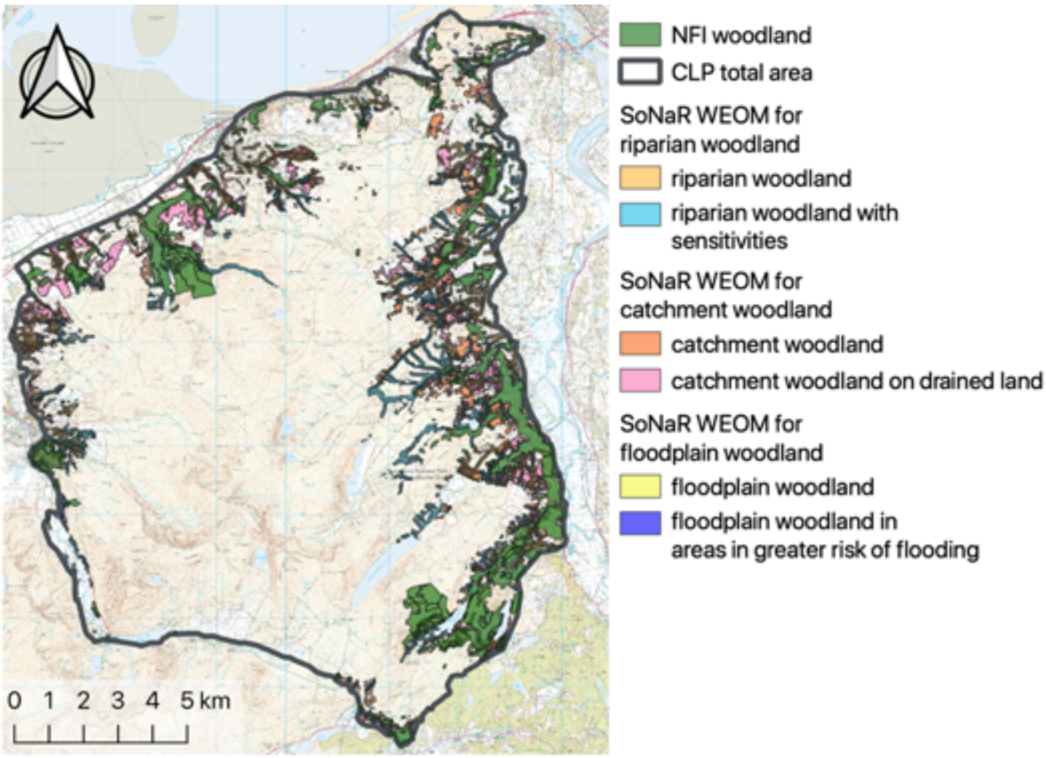

Figure 5-8 WEOM for the Carneddau - SoNaR maps for natural flood management (riparian, catchment, floodplain).

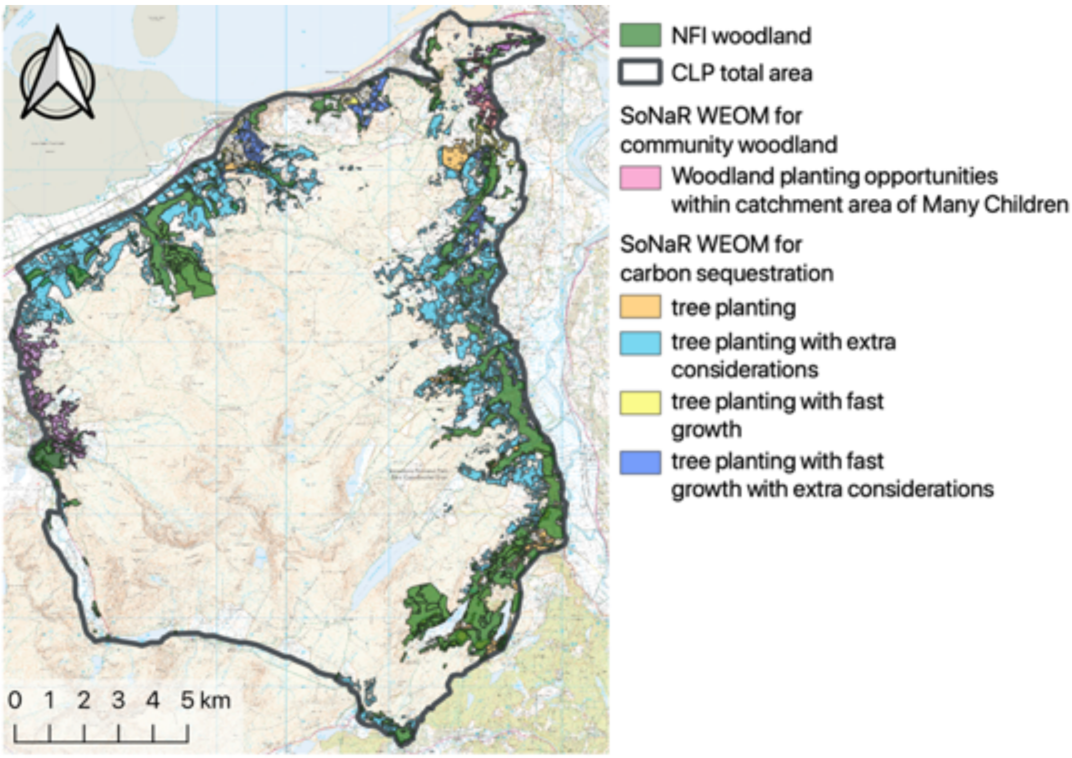

Figure 5-9 WEOM for the Carneddau - SoNaR maps for community woodland and carbon sequestration.

5.2.4.1 WEOM methodological background

Given the complex methodological background of some of the WEOMs, some preparatory research was necessary to understand their methodologies and context, in order to use them within this research. This included reading of technical reports, user guides, and other grey literature that accompanied several of the maps, as well as meetings with key informants, such as the map's original cartographers and other representatives, to fill in specific knowledge gaps (**Table 4**). A detailed description of all the WEOMs can be found in the appendix in section **9.1.1**, and a summary of the most important background can be found below.

Table 4. Participant ID for WEOM representatives.

Participant ID	WEOM	Role
REP1	CLP Upland Framework	Cartographer involved in the original production of the WEOM
REP2	CLP Upland Framework	Representative of the map
REP3	WWNP NFP maps collection	Cartographer involved in the original production of the WEOMs
REP4	SoNaR map collection	Cartographer involved in the original production of the WEOMs
REP5	SoNaR map collection	Representative of the map collection

In principle, all WEOMs try to show where the Carneddau's future woodlands could possibly be located when considering the land trees can biophysically grow on as well as restrictions or sensitivities based on other objectives and land uses (such as areas with special conservation status, high value agricultural land, deep peat areas, etc.). As already mentioned above, the different WEOMs vary in what woodland expansion driver they focus on, be it natural conservation, community cohesion, carbons sequestration, financial revenue from forestry or natural flood management. This changes the area they identify as a WEO, because while the maps often share a lot of the underlying datasets, such as the Phase 1 habitat map (Jones, 2007; Nauman *et al.*, 2018), their treatment of the datasets may be different. For example, the WEOM for community woodland, or the one for rapid turnover forest (**Figure 5-7** and **Figure 5-9**), specifically identify WEOs near communities and those areas with the general characteristics to support rapid turnover forest (soil, accessibility, slope, etc.), respectively. Similarly, six of the 12 WEOMs specialise in woodland expansion for natural flood management, which is why their WEOs follow rivers, floodplains, and catchments (Hanking et al., 2017c; Bell et al., 2020b).

Another reason why WEOs deviate between the different maps is that not all maps share the same underlying datasets. The Glastir WEOM is a good example for this, as is utilised an almost entirely different set of data to the rest of the maps (Welsh Government, 2014b), such as a noise pollution dataset or a specific WEOM that was not available for this research (Bateman *et al.*, 2014). Another example is that both the WWNP and SoNaR map collection each have WEOMs for riparian, catchment and floodplain woodland (**Table 3**), but the WWNP identify a lot more opportunity spaces than the SoNaR maps (compare **Figure 5-6** to **Figure**

5-8). Looking at the methodology, the SoNaR maps include much more constraints and sensitivities than the WWNP maps, such as areas on peat or other habitat types that should not be converted to woodland for conservation or biophysical reasons (priority habitats, cliffs, etc.; Hanking et al., 2017c; Bell et al., 2020a).

Due to these limitations, both the supplementary material for the WEOMs, as well as the representatives that were interviewed emphasised the non-prescriptive nature of the maps (e.g. Hanking et al., 2017b; Bell et al., 2020b). Underlying datasets, such as the Phase 1 habitat map, are limited in their resolution and data quality, which has knock-on effects on the quality and resolution of resulting WEOs. One cartographer gave a local example with regards to natural colonisation [REP1]; when producing their WEOM, they manually categorised a slope of south-facing mountainside far from existing woodland in the Carneddau as a WEO. They did so due to their own experience of existing natural colonisation in that area and their knowledge of the current habitat on site generally transitioning more easily to woodland compared to other habitats. This required them to manually overwrite the algorithm which, based on underlying datasets alone, would have not identified that area as a WEO. Supplementary material of several other WEOMs also speaks of such "*professional judgement*" at the hands of the cartographers that was used to try and improve the maps (Jones, 2007; Nauman *et al.*, 2018; Turner, 2018b).

In addition to inaccurate datasets, there is also an acknowledgment that there may be local opportunities, sensitivities, or constraints for which no dataset exists (or was available). One cartographer said the maps "*are the start of a conversation, not the end*", and that even areas with sensitivities were not meant to be a "*hard no"* for woodland expansion [REP4]; rather a soft check was recommended for further considerations (e.g. "within historic landscape"; Nauman et al., 2018, p. 32). Supplementary material to the WEOMs recommend that local stakeholder engagement be carried out to marry the landscape scale approach of the maps with a more nuanced local assessment of potential WEOs (Bell *et al.*, 2020b). Several representatives of the WEOMs pointed out, however, that in reality the maps were often used more prescriptively than was intended, as "*box ticking*" exercises [REP5], for example, so that "*progress has been achieved on paper*" [REP3], with less interest in the complexity of implementing and synthesising the maps' suggestions with realities on the ground.

Lastly, none of the 12 WEOMs attempt to be 'the' map on WEOs in the Carneddau, and neither of them should be understood as ultimate representations of the 'correct' version of the Carneddau's future landscape with regards to woodland cover. Data limitation is one reason for this, but it is also due to the subjective judgement at the hands of the cartographers on what datasets to use and to show based on (a) the driver of woodland expansion chosen, and (b) what other interests in land use are perceived as competition to new woodlands (expressed by classifying specific datasets are sensitivities or constraints). This is in line with wider literature; for highly complex environments, there likely is not one single best map (Crampton, 2001; Kitchin and Dodge, 2007). There are instead various types/sets of data to look at, at various levels of interactivity, and various levels of scale. It also ties the use of WEOMs in this present chapter with the discussion in Chapter 3; the drivers of woodland expansion may change over time and therefore change what is considered important, as an 'opportunity' or 'constraint', for woodland expansion.

For the research on natural colonisation in this chapter, the WEOMs can and have been used as valuable guides on where tree cover could be beneficial in the future. This was specifically interesting for choosing and discussing areas of interest (AOIs – see below). The close examination of the maps' methodologies and limitations also means, however, that they can be used in a way that appropriately reflects the resolution (of scale or data availability) the maps can (or cannot) provide.

5.2.5 Comparison and observational site visits

After collecting the spatial datasets and assessing them critically on an individual basis, they were compared to identify suitable areas for observational site visits.

5.2.5.1 Critical map comparison

The critical map comparison to identify areas of interest (AOIs) for observational site visits comprised four steps (see also **Figure 5-10**):

1. **Identify areas where the NTM shows significant tree cover outside (NFI) woodlands:**

   'Significant', in this case, was not an absolute assessment of percentage of tree cover, but a relative judgement (based on visual assessment) of the presence of tree cover outside woodlands compared to other areas in the Carneddau.

2. **Identify areas where the WEOMs match or decidedly do not match:**

   Using all 12 WEOMs, an overlay map was created to see where WEOMs overlap the most or least (see Figure 5-15), and from there a qualitative assessment was made to find particular areas with different combinations of overlap between the maps.

3. **Identify areas where the NTM shows spatial distribution of tree cover outside woodlands that falls within (or decidedly out of) one or several WEOs:**

   This step was a way of narrowing down all the areas identified in step 1 & 2 to a combination of specific AOIs that represent a diverse variety of coverage between

WEOMs and NTM. For all those AOIs, data was added whether ecologists had witnessed recent natural colonisation or not.

As a result of step 3, 12 AOIs were chosen (AOI 1-12).

4. **Add areas where the ecologists identified recent natural colonisation:**

   Ecologist information was taken mostly at face value and, as natural colonisation is the focus of this research, all data points were included as AOIs. In several cases, those areas were already covered in the set chosen in step 3. For those areas added in step 4, WEOM and NTM coverage was collected as well.

   As a result of step 4, another 9 AOIs were identified (AOI 13-21).

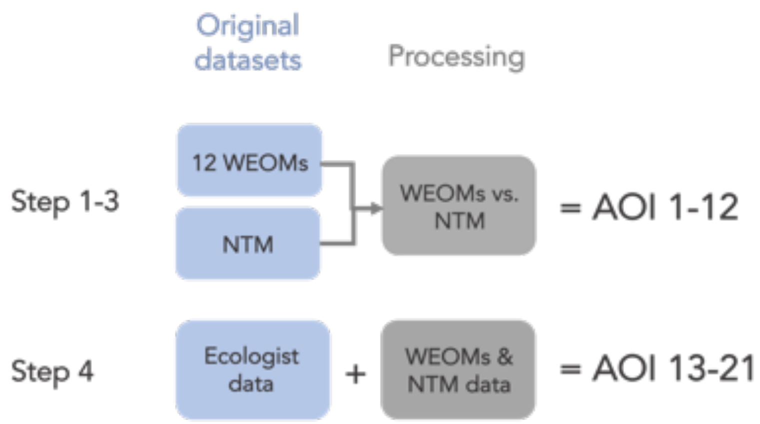

Figure 5-10. Critical map comparison to choose areas of interest (AOIs) for observational profiling. In total, 21 AOIs were chosen.

It was the point of this methodology to identify a range of combinations between NTM (and NFI) coverage, witnessed natural colonisation and WEOMs, with a positive bias towards areas with witnessed natural colonisation. Care was taken so that even if different areas of the Carneddau had been identified as areas of interest (AOI), they would have most likely led to the same (or a very similar) combination matrix between the three datasets. In total, 21 AOIs were identified, offering a wide variety for observational profiling.

A map with the locations of all 21 AOIs can be seen in **Figure 5-11**. A general overview of the data coverage for each AOI can be found in **Table 5**, and a detailed breakdown can be found in **Table 10**, **Table 11**, **Table 12** and **Table 13** in the appendix. A closeup of the first three AOIs can be found in **Figure 5-12**, while closeups for all other AOIs can be found in **Figure 9-1**, **Figure 9-2**, **Figure 9-3**, **Figure 9-4**, **Figure 9-5** and **Figure 9-6** in the appendix.

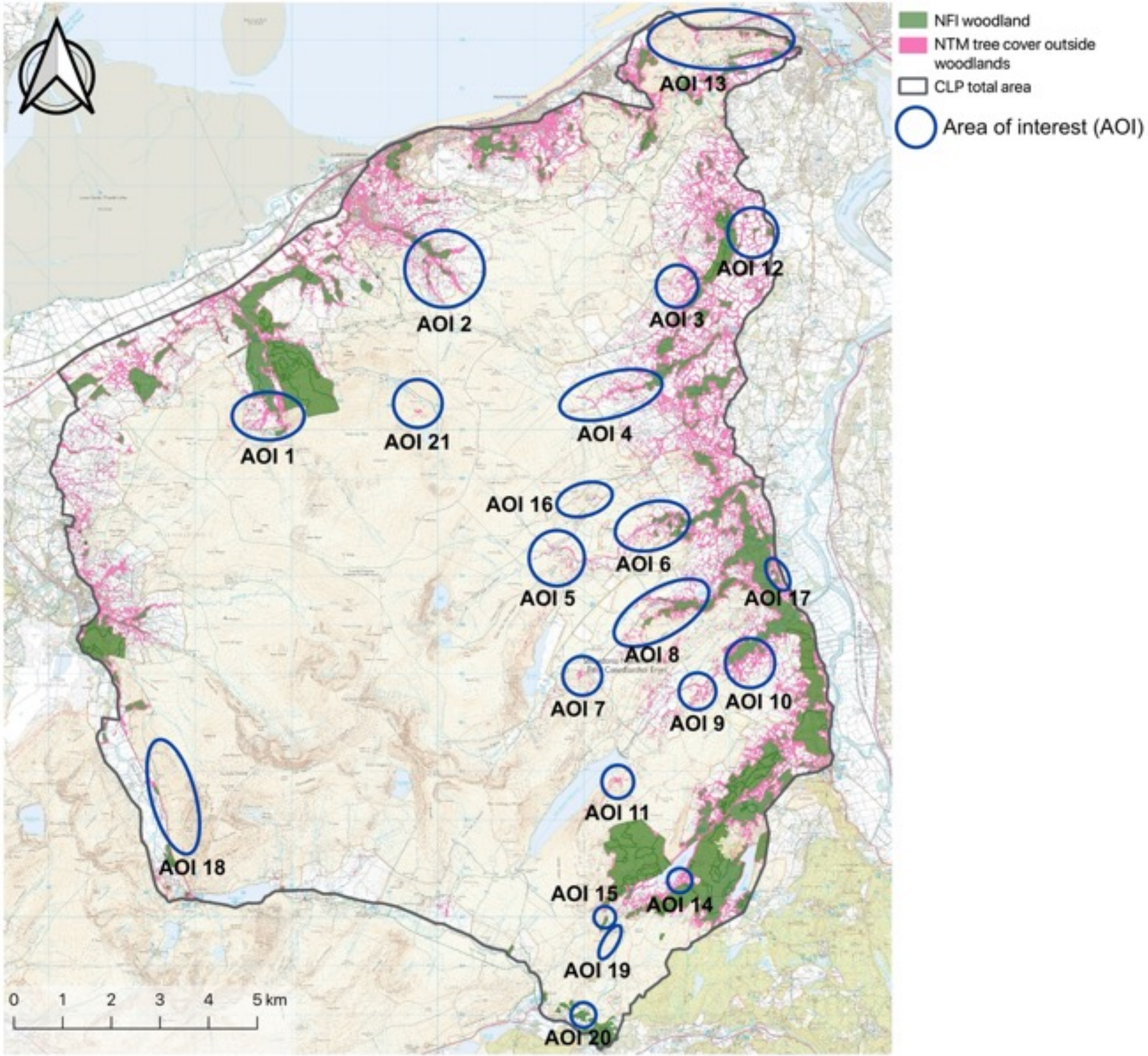

Figure 5-11. Areas of interest (AOIs) in the Carneddau. In total there are 22 AOIs, 12 of which were chosen through comparing WEOMs and NTM, 8 were added via ecologist data and 2 were added due to the CLP planning to plant small scale tree cover there.

Table 5 Summary of data coverage for the 21 areas of interest (AOIs). A more detailed breakdown can be found in table **Table 10**, **Table 11**, **Table 12** and **Table 13** in the appendix.

Code	WEOM coverage	NTM coverage	Ecologist data	Code	WEOM coverage	NTM coverage	Ecologist data
AOI 1	Some WEO for natural flood management and conservation	scattered tree cover surrounding NFI woodland	natural colonisation witnessed	**AOI 12**	Various WEOs	linear tree cover along field margins	no natural colonisation confirmed
AOI 2	many WEOs overlap	linear tree cover alongside three streams and surrounding NFI woodland	natural colonisation witnessed	**AOI 13**	Some WEO for conservation (and a little bit for Glastir)	scattered tree cover around small NFI woodland	natural colonisation witnessed
AOI 3	WEOs for rapid turnover forest and Glastir	scattered tree cover	natural colonisation witnessed	**AOI 14**	WEO for conservation, natural flood management and carbon sequestration	tree cover surrounding NFI woodland	natural colonisation witnessed
AOI 4	many WEOs overlap	linear tree cover alongside stream	natural colonisation witnessed	**AOI 15**	WEO for conservation and natural flood management	tree cover surrounding NFI woodland	natural colonisation witnessed
AOI 5	WEO for conservation (and some natural flood management)	linear tree cover alongside stream	no natural colonisation confirmed	**AOI 16**	Some WEO for natural flood management and Glastir	very little tree cover	natural colonisation witnessed
AOI 6	most WEOs overlap except Glastir	linear tree cover alongside stream and surrounding NFI woodland	no natural colonisation confirmed	**AOI 17**	WEO for conservation, natural flood management and carbon sequestration	tree cover surrounding NFI woodland	natural colonisation witnessed
AOI 7	WEO for conservation (and some natural flood management)	small patch of isolated tree cover	no natural colonisation confirmed	**AOI 18**	no WEO	no tree cover	natural colonisation witnessed
AOI 8	WEO for conservation (and some natural flood management)	tree cover surrounding NFI woodland	natural colonisation witnessed	**AOI 19**	Some WEO for conservation	no tree cover	natural colonisation witnessed
AOI 9	WEO for natural flood management (and a little bit of most other WEOs)	linear tree cover alongside stream	no natural colonisation confirmed	**AOI 20**	most WEOs overlap except community woodland	no tree cover	natural colonisation witnessed
AOI 10	WEO for rapid turnover forest and carbon sequestration	tree cover surrounding NFI woodland and along field margins	no natural colonisation confirmed	**AOI 21**	only WEO for natural flood management	small patch of isolated tree cover	no natural colonisation confirmed

AOI 11	only WEO for conservation	small patch of isolated tree cover	no natural colonisation confirmed	

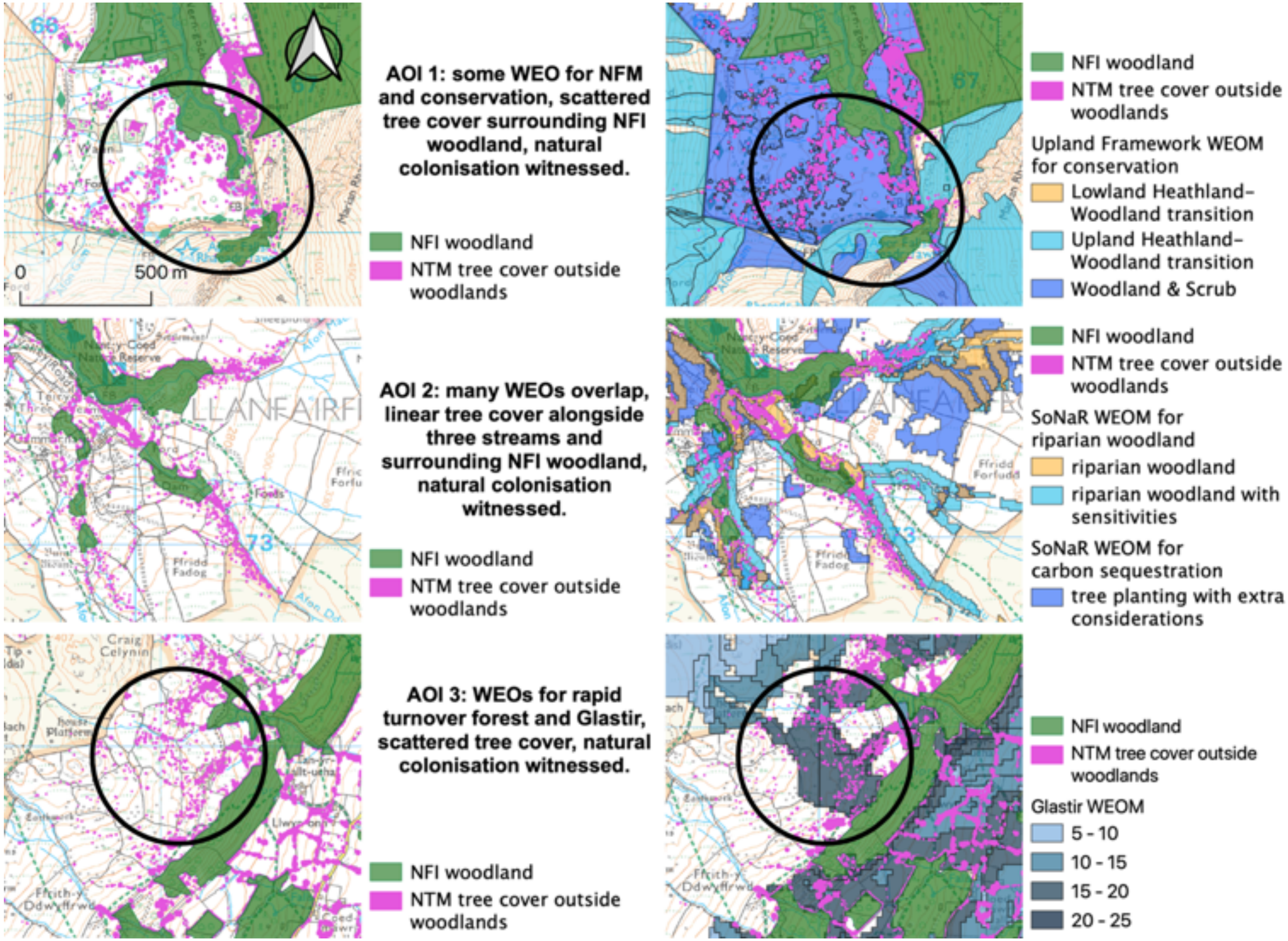

Figure 5-12 Closeup of AOI 1-3. Woodland and NTM tree cover is shown on the left, an example of a WEO that covers that area is seen on the right.

5.2.5.2 Sites visits for observational profiling

Site visits were undertaken between May and August 2021, mostly using a hire car to get as close to the sites as possible before walking. All protocols applicable at the time with regards to Covid and other risks were adhered to. Photographs and notes were taken whenever relevant and uploaded/digitised as soon as possible thereafter. Some AOIs were difficult to access from one direction alone, in which case attempts were made wherever possible to find a different way to access the rest of the area. For AOI 20 and AOI 17 it was not possible to find a feasible way to access them, but all other 19 AOIs were used for observational profiling.

5.3 Results

The result section is split into four parts. Section **5.3.1** is an assessment of existing tree cover in the Carneddau, using NFI and NTM. Section **5.3.2** covers the results of ecologist interviews on where they witnessed recent natural colonisation. Section **5.3.3** is a comparison of existing tree cover on the NTM and the WEOMs. Finally, section **5.3.4** covers the central results of this research, the observational site visits on natural colonisation.

5.3.1 Spatially explicit tree cover in the Carneddau (NTM & NFI)

In the Carneddau, roughly 1,870ha (or 8.5%) is NFI designated woodland, and analysis of the NTM suggests there is another 460ha or 2.1% of additional tree cover outside these woodlands (**Figure 5-13**). This means that almost 20% of all recorded tree cover in the Carneddau is not on the publicly available dataset of the NFI. Much of this tree cover is below the upland boundary, often in line with field margins (most likely as part of hedgerows). However, at the border to the uplands there often are steep slopes and areas of scrub and scattered trees that might be part of a *ffridd* landscape (spatial information on the extend of the *ffridd* is very limited). Further onto the hills the trees outside woodlands often exist along watercourses and nearby slopes. Only a few patches of tree cover are found far from established (NFI) woodland (or significant NTM tree cover); those seem to be outcrops of trees growing on steep ground.

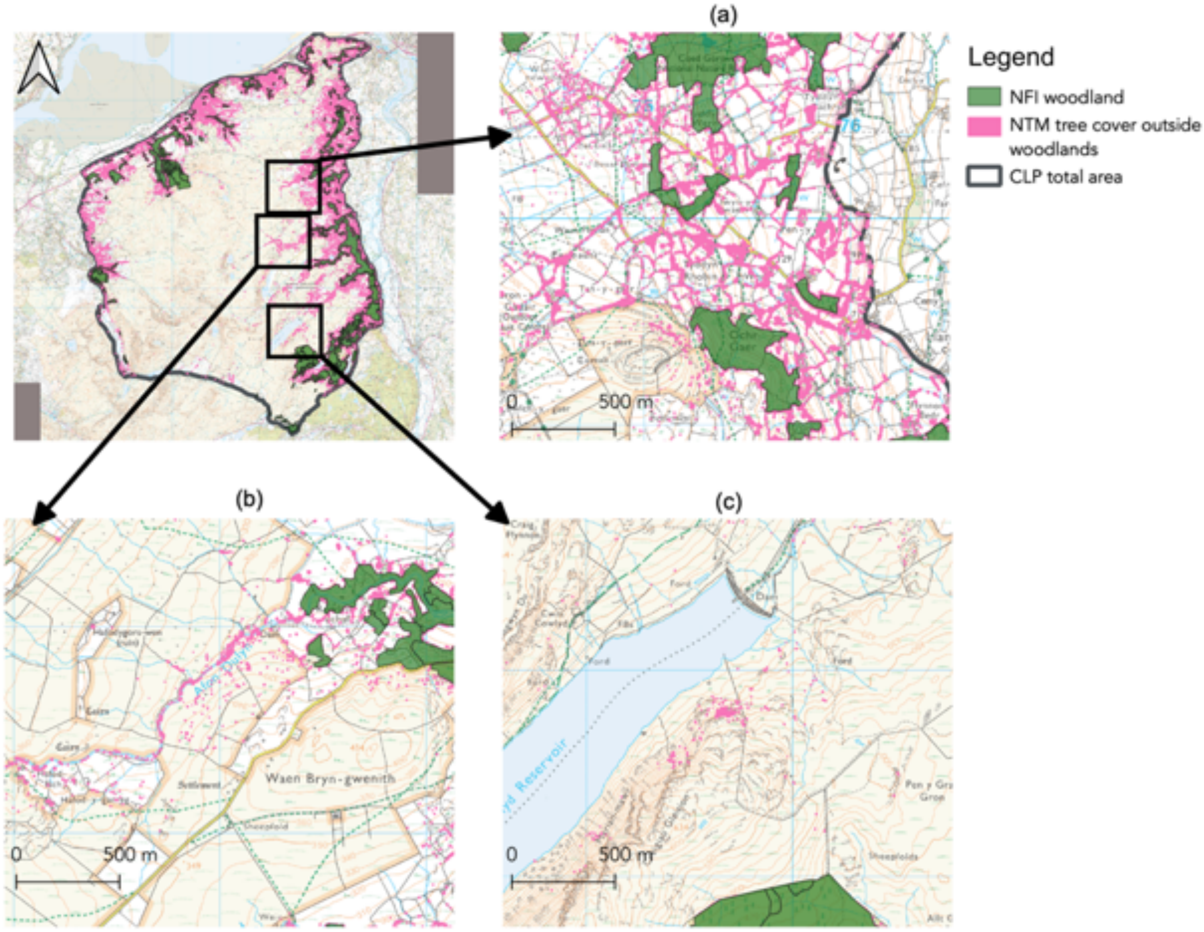

Figure 5-13 National Tree Map (NTM) of the Carneddau. Examples: (a) trees along field boundaries (below upland boundary), (b) trees along watercourses (above upland boundary) and (c) trees on remote outcrops (on open mountain land).

5.3.2 Ecologist data on recent natural colonisation in the Carneddau

According to the NTM, 19.7% of the total spatially mapped tree cover in the Carneddau exists outside of NFI categorised woodlands. With the limitations of the NTM, namely not accounting for tree age, tree species or any trees below 3m in height, certain types of tree cover, recent colonisation being amongst it, is still underrepresented. Natural colonisation does not have a spatial dataset like the ones above, so four ecologists with extensive experience in the Carneddau were asked to identify areas that exhibit recent natural colonisation (in the last 10-20 years). The result can be seen in figure **Figure 5-14**.

The four ecologists pointed out that there might be other areas with natural colonisation in the Carneddau they hadn't seen (yet). They also mentioned how recent natural colonisation may not equal successful establishment of mature trees, as natural colonisation was a process that could be impacted at various stages in various ways (seed dispersal, competition through grasses, herbivory, fire, local climatic conditions, etc.). Furthermore, without long-term tracking it would also be difficult to actually verify whether an area was, in fact, 'transitioning', i.e. whether the overall net cover of trees was increasing. Nonetheless, the ecologists felt that the areas they had identified were good sites to visit for the purpose of this research.

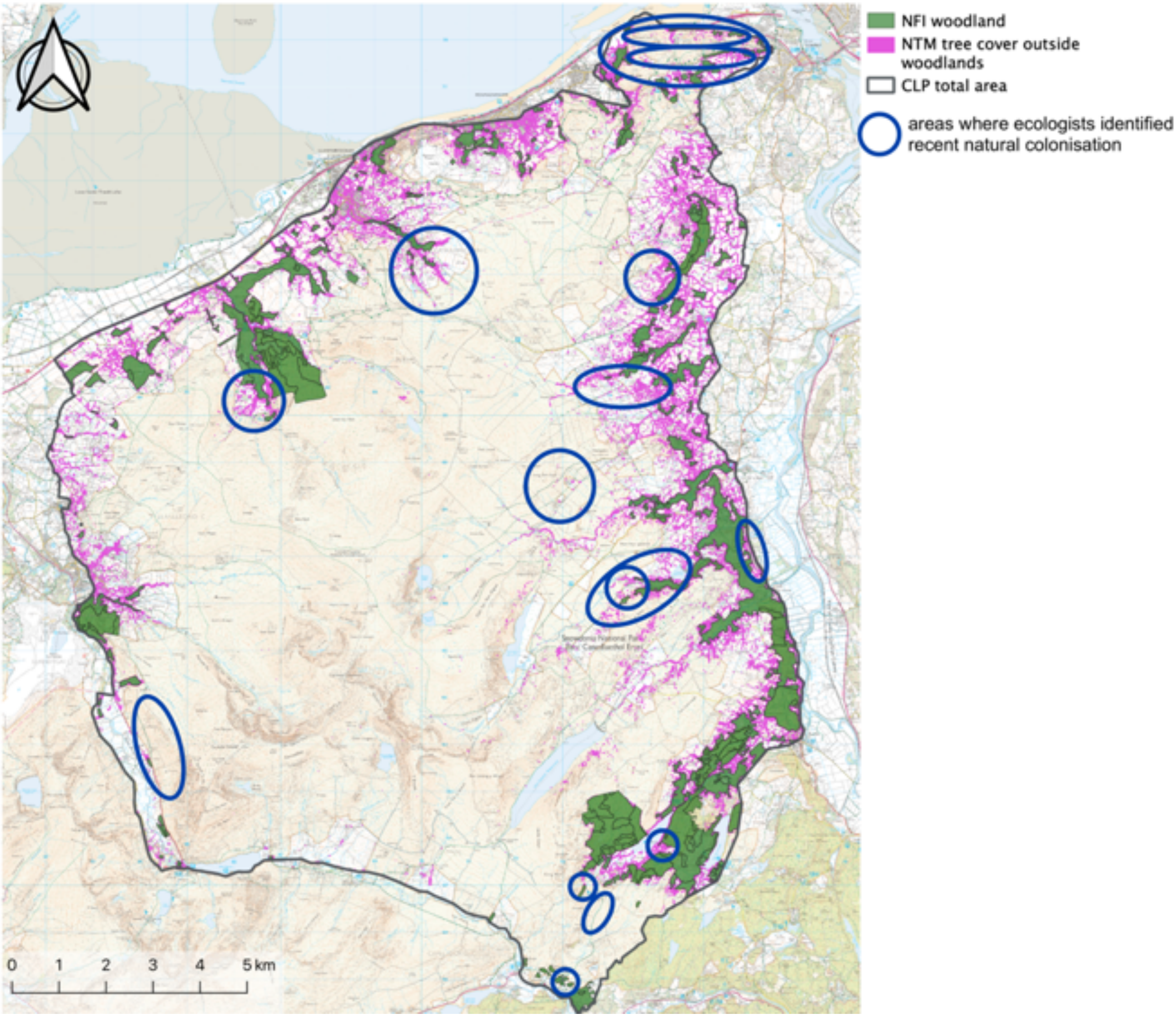

Figure 5-14 Areas with recent natural colonisation in the Carneddau. Identified by four ecologists with experience in the Carneddau.

5.3.3 Woodland expansion opportunities (WEOs) in the Carneddau

In total, 10,800ha or 49% of the whole of the Carneddau has been identified by one or several of the WEOMs as an opportunity space for woodland expansion (**Figure 5-15**). It is quite evident from **Figure 5-4** to **Figure 5-9** as well as **Figure 5-15** below that most of the 12 WEOMs concentrate on the outer margins of the Carneddau, especially on the east side along the Conwy valley and in the North-East and North near Bethesda and along the coast. Large parts of the central Carneddau are above the tree line of 555m (**Figure 5-3**), are far away from established woodland to provide connectivity, and/or are peat areas; all reasons why these areas were likely excluded as a woodland expansion opportunity (WEO). The outskirts of the

Carneddau, on the other hand, have more lowland and an easier to work slope, existing woodland nearby and a higher clarity on land ownership and potential management [REP1, REP3].

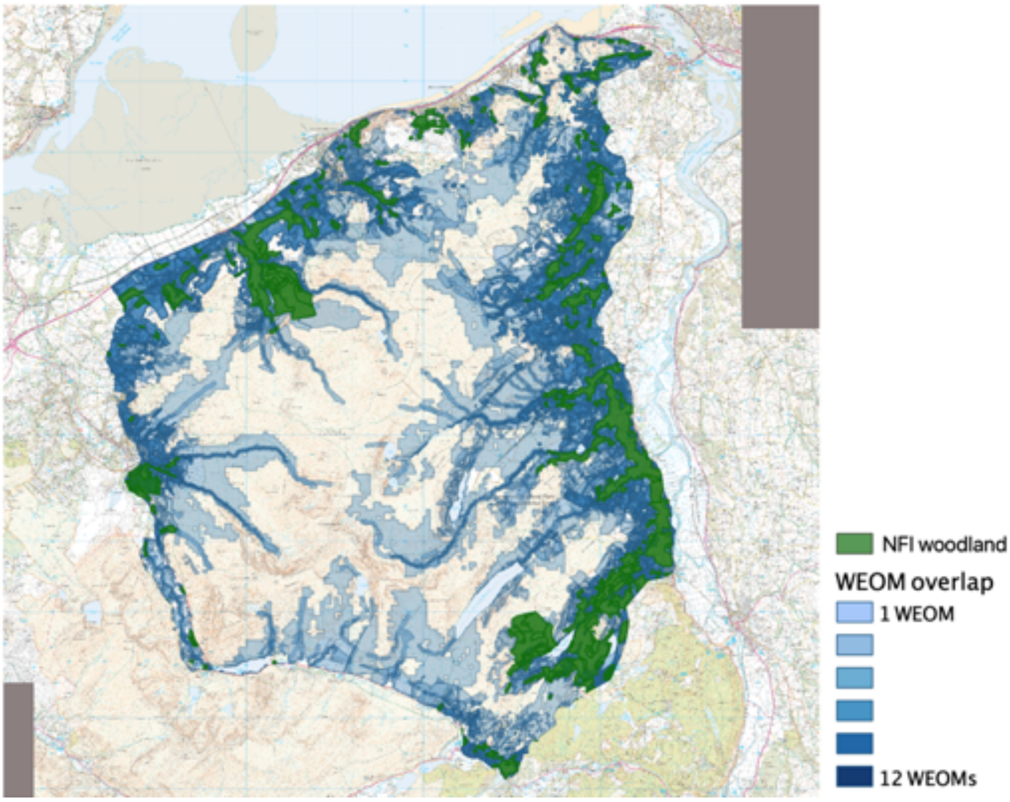

Figure 5-15 WEOM overlap in the Carneddau. The darker (blue), the more heavily featured a given area is on the WEOMs.

