Technical Wildness: Reforestation, Rewilding, and the Environmental Performativity of Forest Measurement in the Scottish Highlands

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This thesis is submitted for the degree of Doctor of Philosophy.

Declaration

- This thesis is the result of my own work and includes nothing which is the outcome of work done in collaboration except as declared in the preface and specified in the text.
- It is not substantially the same as any work that has already been submitted before for any degree or other qualification except as declared in the preface and specified in the text.
- It does not exceed the prescribed word limit for the Degree Committee.
- Ideas in Chapter Two were developed in collaboration with Dr. George Cusworth for a co-published article submitted to *Progress in Environmental Geography.* All written work in that chapter and all the other chapters is my own.

Figure 1 (Front Cover). Pines grow in the most remarkable places.

Abstract

This thesis examines the ecological politics of reforestation in the Scottish Highlands, the large, sparsely populated expanse of mountains and moorland covering the north-western third of Scotland. The region has long been considered one of the UK's last 'wild' places and, somewhat paradoxically, is increasingly framed as an ecologically degraded space ready to restore. The shared concern for reforesting Scotland brings together a range of epistemic groups, with varying commitments to generate profit, sequester carbon, and restore ecological processes. Stakeholders including private companies, research scientists, field ecologists, and state agencies are developing new models, metrics, and technologies to measure reforestation and create data which shows the 'nature-based solutions' forests deliver.

Based on extensive ethnographic fieldwork, this thesis develops a central claim: in the Scottish Highlands, *forests are made as they are measured*, and this process is shaped by uneven distributions of wealth, class, and power. Measurement fixes the ways forests are translated into data, determines which elements of forests are valuable, and ultimately shapes which natures materialise in reforestation schemes. To develop this argument, I draw on critical work from STS, political ecology, and environmental geography to offer a new conceptual framework, which I term 'environmental performativity'. The framework provides a set of analytics which differentiate the various processes described as 'performative' in critical environmental scholarship. By differentiating *object making, environment making* and *society making* performativity, the framework articulates the multiple ways that natures are discursively and materially co-constituted as they are described and represented, especially as they are measured. I offer the concept of *disruptive performativity* to describe how measurement can unsettle the dominant ways natures are made.

The four empirical chapters examine different ways that measurements make forests in the Scottish Highlands. Chapter Five closely analyses the Woodland Carbon Code (WCC), the state-backed metric used to quantify and attribute carbon credits to forests. I trace the political and economic factors that shaped the WCC's creation, investigate how the WCC maintains credibility in a contested political atmosphere, and outline the streamlined natures which emerge from its design. Cognisant of the WCC's technical limitations, start-ups are developing Advanced Measurement Technologies (AMTs), such as drones and remote sensing, to independently verify forest carbon and other natural capital stocks with improved accuracy and

precision. In Chapter Six, I break down the political and economic motivations behind these forms of forest carbon measurement, to argue that carbon is '*known not grown*': more numerous and legitimate carbon credits can be created through a shift in knowledge practices rather than a material change in nature-based carbon sequestration. I outline the potentially dangerous political and economic consequences which emerge from this process.

The first two empirical chapters focus on the multiple ways that forest carbon can be quantified through measurement. They only fleetingly nod to the variable prices that different forest carbon credits command. In Scotland, there is no functioning biodiversity credit market, which means that the ecological value of a reforestation project is bundled into the price of a carbon credit. Chapter Seven disambiguates three performances which create 'wild carbon', an emerging type of high-integrity carbon credit promising ecological uplift alongside carbon sequestration. Through these performances, I argue that rewilding organisations are increasingly drawing on discursive and aesthetic elements of the Romantic and the Modern, Scotland's dominant and often competing strands of environmentalism, to foster a new culture of nature I term 'technical wildness'. Chapter Eight offers an uplifting analysis which empirically traces how environmental measurement can be employed for its *disruptive performativity*, upsetting the natural capital frame which is increasingly dominant for measuring and valuing forests. Based on extensive empirical fieldwork with a rewilding ecologist developing a new ecosystem measurement method, the Wild Trees Survey (WTS), Chapter Eight shows how measurement can be reflexively designed to reframe Highland nature. I describe how three shifts in measurement perform an alternative ontology of forests, which disrupts the status quo modes of forest governance to facilitate more ecologically flourishing forms of nature restoration.

Throughout, the thesis is punctuated with ethnographic vignettes and images which situate my theoretical exploration of environmental measurement within its wider social and ecological context. The Conclusion reviews the arguments developed, hints to future directions for research, and ends with a direct call for prioritising the natural regeneration of wild woodland. The growing appetite for reforestation is not, of course, unique to the Scottish Highlands. Although the empirical nuances are context-specific, the intersecting themes of nature restoration, carbon finance, and the politics of environmental measurement should interest a wide range of scholars studying forests and a range of other landscapes which are being restored and rewilded.

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Forest (noun).

Oxford English Dictionary (2023)

1.a. An extensive tract of land covered with trees and undergrowth, sometimes intermingled with pasture. Also, the trees collectively of a 'forest'. (1375-)

1.b. In Great Britain, the name of several districts formerly covered with trees, but now brought more or less under cultivation, always with some proper name attached, as Ashdown, Ettrick, Sherwood, Wychwood Forest. (1375-)

2. Law. A woodland district, usually belonging to the king, set apart for hunting wild beasts and game, etc.; having special laws and officers of its own. (1297-

3. A wild uncultivated waste, a wilderness. (c1320-1659)

Prelude

It's a miserable day for mid-July: cold, wet, grey, windy. Clouds of biting midges swirl amongst the fog that rolls in from all sides. I am standing looking at a seemingly endless stretch of the Flow Country, the world's largest blanket bog, that sweeps away to the south. Its yellows and purples stand in stark contrast to the dense, dark green wall of Sitka spruce trees on the other side of the glen. The forestry block is a haunting reminder of the environmental destruction that tree plantations can reap on Northern Scotland's often fragile ecology. In the 1980s, when tree planting rates across Scotland were far higher than they are today, the surrounding area was planted with large plantations of non-native conifers.[1] The bog was drained and ploughed, destroying the niche habitat of rare bird species, and emitting potentially millions of tonnes of carbon (Oosthoek, 2013). Forty years later, the environmental future locked in by that past planting regime has materialised. Sitka spruce plantations, creaking in the wind, seemed loaded with symbolic meaning, signifying how some landowners have historically profited from planting trees in Scotland, at the expense of other communities, human and nonhuman.

But it's not the only plantation haunting the glen. A hundred metres south, there's an older woodland, planted in the Victorian era, a mixture of native trees and non-native exotics. It was presumedly planted as something of an aesthetic homage to Nature, the exotic species nodding to the landowners' globalised botanical knowledge. The fence protecting it has gaps in, meaning deer can browse any growing tree saplings, stifling the chances of 'natural regeneration', the process in which trees grow independently of human planting. The trees are mostly gnarled. Old and twisted. Closer to us, there's the standing remnants of a failed native woodland creation scheme which was planted a few decades ago. After the previous landowner received government subsidies for planting the trees, the estate's gamekeeper cut down the fence around the old plantation. Deer, kept at inflated levels to maintain the estate's deer stalking business, had stripped the young trees of their leaves and killed them. But amongst

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[1] Environmental historian Jan Oosthoek lucidly elaborates this story in in *Conquering the Highlands* (2013). In the 1980s, tax concessions and grants were widely used on a large scale by private investors; for high tax income earners, growing timber was a lucrative prospect. The private sector generally turned to the cheapest possible land for their plantations – and this was often in areas of high value for conservationists. The Flow Country in Northern Scotland – poorly suited to growing timber – was drained and planted with monocultures of Sitka Spruce and other non-native tree species.

these ecological ruins, there were still some native trees standing, which could act as a seed source. If deer numbers were restricted, perhaps through the establishment of a new fence or more intensive culling regime, regeneration might sprawl outwards.

Figure 2 Plantation Ghosts.

The smattering of broadleaves in the foreground were planted most recently; the Victorian plantation is behind; and the Sitka spruce is on the horizon.

Plantations of the past stand around me. I'm here today to plan the creation of a new one. I'm walking and talking with Julie, a forester working for a land management company, who has offered to take me to the estate. In our initial interview the week before, I had explained that I wanted to learn how to ecologically survey a site before establishing a new native woodland. I was especially interested to understand how she decides where the "right tree in the right place" (a common mantra in the Scottish forestry sector) will be planted.

As we walk and talk, Julie explains that a wealthy investor had recently purchased the land we were standing on. He was part of a growing cluster of landowners in rural Scotland looking to create revenue from the rapidly expanding natural capital markets. According to Julie, the landowner had no real moral interest in making the land ecologically better. Much like the landowners who purchased land in the 1980s, he wanted to make money from trees. But instead of planting commercial *timber* plantations, he would generate returns from 'nature restoration'. In this case, by planting native trees, such as Scots pine, oak, willow, alder, silver birch and aspen. The new plantation would be accredited with woodland carbon credits that could be sold on the carbon market.

Clutching shovels and rods, we cross the soggy terrain. With each stride we sink several centimetres into the ground, the sphagnum moss absorbing our footsteps. When we are several hundred metres into the heart of the moor, we plunge our rods into the boggy ground, measuring the depth of the peat-rich soil. Our goal is to work out where trees can be planted legally. If we measure peat deeper than 50cm, planting here would be illegal. This relatively arbitrary figure is the threshold at which it is assumed, or at least mandated by the state, that planting would lead to large releases of carbon, potentially more than what could be sequestered by a forest over a decades-long period.[2] We pull out the rod and measure 43cm. It's legal to plant here. Just seven centimetres stands between the state categorically ruling against trees being planted here *at all,* on 'carbon grounds', and the land being ready for tree planting, and subsequently worth large amounts of money for the carbon finance it might generate. Those seven centimetres hint to the incredible, disproportionate power held by the seemingly benign process of environmental measurement.

Raising her other hand, Julie traces the outline of a fence she envisions erecting, which could hypothetically exclude deer from eating regenerating tree saplings. The already existing native trees, planted a few decades before but now left unprotected, could be assimilated into the new fence line. But, she explains, given the stipulation of the UK Forestry Grant Scheme, she would never be able to cover the cost of the fence unless new trees were planted. Tree planting brings

[2] In interviews, it was largely assumed by foresters that planting in soil deeper than 50cm would lead to a net carbon loss; more carbon would be released from soil disturbance than carbon sequestered from tree growth.

in grant funding. And, she explained, tree planting is fundamental to the landlord's agenda. Planted trees are easy to measure, easy to predict, and easy to turn into carbon credits.

And this is the *real* reason she had been hired. On this estate, teams of land managers, carbon consultants, net zero accountants, tree planters, machinery technicians and engineers would be employed in the production of high-value carbon credits. Fossil-powered cars, diggers, and trucks would transport tree saplings to here, the far northern reach of the country, to a relatively inaccessible bog habitat, in the name of capturing carbon and restoring nature. The carbon credits produced at this site were potentially worth millions of pounds, ostensibly sequestering tens of thousands of tonnes of measurable carbon dioxide that could be used to offset – and legitimise – carbon releases elsewhere.

Standing in the pouring rain, boring holes into carbon-rich soil, the paradoxes and absurdities of the UK woodland carbon market were made very apparent. The arbitrary measurements, the strange funding mechanisms, the lucrative natural capital credits. Thoughts were circulating in my brain, thoughts I was too embarrassed to say because they might seem sarcastic or even aggressive. Clearly, creating a new native woodland here, on a privately owned estate recently purchased by a wealthy landowner, was not really a good use of taxpayers' money. And there must surely be better ways to rewild and restore Scotland's nature than *this*. As we see in the chapters that follow, there are many flaws in the status quo ways that reforestation occurs; and there are many better ways in which nature restoration might be pursued. And with that, let's begin.

Introduction: Reforesting the Highlands.

1.1. “PLANT TREES”

Figure 3 PLANT TREES.

A week before submitting this thesis, a graffitied mural caught my eye. It’s emblazoned on a bridge which crosses the M32 motorway, opposite Bristol’s most coveted falafel store.

“STOP THE FOSSIL FUEL ENERGY SYSTEM. EAT PLANTS. PLANT TREES.”

Staring at the mural sparked the usual frustrations I experience when I read the words “plant trees”. The simple phrase represents some of the most problematic narratives at the heart of British environmental politics: the seemingly *obvious* appeal of planting trees, which obscures so much ecological nuance; the representation of forest creation as a radical form of climate action; the implication that planting trees (and by extension, offsetting emissions) should be spoken about in the same political, ecological, climatic, social, ideological, and cultural register as actually stopping the fossil fuel energy system. Even the trees painted on the right-hand side of the mural irritated me. The characteristic Christmas tree shapes are undoubtedly spruce trees, non-native conifers that are grown almost exclusively in the UK for timber (or for Christmas

trees). To me, they represent an extractive mindset about what forests are (a resource to be extracted) and how they should be valued (financial returns). I'm aware this tree literacy is not a part of the public psyche. It probably did not cross the artist's mind to think about *which trees* should be painted when representing ecological and climate action; and I wager, this hints to a widespread lack of common understanding about different species of trees, the different forest worlds they compose, and the different forms of value they hold.

My aim in this thesis is to expose the complicated and fascinating worlds that are united under the umbrella term "plant trees". The Prelude hinted to the ways that planting trees, for various reasons, is not unique to our contemporary zeitgeist. But a new bout of *planting fever* has gripped the UK since 2019, when UK political parties began promising the arboreal world. As politicians bid to prove their climate and ecological credentials in the run-up to the December 2019 general election, tree planting promises functioned as a strange form of political capital. The Conservative Party pledged to plant 30 million trees a year by 2025 as part of a 'Nature for Climate' fund, aiming to treble the national tree planting rate (BBC, 2019). Not to be outdone, the Liberal Democrats pledged to plant 60 million trees a year. The Green Party pledged 700 million trees by 2030 and even the Brexit Party leader Nigel Farage said he would support wide-scale tree planting. The most eye-catching claim came from the Labour Party, who vowed to plant 2 billion trees by 2040 *in England alone* (BBC, 2019). This figure was even more startling considering 80% of UK forestry schemes are planted north of the Scottish-English border (Forest Research, 2022). It did not take a forestry expert to know that these speculative tree planting pledges were highly unrealistic. But they did trigger a series of provocative questions for an environmental geographer. I was fascinated to know which forests were being created, how they were being made, and who was benefitting from their establishment.

1.2. Reforesting the Highlands

Perhaps more than any other region in the UK, planting fever has touched down and shaped the Scottish Highlands (herein, 'the Highlands'), the large, sparsely populated expanse of mountains, forests, lochs and moorland covering Scotland's north-western third. The region has long been the geographical heart of Scotland's nature conservation and restoration efforts, which have crystallised around the term 'rewilding' in the twenty-first century (Deary, 2015). Spurred on by the new societal interest in tree planting and the 'nature-based solutions' forests

offer to a set of interlinked social and ecological problems, an unlikely alliance of ecologists, rewilders, natural capital accountants, entrepreneurs, carbon brokers, corporate offsetters, remote sensing experts, scientists, and commercial foresters, amongst many others, have been brought together. They share an interest in reforesting the Highlands, but many of them hold vastly different understandings of what forests are and how they should be valued, which emerge from the multiple cultures of nature that have historically shaped Scotland's environmental politics (Deary, 2015; H. Lorimer, 2000; Mackenzie, 1998).

Private companies, new and old, large and small, have purchased land to plant trees, offset their emissions and restore nature or rewild landscapes. The largest landowner in Scotland is now fast-fashion entrepreneur and rewilding advocate Anders Povlsen, whose private rewilding company Wildland Limited owns 88,296 hectares of land across Scotland (Wightman, 2024). In 2020, beer company Brewdog purchased Kinrara Estate in the Cairngorms, looking to create a "bio-diverse broadleaf woodland ecosystem" (BrewDog, 2021, p. 21), dubbed 'The Lost Forest' in their marketing material.[3] Start-ups such as Highlands Rewilding have purchased land and joined established conservation NGOs in generating high-integrity natural capital credits, promising ecological gain alongside carbon sequestration. Representative of this new appetite for land and the burgeoning financial and social opportunities that come from reforestation and nature restoration, land prices have drastically risen. According to a report by Community Land Scotland (2021, p. 1), "only 23 rural estates changed hands in 2020, yet the total value of Scottish estates sold last year increased by 43% to £100 million. However, that may be a conservative estimate given that some estate sales occur without ever surfacing onto the open market". Alongside these 'Green Lairds' (the collective term to describe landlords looking to restore nature and/or generate revenue from natural capital (Davidson, 2022) new companies specialising in measuring natural capital have been established. Increasingly, scientists at prestigious universities have directed research attention to reforestation and nature restoration in the Scottish Highlands, using specific locations as 'natural laboratories' for

[3] The name 'The Lost Forest' is particularly ironic, given that the planting scheme is situated near Aviemore, one of the Highlands' largest towns. The project has faced extensive, often public criticism for its lack of attention to local needs and issues. (See Carrell, 2022; Horne, 2021)

research into carbon and biodiversity stocks.[4] They join a complex network of actors in Scottish land governance including environmental NGOs, government agencies, the commercial forestry industry, and traditional landowners, many of whom privilege deerstalking and grouse hunting.

Figure 4 A double-page spread from Brewdog's Lost Forest marketing material.
The choice of trees depicted is particularly noteworthy. The trees are likely a type of spruce, a non-native grown for timber extraction. For many rewilders I spoke with, the image indicates a lack of local knowledge about Highland ecology. Source: Brewdog (2021, p.18). (N.B. This material is publicly available.)

Throughout the thesis, I situate the recent appetite for reforestation within its wider historical, political, and ecological setting. Since the seventeenth century, the Highland landscape has

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[4] The Natural Capital Laboratory in the Central Highlands is a prominent example. Whilst undertaking fieldwork, new interdisciplinary research centres were opened at both the Universities of Cambridge (The Centre for Landscape Recovery) and Oxford (The Leverhulme Centre for Nature Recovery). Both centres study nature restoration efforts in the Scottish Highlands.

transformed under the weight of ideological and economic transitions. Indigenous populations of Gaelic peoples were cleared from land in the eighteenth and nineteenth centuries by landlords looking to maximise financial returns. Large expanses of the Highlands' forests were cut down for timber and fuel in the eighteenth century, as external investment poured into the region (Smout, 2003). The cleared trees were not replaced through natural regeneration as inflated numbers of sheep and deer ate the majority of saplings (Steven & Carlisle, 1959). By 1900 just 6% of Scotland's land mass was forested (Oosthoek, 2013). Deer numbers, which grew throughout the nineteenth century, continue to suppress natural regeneration in the present day, spurred on by concerted efforts to create large herds of huntable stags for the landowning 'hunting elite' (H. Lorimer, 2000).