5.3.3.1 Overlap of NTM & WEOMs in the Carneddau

While all the 12 WEOMs use NFI woodland data as an important underlying dataset, such as to model seed source or habitat connectivity, none of the maps use the NTM or any comparable spatial representation of tree cover outside woodlands. The comparison between NTM and WEOMs suggests that in the Carneddau 402ha or 87% of tree cover outside woodland sits within a WEO identified by one or several of the WEOMs (**Table 6**). Almost 60% of all tree cover outside woodland is within a WEO identified by the CLP Upland Framework (for nature conservation); about 43% is within a WWNP opportunity for natural flood management, and 33% is within an area that might have gotten successful grant application through the latest Glastir scheme (**Figure 5-16a**). When accounting for the size difference of the maps (the WEO for WWNP catchment woodland covers over 7,000ha, while the WEO for SoNaR floodplain woodland only covers 20ha), the SoNaR floodplain WEOM has the highest percentage of existing tree cover with 12.1%, followed by the CLP Upland

Framework WEOM with 9.5% and the Glastir scoring map with 6.5% (**Figure 5-16b**). On average, the 12 WEOMs investigated in this research already have 86.6ha or 5.5% tree cover.

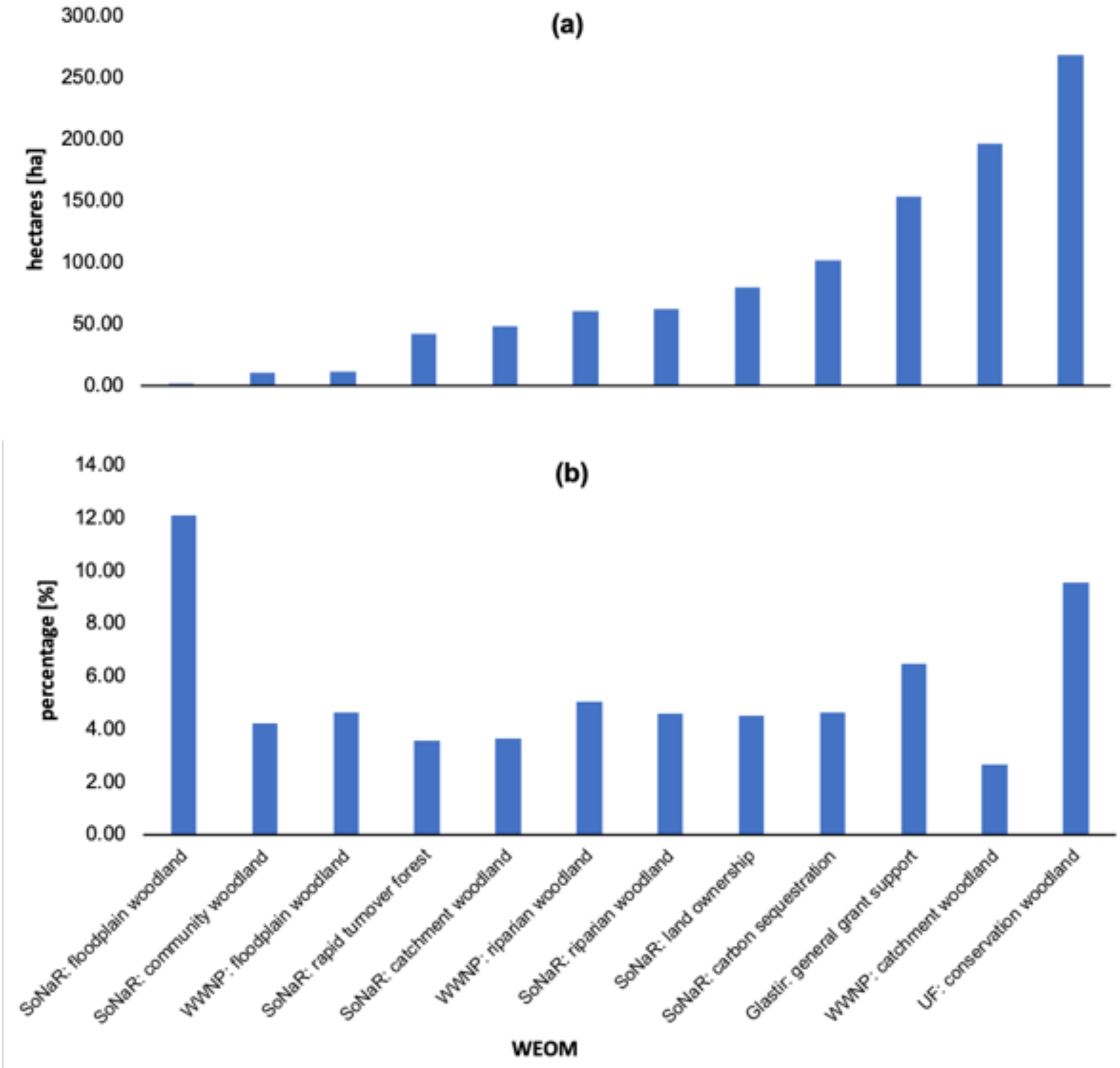

Figure 5-16 Tree cover outside woodland within WEOMs. (a) Amount of NTM tree cover that falls within each WEOM opportunity space, and (b) percentage of each WEOM opportunity covered by NTM tree cover.

Table 6 Tree cover outside woodlands matching WEOMs.

Map ID	Map collection	WEOM opportunity	Amount of NTM tree cover within WEO [ha]	% of NTM tree cover within WEO	% of WEOM with existing tree cover
ID1	CLP Upland Framework	conservation	268.58	58.42	9.54
ID2	Glastir scoring map	for grant support	153.44	33.37	6.48
ID3	WWNP NFP maps collection	catchment woodland	196.17	42.67	2.65
ID4		riparian woodland	60.93	13.25	5.03
ID5		floodplain woodland	11.87	2.58	4.64
ID6	SoNaR map collection	carbon sequestration.	102.33	22.26	4.64
ID7		rapid turnover forest	42.01	9.14	3.55
ID8		community woodland	10.50	2.30	4.23
ID9		land ownership patterns	79.97	17.39	4.52
ID10		catchment woodland	48.47	10.54	3.64
ID11		riparian woodland	62.12	13.51	4.58
ID12		floodplain woodland	2.40	0.52	12.10

5.3.4 Observational profiling

After gathering and critically assessing the three types of datasets above (WEOMs, NTM, ecologist data), they were compared as per section **5.2.5** and **Figure 5-10** to identify areas of interest (AOIs) for observational profiling (see **Figure 5-11**).

The observational profiling of tree cover outside woodlands and natural colonisation below has been approximately categorised along a gradient from lowland fields around the periphery of the Carneddau to the open mountain towards the centre. During the profiling it became evident that the characteristics of tree cover and natural colonisation seem to change along this gradient and an exploration of why this might be, can be found in section **5.4.2**.

5.3.4.1 Trees along field margins – on lowland

Tree cover outside woodlands on lowland fields mostly follow field boundaries. In fact, it many areas, such as AOI 12, it seems possible to discern field boundaries based on tree cover outside woodlands alone (**Figure 5-17**). A lot of this tree cover is larger than 3m in height and prominently features on the NTM, and site visits showed that the trees often cooccur within hedgerows. Most of the fields are used for sheep grazing, and natural colonisation within fields was not evident. In one area, however, several hedgerows and field boundary trees had been fenced off from direct contact with grazing animals, and a few seedlings and saplings which presumably naturally colonised were evident there.

Figure 5-17 Tree cover along field boundaries at AOI 12. These trees are part of hedgerows along grazed grassland.

5.3.4.2 In-field tree cover – on in-bye land

Several of the sites visited, such as AOI 1-3 and the south-west of AOI 8, are areas of so-called in-bye land, which is land that lies on the slopes between open mountain and the lowland fields. This land is still fenced, so grazing animals cannot access the open mountain. Tree cover outside woodlands in these areas of the Carneddau mostly seems to be scattered in-field trees (**Figure 5-18** and **Figure 5-19**), often hawthorn (*Crataegus monogyna*) or blackthorn (*Prunus spinosa*). Given the climatic conditions and the grazing pressure, there is no linear relationship between the age of most of the trees and their size, but what is clear is that the large proportion of the hawthorns, regardless of age, are below 3m in height. AOI 18 shows this very well (**Figure 5-20**); an area that, according to the NFI and the NTM, has neither woodland nor tree cover outside of woodlands is actually full of hawthorn and the natural colonisation of rowan (*Sorbus aucuparia*) and some birch (*Betula pendula*; **Figure 5-21**).

In in-bye land, field boundaries may also have tree cover, often not part of a hedgerow, but rather individual trees along stone walls. Some of these individual trees, especially when they are larger species such as oak, seem to have been planted (or their establishment facilitated), as they often are next to old settlements or other old farming structures. Sometimes in-field trees also grow in a very linear fashion, which could be due to the trees belonging to old field margins that have since been dissolved.

In some areas of the Carneddau (such as AOI 2) in-field tree cover was affected by fire (**Figure 5-22**), and in other areas (such as near AOI 10) it was evident that some of the old in-field trees were declining or dying (**Figure 5-23**).

Figure 5-18 In-field trees at AOI 1.

Figure 5-19 In-field trees at AOI 3.

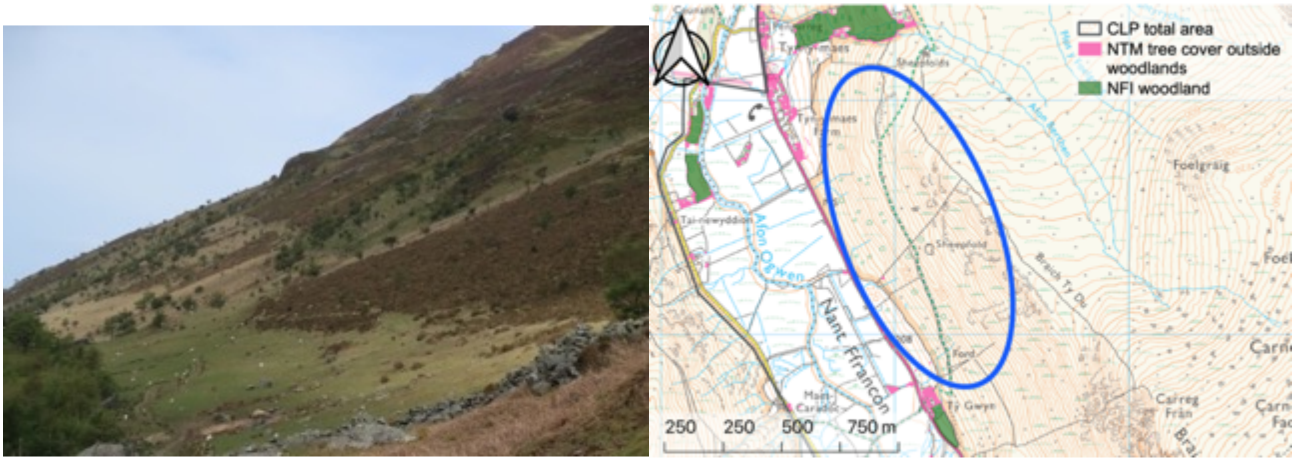

Figure 5-20 In-field trees up the slope at AOI 18. Not even one of them appears on the NTM.

Figure 5-21 Natural colonisation up on the hill at AOI 18. Mostly rowan & some birch, none of which are visible on the NTM.

Figure 5-22 Evidence of upland fires at AOI 2. Two burnt trees amongst burnt gorse in the front, with more in-field trees in the back.

Figure 5-23 Dead in-field trees (AOI 10).

5.3.4.3 Tree cover along water courses – above the mountain wall

Leaving in-bye land and going further up the mountain, tree cover outside woodlands often tends to follow streams, such as AOI 2, AOI 4, AOI 5, AOI 6, and AOI 9 (**Figure 5-24**, **Figure 5-25**). It is interesting that at all these sites the riparian tree cover is connected to an established NFI woodland further down the hill. Whether these trees (now also often including willow) have been planted, naturally colonised, or are indeed remnants of older woodlands along the river and streams is unclear. In many cases there did not seem to be any obvious natural colonisation (or regeneration), despite one ecologist saying they noticed some in the area at AOI 2. The exception is AOI 5, which shows quite evident natural colonisation of rowan, and birch (**Figure 5-26**). This site is part of a long-standing environmental agreement with NRW and has a had a confirmed reduction (but not cessation) of sheep grazing and other changes in land management (local landowner, pers. communication). This might be a reason for the occurrence of natural colonisation.

Figure 5-24 Tree cover along a stream at AOI 2. This tree cover is not NFI woodland (green), but does appear quite evidently on the NTM (red, within blue circle).

Figure 5-25 Tree cover (mostly willow) along a stream at AOI 5.

Figure 5-26 A patch of gorse along the watercourse at AOI 5. Includes what seems to be young rowan (including one which barely sticks out of the gorse in the blue circle).

5.3.4.4 Open and semi-open land – protected sites

On open or semi-open land (semi-open land being above the mountain wall, possibly publicly accessible, but still fenced) the ecologists marked down a range of different sites with recent natural colonisation. What unites most of them (and what unites them with natural colonisation found at other sites) is that they all seem to be protected in some way or form, either from grazing, or from the harsh climate (or both).

5.3.4.4.1 Protected from grazing

In several instances, such as at AOI 21, AOI 2, AOI 5, AOI 13 and some sites outside the areas of interest, patches of natural colonisation of mostly rowan and birch (and rarely the odd conifer) occurred in dense growth of gorse or heather (**Figure 5-27**, **Figure 5-28**). Many of these areas are within a common and/or on open mountain, so they are exposed to grazing, but gorse and heather seem to act as protection for young trees (**Figure 5-30**, **Figure 5-31**). In some cases, even one gorse bush seemed to have been enough keep the tree out of reach from sheep long enough for it to successfully establish (**Figure 5-29**). These trees are often below 3m in height, so they rarely show up on the NTM.

Another type of protection from grazing/browsing seems to be steep, sometimes rocky outcrops and other topographic features that make it hard for sheep to reach (**Figure 5-32**, **Figure 5-33**). This could be the rocky top of a mountain, such as at AOI 8, or one of the smaller rocky outcrops that often occur in the Carneddau, such as at AOI 21, at AOI 1 or AOI 11. These sites are not NFI woodlands, but they do often show up on the NTM, as some of the trees are above 3m in height (**Figure 5-33**, **Figure 5-34**).

5.3.4.4.2 Protected from wind and weather (and possibly fire)

It also seems as though sites of natural colonisation in the Carneddau often have a topographic advantage that protects them from prevailing winds and weather (and possible fire). Weather fronts often come from the western side of the Carneddau and move East, which means North, West, and South facing slopes (and the east side of the Carneddau as a whole) are partially protected from harsher conditions. The outcrops with natural colonisation at AOI 7, AOI 11, and the one at AOI 21 are all not only too steep for grazing sheep to reach, they are also all north-east facing; AOI 13 is north facing as well (**Figure 5-34**, **Figure 5-35**). In addition to that, trees that grow on steep, rocky outcrops may also survive a fire that may burn any dry gorse or dead bracken or grass surrounding them.

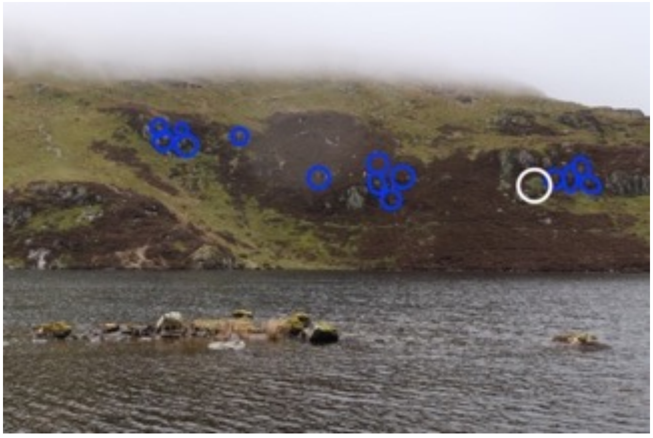

Figure 5-27 Natural colonisation of rowan near AOI 21. At Llyn Anafon (outside the areas of interest, north-east facing slope); ~2km beeline from the next NFI woodland (which used to be conifers, not rowan), and ~1km from any NTM tree cover. There is only one larger tree (in white), which could be the seed parent.

Figure 5-28 Natural colonisation of a conifer tree amongst gorse near AOI 21. On the other side of the valley there used to be a large conifer plantation, which could be the seed source. Much of that is felled now.

Figure 5-29 Natural colonisation at AOI 2. A single rowan naturally colonised in a bush of gorse. Sheep graze in between the gorse, but seem to have missed the rowan.

Figure 5-30 Natural colonisation west of AOI 5. A slope of heather filled with natural colonisation of rowan.

Figure 5-31 Natural colonisation at AOI 13. Established trees and natural colonisation of rowan and birch on a north-facing slope, growing amongst bracken and heather and partially steep terrain.

Figure 5-32 Natural colonisation at AOI 19. Natural colonisation of rowan (blue circles) on a northwest facing slope close to the hilltop.

Figure 5-33 Natural colonisation at AOI 5. Natural colonisation of rowan (blue circles) on north-east facing rocky outcrop.

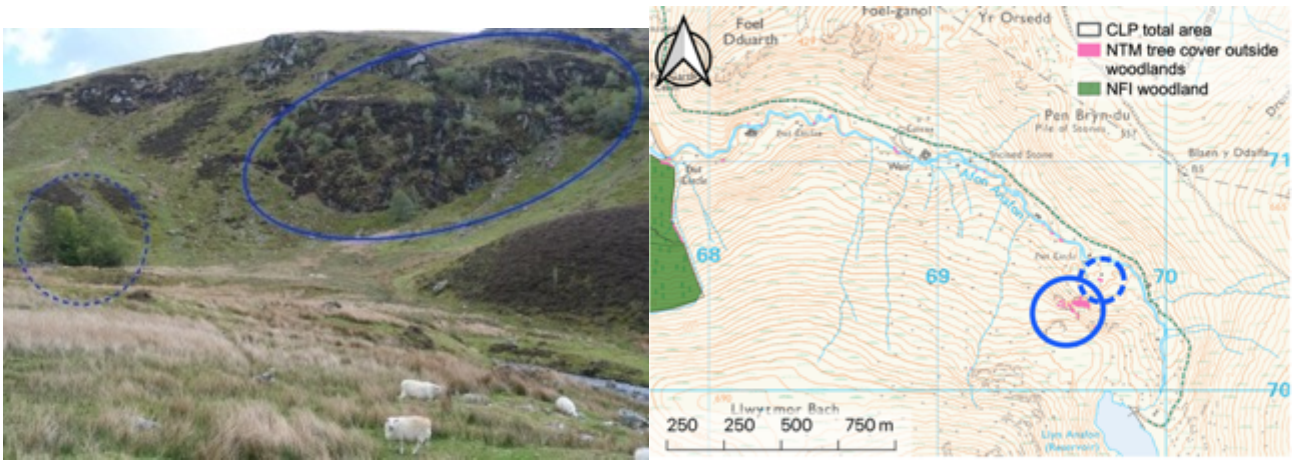

Figure 5-34 Natural colonisation on an outcrop at AOI 21. A steep north-east facing cliff of natural colonisation (blue) and a small patch of established tree cover (blue dashed). The established tree cover seems to have been planted next to a (now abandoned) settlement, and both established trees and natural colonisation show up on the NTM.

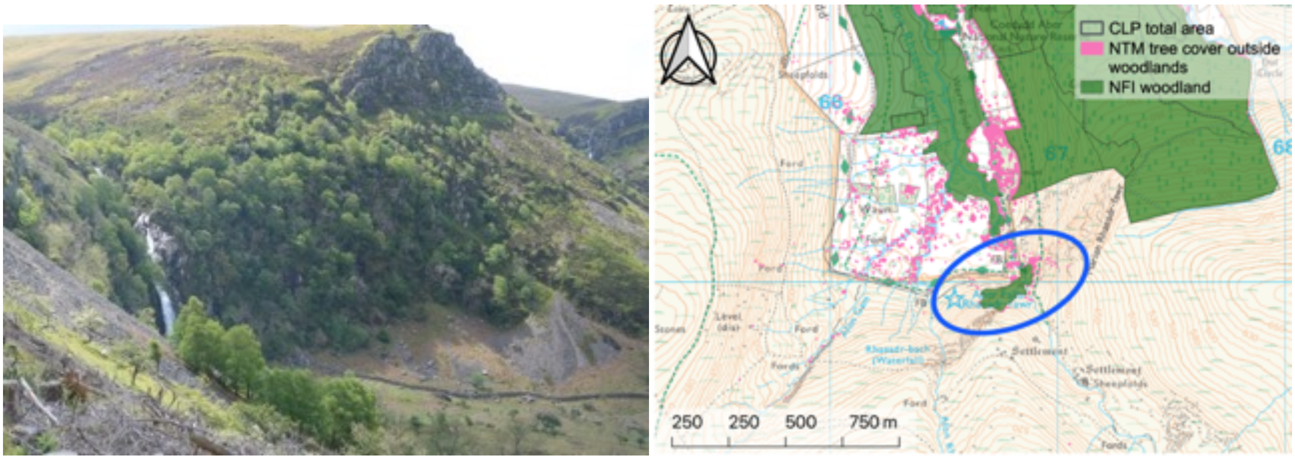

Figure 5-35 Steep north-facing cliff next to the waterfall at AOI 1. The central part is market as NFI woodland, while surrounding trees are on the NTM and further natural colonisation.

5.3.4.5 Exclusion sites

Finally, natural colonisation in the Carneddau also occurs in exclusion sites where grazing (of any kind) has been ceased entirely. Three intentional exclusion sites were identified, two at AOI 15 (over 50 years old and 22 years old, respectively), as well as one site at AOI 5 (29 years old). An inquiry with NRW confirmed that these are all NRW sites, with the two at AOI 15 being on NRW land itself, and the one at AOI 5 being part of an NRW environmental agreement with the local land owner.

The oldest exclusions site, from the 1960s, has now become a very dense NFI classified woodland on steep ground (**Figure 5-36**, **Figure 5-37**). This site is close to a lot of existing woodland at AOI 15 (<200m) which likely provided ample seed source, and while the site itself is fenced, sheep and ponies graze on the land surrounding it. What is notable here is that just north-west of the exclusion site on the grazed area outside the fence there is a small patch with a very high number of birch seedlings (and some that could be hazel - **Figure 5-39**). As birch grows at the border of the exclusion site and birch seeds are small and often don't travel very far, it is likely that an adjacent birch tree is responsible for the colonisation attempt on the grazed side of the fence. On the other hand, all these young trees are seedlings, and no older trees grow amongst them, so it stands to reason that the seedlings may not survive longer than a few years.

The 22-year-old exclusion site at AOI 15 was installed as an extension of the older exclusion site next to it (**Figure 5-38**). What was rough grazing at the start has now become a closed canopy to semi-open habitat with a variety of tree species, such as hawthorn, rowan, birch, hazel, and others. Interestingly, not even one of these trees appears on the NTM.

The two exclusion sites above were identified directly by one of the ecologists, whereas the exclusion site at AOI 5 was found by chance when investigating the NTM riparian tree cover nearby (**Figure 5-40**). This exclusion site is 29 years old, about 4.5 ha in size, and was originally rocky, rough grazing with little to no tree cover (landowner, pers. comm.). Now there is significant tree cover, even though it does not appear as woodland on the NFI and much of it also does not show on the NTM.

Figure 5-36 Two exclusion sites at AOI 15. Fences are market in blue. **Right picture**: open grazing in the front, >50-year-old exclusion site in the back to the right, and 22-year-old exclusion site in the back to the left. **Left picture**: The older exclusion site (dark blue) is NFI woodland now, the younger exclusion site (light blue) is neither marked as NFI woodland, nor is there any tree cover marked on the NTM. A small patch of extensive natural colonisation (seedling stage) was found north-west of the older exclusion site (orange).

Figure 5-37 NFI woodland at AOI 15. Closed canopy on steep ground in the >50-year-old exclusion site at AOI 15.

Figure 5-38 Closeup of the 22-year-old exclusion site at AOI 15. NRW confirmed the site was rough grazing before being fenced. Trees now include hawthorn, blackthorn, rowan, birch, hazel, and others.

Figure 5-39 Natural colonisation at AOI 15. A small patch (**left picture** – in blue) north-west of the >50-year-old exclusion with a high number of young seedlings – about 1/m^2 (mostly birch – **right bottom**; some that might be hazel – **right top**). This patch is not within the exclusion site, but within the surrounding land which is still grazed, mostly by horses. Given that there are no older trees growing this side of the fence, it stands to reason that the seedlings may not survive more than a few years.

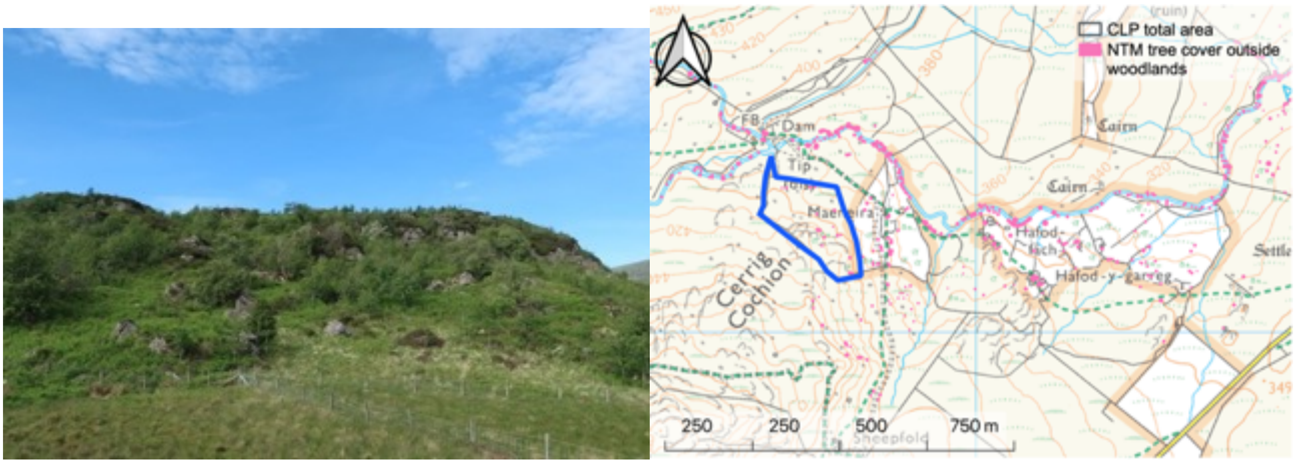

Figure 5-40 Natural colonisation at AOI 5. On a 29-year-old exclusion site (blue). Most of the tree cover now is rowan and does not appear on either NFI map or NTM.

5.4 Discussion

This research drew on a diverse range of datasets and types of data, from large scale spatial maps to interviews with local ecologists and photographic evidence from observational site visits. Despite their diversity, however, the datasets – especially when looked at together – provide interesting insight into the potential place for natural colonisation in Britain's spatial woodland expansion plans.

5.4.1 Much of natural colonisation is still missing from the maps

In addition to the 1,879ha of NFI designated woodlands, the NTM has shown an additional 460ha of tree cover outside woodlands in the Carneddau, which takes the total percentage of tree cover in the Carneddau from 8.5% to 10.6%. This means that at least 20% of tree cover in the Carneddau is missing from the publicly available dataset of the NFI (and this does not include natural colonisation which has not yet been captured on a map). While most of the NFI woodlands in the Carneddau are located around the border on lower elevation (or, often, steep ground at the lower hillside), trees outside woodlands both surround lowland fields and extend tree cover uphill onto in-bye land and further up the mountain, especially along stream networks (**Figure 5-13**). This NTM tree cover is not considered as an opportunity, sensitivity or constraint in any of the WEOMs, despite 402ha of it matching one of the WEOs, most notably conservation and natural flood management (**Table 6**). Given that the NTM has to be purchased and may not be affordable for many projects, this means that this tree cover in the Carneddau is essentially 'invisible' to scientific or environmental policy modelling.

Site visits suggest that a part of the established tree cover outside woodlands is likely due to historic natural colonisation (i.e. more than 20 years ago), such as on rocky outcrops and within bracken and gorse. Indeed, and old study by Good (1990) suggests that the hawthorn cohorts in the south of the Carneddau (around AOI 18) colonised during historic dips of agricultural activity (see also Good, Norris and Daniels, 1995). More so, the older exclusion site at AOI 15 shows that natural colonisation can indeed produce (NFI classified) close canopy woodland (**Figure 5-36**), and given enough time, other sites may also soon classify as woodland, such as AOI 5 or the younger exclusion site at AOI 15.

Interviews with ecologists, paired with observational site visits, confirmed that recent natural colonisation also occurs in the Carneddau. It is not possible to say how much natural colonisation there really is in the Carneddau in total (area, species, etc.), and in the absence of a timeseries it may not be clear which of the identified areas of natural colonisation will fully transition to close canopy woodland (like AOI 15). What further hinders such an assessment is the fact that a lot of recent natural colonisation is missing from both the NFI and NTM. This is mainly due to it being smaller than 3m still and/or too patchy to qualify as a woodland of 0.5ha or more. Good examples for this can be seen at the exclusion sites at AOI 5 and AOI 15, where the natural colonisation is too small to be on the NTM (**Figure 5-36** and **Figure 5-40**), or the patchy natural colonisation at AOI1 8 and AOI 19 (e.g. **Figure 5-20**), where it grows within a hillside of gorse and heather, respectively (see more on this below). Furthermore, the potential decline and death of old-growth in-field tree cover (examples of which were seen near AOI 10) make it even more difficult to ascertain the net tree cover change in an area like the Carneddau (FC Scotland, 2009a; Read and Bengtsson, 2019),

None of the investigated spatial datasets are making or can make any significant statement about the spatial extent of natural colonisation in the Carneddau. This is an important gap that needs to be filled, in order to monitor the progress (or lack thereof) of natural colonisation and its role within a complex British future landscape.

5.4.2 How to find and map natural colonisation

The observational site visits suggest that natural colonisation in the Carneddau seems to follow certain site characteristics and land use patterns. These include grazing patterns and density (e.g. **Figure 5-36** and **Figure 5-29**), surrounding vegetation (**Figure 5-28**), topographic features (**Figure 5-34**), and/or localised climatic conditions (**Figure 5-35**). Emerging (and existing) tree cover could also be checked or constrained by fire (**Figure 5-22**), and the seeming decline of old-growth in-field trees in the absence of natural regeneration (**Figure 5-23**).

These factors are likely the reason why the characteristics of tree cover and natural colonisation change along a gradient from lowland to upland. As the landscape changes from the private farming fields down in the valley towards the steep grazed hills and finally open (and open access) mountain, the topographic and climatic conditions change, and with-it human activities. If these are the main factors that influence tree cover and natural colonisation, then they in turn will follow gradual changes in similar patterns.

These potential influencing factors may then also be a good approximation of where new natural colonisation occurs. How, then, can these approximations be integrated into spatial modelling?

There is no spatial dataset on grazing density, for the Carneddau or the whole of Wales and the UK. Sheep numbers, such as the number of sheep turned out on common land, are recorded, but not publicly available; and if they are, only at low spatial resolution (StatsWales, 2019; Edina, 2022). Small differences can change the establishment success of new tree cover, so understanding (local) sheep density and grazing patterns could be a valuable tool to approximate the emergence of natural colonisation. On the open mountain an overall statistic of sheep density may not say much. Sheep prefer areas where grazing is easier, and with reduced density they may keep up (or even increase) grazing pressure in one area, while completely abandoning another. If the sheep are hefted[6], a grazing reduction might also cause a neighbouring heft to push closer for better food, thereby diluting the effect.

Similar patterns might occur with horses/ponies or goats. The Carneddau has wild Carneddau ponies, who graze and roam the open mountain all year long; wild goats, on the other hand, are on the hills south of the Carneddau and may eventually move into the case study area as well. This would change things for natural colonisation patterns, as goats can, for example, access and graze areas much steeper than sheep would [REP1].

Grazing patterns also interact with topographic features, and surrounding vegetation. There may be some indication of heather and gorse spatial distribution on habitat maps; e.g. the Phase 1 map has heathland categories, but the spatial data has significant limitations and habitat mapping can be very subjective (Hearn *et al.*, 2011). A Digital Terrain Model (DTM) is also available for the whole of Wales (and Britain) to identify steep areas that might offer protection from grazing. In fact, the SoNaR WEOM for rapid turnover forest uses steepness for a different purpose – identifying less steep areas that could be used for rapid turnover forest expansion.

Studies have established grazing priorities of sheep in different habitats (Williams *et al.*, 2010, 2012), but without an accurate (i.e. high resolution) habitat spatial map this information has limited use for spatial modelling. On the other hand, there is increasing development for low cost, low effort automated animal tracking solutions for the farming sector (Dore *et al.*, 2020; Ren *et al.*, 2020); if applications were extended onto more open mountain (GPS systems, time-stamped high resolution satellite imagery, etc.), this could be a way to track the movement and grazing density of sheep for a whole upland landscape like the Carneddau and identify small-scale difference in grazing pressure. A spatial map like this would be very useful for natural colonisation mapping.

The distance to existing woodland or NTM tree cover may also matter and can be spatially mapped, as sufficient seed source is important (Thompson, 2004), but as the natural colonisation of rowan far from existing tree cover has shown, species specific seed distribution can significantly influence this.

Finally, there is no centralised (and publicly available) spatial dataset on potential upland fire hazard or historical fires in the UK, but this data might be relevant to judge the potential establishment success (and longevity) of natural colonisation in the Carneddau, as well as the Welsh and British uplands in general. This is not least due to climate change, whose increased temperatures and decreased humidity will likely make fires more prevalent in Britain's future (Arnell, Freeman and Gazzard, 2021).

[6] Sheep being hefted to an area of open mountain means each generation learns from their mothers which area on the mountain to stay on; together they are called a heft.

A different attempt to map natural colonisation could be the increasing high resolution of technologies like Light Detection and Ranging (LiDAR) (and publicly available aerial photography). Algorithms (and machine learning) for LiDAR are continuously improving and may soon be able to pick out young trees from surrounding vegetation (Thers, Bøcher and Svenning, 2019; Broughton *et al.*, 2021).

It would be very beneficial to have both – a map of existing natural colonisation identified via visual spatial datasets, and a collection of spatially explicit cause/effect assumptions about the presence or absence of natural colonisation. A modelling exercise could match the two and test the actual influence of grazing pressure, wind exposure, surrounding vegetation, and possible other factors that might be unknown so far. This could provide an opportunity to create management change models that can at least give an idea of how land management changes in a cultural landscape like Britain influence the emergence of natural colonisation, intended or not.

5.4.3 The place of natural colonisation in Britain's woodland expansion plans

The synthesis of NFI, NTM, WEOMs, ecologist data and observational profiling of existing natural colonisation suggests that natural colonisation could be a valuable addition to woodland expansion plans in a number of ways.

This research has shown that natural colonisation already exists and could be expanded in areas that have been marked as opportunity spaces for woodland expansion. For example, natural colonisation at AOI 2 or AOI 3 could be used for a whole range of WEOs, including nature conservation, rapid turnover forest, natural flood management and/or carbon sequestration (**Figure 5-41**). Similar arguments can be made for AOI 4 and AOI 21 (**Figure 5-27**, as well as **Figure 5-12** and **Figure 9-1**).

The data from the NTM is very useful for this, as existing tree cover can be a seed source and provide shade, microclimate, and structural diversity for any young woodland to be (Manning, Fischer and Lindenmayer, 2006). Also, news articles report on a shortage of nursery trees and growers, partly due to Brexit (Tapper, 2021), the need of which could partly be circumvented by using natural colonisation wherever feasible.

It may even be possible to include various sites of natural colonisation in environmental policy schemes. As it has been pointed out, the uncertainty around natural colonisation makes it hard to conceptualise it within financial support schemes, but the England Woodland Creation Offer is an exception in that it makes such an attempt (UK government, 2021). Financial support for natural colonisation is offered if the site in question is within 75m of established (NFI classified) woodland and has 60% tree cover after 10 years and at last 100 stems per hectare. For comparison, the two younger exclusion sites in the Carneddau, being 21 and 29 years old (AOI 15 and AOI 5), respectively, likely would have failed these criteria, as they do not have a closed canopy to classify as NFI woodland and have barely a tree large enough to appear on the NTM either (**Figure 5-36** and **Figure 5-40**). Additionally, the 29-year-old site is far from an established NFI woodland. On the other hand, Chapter 3 has shown that for some drivers of woodland expansion, such as nature conservation, cultural landscape conservation or recreation, longer establishment times way well be acceptable. If environmental schemes could nuance their judgement of natural colonisation based on desired future benefit, as well as getting more detailed spatial data on natural colonisation and small-scale tree cover (by including a map like the NTM, for a start), both exclusion sites might have become eligible. After all, the photos in **Figure 5-40** and **Figure 5-36** show that plenty of young trees are establishing at both sites.

Lastly, this research also suggests that the above principles can be expanded to areas where established tree cover exists, but natural colonisation is lacking. The grown trees could still serve as a 'starter cultures' for natural colonisation to establish and close the canopy to a future woodland. Something like this could, for example, be considered at AOI 2, an area surrounded by both NFI woodland and NTM tree cover, and an area with WEOs for carbon sequestration, rapid turnover forest and riparian tree cover (**Figure 5-41**).

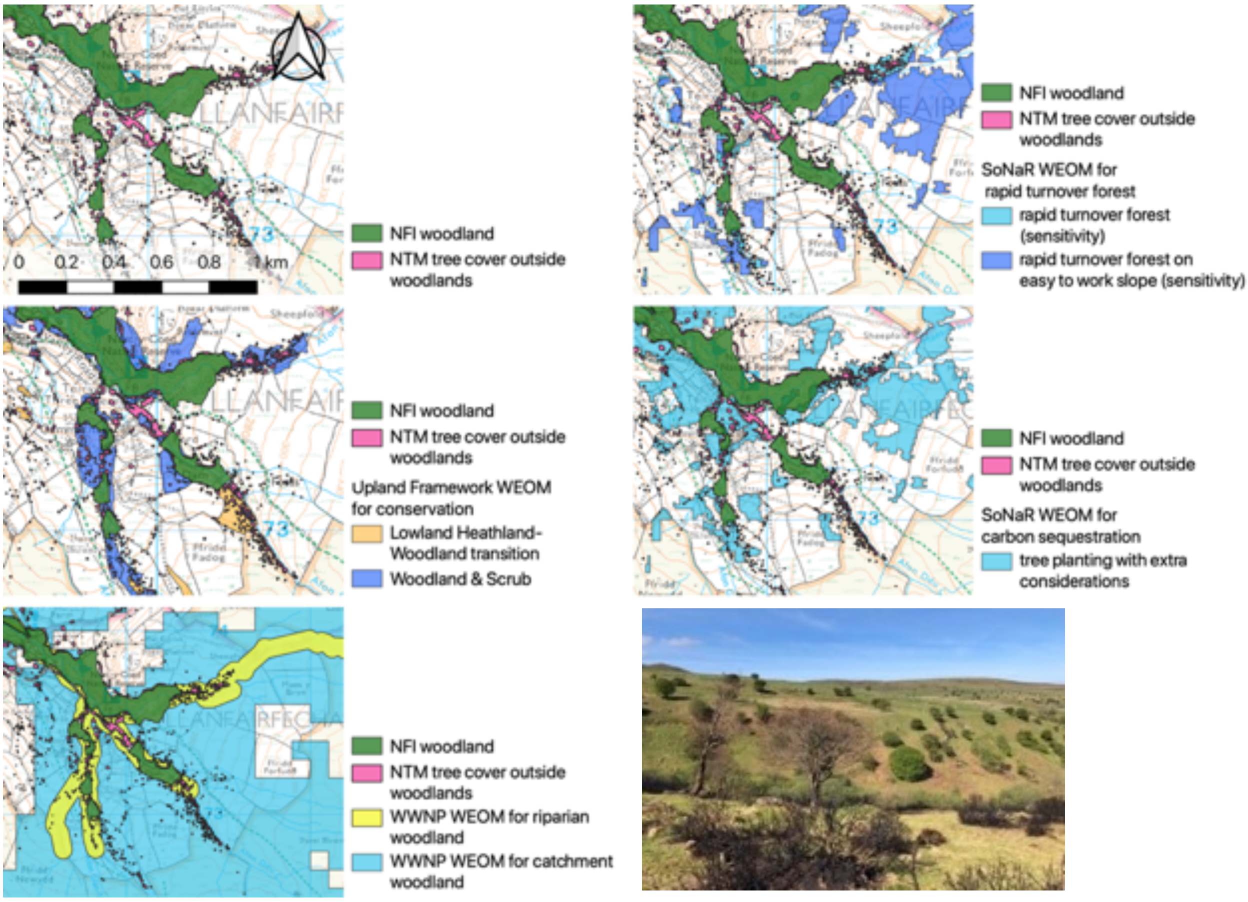

Figure 5-41. Opportunities for woodland expansion at AOI 2. An example for in-field established tree cover on in-bye land and natural colonisation that could be used as a starter for future woodland creation. Several of the WEOMs see an opportunity here. A photo of the area was taken during site visits (see also 5.3.4).

5.4.3.1 A careful deliberation of trade-offs

Despite all the opportunities, it might not be desirable to transform all areas that exhibit recent natural colonisation into future woodlands. For natural colonisation to take over and establish more quickly, it may require a reduction, change or complete cessation of land management. The Upland Framework, for example, suggests zero livestock grazing for 10-20 years to establish tree cover, followed by the reintroduction of light grazing (Jones, 2007). Depending on the site, this could affect the economic viability of the surrounding farm system (Hardaker, 2018), for example at AOI 12 (**Figure 5-17**), where the lowland fields are classed as 3a under the agricultural land classification (ALC), marking 'good quality agricultural land' (Welsh Government, 2021a). Additionally, hawthorn is a pioneer species and a closing canopy might outcompete it, and woody pastures are a historically and culturally valued feature of the British landscape (FC Scotland, 2009a; Read and Bengtsson, 2019). At AOI 18, for example, ecologists pointed out a progressing natural colonisation amongst the hawthorn, but none of the WEOMs have identified any opportunity for woodland creation there (**Figure 5-42**). In this case it might be desirable to prevent the area from becoming closed canopy woodland and encourage a more open woody pasture or *ffridd*.

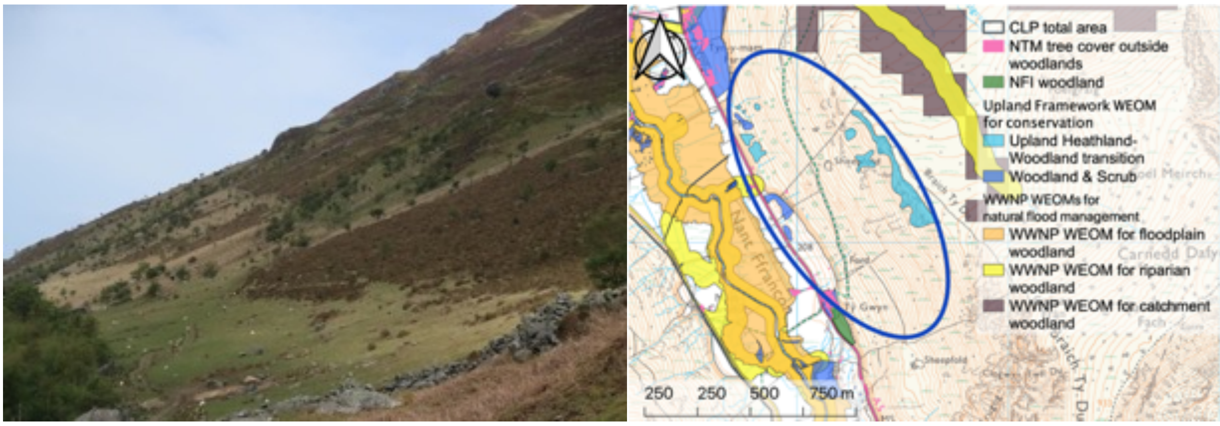

Figure 5-42 Established tree cover outside of WEOs. At AOI 18 (blue circle), hawthorn grows in a woody upland pasture, and rowan and birch naturally colonise, but no WEOM identified this space as an opportunity for woodland expansion.

Instead, fields could be enhanced by natural colonisation, but not entirely given over to it. Studies suggest that semi-open corridors with scattered trees could serve a dual function of simultaneously connecting woodland to woodland and surrounding habitat to each other, such as heathland (Eggers *et al.*, 2010; Boutaud *et al.*, 2019; Travers *et al.*, 2021). Even very small, linear woody patches such as the tree cover along old field margins or streams, can provide significant connectivity between (woodland) habitats that otherwise might go without (Tiang *et al.*, 2021). The Carneddau already shows plenty of examples for this, especially its east lowland side, where several larger woodlands from north to south are connected via an intricate network of trees in fields and along field margins (see the area between AOI 3 and AOI 6 for example, **Figure 5-43**).

On the other hand, some sites may offer an advantage for natural colonisation, not because it is the best possible land use for that site, but simply because these sites are not attractive for other types of land uses. Steep sites seem to protect natural colonisation from sheep grazing (and, if facing the right way, from prevailing winds and weather), but it also makes them rather unmanageable. The SoNaR WEOM for rapid turnover forest excludes these areas for a reason. Then again, they certainly could contribute to a biodiversity rich landscape for conservation, especially when sitting in a mosaic of other habitats. In fact, all 3 exclusion sites (at AOI 5 & AOI 15) – all of them being rather steep – and other steep areas like AOI 11 and AOI 7, feature on the Upland Framework WEOM for conservation as potential opportunity spaces for woodland expansion. These sites are on almost none of the other WEOMs, so they could indeed become a sort of conservation specialty. These steep sites of natural colonisation are not particularly managed, but monitoring of the surrounding landscape should still take place; in the Carneddau this could be to check whether wild goats have entered the area and are grazing on those sites that sheep cannot reach.

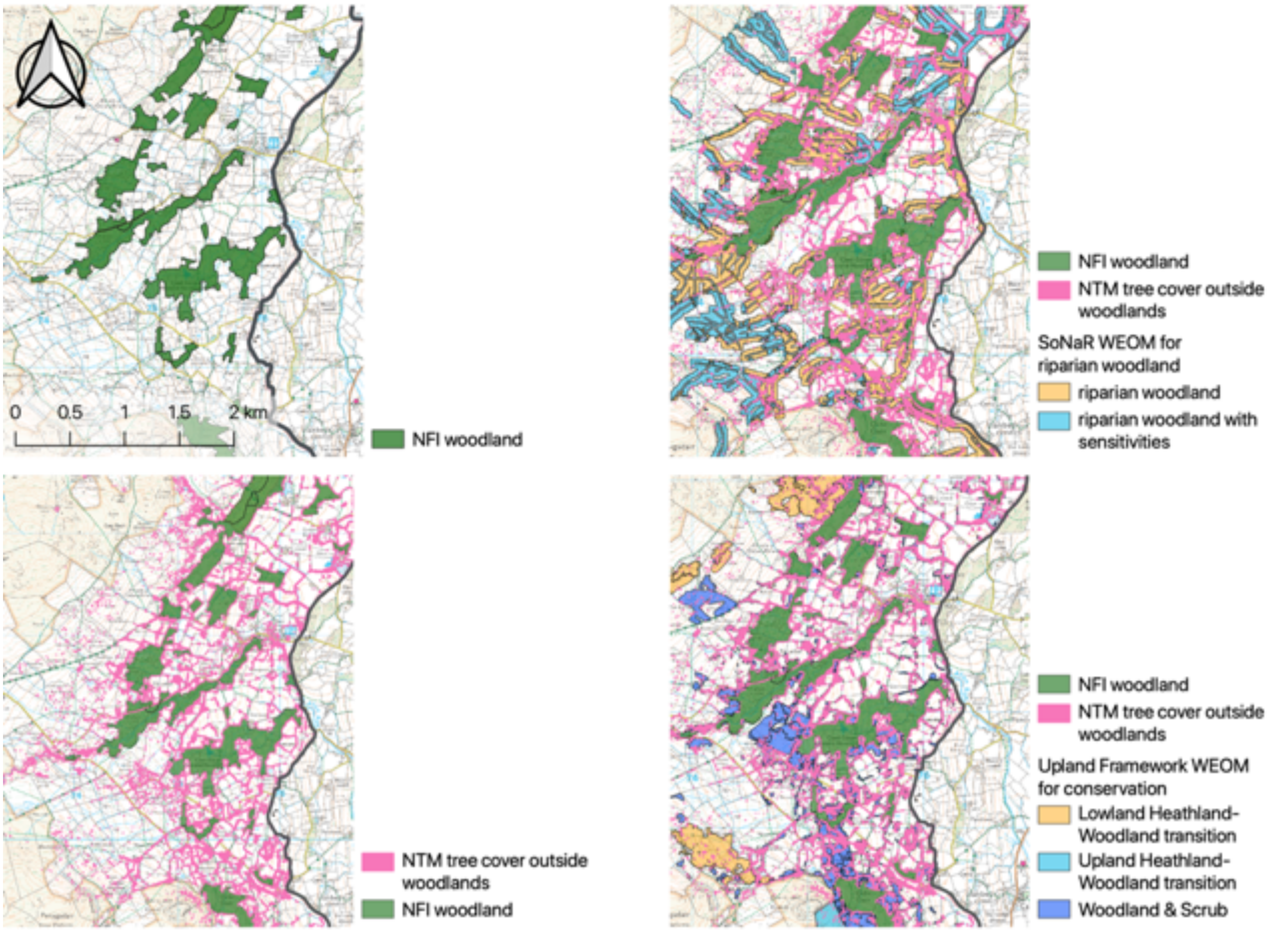

Figure 5-43 Tree cover outside woodlands connecting established woodlands. The existing (NFI) woodlands (here between AOI 3 in the north and AOI 6 in the south, see **Figure 5-11**) are 50-250m apart from one another, but the NTM shows an intricate network of trees in fields and along field margins that connects them. Additional tree cover, even if small scale, could fit e.g. with the WEO for conservation or riparian woodland creation.

Lastly, it is important to emphasize the limits of the WEOMs, and how their use in this research limits the final judgement on what role natural colonisation can play in expanding British woodlands. WEOMs are not prescriptive and are specifically understood as 'decision *support* structures' (e.g. Hanking *et al.*, 2017a; Bell *et al.*, 2020b). Their documentation emphasizes the need to involve local stakeholders in the decision-making process, as regardless of how flawless and/or high resolution the underlying datasets may become, they will never be able to fully capture and harmonize the localized and highly diverse drivers, values and interests of stakeholders (Bell *et al.*, 2020b; Cosby *et al.*, 2020). For example, local farmers in the Carneddau may judge natural colonisation not based on its benefit for nature conservation, or even rapid turnover forest, but based on whether it simply would or would not cut off their route onto the open mountain to move their flocks of sheep. Similarly, on their lowland fields, the ultimate decision on facilitating or inhibiting natural colonisation may have nothing to do with carbon sequestration, or habitat connectivity, but with whether the field in question is a lambing field, which have been shown to profit particularly from added shelter (Pritchard *et al.*, 2021). Local tourism boards and National Parks may want to keep certain areas open as they are favoured lookout spots for hikers, while they would be happy for others to naturally colonise.

Just like the WEOMs, this present research also must be seen as only one perspective on the spatial opportunity for natural colonisation, and it will take consolidation with other perspectives, most importantly ones of local land management and environmental policy making, to bring natural colonisation one step further to being a viable and feasible option in Britain's woodland expansion plans.

5.5 Conclusion

This research indicates that there is a spatial opportunity for natural colonisation within Britain's woodland expansion plans. Much of this natural colonisation is still not represented on any maps, mostly due to the limited resolution of available datasets. Qualitative assessments have shown, however, that it can indeed be found in those areas that have been identified as opportunities for woodland creation. Suggestions have been made for further research into how other datasets could be used to approximate its location, and more research should be conducted into how natural colonisation can fit within the realities of local land management, as well as environmental policy making.

Future WEOMs could profit from including small-scale tree cover and any spatial information on natural colonisation, thereby expanding the potential opportunities for woodland creation by using more existing tree cover. This way, natural colonisation could be a way of unlocking new spaces for woodland expansion; even those that the approach of active planting alone may not have been able to cover.

Ultimately, the future success of natural colonisation as a large-scale approach to creating new woodlands in Britain will be about more than just data resolution and spatial modelling. It will also depend on how the complexity of drivers of woodland expansion, and their mismatching timelines, will be addressed. This research has shown that even the WEOMs, in all their innovation towards integrating competing interests, cannot and do not claim to find '*the*' answer. They themselves end up having to prioritise one driver, such as flood prevention, or nature conservation, or financial revenue from forestry via rapid turnover forests. Although they are not always used like it in practice, they emphasise that best future location of woodlands are likely based on a careful assessment of all available WEOMs, as well as a the involvement of local stakeholders.

Natural colonisation is a representation of this complexity, itself potentially operating on timelines much longer than active planting. Depending on how the various stakeholders of British woodland expansion intend to address this complexity, natural colonisation may take too long, or just long enough.

6 WHAT DO LAND MANAGERS THINK ABOUT NATURAL COLONISATION AND ITS PLACE IN BRITAIN'S CROWDED FUTURE LANDSCAPES?

6.1 Introduction

The previous chapters have shown that while there is a pronounced drive in Britain for creating new woodlands, finding space for them in a cultural landscape rich with other land covers and land uses remains difficult.

6.1.1 The role of land managers in Britain's woodland expansion plans

As 71% of land in the UK is farmland (Committee on Climate Change, 2018; DEFRA, 2020a), there is considerable focus on farmers as being the land managers that ought to integrate new woodlands into their work. Between 2000 and 2020 the area of farm woodland in Britain doubled from around 500,000 ha to 1 million ha (Forest Research, 2020b), and the devolved governments try to encourage farmers to plant more through financial support and other resources (e.g. FC, 2020; e.g. NRW, 2020; Scottish Forestry, 2020b). Research suggests, however, that farmers' opinions on woodland expansion and tree planting remain mixed.

There are farmers who intend to increase tree cover on their farms either by planting woodland (e.g. for diversification (Hopkins *et al.*, 2017)), or by creating small-scale tree cover in hedgerows, shelterbelts or within agroforestry systems (BW, 2018; Clarke, 2019; FFCC, 2021). In 2019 the National Farmers Union (NFU) also published their plans to get the UK farming sector to net zero by 2040 (NFU, 2019). According to them, tree planting and other measures to reduce carbon emissions on farmland can be integrated without the reduction of other ecosystem services (such as food production); a statement that garnered significant media interest (e.g. George, 2019).

As has been introduced in section **2.2.2**, however, many farmers have a range of reservations against increasing tree cover. Balancing cost on behalf of the farm income is one of them, particularly with regards to changing timber prices, lack of short-term financial rewards, and the insufficient financial compensation offered from grant schemes with limited lifespan (Church and Ravenscroft, 2008; Black, 2019; Fitzgerald, Collins and Potter, 2021). There is, however, much more to farmers' decision making than just economics. For example, the bureaucracy and administrative needs attributed to agri-environment schemes are seen as unfavourable (Wynne-Jones, 2013; Lawrence and Dandy, 2014). Additionally, farmers derive a sense of identity and social status from a certain aesthetic of their land – an aesthetic that embodies a productivist farming culture and complex local practices which are acknowledged by other farmers in that region (and beyond) as 'good farming' (Tsouvalis, 2000; Burton, 2004;

Burton, Kuczera and Schwarz, 2008). These practices are not necessarily prioritised based on economic return (Cusworth and Dodsworth, 2021), and the problem for woodland expansion is that woodlands are not seen as part of this identity. They are ‘unproductive’ and the land they occupy is ‘un-farmed’ (Lawrence and Dandy, 2014; Cusworth and Dodsworth, 2021), which means woodlands do not offer much cultural or social capital, and may even affect it negatively (Bourdieu, 1983; Burton, Kuczera and Schwarz, 2008).

What is important for this research is that the above studies primarily (or exclusively) engage with farmers on woodland expansion via the lens of active planting. Studies on farmers’ and other land managers’ decision making around natural colonisation as decidedly absent. Given that natural colonisation would require a very different approach to land management compared to active planting (see more below), it is not clear whether they would think about natural colonisation the same way they do about active planting.

6.1.1.1 A complex network of decision power

Farmers manage a large part of the land in the country, so their opinions and ability to work with woodland expansion plans matter, but they are not the only land managers to consider.

A lot of plans for woodland expansion mention marginal land, itself primarily being in the uplands (Helm, 2017; Dwyer, 2018; Cosby *et al.*, 2020), as the principle focus for woodland expansion plans. So, while woodland expansion schemes do not exclude lowland areas from consideration (UK government, 2021), this present research will focus more on the uplands as an area of interest and the case study area of the Carneddau with it.

A lot of the British uplands are a complex network of land ownership, land management, and related decision power. Common land, for example, is an area where farmers have legal rights to graze their sheep, but may not own the land in question. Nonetheless, as grazing pressure is an important factor for tree establishment (Good, Bryant and Carlill, 1990; Hester, Mitchell and Kirby, 1996; Williams *et al.*, 2012), their management decisions matter for woodland expansion. Graziers on these ‘commons’ are now often organised as a graziers’ associations or committees, as this organisation was (and is) required to apply for certain agri-environment schemes (e.g. Welsh Government, 2020c). This incentive of agri-environment schemes was supported by the EU (Prager, 2015), most notably via governance by the Common Agricultural Policy (CAP), but CAP is not applicable anymore since Brexit.

As British farmers may not own the common land their sheep graze on, the decision power they have on any land management beyond the movement of their sheep is affected. Land in the uplands may be owned privately by individuals, local estates, or by large entities such as the Crown Estate, various government bodies, corporations, or the National Trust (National

Trust, 2021a; Shrubsole and Powell-Smith, 2021; The Crown Estate, 2021). Tenancy agreements, on and off the uplands may have similar arrangements where farmers tenant the land, but depending on their contract their tenancy may not extend to any decision powers regarding woodland expansion.

That might not be the final decision on land management, as the land may be part of a National Park – Snowdonia, Exmoor, Lake District, and other national parks in Britain centre around upland regions – which will impose additional stipulations on what land managers can or cannot do in terms of land cover and land use change. In fact, many National Parks showcase and preserve a naturally and culturally valued *open* landscape character, which puts large-scale woodland expansion at a disadvantage (Cox *et al.*, 2018; Gold, 2019). For example, in the Lake District National Park the National Trust, one of the biggest landowners in the area, (and a public-funded body), "*stands accused of favouring rewilding over traditional farming*" (McKenna, 2016; Anderson, 2020). In this region, the expanded tree cover which is included in the pursuit of rewilding, has in the past and still is by many not seen to fit with the ethos and image of the landscape and its national park, and to certain stakeholders "*leaves no place for people*" (Tsouvalis, 2000; Stewart, 2018).

Similarly, for protected sites the status of protection, such as with an Environmentally Sensitive Areas (ESAs) or Sites of Special Scientific Interest (SSSIs), may not only not involve trees, but it could even require a general absence of them for the protected habitat to be considered in good condition (such as deep peat).

So, while farmers may be the obvious land managers to consider when thinking about woodland expansion, there are a range of other stakeholders that may have a say in what does or does not change on the land. Whoever may favour woodland expansion – farmers, National Trust (National Trust, 2021b), local council, etc. – may have to negotiate with a range of other stakeholders before any action can be taken.

6.1.2 Natural colonisation as a different approach to 'managing' woodland expansion

Natural colonisation is a new area of interest in discussions around woodland expansion in Britain. It is seen as a potentially cheap way to create structurally diverse, native woodlands (Rewilding Britain, 2020; Woodland Trust, 2020). Nonetheless, natural colonisation is harder to predict and/or monitor than planted woodlands, which is likely why thus far it does not feature in many woodland expansion grants for landowners. Chapter 5 elaborated on how better monitoring techniques could change this (section **5.4.2**), but the difference between natural colonisation and afforestation via active planting also affects the way the land is managed, and the choices land managers must make.

Afforestation requires the active decision to plan and plant trees. It is a proactive choice by the land manager who must consider its cost, how it fits with their other day-to-day management, and how they intend to care for it in the years to come (such as thinning or pruning, if applicable). They must acquire the necessary equipment (seedlings, tree guards) and take the time to do the planting. If they intend to use grant money for part of the undertaking, they must apply for it, all bureaucratic hurdles included.

Natural colonisation, on the other hand, follows different principles and is often governed by indirect management influences, such as grazing patterns. Land managers may facilitate its appearance or expansion by fencing areas or facilitating the growth of protective vegetation. Less is managed at the level of the individual tree and more at the level of a whole site. Thus, less can be controlled at the tree level, such as species composition or spacing. Some land managers may choose to simply 'allow' natural colonisation to coexist with their land management, even if they neither facilitate nor impede it. Furthermore, due to these indirect influences governing natural colonisation, it may also appear in the complete absence of intentionality. In this case, land managers may have to decide after the fact (i.e. once natural colonisation has established) whether and how to integrate it into their land management.

6.1.3 Engaging with land managers on natural colonisation

Any methodology seeking to engage with land managers on natural colonisation must consider two things. First, land manager decision making is governed by complex values and interests, many of which go far beyond what is already captured in WEOMs, or other existing quantitative datasets (Lawrence and Dandy, 2014; Black, 2019; Fitzgerald, Collins and Potter, 2021). Secondly, the scarcity of existing research related directly to UK land managers and natural colonisation means that there is no clear theory yet on the role of natural colonisation in land managers' decision-making processes. Researching it means being flexible enough to allow for this lack of theoretical foundation. To resolve both these points, this present research used grounded theory and semi-structured interviews, which will be explained in more detail below.

6.1.3.1 Grounded theory

Grounded theory is an inductive method used to study a particular process or event – in this case land managers' decision-making processes around natural colonisation – by means of collecting and simultaneously analysing real world data (Conrad, 1982; Strauss and Corbin, 1990). This method does not require a pre-defined hypothesis that will be tested, but rather is an inductive exploration of real-world events or processes with the goal to formulate a theory as a direct result of data collection and analysis (Charmaz and Belgrave, 2012; Delve and Limpaecher, 2021). As this type of work often requires an in-depth exploration of a small number of case studies, the resulting theory should be seen as a stepping stone towards further research and an invitation to follow up with different methodologies to further generalise and verify (e.g. via large-scale surveys).

Grounded theory itself is an iterative method, where planning, data collection, data analysis and theory development are interrelated (Vollstedt and Rezat, 2019). According to Atkinson et al. (2012, p. 160), all variants of grounded theory include the following strategies:

1. *"Simultaneous data-collection and analysis;*
2. *Pursuit of emergent themes through early data analysis;*
3. *Inductive construction of abstract categories that explain and synthesize these processes;*
4. *Integration of categories into a theoretical framework that specifies causes, conditions and consequences of the process(es)".*

There are plenty of examples of research using grounded theory to explore environmental problems, especially around stakeholder views and decision making. Bentley Brymer et al. (2020) used it to understand how ecological processes influence stakeholders' sense of well-being in the rural U.S. and Vos and Davies (2021) used it to understand landowners' views on revegetation in North Queensland, Australia. Kabir et al. (2021) and Dominguez and Shannon (2011), on the other hand, used grounded theory to specifically explore decision making (power) of forest owners and users.

In all these examples, as it is the case within this present research, semi-structured interviews were used, where the data collected are interview transcripts. It should be noted that grounded theory data-collection may also utilize secondary data (Whiteside, Mills and McCalman, 2012). Data analysis is done via a process called 'coding', i.e. a "*conceptual abstraction by assigning general concepts (codes) to singular incidences in the data*" (Vollstedt and Rezat, 2019, p. 86). In the iterative process of coding, similar codes, i.e. if they describe similar incidences in the data, are merged in one concept (or 'theme', as it will be referred to in this research), and later related to one another in a hierarchy within categories of higher order (Strauss and Corbin, 1990; Mey and Mruck, 2011). For example, the category of 'land management' may include themes on 'forestry' or 'farming'. Ultimately, coding will unite all themes and categories under one cohesive theory (or 'core category'), i.e. the "*grounded theory that arose from the data*" (Vollstedt, 2015; Vollstedt and Rezat, 2019, p. 89).

Without a pre-determined boundary, data collection may not be structured around a set number of interviews, or a set number of questions. Instead, it continues until what is called 'theoretical saturation', i.e. the point at which "*new data does not seem to contribute any longer to the elaboration of categories*" (Strauss and Corbin, 1990; Vollstedt and Rezat, 2019, p. 85). As the themes are the focus of the research, data is collected until they are well developed and validated.

6.1.3.1.1 Semi-structured interviews

Semi-structured interviews are often utilised when exploring land managers' perceptions and decision-making processes. For example, Schnitzler (2014) used them to understand the perception of large-scale spontaneous forest succession in Germany, Graves et al. (2008) used interviews to explore farmers' perception of silvoarable agroforestry in seven European countries, and Wynne-Jones et al.'s (2018) research on rewilding in Britain includes interviews with rewilding advocates. Ficko et al. (2017) concluded that when researching European private forest owners, over one third of studies incorporated interview methods.

Semi-structured interviews start with an initial set of predetermined open-ended question, after which interviewer and interviewee steer the conversation and follow up questions into the direction that seems most interesting and/or relevant (DiCicco-Bloom and Crabtree, 2006; Lofland *et al.*, 2006). This is particularly useful with grounded theory research, as there is no theoretical foundation yet upon which a more rigid structure with standardized questions and possible answers could be based (DiCicco-Bloom and Crabtree, 2006). Surveys with multiple-choice options would be an example for such a rigid structure; they can be spread more widely, and responses can be generated more quickly and in larger number, but their flexibility to allow for an in-depth exploration of new themes is limited.

<u>Setting of semi-structured interviews</u>

The setting of the semi-structured interviews may be designed to maximise quality of data; this potentially includes anonymising interviewees when researching sensitive topics (Germain, 1993; DiCicco-Bloom and Crabtree, 2006), using aids like photographs or maps to facilitate the conversation, or conducting interviews in places that most closely relate to the interviewees' relevant experiences.

Anonymity in this context refers to keeping participants' identity confidential and only known within the research team itself, and to anyone else and in publications referencing them with a generic ID (Saunders, Kitzinger and Kitzinger, 2015). If the goal of the research is to discuss potentially sensitive topics, and draw out larger themes and theories, participant anonymity may not significantly affect data quality. However, the trade-off between offering rich descriptions of data (and participants in the process) and ensuring anonymity can be difficult. This is the case, for example, if the group of participants that share experience on the research topic is very small, making it much harder to retain data integrity without compromising participant anonymity (Ellersgaard, Ditlevsen and Larsen, 2021). Similarly, while participants' identity might be kept anonymous, explicit details on case study area or institution may make it possible for someone with context-specific knowledge to identify participants (Kaiser, 2009). It is the responsibility of the researcher team to try and minimise any possibility of identifying anonymized participants, even if that risk may never be zero (Kaiser, 2009; Saunders, Kitzinger and Kitzinger, 2015).

As mentioned above, the location interviews take place in may also be relevant for data quality. Walking interviews are a good example, especially in research questions that seek to understand a sense of place and where discussions are about or may be influenced by the landscape they take place in (Jones *et al.*, 2008; Evans and Jones, 2011; King and Woodroffe, 2019). O'Flynn et al. (2021) used walking interviews to explore forest management and managers in the UK; the direct interaction with the forest allowed for a richer data collection on the participants' sense of place, beyond what their job descriptions may entail.

Whether topic or place, consent forms always must be signed before starting the interviews, to make sure participants fully understand what the research is about and what their participation entails (DiCicco-Bloom and Crabtree, 2006). This includes any taking of photos of or with participants, or the recording of audio.

Semi-structured interviews as a tool for grounded theory approaches

Within grounded theory, semi-structured interviews serve the purpose of discovering, exploring, and defining themes. Therefore, as the data collection proceeds and initial analysis/coding takes place, interview questions may change to pursue specific leads on emerging themes (Charmaz and Belgrave, 2012). This also extends to the choice and recruitment of interviewees, which may change over time depending on what the data requires (DiCicco-Bloom and Crabtree, 2006). Instead of random sampling, purposeful sampling is often used to find a relatively homogenous group or participants that share experiences on the research topic (Crabtree, Miller and Swenson, 1995; Kuzel, 1999), and, if the target participants are difficult to reach, snowball sampling may also be used (Naderifar, Goli and Ghaljaie, 2017).

Practically, interviews are often recorded and transcribed word for word (manually or using software), so that coding can be done with data that resembles what participants said as closely as possible. Given the evolving analysis that co-occurs with ongoing interviews, follow-up questions may be posed to participants to clarify things or revisit certain data points considering new coding (Charmaz and Belgrave, 2012). Ultimately, the themes developed by the end of the data collection phase consist of a diverse collection of responses (codes) from different participants that pertain to each theme. This in turn facilitates the development of the overall (grounded) theory that brings all themes together.

6.1.4 Research structure and question

This research used a grounded theory approach and semi-structured interviews with farmers, other land managers and relevant key informants in the Carneddau to explore their ideas around natural colonisation and its use in Britain's future land management. Given the limited existing research, the complexity of land managers' decision making, and the possibility to interview most farmers and other land managers in situ to elicit a sense of place, these methodologies were seen as most promising. Furthermore, purposeful sampling combined with snowball sampling was used to maximise the value of existing contact networks between Bangor University and Carneddau farmers and other land managers, as well as the strong social connections amongst Carneddau farmers themselves. In total, 10 farmers, five other land managers and 11 key informants were interviewed to answer the following research question:

What do farmers and other land managers think about how natural colonisation could or could not be integrated into future land management?

6.2 Methodology

Like in Chapter 5, the area of the Carneddau Landscape Partnership project (CLP) was maintained as a case study area (review section **5.2.1** for details). Due to the critical assessment of existing tree cover and the observational site visits conducted in Chapter 5, the research in this chapter profited from an a-priori understanding of the landscape, its habitats, and the potential location and extent of natural colonisation. As an advantage for this present research the Carneddau offers a diverse management landscape and an area where tension may be expected (due to historical legacies). It is also an area without any pre-existing exposure to natural colonisation related projects or initiatives, making it representative of many other areas in Britain.

The Carneddau is a good example of the complex land management network that exists in many regions in Britain and a good case study area for understanding what land managers think about natural colonisation and its future role in expanding British woodlands.

6.2.1 Interviews

The in-depth interviews focused on land managers and stakeholders with rights and decision power over how the land was being management. This included farmers, representatives of private landowners and representatives of public bodies with rights to approve/deny certain aspects of land management. Although farmers are land managers, going forward they will be called ‘farmers’ and other land managers (representatives of land-owning bodies and organisations) will be referred to as ‘land managers’ to allow for effective comparison.

In addition to this, 11 key informants were interviewed based on their contextual experience about issues relating to land management or decision power with regards to natural colonisation; these key informants were mostly part of relevant governmental or other organisations related to land use and management, such as Natural Resource Wales or Farmers Union.

A combination of purposeful sampling and snowball sampling was used to recruit interviewees and maximise depth and richness of the data (Kuzel, 1999). Positive bias was given to:

- interviewing farmers, as they do represent the majority of land management in Britain (Rae, 2017; Committee on Climate Change, 2018).
- interviewing those farmers and/or land managers overseeing land which had been identified as an area of interest (AOI) in chapter 5 (section 5.2.5.2). These were areas with an interesting configuration of woodland expansion opportunities (WEOs), tree cover outside woodlands and recent natural colonisation, which made them a suitable basis for a conversation about the potential management of natural colonisation.

There is no easily accessible public registry of land ownership in Britain, which means it was not possible to simply identify who owned, tenanted, or managed what land and contact them directly.

Instead, the call for interviewees was advertised through various communication channels in an opportunistic approach to find farmers, land managers, key informants, or gatekeepers to either of them. Gatekeepers in this case where those individuals that had an established contact network with potential participants for this research, such as representatives of Farmers Union, researchers at Bangor University that hard worked with farmers before, or representatives of NRW or the National Trust. Approaches to recruit participants included:

- using university contacts,
- posts on twitter,
- putting flyers into letter boxes (see **Figure 9-7** in the appendix for the flyer),
- attending site visits of land managers on tree planting and related issues, and
- presenting the research at conferences.

Due to Covid, there were not as many local in-person meetings as there usually would have been (such as meetings by graziers' associations). Due to General Data Protection Regulation (GDPR), it was not possible to ask gatekeepers for contact information for potential participants without the participants' prior consent to the contact details being relayed.

Nonetheless, gatekeepers proved most helpful in recruiting farmers, land managers and key informants. They would often reach out to potential participants, give them a small introduction of the research topic, and ask for consent to share contact information. Once farmers were identified, they often turned into gatekeepers themselves and were willing to reach out to other farmers. This word-of-mouth approach recruited all 10 farmers and many key informants. I was also able to draw on Bangor University's existing contact network, which already included gatekeepers to local farmers, land managers and key informants. An overview of the whole contact network that was established for this research can be seen in **Figure 6-1**.

Based on the size of the case study area and conversation with colleagues with experience in inductive qualitative research, a target of 20 in-depth interviews was set as a general guide, but the goal of reaching theoretical saturation remained. Participant information sheets and consent forms can be found in the appendix (**Figure 9-8** and **Figure 9-9**).

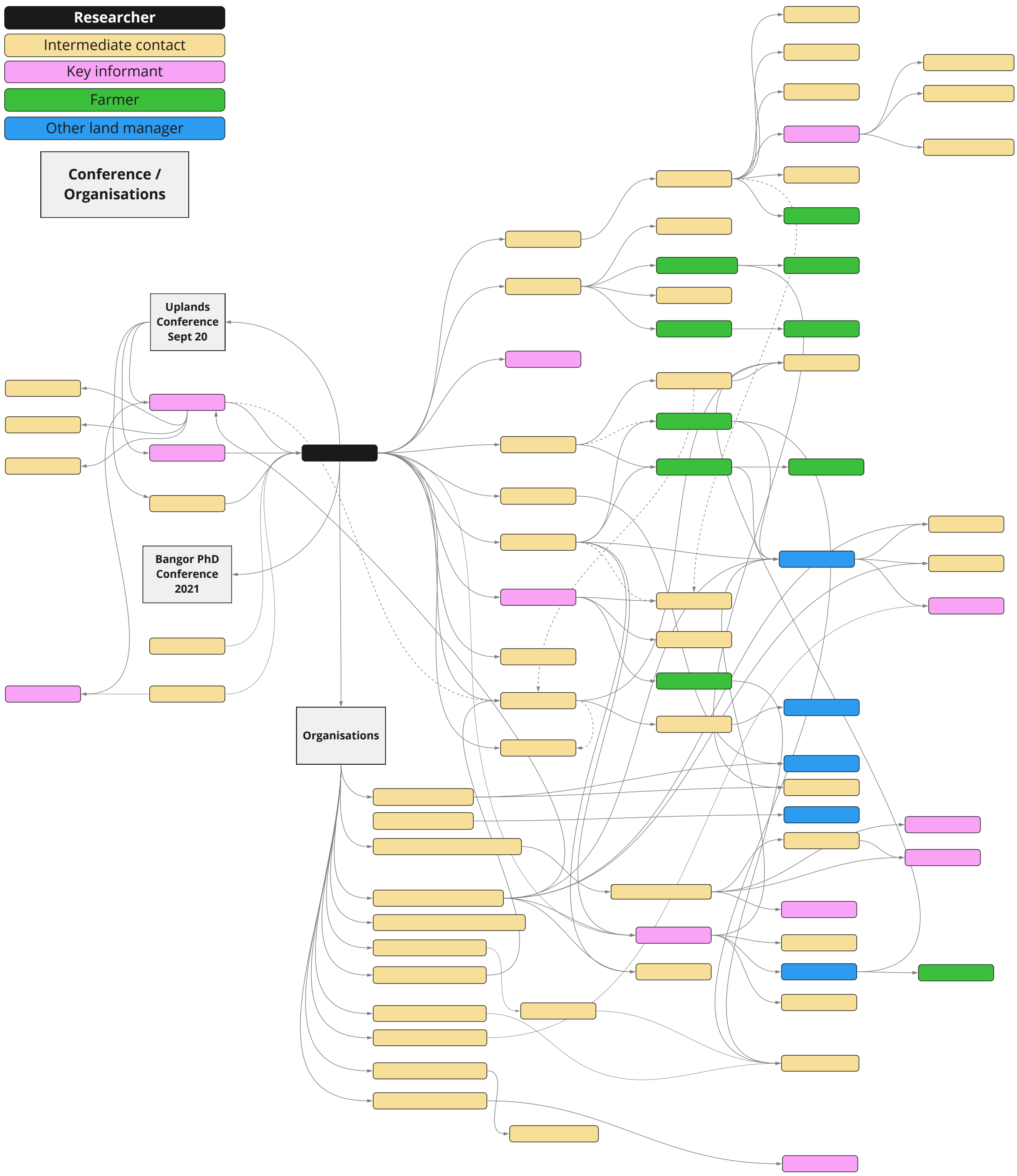

Figure 6-1 Contact network for semi-structures interviews. Word-of-mouth and finding the right gatekeepers proved most successful.

Interviews were conducted between May and July 2020 and May and September 2021, and they lasted between 45 min and 2 hrs. In 2020 only a few key informants were interviewed, after which the research had to be paused due to Covid restrictions. The interviews were restarted in May 2021, when Covid restrictions had eased enough to make them possible.

Farmers were mostly interviewed at their home or at a site in the Carneddau they managed. Online interviews were offered as an option (if they felt more comfortable doing this due to Covid), which was taken up by four of the five land managers. Interviews were often conducted outside, while overlooking part of the land the farmers or land managers cared for. This proved useful to elicit views and practical considerations on natural colonisation based on the land they themselves managed. An Ordnance Survey map (1:50,000 scale) of the Carneddau was used to discuss other sites and landscape scale considerations. Photos were taken whenever participants used a particular surrounding to underline their response, such as vegetation within an exclusion site, or small seedlings colonising a field.

Interview questions for farmers and land managers consisted of a general introduction (what type of land they managed and what the overall management goals were) and open-ended questions around tree cover on their land, natural colonisation in the present, and their thoughts on what management they might employ in the future (for the interview protocol, see section **9.2)**. Interview questions for key informants were more context specific based on the expertise of the interviewee, but always centred around the research question of natural colonisation and its role in future land management and woodland expansion in the Carneddau.

Given that woodland expansion is currently a much debated and sometimes heated topic (Case, 2019; Wallis, 2019; Barkham, 2021), interviews with farmers and land managers were conducted anonymously. The goal of this research was not to profile individual farms or land management units, but to understand larger themes and ideas around natural colonisation in the context of upland land management. Participants' identities were removed and replaced with respondent IDs (see below). Additionally, care was taken to anonymize other data, e.g. not printing photographs that show identifiable farm buildings or landmarks. While this may not reduce the risk of identification to zero, the approach was approved by the College Ethics Committee and was seen as sufficient steps within the context of this research.

Interviews were audio recorded with a HOMDER voice recorder (Model TF-85). Transcripts were produced using the software Trint and then anonymised (Trint, 2021), after which the original audio files were destroyed. All interviewees were made aware of this procedure, of how their data would be used, of whom they could contact for questions, and were asked for written consent to participate in the research. Sometimes, follow up questions were posed via email or telephone, and Covid related checks were conducted.