The Highlands, much like the rest of Scotland, is mostly deforested. A large proportion of its remaining forest coverage is composed of non-native conifer plantations, as these have historically produced the most lucrative returns from growing profitable timber. Despite this, the region has long been considered one of the UK's last 'wild' places (T. M. Devine, 2018) and somewhat paradoxically, the Highlands' bountiful, relatively cheap, and largely treeless moorlands are increasingly seen as ripe for reforestation (Sharma et al., 2019). Scottish rewilding discourse has centred around the restoration of the now-mythologised ancient Caledonian Forest (McMullen, 2019), the old-growth forest which has covered a significant proportion of the Highlands since the ice caps melted some 11,700 years ago (Steven & Carlisle, 1959). The Caledonian Forest was first mapped by Ptolemy of Alexandria in the second century, as seen in the map below. But only a few fragments of the Caledonian Forest still exist (Rainey & Holmes, 2023). Conservation charities such as Trees for Life and Woodland Trust Scotland are developing plans to find fragments of ancient woodland and restore them (McKenzie, 2024). These are often found in the more inaccessible areas of the Highlands, on higher ground, in ravines, and around rivers.

Figure 5 Detail from Ptolemy's 'Europae 1' plate (Ptolemy, 1584)*, which shows the large Caledonian Forest in Scotland in the centre.*

The map was first detailed in the 2nd century A.D. and rediscovered in the 15th century. The North Coast of Scotland appears to be turned at a 90-degree angle.

Figure 6 A native woodland in the Cairngorms National Park, the largest national park in Britain.

The Cairngorms' flagship estates such as Glenfeshie and Mar Lodge are centrepieces of the Scottish rewilding movement, where fragments of Caledonian pinewood are regenerating as landowners are actively reducing deer numbers. Source: Kati Karki, reproduced with permission.[5]

Between Spring 2021 and Spring 2022, I spent several cumulative months living and working in the Highlands with a range of people interested in reforestation. It marked a period when 'planting fever' was touching down on the material world, shaping new and fascinating political ecologies. During this time, I planted trees and watered saplings. I measured forests with sticks, rods, Excel spreadsheets, drones, and tape measures. I learned taxonomic and ecological surveying skills. I pored over maps and read government reports. I attended industry field trips and participated in conferences. I visited countless sites where reforestation was taking place. Getting my 'rubber boots' dirty (Bubandt et al., 2022) helped me understand the

[5] Throughout the thesis I use imagery taken by artist-forester Kati Karki.

unlikely alliances that constitute the social world of reforestation (Goodman & Boyd, 2011), allowing me to trace the different ways reforestation is understood and practiced by a range of epistemic communities.

Figure 7 Surviving pines in Glen Loyne.

Fragments of ancient woodland such as this are some of the last remaining remnants of the ancient Caledonian Forest. Source: Kati Karki

1.3. Key Themes

With the growing interest in nature restoration and carbon sequestration, the Highlands might be considered a pioneer in, and perhaps indicative of, developments associated with the rise of reforestation in Northern and European contexts. Contemporary interest in reforestation is not unique to the Highlands. But the region provides empirical insights into the two dominant trajectories of nature restoration. Citizens in the Global North, argues geographer Jamie Lorimer, are increasingly offered a binary choice in our attempts to restore nature: a romantic retreat into a premodern past or a "techno-optimistic amplification of the status quo" (2020, p. 3). We are offered ecological salvation as we return to a timeless past where humans are

connected with Nature, or an intensified ecomodernist faith that metrics, markets, and technologies, *done better*, will deliver us from the environmental problems that modernity has created. In Latour's (2018) terms we are offered only one timeline: a retreat backward or an acceleration forward. An imagined past or an imagined future.

Planting trees seems to simultaneously fulfil both trajectories. For some, tree planting captures a romantic sentiment that ecologies which have been damaged and lost through hubristic land management can be returned to their former glory; for others, the additional measured biodiversity and carbon gains that emerge from tree planting signify that nature, when rationally managed, can deliver the much-needed 'nature-based solutions' to socioecological problems. Throughout this thesis, I show how the two dominant modes of contemporary environmentalism – the Romantic (which celebrates the irreducibility, wonder, awe, and other-than-humanness of a 'pure Nature') and the Modern (which understands nature as sets of resources to be maximised and extracted) – come into tension and find common ground in attempts to reforest the Highlands. Tracing how the Modern and the Romantic relate in the Highlands provides theoretical insights into two key themes which should interest scholars concerned with nature restoration, in Scotland and elsewhere.

Rewilding and carbon

In the terminology employed within conservation science, rewilding can broadly be understood as an approach to ecological restoration that seeks to bring back ecological functions and non-human autonomy. In theory at least, as Lorimer (2015) describes, rewilding offers an alternative version of conservation to the compositionalist model, common in Euro-American environmental governance, which has largely been concerned with protecting and restoring landscapes in their contemporary state. Within rewilding projects, ecologies can develop in surprising ways as ecological conditions are shifted to allow new dynamics to emerge. Rewilding also offers an alternative mode of nature management to the productivist models commonplace in so-called 'carbon forestry', in which forests are instrumentally valued by their carbon stores and are governed to create a large cache of measurable carbon (Markusson, 2022).

Studying reforestation in the Highlands provides empirical insight into the mutable relationship between rewilding and carbon. As I show, concerns for returning wildness to degraded ecosystems and sequestering carbon from landscapes originate in different genealogies, replete

with contrasting political and epistemological commitments (Sullivan, 2017). Carbon sequestration, especially within market-driven forestry, requires the messiness of the material world to be continually reduced to create exchangeable and governable units of carbon (Robertson, 2012). In contrast, rewilding celebrates emergent ecological dynamics, which are necessarily more difficult to measure and commodify than predictable ones (J. Lorimer, 2020; J. Lorimer & Driessen, 2014). These different worldviews, as other scholars suggest, privilege different attitudes towards conservation and restoration (Sullivan, 2017).

The practices and policies that enact both rewilding and carbon forestry in the Scottish Highlands, as this thesis makes clear, are increasingly entangled. So, too, are their ontological, epistemological, and political commitments. As Andrea Gammon (2018) highlights, rewilding is a flexible term, especially in Scotland (Deary & Warren, 2017). Although rewilding is often framed as an antithesis to some of modernity's hubristic and reductive tendencies (Jørgensen, 2015; Wynne-Jones, 2022), it is increasingly integrated into profit-driven modes of environmental governance, with its practices shifting to reflect public opinion and financing options (McMullen, 2019). Scottish rewilding organisations, who have largely relied on wealthy landowners or philanthropic investment rather than natural capital markets to finance their work (Deary, 2015) are increasingly turning to carbon credits to finance nature restoration. Meanwhile, new private companies, some of whom have received extensive venture capital backing, are promising new governance models to scale-up and speed-up rewilding (Sharma et al., 2023). For some, the conflation of rewilding and carbon concerns poses dangerous threats to the integrity of the rewilding movement. The term 'rewilding' has historically been subject to appropriation by actors looking to assimilate the normative value of rewilding into their practices (Gammon, 2018; Deary & Warren, 2017). The following chapters consider how rewilding and carbon forestry are reconciled (or not) through careful discursive work, providing insight into the future trajectories of rewilding in Scotland and further afield. I consider whether wildness, the ostensibly immeasurable, can ever be made valuable. And I investigate what is sacrificed and what is gained as concerns for rewilding and carbon converge.

High integrity natural capital

Relatedly, the Highlands provides an empirical site for studying an emerging 'boutique' sector of the Global North carbon market. Political ecologists Alice Valiergue and Véra Ehrenstein (2022), in their review of high-quality carbon markets, stressed that the overwhelming majority

of carbon forestry projects have taken place in the Global South, where land might be cheaper, environmental regulations might be looser, and close journalistic investigations are less common than in the Global North (Carton et al., 2020).[6] Projects warrant a premium for their carbon credits when they promise more-than-carbon benefits, such as delivering women's empowerment and local livelihood improvements. In the majority of these projects based in the Global South, as Yiting Wang & Catherine Corson (2015) describe, these 'charismatic carbon' projects are generally linked to social benefits. Carbon finance is framed as a means for realising international development alongside carbon sequestration. These benefits, as geographers Karen Edsedt and Wim Carton (2018) highlight, often fail to materialise. Given the widespread North-South dynamics (carbon offsets purchased by companies in the Global North and grown in projects in the Global South), scholars have shown how carbon forestry often functions according to 'carbon colonialism' logics (Lyons & Westoby, 2014). Situated knowledges, local livelihoods, and place-specific interspecies connections are ignored or destroyed in favour of creating measurable stocks of carbon.

In Scotland, anticipating a likely dynamic across the Global North, different power dynamics are at play. Increasingly, the 'charisma' or more-than-carbon value of woodland carbon credits is generated through selling the story of *ecosystem restoration* alongside carbon sequestration and is linked to the apparent scientificity with which the credits were measured. New technologies and discourses help perform these narratives. Throughout the thesis, I show how reforestation is measured, framed, represented, and described in ways that creates additional financial value for woodland carbon credits.

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[6] James Palmer's study of bioenergy (2020) and Lauren Gifford's (2020) study of carbon forestry in the USA are insightful contributions about Global North carbon forestry, as is Ville Kellokumpu's (2021) study of the depoliticisation of Finnish forestry with the rise of interest in nature-based carbon sequestration.

Figure 8 A treeless glen in the West Highlands. Areas such as this are increasingly framed as ripe for reforestation.

1.4. Measuring Forests

The planting fever which emerged in the late 2010s can be traced back to a run of high-profile scientific publications describing the incredible potential for forests to deliver 'natural climate solutions' (e.g. Griscom et al. 2017; Seddon et al., 2019; Bossio et al., 2020).[7] Findings from these publications were picked up widely by politicians and the media. One widely cited paper, published in *Nature*, described "global tree restoration as one of the most effective carbon

[7] The term 'natural climate solutions' was first coined by the ecologist Bronson Griscom and his colleagues in their 2017 publication. At the time of publication, Griscom was Director of Forest Carbon Science at the eNGO The Nature Conservancy. He is now Vice President of Natural Climate Solutions at Conservation International. In the influential paper that launched the term, the authors claimed that natural climate solutions "can provide 37% of cost-effective CO2 mitigation needed through 2030 for a >66% chance of holding warming to below 2 °C" (2017, p.11645).

drawdown solutions to date" (Bastin et al., 2019, p.76).[8] The claim was hotly contested within the scientific community, with scientists arguing that the carbon and forest measurements employed were based on a series of problematic assumptions, and that the claims about forests' salvatory potential were overstated (see Lewis et al., 2019). As technical experts weighed in on debates regarding metrological design, measuring forests shifted from a 'matter of fact' to a 'matter of concern' (Latour, 2004).

In the intervening five years since the publication of the 'global tree restoration' paper, as political and corporate interest in reforestation has grown, forests have been subjected to an intensification of measurement (Carton et al., 2020). Worldwide, the multiple biophysical dynamics and processes that co-constitute forests are translated into data like never before. New models, metrics, and technologies are being developed to quantify the natural capital benefits of reforestation, measuring forests in 'real-time' (Lewis Hood & Gabrys, 2024). Forests can be objectively known with unprecedented levels of accuracy (Vurdubakis & Rajão, 2022) across a range of geographical, temporal, and ecological contexts, with the help of remote sensing technologies, drones, and a host of other measurement apparatus (Gabrys et al., 2022).

A growing body of critical scholarship has argued that measurement schemes do more than *represent* forests in quantitative terms. Jennifer Gabrys and her colleagues working within the Smart Forest research project describe how the increased measurement and digitalisation of forest governance has "ontological and epistemological consequences that set political worlds in motion" (2022, p. 5). The proliferation of digital technologies and infrastructures used to monitor, manage, and measure forests "compose, constitute and activate forests according to particular designations of politics, science, environment and action" (2022, p. 4). Critical social scientists have shown how experts make forests 'legible' to governance (Scott, 1998) and the market (Lansing, 2012) by measuring forests according to specific metrics, transforming seemingly 'natural' forests into political ecological entities (J. A. Devine & Baca, 2020; Peluso & Vandergeest, 2001). Forests become administered as the object of science-led, data-driven regimes (Gabrys, 2022b; Urzedo et al., 2022). Scholars have argued that forests are framed in increasingly technocratic terms, treated as scalable technologies that require rational economic

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[8] The claim was based off a model which "accurately depicts the regions where tree growth is possible under existing environmental conditions" (Bastin et al., 2019, p. 78).

management to maximise their instrumental value (Markusson, 2022). By creating data about certain elements of forests, they become *enacted* as biodiversity hotspots, resources, wildernesses, or carbon sinks, stores or credits (Scott, 1998; Braun, 2002; Carton et al., 2020).

To borrow a phrase from Gabrys, forests are multiple (cf. Mol, 2002).[9] There cannot exist a single metric that objectively captures the 'real' value of forests, because forests are so many things, valued in numerous ways. The multiple definitions of forest presented at the beginning of this thesis hinted to this diversity. In the drive to *reforest*, there are multiple forests that might be created, expanded, or restored. But this multiplicity, which sits at the heart of an ontological politics (Mol, 2002), is hidden behind the veneer of 'naturalness'. Trees' other-than-humanness eschews them from being framed as technologies (Markusson, 2022), whilst their apparently intrinsic value grants them normative appeal (Elkin, 2022). As geographers have long highlighted, appeals to the naturalness of a phenomena can have a depoliticising effect, foreclosing public debate about environmental governance interventions (Bingham & Hinchliffe, 2008; Swyngedouw & Ernstson, 2018). For many critical environmental geographers, trees and forests cannot be inherently 'natural' because there is not one fixed, timeless Nature (Latour, 2011; J. Lorimer, 2012). Instead, there are multiple natures available, multiple trajectories along which ecologies might develop and multiple relations between humans and the more-than-human world. These natures are both material and semiotic, "out there" and "constructed" (Braun, 2002; Braun & Whatmore, 2010).

With a host of natures available to restore and forests to *reforest*, this thesis develops a central claim: in the Scottish Highlands, *forests are made as they are measured*. Measurement fixes how forests are known, valued, and governed, and this in turn shapes which natures materialise in reforestation schemes. As scholars working in the canon of 'critical metrology' (Cooper, 2015) have shown, measurements are always situated; choices about which elements of a forest to measure are necessarily partial (Lippert, 2015) and contingent (Robertson, 2006). To develop this claim throughout this thesis, I offer a new conceptual framework which I term 'environmental performativity'. Performativity is a big and baggy concept in social theory (Dewsbury, 2000). Broadly conceived, performativity refers to the ways that the materialities and identities of things are continuously (re)made as they are articulated (Butler, 1988).

[9] I borrow this phrase from Gabrys' symposium, *The Forest Multiple,* which took place at the University of Cambridge 27-28 October 2022.

Performativity undoes what philosopher Karen Barad describes as the "metaphysical presupposition" that "beings exist as individuals with inherent attributes, anterior to their representation" (2003, p. 804). In the words of geographer J.D. Dewsbury, performativity "offers an enactment of a path between, and through, the theoretical questions of objectivism and subjectivism" (2000, p. 477). Matter and meaning, and object and subject, can be understood as co-constituting each other. This thesis shows how a nuanced understanding of performativity is especially helpful for environmental social scientists; performativity can articulate how natures are discursively and materially brought into being through the ways they are described, represented, practiced, governed, and known (Kolinjivadi et al., 2017; Sullivan, 2017). Although there are a range of representative practices that perform reforestation, this thesis focuses on the performative consequences of environmental measurement (Gupta et al., 2012; Turnhout et al., 2014).

Taken together, the conceptual framework I term 'environmental performativity' develops STS work on performativity and specifically applies the concept to critical environmental scholarship. Bringing a broad range of critical environmental literatures under one umbrella allows me to highlight how material and discursive processes simultaneously co-produce multiple and differentiated natures, constitute the objects and categories of environmental governance, and stabilise the regimes of power which determine how environmental problems are framed and managed. In so doing, 'environmental performativity' captures the unique world-making power that some humans hold as they produce representations of environmental communities, relations, and processes. Simultaneously, the framework highlights the powerful agencies that nonhumans have in conditioning human-designed regimes of environmental control, subsidisation, commodification, regulation, and management.

1.5. Research Questions

Drawing on and extending scholarship which falls under the remit of 'environmental performativity' (including Bowker, 2000; Callon, 2006; Cusworth, Brice, et al., 2022; Lansing, 2012; Nost, 2022), this thesis ultimately aims to answer one overarching research question:

How does measurement make forests in the Scottish Highlands?

Each of the four formal research questions investigate different elements of the relationship between reforestation and measurement. The empirical chapters (Five, Six, Seven, and Eight) answer a research question in turn.

The first research question has been designed to investigate how forests are made legible to the carbon market using the state's mandated carbon accreditation system, the Woodland Carbon Code (WCC). Answering this question also helps me to understand which forests materialise as a result.

> **RQ1: How does the hegemonic form of forest measurement in Scotland perform reforestation?**

The second research question considers how updates in technoscientific measurement apparatus shape the types of forests which are rendered legible and valuable. It provides insight into the contingent ways that forests are measured and traces the social and ecological impacts of shifts in measurement.

> **RQ2: How are advanced measurement technologies changing the ways reforestation is performed?**

The third research question considers how rewilding organisations can differentiate themselves, and their carbon credits, from other nature restoration and forestry organisations. It captures the central tensions I spelled out above, about whether rewilding's pursuit of wildness can ever be reconciled with market-based strategies to restore nature.

> **RQ3: How do rewilding organisations create a premium carbon credit?**

The fourth research question offers a provocation to 'read for difference' (Gibson-Graham, 2020), seeking to understand how measurement might be employed to perform forests differently to the increasingly market-oriented status quo.

> **RQ4: How might environmental measurement disrupt the status quo ways forests are valued and governed**?

1.6. Key Terms

This thesis engages with a large set of terms used to describe a heterogenous yet overlapping range of practices. These include: rewilding, nature restoration, nature recovery, ecosystem restoration, natural climate solutions, nature-based solutions, natural capital, resurgence, natural regeneration, woodland regeneration, woodland creation, reforestation, afforestation, re/afforestation, and many more. These terms are loaded with varying affective and emotional resonances, with different epistemic communities drawing on different terms' allure as a discursive tactic to legitimise their practices (Bellamy & Osaka, 2019; Markusson, 2022; Welden et al., 2021).[10] Even within academic circles, terms like rewilding are notoriously difficult to pin down to a fixed set of practices (Gammon, 2018). Over the course of developing this project, piecing together different terminologies was a forever-incomplete process, especially as their usages shifted between different organisations.

Therefore, I have chosen to not define the key terms such as restoration, rewilding and recovery. To do so would feel contrived, given their different uses across the land sector in Scotland. Instead, throughout the thesis I engage with these terms in the ways that various research participants mobilised them. Correspondingly, groupings of stakeholders which I refer to, such as 'rewilding organisations', can include a wide range of practitioners with overlapping yet divergent commitments to ecological gain, financial profit, and social justice. My intention is to highlight the flexibility of the terms used, and to avoid a fixed normative stance on what, exactly, constitutes rewilding and nature restoration. Rather, using the conceptual vocabulary associated with 'environmental performativity', I understand these terms as constantly being remade through their discursive and material enactment. In other words, what 'rewilding' and 'nature restoration' *are* remains unfixed, and this thesis takes this flexibility as a point of empirical investigation. In the chapters that follow, there is extensive analysis of the various ways these terms are put to work –performed, one might say – in support of specific political and ecological ends.