6.2.2 Analysis

Interview transcripts were analysed using the software NVivo Version 12 (QSR International Pty Ltd., 2020). Codes were coded manually, revised several times and both themes and raw transcript data were discussed with four other members in this research field to crosscheck whether the themes are consistent. The boundary of what was coded and what wasn't coded was defined, as much as possible, by the boundary of what respondents directly or indirectly considered relevant for natural colonisation or not. For example, tree planting and afforestation is part of certain themes below, as it was seen by respondents as relevant context and/or approximation for/of natural colonisation. In total, seven themes were identified: three broad contextual themes as well as three themes more specific to natural colonisation.

6.2.3 Limitations

Grounded theory, semi-structured interviews and a combination of purposeful and snowball sampling were used in this research, as they were seen as most promising approaches to generate high-quality data and make a valuable contribution to the discourse around natural colonisation. However, some limitations remained.

Criticism of grounded theory includes that there are no set rules on how to identify themes and categories and that researcher-bias can easily be introduced (Bryant and Charmaz, 2012). Similarly, purposeful sampling methods are prone to researcher bias, as the choice of the participants is not random but based on the researcher's assumptions and understanding (Kuzel, 1999; DiCicco-Bloom and Crabtree, 2006). Two things were done to mitigate this. Firstly, the criteria for choosing participants were defined as clearly as possible (land managers in the Carneddau with decision power over land management), as were the two intended biases (farmers and land managers of AOIs). Secondly, data analysis included discussions with other members in this research field to strengthen the choices of themes and categories.

Another bias might have happened during snowball sampling at the hands of the potential participants. For example, some farmers pointed out that others in their contact network might be reluctant to answer to the call for participation as "*they might not feel they have anything interesting to say*". To mitigate this, care was taken to emphasize any farmer (meeting the above sampling criteria) would be a valuable contributor, no matter whether they had pre-existing interest in tree cover expansion or not. Farmers that had already participated in interviews were kindly asked to pass on this emphasis when recruiting other farmers in their network.

Lastly, neither purposeful sampling nor snowball sampling give a random representation of the population, i.e. of farmers and other land managers in the Carneddau (Warren and Murphy, 2006; Naderifar, Goli and Ghaljaie, 2017). They were still seen as best methods to recruit participants, because there is no publicly available land ownership registry of Britain that could have been used, and because Bangor University did have a range of pre-existing contacts within the Carneddau farming community and other stakeholders that own land or have management rights. Nonetheless, section **6.4.3** will return to this (and other methodological limitation) and suggest how future research could provide further steps.

6.3 Results

A summary of participants can be seen in figure **Table 7**, **Table 8** and **Table 9**. All farmers were actively working their farms and deriving income from them at the time of their interviews (no retired and/or ex-farmers, **Table 7**). All farms had privately owned lowland fields (and in-bye land), as well as grazing rights for an upland common in the Carneddau. All farms primarily had sheep, some also had cattle, but only seven farmers exercised their grazing rights by turning sheep out onto the open mountain. A few of the farms had also diversified to offer things like horseback riding or holiday lets.

All five other land managers worked on behalf of a large-scale landowner, itself either being a private company, a charity, a Welsh Government sponsored body, or a local council (**Table 8**). These land managers' responsibilities varied; a few times they explicitly focused on tree related management, and sometimes they included a collaboration with farmers, but this was not always the case.

None of the key informants had land management decision power, but they did have valuable contextual information, either specific to the Carneddau, or more generally (**Table 9**).

Table 7. Participant ID for interviews with farmers.

Participant ID	Kind	Type of management decision power	Grazing rights being exercised	Additional income
F1	Farmer	Private farmland, grazing rights	Yes	Holiday let
F2	Farmer	Private farmland, grazing rights	Yes	Holiday let
F3	Farmer	Private farmland, grazing rights	Yes	Beekeeping
F4	Farmer	Private farmland, grazing rights	Yes	No
F5	Farmer	Private farmland, grazing rights	Yes	No
F6	Farmer	Private farmland, grazing rights	Yes	Horseback riding
F7	Farmer	Private farmland, grazing rights	No	No
F8	Farmer	Private farmland, grazing rights	No	Holiday let
F9	Farmer	Private farmland, grazing rights	Yes	No
F10	Farmer	Private farmland, grazing rights	No	No

Table 8. Participant ID for interviews with other land managers.

Participant ID	Kind	Type of employer	Type of land management decision power
LM1	Land manager	Charity	Tree planting responsibilities
LM2	Land manager	Welsh-Government sponsored body	Exclusion sites, existing woodlands
LM3	Land manager	Welsh-Government sponsored body	Protection sites, collaboration with farmers
LM4	Land manager	Private company	General land management
LM5	Land manager	Local council	General land management

Table 9. Participant ID for interviews with key informants.

Participant ID	Kind	Type of key information
KI1	Key informant	General info on the Carneddau and graziers
KI2	Key informant	Environmental protection zones
KI3	Key informant	Monitoring natural colonisation
KI4	Key informant	Concepts around sustainable uplands
KI5	Key informant	Existing projects involving trees in the Carneddau
KI6	Key informant	History of natural colonisation in the Carneddau
KI7	Key informant	Working with farmers on trees
KI8	Key informant	Upland sheep farms, sheep hefts, Brexit
KI9	Key informant	Working with farmers on trees
KI10	Key informant	Wildfire risks in the uplands & climate change
KI11	Key informant	Natural colonisation projects

From the interview data, seven main themes were identified. Three were headed by the category 'broad contextual themes', and three were classed within the category 'themes specific to natural colonisation'.

6.3.1 Broad contextual themes

Below are three themes that emerged not directly based on the content that related directly to the interview questions, but on the contextual way in which farmers and land managers conceptualised trees, woodland expansion, and natural colonisation.

6.3.1.1 Defence against historic legacies and public perception

A major theme amongst farmers was the emphasis on the disapproval of both the approach to woodland expansion that was taken during the 20th century and a repetition of "*any of that*" now or in the future [F1, F3]**.** This disapproval mostly focused on large-scale non-native tree plantations, and farmers expressed they felt a need to "*defend*" the farming sector against the idea of "*replacing*" upland farms completely with woodlands (and any public discourse that would allude to that):

> *"It's not that I hate trees […] but how can you talk about planting trees and ignore how badly it turned out back then?"[F5]*

This theme took up the first 15-20 min of many interviews, but once farmers had shared their opinions on the past and the large-scale discourse around woodland expansion, and when asked how *they* could imagine tree cover and natural colonisation to be integrated into their land, the conversation focused much more on what tree cover expansion was possible and/or desirable, compared to what was not.

Land managers (and some key informants) also expressed discontent at 20th century practices, but more so of the current (and in their eyes) polarising generalisations "*sold*" by the media [LM1]; specifically, that tree planting was the "*morally right way*" of doing things and that disapproving tree cover expansion and/or retaining open land for farming was the "*wrong*" way [LM1, LM2, as well as KI2, KI8], regardless of local circumstance:

> *"It's already hard enough to do this [manage land to expand woodlands], why complicate things by digging deeper trenches?" [LM1]*

This polarisation was seen as unhelpful in bringing farmers and other land managers together, and that it did not represent the at times very nuanced and site dependent work needed.

6.3.1.2 Characterising woodland expansion as commercial forestry

This theme was exclusive to farmers, wherein there was a repeated statement that "*trees won't grow there*" [F2] – "*there*" being the hills and open mountain of the Carneddau and the uplands in general. However, as the conversations continued, it transpired that woodland expansion in this context was characterised as commercially viable forestry woodland [e.g. F2, F4, F7, F8], and for this type of woodland and land use the climate was seen as too harsh, meaning the trees would take too long to grow. When asked about a different kind of tree cover, such as naturally colonised tree cover, there was agreement that "*yes, of course that'll grow there*" [F2].

6.3.1.3 Utilitarian overlap between tree planting and natural colonisation

Another theme emerged unique to farmers; namely, that farmers judged natural colonisation on their land primarily based on an active and direct management approach, including a utilitarian view on its outcome – namely, the trees. This happened often at the beginning of the conversation, where planted and naturally colonised trees were at times used interchangeably, if the outcome for the farm system was the same (or similar):

> *Question: "Have you thought about using natural colonisation on the hill?"*
>
> *Answer: "Well, the question is what do I get out of it? What are they [the trees] going to do for me? I could get some orchard trees, plant some shelter, things like that." [F6]*

Or:

> *Question: "Do you have any thoughts on natural colonisation on your farm?"*
>
> *Answer: "I haven't used it for anything, really. I do plant the occasional tree, but it needs to be useful. I suppose I could plant some more here and there, for shelter and such."*
>
> *Question: "And natural colonisation specifically? Without planting?"*
>
> *Answer: "It'd have to be useful. I'd have to be able to make sure they will grow." [F3]*

This utilitarian overlap between natural colonisation and tree planting did, however, not always persist. For example, farmers deviated in (or changed) their judgement when discussing the detailed management needs of natural colonisation, which often are significantly different from active planting. Despite a potentially similar outcome, the impact on existing farm operations differs, as it will be discussed in more detail in section **6.3.2.3**.

6.3.2 Themes specific to natural colonisation

In total, four themes emerged from talking to farmers and land managers about the role of natural colonisation in the Carneddau's, and Britain's future land management. They focus on the general presence of natural colonisation in the Carneddau, complex decision power, management responsibility and effects on existing operation, and future changes to land management.

6.3.2.1 Natural colonisation as unmanaged small-scale native trees

A general theme emerged on the definition of natural colonisation, and its extent in the Carneddau. Almost all participants felt they understood the definition of natural colonisation without the need for further clarification (for example, as compared to active planting). Most farmers, as well as some land managers, expressed that their mental picture of natural colonisation comprised small-scale and native tree cover. These two attributes, *small-scale* and *native*, were seen in a positive light and as a welcome contrast to the type of active planting that had taken place in the 20th century.

When asked whether natural colonisation was already taking place in the Carneddau, the consensus was split. None of the participants were willing or able to put a number to it (as in, hectares colonising with trees). KI11 said "*there is natural colonisation, but barely*" in the Carneddau (upland), LM3 spoke about "*quite a bit of natural colonisation*" on land they management (lowland and upland), and F9 said there was "*plenty of new trees*" growing on open upland mountain.

Naturally colonised trees, in this case, were defined as those trees growing without any intentional human management, bar any unintended indirect influences. While trees were already growing in the Carneddau, the conclusion of this theme was that large-scale natural colonisation would require a substantial change in land management:

> *"Nothing substantial is going to happen if you don't change the way we manage things. You can always hope graziers give up on turning out their sheep, but still; we can't wait that long." [K2]*

Substantial, in this case, is defined as whatever management changes farmers defined as such (see more in section **6.3.2.3.3**). This change may be intentional, or unintentional if land management changes are based on developments unrelated to natural colonisation. Nonetheless, the context of this change and its impact on existing operations is what informed the themes below.

6.3.2.2 Decision power

The complex network of decision power emerged as a major theme; specifically, how this complexity may act as a barrier to actively integrating natural colonisation into land management. This theme was shared by farmers, land managers, and key informants.

Farmers saw a clear difference between "*below and above the mountain wall*", i.e. between land around the farm they own, and land "*on the mountain*" which they only have grazing rights for, but do not own. On land they own, they felt they had exclusive decision power, bar any local legal stipulations or agri-environment agreements they had entered voluntarily. If they wished, they could pursue natural colonisation without really having to consult anyone else.

In contrast, the common land in the Carneddau, on which they graze their sheep, the data suggests there are four layers of decision power:

1. **The landowners:** especially for common land, this is the National Trust towards the west and the Crown Estate towards the east of the Carneddau.
2. **Snowdonia National Park**: encompasses almost the whole upland range of the Carneddau and has special stipulations on what the park would like to see persevered, in the interest of the public.
3. **Natural Resources Wales** (NRW): is involved in areas that are within special protection sites in the Carneddau, such as Sites of Special Scientific Interest (SSSIs) or Special Areas of Conservation (SACs). This takes up about half of the Carneddau, especially in the south-west (review **Figure 5-3**).
4. **The farmers:** they have grazing rights on common land. There are more than three graziers' associations in the Carneddau that range in size from about three active graziers to around 40.

When asked who has decision power over land management in the Carneddau, one key informant said:

> *"Everyone! The landowner / land manager must be willing, the policy must be supportive (usually through subsidy or market intervention) and there is a complex series of regulations to ensure that there is no significant damage to acknowledged features of legitimate public interest." [KI2]*

Farmers, other land managers and key informants agree that any facilitation of natural colonisation on common Carneddau land may likely fall victim to the same issue as any proposed change in existing land management; it would require the agreement of everyone with relevant decision power, which, due to the diverse interest of the stakeholders involved, is very hard to achieve.

To illustrate this, several interviewees pointed out the case of fencing. To support natural colonisation, fencing was brought up as a potential management approach, to reduce grazing pressure (at least for a while; see section **6.3.2.3** for more). However, much of the Carneddau is open access land, especially the parts within the national park. Both the park authority and the Ramblers Association, a body identified by farmers as not owning any legal rights to the land but having a strong lobbying power over land use decision making, do not want to introduce more fences. The National Trust would like to create more tree cover and, according to a key informant, is trying to explore natural colonisation in addition to planting, but farmers want, by many of their own admission during the interviews, to preserve their access to the mountain and not "*give up*" any grazing land to woodland and the fencing thereof [F8, F9]. Indeed, two farmers pointed out that it was already hard to get farmers to agree amongst one another within the same graziers' association, much less with other land managers:

> *"Getting them [farmers in the association] to agree on something is like having been through a bitter divorce and then trying to get everybody to get married again." [F5]*

As a result, two key informants pointed out that efforts often end up focused more on areas where fewer people need to agree with one another to change management for natural colonisation:

> *"If the farmer owns the land, and it's not a SSSI, and it's not a graziers' association, then it's just two parties that need to agree to fence: us and them [the farmer]." [KI10]*

> *"You work with who you can" [LM1]*

When asked how this complexity of decision power and conflicting interests can be solved to make changes to the land management, such as the introduction or facilitation of natural colonisation, easier, emphasis was put on collaboration and communication. Neither farmers nor land managers representing other bodies with decision power denied the validity of the other's interests; rather, time needed to be taken to involve everyone and compromise.

According to the data, a minor caveat to this solution, however, was that this compromise would be time consuming and, with the perceived "*stalemate*" [F9] on common land management in the Carenddau, was "*going to take forever*" [K2].

6.3.2.3 Integration into existing operations and substantial management changes

This theme encompasses both the effects of natural colonisation when integrated into existing farm operations, as well as how more substantial management changes could be made to facilitate further natural colonisation.

6.3.2.3.1 Integration into existing farm operations

For farmers, and on land they themselves owned (such as lowland fields), natural colonisation needed to offer utilitarian value for the farm itself. Examples included shelter, or as part of hedgerows:

> *"Over here, you see the ditch? The sheep don't really go there, and there's enough trees around for seed. I just have to wait a bit, maybe fence some, and the trees will grow into a hedgerow by themselves." [F3]*
>
> *Question: "Would you have planted there if there wasn't natural colonisation?"*
>
> *Answer: "That'd be too much work, just buying a whole fence would have been easier. But this way, the trees grow and I get what I need." [F3]*

If the effort of managing natural colonisation, such as fencing or supplementary planting, was disproportionate to the benefit the farmers would derive within their existing operation, other solutions needed to be found, such as financial compensation. A major point here was that farmers were actually "*punished*" for proactively increasing tree cover on their land [F9]:

> *"If you have tree cover, the land the trees shade out gets taken out of the single payments." [F9]*
>
> *"You've got one department – forestry – pushing to plant trees, and another one – agriculture – to take money away from farmers if they do." [F8]*

This emphasis was in the acknowledgment that with Brexit, the policy in question (CAP) had been abandoned, but scepticism remained (see section **6.3.2.4**).

There was further reluctance on using natural colonisation to turn whole fields into woodland, both on lowland and for large upland areas. The lowland fields and the grazing rights for common (up)land are interlinked by the movement of sheep up and down the mountain. If less fields were available down the mountain, sheep numbers needed to decrease, or other lowland fields needed to be leased for the sheep to stay on and graze, especially during winter. The latter would be costly, while the former, reducing sheep numbers, did not sit well with farmers either. They had the same reservation as they had about reducing sheep numbers for natural colonisation on common land:

> *"So, we assume they [the government] can compensate me now, but in five years? New government, money's gone, and so are my sheep. And then?" [F5]*

On common land, however, most of the farmers also pointed out that, as long as their management of sheep was not disadvantaged disproportionately and they were not asked to carry out the management of natural colonisation, they could see themselves "*coexisting peacefully*" with natural colonisation (and the trees it produces) [F5].

> *"I can't see anybody moaning if it's small areas that are fenced off and it doesn't interfere with the way you collect [the sheep]." [F1]*

> *"I think the way forward is to plant a few trees, and fence it of in small doses. Leave if for a few years, let more trees regenerate, and then move the fence somewhere else and resume grazing." [F5]*

The data suggest that scale is important; small-scale, fine-grained integrations are preferable and easier to handle within existing operations. In fact, while only one farmer had planted a woodland on their farm within the last 10 years (with grant money), five others had planted tree cover less than 0.5 ha on their farms, without grant money. Two farmers had used naturally colonising trees to build up their lowland hedgerows.

6.3.2.3.2 Integration into other existing land management operations

For land managers, budget constraints were a main factor for integrating natural colonisation into their existing operations. This related to not enough person-power available to assess natural colonisation and integrate it into management plans, and to limited resources that could be used to sufficiently compensate others, such as farmers with relevant grazing rights, to manage natural colonisation.

Furthermore, organisational structures and regulations were seen as a barrier. One land manager explained, for example, that NRW, unlike Welsh Government (through the Glastir scheme), cannot pay for "*profit forgone*" for reducing sheep on common land, only for "*positive grazing*", e.g. replacing sheep with other grazing animals, such as cattle [LM3].

Land managers had less of a utilitarian approach to integrating natural colonisation within existing operations; the focus was less on the outcome, more on the immediate budgetary and regulatory "*room*" to integrated it [LM1]. In fact, one farmer pointed out that other land managers were paid with a salary, "*no matter what happens*", so they could "*afford*" to think about natural colonisation more expansively [F5]. One land manager said:

> *"You have to remember who you talk to. They are no environmental experts. They are farmers. They are busy farming. That's what you have to work with." [LM1]*

Conversely, a key informant mentioned how hill farms often draw significant public subsidies as part of their farm income, which qualifies their income solely being derived "*off the land*" [KI2].

6.3.2.3.3 Substantive changes to land management

The data suggest that beyond the integration into existing operations, there are more substantive land management changes participants considered to facilitate natural colonisation. 'Substantive', in this case, is defined as whatever management changes farmers (and other land managers) perceived as such.

Fencing has already been mentioned and is seen as beneficial for small areas near existing woodland. On common land this would require other parties to agree, a clear distinction of who would be responsible for the fencing and fences, and sufficient funds for the fences. On farmers' own land the need for retaining ongoing operations, such as grazing areas for sheep, would remain. Here, fencing could work margin of fields to "*thicken*" hedgerows and support natural colonisation, while retaining the core of the open field [F3].

Reduction of grazing pressure was also discussed. On the one hand, land managers felt that common land in the Carneddau, as a lot of the uplands, was overgrazed. Reducing grazing pressure would therefore benefit not only the establishment of natural colonisation, but all habitats in general. Some farmers agreed:

> *"Of course, there's areas that are overgrazed – I don't dispute that. But in those areas, it's down to how they set up their grazing rights. […] Way too many people there got grazing rights for the common." [F6]*

An alternative suggestion was to achieve a selective reduction in grazing pressure not by means of fencing, but by reintroducing shepherds to keep a dynamic, but lower, grazing pressure in those areas chosen for facilitating natural colonisation.

Land managers and key informants suggested a change in type of grazing animals, instead of reducing their numbers. Cattle was brought up most often, and was seen as being more beneficial to facilitating natural colonisation compared to sheep:

> *"They graze differently and penetrate the soil better; that way, you get exposed soil where seedlings can have a chance." [KI6]*

Farmers were aware of land managers and the organisations they represent being interested in cattle, but stated that "*this doesn't work for the open mountain*" [F9]. As cattle are not hefted (i.e. they do not stay by themselves within a certain range of open common land) it would be extremely difficult to manage.

One farmer did, however, disagree, and brought up both cattle and pigs:

> *"Take the sheep off that hill and fence it. Then send cattle and pigs up there for, say, a year; that'll turn over the soil, at least what is left of it. And then every time you have native trees available, walk up there and plant them. Keep doing that for 5 years and the trees will be fine, and there will be new soil. Everything else will be natural colonisation." [F10]*

Impact of management changes

Within the data, participants introduced a variety of impacts of the management changes described above. These centred mainly around cultural significance, vegetation change, economics, permanence of change, and fire risk.

Economic influences have already been mentioned above. Most farmers said that if sheep numbers are reduced, farmers needed to derive income elsewhere. They were weary of financial compensation from the government for "*profit forgone*" [F9], because they could not trust this compensation would be there long-term. More so, farmers pointed out that wider farm economics mattered, even for seemingly unrelated things like the uptake of natural colonisation. When the interviews with farmers were conducted, the UK was in process of introducing a trade deal on lamb with Australia. It was brought up that this would endanger the price farmers could get for their own lamb. When asked how this related to natural colonisation, one farmer explained:

> *"I want a good price for the food I produce, not to be undercut by some deals by the government. If I have that I can spend time musing about trees and all that. But I have to run a farm, sustain livelihoods. That has to come first." [F2]*

And:

> *"They want us to take our sheep off the mountain for carbon, but then they go and import the lamb from halfway around the world? Really?" [F5]*

Another point raised was cultural significance. To the farmers, sheep farming in the Carneddau had a long-standing tradition, and to some their families had been farming their land for generations already. In fact, one farmer turned it around and said:

> *"The hills belong to the sheep. They are hefted and the same genetic lineage of sheep has been on that hill for over 200 years. […] These sheep have been on these hills for longer than my family has." [F6]*

Several farmers still exercised their grazing rights by bringing sheep up the mountain, not because it would derive farm income, but to uphold that cultural lineage. One of the farmers said their son, himself budding to take over the farm, "*doesn't see the point in doing it, because economically it makes no sense anymore*". Key informants raised the point that in the future increasingly fewer farmers would exercise their grazing rights and bring sheep onto common land "*whether they [the farmers] liked it or not*" [KI2], and independent of any Agri-environment schemes; this is because there were other factors at play, such as a changed market preference for less hardy sheep breeds that cannot live on the mountain and a competition with rising cattle numbers taking up lowland fields formerly used to winter sheep. Many key informants viewed this trend as a positive development on behalf of biodiversity conservation and natural colonisation.

Considering the type of vegetation change, farmers were sceptical whether a reduction in sheep grazing would indeed cause natural colonisation. One farmer pointed out a fenced area he had erected on one of his fields; after 20 years of no grazing, it was now a thicket of tall gorse, grass, bramble, and the occasional rowan tree (**Figure 6-2**).

Figure 6-2. 20-year-old exclusion site on farmland. Most of the vegetation now is tall gorse, grass, bramble, and the occasional rowan tree.

To these farmers, the reduction of sheep grazing would mostly cause gorse, bracken and bramble to take over. The grass that sheep currently kept short, would grow long and remove the ability for surrounding bird populations to feed. Trees, especially when naturally colonised, would hardly be part of this process, at least not for a very long time:

> *Question: "Do you think you will never have a woodland there [hillside on common land, currently grazed and without tree cover]?"*
>
> *Answer: "Of course you will. Eventually, in 100 years, maybe. But until then you won't get anything." [F2]*

Farmers also thought that the complete removal of grazing would be a problem for biodiversity. Several of them discussed the perceived "*mosaic*" character of the Carneddau

[F5], and Welsh lowland and uplands in general. If grazing were removed, habitats would become more uniform and less able to accommodate a variety of fauna and flora.

This view on vegetation change was not shared by land managers. Many of them believed that *some* level of grazing was beneficial for overall biodiversity, but that that level was significantly below current levels of grazing.

Farmers also put particular emphasis on the increase in fuel load that would occur if grazing was ceased, especially via the expansion of gorse and bracken:

> *"This is what I'm trying to show people [pulls out thick pile of dead and dry grass from the ground on an exclusion site -* ***Figure 6-3****]. This is what your George Monbiot and your rewilding gets." [F5]*

> *"One spark to it and the whole lot goes up in flames" [F5]*

Figure 6-3. Pile of dead grass on a slope without grazing. The farmer used this to explain the increased fuel load and fire risk.

If such a fire would occur, the increased fuel load would make it harder to put out. Currently, some farmers, especially if not part of an agri-environment scheme, use controlled burns to reduce the amount of gorse in a certain area, as well as support the growth of new vegetation tips for grazing. A key informant, specifically interviewed due to their expertise on wildfire risks, agreed that the cessation of grazing in favour of approaches such as rewilding or natural colonisation also increases the risk of fires:

> *"Any environmental projects that plan to stop managing large areas of land should consider what the increased growth does to fire risk." [K10]*

> *"With climate change, we [Britain] are becoming a fire nation. But we don't have the tools other countries have to combat fire. We work on foot, trying to put out the fire, that's all. If nobody cuts any control strips, and accessibility is hard to impossible, there's nothing we can do." [K10]*

The fire risk would also be a problem for existing natural colonisation, as young trees growing amongst the vegetation may be killed in the process.

The risk of large-scale fires without the ability to stop them also relates to the last point made, about the permanence of change. Farmers worried that large fires would irrevocably remove the mosaic character of the landscape, by burning down everything at once. It was perceived that this would be permanent, largely irreversible change.

> *"One large fire, and the mosaic is gone for good." [F9]*

Taking sheep off the mountain would also be permanent; sheep are hefted, in that each generation learns from their mothers which area on the mountain to stay on. As this is learned behaviour, one missed generation means the loss of the whole heft. New sheep cannot be introduced back to grazing that common land:

> *"You can't take the sheep off the mountain for, say, five years, and just put them back. That's not how it works." [F6]*

This potential permanence of change makes farmers very reluctant to support large-scale changes in land management, land use and land cover. Once enacted, they fear a chain reaction that would change the face of the Carneddau irreversibly, away from a landscape character they perceive as environmentally, culturally, and economically optimal (at least to them).

Land managers were less vocal about fire risk and permanence of change. They did agree that careful management was needed to make sure natural colonisation would really occur, but they qualified this with the perceived need to change and increase the amount of tree cover in the Carneddau for the future:

> *"We can't always be talking. We gotta start doing something." [LM3]*

6.3.2.4 Future changes to land management

This theme mainly focusses on future changes to land management, and how that might relate to natural colonisation. One key informant summarized it like this:

> *"Things are changing, that's the only certainty we have." [KI2]*

For example, the CAP basic payment scheme, mentioned in section **6.3.2.3** as the cause of farmers losing money for creating tree cover on their land, has been discontinued with Brexit, but farmers did not feel that either they, the Welsh government or the UK government had a sufficient grasp on what future policies will look like for farmers:

> *"It's not clear what will happen with Brexit. The government talks about farming just for the environment, not food, but that's impossible." [F8]*

> *"They've been talking about payments for outcome for 30 years now. I don't see it happening." [F7]*

The common response to this uncertainty was "*waiting to see what happens*" [F6]; i.e. waiting on further information on what agri-environment schemes would be introduced, and when. This uncertainty increased the reluctance in committing to any new long-term plans, such as woodland creation or substantive management changes to facilitate natural colonisation.

The data also revealed that climate change was a key concern. Land managers and several key informants worried about being able to realise goals of woodland creation, given the complex situation in the uplands, as it has been outlined so far. Farmers worried about being "*saddled*" with the responsibility of creating trees as a *"cosmetic procedure"* while large corporations were scrutinised much less for the carbon emissions they still produce [F5]. Several farmers believed their role in saving emissions was much more in improving their farm systems, with tree cover creation, via natural colonisation or active planting, only being a small part of this:

> *"I think our battle starts now. And out battle is to prove to the government what we are doing; storing carbon, producing clean water, benefiting the environment, […] and don't forget, producing top quality protein and wool from marginal land." [F5]*

6.4 Discussion

The grounded theory approach in this research uncovered a range of themes; some of them overlapping with active approaches to woodland creation like tree planting, others being rather unique to natural colonisation. The discussion below covers both the themes in the context of wider literature and potential further research that could be done to strengthen this research and address some of its limitations.

6.4.1 The role of natural colonisation in future land management

The data in this present research suggests that there is an opportunity for natural colonisation in future land management. This mostly focuses on small-scale, native tree cover, and on taking time to slowly move the areas of facilitated natural colonisation across the landscape to preserve the landscape's mosaic character while creating tree cover of diverse age and structure. Specifically, farmers suggested an approach like this could circumvent negative trade-offs, such as fire risk, biodiversity loss or permanence of change. This is quite similar to studies done on active planting that identified land managers' concern about the impact of large-scale management changes towards woodland creation (Fischer, Hartel and Kuemmerle, 2012; Navarro and Pereira, 2012; Terres, Nisini Scacchiafichi and Anguiano, 2013). Fitzgerald et al. (2021), for example, found these same perceived trade-offs as some of the reasons farmers in Exmoor National Park had reservations against large-scale woodland expansion. Additionally, the land managers in the study by Burton et al. (2018) thought that keeping woodland expansion via active planting to a small scale and doing it slowly would alleviate a lot of the perceived problems.

In this present research, on lowland fields farmers often saw natural colonisation as offering the same opportunity as active planting, if the outcome (and its use for the farm) would be the same; this included creating shelter, thickening hedgerows, or growing orchards. Using this utilitarian view, British farmers may embrace a type of farmer managed natural regeneration (FMNR), as it has been introduced in Section **2.2.4.1**. Naturally colonised trees would be selected, and their establishment supported based on individual farm requirements.

Sometimes, natural colonisation was considered in areas where active planting was not, such as remote or low-yield parts of the farm; here, active planting would be too much work, but fencing and natural colonisation may be more reasonable. On land further up the mountain, the complexity of decision power would have to be addressed first, and natural colonisation was not seen as feasible far from established tree cover. A combination with active planting may be able to alleviate the latter, and if fencing is not possible, shepherds could be reintroduced to channel the movement of sheep across the mountain and keep a dynamic but lower grazing pressure in certain areas to facilitate natural colonisation. This would also help with fire risk management, as a certain level of grazing would remain. Nonetheless, at least on a small scale, the data suggests that natural colonisation would persist and possibly expand even in the absence of any active facilitation (see more below).

This type of opportunity for natural colonisation fits in with a landscape called 'Native Networks', coined by Burton et al. (2018) when working with stakeholders in Scotland. In this vision of a landscape-scale approach to woodland expansion, emphasis is on native, linear (e.g. riparian or shelterbelt) and farm woodlands that are integrated with other land uses and where "*natural regeneration and transition zones are encouraged*" (Burton, Metzger, *et al.*, 2018, p. 1698). An approach like this used for a whole landscape reinforces the need for a more fine-scale spatial map or tree cover, as it was laid out in section **5.4.2** in Chapter 5 (compare **Figure 5-13**). The WEOMs could also be included in this planning process, highlighting areas where natural colonisation would have particular benefits, as well as areas where open habitats could be retained.

In many ways, however, this approach also reflects the inherent problem pointed out in Chapter 3 and Chapter 5; creating 'Native Networks' and expanding tree cover bit by bit in a small-scale fashion takes time. In this present research, while farmers were worried about changes being introduced too quickly and the negative impact this would have, land managers and key informants often expressed worry about progress being too slow. Iversen et al. (2022) found similar trends in Cumbria and characterised these stakeholders under the banner of "*'Not enough is done to protect the environment'*". Interestingly, both in Cumbria and in the Carneddau the majority of these stakeholders earned salaries that were not dependent on any farm income, or any income directly derived from a specific land use (e.g. agricultural products); something that the farmers in this present research pointed out as being relevant to whether one could "*afford*" to think about woodland expansion more expansively – with respect to wider public benefits – or not.

6.4.2 Natural colonisation as a step beyond active planting

This research suggests that while natural colonisation seems to overlap with active planting in certain aspects of land management, some more fundamental aspects differ. This seems due to two reasons; the difference in management need, and the ability for natural colonisation to establish in the absence of intentionality.

The difference in management need has already been mentioned above; farmers considered natural colonisation in some areas on their farms where they would not consider active planting, simply because they perceived the management needs for the former would be less laborious or expensive than the latter.

To consider the ability for natural colonisation to establish in the absence of any intentionality, the complex decision power over land management needs to be considered. Other publications have already established that natural colonisation shares this barrier with active planting, in any low- or upland where the parties who own, tenant, and legally govern the land are not the same and each affect part of the land management, sometimes towards conflicting goals (Munton, 2009; Lawrence and Dandy, 2014; Fitzgerald, Collins and Potter, 2021). Suggestions on solving this complexity centre around carefully aligning all parties' involvement and goals (Brown *et al.*, 2018; Burton, Metzger, *et al.*, 2018), but a collaborative approach like this is not necessarily seen as fast enough to account for the time sensitivity of drivers such as climate change (Iversen *et al.*, 2022). This particularly affects large-scale woodland expansion, by means of active planting or facilitating natural colonisation; if all parties need to agree for significant management changes to occur, but those parties' interests oppose each other in their management requirements (Hardaker, 2018; Sing *et al.*, 2018), progress will be difficult and often slow.

Unlike active planting, natural colonisation does, however, have the advantage that it may occur without any intentionality or active management requirements; including any stakeholder buy-in. Other studies, such as Fitzgerald et al. (2021) and their investigation of farmers' views on woodland expansion in Dartmoor National Park, or Iversen et al.'s (2022) exploration of contrasting values with regards to woodland creation in Cumbria, have not specifically asked about the presence of natural colonisation. Chapter 5 has established a range of circumstances under which it could occur (protected from weather, grazing, surrounding vegetation, etc.), and those conditions may well be found in many other lowland or upland regions in Britain. The participants in this present research indeed agreed that natural colonisation had independently established in the Carneddau, but at the same time they believed that no large-scale woodland expansion would come of it without any substantial changes to land management. In fact, some evidence of this could be seen in Chapter 5; near an exclusion site at AOI 15, a small batch of seedlings had colonised just outside the fence on a grazed site (**Figure 5-39**), but the absence of any older saplings in that area suggested that the seedlings would likely not survive the current level of grazing.

The large-scale management changes may have to be intentional, reintroducing the problem of coordination and buy-in from a range of land managers. O'Neill et al. (2020) argue that naturally colonised woodlands, unlike planted woodlands and sheep farming, can be economically viable without the need for subsidies due to cheap establishment cost and a strong carbon offset market (O'Neill *et al.*, 2020). In Wales alone, one third of farm holdings face "*serious financial difficulties*" without the continuation of pre-Brexit CAP subsidies, and an even higher percentage of agricultural land may be vulnerable to land use change or abandonment (Arnott *et al.*, 2021, p. 1). Given the low establishment cost and recent research on the potential loss of carbon stock in active planting due to ground preparation (Matthews, 2020), natural colonisation may have a unique and much more large-scale role to play in a future of such intentional 'carbon farms'. Here again the difference in management between natural colonisation and active planting is relevant.

Alternatively, or possibly going hand in hand with the above, natural colonisation may also profit off land management changes made for reasons entirely unrelated to trees. For example, farmers in this research mentioned that the number of farmers exercising their grazing rights on common land was already decreasing, and key informants stipulated that this trend would continue even without any further facilitation by agri-environment schemes or tree-related initiatives. The result of this may well be a window of opportunity for natural colonisation to expand, where complex decision power would still impede active planting. A comparison with scientific and grey literature has found that there is little spatially explicit historical data available on sheep numbers on commons in Britain. Some datasets go to county level (StatsWales, 2019), and the agCensus Digimap, a public output of the annual agricultural census, reports sheep numbers per $2km^2$ square back to 2004 (Edina, 2022), but this is still a low resolution. If the number of sheep on common British land really is decreasing, and if it will continue to do so due to triggers independent of agri-environment schemes and/or tree related driver, more attention should be paid to it as a clue to expanding opportunities for unintended natural colonisation.

6.4.3 Further research

Following from the above, there are a few areas that should be explored further to strengthen this present research and address some of its limitations.

Firstly, the engagement with land managers on natural colonisation should be expanded to other areas of Britain, both upland and lowland. A large-scale quantitative assessment could, for example, compare whether the stratification Hopkins et al. (2017), Eves et al. (2015), or Morgan-Daves et al. (2008) found on which farmers are more likely to consider tree planting also is true for natural colonisation. Additional research should also be conducted to see how natural colonisation interacts with land managers' sense of place, and with the ideas of tidiness and productivity (Burton, Kuczera and Schwarz, 2008; Cusworth and Dodsworth, 2021). Lessons learned overseas, for example on how African farmers introduce naturally colonised trees into their farm systems via Farmer Managed Natural Regeneration (FMNR), may offer interesting parallels to how British farmers might envision integrating natural colonisation on their land (Tougiani, Guero and Rinaudo, 2009; Moore *et al.*, 2020).

It would also be beneficial to engage more with the drivers of historic (local) changes in sheep density as an indirect pointer towards the past, present and future potential for unintended natural colonisation. Chapter 5 and relevant research investigated the result of changing grazing pressure on tree establishment (Hester, Mitchell and Kirby, 1996; Williams *et al.*, 2012; Ford *et al.*, 2018), but while Chapter 3 and Chapter 4 established the drivers and actual changes of active tree cover expansion, unintentional natural colonisation may well be governed much more by drivers of sheep density on British upland (and lowland), many of which may have nothing to do with trees at all. In a landscape where natural colonisation will have to sit within a variety of other land uses, large-scale trends in those are extremely relevant pointers towards the future. This is not least because a decrease in the use of land for sheep grazing may also increase the feasibility of bringing natural colonisation into active management, as the 'carbon farms' above suggest (Matthews, 2020; O'Neill *et al.*, 2020).

A case study approach could be taken with local initiatives that seek to integrate natural colonisation into their management plans. The results of this research could inform the design of these initiatives and their execution could be used to go beyond theory and understand the process of actively implementing natural colonisation on the ground. This could be rewilding initiatives, such as the Cambrian Wildwoods or the Affric Highlands (Cambrian Wildwood, 2018; Trees for Life, 2021), or woodland expansion plans like the National Forest for Wales or the Northern Forest in England (Mash, 2018; Welsh Government, 2020d), or other projects like community woodlands (Llais y Goedwig, 2022).

Lastly, considering the perceived importance of woodland expansion drivers identified in Chapter 3, important questions remain around the large-scale integration and coordination of natural colonisation management. Can and will the land management stalemates be resolved that farmers and other land managers in this research have outlined? And if so, will farmers be responsible for facilitating and managing natural colonisation, or will it be someone else? Who will it be and what will be for? This present and future research on the potential management of natural colonisation should also encompass a view on how it can be integrated into managing British woodlands as a whole, and what they will be managed for.

6.5 Conclusion

This research has shown that both farmers and other land managers think that natural colonisation could be integrated into future land management in the Carneddau and beyond. They envision it mostly as small-scale, native, mosaic natural colonisation that coinhabits or enhances upland regions and their existing land management. This way, negative trade-offs such as fire risk, biodiversity loss or permanence of change can be minimised. Large-scale facilitation of natural colonisation is seen as more difficult, as it requires substantive management changes and the buy-in from all relevant stakeholders.

What sets natural colonisation apart from active planting, however, is the difference in management needs and the ability of natural colonisation to establish without active management. Natural colonisation can be used in areas where active planting would be too laborious or expensive, and unintended natural colonisation can circumvent complex decision power structures (and bureaucracy), as long surrounding land use changes offer an opportunity for it.

More research should be done to survey land managers on natural colonisation in Britain, and further work is also needed on how large-scale trends of land use change independent from woodland expansion trends, such as the gradual cessation of upland grazing, may influence the role natural colonisation will play within Britain's future woodland expansion – intentionally or not.