[10] I was constantly trying to understand semantic differences which were not *a priori* clearcut. For example, in the very first interview I undertook, a commercial forester-turned-carbon broker talked for about ten minutes about how 'foresters' (which I came to understand to mean commercial foresters, which I came to understand as people historically concerned with producing timber) were increasingly naming their 'forests' (which I came to understand to mean productive, linear, commercial forests, composed mainly of Sitka spruce) as 'woodlands' (which I came to understand to generally mean woodlands composed of native species).

And lastly, a note on the terms 'nature' and 'environment'. Despite their often-overlapping usage in the field, in this thesis 'environment' can be disambiguated from 'nature(s)'. I widely employ the term 'environment' to describe the existing more-than-human constellations which make up the material world; it is not a term necessarily linked to a normative vision of what is, should, or could be considered 'natural'. I take no fixed position on what a 'natural' landscape or ecology in Scotland. As I argue in Chapter Four, there has been extensive and highly politicised contestation about what is natural in Scotland, to the extent that drawing a fixed position on the true state of Scotland's nature is necessarily arbitrary. Throughout, following Lorimer's helpful guidance (2012), I use the (uncapitalised) term 'nature' to describe the multiple and contingent ways that ecologies can materialise, and to highlight the various ontologies which makes claims regarding what constitutes 'naturalness'. As the following chapters make clear, there are many different natures pursued in Scottish nature restoration, each of which is linked to a particular culture of nature who performatively enact them (Braun, 2002).

1.7. Chapter Outline

To build a set of concepts that help me answer these questions, Chapter Two provides a conceptual framework for the thesis, which I term 'environmental performativity'. Synthesising work from across the environmental social sciences, I provide a disambiguated set of analytics to describe various processes that get labelled as 'performative' in critical environmental scholarship. ***Object making performativity*** refers to the ways that messy and complex ecological systems are translated into *nature objects,* the fungible units of nature (such as carbon credits, biodiversity offsets, and so on) that can be traded and governed. ***Environment making performativity*** refers to the ways that the material compositions of environments are shaped by the policies, measurement devices and metrics which govern them. ***Society making performativity*** refers to the emergent societal dynamics which are reproduced as natures are measured and translated into natural capital or other forms of environmental data. Building on existing literature regarding the contingency of measurement, I develop the concept of ***disruptive performativity,*** to describe the ways that measurement can be reflexively enrolled as a political intervention that disrupts hegemonic dynamics of power and can create alternative environmental futures.

Chapter Three describes how I undertook the research, offering reflections on how I designed this project and explaining why I chose to undertake a multi-sited ethnographic approach. I outline my methods, principally participant observation, semi-structured interviews, and an Actor-Network Theory-inspired method I term 'following translations'. I also describe the methods associated with my historical review and write-up process. Drawing on moments of ethnographic insight throughout the chapter, I reflect on the ethical and practical difficulties I faced during fieldwork and consider how these affected the arguments I develop.

To understand the Scottish context in further detail, in Chapter Four I review environmental history to map how the ideological and material place of forests in the Highlands has morphed over time. Collectively, these historical literatures emphasise that there is not one inherently 'natural' baseline in Scotland to which nature restoration should be directed; instead, these literatures highlight that appeals to the apparent naturalness of different species, landscapes, and modes of governance have functioned as mechanisms to enact control over the Highlands and its multispecies inhabitants. These historical trajectories are related to contemporary efforts to reforest, restore, and rewild the Highlands. By highlighting the distinct cultures of nature which have historically shaped Scottish environmental politics, the chapter also serves as an analytical springboard. Building on this historical material, I identify the emergent cultural and economic currents which affect the contemporary Highlands. I argue that a novel culture of nature, which I term 'technical wildness', is increasingly shaping how nature restoration is taking place. The chapter ends with a brief overview of the concept, which is fleshed out later in the thesis, especially in Chapter Seven.

Chapter Five sets the metrological scene, answering the first research question: ***how does the hegemonic form of forest measurement in Scotland perform reforestation?*** The chapter is concerned with the Woodland Carbon Code (WCC), the state-backed metric used to quantify forest carbon credits. I trace the political and economic factors that shaped the WCC's emergence and investigate how the WCC maintains credibility in a contested political atmosphere. I identify the WCC's commitments to measurement conservativism and metric integrity, which function as part of an *object making* performance, stabilising the legitimacy of the carbon credits generated. These performances, in turn, have *environment making* effects of their own, determining which forest ecologies are rendered valuable and subsequently materialised. I show how woodland creation, even under the banner 'nature restoration', is distorted in pursuit of carbon finance. By differentiating object making and environment

making performativity and showing how they interact, the chapter brings empirical nuance to understandings of how natures are performatively constituted. It also highlights the flaws in relying overtly on carbon finance to realise diverse ecological goals.

Cognisant of the WCC's technical limitations, start-ups are developing Advanced Measurement Technologies (AMTs), such as drones and remote sensing, to independently verify forest carbon and other natural capital stocks with seemingly incredible accuracy and precision. These offer an update to the WCC's standard modes of forest carbon verification. In Chapter Six, I break down the political and economic motivations behind these forms of forest carbon measurement, to answer my second research question: ***how are advanced measurement technologies changing the ways reforestation is performed?*** Drawing on ethnographic and interview data, I argue that AMTs are enrolled to find more carbon in forests than standard measurement practices allow. Carbon, I argue, is '*known not grown'*: more numerous and legitimate carbon credits can be created through a shift in knowledge practices rather than a material change in nature-based carbon sequestration. I identify three epistemic processes that allow for more carbon to be 'known not grown': (i) more carbon can be identified; (ii) conservative carbon estimates can be bypassed; and (iii) AMT developers develop a situated form of measurement accuracy. I trace the political consequences that emerge from 'known not grown' and situate them in reference to other emerging nature-based carbon markets.

The first two empirical chapters focus on the various ways forest carbon is *quantified* through measurement. They only fleetingly nod to the variable prices that different forest carbon credits warrant, which are dependent on their apparent *quality*. In Scotland, there is no biodiversity credit market, which ensures that the ecological value of a reforestation project is bundled into the price of a carbon credit. Chapter Seven investigates how carbon credits become differentiated from others in reforestation schemes. It unpacks how woodland carbon credits are "qualified" (Callon et al., 2002) as 'wild carbon', a type of high-integrity carbon credit which promises ecological uplift alongside carbon sequestration. The chapter responds to the third research question, ***how do rewilding organisations create a premium carbon credit?*** I disambiguate three performances that qualify a high-quality carbon credit: i) an alluring visual representation of Highland nature; ii) the development of trustworthy numbers; and iii) a spectacular representation of measurement expertise. I show how these different qualification processes are variably weighted in an object making performance and develop the concept of '*technical wildness*' to account for a culture of nature growing in prominence in the Scottish

rewilding sector. The Modern and the Romantic, the two dominant and largely competing strands of Scottish environmentalism, are made ontologically and epistemically commensurable.

Chapter Eight explores the emancipatory potential inherent within environmental measurement. I answer my fourth research question, ***how might environmental measurement disrupt the status quo ways forests are valued and governed****?* Based on extensive empirical fieldwork with a rewilding ecologist developing the Wild Trees Survey (WTS), a new ecosystem measurement method, the chapter shows how environmental measurement can be employed to disrupt the increasingly dominant natural capital frame for valuing forests. Measurement is strategically put to work to upset the widespread reductive ontologies that shape how forest creation takes places. I trace three measurement shifts that the WTS employs compared to the standard mode of measuring forests and show how each of these brings legitimacy to an alternative ontology of forests. This, I argue, is an example of *disruptive performativity:* environmental measurement is directed to destabilise the hegemonic ways forests are valued and governed in the Highlands.

In Chapter Nine, I offer a Conclusion to the thesis, in which I summarise my argument, outline my key contributions, and spell out some further directions for future study. I end by offering an honest call for prioritising nature's *regeneration*. The Interludes scattered throughout the thesis have been added to bring a sense of ethnographic detail to the analysis. They describe the vibrant characters and material ecologies that sit at the heart of the debates about nature and measurement, which can easily slip from focus in theoretical scholarship. The extensive use of images throughout captures the different ways that natures are visually performed, and collectively underscore my own ecological imaginary of what the Highlands *could, should,* and *would* look like if political ecological conditions might change.

2. Environmental Performativity: A Conceptual Framework

2.1. Introduction

In this chapter, I provide a conceptual framework which the following chapters build upon. One of my main intentions is to emphasise the highly politicised and contingent ways that measurement occurs. But what, exactly, is measurement?

Perhaps in the plainest possible language, measurement involves quantifying attributes of an event, object, or process, to create comparisons between different things. By proving equivalences and differences, it is often framed as a depoliticised arbiter of unbiased decision-making (Callon, 1998) and is granted an unparalleled epistemic legitimacy in modern forms of science-led governance (Cooper, 2015; Daston & Galison, 2007; Tadaki & Sinner, 2014). As STS scholars Lorraine Daston and Peter Galison (2007) argue, measurement has been so widely lauded in modernist governance as it offers an apparent way to remove The Self and associated subjective opinions. The impartiality of measurement obscures an insight articulated by political economist Michel Callon, that measurement technologies "do not merely record a reality independent of themselves; they contribute powerfully to shaping, simply by measuring it, the reality that they measure" (1998, p. 23). Sociotechnical assemblages composed of technologies, metrics, scientists, accountants, spreadsheets, and a host of other things, fundamentally change the world as they measure it (Callon, 2006).

In Callon's terms, measurement is *performative,* as assemblages of humans and nonhumans operate together to create the identities of material-discursive 'things'. Callon extends Judith Butler's theory of performativity, the idea that things get made through their articulation, to expose the ways that a range of technologies, markets, metrics, concepts, and devices constitute the identities of things. In Butler's terms, identities are brought into being, *performed* by humans through the "stylized repetition of acts through time" (1988, p. 521). When people act as if a particular entity exists and accumulate knowledge about it through naming, researching, mapping, and measuring it, they make it real (Bowker, 2000; Dewsbury, 2000). And in doing so, reality conforms to the way it is imagined. In the words of anthropologist Anne-Marie Mol, a mixture of discourses and concrete practices, "techniques that make things visible, audible, tangible, knowable" (2002, p.33), *enact* ontologies into being.[11]

[11] Mol prefers the term 'enactment' to 'performativity', as enactment hints more towards the everyday practices that people do which constitute the realities of things.

Performativity offers a helpful analytic for understanding the powerful role of measurement in environmental governance. The term can account for how representation and materiality co-constitute each other, especially in schemes that make 'new natures'. No net loss biodiversity schemes, carbon offsetting, wetland banking and a host of other interventions require measurement to prove that these new natures deliver the 'nature-based solutions' promised. As political ecologist Lauren Gifford (2020, p. 1) summarises, "you can't value what you can't measure". Political ecologists and STS scholars have shown how measurement allows stable, fungible, and tradable representations of environmental processes, such as carbon credits, to be generated from the world's complexity (Lansing, 2012). They show how the material composition of landscapes and ecologies emerge as a direct consequence of metrological design (Markusson, 2022; Palmer, 2020; Palmer & Carton, 2021). And they document how displays of measurement expertise legitimise the contingent ways that environmental problems are framed and responded to (Carver et al., 2021; Kolinjivadi et al., 2017).

Environmental scholars describe a broad range of practices as 'performative'. The capaciousness of the term hints to its value. However, I propose, its widespread usage has dulled some of its critical edge. In this chapter, I make a theoretical intervention, offering a disambiguated set of analytical categories for environmental social scientists which can more carefully account for the multiple ways that measurement plays a powerful role in making natures. I integrate a wide range of scholarship from geography, anthropology, political ecology, STS and other fields into one conceptual framework, which I term *'environmental performativity'.* I disambiguate three *types* of performance: *object making performativity, environment making performativity, and society making performativity*. These performances occur at different stages in the process of environmental governance interventions that make natures. Firstly*, object making performativity* requires ongoing performances by actors (carbon accountants, foresters, and scientists, etc.) armed with measurement devices (quadrats, tape measures, lasers, etc.) to translate the material world into new 'nature objects' (representations of nature, such as offsets and credits). Appearing scientific, altruistic, and politically disinterested are crucial elements in making these translations appear convincing and legitimate. Secondly*, environment making performativity* describes the process through which natures are produced in ways that reflect the specificities of their metrological design, sometimes with perverse outcomes. And lastly, *society making performativity* accounts for the ways that ontological, epistemological, and political foundations from which schemes were developed are legitimised by the calculative rigour with which environments are measured.

I refer to these three performances throughout the analytical chapters of the thesis, bringing empirical insight into the ways they differ and relate to one another. The following three sections articulate each of these versions of environmental performativity in turn. To inform my argument, I direct particular attention to studies of carbon and forest measurement, which helps me develop the thesis' overarching claim that *forests are made as they are measured.* Actors lean on narratives of 'naturalness' or appeals to expertise to foreclose political contestation about how nature restoration, reforestation, habitat creation, or a range of other processes which make new natures should take place (Landström & Whatmore, 2014). Not all the scholars that I review employ the term 'performativity' in their analyses. But bringing them together here highlights the ways that measurement, governance interventions, and human-nature relations play a mutual part in co-constituting one another. Many of these researchers I review analyse projects in vastly different empirical sites to the Scottish Highlands, and clearly their insights might not map directly onto Scotland. As such, throughout the chapter I point to where I will build on their ideas in the chapters that follow.

This chapter, I hope, not only brings terminological nuance to the concept of *performativity* in environmental studies and lays a conceptual framework through which to understand the multiple ways forests are performed in the Scottish Highlands. It also spells out possible ways that measurement might be employed as a *disruptive* political ecological intervention. If performances make realities, then the script can be ripped up and written anew. Shifting the ways that natures are measured can alter which natures become legible to governance, and might undermine the hegemonic political frameworks on which governance schemes are built. This is what I call *disruptive performativity,* which I outline at the end of the chapter. Throughout the chapter, I refer to the diagram below, which I developed alongside geographer George Cusworth and artist Vivian Martineau, to explain how the multiple performances relate to one another.

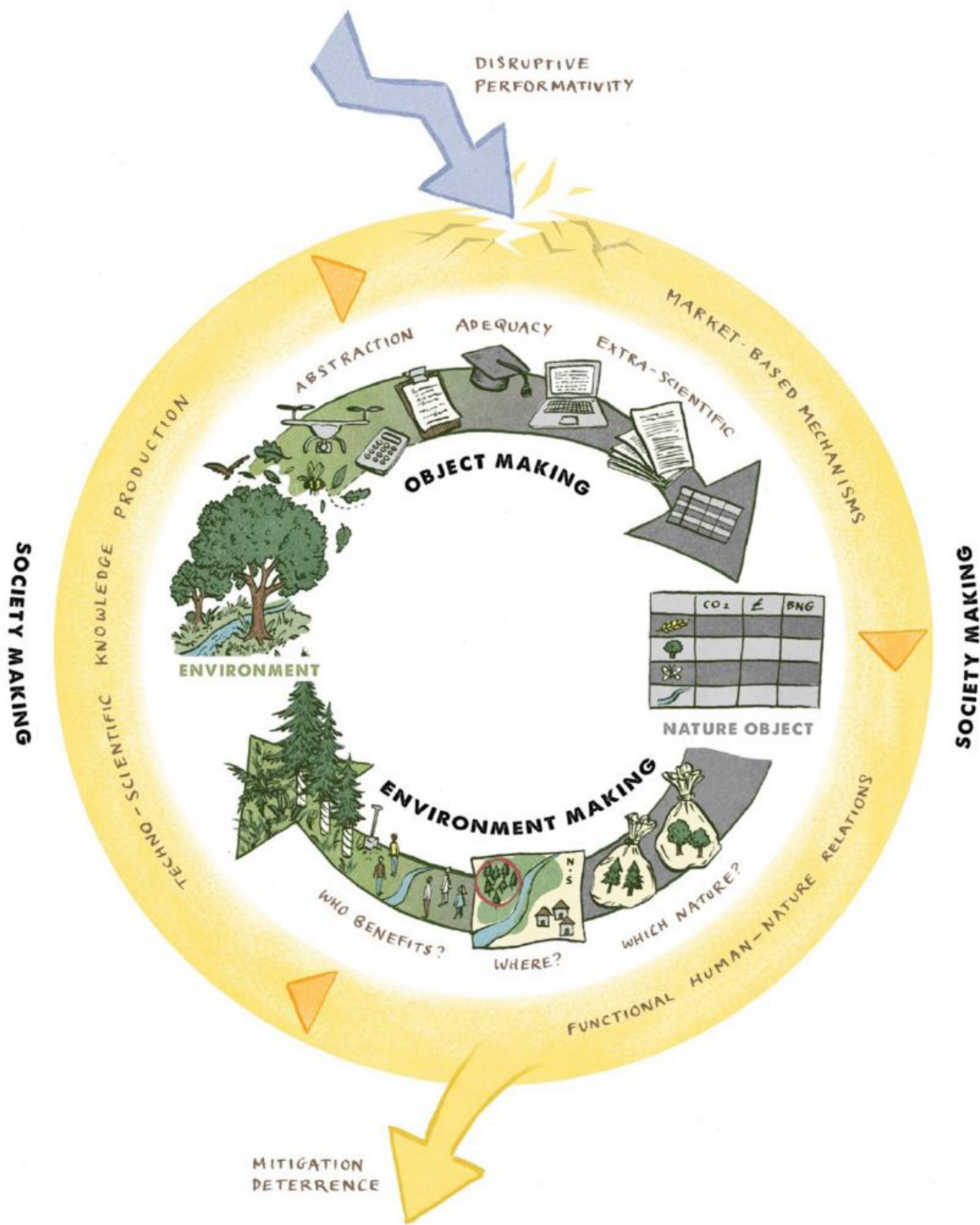

Figure 9 Environmental Performativity in Three Acts. Image by artist Vivian Martineau, developed with geographer George Cusworth.

2.2. Object Making Performativity

In Scotland, as elsewhere, forests and other ecologies must be 'translated' (Latour, 1993) into *nature objects:* quantifiable units governable using state apparatus and tradable within natural capital markets (Robertson et al., 2023a). For net zero, no net loss, and offsetting schemes to work, different parts of the material world must be constantly 'made the same' (MacKenzie, 2009) so they can be traded and governed elsewhere. For example, the carbon market requires that a heterogeneous range of entities, despite their spatial and temporal differences, must be translated into fungible quantities of carbon (Carton et al., 2021). This translation, notes Wim Carton and his colleagues, "is necessarily based on the simplification, abstraction, and standardization of local and regional processes" (2020, p. 7) As a host of STS and political ecology scholars have highlighted, there is no *a priori* equivalence between forests, soil, oceans, and car emissions (Carton, 2020; Carton & Edstedt, 2021; Lohmann, 2011). Only through *measurement* can seemingly disparate elements of the world be fixed into exchangeable units of equivalence (McElwee, 2017). This translation is the *object making performance.* As seen in the diagram above, this performance uses drones, calculators, fieldnotes, scientific associations, accountancy logics, contractual agreements, and spreadsheets to convincingly perform the translation of natures into nature objects. Three processes are important elements of this performance: **abstraction**, as nature is translated into data; **adequacy**, which convinces others of the legitimacy of these translations; and **extra-scientific** legitimisation, as more-than-scientific actors bring credibility to the performance.

Abstraction

Object making performances require measurement tools to use as material-semiotic props. Stakeholders make choices about which environmental processes are valuable in new environmental governance schemes (carbon, biodiversity, etc.) and technologies are employed to measure them (Robertson et al., 2023a). This is the process Callon (2006) calls 'framing', as human and nonhuman "*agencements* (dedicated professionals and observation tools)" continually determine which translations of the world are legitimate. In environmental schemes, the choice of measurement tools determines which elements of an ecology 'count' in a scheme (Joronen & Häkli, 2017; Sullivan, 2017). Political ecologists Morgan Robertson, Rebecca Lave and Martin Doyle (2023a, p. 1) highlight how apparatus such as spreadsheets, databases, algorithms, and field science tools which perform this translation are "scavenged from a wide range of scientific and governance practices and are not themselves inherently capitalist or developed for capitalist purposes" but become used to delineate interacting

ecological processes into "discrete ecosystem objects amenable to governance with markets". The translation of ecologies into tradable natural capital units, Robertson argues elsewhere, largely “occur[s] through rather mundane and incomplete acts of reduction and simplification” (2012, p. 397).

In the creation of negative carbon emissions from forests, political ecologist David Lansing notes how assemblages of GPS tracking technologies, maps, brochures, websites, and expert testimonials are needed to “perform carbon’s materiality” (Lansing, 2012, p. 204). Fences designate where a forest ends, performing the boundedness of a forest with fixed borders. They materially define what can be measured and therefore bring legitimacy to the creation of bounded quantifications from messy ecologies. Lansing argues that representations of this bounded forest, circulated in marketing material, perform a forest’s identity *as carbon* and render it an attractive commodity for potential investors. Drawing the geographical and temporal boundaries of where to start/stop measuring clearly affects the measurements one produces (Carton et al., 2021), and thus affects which ecological elements can become legible to the market (Edstedt & Carton, 2018). In Chapters Five and Six, I closely attend to how this boundary setting is differentially performed by the state (through the Woodland Carbon Code) and private companies (with high-tech measurement apparatus), for measuring forest carbon. I show how private companies develop new technologies to change the boundaries of where the process of translation can occur. Redrawing these boundaries is framed as a move towards objective measurement; a narrative which, as I argue in Chapter Six, can obscure the political and economic motivations behind changing these boundaries of translation.

As Callon (2006) makes clear, translating the world into representations is often left to the domain of technicians and accountants. The supposed impartiality of measurement obscures the partial, highly politicised decisions that go into creating value for different elements of the material world (Robertson, 2012), set the parameters of what or what not to measure (Gifford, 2020), or determine which measurement techniques or metrics to use (Cusworth, Brice, et al., 2022). Although appearing scientific is a crucial element in the object making performance, as I detail further below, there is only ever a *partial* uptake of ecological science when it is employed in the creation of natural capital. As Robertson highlights, some scientific practices do not allow for smooth abstraction from the world ‘out there’ into nature objects. Robertson explains how ecologists, when employed to "produce ecological data that can circulate in the logics of capital and law" are "continually forced to depart from the methodology and logic of

ecological science" (Robertson, 2006, p. 375). Uncertainties, which cannot be easily translated into a natural capital number, are ironed out in the abstraction process. Streamlining measurement systems allows for materially diverse ecologies to be folded into the same governance logics; measurement systems can 'see' no net loss (Carver et al., 2021), as the accountancy spreadsheets make it 'visible'.

Powerful individuals and organisations, including state representatives, scientists, and corporate actors, hold privileged positions in determining which modes of measurement become legitimate in this object making performance. The acceptance of a measurement regime or metric is not necessarily determined by a smooth coalition of scientific knowledges, but is an ongoing and fraught process. For STS scholar Mark Cooper, the legitimacy of a metric is maintained through "the establishment, fixity, and resilience of systems of measurement and commensuration" (2015, p.1787) rather than the necessarily 'best' (most accurate, most impartial) mode of measurement. Who is considered an 'expert' in forest carbon measurement, as Gifford describes, "often falls to the organizations who first identified and meet market needs" (2020, p.299), such as organisations who have created standards for carbon credits. Calculations of a 'baseline' (the amount of carbon stored independent of an intervention) and 'additionality' (the gulf between a measured baseline and a future measurement) are highly conditional, based on multiple hypothetical claims about a multitude of unknowable factors. But of course, there are always political and economic motivations behind these modes of translation, especially when the translation is carried out by private companies developing value-bearing carbon credits. In Scotland, as I argue in Chapter Six, natural capital verification start-ups are developing new tools to shift how additionality is calculated.

Adequacy

Object making performances are fragile and can easily fall apart (Robertson, 2012). As Lansing (2012) notes, when the signs, maps, indexes, spreadsheets, or accounts that perform carbon's materiality falter, the performance stutters, the illusion breaks, and its legitimacy breaks down. Therefore, the abstractions must be continually re-proved through performances of *adequacy.* A translation might be successful for a time but requires constant improvisation (Callon & Law, 2005). If performances 'misfire', they require 'adjustment-making' (Callon, 2006). Actors are reflexive about their translations being constantly subject to scrutiny (Cusworth, Brice, et al., 2022). Taking new photographs, writing new reports, and generating new measurements keep the object making performance believable (Lansing, 2010; 2012; Nost,

2015).

Appeals to the scientific credibility of the translations function as a central part of the performance of adequacy. Political ecologist Eric Nost (2022) describes how displaying technological prowess signifies the political disinterestedness with which the object making performance occurred. The uptake of new tools which “appear to more authoritatively describe ecological complexity” (Nost, 2015, p. 2584) than previous methodologies allow is an important part of the script. For example, using sophisticated measurement and prediction devices, such as climate models, remote sensing technologies, or algorithms operate as “vehicles of expertise” (Landström & Whatmore, 2014, p.579), providing a source of epistemic authority to truth claims. References to academic and scientific literature, which prove the legitimacy of one mode of measurement over another, are commonplace (Cusworth, Brice, et al., 2022). We see this pattern happening in Scotland. As I argue elsewhere (Stanley, 2024), and develop in Chapter Six, increasingly sophisticated tools and measurement techniques, such as drones and laser scanners, are being introduced to natural capital verification in Scotland. These technologies’ apparent scientific authenticity maintains the veneer of independent objectivity required for these measurements to be accepted as legitimate. My analysis flags how measurement accuracy can be strategically put to work to allow for *increased* amounts of natural capital to be found.

In Scotland, as elsewhere, the generation of numbers through seemingly objective processes allows a decision-maker to present their systems of measurement as overcoming the shortcomings of subjectivity.[12] This is what STS scholar Theodore Porter (2021) describes as ‘trust in numbers’. Porter warns that this trust can be dangerous, by obscuring the political processes that go into decision-making (see also Nost, 2022). After all, as countless STS scholars have highlighted, numbers that emerge from measurement are the outcome of human-designed, human-operated, and inevitably partial material and discursive processes (Haraway, 1988; Lippert, 2018; Stark, 2019). Yet they can circulate as facts independently of the original conditions through which they were created (Bowker, 2000). Architectural theorist Rosetta

[12] Porter (2021) provides a compelling example: within medical science, instruments that numerically prove what a doctor might intuitively know (through their embodied experience, accumulated through a career of studying the body) function as part of a performance of expertise, bounding and bringing legitimacy to knowledge claims. Simply making claims, not backed up by numbers, is insufficient to garner trust (and protect from lawsuits).

Elkin (2022) notes how numbers, divorced from their production, confer legitimacy to truth claims about the benefits of reforestation. In her study of afforestation in China, she highlights how discourses centre the number of trees planted to garner public trust.

The discursive appeal and depoliticising power of numbers and objectivity are of central concern throughout my analysis. Representatives from state departments, private companies, and rewilding NGOs, who we meet in the following chapters, make strategic appeals to objectivity to build legitimacy for their forms of carbon quantification (Chapters Five and Six), exemplify the value of a novel measurement techniques (Chapter Six), and build brand value for their organisation (Chapter Seven). Comparing multiple organisations who develop similar discourses highlights the fraught ways that epistemic legitimacy is contested in the Highlands. Chapter Five provides insight into what happens when the numbers generated as part of the object making performance are *not good enough.* We see how the state must draw on a narrative of measurement *conservativism* rather than *accuracy* to maintain legitimacy for their object making performance.

Extra-scientific

Object making performances require more than quantifying the material world with sufficient scientific expertise. Even seemingly technical issues, such as how to measure forests, need more-than-scientific alliances to bring legitimacy to the nature objects being created. Collaborations with NGOs (Wilshusen, 2019) and compliance with standards and codes of conduct (Valiergue & Ehrenstein, 2022) are also required. Abstracted and exchangeable nature objects undergo what Callon and his colleagues describe as 'qualification', the process through which a good becomes a product, as its "qualities are attributed, stabilized, objectified and arranged" (Callon et al., 2002, p. 199). For example, carbon credits sold on the voluntary carbon market must be differentiated from other products to make them attractive to potential buyers. The relative value of a good, such as a carbon credit, is made, remade, and communicated in different registers, dependent on the purchaser's set of values and knowledges (Graeber, 2013; Heuts & Mol, 2013; Tsing, 2013). Effectively, it is not sufficient for heterogenous elements of the world to be 'made the same' and abstracted into offsetable credits. Their differences must also be performed. In Scotland, there are no fixed prices for carbon credits. Even though each carbon credit signifies an equivalent and (theoretically) interchangeable tonne of carbon, they warrant highly variable prices.

Characteristic of other natural capital schemes which produce exchangeable credits, credit sellers must prove their schemes deliver ostensibly non-capitalist goals (social benefits, ecological uplift, etc.). For example, a carbon credit must be sold with the right story to make it valuable for a buyer. High-quality carbon projects sell 'charismatic carbon' (Wang & Corson, 2015), carbon credits loaded with 'more-than-carbon' appeal (Huff, 2021; Nel, 2017; Paterson & Stripple, 2012). Alice Valiergue and Véra Ehrenstein (2022) highlight how 'low-quality' carbon credits sell for under $1 per tonne of carbon (such as credits generated from emissions reductions from dams in China) whereas 'high-quality' carbon credits that promise eco-social renewal can sell for more than $30 per tonne (such as in biodiversity regeneration projects in Australia). Selling charismatic carbon credits relies on maintaining the image of a successful project that brings social and ecological benefit; although the difficulties of realising these benefits is often obscured (Wang & Corson, 2015).

The delivery of more-than-carbon benefits is increasingly subjected to objective measurement, with metrics designed to quantify 'social' values' (Tadaki & Sinner, 2014; McElwee, 2017). Gulfs between lived realities and the realities mediated by marketing material are commonplace (Wang & Corson, 2015). The benefits generated within carbon credit schemes, especially within carbon forestry projects, can be 'the benefits that capital can see' (Edstedt & Carton, 2018). These are benefits easily represented and sold to companies looking to invest in charismatic carbon projects; they are easily circulated on websites and in brochures and do not necessarily equate with the benefits needed and wanted by local community groups.

Due to the dominant geographical patterns which typify the charismatic carbon market worldwide, most research attention has focused on projects in which charismatic carbon is generated in the Global South and sold to offsetters in the Global North (Valiergue & Ehrenstein, 2022). By closely analysing the qualification performances that create high-value carbon credits from Scottish nature restoration, Chapter Seven considers an emerging new trajectory within the Global North charismatic carbon market. Ecological authenticity, or 'wildness' as some interviewees called it, is increasingly framed as a more-than-carbon benefit generated through carbon offsetting schemes. Companies selling or developing natural capital credits, especially operating under the banner of nature restoration or rewilding schemes, are also increasingly turning to prestigious scientific institutions to increase their organisation's brand value and raise the value of their carbon credits. The analysis I develop hints to novel trajectories in the ways nature is both quantified and qualified in natural capital schemes.

2.3. Environment Making Performativity

Object making performances have, in the terms of Wim Carton and Karin Edstedt, "world-making" potential (Carton & Edstedt, 2021, p. 405). Choices about how to measure the environment have significant environment making performative effects of their own. By fixing which base units are counted, such as species, processes, or genes, measurement regimes determine which ontological categories become the foci of governance regimes (Bowker, 2000; Gabrys, 2020). This determines **which natures** become materialised through environmental schemes. As environmental governance frameworks can only successfully operate with the natures legible to them (Scott, 1998), the natures which emerge through these schemes take on the particularities of their measurement design. Especially in forestry projects, **legible natures** are often created in streamlined material arrangements. Sometimes, the need for measurability and productivity ensures that **degraded natures** emerge as a result.

Which natures?

STS scholars Geoffrey Bowker and Susan Leigh Star (1999) describe how scientific practices of classification, categorisation, and boundary setting, which are so crucial to the object making performance, are not mere reflections of a pre-given reality but generate and stabilise it. Even in the most apparently 'scientific' metrological endeavours, hidden human power structures shape the information generated (Barry, 2005), and this information in turn shapes the world. For example, Bowker (2000) notes that there is clearly more data available about things that people like (aesthetically, ethically, economically, politically), whereas "things that people don't generally like or need get less attention" (2000, p. 658). For example, as Jamie Lorimer (2007) notes, charismatic animal species receive more research funding and attention than others and hence more 'science-led' conservation effort is directed towards these species. As 'objective' environmental governance is increasingly based on an available database, and a database's composite data are shaped implicitly by economic concerns and subjective biases,

> "the database itself will ultimately shape the world in its image: it will be performative. If we are only saving what we are counting, and if our names are skewed in many different ways, then we are creating a new world in which those counts become more and more normalized" (Bowker, 2000, p.675).

Whilst Bowker was writing about the performativity of biodiversity databases, scholars such as Jennifer Gabrys and her colleagues (2022) note that, as scientists develop new databases about the carbon stored in landscapes such as forests, these landscapes are increasingly governed *as* their carbon content (see also Carton & Edstedt, 2021; Markusson, 2022). Political ecologist Amber Huff describes the ways that the "discursive framings and techniques of abstraction" (Huff, 2021, p. 7) which translate forests into their carbon content, allow forests to be exchanged as marketable natural capital commodities.

Robertson argues that as ecologies become translated into value-bearing units, such as carbon credit commodities, two natures emerge. On one hand, the 'nature that capital can see' (2006) comes into view, composed of the environmental and ecological dynamics knowable through epistemic practices that measure with relative certainty. These measured stocks and processes can be successfully translated into measurable commodities which can be bought and sold in natural capital markets. Simultaneously, a nature invisible to capital, which is not easily reduced or quantified, slips from view (see also Lovell & Liverman, 2010). Edstedt and Carton (2018) describe how more-than-human ecological dynamics, landscape aesthetics, ecological resilience, local knowledges, and a range of other elements invisible to capitalism's reductive logics are obscured from environmental policy and practice, especially within forestry. In Carton and his colleagues' terms, "biodiverse and socioculturally rich landscapes [are reduced] to current and/or potential carbon sinks" (2020, p. 7), as underlying social and ecological nuances between forests are obscured.

The idea that there are natures 'invisible' to capital takes on a significance in the Highlands, where carbon finance is increasingly framed as a *necessary* mechanism for scaling up nature recovery. As other scholars have suggested (J. Lorimer, 2012), with multiple natures available to restore, it is not self-evident *which nature* will be financed through carbon schemes (Brock, 2020; Urzedo et al., 2022). It becomes crucial, therefore, to investigate which natures materialise because of the specificities of the Woodland Carbon Code (WCC), the state-backed woodland carbon accreditation system. Chapter Five picks up this question and shows the specific ecologies that are rendered valuable through the WCC.

Legible natures

The environment making power of measurement design has a long historical precedence. Historian James Scott describes how, since the eighteenth century, forest ecosystems in

colonial states have been measured and thus translated into “a single number” (Scott, 1998, p. 12), which can be calculated and controlled to usher in their ‘effective’ (streamlined, rational, reductionistic) management. The pursuit of one number, generally quantities of extractable timber, created very extensive material effects on eighteenth century forests, which Scott describes:

> “Forest science and geometry, backed by state power, had the capacity to transform the real, diverse, and chaotic old-growth forest into a new, more uniform forest that closely resembled the administrative grid of its techniques. To this end, the underbrush was cleared, the number of species was reduced (often to monoculture), and plantings were done simultaneously and in straight rows on large tracts.” (1998, p. 15)

This streamlined forest, easily represented in spreadsheets and maps, could be governed according to scientific practices in spatially distant locations, making it simpler for a (colonial and post-colonial) state to govern. Ecologies growing in standardised material forms are easily commensurable and accountable (Barua, 2023). In Scott’s (2022) terms, all plants not legible to the state are considered ‘weeds’ and have been systematically excluded from a rightful place in legible natures.

Robertson (2006, 2012) describes how the pursuit of legibility has shaped which natures become valuable and are subsequently produced within modern environmental governance schemes. Forests and species that are valuable for aesthetic, ethical, historical, and even *ecological* reasons are rendered relatively worthless if their processes are illegible, or their benefits quantitatively negligible in the dominant frames with which forests are measured. For example, in Scotland, protecting and facilitating the restoration of ancient woodlands is relatively worthless in the hegemonic frames of valuation. Pockets of endemic trees, which sometimes have a historically continuous population stretching back millennia, are worth little in ‘net’ carbon terms, and their biodiversity value is difficult to measure and bring to market. In Chapter Eight, we meet rewilders who are seeking to shift the measurement frame away from the reductive tendencies of natural capital to highlight other ecological properties such as ecological health and resilience. I show how a change in measurement can highlight otherwise side-lined ecological properties, reflexively performed to create alternative ecological dynamics and new natures as a result.

Political ecologists have highlighted how carbon forestry is constrained by the need to quantify and translate the process of carbon sequestration into a fixed value; and this has very material effects. Larry Lohmann describes the socionatures of carbon credits as "landscapes in which regions of accelerated degradation are interspersed with areas specializing in the production of a few technician-selected aspects of 'nature'" (2011, p. 113). These areas of legible nature might be offered as 'green sacrifice zones' (Zografos & Robbins, 2020) where legible natures are maximised for their measurable stocks (of carbon, biodiversity, etc.) and multispecies communities are excluded from accessing flourishing livelihoods (Carton & Edstedt, 2021). Within these areas of legible nature, as Carton & Andersson (2017) note, trees should grow in measurable, linear, and uniform ways to make them measurable. Although forests are presented as 'natural' carbon removal in discourse, in practice they are increasingly employed as a carbon removal *technology*, "that is, standardized, engineered, machine-like, enclosed systems" (Markusson, 2022, p. 6). They are designed to maximise the amount of *measurable* carbon sequestered, because this quantified number can be translated into carbon credits and sold in the voluntary carbon market.