7 SYNTHESIS AND CONCLUSION

The purpose of this thesis was to explore emerging opportunities for native woodland expansion in Britain's crowded future landscapes. Compared to an EU average of 38%, only 13.5% of British land is covered in woodlands (Forest Research, 2020b), which is considered too little to provide the range of woodland ecosystem services which are relevant today, such as climate change mitigation (via carbon storage), biodiversity conservation, timber and wood fuel supply or flood protection (Sing *et al.*, 2018).

The amount of woodland created in Britain in recent years is merely one third of the targets that had been set and unevenly distributed at that, with the majority of woodland creation taking place in Scotland (Forest Research, 2020b). Given the extensive history of British woodland expansion, specifically in the 20th century, this thesis intended to fill a knowledge gap by undertaking a comprehensive review of past drivers of woodland expansion that governed the 100-year increase from 4.8% in 1905 to 13.5% woodland cover in the new millennium (FC, 1921; Forest Research, 2020b), and what this legacy may say for the future. It also added a comprehensive collation of data of afforestation targets and realised afforestation during this time, which had not been done before, as well as a critical comparison of past targets (and their success) with the level of woodland creation the UK government has committed itself to in the decades to come. Given that woodland expansion targets have once again become important pillars of planning future woodland – so much so that recent electoral candidates tried to outdo each other with the most ambitious targets (BBC, 2019; Lyon, 2019; Shrubsole, 2019) – this was vital information to understand what the future targets might say about how much new woodland there will really be.

New woodlands must fit into a crowded British landscape, where much of the land is already part of an intricate mosaic of land uses, providing a range of existing ecosystem services (Cox *et al.*, 2018; Savillis, 2019). With the introduction of rewilding as a new concept for engaging with the British landscape and the benefits derived from it (Wynne-Jones, Strouts and Holmes, 2018; Crouzeilles *et al.*, 2020; Rewilding Britain, 2020), natural colonisation is being increasingly widely advocated as a strategy for 'creating' new woodlands (Rewilding Britain, 2020; Woodland Trust, 2020). With so little known about how much natural colonisation there may be in Britain, this thesis used existing spatial data of tree cover as well as WEOMs as the basis of analysing the coverage of natural colonisation in both existing spatial data and observational site visits, ultimately assessing its potential contribution to future woodland cover. Furthermore, while Chapter 2 discussed existing body of research regarding farmers' and other land manager's decision making on tree planting (Wynne-Jones, 2013; Lawrence and Dandy, 2014; Cusworth and Dodsworth, 2021), research on decision making with regards to natural colonisation is scarce. Therefore, this research used a grounded theory approach and semi-structured interviews to gain in-depth knowledge on the potential role of natural colonisation in future land management, from the perspective of farmers and other land managers.

This synthesis chapter is comprised of two parts. The first will discuss the answers to the four research questions, highlighting original contributions and the implications of new knowledge gained. This includes cross-references between the chapters, as a lot of implications gain strength when considering knowledge gained in other chapters. The second part, then, will discuss limitations of this thesis and suggest further research that could be done to strengthen and expand the insights gained within this thesis.

7.1 Research questions

Below is a discussion of the research questions investigated in Chapter 3 to Chapter 6, as well as implications of this new knowledge for native woodland expansion going forward.

7.1.1 Drivers of woodland expansion in Britain's past and future

Chapter 3 used a comprehensive review of scientific and grey literature to assess the drivers of woodland expansion in Britain between 1919 and 2019. It has shown that woodlands today must provide more large-scale benefits than ever before; what started with four drivers influencing large-scale woodland expansion in 1919 has since diversified into 12 drivers (and counting, considering the emerging importance of natural flood management). New types of stakeholders are investing time and resources into woodland expansion, such as local communities (Fristrom, 2021; Woodland Trust, 2022), farmers (Soil Association Scotland, 2019; Henman, 2021), urban planners (UK Government, 2019; LUFP, 2020), or interested private individuals (Morris, 2021; Newsdesk Cambridge, 2021). Furthermore, this range of drivers and stakeholders also diversified the size, location and character of tree cover that is being pursued. The management of small woods has become of interest (Small Woods, 2021), as well as trees outside woodlands on farms on uplands and lowlands (NFU, 2019; Soil Association Scotland, 2019; Wheeler, 2019), and even individual urban trees (UK Government, 2019; BBC, 2020; LUFP, 2020). Woodlands may now also be native broadleaves (Welsh Government, 2018; UK Government, 2021), and instead of (single-species) even-aged stands stakeholders may pursue structurally diverse mixed woodlands (Rewilding Britain, 2019b; CEH, 2021).

There are a range of implication of this diversification for the future of woodland expansion in Britain. Firstly, despite the changing drivers, most of this history was governed by active planting. Natural colonisation as a way of creating woodland cover was only introduced via rewilding in the 2010s and is thus a decided departure of how woodland expansion used to be pursued during the last century.

Secondly, balancing priorities for future native British woodlands will be difficult. The drivers of woodland expansion show that today, *all* British land offers multiple strong values that are actively articulated. Where the FC used to be able to ignore or resolve any reservations against woodland expansion by moving into the uplands and buying cheap 'derelict' land (James, 1981), attempting the same today will likely be impossible; these 'derelict' lands of the 20th century now host National Parks (Snowdonia, Exmoor, Lake District and other national parks centre around upland regions), special conservation zones (e.g. Lle, 2022), and with it an explicit valuation of the landscapes existing *open* character (Cox *et al.*, 2018; Gold, 2019). Trade-offs will have to happen, and some interests will have to make more concessions than others. The difficulty of negotiating this balance is particularly reinforced by the time sensitivity of climate change (and species extinction); to act swiftly and triple the country's woodland expansion rates, ideally within the next year, stands in direct contrast with taking the time to involve all relevant stakeholders and design diverse and multipurpose woodlands.

Furthermore, the research in this chapter also showed that there is an additional problem with growing trees *deliberately* for any (be it one or many) anthropocentric purpose. Woodlands operate on timescale much longer than humans and with it, much longer than many drivers of woodland expansion; designing future woodlands based on present drivers is taking the risk that by the time these woodlands mature, the world has already moved on. The narrower the set of drivers for the original design, the higher the risk that the mature woodlands will not be fit for a new world order. This was true for the conifer plantations of the 1930s, which matured in the 1980s and the age of multi-purpose broadleaved woodlands, and it was true for the multi-purpose broadleaved woodlands planted in the 1980s that now mature in the 2020s in the midst of arguments about whether conifers plantations may not be better suited for carbon sequestration (Forster *et al.*, 2021).

Woodland expansion in Britain's future must deliver an extremely difficult feat; to balance existing interests in woodland creation in a time of climate urgency and create woodlands which are resilient enough for a potentially drastic repurposing to fit new objectives in the decades to come. This will not happen without significant trade-offs, on a national, regional, and local level, including the scrutiny on behalf of those interests that are forced to take a step back.

7.1.2 The scale of afforestation in Britain's past and future

Chapter 4 analysed archived statistical reports and related grey literature from the last 100 years of British forestry history to collate a comprehensive picture of both afforestation targets and realised annual afforestation between 1919 and 2019. It is the first time these numbers have been extracted and unified to such a degree of detail and over such a long time-span. This dataset has then been compared to the levels of woodland creation that is planned for the future, in order to reflect on how realistic or achievable current targets may in fact be.

The research showed that eight afforestation programmes were introduced during those 100 years, covering the full timespan. In fact, there was a slight upwards trend in the average annual afforestation targets, i.e. the more woodland was created in Britain, the more new woodland was desired. Despite this, realised afforestation matched (or exceeded) the targets only until the late 1970s; since then, realised afforestation has not been able to keep up, and by 2018 British woodlands were missing over 250,000 ha compared to their theoretical aspiration. This is about 40% of what the new targets stipulate is necessary to comply with Britain's 2050 Net Zero agenda (DEFRA, 2020b). The woodland creation targets of today, being around 30,000 ha annually (CCC, 2019; DEFRA, 2020b), have last been achieved in the late 1980s, and before during the 1950s and 1960s. This means current targets hope to double or triple annual woodland cover expansion within the coming years (Forest Research, 2020b).

The departure of ideal targets and realised afforestation in the 1980s can be seen as a direct reflection of the diversification in woodland expansion drivers during that time. With private sector (conifer) afforestation being significantly dampened by the aftermath of the Flow Country events (Mackay, 1995; Wigan, 1998), and the FC being made responsible for much more diverse objectives in the broadleaf policy (FC, 1985; Oosthoek, 2013), the developments of this decade significantly challenged the afforestation rates (and woodlands they created) at the time. It should be noted, however, that the years since the 1980s have seen significant success for both broadleaf afforestation and the restocking of broadleaves of (presumably conifer) stands, especially by the private sector.

The matches and mismatches between realised afforestation rates and the drivers of woodland expansion from Chapter 3 also demonstrate how complex this relationship is. Neither historical accounts nor afforestation data alone seemed to be able to tell the full story. For example, the developments in the Lake District set an important precedent for the opposition to woodland expansion, but afforestation data obscured regional effects and did not show much impact. Conversely, the 1970s likely deserve more consideration in historical accounts, given how significant the drop in afforestation rates was at the time.

There is a range of implications from this research for future woodland expansion, especially with regards to the use of woodland expansion targets and related methodologies. Firstly, the last 50 years have shown what other studies have already suggested (Chazdon *et al.*, 2017); that woodland expansion targets are no prophecies, they are only ever as good as the plans to get there, and creating woodlands in Britain's future will take much more than simply pledging them on paper. This is not least due to the underlying complexity of drivers that needs solving (as Chapter 3 has discussed), because it is these trade-offs that govern the rate and success of woodland creation in meeting its goals. Without sufficiently addressing the first, an overreliance on the latter seems pointless; woodland creation will likely remain significantly off-target, unless (a) priorities are struck (e.g. for climate change), trade-offs are accepted, so woodland creation rates can rise, or (b) careful creation of multipurpose woodlands are given priority, the time this will take is accepted, the targets are corrected downward and woodland creation can match them with slight to moderate increase. This is, of course, no dichotomy, but the rationale of the targets needs to reflect whatever course will be taken for the underlying interests they are supposed to reflect.

This also highlights another important implication on methodologies. The way woodland expansion targets and realised woodland expansion are measured may not be fit for purpose anymore. Most notably, woodland expansion targets say nothing about the state of the new woodlands, or about whether they are indeed capable of providing whatever benefit they were created for. During the early 20th century, when the growing of timber (and related labour creation) was the main goal, measuring the amount of new land covered in trees was a reasonable proxy of woodland expansion 'success'; if more land were to be covered in trees, more timber would be available and, as forestry at the time required much labour, more employment would be needed in the sector. The difference is that today's complex drivers of woodland expansion have no straightforward relationship anymore with the mere amount of land covered in trees (Tengberg *et al.*, 2012; Veldman *et al.*, 2015; Carrick *et al.*, 2019). This includes carbon sequestration, which was the main reason in the 2010s for reintroducing woodland expansion targets; a lot of nuance remains about which woodlands, woodland soils and management techniques yield the best carbon sequestration (Falloon *et al.*, 2004; Noormets *et al.*, 2014), and indeed, whether they really do so better than the habitats they are meant to replace.

Issuing woodland expansion targets may still have some use, not least to hold the government issuing them accountable in the future; but there should be much more scrutiny of what the targets really represent, and when woodland expansion can be considered 'successful'.

7.1.3 The extent of natural colonisation in spatial data and field observations

With the advent of natural colonisation as a decided departure from established approaches to woodland expansion as it had been pursued during the last century of British woodland expansion, Chapter 5 used a mixed-method approach to assess the coverage of natural colonisation in existing spatial data, and relevant implications thereof. By comparing spatial data on tree cover (NFI & NTM) and primary qualitative data (ecologist interviews & site visits) for a landscape-scale case study area (Carneddau), it qualitatively profiled the location and extend of natural colonisation. It also compared the results with a collection of 12 WEOMs, to provide insight into how natural colonisation might be integrated into future woodland creation.

The results show that recent natural colonisation is not featured on either the NFI or the NTM. Despite the NTM capturing trees outside woodlands, the methodological criteria of these trees having to be above 3m in height excludes not only a lot of young natural colonisation, it also omits a range of grown trees, such as upland hawthorn and blackthorn that never reach a height above 3m. In fact, even without accounting for recent natural colonisation and those small trees, 20% (460 ha) of all tree cover in the Carneddau is not on any publicly available map. For the whole of Britain, this percentage is quite comparable. Ditchburn and Brewer (2017b) used the NTM to estimate there is 740,000 ha of tree cover outside woodlands in Britain; given a total woodland cover of 3.85 mha (Forest Research, 2020b), over 19% of all British tree cover lies outside woodlands; recent natural colonisation not included. With the importance of woodland expansion, missing almost 20% of tree cover from publicly available datasets is a significant shortcoming.

The critical assessment of the WEOMs also showed that they do not include the NTM or any information on natural colonisation in their modelling, and only use the NFI as a dataset, for example to model potential habitat connectivity. In the Carneddau, 49% of all land has been identified as one or several WEOs, and 87% of trees outside woodlands are within one of these WEOs (most notably for nature conservation, catchment woodland and Glastir grant support).

Despite its absence from spatial datasets and WEOMs, this research also demonstrated that natural colonisation occurs in the Carneddau, especially rowan and birch. Its patterns follow the changes in land management, from fenced natural colonisation on lowland field hedgerows, to natural colonisation along protected waterways, and all the way to natural colonisation on steep open mountain. The trees seem to use any opportunity surrounding land uses/covers offer them, especially with regards to protection from prevailing weather, grazing, and competing vegetation. In various areas, natural colonisation also overlapped with WEOs, which means it could indeed be used for creating future woodlands where they would be desired. Given certain land management changes (of different severity), the scale of natural colonisation could expand (for example by a temporary cessation of grazing, as Jones (2007) suggests), or it could be further facilitated as part of a very small-scale mosaic landscape.

There are two very important implications from this research. Firstly, natural colonisation already takes place in the Carneddau. It also stands to reason that the same is true for other areas in Britain, given that the land management conditions that likely govern natural colonisation (topography, grazing patterns, surrounding vegetation) are not unique to the Carneddau alone (Thompson, 2004; Tanentzap, Zou and Coomes, 2013; Turczański, Dyderski and Rutkowski, 2021). Without facilitation, the scale of natural colonisation depends on what happens with the surrounding land uses and covers that govern it. For example, farmers interviewed in chapter 6 suggested that sheep grazing in the uplands (especially open mountain) is already decreasing for reasons unrelated to trees (see also McGinlay, Gowing and Budds, 2017; Arnott *et al.*, 2021), so natural colonisation may become an unintentional profiteer.

Because this is the case, more must be done to spatially capture this type of tree cover and make it visible for environmental modelling and thus, environmental policy making. This present research has further cemented that tree cover outside woodlands and natural colonisation can provide valuable benefits (Tanentzap, Zou and Coomes, 2013; Douglas, Groom and Scridel, 2020; Tiang *et al.*, 2021), so ignoring these trees – and with it over 20% of all British tree cover – is a mistake.

7.1.4 The role of natural colonisation in future land management

Chapter 6 focused on the potential land management changes that might have to happen to facilitate natural colonisation. It used a grounded theory approach with semi-structured interviews to understand what farmers and other land managers think of natural colonisation, and indeed whether they think about it differently than active planting. Interviews were conducted with ten farmers, five other land managers and 11 key informants.

This research showed that farmers see natural colonisation as useful in a mosaic, small-scale fashion that fully reconciles the crowdedness of the British landscape. They look at it through the lens of their farm operations, and judge opportunities for natural colonisation based on practical considerations, and with a focus on outcome. On a large-scale, farmers are worried about what irreversible impacts large-scale land management changes to facilitate natural colonisation may have, such as fire risk, the loss of a mosaic landscape character, as well as negative effects on their farm income. They are not convinced that a cessation of grazing, which they perceive as one of the main land management changes being proposed, will actually yield woodland cover as a result – at least not for a very long time. Furthermore, they point out that on common land, a complex network of decision power makes any drastic management changes extremely difficult to negotiate.

There are a few implications of this research. Firstly, concerns about the impact of large-scale management changes for natural colonisation are quite similar to those being brought forward on active planting (Fischer, Hartel and Kuemmerle, 2012; Navarro and Pereira, 2012; Terres, Nisini Scacchiafichi and Anguiano, 2013). The same is true for proposed solutions; for active planting and natural colonisation farmers see a small-scale approach as key, to slowly and continuously create new tree cover of diverse age and structure (Burton, Metzger, *et al.*, 2018). Generally, farmers saw natural colonisation as offering the same opportunity as active planting, if the outcome (and its use for the farm) would be the same; this included creating shelter, thickening hedgerows, or growing orchards.

This research also showed that perceptions of past (non-native conifer) planting constitute a barrier for conversations about natural colonisation. When speaking about creating forests, farmers envisioned planted non-native commercial forestry, and considerable time was necessary to establish natural colonisation as an independent concept. If the government or other stakeholders would want to support the uptake of natural colonisation amongst farmers (UK Government, 2022b), this conceptual barrier would have to be addressed. As Avery and Lesley (1990) and Mackay (1995) wrote in their reflection on the Flow Country events, trees take long to grow and the (conifer) legacy of 20th century afforestation would be visible in the countryside for decades, prolonging the tainted image of forestry. This time still has not passed, and natural colonisation, though innocent of perceived 20th century mistakes, is being scrutinised through the same lens.

Having said that, natural colonisation, especially where unintended, offers certain advantages over active planting. It can exist outside complex decision power structures; if there is no need to plant, fence, thin or otherwise tend to the trees, they may, as Chapter 5 has demonstrated, grow wherever surrounding land uses offer an opportunity. Farmers discussed that they would feel positive about 'mutually coexisting' with such natural colonisation – not least because they perceived the resulting type of tree cover to be native, patchy and structurally diverse. Furthermore, natural colonisation may also be able to circumvent the bureaucratic hurdles and lack of compensation of agri-environment schemes, which land managers have named as specific barriers to their uptake of tree planting (Urquhart, Courtney and Slee, 2010; Wynne-Jones, 2013; Lawrence and Dandy, 2014). If it is true that the number of sheep on British open mountains is decreasing (as farmers have said, see also McGinlay, Gowing and Budds, 2017; Arnott *et al.*, 2021), the easiest and maybe least controversial way to expand woodland cover in these regions might be to simply sit back and wait. If active large-scale changes to facilitate woodland expansion, via planting, fencing or other direct intervention, would be prevented or at the very least significantly complicated by strong opposition from other interests, unintended natural colonisation may also end up being a comparatively fast way of expanding native British woodlands.

7.2 Thesis limitations & further research

This thesis is the culmination of three years of research, a significant part of which was conducted under Covid restrictions and a range of changes had to be made because of this. Data limitation, as well as time and budget constraints further informed the type and extent of research possible, as the individual chapters discussed. Nonetheless, the shortcomings of this research are also an invitation for further studies, especially with regards to natural colonisation and the appreciation of a complex 21st woodland expansion agenda.

Firstly, in Chapter 5 it was not possible to create a large-scale, high resolution spatial map of natural colonisation (and small-scale tree cover), but this thesis showed the importance of producing such a map, especially for public use. This could be done either by using new technologies and the ever-increasing resolution of available spatial data (Thers, Bøcher and Svenning, 2019; Broughton *et al.*, 2021), or by approximating natural colonisation through surrounding land uses and influencing factors. An example for the latter could be a high-resolution tracking of sheep movement across the uplands (Dore *et al.*, 2020; Ren *et al.*, 2020), to understand their grazing patters and establish opportunity indicators for natural colonisation (Rutter, Beresford and Roberts, 1997).

Until then – or possibly in tandem with research on the above – the qualitative assessment of natural colonisation from Chapter 5, especially in comparison to existing WEOMs, should be repeated for other areas in Britain. It was not possible in Chapter 5 to choose the sites for field visits via random sampling, but with more resources available, such an approach could be taken. Furthermore, other areas in Britain may be covered by other WEOMs (e.g. Friends of the Earth, 2020), and it would be interesting to know the overlap between recent natural colonisation and areas identified as woodland expansion opportunities for a range of British landscapes.

All this spatial exploration would further establish how much natural colonisation there already is in Britain, and at what scale it could contribute to the many thousand hectares of new woodland needed to meet the Paris Agreement (CCC, 2019). It would also mean that over 20% of existing but invisible tree cover in Britain would become visible for environmental policy making, and the design of new grant schemes could get closer to integrating natural colonisation as an option.

At the same time, however, more research is also recommended on the integration of natural colonisation into land management. For example, building on the results from Chapter 6, a large-scale quantitative approach could be taken to test whether the type of land manager stratifications and typologies Hopkins et al. (2017), Eves et al. (2015), or Morgan-Daves et al. (2008) found map on to attitudes to natural colonisation. Considering existing research in the space, an important question also needs to be addressed on how the natural colonisation of trees interacts with land managers' sense of place; with the ideas of tidiness and productivity (Burton, Kuczera and Schwarz, 2008; Cusworth and Dodsworth, 2021). Farmers interviewed in Chapter 6 said they would feel positive towards small-scale natural colonisation within their landscape; does this mean natural colonisation can be part of 'good farming' (Burton, 2004, 2012)? Does intentionality and level of agency on behalf of the land manager make a difference, as Burton et al. (2008) suggest on the uptake on agri-environment schemes?

Lastly, further research could be done on woodland expansion targets and alternative or complementary metrics that could be used to better appreciate the complexity of today's woodland expansion drivers and what 'success' means in this context. For example, instead of woodland expansion targets expressed in hectares of new land covered in trees, will the next round of election campaigns compete over amount of carbon sequestered, regardless of how much new are of woodland it takes to reach that goal? Could it be amount of money saved by the NHS through the provision of woodland recreational spaces (Saraev *et al.*, 2020), or the contribution of new woodland cover to improved biodiversity indicators, such as woodland birds (DEFRA, 2021b)? These suggestions likely come with their own set of data limitations and imperfect generalisations, but they may nonetheless be closer to the actual benefits the new woodlands are to provide. Natural colonisation, in this case, may profit by being judged not based on area of land covered or time taken to do so, but based on its actual contribution to a biodiverse and/or recreational and/or carbon negative landscape.

7.3 Conclusion

This research has shown that natural colonisation offers a range of opportunities for native woodland expansion, especially in a crowded landscape like Britain. It cannot yet be found on any available spatial datasets of tree cover, which needs remedying, because recent natural colonisation already exists, and critically a lot of it matches areas identified as woodland expansion opportunities. Unlike what might have been the case in the early 20th century, natural colonisation can now provide a range of benefits 21st century woodland expansion in Britain is looking for. It can unlock areas of woodland expansion where active planting is not suitable; more so, unintended natural colonisation is able to circumvent land management barriers that hinder other options of woodland expansion. It does not need an active decision on behalf of land managers or policy makers to establish; instead, it can take an opportunistic approach and use whatever chance surrounding land cover and land uses offer.

Because of this, natural colonisation should be emancipated as an equal and valid approach to 21st century native woodland expansion. In this, it should not be considered a replacement for active planting, merely the opposite end on a spectrum of human intervention, opening the playing field for a much wider variety of methods (and combinations thereof) to create new native woodland cover.

Future research can support this, by mapping natural colonisation for spatial datasets, thereby making this tree cover available for spatial modelling (such as the WEOMs) and environmental policy making; by engaging with land managers and widening the body of knowledge on land management decision making to cover natural colonisation; and by critically reviewing woodland creation targets and redefining when, exactly, woodland expansion should be considered 'successful'.

Integrating natural colonisation as a valid and equal option for creating native woodlands in Britain means embracing the crowdedness of the British landscape and its drivers, where no one 'perfect' woodland fits all. Whichever trade-off of interests will be negotiated in the pursuit of future woodlands – on a national, regional, or local level – the more options available to create them in a diverse landscape like Britain the better. Natural colonisation, as this research has demonstrated, is one of them.

8 References

Aigas Community Forest (2020) *Welcome to Aigas Community Forest*, *Aigas Community Forest*. Available at: https://www.aigasforest.org.uk/ (Accessed: 6 July 2022).

Alan, J. and Macdońald, B. (1945) 'The lon mor: Twenty years' research into wasteland peat afforestation in Scotland', *Forestry* [Preprint]. Available at: https://doi.org/10.1093/forestry/19.1.67.

Aldhous, J.R. (1997) 'British forestry: 70 years of achievement', *Forestry*, 70(4), pp. 283–291.

Alix-Garcia, J. *et al.* (2016) 'Drivers of forest cover change in Eastern Europe and European Russia, 1985–2012', *Land Use Policy* [Preprint]. Available at: https://doi.org/10.1016/j.landusepol.2016.08.014.

Anderson, J. (2020) *A balance must be struck between rewilding the Lake District and farming*, *The Mail*. Available at: https://www.nwemail.co.uk/news/18160047.balance-must-struck-rewilding-lake-district-farming/ (Accessed: 7 February 2022).

Arnell, N.W., Freeman, A. and Gazzard, R. (2021) 'The effect of climate change on indicators of fire danger in the UK', *Environmental Research Letters*, 16(4). Available at: https://doi.org/10.1088/1748-9326/abd9f2.

Arnott, D. *et al.* (2021) 'Vulnerability of British farms to post-Brexit subsidy removal, and implications for intensification, extensification and land sparing', *Land Use Policy*, 107, p. 104154. Available at: https://doi.org/10.1016/J.LANDUSEPOL.2019.104154.

Atkins, J.P. *et al.* (2011) 'Management of the marine environment: Integrating ecosystem services and societal benefits with the DPSIR framework in a systems approach', *Marine Pollution Bulletin* [Preprint]. Available at: https://doi.org/10.1016/j.marpolbul.2010.12.012.

Atkinson, P. *et al.* (2012) *Handbook of Ethnography*, *Handbook of Ethnography*. Available at: https://doi.org/10.4135/9781848608337.

Avery, M. and Lesley, R. (1990) *Birds and Forestry*. SPCK Publishing.

Ayres, S. and Wynne-Jones, S. (2014) 'Cambrian Wildwood – new ventures in a wilder landscape', *Ecos*.

Barbier, E.B., Burgess, J.C. and Grainger, A. (2010) 'The forest transition: Towards a more comprehensive theoretical framework', *Land Use Policy* [Preprint]. Available at: https://doi.org/10.1016/j.landusepol.2009.02.001.

Barclay, C. and Hughes, P. (1995) *Forest Policy: Research Paper 95/91*. London.

Barkham, P. (2019) *Can planting billions of trees save the planet*, *The Guardian*.

Barkham, P. (2021) *'I'm seen as the fool': the farmers putting trees back into the UK's fields*, *The Guardian*. Available at: https://www.theguardian.com/environment/2021/may/16/im-seen-as-the-fool-the-farmers-putting-trees-back-into-the-uks-fields (Accessed: 22 May 2021).

Barnes, A.P. *et al.* (2022) 'Farmer intentional pathways for net zero carbon: Exploring the lock-in effects of forestry and renewables', *Land Use Policy*, 112, p. 105861. Available at: https://doi.org/10.1016/J.LANDUSEPOL.2021.105861.

Barnosky, A.D. *et al.* (2017) 'Merging paleobiology with conservation biology to guide the future of terrestrial ecosystems', *Science*. Available at: https://doi.org/10.1126/science.aah4787.

Barrington, C.A.J. (1957) 'Forestry in Relation to Landscape', *Jounral of the Forestry Commission*, 26, pp. 223–225.

Bateman, I. *et al.* (2014) *UK National Ecosystem Assessment Follow-on*, *UK National Ecosystem Assessment Follow-on: A synthesis of key findings*.

BBC (2019) *General election 2019: Tories and Lib Dems in rival tree-planting pledges*, *BBC News*. Available at: https://www.bbc.co.uk/news/election-2019-50440867 (Accessed: 28 January 2021).

BBC (2020) *'UK's first tiny forest' in Witney helps urban environment*, *BBC News*.

Bell, G. *et al.* (2020a) *GIS for Area Statements: Map Atlas*. Aberystwyth.

Bell, G. *et al.* (2020b) *Opportunity Maps for Area for Implementing the Natural Resources Policy*. Aberystwyth.

Benítez, P.C. *et al.* (2007) 'Global potential for carbon sequestration: Geographical distribution, country risk and policy implications', *Ecological Economics*, 60(3). Available at: https://doi.org/10.1016/j.ecolecon.2005.12.015.

Bennett, C. (2019) *Why doubling tree cover will help stop climate chaos*, *Friends of the Earth*. Available at: https://friendsoftheearth.uk/climate-change/doubling-trees-will-help-stop-climate-chaos (Accessed: 3 December 2020).

Bentley Brymer, A.L. *et al.* (2020) 'Social-Ecological Processes and Impacts Affect Individual and Social Well-Being in a Rural Western U.S. Landscape', *Frontiers in Sustainable Food Systems*, 4. Available at: https://doi.org/10.3389/fsufs.2020.00038.

Bibby, P. (2009) ‘Land use change in Britain’, *Land Use Policy* [Preprint]. Available at: https://doi.org/10.1016/j.landusepol.2009.09.019.

Binder, C.R. *et al.* (2013) ‘Comparison of frameworks for analyzing social-ecological systems’, *Ecology and Society* [Preprint]. Available at: https://doi.org/10.5751/ES-05551-180426.

Black, A. (2019) ‘Quality in demand despite uncertainty’, *Farmers Guardian*, 24 May, p. 16.

Bluesky (2021) *National Tree Map*, *Bluesky International Ltd*. Available at: https://www.bluesky-world.com/ntm (Accessed: 14 March 2021).

BMEL (2015) *The Forests in Germany: Selected Results of the Third National Forest Inventory*. Berlin.

Bourdieu, P. (1983) ‘Economic Capital, Cultural Capital, Social Capital’, *Soziale Welt*, Supplement.

Boutaud, E. *et al.* (2019) ‘Life-history traits matter for dispersal into semi-open habitat corridors’, *ARPHA Conference Abstracts*, 2. Available at: https://doi.org/10.3897/aca.2.e37233.

Bowler, D.E. *et al.* (2012) ‘What are the effects of wooded riparian zones on stream temperature?’, *Environmental Evidence*. Available at: https://doi.org/10.1186/2047-2382-1-3.

BrewDog (2020) *BrewDog - Planet*, *BrewDog*. Available at: https://www.brewdog.com/uk/brewdogplanet (Accessed: 11 July 2022).

Bright, A., Gill, R. and Willings, T.H. (2016) ‘Tree cover and injurious feather-pecking in commercial flocks of freerange laying hens: A follow up’, *Animal Welfare*, 25(1). Available at: https://doi.org/10.7120/09627286.25.1.001.

Broome, A. *et al.* (2019) ‘Responding to ash dieback (Hymenoscyphus fraxineus) in the UK: Woodland composition and replacement tree species’, *Forestry*, 92(1). Available at: https://doi.org/10.1093/forestry/cpy040.

Broughton, R.K. *et al.* (2021) ‘Long-term woodland restoration on lowland farmland through passive rewilding’, *PLoS ONE*, 16(6 June 2021). Available at: https://doi.org/10.1371/journal.pone.0252466.

Brown, C. *et al.* (2018) ‘Land managers’ behaviours modulate pathways to visions of future land systems’, *Regional Environmental Change* [Preprint]. Available at: https://doi.org/10.1007/s10113-016-0999-y.

Brown, N. (1997) ‘Re-defining native woodland’, *Forestry* [Preprint]. Available at: https://doi.org/10.1093/forestry/70.3.191.

Bryant, A. and Charmaz, K. (2012) *The SAGE Handbook of Grounded Theory*, *The SAGE Handbook of Grounded Theory*. Available at: https://doi.org/10.4135/9781848607941.

BTO (2020) *Environmental Change in The Scottish Uplands*.

Burke, T. *et al.* (2021) ‘Achieving national scale targets for carbon sequestration through afforestation: Geospatial assessment of feasibility and policy implications’, *Environmental Science and Policy*, 124. Available at: https://doi.org/10.1016/j.envsci.2021.06.023.

Burns, S. (1999) ‘The natural step: A compass for environmental management systems’, *Corporate Environmental Strategy* [Preprint]. Available at: https://doi.org/10.1016/S1066-7938(00)80049-4.

Burton, R.J.F. (2004) ‘Seeing through the “good farmer’s” eyes: Towards developing an understanding of the social symbolic value of “productivist” behaviour’, *Sociologia Ruralis* [Preprint]. Available at: https://doi.org/10.1111/j.1467-9523.2004.00270.x.

Burton, R.J.F. (2012) ‘Understanding Farmers’ Aesthetic Preference for Tidy Agricultural Landscapes: A Bourdieusian Perspective’, *Landscape Research*, 37(1). Available at: https://doi.org/10.1080/01426397.2011.559311.

Burton, R.J.F., Kuczera, C. and Schwarz, G. (2008) ‘Exploring farmers’ cultural resistance to voluntary agri-environmental schemes’, *Sociologia Ruralis* [Preprint]. Available at: https://doi.org/10.1111/j.1467-9523.2008.00452.x.

Burton, V., Metzger, M.J., *et al.* (2018) ‘Green Gold to Wild Woodlands; understanding stakeholder visions for woodland expansion in Scotland’, *Landscape Ecology*. Available at: https://doi.org/10.1007/s10980-018-0674-4.

Burton, V., Moseley, D., *et al.* (2018) ‘Reviewing the evidence base for the effects of woodland expansion on biodiversity and ecosystem services in the United Kingdom’, *Forest Ecology and Management* [Preprint]. Available at: https://doi.org/10.1016/j.foreco.2018.08.003.

BW (2018) *Trees and hedges can improve livestock survivability on Welsh upland farms*, *Business Wales*. Available at: https://businesswales.gov.wales/farmingconnect/news-and-events/news/trees-and-hedges-can-improve-livestock-survivability-welsh-upland-farms (Accessed: 2 March 2021).

Cambrian Wildwood (2018) *Cambrian Wildwood: About the Project*. Available at: https://www.cambrianwildwood.org/about-the-project (Accessed: 17 April 2019).

Carnell, S. (2022) *Lost Forest: Why is BrewDog's green scheme causing controversy?*, *The Guardian*. Available at: https://www.theguardian.com/environment/2022/mar/05/lost-forest-why-is-brewdog-green-scheme-causing-controversy (Accessed: 11 July 2022).

Carrick, J. *et al.* (2019) 'Is planting trees the solution to reducing flood risks?', *Journal of Flood Risk Management*, 12. Available at: https://doi.org/10.1111/jfr3.12484.

Carrington, D. (2018) *Tree planting in UK 'must double to tackle climate change'*, *The Guardian*. Available at: https://www.theguardian.com/environment/2018/nov/15/tree-planting-double-uk-climate-change (Accessed: 28 August 2019).

Carrington, D. (2019) *Tree planting 'has mind-blowing potential' to tackle climate crisis*, *The Guardian*. Available at: https://www.theguardian.com/environment/2019/jul/04/planting-billions-trees-best-tackle-climate-crisis-scientists-canopy-emissions (Accessed: 28 January 2021).

Carroll, Z.L. *et al.* (2004) 'Can tree shelterbelts on agricultural land reduce flood risk?', *Soil Use and Management*, 20(3). Available at: https://doi.org/10.1079/sum2004266.

Case, P. (2019) 'Farmers fight back against anti-meat climate agenda', *Farmers Weekly*, 27 September, p. 15.

CCC (2019) *Net Zero: The UK's contribution to stopping global warming*. London. Available at: https://www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming/.

Ceauşu, S. *et al.* (2015) 'European wilderness in a time of farmland abandonment', in *Rewilding European Landscapes*. Available at: https://doi.org/10.1007/978-3-319-12039-3_2.

Ceausu, S. *et al.* (2015) 'Mapping opportunities and challenges for rewilding in Europe', *Conservation Biology* [Preprint]. Available at: https://doi.org/10.1111/cobi.12533.

CEH (2021) *Passive rewilding can rapidly expand UK woodland at no cost*, *UK Centre for Ecology & Hydrology*. Available at: https://www.ceh.ac.uk/press/passive-rewilding-can-rapidly-expand-uk-woodland-no-cost (Accessed: 7 July 2022).

Charmaz, K. and Belgrave, L.L. (2012) 'Qualitative interviewing and grounded theory analysis', in *The SAGE Handbook of Interview Research: The Complexity of the Craft*. Available at: https://doi.org/10.4135/9781452218403.n25.

Chazdon, R.L. *et al.* (2017) 'A Policy-Driven Knowledge Agenda for Global Forest and Landscape Restoration', *Conservation Letters* [Preprint]. Available at: https://doi.org/10.1111/conl.12220.

Chew, M.K. (2015) 'Ecologists, Environmentalists, Experts, and the Invasion of the "Second Greatest Threat"', *International Review of Environmental History*, 1. Available at: https://doi.org/10.22459/ireh.01.2015.02.

Church, A. and Ravenscroft, N. (2008) 'Landowner responses to financial incentive schemes for recreational access to woodlands in South East England', *Land Use Policy*, 25(1), pp. 1–16. Available at: https://doi.org/10.1016/J.LANDUSEPOL.2007.02.003.

Churchill, S. (2011) 'The need for a target in England?', in *The state of the UK's forests, woods and trees: Perspectives from the sector*. The Woodland Trust.

Clarke, P. (2019) 'Agroforestry offers multiple benefits for early adopters', *Farmers Weekly*, 23 August, p. 14f.

CLP (2018a) *Carneddau Landscape Partnership Scheme*.

CLP (2018b) *Carneddau Scheme - detailed project plans*.

Committee on Climate Change (2018) 'Land use: Reducing emissions and preparing for climate change', *Committee on Climate Change* [Preprint], (November).

Community Forest Trust (2020) *England's Community Forest Map*, *Community Forest Trust*. Available at: https://www.communityforest-trust.org/englands-community-forests-map (Accessed: 10 July 2022).

Confor (2019a) 'A 40,000 ha carbon capture factory', *Forestry & Timber News*, April, p. 14f.

Confor (2019b) *Woodland carbon targets for the UK*. Edinburgh.

Conrad, C.F. (1982) 'Grounded Theory: An Alternative Approach to Research in Higher Education', *The Review of Higher Education*, 5(4). Available at: https://doi.org/10.1353/rhe.1982.0010.

Corlett, R.T. (2016) 'Restoration, Reintroduction, and Rewilding in a Changing World', *Trends in Ecology and Evolution* [Preprint]. Available at: https://doi.org/10.1016/j.tree.2016.02.017.

Cosby, B.J. *et al.* (2020) *Environment and Rural Affairs Monitoring & Modelling Programme*. Bangor.

Countrysideinfo (2019) *Types of Coniferous Woodland*, *Countrysideinfo*. Available at: http://www.countrysideinfo.co.uk/woodland_manage/conifer.htm (Accessed: 2 September 2019).

Cox, K. *et al.* (2018) 'National parks or natural parks: How can we have both?', *British Wildlife*, 30(2).

CPRE (1937) *Council for the Preservation of Rural England: Annual Report 1936*.

Crabtree, B.F., Miller, W.L. and Swenson, M.M. (1995) 'Doing Qualitative Research', *Nursing Research* [Preprint]. Available at: https://doi.org/10.1097/00006199-199507000-00011.

Cramer, V.A., Hobbs, R.J. and Standish, R.J. (2008) 'What's new about old fields? Land abandonment and ecosystem assembly', *Trends in Ecology and Evolution* [Preprint]. Available at: https://doi.org/10.1016/j.tree.2007.10.005.

Crampton, J.W. (2001) 'Maps as social constructions: Power, communication and visualization', *Progress in Human Geography* [Preprint]. Available at: https://doi.org/10.1191/030913201678580494.

Crouzeilles, R. *et al.* (2020) 'Achieving cost-effective landscape-scale forest restoration through targeted natural regeneration', *Conservation Letters*. Available at: https://doi.org/10.1111/conl.12709.

Cuff, M. (2020) *Public back trees planting and renewable energy over new technologies such as carbon storage*, *Inews*. Available at: https://inews.co.uk/news/environment/public-backs-tree-planting-and-renewable-energy-over-new-technologies-such-as-carbon-storage-759540 (Accessed: 2 March 2021).

Cusworth, G. and Dodsworth, J. (2021) 'Using the "good farmer" concept to explore agricultural attitudes to the provision of public goods. A case study of participants in an English agri-environment scheme', *Agriculture and Human Values*, 38(4). Available at: https://doi.org/10.1007/s10460-021-10215-z.

CWP (1963) *Cabinet Working Party on Forest Policy, Draft Report, TNA: PRO F18/815*. London.

Dandy, N. and Wynne-Jones, S. (2019) 'Rewilding forestry', *Forest Policy and Economics* [Preprint]. Available at: https://doi.org/10.1016/j.forpol.2019.101996.

Darling, F.F. (1955) 'West Highland Survey. An Essay in Human Ecology', *AIBS Bulletin*, 5(3), p. 7.

Davidson, J. and Wibberley, G.P. (1977) *Planning and the Rural Environment*. Oxford: Pergamon Press.

Davies, J. (1979) *The Scottish Forester*. London: William Blackwood.

DEFRA (2008) *Understanding behaviours in a farming context: Defra Agricultural Change and Environment Observatory Discussion Paper*.

DEFRA (2013) *Government Forestry and Woodlands Policy Statement*. London.

DEFRA (2018) *Health and Harmony: the future for food, farming and the environment in a Green Brexit*. London.

DEFRA (2020a) *Agriculture in the United Kingdom 2020*, *Department for Environment Food and Rural Affairs (DEFRA)*.

DEFRA (2020b) *England Tree Strategy: Consultation*. London. Available at: https://consult.defra.gov.uk/forestry/england-tree-strategy/supporting_documents/englandtreestrategyconsultationdocument correctedv1.pdf.

DEFRA (2021a) *Environmental Land Management schemes: Overview*, *Department for Environment, Food & Rural Affairs*. Available at: https://www.gov.uk/government/publications/environmental-land-management-schemes-overview/environmental-land-management-scheme-overview (Accessed: 30 June 2022).

DEFRA (2021b) *UK Biodiversity Indicators 2021 Revisited*. London.

Delve, Ho. and Limpaecher, A. (2021) *Practical Guide to Grounded Theory Research*, *Delvetool*. Available at: https://delvetool.com/groundedtheory (Accessed: 30 May 2022).

Deng, S. *et al.* (2011) 'A GIS-based approach for quantifying and mapping carbon sink and stock values of forest ecosystem: A case study', in *Energy Procedia*. Available at: https://doi.org/10.1016/j.egypro.2011.03.263.

Denzler, L. (2018) *Wälder können einen riesigen Beitrag zum Klimaschutz leisten*, *Neue Zürcher Zeitung*. Available at: https://www.nzz.ch/wissenschaft/was-waelder-zum-klimaschutz-beitragen-koennen-ld.1402068 (Accessed: 25 March 2019).

Department for the Environment (1994) *Sustainable forestry: the UK programme. Cm 2429*. London. Available at: https://doi.org/9780101242929.

DiCicco-Bloom, B. and Crabtree, B.F. (2006) 'The qualitative research interview', *Medical Education* [Preprint]. Available at: https://doi.org/10.1111/j.1365-2929.2006.02418.x.

Ditchburn, B. *et al.* (2016) *Preliminary estimates of the changes in canopy cover in British woodlands between 2006 and 2015*. Edinburgh.

Ditchburn, B. and Brewer, A. (2017a) *Tree cover outside woodland in Great Britain*. Edinburgh.

Ditchburn, B. and Brewer, A. (2017b) *Tree cover outside woodland in Great Britain: statistical Report*. Edinburgh.

Dittrich, R. *et al.* (2019) 'A cost-benefit analysis of afforestation as a climate change adaptation measure to reduce flood risk', *Journal of Flood Risk Management*, 12(4). Available at: https://doi.org/10.1111/jfr3.12482.

Domínguez, G. and Shannon, M. (2011) 'A wish, a fear and a complaint: Understanding the (dis)engagement of forest owners in forest management', *European Journal of Forest Research*, 130(3). Available at: https://doi.org/10.1007/s10342-009-0332-0.

Dore, A. *et al.* (2020) ‘A non-invasive radar system for automated behavioural tracking: application to sheep’, *bioRxiv* [Preprint]. Available at: https://doi.org/10.1101/2020.12.09.418038.

Douglas, D.J.T., Groom, J.D. and Scridel, D. (2020) ‘Benefits and costs of native reforestation for breeding songbirds in temperate uplands’, *Biological Conservation*, 244. Available at: https://doi.org/10.1016/j.biocon.2020.108483.

Dowson, B. and Hill, T. (1998) ‘Community forest recreation - a dynamic model for our future countryside?’, *Managing Leisure*, 3(1). Available at: https://doi.org/10.1080/13606719808559323.

Duckett, D. *et al.* (2016) ‘Tackling wicked environmental problems: The discourse and its influence on praxis in Scotland’, *Landscape and Urban Planning*, 154. Available at: https://doi.org/10.1016/j.landurbplan.2016.03.015.

Duesberg, S., O’Connor, D. and Dhubháin, áine N. (2013) ‘To plant or not to plant—Irish farmers’ goals and values with regard to afforestation’, *Land Use Policy*, 32, pp. 155–164. Available at: https://doi.org/10.1016/J.LANDUSEPOL.2012.10.021.

Dwyer, J. (2018) *The Implications of Brexit for Agriculture, Rural Areas and Land Use in Wales*.

Eddy, J. (2020) *White Paper: National Tree Map Application*. Ashby-De-La-Zouch.

Edina (2022) *agCensus Digimap*, *Edina*. Available at: https://digimap.edina.ac.uk/agcensus (Accessed: 9 June 2022).

EEA (2002) *Towards an urban atlas*, *Assessment of spatial data on 25 European cities and urban areas*. European Environment Agency.

EEA (2004) *High nature value farmland: Characteristics, trends and policy challenges*. Luxembourg.

Eggers, B. *et al.* (2010) ‘Value of semi-open corridors for simultaneously connecting open and wooded habitats: A case study with ground beetles: Contributed paper’, *Conservation Biology*, 24(1). Available at: https://doi.org/10.1111/j.1523-1739.2009.01295.x.

Ellersgaard, C.H., Ditlevsen, K. and Larsen, A.G. (2021) ‘Say my name? Anonymity or not in elite interviewing’, *International Journal of Social Research Methodology* [Preprint]. Available at: https://doi.org/10.1080/13645579.2021.1932717.

Elliott, M. *et al.* (2017) ‘“And DPSIR begat DAPSI(W)R(M)!” - A unifying framework for marine environmental management’, *Marine Pollution Bulletin* [Preprint]. Available at: https://doi.org/10.1016/j.marpolbul.2017.03.049.

England, R. (2019) *Climate Change: tree planting rise ‘needs to happen quickly’*, *BBC News*.

ESBC (2020) *Enjoy more in Staffordshire*, *East Staffordshire Borough Council*. Available at: https://www.eaststaffsbc.gov.uk/tourism/enjoy-more-in-staffordshire (Accessed: 6 July 2022).

Eurostat (1999) *Towards environmental pressure indicators for the EU*. Luxembourg.

Evans, J. and Jones, P. (2011) ‘The walking interview: Methodology, mobility and place’, *Applied Geography*, 31(2). Available at: https://doi.org/10.1016/j.apgeog.2010.09.005.

Eves, C. *et al.* (2015) *Analysis of the potential effects of various influences and interventions on woodland management and creation decisions, using a segmentation model to categorise sub-groups. Volume 4: Woodland creation segmentation and assessment of interventions*.

Fall, J. (2017) *Drawing the line: Nature, hybridity and politics in transboundary spaces*, *Drawing the Line: Nature, Hybridity and Politics in Transboundary Spaces*. Available at: https://doi.org/10.4324/9781351159562.

Falloon, P. *et al.* (2004) ‘Managing field margins for biodiversity and carbon sequestration: a Great Britain case study’, *Soil Use and Management*, 20(2). Available at: https://doi.org/10.1079/sum2004236.

FAO (2008) ‘Fighting food inflation through sustainable investment - Grain production and export potential in CIS countries’, in *Food and Agriculture Organization of the United Nations*.

FC (1921) *First Annual Report of the Forestry Commissioners. Year ending September 30th, 1920.* London.

FC (1924) *Fourth Annual Report of the Forestry Commissioners. Year ending September 30th, 1923.* London.

FC (1930) *Tenth Annual Report of the Forestry Commissioners. Year ending September 30th, 1929.* London.

FC (1935) *Report of the National Forest Park Committee 1935*. London.

FC (1936) *Sixteenth Annual Report of the Forestry Commissioners for the year ending September 30th 1935*. London.

FC (1937) *Seventeenth Annual Report of the Forestry Commissioners for the Year ending September 30th 1936*. London.

FC (1939) *Nineteenth Annual Report of the Forestry Commissioners for the year ending September 30th 1938*. London.

FC (1943a) *Post-War Forest Policy. Report by H.M. Forestry Comissioners. Cmd. 6447.* London.

FC (1943b) *Twenty-Third Annual Report of the Forestry Commissioners for the year ending September 30th 1942*. London.

FC (1944) *Twenty-fourth Annual Report of the Forestry Commissioners for the Year ending September 30th 1943*. London.

FC (1945a) *Review of the first twenty-five years work 1919-1944*. London.

FC (1945b) *Twenty-fifth Annual Report of the Forestry Commissioners for the Year ending September 30th 1944*. London.

FC (1946) *Twenty-Sixth Annual Report of the Forestry Commissioners for the year ending September 30th 1945*. London.

FC (1947) *Twenty-Seventh Annual Report of the Forestry Commissioners for the year ending September 30th 1946*. London.

FC (1949) *Twenty-Ninth Annual Report of the Forestry Commissioners for the year ending September 30th 1948*. London.

FC (1950) *Thirtieth Annual Report of the Forestry Commissioners for the year ending September 30th 1949*. London.

FC (1952a) *Census of Woodlands 1947-1949: Census Report no. 1*. London.

FC (1952b) *Thirty-Second Annual Report of the Forestry Commissioners for the year ending September 30th 1951*. London.

FC (1954) *Thirty-Fourth Annual Report of the Forestry Commissioners for the year ended September 30th 1953*. London.

FC (1955) 'Forestry Commission: proposal to use compulsory purchase order to acquire derelict woodland for rehabilitation'. Kew.

FC (1956) *Thirty-Sixth Annual Report of the Forestry Commissioners for the year ended 30th September 1955*. London.

FC (1958) *Thirty-Eight Annual Report of the Forestry Commissioners for the year ended 30th September 1957*. London.

FC (1959) *Thirty-Ninth Annual Report of the Forestry Commissioners for the year ended 30th September 1958*. London.

FC (1960) *Fortieth Annual Report of the Forestry Commissioners for the year ended 30th September 1959*. London.

FC (1962) *Forty-Second Annual Report of the Forestry Commissioners for the year ended 30th September 1961*. London.

FC (1964) *Forty-Fourth Annual Report of the Forestry Commissioners for the year ended 30th September 1963*. London.

FC (1966) *Forty-Sixth Annual Report of the Forestry Commissioners for the year ended 30th September 1965*. London.

FC (1968) *Report and Accounts of the Forestry Commission for the year ended 30th September 1967 together with the Comptroller and Auditor General's Report on the Accounts*. London.

FC (1972) *Fifty-Second Annual Report of the Forestry Commission 1971-1972*. London.

FC (1976) *Forestry Commission Fifty-Sixth Annual Report and Accounts 1975-1976*. London.

FC (1977) *The Wood Production Outlook in Britain*. Edinburgh.

FC (1980) *Forestry Commission 60th Annual Report and Accounts 1979-1980*. London.

FC (1985) *The Policy for Broadleaved Woodlands*. Edinburgh.

FC (1987) *Forestry Commission 67th Annual Report and Accounts 1986-87*. London. Available at: https://www.forestresearch.gov.uk/research/archive-forestry-commission-67th-annual-report-and-accounts-1986-87/.

FC (1991) *Forestry Commission 71st Annual Report and Accounts 1990-91*. London. Available at: https://www.forestresearch.gov.uk/research/archive-forestry-commission-71st-annual-report-and-accounts-1990-91/.

FC (1992) *72nd Annual Report and Accounts for the year ended 31 March 1992*. London.

FC (1996) *Forestry Commission 76th Annual Report and Accounts 1995-96*. London. Available at: https://www.forestresearch.gov.uk/research/archive-forestry-commission-76th-annual-report-and-accounts-1995-96/.

FC (1999) *Forestry Commission 79th Annual Report and Accounts 1998-99*. London. Available at: https://www.forestresearch.gov.uk/research/archive-forestry-commission-79th-annual-report-and-accounts-1998-99/.

FC (2004) *Forestry Commission Annual Report and Accounts: GB and England 2003-2004*. Edinburgh.

FC (2011) *The UK Forestry Standard*. Edinburgh.

FC (2017) *The UK Forestry Standard - the government's approach to sustainable forestry*. Edinburgh.

FC (2018a) *Forestry Statistics 2018. Chapter 1: Woodland Areas and Planting.* Edinburgh.

FC (2018b) *Forestry Statistics 2018. Chapter 2: UK-Grown Timber.* Edinburgh.

FC (2018c) *Forestry Statistics 2018. Introduction, Glossary, Sources.* Edinburgh.

FC (2020) *Woodland Creation Planning Grant: Guidance*, *UK government*. Available at: https://www.gov.uk/guidance/woodland-creation-planning-grant (Accessed: 2 March 2021).

FC (2021) *Using natural colonisation for the creation of new woodland*. Available at: https://www.gov.uk/government/publications/using-natural-colonisation-for-the-creation-of-new-woodland.

FC Scotland (2009a) *Management of ancient wood pasture: Guidance*. Edinburgh.

FC Scotland (2009b) *The Scottish Government's Rationale for Woodland Expansion*. Edinburgh.

FFCC (2021) *Farming for Change: Mapping a route to 2030*. London.

Ficko, A. *et al.* (2017) 'European private forest owner typologies: A review of methods and use', *Forest Policy and Economics*. Available at: https://doi.org/10.1016/j.forpol.2017.09.010.

Fischer, J., Hartel, T. and Kuemmerle, T. (2012) 'Conservation policy in traditional farming landscapes', *Conservation Letters* [Preprint]. Available at: https://doi.org/10.1111/j.1755-263X.2012.00227.x.

Fisher, B., Turner, R.K. and Morling, P. (2009) 'Defining and classifying ecosystem services for decision making', *Ecological Economics* [Preprint]. Available at: https://doi.org/10.1016/j.ecolecon.2008.09.014.

Fitzgerald, O., Collins, C.M. and Potter, C. (2021) 'Woodland Expansion in Upland National Parks: An Analysis of Stakeholders Views and Understanding in the Dartmoor National Park, UK', *Land*, 10(270), p. 18. Available at: https://doi.org/10.3390/land10030270.

FLD (2019) *History - Timeline*, *Friends of the Lake District*. Available at: https://www.friendsofthelakedistrict.org.uk/pages/faqs/category/history-timeline (Accessed: 2 July 2018).

Flow Country Partnership (2022) *Aiming to become the UK's next Natural World Heritage Site*, *The Flow Country Partnership*. Available at: https://www.theflowcountry.org.uk/ (Accessed: 5 July 2022).

FLS (2019) *What we do*, *Forestry and Land Scotland*.

Forbes, A.C. (1904) *English Estate Forestry*. London: Edward Arnold.

Forbes, A.C. (1932) 'Fifty Years of English Forestry', *Quaterly Journal of Forestry*, XXVI, pp. 111–121.

Ford, H. *et al.* (2018) 'How does grazing management influence the functional diversity of oak woodland ecosystems? A plant trait approach', *Agriculture, Ecosystems and Environment*, 258. Available at: https://doi.org/10.1016/j.agee.2018.02.025.

Forest Research (2019) *Tools & Resources: Data Downloads*. Available at: https://www.forestresearch.gov.uk/tools-and-resources/statistics/data-downloads/ (Accessed: 19 February 2022).

Forest Research (2020a) *All publications and research*, *Forest Research*. Available at: https://www.forestresearch.gov.uk/research/ (Accessed: 20 December 2020).

Forest Research (2020b) *Forestry Statistics 2020*. Edinburgh. Available at: https://www.forestresearch.gov.uk/tools-and-resources/statistics/forestry-statistics/forestry-statistics-2020/.

Forest Research (2022) *Publications*, *Forest Research*. Available at: https://www.forestresearch.gov.uk/publications/ (Accessed: 26 June 2022).

Forest Service (2013) *The Second National Forest Inventory: Republic of Ireland: Field Procedures and Methodology*. Wexford.

Forestry and Land Scotland (2022) *Forests and land that Scotland can be proud of*, *Forestry and Land Scotland*. Available at: https://forestryandland.gov.scot/ (Accessed: 30 June 2022).

Forestry Commission (2021a) *Managing ash dieback in England*, *UK Government*. Available at: https://www.gov.uk/guidance/managing-ash-dieback-in-england (Accessed: 1 July 2022).

Forestry Commission (2021b) *Woodland creation and maintenance grant: Countryside Stewardship*. Available at: https://www.gov.uk/guidance/woodland-creation-grant-countryside-stewardship (Accessed: 21 February 2022).

Forestry Commission Wales (2009) *Woodlands for Wales. The Welsh Assembly Government's Strategy for Woodlands and Trees*.

Forestry England (2021) *The Forestry England Woodland Partnership*.

Forestry England (2022a) *Forestry England*, *Forestry England*. Available at: https://www.forestryengland.uk/ (Accessed: 30 June 2022).

Forestry England (2022b) *Growing the nation's forests*, *Forestry England*. Available at: https://www.forestryengland.uk/woodland-creation (Accessed: 29 June 2022).

Forster, E.J. *et al.* (2021) 'Commercial afforestation can deliver effective climate change mitigation under multiple decarbonisation pathways', *Nature Communications*, 12(1). Available at: https://doi.org/10.1038/s41467-021-24084-x.

Fowler, J. and Stiven, R. (2005) *Community Partnerships on the national forest estate*. Inverness.

Friends of the Earth (2020) *Woodland opportunity mapping - Where could we create woodland in England?*, *Friends of the Earth*. Available at: https://takeclimateaction.uk/woodland-opportunity-mapping-england (Accessed: 3 March 2021).

Fuchs, R. *et al.* (2013) 'A high-resolution and harmonized model approach for reconstructing and analysing historic land changes in Europe', *Biogeosciences* [Preprint]. Available at: https://doi.org/10.5194/bg-10-1543-2013.

Garside, R. and Wyn, I. (2021) *Tree-planting: Why are large investment firms buying Welsh farms?*, *BBC*. Available at: https://www.bbc.co.uk/news/uk-wales-58103603 (Accessed: 10 February 2022).

Gavinelli, F. *et al.* (2020) 'Unpredicted ecological and ecosystem services of biodiversity. Spontaneous vegetation, hedgerows, and maple trees as useful landscape components to increase predatory mite population in agroecosystems', *Applied Soil Ecology*, 154. Available at: https://doi.org/10.1016/j.apsoil.2020.103584.

George, S. (2019) *NFU: UK farming sector can reach net-zero by 2040, without ditching beef*, *Edie*. Available at: https://www.edie.net/news/6/NFU--UK-farming-sector-can-reach-net-zero-by-2040--without-ditching-beef/ (Accessed: 27 September 2019).

Gerard, F. *et al.* (2010) 'Land cover change in Europe between 1950 and 2000 determined employing aerial photography', *Progress in Physical Geography* [Preprint]. Available at: https://doi.org/10.1177/0309133309360141.

Germain, C.P. (1993) 'Qualitative approaches in nursing research. Ethnography: the method.', *NLN publications* [Preprint], (19–2535).

Gibbs, L., Atchison, J. and Macfarlane, I. (2015) 'Camel country: Assemblage, belonging and scale in invasive species geographies', *Geoforum*, 58. Available at: https://doi.org/10.1016/j.geoforum.2014.10.013.

Gimona, A. and Van Der Horst, D. (2007) 'Mapping hotspots of multiple landscape functions: A case study on farmland afforestation in Scotland', *Landscape Ecology* [Preprint]. Available at: https://doi.org/10.1007/s10980-007-9105-7.

Gold, S. (2019) *The effects of tree and scrubs on ecosystem services and biodiversity in the UK uplands a scoping review (NEER13)*. London.

Good, J.E.G., Bryant, R. and Carlill, P. (1990) 'Distribution, Longevity and Survival of Upland Hawthorn (Crataegus monogyna) Scrub in North Wales in Relation to Sheep Grazing', *The Journal of Applied Ecology* [Preprint]. Available at: https://doi.org/10.2307/2403584.

Good, J.E.G., Norris, D.A. and Daniels, A. (1995) *ESA research on upland scrub in Wales. Annaul Report 1995*. Bangor.

Goodeney, A.S. (2015) *Social cohesion and wellbeing deriving from woodland activities: Good from Woods*.

Goodenough, A. (2010) 'Are the ecological impacts of alien species misrepresented? A review of the "native good, alien bad" philosophy', *Community Ecology*, 11(1). Available at: https://doi.org/10.1556/ComEc.11.2010.1.3.

Goodenough, A. (2013) *In the wrong place at the wrong time*, *The Biologist*. Available at: https://thebiologist.rsb.org.uk/biologist-features/in-the-wrong-place-at-the-wrong-time (Accessed: 1 July 2022).

Graham, C.T. *et al.* (2017) 'Implications of afforestation for bird communities: the importance of preceding land-use type', *Biodiversity and Conservation*, 26(13). Available at: https://doi.org/10.1007/s10531-015-0987-4.

Graves, A.R. *et al.* (2008) 'Farmer Perceptions of Silvoarable Systems in Seven European Countries', in *Agroforestry in Europe*. Available at: https://doi.org/10.1007/978-1-4020-8272-6_4.

Greenhill, S. (2019) 'Propaganda war', *Farmers Guardian*, 16 August, p. 11.

Gregory, A.J. *et al.* (2013) 'A problem structuring method for ecosystem-based management: The DPSIR modelling process', *European Journal of Operational Research* [Preprint]. Available at: https://doi.org/10.1016/j.ejor.2012.11.020.

Griffiths, E. (2010) *A survey of Community Woodland Groups in Wales*.

Hale, K. *et al.* (2019) 'Rapid carbon accumulation within an unmanaged, mixed, temperate woodland', *Scandinavian Journal of Forest Research* [Preprint]. Available at: https://doi.org/10.1080/02827581.2019.1575975.

Halpern, B.S. *et al.* (2008) 'A global map of human impact on marine ecosystems', *Science* [Preprint]. Available at: https://doi.org/10.1126/science.1149345.

Hanking, B. *et al.* (2017a) *Mapping the potential for Working with Natural Processes - user guide*. Bristol.

Hanking, B. *et al.* (2017b) *Working with Natural Processes - Using the evidence base to make the case for Natural Flood Management*. Bristol.

Hardaker, A. (2018) 'Is forestry really more profitable than upland farming? A historic and present day farm level economic comparison of upland sheep farming and forestry in the UK', *Land Use Policy* [Preprint]. Available at: https://doi.org/10.1016/j.landusepol.2017.11.032.

Hardaker, A. (2021a) *Enhancing ecosystem service provision in the Welsh uplands - the role of increasing tree cover*.

Hardaker, A. (2021b) *Pathways for tree planting in the Welsh uplands to enhance ecosystem service provision. Project report to Coed Cymru.*

Hardaker, A., Pagella, T. and Rayment, M. (2021) 'Ecosystem service and dis-service impacts of increasing tree cover on agricultural land by land-sparing and land-sharing in the Welsh uplands', *Ecosystem Services*, 48. Available at: https://doi.org/10.1016/j.ecoser.2021.101253.

Hart, C. (1991) *Practical forestry for the Agent and Surveryor*. 3rd edn. The History Press.

Hearn, S.M. *et al.* (2011) 'The repeatability of vegetation classification and mapping', *Journal of Environmental Management* [Preprint]. Available at: https://doi.org/10.1016/j.jenvman.2010.11.021.

Helm, D. (2017) 'Agriculture after Brexit', *Oxford Review of Economic Policy*, 33. Available at: https://doi.org/10.1093/oxrep/grx010.

Hemery, G.E. (2006) 'Forestry in the early 21st Century - a historical perspective'. Oxon: Institute of Chartered Foresters, p. 4.

Hester, A.J., Mitchell, F.J.G. and Kirby, K.J. (1996) 'Effects of season and intensity of sheep grazing on tree regeneration in a British upland woodland', *Forest Ecology and Management*, 88(1–2). Available at: https://doi.org/10.1016/S0378-1127(96)03815-7.

HLL (2019) *Forestry Act 1919: 100 years*. London.

Hobbs, R.J. and Cramer, V.A. (2007) 'Why Old Fields? Socioeconomic and Ecological Causes and Consequences of Land Abandonment', *Old Fields*, pp. 1–14.

HoL Library (2019) 'Forestry Act 1919: 100 Years'. London: House of Lord Library, p. 4.

Hopkins, J. *et al.* (2017) 'Scottish farmers' intentions to afforest land in the context of farm diversification', *Forest Policy and Economics* [Preprint]. Available at: https://doi.org/10.1016/j.forpol.2017.01.014.

House of Commons Hansard (1943a) 'Civil Estimates, 1943: 06 July 1943, Volume 390'. London: UK Parliament.

House of Commons Hansard (1943b) 'Post-War Forestry Policy: HL Deb 29 July 1943 vl 128 cc847-927'. London: UK Parliament.

House of Commons Hansard (1957) 'Forestry, Agriculture and Marginal Land: HL Deb 29 October 1957 vol 205 cc536-44'. London: UK Parliament.

House of Commons Hansard (1973) ' Forestry Policy Volume 343: debated on Wednesday 20 June 1973', *House of Commons Hansard* [Preprint]. London: UK Parliament.

Howley, P. *et al.* (2015) 'Explaining the economic "irrationality" of farmers' land use behaviour: The role of productivist attitudes and non-pecuniary benefits', *Ecological Economics*, 109. Available at: https://doi.org/10.1016/j.ecolecon.2014.11.015.

Hughes, K. (2020) *Storms inflict £7.7bn worth of damage on a third of UK property*, *The Independent*. Available at: https://www.independent.co.uk/money/spend-save/storms-ciara-dennis-ellen-damage-flooding-trees-roof-tiles-insurance-claims-a9341536.html (Accessed: 10 February 2022).

Investment Property (2022) *Forestry Investment - Investing in commercial forestry*, *Investment Property*. Available at: https://investmentproperty.co.uk/property-investment-resources/forestry-investment-investing-in-commercial-woodlands/ (Accessed: 11 July 2022).

Iversen, S. v. *et al.* (2022) 'Why understanding stakeholder perspectives and emotions is important in upland woodland creation – A case study from Cumbria, UK', *Land Use Policy*, 114, p. 105929. Available at: https://doi.org/10.1016/J.LANDUSEPOL.2021.105929.

James, N.D.G. (1981) *A History of English Forestry*. Oxford: Basil Blackwell Publisher.

Jerome, G. (2017) ‘Defining community-scale green infrastructure’, *Landscape Research*, 42(2). Available at: https://doi.org/10.1080/01426397.2016.1229463.

JNCC (2021) *UK Biodiversity Indicators 2021: B6. Pressure from invasive species*, *Joint Nature Conservation Committee*. Available at: https://jncc.gov.uk/our-work/ukbi-b6-invasive-species/ (Accessed: 1 July 2022).

Joint Comittee FC & CPRE (1936) ‘Afforestation in the Lake District. Report by the Joint Informal Committee of the Forestry Commission and the CPRE, published as a White Paper in 1936.’

Jones, B. (2007) *A Framework to set Conservation Objectives and achieve favourable condition in the Welsh upland SSSIs*. Bangor.

Jones, E.L. and Thomas, K. (2006) ‘Man and the Natural World: Changing Attitudes in England, 1500-1800.’, *The Economic History Review* [Preprint]. Available at: https://doi.org/10.2307/2597247.

Jones, P. *et al.* (2008) ‘Exploring space and place with walking interviews’, *Journal of Research Practice*, 4(2).

de Jonge, V.N., Pinto, R. and Turner, R.K. (2012) ‘Integrating ecological, economic and social aspects to generate useful management information under the EU Directives’ “ecosystem approach”’, *Ocean and Coastal Management* [Preprint]. Available at: https://doi.org/10.1016/j.ocecoaman.2012.05.017.

Jounis, T. (1997) ‘Bottom up Interpretation after Rio: Rural Community Participation in Scottish Forestry’, *Community Development Journal*, 32(4), pp. 299–311.

Kabir, K.H., Knierim, A. and Chowdhury, A. (2021) ‘No forest, no dispute: the rights-based approach to creating an enabling environment for participatory forest management based on a case from Madhupur Sal Forest, Bangladesh’, *Journal of Environmental Planning and Management*, 64(1). Available at: https://doi.org/10.1080/09640568.2020.1744430.

Kail, J. *et al.* (2021) ‘Woody buffer effects on water temperature: The role of spatial configuration and daily temperature fluctuations’, *Hydrological Processes*, 35(1). Available at: https://doi.org/10.1002/hyp.14008.

Kaiser, K. (2009) ‘Protecting respondent confidentiality in qualitative research’, *Qualitative Health Research*, 19(11). Available at: https://doi.org/10.1177/1049732309350879.

Kaplan, J.O., Krumhardt, K.M. and Zimmermann, N. (2009) ‘The prehistoric and preindustrial deforestation of Europe’, *Quaternary Science Reviews* [Preprint]. Available at: https://doi.org/10.1016/j.quascirev.2009.09.028.

Keenleyside, C. and Tucker, G. (2010) ‘Farmland abandonment in the EU: an assessment of trends and prospects’, *Report prepared for WWF, Institute for European Environmental Policy* [Preprint]. Available at: https://doi.org/10.1016/j.outlook.2010.06.002.

King, A.C. and Woodroffe, J. (2019) ‘Walking interviews’, in *Handbook of Research Methods in Health Social Sciences*. Available at: https://doi.org/10.1007/978-981-10-5251-4_28.

Kitchin, R. and Dodge, M. (2007) ‘Rethinking maps’, *Progress in Human Geography* [Preprint]. Available at: https://doi.org/10.1177/0309132507077082.

Knepp Wildland (2020) *Knepp Wildland*, *Knepp Wildland*. Available at: https://knepp.co.uk/home (Accessed: 6 July 2022).

Kristensen, P. (2004) ‘The DPSIR framework’, *A comprehensive / detailed assessment of the vulnerability of water resources to environmental change in Africa using river basin approach.* [Preprint].

Kueffer, C. and Kull, C.A. (2017) ‘Non-native Species and the Aesthetics of Nature’, in *Impact of Biological Invasions on Ecosystem Services*. Available at: https://doi.org/10.1007/978-3-319-45121-3_20.

Kuemmerle, T. *et al.* (2011) ‘Post-Soviet farmland abandonment, forest recovery, and carbon sequestration in western Ukraine’, *Global Change Biology* [Preprint]. Available at: https://doi.org/10.1111/j.1365-2486.2010.02333.x.

Kuzel, A. (1999) ‘Sampling in qualitative inquiry’, in *Doing qualitative research*.

Lal, R. (2005) ‘Forest soils and carbon sequestration’, *Forest Ecology and Management* [Preprint]. Available at: https://doi.org/10.1016/j.foreco.2005.08.015.

Lambin, E.F. and Meyfroidt, P. (2010) ‘Land use transitions: Socio-ecological feedback versus socio-economic change’, *Land Use Policy* [Preprint]. Available at: https://doi.org/10.1016/j.landusepol.2009.09.003.

Lavalle, C. *et al.* (2001) ‘Monitoring megacities: The MURBANDY/MOLAND approach’, *Development in Practice* [Preprint]. Available at: https://doi.org/10.1080/09614520120056478.

Lawrence, A. and Dandy, N. (2014) ‘Private landowners’ approaches to planting and managing forests in the UK: What’s the evidence?’, *Land Use Policy* [Preprint]. Available at: https://doi.org/10.1016/j.landusepol.2013.09.002.

Lawrence, A., Dandy, N. and Urquhart, J. (2010) ‘Landowners’ attitudes to woodland creation and management in the UK A review of current evidence’, *Forestry Commission* [Preprint].

Linnard, W. (1982) *Welsh Woods and Forests: History and Utilization*. Cardiff: National Museum of Wales.

Llais y Goedwig (2022) *Community Woodlands*, *Llais y Goedwig*. Available at: https://llaisygoedwig.org.uk/about-community-woodlands/creating-a-new-community-woodland/ (Accessed: 10 June 2022).

Lle (2022) *Sites of Species Scientific Interest (SSSIs)*, *Lle - A Geo-Portal for Wales*. Available at: https://lle.gov.wales/catalogue/item/ProtectedSitesSitesOfSpecialScientificInterest/?lang=en (Accessed: 12 July 2022).

Lobley, M. *et al.* (2012) *Making Land Available for Woodland Creation*. Exeter.

Locke, G.M.L. (1987) *Census of Woodlands and Trees 1979-1982*. London.

Lofland, J. *et al.* (2006) 'Analyzing Social Settings: A guide to qualitative observation and analysis (4th Ed.)', *Analyzing Social Settings: A guide to qualitative observation and analysis (4th Ed.)* [Preprint].

Lorimer, J. *et al.* (2015) 'Rewilding: Science, Practice, and Politics', *Annual Review of Environment and Resources* [Preprint]. Available at: https://doi.org/10.1146/annurev-environ-102014-021406.

LUFP (2020) *London Urban Forest Plan*. London. Available at: https://www.london.gov.uk/sites/default/files/londonurbanforestplan_final.pdf (Accessed: 26 February 2022).

Lyon, G. (2019) *'Election campaign becomes bidding war on tree planting'*, *The Press and Journal*. Available at: https://www.pressandjournal.co.uk/fp/business/farming/1907100/election-campaign-becomes-bidding-war-on-tree-planting/ (Accessed: 6 April 2021).

Mackay, D. (1995) *Scotland's Rural Land Use Agencies: The History and Effectiveness in Scotland of the Forestry Commission, Nature Conservancy Council, and Countryside Commission for Scotland*. Aberdeen: Scottish Cultural Press.

MacKenzie, N.A. (1999) 'The Native Woodland Resource of Scotland', *Forestry Commission Technical Paper*. Edinburgh: Forestry Commission.

Manning, A.D., Fischer, J. and Lindenmayer, D.B. (2006) 'Scattered trees are keystone structures - Implications for conservation', *Biological Conservation*, 132(3). Available at: https://doi.org/10.1016/j.biocon.2006.04.023.

Martínez, D. and García, D. (2017) 'Role of Avian Seed Dispersers in Tree Recruitment in Woodland Pastures', *Ecosystems* [Preprint]. Available at: https://doi.org/10.1007/s10021-016-0043-6.

Martínez-Ruiz, C. *et al.* (2021) 'Effect of the forest-mine boundary form on woody colonization and forest expansion in degraded ecosystems', *Forests*, 12(6). Available at: https://doi.org/10.3390/f12060773.

Mash, S. (2018) *Plans unveiled for 50 million tree new Northern Forest*, *Woodland Trust*. Available at: https://www.woodlandtrust.org.uk/blog/2018/01/new-northern-forest/ (Accessed: 17 April 2019).

Maslow, A.H. (1987) *Motivation and personality, 3rd ed.*, *Motivation and personality, 3rd ed.*

Mason, W.L. and Connolly, T. (2014) 'Mixtures with spruce species can be more productive than monocultures: Evidence from the Gisburn experiment in Britain', *Forestry* [Preprint]. Available at: https://doi.org/10.1093/forestry/cpt042.

Mather, A. (1987) 'The Structure of Forest Ownership in Scotland: a First Approximation', *Journal of Rural Studies*, 3(2), pp. 175–182.

Mather, A.S. (1993) 'Protected areas in the periphery: Conservation and controversy in northern Scotland', *Journal of Rural Studies*, 9(4). Available at: https://doi.org/10.1016/0743-0167(93)90049-P.

Matthews, R. (2020) *Environment and Rural Affairs Monitorint & Modelling Programme (ERAMMP): National Forest in Wales: Evidence review Annex -4. Report to Welsh Government (Contract C210/2016/2017)(UKCEH 06297)*. Bangor.

Maxwell, J.S. (1930) 'A decade of state forestry and its lessons', *The Scottish Forestry Journal*, 44(1), pp. 1–6.

McGinlay, J., Gowing, D.J.G. and Budds, J. (2017) 'The threat of abandonment in socio-ecological landscapes: Farmers' motivations and perspectives on high nature value grassland conservation', *Environmental Science and Policy* [Preprint]. Available at: https://doi.org/10.1016/j.envsci.2016.12.007.

McKenna, K. (2016) *The National Trust, the sheep farm and the fight for a Lakes way of life*. Available at: https://www.theguardian.com/environment/2016/sep/03/national-trust-lake-district-borrowdale-sheep-farm-sale-fight (Accessed: 7 February 2022).

MCPFE (2015) *State of Europe's forests 2015*, *The MCPFE report on sustainable forest management in Europe*. Available at: https://doi.org/10.1017/CBO9781107415324.004.

MEA (2005) *Guide to the Millennium Assessment Reports*, *Millennium Assessment*. Available at: https://www.millenniumassessment.org/en/index.html (Accessed: 5 September 2019).

Mell, I.C. (2011) 'The changing focus of England's Community Forest programme and its use of a green infrastructure approach to multi-functional landscape planning', *International Journal of Sustainable Society*, 3(4). Available at: https://doi.org/10.1504/IJSSOC.2011.043641.

Mey, G. and Mruck, K. (2011) 'Grounded-Theory-Methodologie: Entwicklung, Stand, Perspektiven', in *Grounded Theory Reader*. Available at: https://doi.org/10.1007/978-3-531-93318-4_1.

Milbrath, L.W. (1984) *Environmentalists: Vanguard for a New Society*. New York: State University of New York Press.

Miles, R.O. (1967) *Forestry in the English Landscape: a study of the cultivation of trees and their relationship to natural amenity and plantation design*. London: Faber.

Millennium Ecosystem Assessment (2005) *MA Conceptual Framework*. Available at: https://www.millenniumassessment.org/en/Condition.html#download (Accessed: 11 February 2023).

Miller, R. (1981) 'State Forestry for the Axe: A Study of the Forestry Commission and De-nationalisation by the Market', *Hobart Paper* [Preprint]. London: Institute of Economic Affairs.

Moore, E. *et al.* (2020) 'Species Selection and Management Under Farmer Managed Natural Regeneration in Dodoma, Tanzania', *Frontiers in Forests and Global Change*, 3. Available at: https://doi.org/10.3389/ffgc.2020.563364.

Morgan-Davies, C. *et al.* (2008) 'Integrating hill sheep production and newly established native woodland: Achieving sustainability through multiple land use in Scotland', *International Journal of Agricultural Sustainability*, 6(2). Available at: https://doi.org/10.3763/ijas.2007.0248.

Moseley, D. *et al.* (2018) 'Developing an indicator for the physical health benefits of recreation in woodlands', *Ecosystem Services* [Preprint]. Available at: https://doi.org/10.1016/j.ecoser.2017.12.008.

Munton, R. (2009) 'Rural land ownership in the United Kingdom: Changing patterns and future possibilities for land use', *Land Use Policy*, 26(SUPPL. 1). Available at: https://doi.org/10.1016/j.landusepol.2009.08.012.

Naderifar, M., Goli, H. and Ghaljaie, F. (2017) 'Snowball Sampling: A Purposeful Method of Sampling in Qualitative Research', *Strides in Development of Medical Education*, 14(3). Available at: https://doi.org/10.5812/sdme.67670.