Degraded natures

Unsurprisingly, the pursuit of legible natures can correspondingly lead to the creation of degraded natures. Anthropologist Sophie Chao describes the 'plantation logic' at the heart of modern state power, which involves "ordering, narrating-historicizing-authoring, controlling, and managing" (Chao, 2022, p. 364) nonhuman life into productive ecologies that serve the interests of a few humans, at the expense of local multispecies lifeworlds (Haraway, 2015; Lyons & Westoby, 2014). These plantations, anthropologist Anna Lowenhaupt Tsing forewarns, "kill off beings that are not recognized as assets" (2017, p. 52). Modernity's material and ideological streamlining, acutely felt in commercial forestry and agriculture, have made natures "safe, productive, and orderly" (J. Lorimer, 2020, p. 3) but have also led to a series of 'blowbacks' (Wallace & Wallace, 2015; see also Wakefield, 2020) new pathological conditions driving a planetary transition towards the Anthropocene. Diseases, extinctions, wildfires, droughts, and famines are the material outcome of attempts to streamline nature's complexity. In Scotland, as Chapter Four explains in more detail, the historical focus on maximising revenue through the production of sheep and timber has led to a streamlining of ecological function. But in the Highlands, messy and diverse natures are increasingly framed as valuable 'solutions' to socioecological problems. What might have previously been considered

uneconomical ‘weeds’ by the state (Scott, 2022) – such as the naturally regenerating native woodlands which ostensibly serve no economic purpose – are central to rewilding and are being framed as *instrumentally* important for nature and climate. How, then, do they become legible to governance? This is a central tension I return to, especially in Chapters Seven and Eight.

Demand for measurable gains can have apparently perverse ecological effects. Political ecologist James Palmer describes how a focus on maximising carbon sequestration entails that, “a stand of juvenile trees appears far more advantageous to climate change mitigation than a stand of larger, more mature, but nonetheless slower growing trees. Dynamism and productivity are hence privileged over size and stability” (2020, p. 149). Correspondingly, in his study of North American forestry, fast-growing commercial species such as eucalyptus are presented as crucial nature-based solutions ahead of the protection or conservation of old growth forests. In Scotland, the increased public appetite for native woodlands and rewilding problematises the narrow idea that carbon finance necessarily creates forests in a streamlined or degraded way. Chapter Five develops this theme, to consider how specific elements of the Woodland Carbon Code variably determine which types of forest are rendered valuable in Scottish reforestation attempts. Operating under public scrutiny, the legitimacy of the carbon credits created through carbon finance breaks down if clearly profitable commercial rows of non-native conifer emerge from the WCC’s metric design. In the chapter, I trace how carefully curated object making performances of conservativism and integrity have environment making performative outcomes, *increasing* the number of native broadleaves planted in Scotland but potentially *streamlining* the types of woodland that can be realised with carbon finance.

How, then, can measurement be enrolled in ways that realise a multitude of ecological dynamics and performatively usher in more flourishing ecologies? As we see in the following chapters, Scottish organisations are reflexive about the interconnected object making and environment making performances, and concerned with the streamlined ecologies that emerge from nature’s commodification (a process I identify in Chapter Five). Organisations across seeming political-economic divides are attempting to make these difficult-(potentially impossible)-to-quantify ecological processes legible to both the market and state. Chapter Seven considers how private companies are subjecting a more diverse range of ecological processes to measurement, putting faith in more accurate measurement techniques to enable improved environment making effects. But many rewilders are sceptical that an improved system of measurement, no matter *how* high-tech, can ever successfully measure and place a

financial value on the full range of process that rewilding delivers. In Chapter Eight, we see how one rewilding organisation is increasingly leaning on measurement to shift the boundaries of what 'counts' in reforestation schemes.

2.4. Society Making Performativity

To summarise, environmental measurement schemes are performative in the ways they determine which parts of nature can become fungible nature objects, and how they shape the material composition of the ecologies they measure. Modern assumptions about the essential objects of environmental governance (such as carbon and biodiversity) become locked in, and their negotiation is framed as the rational, science-led means of 'restoring nature' (Turnhout et al., 2014; Mahony & Hulme, 2018). Through the displays of scientific expertise and technological prowess underpinning the object making performance, and reference to the new natures which materialise as a result, the ideologies that fed *into* the measurements of nature outlined above become reified through their apparent success (Lansing, 2012; Nost, 2015). This can be seen in the diagram above: the society making performances operate at a further level of abstraction than the other two performances, whipping round and amplifying over time. The intersecting environment making and object making performances, which occur inside the society making loop, become more tightly bound. These entwined performances legitimise **market-based mechanisms** as the normatively best strategy for realising nature restoration (Nost & Goldstein, 2022), and frame **technoscientific knowledge production** as the depoliticised and rational way to govern independently of subjective bias. Together, these can lead to ***mitigation deterrence,*** as the much-needed interventions to avoid climate and ecological breakdown are framed as not necessary and are subsequently not pursued.

Market-based mechanisms

Several scholars have highlighted the ways that measurement legitimises the underlying frames at the heart of neoliberal modes of governance. David Lansing's (2012) study of carbon credits in Costa Rica demonstrates how measurement performances not only make credits and shape the world, but also have society making effects. An august array of tools, metrics, spreadsheets, brochures, and scientific papers not only *perform carbon's materiality* (as I explained above) but also *perform* the carbon market's entire calculative frame. They simultaneously create legitimacy for the credits and modes of market environmentalism being developed, making the

frame of exchange appear a ‘civilised market’ (Callon, 2009), despite the fact it is constantly subjected to controversies.

Vijay Kolinjivadi and their colleagues (2017) argue that modernity’s systematic pursuit to maximise the tradable units extracted from a landscape is so widespread that societal actors cannot ‘see’ the neoliberal governmentality at work in payment for ecosystem services projects. Esther Turnhout and colleagues (2014) similarly describe how dominant political discourses about natural capital and offsetting shape how scientific knowledge is employed within environmental policymaking. They describe this science-policy interface as measurementality, in which “the environment is measured and represented in a very specific way: one that enables a specific mode of governing that happens to be associated with very specific sets of scientific, political, or economic interests” (Turnhout et al., 2014, p. 581). Whilst this makes biodiversity governance easier to fold into market logics, it also creates a streamlining of knowledge production and implementation, leading to not only “an impoverishment of the biodiversity research agenda, but also in an impoverished understanding of biodiversity itself” (2014, p. 581). As scientists look for ‘impact’ in the real world, and private companies collaborate (and finance) scientific research, scientific knowledge fits and supports the overarching modern ontology (Sullivan, 2017). We see nature in ways that fit with the dominant economic, social, and political order.

Critics suggest that functional human-nature relations become formatted as the ‘correct’ way to govern natures. By measuring the nature-based solutions that natural capital-financed forms of nature restoration deliver, the data generated *proves* the modes of governing we are undertaking are *delivering* nature-based solutions (Sullivan, 2018; Elkin, 2022). There’s a clear link between measuring a process and creating data that legitimises that very process. Mercantile human-nonhuman relations are shown to be working instrumentally. Publics are reassured of the expedience of natural capital schemes and offset markets in creating successful environmental governance schemes. The frames that problems and solutions are represented are not questioned.

Technoscientific knowledge production

Eric Nost (2015; 2022) argues that the sophisticated performance of technoscientific measurement makes it appear that it is necessary and inevitable for good environmental governance. The value of new technologies seems obvious. As Karen Bakker & Max Ritts,

(2018) describe, with updated measurement technologies, seemingly "raw" information can flow faster, making previously invisible environmental problems not only visible, but ostensibly solvable in real-time. But despite the apparent benefits of certain technologies, there is always a moral contingency and ambivalence in using digital technologies to measure and monitor ecologies (Gabrys et al., 2022; Millner et al., 2024). Measurement technologies and information-processing algorithms can narrow the possible avenues for intervention into how natures are managed (Turnbull et al., 2022; von Essen et al., 2021). As I mentioned above, the measurable elements of an environment might become the foci for governance ahead of other considerations. Simultaneously, with increased data available, the governance of ecosystems can be often stripped away from locally situated decision-makers and local community groups and towards often technical or scientific 'experts' (Adams, 2019).

Environmental measurement can create unjust distributions of benefits from environmental schemes, but these dynamics can be obscured behind the allure of objectivity (Daston & Galison, 2007). As political ecologist Lucas Brunet (2022) notes, numbers generate a positive, communicable story about political interventions by making them appear independent of biased concerns. For example, Nost highlights how state actors increasingly rely on the performative allure of 'Big Data', which is "pointed to as providing objective answers that emerge untampered from observations of the world as it is - a view from nowhere" (Nost, 2022, p. 1). This allows state actors to develop "accountability claims that appear contradictory: their decisions are legitimate because they are driven by the best available… science and technology, while their data tools 'didn't make decisions for us'" (2022, p. 1). Objective decisions, informed by measurement, are presented simultaneously as the best available choice and not a choice at all, which leaves space for praise but forecloses the opportunity for political critique. This contributes to a depoliticization of environmental problems, as data-driven (often market-based) solutions are framed as the only 'realist' option available within capitalism (Büscher & Fletcher, 2019; Fletcher, 2017). More radical and disruptive modes of doing conservation or restoring nature, which might not produce the same alluring 'trust in numbers' that high-tech measurement affords, slip from focus.

Mitigation deterrence

Political economist Nils Markusson and his colleagues (2022) argue that the scientific veneer of measurement technologies is crucial for framing net zero as an ostensibly expert, depoliticised form of climate governance, rather than a risky governance approach to address

climate breakdown. New measurement technologies are crucial in convincing publics that these technical fixes to environmental problems are expertly devised and thus have "few side-effects, certain outcomes and with knowable overall capacity" (2022, p. 4). Markusson and his colleagues (2018) term this *mitigation deterrence,* the process of delaying or avoiding timely and much-needed climate mitigation, resulting from the introduction, consideration, or promise of an alternative intervention. The promise that today's emissions can be captured in the future legitimises continued emissions. Carbon offsetting is, as Andreas Malm and Wim Carton wryly remark, "the institutionalised mitigation deterrence that never goes out of fashion" (2021, p. 27). A widespread, normalised system has been co-produced by private companies and governments that allows, both morally and bureaucratically, emitters to keep emitting. Similarly, the supposed naturalness of nature-based solutions presents them as the natural way to address atmospheric carbon levels (Bellamy and Osaka, 2019).

Extensive literature on mitigation deterrence has highlighted how corporate actors can make their emitting practices appear less dangerous using complicated measurement techniques. Political economist Ingmer Lippert (2015) describes how carbon managers do not necessarily need to lie about their emissions but rather organise their emissions accounts to *externalise* emissions from their companies' core processes (i.e. to render themselves not responsible for emissions). Given the epistemic impossibility of ever exhaustively measuring the operations of a company, and the sheer complexity of the methodologies, standards, and databases used in carbon measurement, there "is not a singular reality that is produced but a space of multiple and situated possible realities" (Lippert, 2015, p. 8). Especially when performing calculations of *future* emissions, complex prediction models can 'prove' that emissions can be offset in the future (Beck & Oomen, 2021).

Mitigation deterrence appears in the diagram above. The arrow shooting outwards from the society making loop signifies the knock-on effects which emerge from the ongoing society making performances. In Chapter Six, I argue that a novel form of mitigation deterrence is emerging in Scotland's natural capital market. Instead of strategically finding ways to *exclude* emissions, private natural capital verification companies are developing ways to make more nature measurable to *include* sequestration, which allows for more negative emissions to be created from a fixed form of biophysical matter. It is not a logic of *strategic ignorance,* which Linsey McGoey (2012) highlights is widespread in climate politics, that is put to work, but a logic of strategic *accuracy.*

2.5. Disruptive Performativity

Most studies I have reviewed offer what J.K Gibson-Graham call a 'thick' critical reading of economic reality, "focused on identifying the ways that capital relations are ever inventively shaping economic, political and ecological realities" (2020, p. 478). Gibson-Graham argues that in revealing only the harsh structural realities of neoliberal governance that reinforce capitalist power structures, a critical reading of the world becomes performatively reinforced as the sole reading of reality. The categories and objects used to describe the world get locked in; governance responds accordingly, enacting these categories. And with this, "the possibility of change evermore diminishes" (2020, p.479). They call for a more open 'reading for economic difference', which involves paying close attention to how alternative modes of economic activity might be enacted. They suggest that critique can be used as a political intervention, to "unravel capitalonormativity and to highlight the radical heterogeneity of economic identities and relationships and trajectories" (2020, p. 481). Therefore, this thesis explores how environmental measurement might be *done otherwise,* disrupting a narrow focus on natural capital quantification and its environment making effects. If measuring is always, as Lippert describes, "ongoing, reflexive, partial and always situated" (2015, p. 126), and has the power to enact alternative ontologies, materialise different natures, and support different political regimes, then how might it be put to work in support of alternative forms of nature restoration to the neoliberal status quo? Measurement, I argue, can create moments of *disruptive performativity,* which occurs when the **performativity** of measurement is **reflexively** engaged with. This can foster a **transformative politics,** especially when technologies **measure more-than-human dynamics**. The diagram above shows that these disruptive performances can make cracks in the hegemonic society making performance. But although these disruptions are noticeable, they can be smoothed over by the sheer momentum with which the status quo reproduces itself.

Reflexive Performativity

The substantial performative power held by the apparently mundane practices of environmental measurement is an open secret. Cusworth and his colleagues note (2022) that metric design has become a site of considerable political contestation. A range of stakeholders, reflexively aware of measurement's world-making power and "that these calculations might be done otherwise" (2022, p.14), lobby for measurement regimes that make their industries' practices appear less

environmentally destructive. They suggest that "non-technical and non-scientific actors weigh in on seemingly arcane discussions about metric design, knowing that such decisions will shape the worlds they have to inhabit" (2022, p.2). Different parties engage in 'reflexive performativity': they are "anticipatory and strategic in their engagement with the metrics that are used to govern their lives" (2022, p.1). Cusworth and his colleagues highlight an important insight: when it comes to measurement, the script is not fixed and can be written anew. Stakeholders can make interventions into how natures are measured, well aware of the performative effects these might have on a plethora of social and ecological outcomes: on landscape composition, more-than-human relations, the distribution of benefits, the types of forests that are rendered valuable, the types of natures 'legible' to governance, who is considered an expert, and so on.

Whilst the actors in Cusworth's study are commercial groups lobbying for measurement regimes to be accepted to maintain the status quo distributions of power and wealth, engaging in reflexive performativity is by no means an intervention inherently linked to maintaining conservative and hegemonic interests. In cases of disruptive performativity, measurement can be strategically employed to upset the performative outcomes of environmental governance schemes. In Chapter Eight, I show how rewilders make reflexive interventions upstream in the measurement process, creating new systems of measurement to change how forests are rendered legible. This is particularly important for foregrounding emergent ecological properties such as ecological resilience and wildness which are difficult to measure using measurement systems which quantify natural capital stocks. As Lorimer highlights (2020), these properties are celebrated by rewilders but are not easily translatable into a reductive and exchangeable economic quantity (Cusworth & Lorimer, 2024). In hegemonic modes of measuring forests, principally through quantifying forest carbon content, these can easily be ignored; this is a claim I grant more empirical attention in Chapter Five.

Transformative politics

Of course, a lot of natural history measurement that has informed biodiversity conservation has been undertaken with a genuine concern for the plight of a species or habitat. Lorimer's (2008) ethnographic study of corncrake scientists and Gandy's (2022) study of urban ecologists are a testament to this fact. Although disruptive performativity is a new framing, scholars working in the growing field of 'digital ecologies' have shown how digital technologies can create novel affordances for more care-filled interspecies relations (for a full review, see Turnbull et al.,

2022). Technologies such as sensors can facilitate further citizen science participation (Gabrys, 2019) and public engagement with conservation (Adams, 2019). They also increase the ability of scientists to measure spatiotemporal changes in abiotic and biotic communities (Turnbull et al., 2022), provide entries to alternative worlds of experience that are otherwise silenced (Searle et al., 2022), and offer forms of evidence that hold state actors or industry to account (Weizman, 2017). 'Counter-mapping' practices can highlight and foreground otherwise obscured land claims within forests (Peluso, 1995), make legible other modes of seeing (Millner et al., 2024) and being with the more-than-human world (Westerlaken et al., 2023).

Disruptive performativity shares common political sentiment with scholars such as David Chandler (2018) and Stephanie Wakefield (2020), who call for modernity's techniques and technologies to be reworked to create sociotechnical 'transformation'. Reflexive of how technologies and politics co-produce each other and stabilise normative dynamics of knowledge and power, they distance themselves from a subset of environmental humanities scholarship that too quickly abandons "commitments to the ideals of progress, truth, and improvement, and forsakes modernist aspirations for socioecological transformation" (Lorimer, 2020, p.228; see also Chandler, 2018). They argue that 'living in capitalist ruins', as Tsing calls for (2015), is not disruptive enough to realise emancipatory ecological futures. Instead, existing technologies must be, in Robertson and his colleagues' terms, "scavenged" (2023a, p.1) from existing scientific practices to create novel measurement regimes. In Chandler's terms, practitioners and theorists looking to transform modes of governance with the help of modernity's tools can 'map' ecological dynamics, 'sense' environmental processes and degrading practices, and 'hack' available technological infrastructure to generate novel forms of data (Chandler, 2018).

Instead of obscuring the necessarily political and partial nature of knowledge production, situatedness can be strategically directed in support of engaged political ecological projects. Eyal Weizman, founder of the investigative research agency Forensic Architecture*,* calls for activist-researchers to "tak[e] over the means of evidence production" (2017, p. 64), operating with an 'engaged objectivity', in which "political motivations must not be an obstacle to gathering knowledge, but rather the precondition for attaining it" (Weizman, 2017, p.74). As I explore in Chapter Eight, alternative modes of measurement might create different political conditions that enact different forms of more-than-human biopolitics, forms of valuation, and methods of knowledge production (Wakefield & Braun, 2019). This is not an ecomodernist

intensification of the status quo, with more faith in markets, metrics, and capital to lead society towards salvation (Lemke, 2021; Wakefield, 2018). Instead, I argue that new forms of ecological measuring shift what gets measured, knowing a shift can change which natures might emerge.

Measuring more-than-human dynamics

Increasingly, scholars highlight the transformative potential of sensing and measuring the more-than-human world to create novel forms of environmental data which upset fixed constellations of power. STS scholar Frédéric Keck (2015) describes the ways that birds increasingly function as 'sentinels' for environmental change, revealing otherwise invisible ecological dynamics. Likewise, geographer Oscar Hartman-Davies (2023) shows how mapping the flightpaths of seabirds can reveal where illegal fishing practices take place. Cultural geographer Matthew Gandy builds on Weizman's work to consider how scholars increasingly "move beyond the human sensorium [which] incorporates a wider range of nonhuman and material sensors: the environment itself becomes a recording device or 'material witness' to historical events derived from a panoply of different elements (Gandy, 2022, p. 159). Researchers might develop a 'tactical epistemology' (Gandy, 2022, p.167), employing measurement practices that make otherwise unnoticed or unsensed ecological rhythms and dynamics legible to governance regimes. For example, Michelle Westerlaken and colleagues (2023) show how forest measurement technologies construct new realties when they measure more-than-human ecological relations rather than carbon stocks. Marginalised ontologies can be enacted through a shift in measurement practice.

For both Weizman and Gandy, plants are important nonhuman sensors that can be measured to understand the environmental impact of historical or contemporary practices. They serve as bioindicators, providing data in an alternative register to the dominance of representational forms (Gabrys, 2016). Non-humans' lively agencies can be mapped using a range of digital techniques, revealing the 'technonatural histories' of ecologies, plants, and animals (Searle et al., 2022). Gabrys and her colleagues (2022) note how forest measurement can support distinct more-than-human forest worlds, by making visible otherwise obscured lives of nonhumans. Similarly, Indigenous, poor, rural, and marginalised communities operating outside the state-capitalist nexus, who are largely excluded from generating environmental data due to a lack of access to cutting-edge measurement techniques, can access novel opportunities to participate

in political debates about forests when given the opportunities to measure them (Gabrys et al., 2022; Millner, 2020).

There are a host of empirical and conceptual challenges associated with disruptive performativity. How can environmental measurement be employed to enact a mode of biopolitics in which the emergent properties of ecologies are measured and celebrated? How can environmental measurement be reconciled with the uncertainty that characterises rewilding (J. Lorimer & Driessen, 2014)? How can measurement capture important yet obscured values such as historical continuity, endemism, and aesthetic importance? These are themes I return to at length in Chapter Eight.

2.6. Conclusions

This chapter has articulated the many processes and actions that get labelled 'performative' in environmental scholarship and synthesised them into one framework. These performances include politicians making appeals to their scientific credentials, companies referring to their green credentials to gain trust from consumers, and accountants using spreadsheets and databases to bring a sense of epistemic realness to the creation of natural capital credits. The width and breadth of environmental scholarship which employs the term 'performativity' hints to its clear analytical appeal. Clearly, performativity's anti-essentialism brings clarity to geographical scholarship which has highlighted that Nature does not exist independently of Society, just waiting to be measured (Bingham & Hinchliffe, 2008; Lorimer, 2012; 2015). Rather, natures are constantly made and remade through their representations and descriptions, especially by their measurement.

The synthesis offered here, and the articulation of *object making*, *environment making*, and *society making performativity,* show how multiple performances, played out by different more-than-human assemblages and directed by a range of people and organisations, occur simultaneously. They support each other in reproducing the status quo ways that forests are governed, and nature restoration is pursued. Building on Anne-Marie Mol (2002), nature restoration can be understood as multiple: it is the contingent outcome of ongoing performances, constituted through the everyday happenings that bring nature restoration into being, rather than a pre-given ontological category. Therefore, it becomes important to investigate *which* natures emerge from environmental schemes operating under the banner of

‘nature restoration’ and which forests of the ‘forest multiple’ emerge. And more importantly, this review has highlighted a political opening: when nature restoration is the contingent outcome of malleable measurement performances, it can be done differently. The following chapters tease out the different natures that are enacted by different measurement performances, taking care to spell out the social, political, and economic contexts to which measurement regimes are directed. In the following chapter, I describe the context in which contemporary efforts to reforest Scotland have emerged, taking care to explain how measuring Scottish natures has a long history.

3. Methodology and Methods

Nature restoration, reforestation, and rewilding are enacted in multiple ways: they are represented in spectacular imagery and romantic prose; known through complex assemblages of scientists and calculative devices; and materialised through the hands-on practices of fencing, culling, planting. There is clearly a difference between the ways things are described, and the ways they are done in practice. And thinking with the conceptual framework of '*environmental performativity',* the discursive and the material co-constitute each other. How, then, to disambiguate this multiplicity? How to study the intersection of matter and meaning?

This chapter outlines how and why this project developed. I begin by describing my **(3.1.) Research Design**, explaining how I have situated my project between STS and political ecology by drawing on methodological strands of both. I document how the project's central focus iteratively shifted, from a focus on *forest carbon* to the more capacious focus on *forest measurement*, to reflect the empirical insights I gathered in the field. I explain my choice for undertaking a **(3.2.) Multi-Sited Ethnography** and describe how and why I carried out fieldwork over a relatively large geographical area with multiple organisations. Then I outline my **(3.3.) Methods**, justifying the rationale for relying on **Interviews, Participant Observation** and **Following Translations**. Building on insights from several ethnographic moments, I describe how these methods succeeded and reflect on how they failed or could have been improved. I also document my **Historical Methods** and describe my **Writing and Data Analysis.** I end the chapter with a consideration of my **(3.4.) Ethics and Positionality,** paying close attention to the power dynamics and identity politics that helped and hindered the delivery of this project.

3.1. Research Design

As I described in the Introduction, I was initially fascinated by the 'planting fever' that gripped the nation in 2019. I was especially interested to understand how trees could *become* carbon, by being translated into the quantified units necessary for generating negative emissions. Unpacking the mechanisms through which these translations could occur has been a central concern for ANT-inspired science studies, with scholars opening up the 'black box' of science to see how scientists and technical experts 'pack the world into words' (Latour, 1999) and other calculative or representative spaces, such as accountancy spreadsheets (Lippert, 2015). Inspired by other geographers who trace the material and semiotic processes through which scientific translations and abstractions happen in conservation (such as Greenhough, 2006; J.

Lorimer, 2008), I wanted to be in 'the field' with people measuring forest carbon, and follow where these measurements ended up. As geographer Jamie Lorimer notes, ethnographically following scientists in the field, outside the sanitised conditions of the laboratory, allows a researcher to understand the "importance of embodied skill, emotions, and an ethical sensibility in the generation of scientific representations" (2008, p.379). Bringing a close ethnographic investigation to what Callon and his colleagues (2009, p.537) call the "real world" spaces of measurement could, I hoped, reveal the political, ecological, and ethical commitments shaping the ways forest carbon was being measured, and situate these knowledges within the different 'epistemic cultures' shaping the Scottish land sector (Mahony & Hulme, 2018).

Whilst these STS methodologies were crucial for highlighting how different experts generated scientific claims and determined which translations were sufficiently adequate to be accepted as objective, I also wanted a more extensive ethnographic approach that not only traced how measurements were taken and facts were made (the process I termed 'object making performativity' in Chapter Two), but also examined how the material world was being shaped by the new knowledges, policies, and practices associated with forest carbon (which I termed 'environment making performativity'). Following the work of other political ecologists, especially Morgan Robertson, Lauren Gifford, and David Lansing, I borrowed a 'follow the thing' methodology from ethnographer Ian Cook (2004): I wanted to trace how a single nonhuman – in my case, forest carbon – was being found, known, measured, marketed, bought, sold, and represented by different but interlinked epistemic groups.

The methodology employed by Anna Tsing in *The Mushroom at the End of the World* (2015) was a reference I continually referred to for guidance. Instead of focusing ethnographic attention on one group of people or one specific area (such as a National Park), Tsing treats the matsutake mushroom as her ethnographic protagonist, following it round the world across sectors and geographies. Her fieldwork takes her into laboratories and forests with a range of more-than-human communities, seeing how people of myriad identities had strong and specific relations with matsutake. Instead of matsutake, I wanted to follow forest carbon, being caught up in what Michael Goodman & Emily Boyd (2011) call the 'social life' of carbon. Inspired by Tsing's method, I too wanted to meet different communities of scientists, ecologists, and traders, who might hold different epistemological and ontological commitments but are united through a shared interest in one thing.

Undertaking extensive, embodied, *in situ* fieldwork seemed a clear methodological choice. Only by being there, in person, could I answer Gifford's call to pay close attention to "how, and by whom, carbon is quantified, standardized, and commodified" (2020: 292). Upon arriving in Scotland, I was relieved to realise that forest carbon – how it was being measured, sold, traded, governed – could increasingly be understood as a 'matter of concern' (Latour, 2004), with different experts making competing claims about the best ways to measure forest carbon. It was easy to find contacts to speak with about such a controversial, provocative topic.

But simultaneously, I realised that focusing narrowly on forest carbon seemed to miss opportunities for unpacking the complicated ontological politics ongoing in the Highlands which I spelled out in the Introduction. Forests, I realised, were clearly *multiple* in the Highlands, and were being variously enacted by different measurement techniques. Experts with vastly different political and epistemic commitments were measuring different elements of forests, including but not limited to carbon. Following extensive conversations with rewilders and ecologists during my fieldwork, especially during ecological surveying trips which I detail further below, it dawned on me that a research focus on forest carbon might have an unintended performative effect of its own, locking-in a carbon-centric mode of describing forest governance, much as Gabrys and her colleagues (2022) forewarn. Broadening my analysis beyond forest carbon measurement also afforded me political space to consider how measurement might be 'read for difference' (Gibson-Graham, 2020), operationalised outside the neoliberal status quo. My hope is that examining the multiple ways forests are measured, rather than focusing solely on political contestation about how best to account for forest carbon, will have a *disruptive performative* effect in elevating an environmental agenda which pushes back against the reductive focus on carbon in forest governance.

3.2. Multi-sited Ethnography

To capture the diversity of knowledges and practices relating to reforestation, it seemed plain that I undertake multi-sited ethnographic fieldwork. My fieldwork practice followed a quite traditional model, in which I lived "out there" to collect data, wrote it up in Oxford, and subsequently returned to the field to collect more data. In part a legacy of its colonial roots, this version of fieldwork has held an epistemic privilege in geography, as a means of collecting data, authority, and expertise. Although this form of fieldwork has received critique from feminist and decolonial scholars for its reproduction of masculine explorer tropes, a 'rubber

boots method' (Burbandt et al., 2022) study seemed necessary to observe what people *do* in forests, rather than hearing them describe what they do in forests. This witnessing of material practice and discourse is, as Anne-Marie Mol (2002) highlights, central to studying ontological politics. Relying only on the mediated representations of places and practices, explained to me through interviews and visible in visual discourse, would not have highlighted the differences between realities and their representations that have been so central to environmental geography and this study's critique.

Instead of narrowing the focus too early and creating my own arbitrary distinction about which organisations fell under my study's remit, I endeavoured to speak with representatives from as many organisations within the Scottish land sector as possible. In attempting to understand the wider land sector in Scotland, I collected an incredible amount of data about themes which have not found a home in this thesis, such as community land ownership, deer management and peatland restoration. These are themes I would like to return to in future research.

Most fieldwork took place at sites located south of Inverness and north of Fort William. Their location can be seen in the map below. This reflected the concentration of rewilding and natural capital organisations operating near the Great Glen and the Cairngorms, which have good road access from Inverness, the 'capital city' of the Highlands with an airport and direct trains to London. I also spent a significant amount of time in the Glen Affric area in the West Highlands, where there is a concerted effort at conserving and restoring native Caledonian pinewood. But my geographic boundaries were not fixed. Many nature restoration and forestry organisations operate across rural Scotland, meaning that a geographic exclusion line seemed relatively arbitrary. It is no exaggeration to say I visited the length and breadth of the country.[14] I visited woodland creation projects in Caithness, the North-Eastern tip of the country, and commercial forestry projects in Perthshire, an hour's drive north of Edinburgh. I even attended several field sites in the Scottish Borders, near England, as part of the 2022 Royal Scottish Forestry Society's annual study tour, which I describe in detail below. And I attended conferences in Edinburgh, Glasgow, and across the Highlands.

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[14] Representative of the project's geographical range, towards the end of my fieldwork, I realised I had impromptu driven the entire NorthCoast500, a 500-mile-long route popular with tourists that begins and ends in Inverness, following the East, North, and West Coasts before crossing the Highlands.

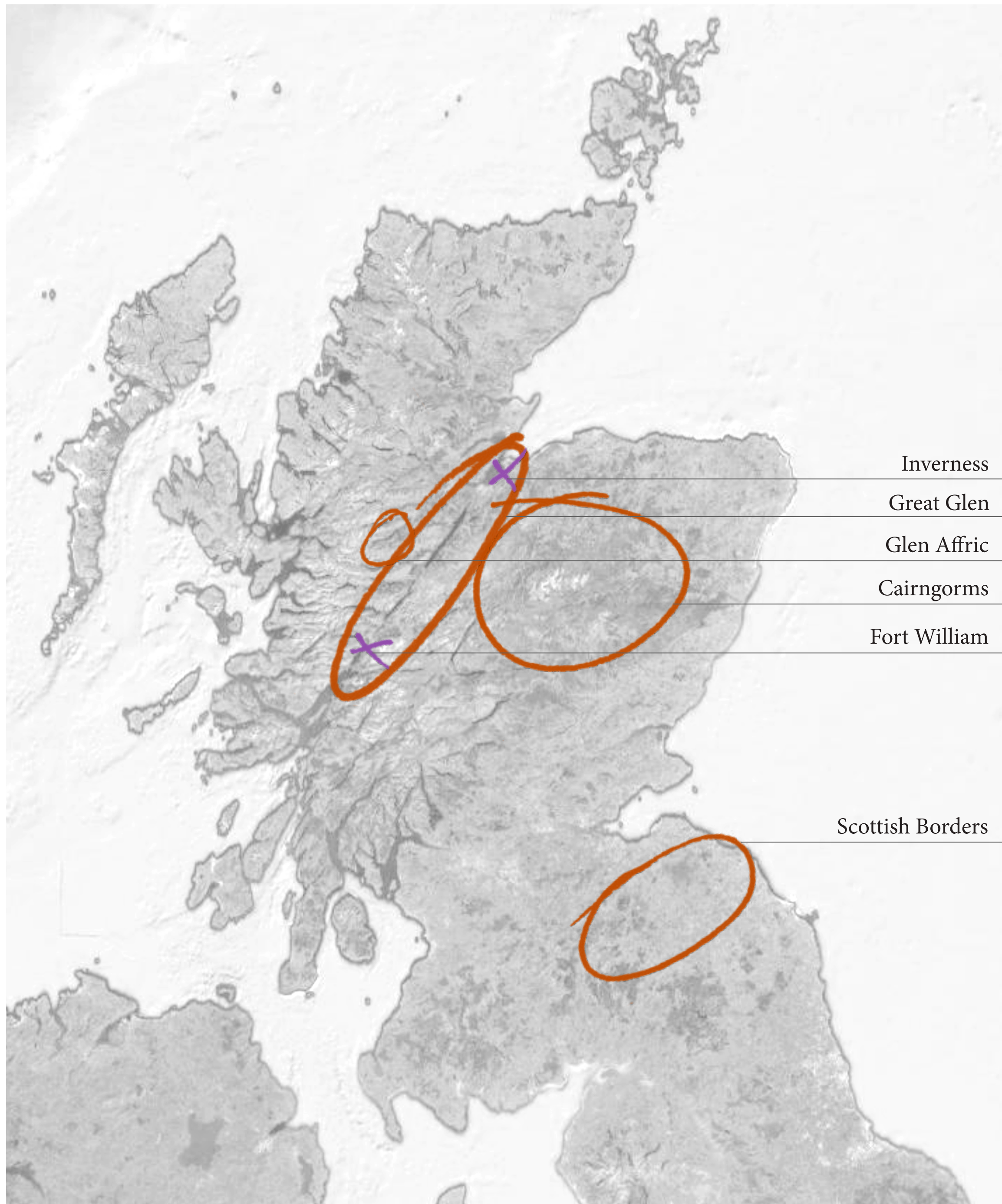

Figure 10 Fieldwork map.

Most of my fieldwork took place in the circled red areas, although these boundaries were not fixed.

This geographical flexibility was partly due to necessity. Rural Scotland, especially the Highlands, has a very low population density. Extending the geographical range of acceptable field sites meant more organisations fell into the study's remit. This was particularly important during the early stages of fieldwork when I was defining what, exactly, my project would become. I also stayed flexible simply because I could.

During my fieldwork, I lived in a van. This gave me incredible access to multiple estates across the country. Often, research participants would email me saying something like, "if you can meet me at this carpark at 8am on Tuesday morning, you can join for a day of ecological surveying". Because of the flexibility that a van affords, I *could* be there, even in isolated corners of the country. I'd drive the evening before, park up by a loch, swim, sleep, and be ready for a day on the hill. Van mobility meant I was not dependent on staying with research participants, even when visiting distant sites. This likely meant more participants were ready and willing to have me visit (at no economic or social cost outside work hours), and because I was not necessarily lodging with research participants, I hoped I would not be compromised in my writing.

Figure 11 Cuthbert, the Mercedes Sprinter, parked up on a Highland curb.

But this Instagram-influencer lifestyle was not all rosy. As anthropologist Cody Rodiguez explains, van dwelling is simultaneously "living the dream [and] surviving the nightmare" (Rodriguez, 2023, p. 68); it grants a sense of autonomy and freedom, but the van dweller must simultaneously negotiate precarious living conditions and prejudice.[15] For me, the experience was often difficult, especially early in my fieldwork. I had no neighbours, housemates, or colleagues. I was responsible for an enormous, expensive metal box that, if it broke, would not only ruin my research period but render me homeless. My quotidian lifestyle never settled; I never had a comfortable space to write up fieldnotes, organise meetings, or just switch off. Bad moments were a frequent occurrence. Perhaps the worst happened in a Tesco carpark. In April 2022, I had driven to Aviemore to catch a train to Glasgow, desperate for some urban respite and a hot shower. As I slammed the van's sliding door shut, two things happened. The sleety slush that had fallen all day metamorphosed into snow, and the door yanked off its hinges.

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[15] For an interesting study of vanlife and digital nomadism, see Gretzel & Hardy (2019).

Lying prone under the van, hands freezing, trying to dismember the van's footwell to put the door back in its groove, I heard my train depart.

Figure 12 Inside my mobile research base.

Upon returning to Oxford and chatting with other PhD researchers about their fieldwork experiences, I regretted not seeking out a Visiting Research Placement at the University of Highlands and Islands, which has bases in several Scottish towns. A placement would have given me a much-needed scholarly base and network of like-minded individuals and would have accelerated the difficult first few months of networking and initial contact with participants.

3.3. Methods

My data collection took place between April 2021 and June 2022.[16] After an initial round of online interviews and finalising preparations for fieldwork (which included sorting out the van's electrics, insulation, and plumbing) in April 2021, I made the long journey north from Oxford to the Highlands in May, where I stayed until September. During this period, I conducted interviews and spent as much time as I could undertaking participant observation, on estates and at conferences. I returned to Scotland in November, when the COP26 conference was taking place in Glasgow. I based myself in Oxford over winter, reading, writing up fieldnotes and honing my research focus. Clear gaps in my knowledge and data appeared, so I returned to the Highlands in the spring (between March and May 2022), when I interviewed new and old participants, visited new field sites, and revisited several estates and organisations. Throughout my fieldwork, I attended conferences and seminars organised by different organisations in the land sector, online and in-person.

Interviews

Over the course of my fieldwork, I conducted 61 semi-structured or unstructured interviews with actors across the land sector in Scotland. Interviewees included ecologists, rewilders, CEOs and managers of eNGOs and for-profit rewilding companies, technology developers, ecological and soil scientists, metric developers, environmental activists, commercial foresters, land managers and landowners. (For a full list of interviewees, see the Appendix.) This range of interviewees allowed me to hear the variable political, economic, ecological, and epistemic commitments of different organisations. Interviewees were initially selected following purposive sampling informed by desk-based research, and then through snowballing. I selected individuals based on their organisations' reputation, their positions within their organisations, or because other interviewees recommended talking to them. I did not prepare pre-set questions to ask, but rather noted down bullet points to discuss. This created a more conversational atmosphere and allowed me to pick up on interesting comments. Interviewees were often forthcoming with recommending further contacts to talk to.

27 interviews were conducted online, which generally lasted one hour. These were helpful for making initial contact with organisations, many of whom I subsequently visited in-person.