Nair, P.K.R., Kumar, B.M. and Nair, V.D. (2009) 'Agroforestry as a strategy for carbon sequestration', *Journal of Plant Nutrition and Soil Science* [Preprint]. Available at: https://doi.org/10.1002/jpln.200800030.

NAO (1986) *Review of Forestry Commission Objectives and Achievements*. London.

National Parks UK (2019) *History of the National Parks*, *National Parks UK*. Available at: https://nationalparks.uk/students/whatisanationalpark/history (Accessed: 27 June 2019).

National Trust (2021a) *Discover Our Land Ownership Map | National Trust*, *The National Trust*. Available at: https://www.nationaltrust.org.uk/features/follow-the-history-of-our-places-with-land-map (Accessed: 6 December 2021).

National Trust (2021b) *Our tree planting ambition | National Trust*, *National Trust*. Available at: https://www.nationaltrust.org.uk/features/our-tree-planting-ambition (Accessed: 6 December 2021).

Nauman, E.-K. *et al.* (2018) *GIS for Area Statements Technical Report*. Aberystwyth. Available at: https://www.arcgis.com/apps/MapSeries/index.html?appid=f8741b82f4974486ae3ad0ddd8285692#.

Navarro, L.M. and Pereira, H.M. (2012) 'Rewilding abandoned landscapes in Europe', in *Ecosystems*. Available at: https://doi.org/10.1007/978-3-319-12039-3_1.

NCC (1986) *Nature Conservation and Afforestation in Britain*. Peterborough: Nature Conservancy Council.

Newby, H. (1999) *The National Trust: The Next Hundred Years*. The National Trust.

NFU (2019) *Achieving NET ZERO: Farming's 2040 goal*. Stoneleigh. Available at: https://www.nfuonline.com/nfu-online/business/regulation/achieving-net-zero-farmings-2040-goal/.

Ni Dhubhain, A. and Gardiner, J.J. (1994) 'Farmers' attitudes to forestry', *Irish Forestry 51* [Preprint], (1–2).

Nolan, P. (2019) 'Twenty five years of creating the Mersey Forest', *Environmental Law Review*, 21(4). Available at: https://doi.org/10.1177/1461452919889802.

Noormets, A. *et al.* (2014) 'Effects of forest management on productivity and carbon sequestration: A review and hypothesis', *Forest Ecology and Management* [Preprint]. Available at: https://doi.org/10.1016/j.foreco.2015.05.019.

NRW (2018) *Glastir Woodland Creation Planners' Guide: A guide to identifying and accommodating sensitivities when producing Woodland Creation Scheme plans*.

NRW (2020) *Glastir Woodland Scheme*, *Natural Resources Wales*. Available at: https://naturalresources.wales/guidance-and-advice/environmental-topics/woodland-management/new-woodland-creation/glastir-woodland-scheme/?lang=en (Accessed: 11 February 2021).

NRW (2022) *Natural Resources Wales: Looking after our environment for people and nature*, *Natural Resources Wales*. Available at: https://naturalresources.wales/?lang=en (Accessed: 30 June 2022).

NWLEICS (2022) *The National Forest*, *The North West Leicestershire District Council*. Available at: https://www.nwleics.gov.uk/pages/the_national_forest (Accessed: 6 July 2022).

O'Flynn, T. *et al.* (2021) 'Attending to nature: Understanding care and caring relations in forest management in the UK', *Journal of Rural Studies*, 86. Available at: https://doi.org/10.1016/j.jrurstud.2021.05.022.

O'Neill, C. *et al.* (2020) 'Forest regeneration on European sheep pasture is an economically viable climate change mitigation strategy', *Environmental Research Letters*, 15(10). Available at: https://doi.org/10.1088/1748-9326/abaf87.

Oosthoek, J. (2013) *Conquering the Highlands : A history of the afforestation of the Scottish uplands*, *Conquering the Highlands : A history of the afforestation of the Scottish uplands*. ANU Press. Available at: https://doi.org/10.26530/oapen_459902.

Oosthoek, J.-W. (2000) 'The Logic of British Forestry Policy, 1919-1970'. Stirling: Department of History, University of Sterling, p. 20.

Orr, H.G. *et al.* (2008) 'Climate change in the uplands: A UK perspective on safeguarding regulatory ecosystem services', *Climate Research*. Available at: https://doi.org/10.3354/cr00754.

Owen, T. (2021) *Fears large companies are buying mid Wales farms for tree planting*, *County Times*. Available at: https://www.countytimes.co.uk/news/19439739.fears-large-companies-buying-mid-wales-farms-tree-planting/ (Accessed: 10 February 2022).

Patrício, J. *et al.* (2015) 'DPSIR (and its offspring!) in marine and coastal ecosystems: Lessons from two decades of use'. London.

Patrício, J. *et al.* (2016) 'DPSIR-Two decades of trying to develop a unifying framework for marine environmental management?', *Frontiers in Marine Science* [Preprint]. Available at: https://doi.org/10.3389/fmars.2016.00177.

Pearce, D. (2006) *Environmental valuation in developed countries: Case studies*, *Environmental Valuation in Developed Countries: Case studies*.

Peterken, G. (2002) 'Reversing the habitat fragmentation of British woodlands', *WWF. assets.panda.org/downloads/ukforestsfragmentation.pdf* [Preprint].

Pickle, L.W. and Monmonier, M. (1997) 'How to Lie with Maps', *The American Statistician* [Preprint]. Available at: https://doi.org/10.2307/2685420.

Prager, K. (2015) 'Agri-environmental collaboratives for landscape management in Europe', *Current Opinion in Environmental Sustainability*. Available at: https://doi.org/10.1016/j.cosust.2014.10.009.

Pringle, D. (1994) *The First 75 Years. A brief Account of the History of the Forestry Commission*. Edinburgh.

Pritchard, C.E. *et al.* (2021) 'Spatial behaviour of sheep during the neonatal period: Preliminary study on the influence of shelter', *Animal*, 15(7). Available at: https://doi.org/10.1016/j.animal.2021.100252.

QGIS.org (2021) 'QGIS Geographic Information System'. QGIS Association.

QSR International Pty Ltd. (2020) 'NVivo'. QSR International Pty Ltd. . Available at: https://support.qsrinternational.com/nvivo/s/ (Accessed: 31 May 2022).

Quine, C.P., Bailey, S.A. and Watts, K. (2013) 'PRACTITIONER'S PERSPECTIVE: Sustainable forest management in a time of ecosystem services frameworks: Common ground and consequences', *Journal of Applied Ecology* [Preprint]. Available at: https://doi.org/10.1111/1365-2664.12068.

Quine, C.P. and Watts, K. (2009) 'Successful de-fragmentation of woodland by planting in an agricultural landscape? An assessment based on landscape indicators', *Journal of Environmental Management* [Preprint]. Available at: https://doi.org/10.1016/j.jenvman.2007.09.002.

R Core Team (2013) 'R: A language and environment for statistical computing. R Foundation for Statistical Computing.' Vienna: R Foundation for Statistical Computing.

Rae, A. (2017) *A land cover atlas of the United Kingdom*. Available at: https://figshare.com/articles/journal_contribution/A_Land_Cover_Atlas_of_the_United_Kingdom_Document_/5266495.

Ratcliffe, P.R. (2011) 'Population dynamics of red deer (Cervus elaphus L.) in Scottish commercial forests', *Proceedings of the Royal Society of Edinburgh. Section B. Biological Sciences* [Preprint]. Available at: https://doi.org/10.1017/s0269727000003808.

Raum, S. and Potter, C. (2015) 'Forestry paradigms and policy change: The evolution of forestry policy in Britain in relation to the ecosystem approach', *Land Use Policy* [Preprint]. Available at: https://doi.org/10.1016/j.landusepol.2015.08.021.

Read, D.J. *et al.* (2009) *Combating Climate Change: A Role for UK Forests. An assessment of the potential of the UK's trees and woodlands to mitigate and adapt to climate change*. Edinburgh.

Read, H. and Bengtsson, V. (2019) 'The Management of Trees in the Wood Pasture Systems of South East England', in *Silvicultures - Management and Conservation*. Available at: https://doi.org/10.5772/intechopen.86100.

Rebele, F. (2013) 'Differential succession towards woodland along a nutrient gradient', *Applied Vegetation Science*, 16, pp. 365–378. Available at: https://doi.org/10.1111/avsc.12006.

Reid, C.T. (1997) 'The Changing Pattern of Environmental Regulation: British Forestry and the Environmental Agenda', *Journal of ENvironmental Law*, 9(1), pp. 23–42.

Ren, K. *et al.* (2020) 'A sensor-fusion-system for tracking sheep location and behaviour', *International Journal of Distributed Sensor Networks*, 16(5). Available at: https://doi.org/10.1177/1550147720921776.

Rewilding Britain (2019a) *About us*, *Rewilding Britain*. Available at: https://www.rewildingbritain.org.uk/about/ (Accessed: 4 September 2019).

Rewilding Britain (2019b) *Rewilding*, *Rewilding Britain*. Available at: https://www.rewildingbritain.org.uk/rewilding/ (Accessed: 5 September 2019).

Rewilding Britain (2020) *Reforesting Britain: Why natural regeneration should be our default approach to woodland expansion*. Steyning. Available at: https://www.rewildingbritain.org.uk/news-and-views/research-and-reports/reforesting-britain.

Rey Benayas, J.M. and Bullock, J.M. (2012) 'Restoration of Biodiversity and Ecosystem Services on Agricultural Land', *Ecosystems* [Preprint]. Available at: https://doi.org/10.1007/s10021-012-9552-0.

Rey Benayas, J.M., Bullock, J.M. and Newton, A.C. (2008) 'Creating woodland islets to reconcile ecological restoration, conservation, and agricultural land use', *Frontiers in Ecology and the Environment* [Preprint]. Available at: https://doi.org/10.1890/070057.

RFS (2020) *Forestry and Climate Change*. Banbury. Available at: https://www.confor.org.uk/media/247656/rfs-forestry-and-climate-change-position-2020.pdf.

Ricketts Hein, J., Thomas Lane, E. and Williams, A. (2017) *The Future of the Welsh Uplands after the Common Agricultural Policy: Stakeholder Policy priorities.*

Roberts, G.C.S. and Kelly, R. (1994) 'The welsh hill farm - a cultural landscape in decline', *Landscape Research* [Preprint]. Available at: https://doi.org/10.1080/01426399408706445.

Robertson, W.A. (1943) *Post-War Forest Policy*. London.

RSPB (2012) *From conifer plantation to blanket bog: Peatland restoration in the Flow Country*, *Royal Society for the Preservation of Birds*. Available at: https://www.rspb.org.uk/our-work/conservation/projects/from-conifer-plantation-to-blanket-bog-peatland-restoration-in-the-flow-country/ (Accessed: 6 April 2021).

Rutley, D. (2019) *Tree Planting: Written question*, *UK Parliament*. Available at: https://www.parliament.uk/written-questions-answers-statements/written-question/commons/2019-02-04/216358 (Accessed: 4 September 2019).

Ryan, M. *et al.* (2022) 'Understanding planting preferences – A case-study of the afforestation choices of farmers in Ireland', *Land Use Policy*, 115, p. 105982. Available at: https://doi.org/10.1016/J.LANDUSEPOL.2022.105982.

Ryle, G. (1969) *Forest Service: The first forty-five years of the Forestry Commission of Great Britain*. David & Charles.

Sagoff, M. (2020) 'Fact and value in invasion biology', *Conservation Biology*, 34(3). Available at: https://doi.org/10.1111/cobi.13440.

Saraev, V. *et al.* (2020) *Scoping Study on Valuing Mental Health Benefits of Forests*.

Sarmin, N.S. *et al.* (2016) 'The DPSIR framework for causes analysis of mangrove deforestation in Johor, Malaysia', *Environmental Nanotechnology, Monitoring and Management* [Preprint]. Available at: https://doi.org/10.1016/j.enmm.2016.11.002.

Saunders, B., Kitzinger, J. and Kitzinger, C. (2015) 'Anonymising interview data: challenges and compromise in practice', *Qualitative Research*, 15(5). Available at: https://doi.org/10.1177/1468794114550439.

Savillis (2019) *Current Land Use*. Available at: https://www.savills.co.uk/research_articles/229130/274017-0 (Accessed: 15 March 2019).

Scambler, A. (1989) 'Farmers' attitudes towards forestry', *Scottish Geographical Magazine*, 105(1). Available at: https://doi.org/10.1080/00369228918736752.

Schama, S. (1996) *Landscape and Memory*. London: Fontana Press.

Scharin, H. *et al.* (2016) 'Processes for the sustainable stewardship of marine environments', *Ecological Economics* [Preprint]. Available at: https://doi.org/10.1016/j.ecolecon.2016.04.010.

Schmitzberger, I. *et al.* (2005) 'How farming styles influence biodiversity maintenance in Austrian agricultural landscapes', *Agriculture, Ecosystems and Environment*, 108(3). Available at: https://doi.org/10.1016/j.agee.2005.02.009.

Schnitzler, A. (2014) 'Towards a new European wilderness: Embracing unmanaged forest growth and the decolonisation of nature', *Landscape and Urban Planning* [Preprint]. Available at: https://doi.org/10.1016/j.landurbplan.2014.02.011.

Scholefield, P. *et al.* (2016) 'A model of the extent and distribution of woody linear features in rural Great Britain', *Ecology and Evolution* [Preprint]. Available at: https://doi.org/10.1002/ece3.2607.

Scholz, R.W. and Binder, C.R. (2003) 'The Paradigm of Human-Environment Systems', *Working Paper 37. Natural and Social Science Interface* [Preprint]. Available at: https://doi.org/10.3929/ethz-a-004520890.

Scotland's Environment (2019) *Woodland and Forests*, *Scotland's Environment*. Available at: https://www.environment.gov.scot/our-environment/habitats-and-species/woodland-and-forests/ (Accessed: 30 June 2022).

Scotland's Nature (2015) *Trees for Life*, *Scotland's Nature* . Available at: https://scotlandsnature.blog/2015/01/07/trees-for-life/ (Accessed: 6 July 2022).

Scottish Forestry (2019) *Supporting Sustainable Scottish Forestry*, *Scottish Forestry*.

Scottish Forestry (2020a) *Tweet from 14th Sept 2020*, *Twitter*. Available at: https://twitter.com/scotforestry/status/1305426799053148161?s=11 (Accessed: 19 February 2022).

Scottish Forestry (2020b) *Woodland Creation*, *Scottish Forestry*. Available at: https://forestry.gov.scot/support-regulations/woodland-creation (Accessed: 2 March 2021).

Scottish Forestry (2022a) *Phytophthora ramorum in Scotland*, *Scottish Forestry*. Available at: https://forestry.gov.scot/sustainable-forestry/tree-health/tree-pests-and-diseases/phytophthora-ramorum (Accessed: 1 July 2022).

Scottish Forestry (2022b) *Scottish Forestry is the Scottish Government agency responsible for forestry policy, support and regulations*, *Scottish Forestry*. Available at: https://forestry.gov.scot/ (Accessed: 30 June 2022).

Scottish Forestry (no date) *Forestry Grant Scheme*, *Scottish Forestry*. Available at: https://forestry.gov.scot/support-regulations/forestry-grants (Accessed: 21 February 2022).

Scottish Government (2011) *Getting the Best from Our Land: A Land Use Strategy for Scotland*. Edinburgh.

Scottish Government (2017) *Draft Climate Change Plan*. Edinburgh.

Scottish Government (2018) *Climate Change Plan: The Third Report on Proposals and Policies 2018-2032*. Edinburgh.

Scriban, R.E. *et al.* (2019) 'Governance of the forest restitution process in Romania: An application of the DPSIR model', *Forest Policy and Economics* [Preprint]. Available at: https://doi.org/10.1016/j.forpol.2017.10.018.

Seabrook, A. (2021) *Call to plant thousands of trees across Cardiff in fight against climate change*, *Wales Online*. Available at: https://www.walesonline.co.uk/news/politics/call-plant-thousands-trees-across-19730461 (Accessed: 2 March 2021).

Sene, J. (2020) *Planting Trees Isn't a Climate Plan - It's a Distraction*, *Natural Resources Defence Council*. Available at: https://www.nrdc.org/experts/jennifer-skene/planting-trees-isnt-climate-plan-its-distraction (Accessed: 19 March 2021).

Sherwood, H. (2019) *Getting back to nature: how forest bathing can make us feel better*, *The Guardian*.

Shrubsole, G. (2019) *General Election: party pledges on tree planting*, *Friends of the Earth*. Available at: https://friendsoftheearth.uk/system-change/general-election-party-pledges-tree-planting (Accessed: 6 April 2021).

Shrubsole, G. and Powell-Smith, A. (2021) *Who owns England*, *Who owns England*. Available at: https://map.whoownsengland.org (Accessed: 6 December 2021).

Silvasti, T. (2003) 'The cultural model of "the good farmer" and the environmental question in Finland', *Agriculture and Human Values*, 20(2). Available at: https://doi.org/10.1023/A:1024021811419.

Sing, L. *et al.* (2018) 'A review of the effects of forest management intensity on ecosystem services for northern European temperate forests', *Forestry: An International Journal of Forest Research*, 91(2), pp. 151–157. Available at: https://doi.org/10.1093/forestry/cpx042.

Sing, L., Towers, W. and Ellis, J. (2013) 'Woodland expansion in Scotland: an assessment of the opportunities and constraints using GIS', *RSFS Scottish Forestry* [Preprint].

Small Woods (2021) *Small Woods - Bringing Woodlands to Life*, *Small Woods*. Available at: https://www.smallwoods.org.uk/en/about-small-woods/ (Accessed: 11 July 2022).

Soil Association Scotland (2019) *A farming couple from East Renfrewshire say they have turned their livestock farm around by planting acres of hard-to-farm land with trees*, *Soil Association Scotland*. Available at: https://www.soilassociation.org/our-work-in-scotland/scotland-farming-programmes/resources-for-farmers/agroforestry/benefits-of-agroforestry/why-plant-trees-on-farms/ (Accessed: 26 February 2022).

Squires, N. (2014) *Rapid rise of forests changes the landscape for Italians: Abandonement of farm land has seen forested areas boom*, *The Telegraph*. Available at: https://www.telegraph.co.uk/news/worldnews/europe/italy/10828717/Rapid-rise-of-forests-changes-the-landscape-for-Italians.html (Accessed: 18 March 2019).

Stanley, J. (2019) '"Industrial" is no insult when it comes to productive farming', *Farmers Weekly*, 7 June.

StatsWales (2019) *Total lifestock in Wales per year*, *StatsWales*. Available at: https://statswales.gov.wales/Catalogue/Agriculture/Agricultural-Survey/Annual-Survey-Results/total-livestock-in-wales-by-year (Accessed: 10 June 2022).

Stewart, R. (2018) *Rory Stewart MP: rewilding leaves no place for people in the Lake District*, *Campaign for National Parks*. Available at: Rory Stewart MP: rewilding leaves no place for people in the Lake District (Accessed: 30 May 2022).

Stiles, W. (2017) *Agroforestry: an opportunity for sustainable intensification of farmland to improve productivity and reduce environmental impact*. Aberystwyth.

Strauss, A. and Corbin, J. (1990) 'Grounded Theory Procedures and Techniques', *Journal of Environmental Psychology*, 11(4).

Tanentzap, A.J., Zou, J. and Coomes, D.A. (2013) 'Getting the biggest birch for the bang: Restoring and expanding upland birchwoods in the Scottish Highlands by managing red deer', *Ecology and Evolution*, 3(7). Available at: https://doi.org/10.1002/ece3.548.

Tapper, J. (2021) *'How can we grow new forests if we don't have enough trees to plant?'*, *The Guardian*. Available at: https://www.theguardian.com/environment/2021/oct/31/how-can-we-grow-new-forests-if-we-dont-have-enough-trees-to-plant (Accessed: 18 December 2021).

Taylor, M., Goodley, S. and Syal Rajeev (2015) *Cost of UK floods tops £5bn, with thousands facing financial ruin*, *The Guardian*. Available at: https://www.theguardian.com/environment/2015/dec/28/uk-floods-costs-financial-ruin (Accessed: 10 February 2022).

Tembata, K. *et al.* (2020) 'Don't rely too much on trees: Evidence from flood mitigation in China', *Science of the Total Environment*, 732. Available at: https://doi.org/10.1016/j.scitotenv.2020.138410.

Temple, J. (2020) *'A Trillion Trees' is a great idea - that could become a dangerous climate distraction*, *MIT technology review*. Available at: https://www.technologyreview.com/2020/01/28/276052/tree-planting-is-a-great-idea-that-could-become-a-dangerous-climate-distraction/ (Accessed: 19 March 2021).

Tengberg, A. *et al.* (2012) 'Cultural ecosystem services provided by landscapes: Assessment of heritage values and identity', *Ecosystem Services* [Preprint]. Available at: https://doi.org/10.1016/j.ecoser.2012.07.006.

Terres, J.M., Nisini Scacchiafichi, L. and Anguiano, E. (2013) *Assessing the risk of farmland abandonment in the EU*, *Joint Research Centre Scientific and Policy Reports*. Available at: https://doi.org/LB-NA-25783-EN-N.

Thames Chase (2020) *The Thames Chase Plan*, *Thames Chase*. Available at: https://www.thameschase.org.uk/about-thames-chase/thames-chase-plan (Accessed: 6 July 2022).

The Crown Estate (2021) *Asset map | The Crown Estate*, *The Crown Estate*. Available at: https://www.thecrownestate.co.uk/en-gb/what-we-do/asset-map/ (Accessed: 6 December 2021).

The Mersey Forest (2020) *What is the Mersey Forest*, *The Mersey Forest*. Available at: https://www.merseyforest.org.uk/about/what-is-the-mersey-forest/ (Accessed: 6 July 2022).

The National Forest (2020) *The beginning of the National Forest*, *The National Forest*. Available at: https://www.nationalforest.org/about/our-history (Accessed: 6 July 2022).

The Scottish Government (2016) *Getting the best from our land: A land use strategy for Scotland*. Edinburgh.

The Scottish Government (2017) *Draft Climate Change Plan: The draft third report on policies and proposals 2017-2032*. Edinburgh.

Thees, O. and Olschewski, R. (2017) 'Physical soil protection in forests - insights from production-, industrial- and institutional economics', *Forest Policy and Economics* [Preprint]. Available at: https://doi.org/10.1016/j.forpol.2017.01.024.

Thers, H., Bøcher, P.K. and Svenning, J.C. (2019) 'Using lidar to assess the development of structural diversity in forests undergoing passive rewilding in temperate Northern Europe', *PeerJ* [Preprint]. Available at: https://doi.org/10.7717/peerj.6219.

Thomas, H.J.D. *et al.* (2015) 'Towards a research agenda for woodland expansion in Scotland', *Forest Ecology and Management* [Preprint]. Available at: https://doi.org/10.1016/j.foreco.2015.04.003.

Thompson, R. (2004) 'Predicting site suitability for natural colonisation - upland birchwoods and native pinewoods in northern Scotland', *Forestry Commission Information Note* [Preprint].

Tiang, D.C.F. *et al.* (2021) 'Ecological connectivity in fragmented agricultural landscapes and the importance of scattered trees and small patches', *Ecological Processes*, 10(1). Available at: https://doi.org/10.1186/s13717-021-00284-7.

Tompkins, S. (1989) *Forestry in crisis - the battle for the hills*. London: Christopher Helm.

Tougiani, A., Guero, C. and Rinaudo, T. (2009) 'Community mobilisation for improved livelihoods through tree crop management in Niger', *GeoJournal*, 74(5). Available at: https://doi.org/10.1007/s10708-008-9228-7.

Travers, E. *et al.* (2021) ‘The role of semi-open habitats as dispersal corridors for plant species of woodlands and open habitats’, *Applied Vegetation Science*, 24(1). Available at: https://doi.org/10.1111/avsc.12526.

Trees for Life (2019) *Introducing Trees for Life*, *Trees for Life*. Available at: https://treesforlife.org.uk/work/ (Accessed: 17 April 2019).

Trees for Life (2021) *Affric Highlands*, *Trees for Life*. Available at: https://treesforlife.org.uk/about-us/affric-highlands/ (Accessed: 10 June 2022).

Trint (2021) *Trint Audio and Video Transcription Service*, *Trint*. Available at: https://trint.com/?tid=1811565a3b5504-0dc741bc9e32d68-402e2c34-13c680-1811565a3b66c2.

Trust, W. (2019) *Pine, Scots (Pinus Sylvestris)*, *Woodland Trust*. Available at: https://www.woodlandtrust.org.uk/visiting-woods/trees-woods-and-wildlife/british-trees/a-z-of-uk-native-trees/scots-pine/ (Accessed: 2 September 2019).

Tsouvalis, J. (2000) *A Critical Geography of Britain’s State Forests*. Oxford: Oxford University Press.

Turczański, K., Dyderski, M.K. and Rutkowski, P. (2021) ‘Ash dieback, soil and deer browsing influence natural regeneration of European ash (Fraxinus excelsior L.)’, *Science of the Total Environment*, 752. Available at: https://doi.org/10.1016/j.scitotenv.2020.141787.

Turner, A. (2018a) *Habitat and Species Characterisitcs of the Landscape Character Areas of the Carneddau*. Penrhyndeudraeth.

Turner, A. (2018b) *Production of key summaries of ecological data in support of the Carneddau Landscape Partnership project*. Penrhyndeudraeth.

UK Government (2019) *Urban Tree Challenge Fund*, *UK Government*. Available at: https://www.gov.uk/guidance/urban-tree-challenge-fund (Accessed: 26 February 2022).

UK government (2021) *England Woodland Creation Offer Application form*, *UK government*. Available at: https://www.gov.uk/government/publications/england-woodland-creation-offer-application-form (Accessed: 9 September 2021).

UK Government (2021) *The England Trees Action Plan 2021-2024*. London.

UK Government (2022a) *Forestry Commission*, *UK Government*. Available at: https://www.gov.uk/government/organisations/forestry-commission (Accessed: 30 June 2022).

UK Government (2022b) *Using natural colonisation for the creation of new woodlands*, *UK Government*. Available at: https://www.gov.uk/government/publications/using-natural-colonisation-for-the-creation-of-new-woodland (Accessed: 18 July 2022).

UK NEA (2011a) *UK National Ecosystem Assessment - Chapter 8: Woodlands*. Cambridge. Available at: http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx (Accessed: 30 June 2022).

UK NEA (2011b) *UK National Ecosystem Assessment: Technical Report*. Cambridge. Available at: http://uknea.unep-wcmc.org/LinkClick.aspx?fileticket=m%2BvhAV3c9uk%3D&tabid=82.

UK Parliament (2021) ‘Woodland Creation: Postnote No 636 January 2021’. London: UK Parliament Post.

UKandEU (2019) *When did Britain decide to join the European Union?*, *UK in a Changing Europe*. Available at: https://ukandeu.ac.uk/fact-figures/when-did-britain-decide-to-join-the-european-union/ (Accessed: 6 August 2019).

Urquhart, J., Courtney, P. and Slee, B. (2010) ‘Private ownership and public good provision in english woodlands’, *Small-scale Forestry*, 9(1). Available at: https://doi.org/10.1007/s11842-009-9098-y.

Veldman, J.W. *et al.* (2015) ‘Where Tree Planting and Forest Expansion are Bad for Biodiversity and Ecosystem Services’, *BioScience*. Available at: https://doi.org/10.1093/biosci/biv118.

Vellend, M. (2017) ‘Are local losses of biodiversity causing degraded ecosystem function?’, in *Effective Conservation Science: Data Not Dogma*. Available at: https://doi.org/10.1093/oso/9780198808978.003.0004.

Verburg, P.H. and Overmars, K.P. (2009) ‘Combining top-down and bottom-up dynamics in land use modeling: Exploring the future of abandoned farmlands in Europe with the Dyna-CLUE model’, *Landscape Ecology* [Preprint]. Available at: https://doi.org/10.1007/s10980-009-9355-7.

Vollstedt, M. (2015) ‘To See the Wood for the Trees: The Development of Theory from Empirical Interview Data Using Grounded Theory’, in. Available at: https://doi.org/10.1007/978-94-017-9181-6_2.

Vollstedt, M. and Rezat, S. (2019) ‘An Introduction to Grounded Theory with a Special Focus on Axial Coding and the Coding Paradigm’, in. Available at: https://doi.org/10.1007/978-3-030-15636-7_4.

Vos, A. and Davies, K. (2021) ‘Landholder perceptions of revegetation on the Atherton Tablelands, far North Queensland’, *Ecological Management and Restoration*, 22(1). Available at: https://doi.org/10.1111/emr.12438.

Wade, T.G. *et al.* (2003) ‘Distribution and causes of global forest fragmentation’, *Ecology and Society* [Preprint]. Available at: https://doi.org/10.5751/ES-00530-070207.

Wallace, L. *et al.* (2012) 'Development of a UAV-LiDAR system with application to forest inventory', *Remote Sensing* [Preprint]. Available at: https://doi.org/10.3390/rs4061519.

Wallis, W. (2019) *'Land will be abandoned': UK's farmers feel squeeze as Brexit looms*, *Financial Times*. Available at: https://www.ft.com/content/0f3dce0e-eb87-11e9-a240-3b065ef5fc55 (Accessed: 28 April 2020).

Warren, C. (2000) '"Birds, bogs and forestry" revisited: The significance of the flow country controversy', *Scottish Geographical Journal* [Preprint]. Available at: https://doi.org/10.1080/00369220018737103.

Warren, C.R. (2021) 'Beyond "Native V. Alien": Critiques of the Native/alien Paradigm in the Anthropocene, and Their Implications', *Ethics, Policy and Environment* [Preprint]. Available at: https://doi.org/10.1080/21550085.2021.1961200.

Warren, T. and Murphy, A.J. (2006) 'Discovering Qualitative Methods: Field Research, Interviews, and Analysis/Doing Qualitative Research: A Practical Handbook/Qualitative Interviewing: The Art of Hearing Data.', *Technical Communication* [Preprint].

Watkins, C. (1986) 'Recent changes in government policy towards broadleaved woodland', *Area*, 18(2).

Watson, F. and Smout, T.C. (2007) 'Nature Contested: Environmental History in Scotland and Northern England Since 1600', *Environmental History* [Preprint]. Available at: https://doi.org/10.2307/3985461.

Watts, K. (2006) *British Forest Landscapes: The Legacy of Woodland Fragmentation*.

Watts, K. (2021) *Tweet from 29th Jul 2021*, *Twitter*. Available at: https://twitter.com/watts_km/status/1420693044219633670 (Accessed: 20 August 2021).

Welsh Assembly Government (2010) 'Climate Change Strategy for Wales', *Business* [Preprint]. Available at: https://doi.org/10.1109/TIP.2015.2505184.

Welsh Government (2014a) *Glastir Woodland Creation - Opportunities Map*, *Lle*. Available at: http://lle.gov.wales/apps/woodlandopportunities/ (Accessed: 11 February 2021).

Welsh Government (2014b) *Glastir Woodland Creation Opportunities Map Guidance*. Cardiff.

Welsh Government (2018) *Woodlands for Wales: The Welsh Government's Strategy for Woodlands and Trees*. Cardiff.

Welsh Government (2020a) *Agriculture (Wales) White Paper: Consultation Document*. Cardiff.

Welsh Government (2020b) *First sites announced for National Forest - 'Among very best woodland in Wales'*, *Welsh Government*. Available at: https://gov.wales/first-sites-announced-national-forest-among-very-best-woodland-wales (Accessed: 2 March 2021).

Welsh Government (2020c) *Glastir Commons 2020/2021*. Cardiff. Available at: https://gov.wales/sites/default/files/publications/2020-02/glastir-commons-general-rules-booklet-2020-2021.pdf (Accessed: 22 February 2022).

Welsh Government (2020d) *Together we can create a National Forest the length and breath of Wales - First Minister Mark Drakeford*, *Welsh Government*. Available at: https://gov.wales/together-we-can-create-national-forest-length-and-breadth-wales-first-minister-mark-drakeford (Accessed: 10 June 2022).

Welsh Government (2021a) *Agricultural land classification: predictive map*, *Welsh Government*.

Welsh Government (2021b) *Lle: A Geo-Portal for Wales*, *Lle*. Available at: http://lle.gov.wales/home?lang=en (Accessed: 9 March 2021).

Welsh Government (2021c) *Sustainable Farming Scheme*, *Welsh Government*. Available at: https://gov.wales/sustainable-farming-scheme (Accessed: 30 June 2022).

Westhoek, H.J., van den Berg, M. and Bakkes, J.A. (2006) 'Scenario development to explore the future of Europe's rural areas', in *Agriculture, Ecosystems and Environment*, pp. 7–20. Available at: https://doi.org/10.1016/j.agee.2005.11.005.

Wheeler, J. (2019) 'Farm trees could help provide carbon cure', *Farmers Guardian*, August, p. 12.

White Rose Forest (2020) *About the White Rose Forest*, *The White Rose Forest*. Available at: https://whiteroseforest.org/about/ (Accessed: 6 July 2022).

Whiteside, M., Mills, J. and McCalman, J. (2012) 'Using Secondary Data for Grounded Theory Analysis', *Australian Social Work*, 65(4). Available at: https://doi.org/10.1080/0312407X.2011.645165.

Wieser, T. (2019) *Klimaschutydemo in Leibnity | Schüler fordern: Weniger Asphalt und mehr Wald*, *Kleine Zeitung*. Available at: https://www.kleinezeitung.at/steiermark/suedsuedwest/5596344/Klimaschutzdemo-in-Leibnitz_Weniger-Asphalt-und-mehr-Wald (Accessed: 25 March 2019).

Wigan, M. (1998) *The Scottish Highland Estate: Preserving an Environment*. Swan Hill Press.

Williams, B. *et al.* (2010) 'Resource selection by hill sheep: Direct flock observations versus GPS tracking', *Applied Ecology and Environmental Research*, 8(4). Available at: https://doi.org/10.15666/aeer/0804_279299.

Williams, B. *et al.* (2012) 'Habitat selection by grazing animals in heterogeneous environments: The case of hill sheep in western Ireland', *Biology and Environment*, 112(3). Available at: https://doi.org/10.3318/BIOE.2012.16.

Williams, J. (2022) *Climate Change: Tree planting used as scapegoat, minister says*, *BBC*. Available at: https://www.bbc.co.uk/news/uk-wales-60182068 (Accessed: 10 February 2022).

Winter, M. (1996) *Rural Politics: Policies for Agriculture, Forestry & the Environment*. London: Routledge.

Wolfslehner, B. and Vacik, H. (2011) 'Mapping indicator models: From intuitive problem structuring to quantified decision-making in sustainable forest management', *Ecological Indicators* [Preprint]. Available at: https://doi.org/10.1016/j.ecolind.2010.05.004.

Wood, R.F. (1974) *Fifty Years of Forestry Research : A Review of Work Conducted and Supported by the Forestry Commission, 1920-1970* . London.

Woodland Trust (2011) *Community ownership for woodland management and creation*. Grantham.

Woodland Trust (2017) *A new Northern Forest*. Available at: https://www.merseyforest.org.uk/files/documents/1454/Northern+Forest+Manifesto_B5_spreads_web_final.pdf (Accessed: 17 April 2019).

Woodland Trust (2020) *Emergency Tree Plan for the UK*. Gantham. Available at: https://www.woodlandtrust.org.uk/media/47692/emergency-tree-plan.pdf.

Woodland Trust (2021a) *Can trees and floods reduce flooding?*, *Woodland Trust*. Available at: https://www.woodlandtrust.org.uk/trees-woods-and-wildlife/british-trees/flooding/ (Accessed: 10 February 2022).

Woodland Trust (2021b) *My Tree - Our Forest*, *Woodland Trust*. Available at: https://www.woodlandtrust.org.uk/plant-trees/wales-tree-giveaway/ (Accessed: 11 July 2022).

Wordsworth, W. (1835) *A guide through the district of the lakes in the north of England: with a description of the scenery, &c., for the use of tourists and residents*. Englang: Kendal: Hudson and Nicholson.

Worrell, R. (1996) 'The Boreal Forests of Scotland', *Forestry Commission Technical Paper*. Forestry Commission.

Wright, D. (2018) 'Future of FGS and Update on Budget Categories and Threshold Scores'. Edinburgh: Forestry Commission Scotland, p. 4.

Wright, J.P. and Fridley, J.D. (2010) 'Biogeographic synthesis of secondary succession rates in eastern North America', *Journal of Biogeography*, 37(8). Available at: https://doi.org/10.1111/j.1365-2699.2010.02298.x.

WWF (2018) *Keeping It Cool: How the UK can end its contribution to climate change*. London.

Wynne, G. (1993) *Biodiversity Challenge: an agenda for conservation action in the UK*. 1st Editio. Sandy: Royal Society for the Preservation of Birds.

Wynne-Jones, S. (2013) 'Carbon blinkers and policy blindness: The difficulties of aGrowing Our Woodland in Walesa', *Land Use Policy* [Preprint]. Available at: https://doi.org/http://dx.doi.org/10.1016/j.landusepol.2012.10.012.

Wynne-Jones, S., Strouts, G. and Holmes, G. (2018) 'Abandoning or reimagining a cultural heartland? Understanding and responding to rewilding conflicts in wales – The case of the cambrian wildwood', *Environmental Values* [Preprint]. Available at: https://doi.org/10.3197/096327118X15251686827723.

Zanchi, G. *et al.* (2014) 'Modelling the effects of management intensification on multiple forest services: A Swedish case study', *Ecological Modelling* [Preprint]. Available at: https://doi.org/10.1016/j.ecolmodel.2014.04.006.

ZUMA Press (2019a) *Munich. 100 students and concerned citizens participated in a climate strike at Munich's Max Joseph Platz*, *Alarmy*. Available at: https://www.alamy.com/munich-bavaria-germany-14th-dec-2018-as-part-of-a-worldwide-action-100-students-and-concerned-citizens-participated-in-a-climate-strike-at-munichs-max-joseph-platz-the-protestors-are-calling-on-world-governments-to-take-decisive-acti (Accessed: 25 March 2019).

ZUMA Press (2019b) *Munich. Showing no signs of abating, over 3,500 students participated in the Fridays for Future climate strike at Munich's Max Joseph Platz*, *Alarmy*. Available at: https://www.alamy.com/munich-bavaria-germany-25th-jan-2019-showing-no-signs-of-abating-over-3500-students-participated-in-the-fridays-for-future-climate-strike-at-munichs-max-joseph-platz-the-protestors-are-calling-on-world-governments-to-take-decisive-ac (Accessed: 25 March 2019).

9 APPENDIX

9.1 Supplementary material to Chapter 5

The sections below cover supplementary material for Chapter 5, with both a detailed description of the 12 WEOMs used in this research, as well as a detailed description of the AOIs.

9.1.1 Individual descriptions of the 12 WEOMs

Below is a detailed description of the 12 WEOMs, focussing on methodological background that related to how the maps were used within the research in Chapter 5.

9.1.1.1 The CLP Upland Framework map

The Carneddau Landscape Partnership (CLP) Upland Framework Map has been produced specifically for the CLP and is actually an extension of the Upland Framework map produced by Natural Resources Wales (NRW) in 2007 and updated in 2015.

9.1.1.1.1 The NRW Upland Framework map

The updated Upland Framework map (from 2015) covers mostly Sites of Special Scientific Interest (SSSIs) in Wales (Jones, 2007), and includes more specific information on peat bodies and habitat connectivity layers than the original map [REP1]. Both the original and the update outline the "*future, long-term conservation ideas for each upland statutory site*" and takes a "*long-term view of 100 years or more*" (Jones, 2007, p. 8). The maps have been created based on responses from farmers that instead of being told "*what not to do*" they'd like to hear more about "*what to do*" [REP2]. Specifically, woodlands are said to probably take 50 years or more before they would create a significant change to the visual character of the landscape.