[16] 2 extra interviews took place in Autumn 2022, as new contacts reached out to me.

Online interviews allowed me to access high-profile individuals, such as CEOs, scientists, and senior representatives of NGOs, who tended to not be available for estate visits. 34 interviews took place face-to-face. 11 I classify as ‘static’, which took place in estate offices or cafes. These generally lasted an hour and were recorded. The other 23 I classify as ‘ethnographic visits’, which ranged from an hour to a week. These often took place as I joined someone undertaking environmental measurement. (N.B. The distinction between these ‘ethnographic visits’ and field visits was not clear-cut, so I save an in-depth discussion of the embodied and affective dimensions of these interactions for the following sub-section.)

Online and in-person interviews were generally recorded with a mobile phone, whereas ethnographic interviews were not, due to material constraints (wind, rain, midges, hills, etc.). Recordings were anonymised, transcribed using Descript, and allocated a code for identifying interviewees. These data were kept separate from identifying information. For interviews which proved unrecordable, I took field notes during and after site visits. The first 41 interviews took place between May 2021 and September 2021. 17 took place during my second fieldwork period, between February and June 2022. (1 took place in November 2021 and 2 took place in late-2022, as new contacts reached out to me.)

Interviews provided insight into how different organisations conceptualised and described carbon, nature, measurement, science, rewilding, and the host of other themes I was interested in. Characteristic of other expert interviews, I was able to learn technical specificities relating to topics that I knew relatively little about, such as how UK forest carbon is accredited (as I describe in Chapter Five), the widespread epistemic uncertainty within soil science (Chapter Six), or the success of rewilding charities in selling premium carbon credits (Chapter Seven). As my own situated knowledge expanded, and I learned to disambiguate competing discourses and knowledge claims, the value of interviews shifted. Interviews were not necessarily insightful for the information relayed. They became spaces to witness how nature restoration was being discursively performed, as knowledge claims and political discourses were put to work to naturalise or legitimise different practices and land uses. Instead of flatly rejecting or accepting interviewees’ assertions, I would ask questions about how and why people believed them. Interviewees would often support their arguments with scientific claims and send me follow-up emails with links to academic papers and journalistic articles that supported their claims. Reading these, I began to understand the different epistemic cultures through which knowledges about commercial forestry, carbon sequestration, and rewilding were developed.

After analysing and coding my first set of fieldwork data in Winter 2021/22, I felt there was a clear empirical gap. To better understand broader trajectories of power and finance, I needed to speak to more powerful individuals. In my second fieldwork period I directed my attention to interviewing high-profile and elite stakeholders, including landowners, senior representatives and CEOs of charities and companies, and state employees. Living in Scotland for several months prior no doubt granted me an authority to participate in these conversations. Some interviewees, especially from private companies developing natural capital technologies which measure Scotland's landscape, did not know Scotland or the Highlands particularly well. They seemed keen to hear about my insights from spending time with ecologists.

Although I spoke to several elite stakeholders (such as professors, CEOs, and landowners), I was unable to contact other elite actors who have a disproportionate power in shaping Scotland's land, such as landowners owning large, often ecologically important or degraded, estates. These landowners were often difficult to identify and contact, as other researchers have highlighted (McIntosh, 2023; Wightman, 2010). Interviewees, especially from natural capital companies, noted that these landowners were increasingly interested in the financial opportunities associated with nature restoration. Further empirical work might pick up on this theme. I also did not speak to venture capitalists or pension fund managers, who invest in nature restoration and tree planting in Scotland. Although I knew these people existed, I did not know how to access them. This is no doubt a limitation of the research; there are powerful undercurrents of finance that are missing from this thesis' critique.[17]

Participant Observation

I met with practitioners to observe how they work, and offered to volunteer where I could. This participant observation took place in a range of settings, including **field visits**, on **ecological surveying** trips and at **events.**

i. Field visits

[17] Their email addresses were not in the public domain and identities were often hidden behind shadow company names. Collaboration with lawyers and investigative journalists might be a potentially fruitful elaboration on this thesis' insights. In fact, at one point during fieldwork, I consulted with an investigative reporter for a leading media company. Due to the opacity of names and identities, it proved difficult to develop a publication together.

I visited countless sites where nature restoration or forest creation was taking place or being measured. These included new forest creation projects, peatland restoration sites, tree nurseries, rewilding projects, and community-owned woodlands. I would endeavour to spend extended periods on site, preferably for a day or more, to meet a range of employees or volunteers, and to witness the day-to-day, largely unspectacular ways that reforestation was happening. To gain access to these spaces, I would generally introduce myself over email and describe my research. I explained that I preferred accompanying someone at work or helping them undertake daily tasks (carrying equipment, taking measurements etc.) rather than interviewing. For many nature restoration organisations, who often rely on volunteer labour, this proved a helpful way of getting access. I preferred lending a hand, because it provided an endless supply of things to talk about, granted my field visits an instrumental purpose, and allowed me to observe conservation, restoration, and science 'in-action'. During the Prelude, for example, I described how I was able to tag along with a forester after describing my research and offering to take soil surveys for a new woodland creation project.

I spent several accumulated days at the estate of one company developing natural capital verification techniques. Following an initial online interview, I was invited to the estate for two days of peatland surveying.[18] This involved long, muddy days plunging rods into peat soil, to generate peat depth data which was subsequently used to quantify overall carbon storage. As Jamie Lorimer notes, spending time with scientists in 'the field' as they collect data allows a researcher to witness "the importance of embodied skill, emotion and an ethical sensibility in the generation of scientific representations" (2008, p.377). I could see how exhaustion, excitement, and material conditions such as difficult terrain hindered scientists from collecting field data about certain areas.[19] Spending extensive time on-site with technical experts in this way provided great space for conversation about a range of topics. I was subsequently invited back to the estate for other days when environmental measurement was taking place, where I was able 'go-along' with measurement experts and conduct long interviews, which often lasted several hours. As sociologists Eva Duedahl & Bodil Stilling Blichfeldt describe, "participant led ways of engaging with nature force researchers to navigate with others as [they are] led along by others through literal and figurative unknown terrains of nature, sociality,

[18] This was not the same estate which I described in the Prelude.
[19] I subsequently spent several days during fieldwork helping with peatland surveys at multiple field sites. Explaining that I had experience in peat surveying was a helpful means for legitimising my visit.

(dis)empowerment and embodiment" (2020, p.438). In practical terms, I could ask questions about several 'unknowns' (such as the reason why landscapes looked a certain way, the cultural significance of certain practices, or the justification for a particular measurement technique) that I would otherwise not have thought to ask about. Being out in the field also meant I could witness surprising events. For example, stumbling across the capercaillie which I described in the previous Interlude could only have occurred through joining an ecologist for a field visit.

Figure 13 (LEFT) Map with pre-defined points plotted for a peat survey; (RIGHT) a guide for identifying and assessing peatland health.

Figure 14 Peatland Surveying in the West Highlands.

Note the peat rod held in my right hand, which is used to gauge peat soil depth. Peat depth surveying is long and tiring but provides great access to spend extended periods of time with research participants. The image above is slightly cringe-inducing, emulating the classic romantic painting 'Wanderer Above the Sea of Fog' *by Casper David Friedrich (1818). I include it here as it hints to the sense of prospecting which peat surveying conjures. What might we find?*

The nature restoration and forestry projects I visited ranged in scale, scope, and ambition. I visited several large and famous rewilding projects, where I sometimes felt uncomfortable. These estates seemed accustomed to hosting (sometimes elite, paying) guests and fielding journalists, and the site visits could feel like staged performances convincing me of the estate's ecological or communitarian virtue. The discomfort of these site visits contrasted with the warmth I often felt when visiting small-scale, generally community-run forest organisations. I stayed at two community tree nurseries on the West Coast for a week apiece, collecting seeds, planting saplings, and watering plants. Being on-site for longer periods afforded more

opportunities to meet with a range of stakeholders, in often surprising settings. For example, whilst visiting one community forestry organisation, I bumped into a senior land manager working for an environmental NGO aiding the community group in restoring a native woodland. Following an impromptu chat, we spent the following day driving around the estate in a 4x4 buggy, foraging mushrooms, and discussing the NGO's visions and relations to carbon finance. Spontaneous moments like these revealed the intricate collaborations between different organisations. Due to a range of factors (such as phone signal, remote estates, and busy schedules), estate managers were generally difficult to track down and meet with. Being on-site provided opportunities to find them.

Figure 15 Surveying in the West Highlands.

Note the mosaic of different land use types in the area. The bright green field at the base of the glen was largely used for sheep farming, and the surrounding estates were generally run for deerstalking.

It was particularly interesting to visit sites which were doing similar things very differently. For example, visiting a commercial forestry tree nursery (which grew long rows of Sitka spruce saplings) contrasted drastically with tree nurseries run by rewilding NGOs, which were growing ecologically rare native species. Or visiting woodland creation projects with foresters developing carbon credits compared to visiting similar sites with ecologists, who were mapping ecological health.

Figure 16 Rows of Sitka spruce saplings at a commercial tree nursery.

Figure 17 A small-scale tree nursery, growing hand-collected Scots pine saplings on the West Coast.

Figure 18 The tree nursery run by environmental NGO Trees for Life.

This image depicts their aspen recovery project, for which they are developing new methods for forcing aspen to produce seeds.

Sometimes site visits would prove frustrating. Having framed myself as a keen volunteer, I would be sent to do jobs that seemed unrelated to my research project. This would sometimes mean I was separated from the people whose insights I wanted to hear. For example, early in the fieldwork, I found myself alone in a sycamore plantation, with the rain pouring, cutting limbs off trees with a hand-held saw. Another week, I worked as an assistant for an estate manager in the Western Highlands, erecting deer fencing. For several hours, I was tasked with unrolling wire fencing. My thumbs were bloody when the rain, and then the midges, arrived. (The image below shows the extent of their attack!) Over time, I learned that these seemingly tangential fieldwork moments were fundamental to my ethnographic method, as they helped me to understand an overarching working culture and, I hope, earned me trust and respect. They also created new research opportunities: the forester whose sycamores I pruned quickly became a close friend and introduced me to several research contacts. The estate manager who I helped with the fencing gave me lifts in his speedboat to some of the most remote pines in the country, which would have been otherwise inaccessible (as they were more than a day's walk from a road).

Figure 19 (LEFT) An attack of the midges and Boat rides (RIGHT) to inaccessible pines (BELOW) were a surprising reward.

ii. Ecological Surveying

I spent several accumulated weeks ecological surveying, which changed the ways I understood ecological dynamics and ultimately shaped the arguments developed in this thesis, especially in Chapters Seven and Eight. Most of the surveying I undertook was with Mike, a Highland ecologist employed by a leading rewilding NGO. We were put in touch in June 2021 by Mike's boss, as Mike was gathering ecological data about Caledonian pinewoods, as part of a nationwide survey about their health, resilience, and threats.[20] He initially invited me to join for a few days of surveying an estate in the West Highlands. Over time, as I gained an ecological literacy, Mike invited me to help with other surveys, which took us to several well-known forests in the Cairngorms and West Highlands.

Days surveying generally followed the same pattern. Mike would pick me up in his 4x4, with a map of GPS coordinates that had been identified the night before. We would head up through a glen, ticking off the plots one-by-one. To plot a site, we would throw a rucksack down on the exact GPS point. Mike would walk around the plot and bark out data that I noted down, such as species names and their abundance, as well as peat depth.[21] Over time, my role shifted from just notetaking to offering a second pair of eyes for identifying species and measuring herbivore impact pressure, which involved assessing the extent that foliage of common species, such as blaeberry, had been nibbled. Mike's pursuit of scientific rigour (he had to measure the *exact* location of the survey points) led to an incredible amount of huffing and puffing up and down sheer hillsides, boggy terrain, and thick brash. For example, we came across the capercaillie together, as I described in the previous Interlude, after bush bashing for several hundred metres. Whilst this was exhausting, it also meant I saw landscape types that would otherwise be unvisited, such as peatbog-woodland (seen in the image below) and areas with dense undergrowth.

[20] In lay terms, Mike was collecting data about the ability for forests to grow back after large-scale disturbance, such as forest fire. There is a widespread fear that old-growth native woodlands, such as Caledonian pinewoods, will not be able to regenerate following disturbance events due to the overpopulation of deer.

[21] I describe the process of ecological surveying in more detail in Chapter Eight.

Figure 20 Bog woodland in the Cairngorms. Visiting forests such as this was only made possible due to Mike's perseverance and resilience. This site was several hundred meters from a path, with thick bog and thicket keeping most hikers away. There was a commonly held belief amongst interviewees that pine struggles to grow on boggy terrain; Mike took me to sites such as this, to prove that this belief was ungrounded.

Figure 21 A panorama image shot from a ridge edge. I took this picture standing on the ridge (the yellower section in the middle of the image), with sheer drops either side of me (the darker greens are trees underneath me). The survey plot we were trying to survey was 5 metres to the

right of us but 50 metres down. It was the only moment I ever saw Mike fail to reach an exact GPS point.

I shared common ground with Mike: we were the same age, had studied at the university, and had similar political leanings. Spending countless days battling wind, bog, rain and midges almost inevitably creates friendship. Soon we started spending time together outside of work, hanging out with other ecology and rewilding advocates. We would sometimes go in search of rare pine trees, as I explain in more detail in the Interlude between Chapters Seven and Eight. During my fieldwork period, Mike was developing an alternative approach to rewilding, which he termed the 'Wild Trees Framework'. Part of the Framework is the Wild Trees Survey, the measurement survey which constitutes the main empirical focus of Chapter Eight. Over the many trips we went on, I developed what Anna Tsing calls the 'art of noticing' (2015, p.37), learning to understand the interrelated more-than-human dynamics and agencies that had created the Highlands' ecological composition. Hands-on, embodied, phenomenological experience combined with my reading of Scottish environmental history (especially the works of Tom Devine and Chris Smout, which I reviewed in the previous chapter), which allowed what Tsing calls 'multispecies histories' to come into view (Tsing et al., 2019).

Figure 22 Info sheet from an ecological surveying trip with Mike.

Tree species are noted in the left-hand column (Douglas Fir, 'B' for birch, 'R' for rowan, et cetera), with their abundance and age documented in the boxes. Further species, such as flowers, are noted in the right-hand column. Often when surveying with Mike, I would be tasked with filling in these sheets.

As I described in Chapter Two, cultural geographer Matthew Gandy argues that paying close attention to the vibrant agencies of plants can function as part of collective, more-than-human modes of knowledge production (2022, p.155). Building from a new materialist conception of agency, Gandy considers, "how far can emerging ontologies of the nonhuman illuminate the material dynamics of environmental destruction or identify effective strategies for political resistance?" (2022, p.155). From spending extensive time ecological surveying, I underwent the process of what Jane Bennett (2010) calls 'attunement' to the more-than-human world, learning to understand that non-humans such as plants were not passive objects on which human politics were done, but active and lively in making natures. They are constantly, in Eyal Weizman's terms, "prehending" the environment by "absorbing environmental forces into its

material organization" (2017, p.95), and subsequently become inscribed with signs of interrelated social, cultural, and environmental processes.

Figure 23 Pines in the upper reaches of a glen on the West Coast. Even in apparently treeless glens such as this, there are often a few lone pines that hint to the widespread forest that once covered an area. Source: Kati Karki (reproduced with permission)

In practical terms, I learned to understand when foliage looked over-browsed, signifying an overpopulation of deer which would stifle conditions for natural regeneration. Or I could identify rare flowers which hinted at ecological health, such as melancholy thistle (*Cirsium hetrophyllum)*. Learning to read these bioindicators allowed me to, as sociologist Jennifer Gabrys describes, "go beyond representational modes of politics" (2018, p. 352). Embodied epistemological tools joined the assemblage of words, texts, and images commonplace in representational-focused methodologies.

Learning the 'art of noticing' and being able to witness the degraded state of Scotland's ecology helped me cherish the fragmented and rare pockets of native woodland where diverse ecologies flourished, which I describe at more length in Chapter Eight and the Conclusion. I developed

a new political-aesthetic sensibility, tuned towards what might be called an 'ecological aesthetic' rather than the sublime. Previously forgettable treescapes took on a new political importance, as I appreciated taxonomic and geographical diversity. Magnificent vistas lost their charm. Where others saw beauty, I saw bald hills, a legacy of uneven class politics and clearance. Trips to Glenfeshie Estate and Mar Lodge,[22] commonly praised as the most successful restoration projects in Scotland, never failed to inspire. They held a prefigurative power, reminding me what was ecologically possible if natural regeneration was facilitated through tempering the disproportionate world-making agencies of deer.[23]

Figure 24 Naturally regenerating Caledonian pinewood at Mar Lodge Estate.
On days off, I often drove to the Cairngorms to explore the pines. Over time, my understanding of ecological dynamics improved. Note the young regenerating pines by the riverbank. These

[22] For an in-depth socioecological history of Mar Lodge, see Andrew Painting's *Regeneration* (2021).
[23] Trips to the forests in South-West Norway and New Hampshire in the USA were also incredibly inspiring. They showed that woodland regeneration was possible. Both these areas were widely deforested in recent history but native woodlands have returned. Future research might compare the environmental politics of these different regions.

would be less than 10 years old and have emerged since widespread deer control has been introduced.

iii. Event Ethnography

Alongside site visits and surveying trips, I also attended several workshops and conferences in-person. These related to nature restoration, carbon finance, forestry, rewilding, and land, and functioned as helpful spaces to hear divergent narratives developed by different organisations. Watching PowerPoints and lectures allowed me to see the multiple ways nature restoration and reforestation were performed to different audiences. I was keen to avoid 'lurking', when researchers obscure their aims and do not participate whilst collecting data at events, which "has been criticised as encroaching upon the unwitting participants' privacy and placing too much power in the hands of the researcher" (Grinyer, 2007, p. 2). For transparency, I would explain my research to organisers and attendees and ask informal questions about their work and visions for Scottish land. Conversations were generally off-the-record, and I have not directly quoted anyone without them giving explicit consent.

Twice, I attended the Royal Scottish Forestry Society's (RSFS) Annual Study Tours. These were 3-day long trips to The Cairngorms and Deeside (September 2021) and the Scottish Borders (May 2022), where participants visited different forest sites. Aged 26, I was by far the youngest attendee. The average age of the attendees was about 60. These study tours allowed me to talk to senior foresters with decades of experience in the forestry sector. Society members were very kind to me, open in conversation, and appeared genuinely excited to have younger people in attendance. The dinners, lunches, bus journeys, fire-side whiskies, and ceilidhs provided great spaces to have informal conversations with retired foresters, or foresters working for commercial and state organisations. These were particularly insightful for understanding a more culturally conservative vision of Scottish land politics, which differed from the outlooks of many rewilding organisations I had spoken with. Hearing several landowners' and foresters' concerns with rewilding, habitat restoration, and species reintroduction helped me understand what the perceived controversies associated with rewilding were. At the RSFS, I met powerful actors in the forestry sector, some of whom I subsequently interviewed.