This WEOM has a clear focus on conservation opportunities and is based amongst others on the Phase 1 habitat dataset, the Habitat Directive Annex 1 & 2 list, the Biodiversity Action Plan habitat distribution and targets, and "*the collective experience of staff who have worked in the regions and headquarters for a number of years*" (Jones, 2007, p. 47).

The map acknowledges the existence of other interests besides conservation in the uplands and should be a "*starting point for discussion*" to find a "*common ground*" to widen the framework the map is based on (Jones, 2007, p. 8). Target end users of the map are stakeholders involved in land management on a larger scale, such as singular large-scale land owners, collaborations of several adjacent farmers or singular large-scale units of management (common land grazed through an association). This is due to the map only providing a broad vision and having to generalise due to data limitations (Jones, 2007).

In a specific comment on the restoration of woodland/scrub, the Upland Framework suggests zero livestock grazing for 10-20 years, followed by the reintroduction of light grazing (e.g. "where grazing is required for e.g. bryophytes"; Jones, 2007, p. 23).

9.1.1.1.2 The CLP extension to the Upland Framework map

The NRW Upland Framework map covers about 79% of the Carneddau. Alex Turner, commissioned by the CLP, expanded the dataset according to the general principles of the original map to cover the remaining area (**Figure 5-4**). The resulting WEOM is to be used as one of the reference maps for the CLP's land management planning (with objectives such as protecting rare habitats and species and promoting sustainable land-use practices; Turner, 2018a, 2018b). This work was done in 2018 and an update is due in 2021, but is not publicly available yet [REP2].

As well as adding modifications "*if they [the rules] were incompatible with the underlying habitat map vegetation*" (i.e. other relevant datasets), in some cases, professional judgement to override individual map suggestions [REP1].

The CLP Upland Framework map should be used in conjunction with other maps of the wider collection Turner (2018b) produced (that are not WEOM but reference maps, such as a Habitat map which is based on Phase 1 habitat data and several layers of updates/refinement). When considering habitats on site, management objectives and other influences, decisions might be made that deviate from what the WEOM suggests; this WEOM therefore is also not meant to be prescriptive. Again, part of this is also due to data limitations, where underlying datasets (such as the Phase 1 habitat map) can have poor information.

9.1.1.2 The Glastir Woodland Creation Scoring map

The Glastir Scoring map (**Figure 5-5**) was developed for the Welsh Governments Glastir Woodland Creation scheme (as part of the Welsh Government's Rural Development Programme 2014-2020), which financially rewards land managers and farmers for creating woodland.

This WEOM was produced in 2014 and was intended to be used till 2020. In the aftermath of Brexit, the Sustainable Farming Scheme, which will replace all other pre-Brexit farm support schemes, intends of produce a new iteration of the WEOM (Welsh Government, 2020a, 2021c).

The Glastir Scoring map itself is based on eight underlying datasets that address Communities First areas, noise pollution areas, nitrate vulnerable zones, habitat suitability, floodplain and riparian woodland potential, air pollution areas, and economic return from woodlands (Welsh Government, 2014b). These eight datasets are stacked on top of each other and produce the

Scoring map, i.e. the higher the score, the more underlying datasets align and the better the perceived opportunity to create woodlands.

The WEOM is accessible to land managers via an online platform, where they can mark their land on the map and see the score it has for woodland planting. Additional layers are given that show "*special guidance*" information on why an area may be more sensitive to woodland creation (e.g. due to being in a Historic Landscape Area), even if in principle there is an opportunity (Welsh Government, 2014a). The land managers can use this tool to support their application for Glastir woodland creation grants, which then will be screened by NRW. Having a good score alone does not mean the land manager's plan will automatically be approved by the scheme, though other actions such as showing compliance with other regulations or showing evidence of local stakeholder consultation (with large scale plans) may help (NRW, 2018, 2020). This is also due to the map's resolution only being 20 m^2 (NRW, 2018).

9.1.1.3 The Working with Natural Processes Natural Flood Management map collection

The three WEOMs in the Working with Natural Processes (WWNP) Natural Flood Management (NFM) map collection (**Figure 5-6**) have been commissioned specifically as part of flood and coastal erosion risk management research and development (Hanking et al., 2017c), and were finalised in 2017.

The spatial data for the WEOMs is available on Lle, an online portal for publicly available spatial data for Wales (Welsh Government, 2021b), and centre around riparian, floodplain and wider catchment woodland with the following assumptions (Hanking et al., 2017b, p. 7; Welsh Government, 2021b):

- *"**Riparian woodland:** a 50m buffer of riparian land on smaller river networks*
- ***Floodplain woodland**: Flood Zone 2 (0.1% annual exceedance probability, AEP)*
- ***Wider catchment woodland**: slowly permeable soils where woodland could break up naturally impermeable soils and reduce surface run-off"*

The maps are "*not prescriptive*" and do not include wider environmental or social factors, which need to be considered as well (Hanking et al., 2017b, p. 4); they should be used as a reference for stakeholder engagement on NFM and in some areas woodland creation may not be possible the way the maps suggest (Hanking et al., 2017b, 2017c).

9.1.1.4 The SoNaR map collection

The State of Natural Resources (SoNaR) map collection (**Figure 5-7**, **Figure 5-8**, and **Figure 5-9**) was created by Environment Systems for NRW to support the Area Statements for Wales (Bell *et al.*, 2020b). They are intended as a "*comprehensive 'map atlas' of opportunity, demand*

and constraining maps, with accompanying spatial data, to facilitate broad, cross-sectoral discussion on sustainable management of natural regeneration" (Nauman *et al.*, 2018, p. 4).

The maps were created in 2018 and comprise seven WEOMs :

- **WEOM for carbon sequestration (Figure 5-9):**

  Based on biophysical characteristics, Phase 1 habitat data + sensitivities like historical landscape features or common land

- **WEOM for rapid turnover forest (biomass and timber - Figure 5-7):**

  Based on biophysical characteristics, Phase 1 habitat data, slope (shallow can be worked easier), elevation (too high means less growth), aspect (for storm sensitivity) + sensitivities & constraints as above

- **WEOM for community woodland (Figure 5-9):**

  Based on distance to settlements, areas of specific deprivation, presence of young people, woods for people data, etc.

- **WEOM of small, medium and large woodlands:**

  WCO for carbon sequestration map, categorising small (<5ha), medium (5-500ha) and large (>500ha) woodlands, but scored based on how many landowners there are that would have to be negotiated with;

- **WEOM for natural flood management: riparian (Figure 5-8):**

  Based on biophysical factors, closeness to rivers and channels, minus restraints.

- **WEOM for natural flood management: catchment (Figure 5-8):**

  Based on generally biophysical possibilities to plant trees and artificially drained areas.

- **WEOM for natural flood management: floodplain (Figure 5-8):**

  Crossover of planting possibilities and flood zone designations, minus constraints such as common land, acid sensitive catchments, etc.

Several of these WEOMs are based on a wide range of underlying datasets; detailed information on those can be found in Nauman et al. (2018). Principally, the datasets that were used to create the maps are split into "*constraints*" and "*sensitivities*"; sensitivities are not generally considered as a "*hard no*" to woodland expansion, but rather a soft check to use for further considerations (e.g. "within historic landscape"; Nauman et al., 2018, p. 32; REP4).

These WEOMs are not intended to be prescriptive and, apart from having a reporting function for the Area Statements, are intended as 'conversation starters' for landscape and regional considerations (Bell *et al.*, 2020b). Stakeholder engagements and site visits with ground truthing of the maps are still necessary. As with the other maps, the ground truthing is also necessary due to underlying data limitations of the various datasets the WEOMs are derived from.

9.1.2 Detailed descriptions of all AOIs

Table 10 Breakdown of data coverage for AOI 1 - AOI 6.

ID	subset	AOI 1	AOI 2	AOI 3	AOI 4	AOI 5	AOI 6
CLP Upland Framework	conservation	Scrub	Scrub; Lowland Heathland Woodland Transition	Scrub; Lowland Heathland Woodland Transition	Srub	Upland Heathland-Woodland Transition; scrub	Scrub; Lowland Heathl.-Woodl. Transition; Upland Heathl.-Woodl. Transition;
Glastir	overall (financial support)	NO	YES	YES (scores 15-19)	YES (score 2-8)	NO	NO
WWNP	catchment	YES	YES	YES	YES	YES	YES
WWNP	riparian	YES	YES	NO	YES	YES	YES
WWNP	floodplain	YES	NO	NO	YES	YES	YES
SoNaR	carbon sequestration	NO	YES	YES	YES	NO	YES
SoNaR	rapid turnover forest	NO	YES	YES	YES	NO	YES
SoNaR	community woodland	NO	NO	NO	NO	NO	NO
SoNaR	ownership	NO	small woods	medium woodland	small & medium woodland	NO	small & medium woodlands
SoNaR	catchment	NO	YES	YES	YES	NO	YES
SoNaR	riparian	YES	YES	YES	YES	YES	YES
SoNaR	floodplain	NO	NO	NO	YES	NO	YES
NTM tree cover (outside woodlands)	tree cover outside woodlands	scattered tree cover surrounding NFI woodland	linear tree cover alongside three streams and surrounding NFI woodland	scattered tree cover	linear tree cover alongside stream	linear tree cover alongside stream	linear tree cover alongside stream and surrounding NFI woodland
Ecologist data	observed natural colonisation	natural colonisation witnessed	natural colonisation witnessed	natural colonisation witnessed	natural colonisation witnessed	no natural colonisation confirmed	no natural colonisation confirmed

Table 11 Breakdown of data coverage for AOI 7 - AOI 12.

ID	subset	AOI 7	AOI 8	AOI 9	AOI 10	AOI 11	AOI 12
CLP Upland Framework	conservation	Upland Heathl.-Woodl. Transition; Scrub	Scrub; Upland Heathl.-Woodl. Transition	Lowldand Heathl.-Woodl. Transition	scrub (others adjacent)	Upland Heathl.-Woodl. Transition	NO
Glastir	overall (financial support)	NO	NO	YES (score 5-10)	adjacent (score 5-13)	NO	YES (13-14)
WWNP	catchment	YES	YES	YES	YES	NO	YES
WWNP	riparian	YES	YES	adjacent	YES	NO	YES
WWNP	floodplain	NO	YES	adjacent	NO	NO	NO
SoNaR	carbon sequestration	NO	very little	NO	YES	NO	very little
SoNaR	rapid turnover forest	NO	very little	NO	YES	NO	very little
SoNaR	community woodland	NO	NO	NO	NO	NO	NO
SoNaR	ownership	NO	1 small woodland	NO	small & medium woodlands	NO	very little
SoNaR	catchment	NO	very little	NO	YES	NO	NO
SoNaR	riparian	somewhat	YES	NO	YES	NO	YES
SoNaR	floodplain	NO	very little	NO	NO	NO	NO
NTM tree cover (outside woodlands)	tree cover outside woodlands	small patch of isolated tree cover	tree cover surrounding NFI woodland	linear tree cover alongside stream	tree cover surrounding NFI woodland and along field margins	small patch of isolated tree cover	linear tree cover along field margins
Ecologist data	observed natural colonisation	no natural colonisation confirmed	natural colonisation witnessed	no natural colonisation confirmed	no natural colonisation confirmed	no natural colonisation confirmed	no natural colonisation confirmed

Table 12 Breakdown of data coverage for AOI 13 - AOI 18.

ID	subset	AOI 13	AOI 14	AOI 15	AOI 16	AOI 17	AOI 18
CLP Upland Framework	conservation	scrub	Scrub	Upland Heathland-Woodland Transition; scrub	NO	Scrub	NO
Glastir	overall (financial support)	YES (5-10)	YES (0-5)	NO	YES (0-5)	NO	NO
WWNP	catchment	NO	YES	YES	YES	YES	NO
WWNP	riparian	NO	YES	YES	NO	NO	NO
WWNP	floodplain	NO	NO	NO	NO	NO	NO
SoNaR	carbon sequestration	very little	YES	NO	NO	YES	NO
SoNaR	rapid turnover forest	NO	NO	NO	NO	NO	NO
SoNaR	community woodland	very little	NO	NO	NO	NO	NO
SoNaR	ownership	NO	YES	NO	NO	NO	NO
SoNaR	catchment	very little	YES	NO	NO	YES	NO
SoNaR	riparian	NO	NO	YES	YES	NO	NO
SoNaR	floodplain	NO	NO	NO	NO	NO	NO
NTM tree cover (outside woodlands)	tree cover outside woodlands	scattered tree cover around small NFI woodland	tree cover surrounding NFI woodland	tree cover surrounding NFI woodland	very little tree cover	tree cover surrounding NFI woodland	no tree cover
Ecologist data	observed natural colonisation	natural colonisation witnessed	natural colonisation witnessed	natural colonisation witnessed	natural colonisation witnessed	natural colonisation witnessed	natural colonisation witnessed

Table 13 Breakdown of data coverage for AOI 19 - AOI 21.

ID	subset	AOI 19	AOI 20	AOI 21
CLP Upland Framework	conservation	Scrub; Lowland Heathl.-Woodl. Transition; Upland Heathl.-Woodl. Transition;	Scrub	NO
Glastir	overall (financial support)	NO	YES (15-20)	NO
WWNP	catchment	NO	YES	NO
WWNP	riparian	very little	YES	YES
WWNP	floodplain	NO	NO	YES
SoNaR	carbon sequestration	NO	YES	NO
SoNaR	rapid turnover forest	NO	YES	NO
SoNaR	community woodland	NO	NO	NO
SoNaR	ownership	NO	YES	NO
SoNaR	catchment	NO	YES	NO
SoNaR	riparian	NO	YES	NO
SoNaR	floodplain	NO	NO	NO
NTM tree cover (outside woodlands)	tree cover outside woodlands	no tree cover	no tree cover	small patch of isolated tree cover
Ecologist data	observed natural colonisation	natural colonisation witnessed	natural colonisation witnessed	no natural colonisation confirmed

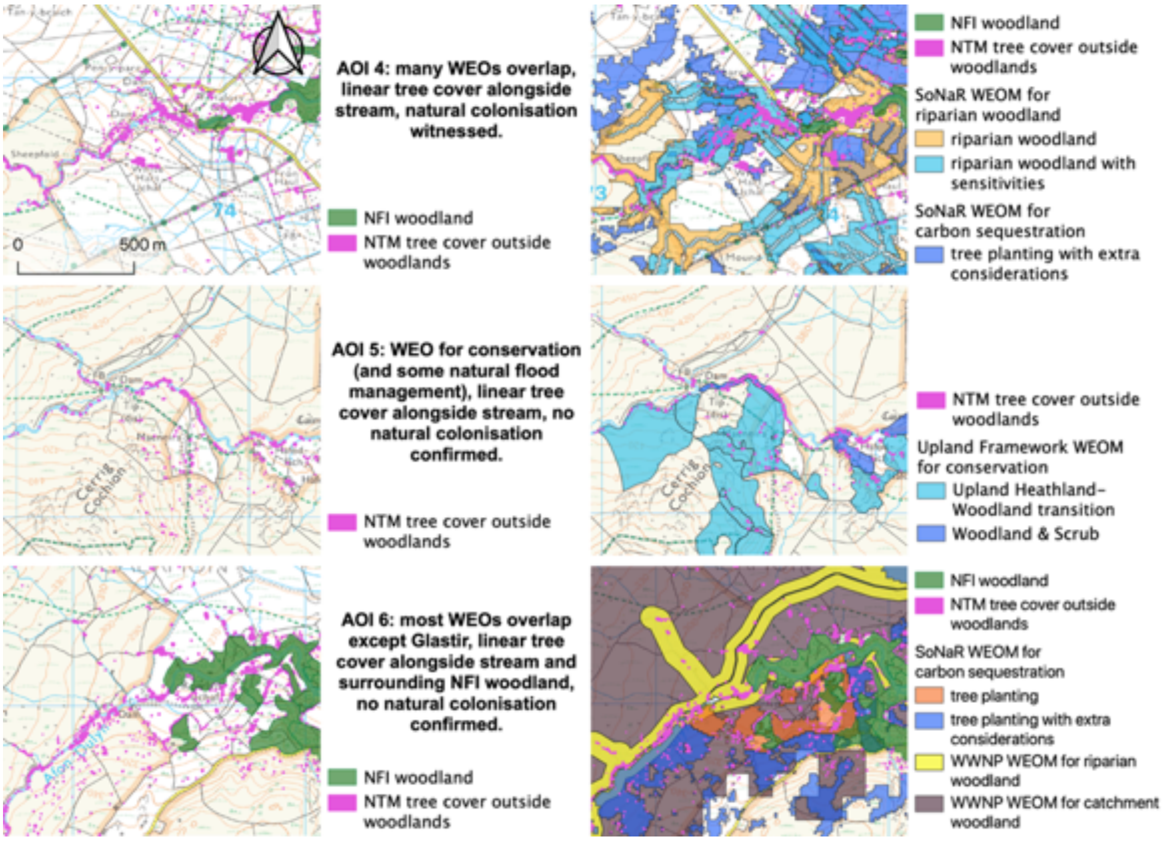

Figure 9-1 Closeup of AOI 4-6. Woodland and NTM tree cover is shown on the left, an example of a WEO that covers that area is seen on the right.

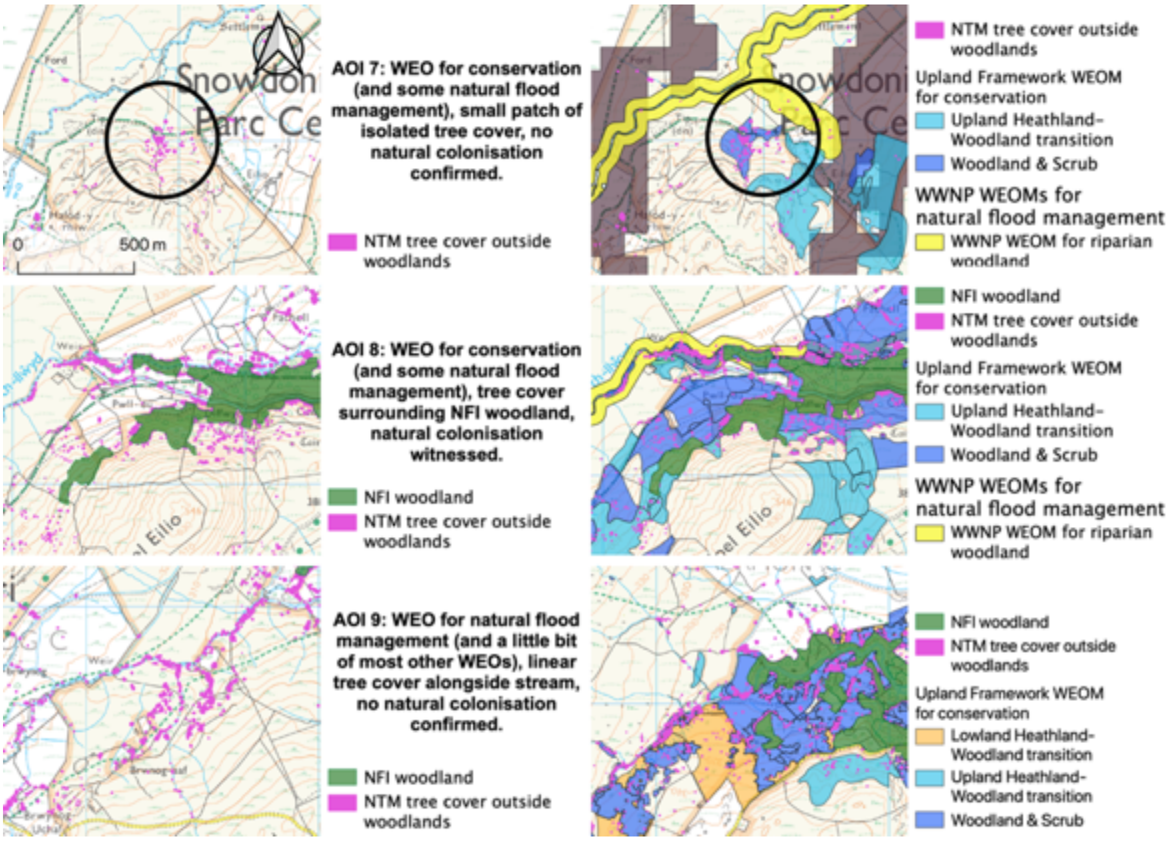

Figure 9-2 Closeup of AOI 7-9. Woodland and NTM tree cover is shown on the left, an example of a WEO that covers that area is seen on the right.

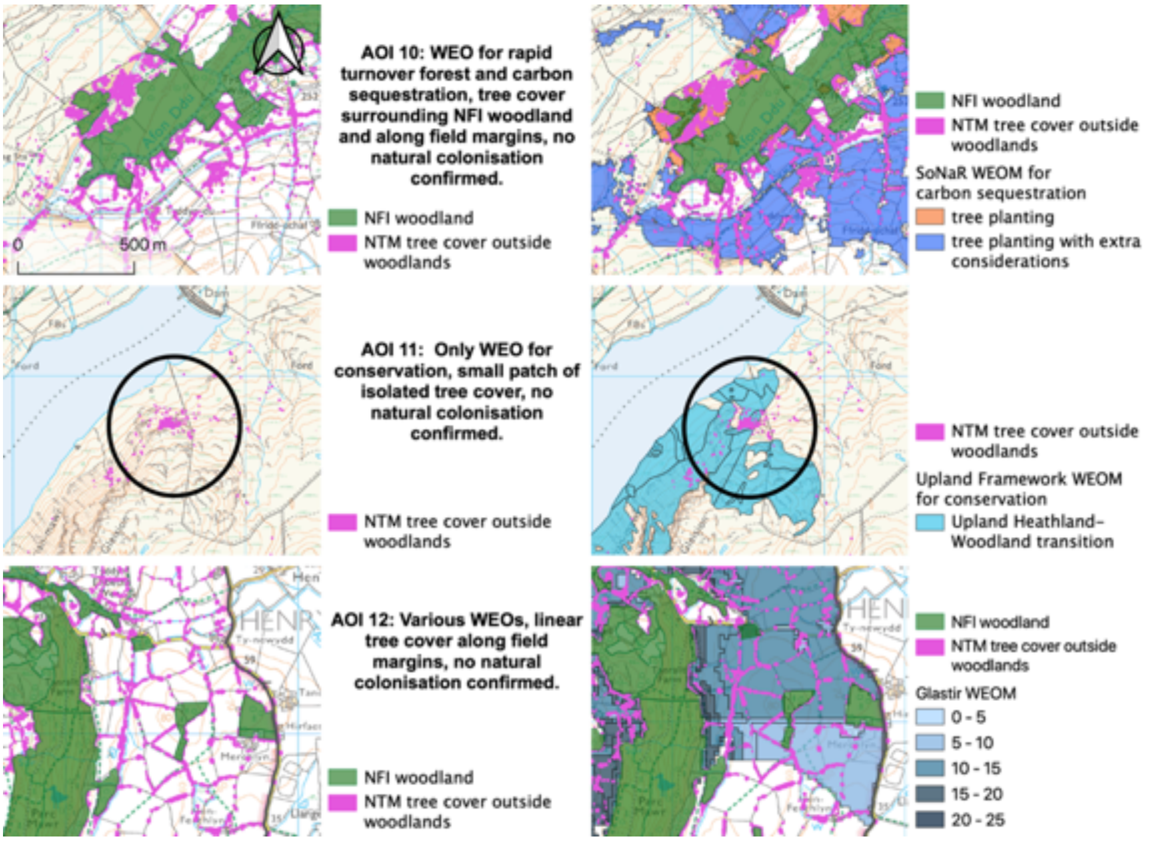

Figure 9-3 Closeup of AOI 10-12. Woodland and NTM tree cover is shown on the left, an example of a WEO that covers that area is seen on the right.

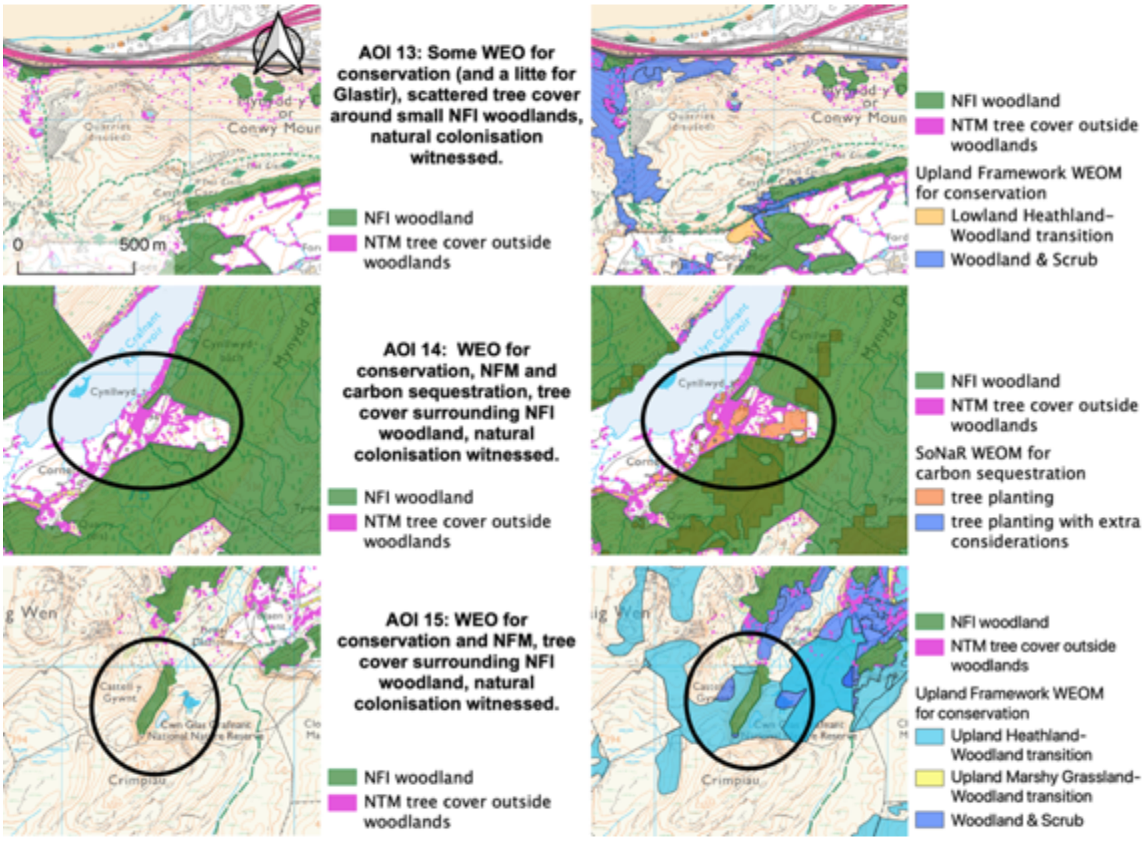

Figure 9-4 Closeup of AOI 13-15. Woodland and NTM tree cover is shown on the left, an example of a WEO that covers that area is seen on the right.

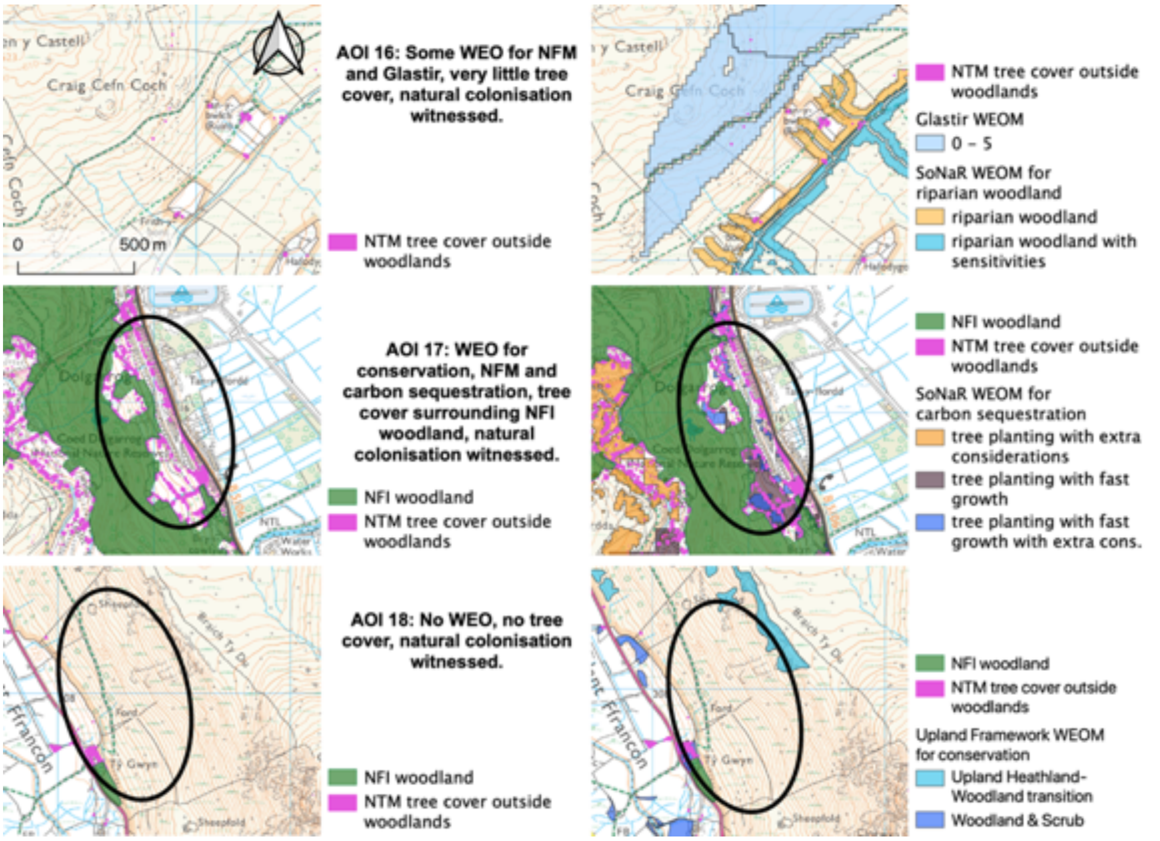

Figure 9-5 Closeup of AOI 16-18. Woodland and NTM tree cover is shown on the left, an example of a WEO that covers that area is seen on the right.

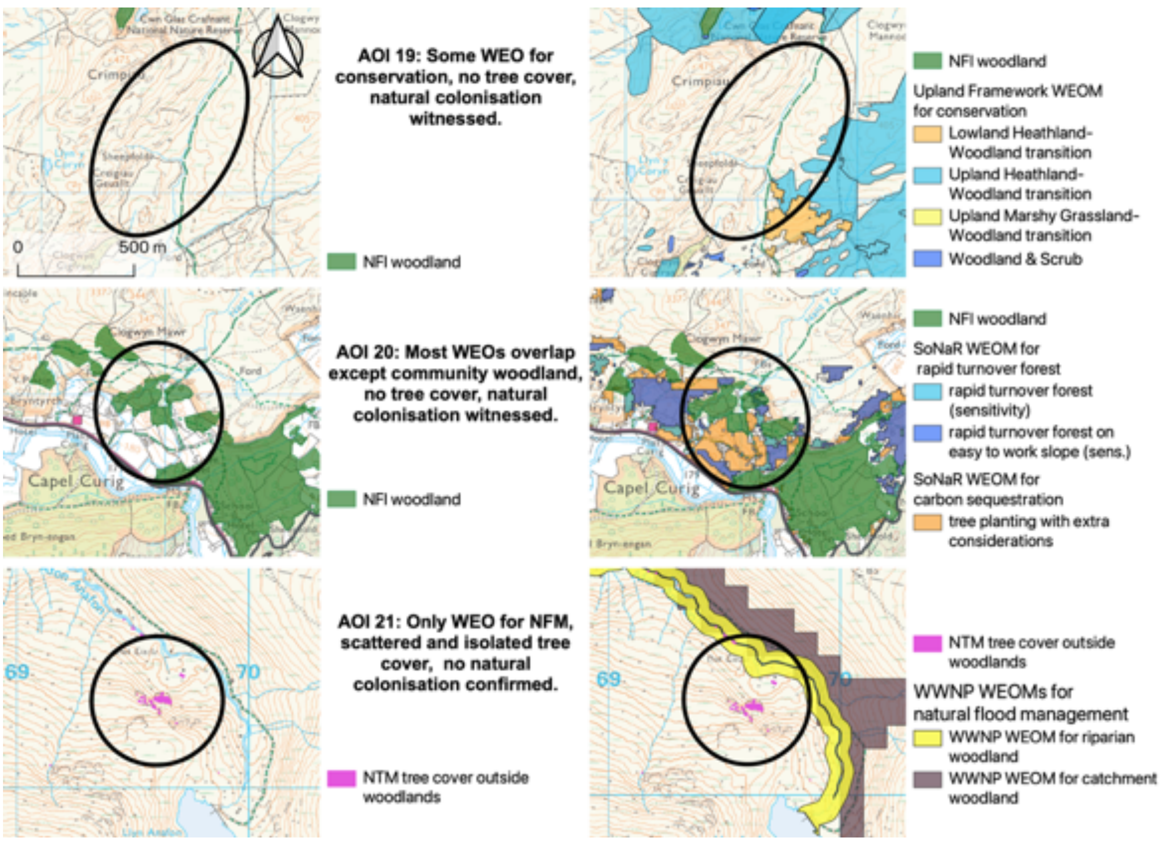

Figure 9-6. Closeup of AOI 19-21. Woodland and NTM tree cover is shown on the left, an example of a WEO that covers that area is seen on the right.

9.2 Supplementary material for Chapter 6

Below are the predetermined interview questions used at the beginning of data collection in Chapter 6. Given the grounded theory approach, the questions were adjusted as data collection proceeded, to further explore specific themes. **Figure 9-7**, **Figure 9-8**, and **Figure 9-9** thereafter show the ‘call for key informants’ flyer used as well as participant information sheet and consent form. The two latter were also translated into Welsh.

Introduction

- *Can you tell me a bit more about our farm / about how you manage your land?*
- *Do you have any plans to change the way you manage your land in the future?*
- *Are there woodlands on your land, or any trees outside woodlands?*
- *What does this tree cover look like? Was it planted?*

Unintended natural colonisation

- *Are there any areas on your land where in the last years you have notices natural regeneration of trees happening?*
- *Do you have any ideas of what the drivers of this natural colonisation of trees are?*
- *How do you feel about this natural colonisation being there? Do you think it belongs there? Does it make a difference to you that it’s ‘natural’ rather than planted?*
- *Is the natural colonisation (where it is now) affecting the management of your land?*
- *Do you think more natural colonisation on your land or in the Carneddau will appear in the future? Why/Why not?*

Capitalizing on unintended natural colonisation

- *Have you thought about doing something with the natural colonisation?*
- *Do you think natural regeneration could eventually form the foundation of new woodland in the Carneddau? What timescale do you think we could be talking about?*
- *Are there circumstances under which you could see yourself capitalising on this natura colonisation?*

Conclusion

- *Is there anything else about woodlands or natural colonisation of trees on your land that you want to add?*
- *Are there any other question you have about this research, or how the information you’ve shared today will be used?*

Alternative route

If the land manager knows of no natural colonisation on their land, use these questions:

- Are there any areas adjacent to your land or elsewhere in the Carneddau where you have noticed natural colonisation of trees in the last years or decades?
- What do you think might be preventing natural colonisation of trees in the Carneddau?
- Could there be natural colonisation on your land in the future? How could it be facilitated?

Figure 9-7. 'Call for key informants' flyer used to find study participants. The flyer was printed to be handed out and used as an online version for Bangor University's website, twitter and email.

PRIFYSGOL BANGOR UNIVERSITY

Canolfan Defnydd Tir Cynaliadwy Sir William Roberts Centre for Sustainable Land Use

PARTICIPANT INFORMATION SHEET

Emerging spaces for native woodland growth in Britain's crowded future landscapes

Thank you once again for considering participating in my research. Before we start is important that you understand why the research is being conducted and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish.

Theresa Bodner, MMSc
Postgraduate Researcher
theresa.bodner@bangor.ac.uk

This project is funded by the Sir William Roberts Centre for Sustainable Land Use (http://swrc.bangor.ac.uk/).

What is the purpose of this research?

The purpose of this research is to understand the role of unintended natural regeneration of trees in the Carneddau, and its relevance for the future of sustainable land use in relation to woodland expansion in Britain. As a land manager in the Carneddau your perspective on how the land is changing or may change in the future is critical for this research. I'm hoping to speak to approximately 30 land managers in total, to capture a diverse set of perspectives and opinions.

What would I be asked to do if I took part?

If taking part, you will participate in a **face-to-face interview (ca. 45 min to 1 hr)** about your management decisions and perception of land changes in the Carneddau, and any relevant thoughts related to this and to natural regeneration of trees in the area. I might also contact you for a 10-20 min follow up conversation to clarify information (this is optional).

What will happen to the information I provide?

The **interviews will be audio-recorded**, for transcription and analysis. All transcripts will be anonymised and stored securely. No-one outside the project team will have access to them, with a possible exception of a professional data transcript service (if required) working to full data protection guidelines. The project team is:

- Theresa Bodner I Postgraduate Researcher I Bangor University
- Dr Norman Dandy I Supervisor I Bangor University
- Dr Sophie Wynne-Jones I Supervisor I Bangor University

Maps used to take notes will be scanned and stored securely. No-one outside the project team will have access to them. Audio recordings, scanned maps & contact details will be **retained for 5 years** (or longer, if you consent for the anonymised data to be used for further research on land use and land cover change via the consent form).

Your participation in the study will be kept confidential. Audio recordings will be de-identified using an anonymous participant ID. If you decide to take part you are free to withdraw at any time without giving a reason and without detriment to yourself. You can also participate in the interview without being audio-recorded, in which case with your permission I will take notes during the interview.

Will my data be used for future research?

In the consent form, you can indicate whether your anonymised data may be stored longer than 5 years and be used for other research on land use and land cover change. Data sharing and re-use can be extremely useful for future research and save time and resources. The outcomes of this research will primarily be published as a PhD thesis, though they will also be published as a scientific paper or communication targeted to specific stakeholders (policy makers, practitioners, etc.).

This project has been reviewed and approved by the Bangor University College of Environmental Science and Engineering Ethics & Governance Committee.

Figure 9-8. Participant information sheet. This document was also provided in Welsh.

PRIFYSGOL BANGOR UNIVERSITY

Canolfan Defnydd Tir Cynaliadwy Sir William Roberts Centre for Sustainable Land Use

PARTICIPANT CONSENT FORM

Emerging spaces for native woodland growth in Britain's crowded future landscapes

		Please initial each box
1	I have read and have been given a copy of the information sheet for the above study. I have had the opportunity to ask questions and have had these answered satisfactorily.	
2	I understand that my **participation is voluntary** and that I am free to withdraw at any time, without giving any reason.	
3	**I agree to take part in the study.**	
4	I consent to being audio recorded.	
5	I understand who will have access to any data collected, how the data will be stored and what will happen to it at the end of the project.	
6	I understand how this research will be written up and published.	
7	I give permission to the members in the study team to access my data (interview transcripts, scanned maps).	
8	I agree to the use of **anonymised** quotes by me in research outputs.	
9	I consent to my anonymised data being stored for future research.	
10	I understand that this project has been reviewed by, and received ethics clearance through, the Bangor College of Environmental Science and Engineering Ethics and Governance Committee.	
11	I consent to possibly being contacted for a 10-20 min follow up phone call (or email correspondence) for potential clarification of information.	
12	I understand how to raise a concern or make a complaint.	
13	I understand that I will be contacted again 5 days and 10-14 days after the interview to confirm that neither the interviewer nor I have developed Covid-19 since the interview.	

	dd / mm / yyyy	
Name of Participant	Date	Signature
	dd / mm / yyyy	
Name of person taking consent	Date	Signature

Figure 9-9. Participant consent form. This document was also provided in Welsh.