These RSFS trips greatly differed from other conferences I attended. In November 2021 I spent two weeks at COP26. Hearing corporate and national commitments to climate and nature

emphasised the technocratic ways that nature restoration and rewilding are performed on the international stage. Attending COP26 allowed me to witness how rewilding consultancies and natural capital verification companies were presenting themselves as key actors in scaling-up nature restoration, as I describe further in Chapter Six. My experiences at COP26 differed greatly from those I experienced at the Community Land Scotland Conference in May 2022, which outlined a community-based, regenerative model vision of nature restoration. And this differed from the Integrated Land Use Conference in March 2022, entitled 'The Road to Net Zero', which essayed to show a 'balanced' version of the land sector. These conference spaces often proved wearisome, as the discourses legitimising ecologically degrading practices (speed, scale, urgency, growth) clashed against my own political convictions.

Following Translations

Spending extensive time with people measuring forests allowed me to follow other STS scholars, in opening up the 'black box' of measurement (Pinch, 1992; Purdon, 2015). But to engage in Cooper's (2015) 'critical metrology' methodology, I also needed to map how these measurements were employed as part of wider political strategies. This involved tracing how these translations of nature-into-data were translated *again* to become sophisticated reports, presentations, and scientific papers. Having read the works of David Lansing (2012) and Ingmer Lippert (2015), I knew these processes were likely a space where political agendas were implemented, but largely obscured under the veneer of expertise.

I read published materials, paying particular care to read the publications which used the data I helped to collect. For example, I closely read the reports based on the ecological surveying data that I helped Mike gather. To understand how these data were being put to work, I informally spoke to Mike throughout his write up period over call and text, hearing about how he organised the findings to develop his conclusions. I also read the reports from other natural capital companies who I spent time with or interviewed, and even attended a natural capital report launch party at COP26, which we hear more about in Chapter Seven. I read scientific papers written by the scientists I interviewed and followed how their publications were reported within the media and by industry bodies. This helped cement my understanding that claims about nature restoration and the 'right' way to measure it were hotly contested.

Another central governance technology which I followed was the Woodland Carbon Code's Excel spreadsheets, which I describe at length in the following chapter. Understanding their

functioning was important given their powerful capacities to determine which forests are translatable into carbon credits. At first, I played around with the spreadsheets for several accumulated hours. It took some technical literacy to understand how they operated, so I asked some foresters I was friendly with to give me an in-depth walkthrough. These spreadsheets are readily available from the Land Carbon Inventory, an open-access database findable online. By becoming hands-on acquainted with the Woodland Carbon Code's operation, I felt more comfortable speaking about its technical details with carbon brokers. And to my surprise, developing an understanding for the WCC gave me some political capital with several community foresters I met, who appreciated being talked through how it worked.

Historical Methods

To situate my empirical study within a wider historical timeline, I was keen to map the shifting social, cultural, historical, and environmental identity of forests in the Highlands over time. Doing so, I hoped, would allow me to understand what was *different* in contemporary Scottish environmental politics compared to the past, and to see which narratives were being resurrected or repressed. Chapter Four offers, to some extent, the final product of these labours. And throughout the other chapters of the thesis, I refer back to the multiple natures that have been historically pursued in Scottish environmental governance.

To begin my historical research, on the recommendation of Matthew McMullen, an anthropologist who completed his doctoral thesis about rewilding in the Highlands in 2019, the first book I read during my doctoral studies was Jan Oosthoek's 'Conquering the Highlands: A History of the Afforestation of the Scottish Uplands' (2013). The book provided extensive detail about the development of commercial timber production in Scotland, and offered a huge range of primary sources which I combed through online. Combined with the historical review chapter in McMullen's (2019) brilliant thesis, I compiled an extensive reading list on matters relating to Scottish land politics. During the first several months of my doctoral studies, I read papers and books about Scottish history, which, I hoped, would prepare me for my fieldwork.

When I was living in the Highlands, local practitioners would often make historical references, or recommend books about forest or conservation history. For example, two rewilding ecologists recommended reading Steven and Carlisle's (1959) 'The Native Pinewoods of Scotland'. The text became fundamental to my understanding of pinewood history; not only because the book provides such extensive detail about the environmental histories of specific

forests, but also because it serves a historical record of ecological thought in the late-1950s. Reading the book, and knowing that it was published over 60 years ago, highlighted how an ecological consciousness – attuned to the widespread dangers of deer overpopulation and flagging an existential need to protect fragments of native wild trees – had existed in the Highlands for a very long time.

As I read more widely about Scottish environmental history, I began to widen my range of historical materials beyond written text. Several trips to the National Galleries of Scotland in Edinburgh, which boast extensive collections of aristocratic portraits and paintings of the Scottish landscape, especially from the romantic art movement of the mid-to-late nineteenth century, were important for helping me see the intersection of wealth, class, ecology and representation. Equipped with my newfound art-historical knowledge, having read the likes of Thomas Devine and Fraser MacDonald, these trips allowed me to read first-hand how a few wealthy individuals were able to finance representations of how the Scottish landscape should look – a powerful political intervention in securing a partial yet enduring vision of Highland wilderness. Furthermore, countless trips to old castles and historical buildings, such as Mar Lodge in the Cairngorms and Leith Hall in Aberdeenshire, helped me to visualise how power and wealth were historically concentrated and became materialised in incredible estates. Visits such as these also allowed me to witness how histories were being performed in the present by powerful institutions such as the National Trust Scotland. The ways histories were framed varied from progressive (highlighting historical links to slavery and colonialism) to dated (celebrating the nobility of the lords and ladies of the manor). Learning to read what was *not* being said or written was a fundamental element in my historical method.

The historical review in Chapter Four was written after I had developed first drafts of the four analytical chapters (Chapters Five, Six, Seven, and Eight). For this reason, the historical chapter could document how certain cultures, ideologies, and practices (such as rewilding or commercial forestry), which are spoken about at length in the empirical chapters, had emerged and developed over time.

Writing and Data Analysis

During and after each of the two rounds of fieldwork, I uploaded documents, fieldwork notes and diaries, and transcriptions of interviews into NVIVO, then inductively coded my data to identify common themes, which emerged after two rounds of coding. This formula provided a

neat set of written materials which helped me to think through the thesis' structure and arguments. I curated folders with images, stories, and interesting quotations. Keen to emulate ethnographers with a compelling narrative approach such as Anna Tsing and Eben Kirksey, I was hesitant to begin writing with an overly jargonistic style, squeezing my fieldwork's richness into a digestible academic register. I wanted to bring some of the emotional strains and enchantment of fieldwork into the thesis' overall atmosphere. Whilst thinking with my notes and images, I authored short stories and vignettes to bring more flavour to my fieldwork notes; several of these have found their ways into this thesis, whilst far more slipped out. This process shaped the clarity of my fieldwork materials. For me, writing was not only representative, but also functioned as an epistemic practice and form of geographic method (Burlingame, 2019). Writing held performative power in making sense of materials.

3.4. Research Ethics and Positionality

Arriving in Scotland as an English person researching rewilding holds its own cultural complications (Wynne-Jones, 2022). As historian Ian Mackinnon (2017) notes, Scotland can be understood as a space of 'internal colonialism', with wealth and power historically concentrated in the hands of elite, often English, men. My pale skin and red hair let me pass relatively easily in rural Scotland, but my middle-class English accent placed me within the "latte sipping urban elite", a characterisation of rewilders that the CEO of one of Scotland's leading rewilding charities had jokingly (if somewhat accurately) described. Nevertheless, I did not face the abuse or critique I was half-expecting for being foreign, English, or posh – at least not to my face. As a cis-presenting, physically fit, White researcher from an esteemed (English) university, I embody the myriad and interrelated traits that sociologist Charles Gallagher (2000) describes as 'methodological capital'. I tried to stay reflexive of the associated privileges that these afforded me, which doubtless shaped the empirical spaces I had access to, the types of conversations I held, and my interpretation of those experiences. I was also uncomfortably aware that, as Gillian Rose (1997) articulates, these privileges shaped interpersonal dynamics in ways that far exceeded my reflexive understanding.

I generally spoke with middle-class and upper-class people, who largely held wide-ranging political leanings (regarding finance, natural capital, and land ownership) but had a shared educational history: several interviewees were educated at Oxford, whilst most interviewees knew Oxford employees or students, past or present. My Oxford affiliation provided me with

wonderful access to in-depth conversations with powerful decision-makers but there was occasion to feel uncomfortable. As my fieldwork progressed, I felt my brand as a University of Oxford researcher was being sought after and put to work for legitimacy and credibility. For example, an interview with the CEO of a private company, which I recorded and transcribed, was uploaded onto the company's website. At the time, it felt like a fair deal: I was granted access to interview a leading figure in Scottish land politics; and his hour was not wasted because other people could read about his model for rewilding. Upon reflection, perhaps my Oxford researcher tag provided academic credentials to his organisation (a theme I explore further in Chapter Seven) – although I am uncertain about whether this was actually the case.

The intentions of other interviewees were less opaque. For example, I was headhunted to work for a natural capital company and a carbon brokerage. As I explain in more detail in Chapter Seven, a private rewilding consultancy told me they wanted to work with me specifically because of my "brand" as an Oxford researcher. Another carbon broker, at the end of a formal interview, told me that if I ever wanted a job after graduation, I need only message. At these moments, I did not know how I was perceived by my research participants: threat, collaborator, or a potential employee? Although the intentions of an interviewee are always to an extent unknowable and ambiguous, these interviews were particularly difficult to analyse. It dawned on me that I was not only an interview*er*, but also an implicit interview*ee* for a job I had not applied for.

Difficulties arose when my political leanings, especially my scepticism of market environmentalism, conflicted with those held by my interlocutors. Most people I interviewed would, I presume, identify as environmentalists (although some were very explicit that they were *not*). It felt as though most research participants assumed that because I 'loved nature', I would envision the same model of change as them. I leaned into this relatively uncritical assumption during fieldwork. Although this allowed me to collect in-depth empirical material, it also led to ethical challenges as I began publishing my research. For example, following the publication of a version of Chapter Six in *Environmental Science and Policy* (2024), I received an email from a research participant who had been kind to me during fieldwork and whose insights I respected. Following due process, I had pseudonymised him and his company, but he was frustrated about the way I had framed his work and published the article without his consultation. On reflection, I should have been more careful in my phrasing, and should have emailed the company for comment and reflection before publishing, which would have

certainly nuanced the argument I developed. The situation became more complicated as my Oxford colleagues were still working with the company. I subsequently rewrote sections of the following chapters, to further obscure identities and avoid adding increased pressure to the strained relationships between the individuals involved.

A more serious ethical challenge was ever-present in fieldwork. Characteristic of the carbon market worldwide (Valiergue & Ehrenstein, 2022), I often heard about data fudging, "gaming the system", malpractice and straight-up fraud in carbon forestry projects. Although it was fascinating to hear the nitty-gritty realities of the carbon market, these insights often made me feel deeply uncomfortable. It was also frustrating to hear how new 'green' terminology was being assimilated into the discourses of commercial foresters who were explicit in their rejection of environmentalist ideals. (I give an example of this 'green rebranding' (Cusworth, Lorimer, et al., 2022) in the Conclusion to Chapter Seven.) I was acutely aware that I was dependent on maintaining a positive reputation to access participants. Biting my tongue is a skill that does not come naturally to me; I had to learn it, and sometimes failed.

The thesis' intersectional environmental politics were directly informed by several research participants who became close friends, whose conversations gave me a richer sense of the broader political dynamics affecting the Highlands. During and after fieldwork periods, I went for hiking and foraging trips with research participants, stayed at their homes and volunteered at their estates and tree nurseries. Hearing about the difficulties of finding good employment and housing in the Highlands situated my analysis within a rural Scottish *realpolitik*. They highlighted the interconnected ecological and social struggles present in nature restoration. Although endless hours of conversation informed the findings of the thesis, direct quotations are only taken from recorded interviews, which were consensually agreed after Free, Prior and Informed Consent.[24]

Even though some participants told me they were happy to be named and quoted, to ensure a fair and even representation of all parties, I have pseudonymised all the participants. I have also pseudonymised the names of organisations, such as companies and charities, that

[24] I have pseudonymised the identities of all research participants involved. My thesis was passed by Oxford's Central University Research Ethics Committee (CUREC), reference number SOGE 1A2020-95

participants work for. The exception to this rule is Zulu Ecosystems in Chapter Seven, which is a real company. Analysing their website aesthetics, as I do in Chapter Seven, meant the company would have been impossible to anonymise. State-backed institutions, such as the Woodland Carbon Code, are not pseudonymised but its operatives are.

4. The Romantic and the Modern: An Environmental and Cultural History

Figure 25 (ABOVE) 'A View of Lochnagar' *by James Giles (1848), (BELOW)* 'A View of Balmoral' *by James Giles (1848).*

Images reproduced from the Royal Collection Trust Her Majesty Queen Elizabeth II (2019).

To commemorate the natural splendour of Balmoral Estate, Queen Victoria commissioned two paintings by Aberdeenshire artist James Giles in 1848. Victoria gave them to Prince Albert, her husband, for Christmas the same year. They provide an archetypal image of the Highlands, which continues to be reproduced on countless whisky bottles and tourist brochures. Antlers and mountain peaks pierce the sky. Silvery light caresses hillsides. And sandwiched between the wispy birch and wispier clouds, the Great, White, Royal castle looms.

The two paintings, depicting *the moor* and *the wood,* are characteristic of the romantic imaginary of the Highlands, which emerged in the late eighteenth century and sedimented in the nineteenth (H. Lorimer, 2000). The paintings promise a timeless wilderness of magical natural beauty, replete with still lochs, sharp mountains, and wild deer, offering spiritual renewal away from the intensities of modern life. Cultural geographers such as Hayden Lorimer (2000) and Fraser MacDonald (2023) have pointed to the ways paintings such as these naturalise and valorise the place of deer and private landownership in the Highland landscape. They also, I propose, construct a romanticised understanding of trees, regarding where they are and how they should look; a construction that continues into the present day and shapes the politics of reforestation that I discuss in the chapters that follow. Taken together, these two paintings offer a snapshot into contingent historical attitudes towards the presence and absence of trees across the Highlands. Trees have historically been part of Highland nature, but they are not *meant* to be everywhere.

A View of Balmoral suggests that the natural Highland landscape has plush woodlands in its lower regions, to be enjoyed by the landscape's royal owners. These wooded glens contrast to the relatively treeless moorlands in the upper reaches of the landscape, populated by large herds of deer, as depicted in *A View of Lochnagar.* The smattering of old Scots pine in the darkness on the right-hand side hints at their inferior value to the deer, foregrounded in the light. The sun literally shines on the stag, just as it shines on Balmoral Castle, the ultimate symbol of British aristocratic power. Casting a stag as the painting's protagonist obscures the humans responsible for the widespread clearance of the Highlands' native woodlands in the century preceding these paintings' commissioning, a history which I review in this chapter. Paintings such as *A View of Lochnagar* implicitly celebrate a degraded Highland ecology in which the proliferation of deer stifles the chance for native woodlands to naturally regenerate.

Environmental historians have long highlighted that this romantic Highland imaginary is a relatively recent construction. It's part of a wider environmental-cultural history, in which the nature of Scottish nature – how the landscape should look, who land is for, and what counts as 'natural' – has drastically changed over time. Historically, as Hayden Lorimer (2000) notes, appeals to the depoliticising allure of 'nature' have been used by powerful actors to legitimise wealth and class divides, by presenting ecologies that privilege certain interests, especially treeless ones, as the 'natural' Scottish landscape. However, as environmental historians such as Chris Smout (2000) and Charles Warren (2002) have argued, there is no single, fixed ecological baseline in Scotland; there is not one objective Nature. As I highlight throughout this chapter, humans have lived in Scotland since the glaciers retreated several thousand years ago and the climate, landscape and ecological conditions were far different from how they are today.

Natures in Scotland have been, as anthropologist Fiona MacKenzie describes, "produced materially and discursively in the interest of a particular politics" (2013, p. 10). This chapter unpacks these 'particular politics', by tracing how the Highland landscape – its representation and its material composition – have co-evolved with ideological changes, with a particular focus on the intersecting environmental and social history of trees. My intention is to situate the development of two dominant strands of Scottish environmentalism, the Modern and the Romantic, which shape the cultural politics of Scottish reforestation efforts in the 2020s. Reviewing exiting literatures shows how historical distributions of land and capital have determined which natures have been rendered valuable and materialised in the Highland landscape. These distributions, as the following chapters reveal, shape the normative vision of trees in the Highland landscape, generating competing visions of the role and value of Scotland's forests.

Summarising existing scholarship, I begin by outlining the ancient historical shifts in the Highlands' forest ecology since the glaciers retreated roughly 11,700 years ago (Steven & Carlisle, 1959) up until the eighteenth century, when Highland society was largely constituted by clans. As historian Frederik Jonsson argues, the Highlands functioned as the 'Enlightenment's Frontier': a space for knowledge production and scientific experimentation,

where metrological techniques and economic models were developed. Indigenous,[25] nondualist understandings of human-environment relations were replaced by a modern Enlightenment ontology in which Nature's nature was understood as unfixed; it could be 'improved' through rational stewardship, and its value depended on its functional use to humans. Rural human populations were cleared by landlords and forced to relocate, land was 'improved' as it was turned into farmland, and native woodlands were felled for timber and fuel.

I then chart how the Highlands' dominant culture of nature shifted over the course of the nineteenth century. The Highland landscape increasingly signified Nature's sublime power and became a playground for elite actors to accumulate social and cultural prestige. The Highlands' material ecologies shifted in response to this ideological transition: deer proliferated, natural regeneration was stifled, and species considered 'vermin' were culled (Steven & Carlisle, 1959). As the resource pressures at the end of the Great War grew in 1918, the Highland landscape once again changed. Echoing a framing developed nearly two centuries before, the landscape was increasingly seen as 'unproductive'. I document how commercial forestry became established during the twentieth century, and correspondingly, how a conservationist movement emerged in the 1980s to counter some of its degrading practices. Lastly, I outline the rise of rewilding, tracing its initial romantic commitments and connotations, and mapping how it has morphed to fit within the constantly changing field of power in the Highlands.

Tracing this history highlights the usefulness of thinking with '*environmental performativity*' when analysing the social and ecological history of Scotland. In this chapter, I review how previous research has highlighted how representations of Scottish nature, forests, and land have performed their material constitution. Measurement has played a crucial role in making Scottish natures: in surveying the woods ready for extraction, in measuring the agricultural productivity of land during the Enlightenment, and in counting the overpopulation of the region in the nineteenth century. The types of measurement that have been undertaken have created data supporting specific modes of environmental politics, legitimising interventions that are

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[25] 'Indigeneity' is a controversial term in the Highlands, used in the twenty-first century by several different cultural groups (such as crofters, tenant farmers and deerstalkers) to legitimise their lifestyle practices. However, the term is less controversial when applied to pre-Clearance communities, many of whom had settled the glens for generations (Devine, 2018; Mackinnon, 2017). As such, I use the term here to capture what historian Ian Mackinnon (2017) describes as the 'inner colonialism' which shaped the Clearances.

based on necessarily partial and contingent understandings of nature. They have had significant environment making and society making effects.

Reviewing this material is important for situating the arguments I make in the following chapters, for three reasons. Firstly, this chapter highlights the changing position of trees in the Highlands. The absence, presence, and naturalness of trees have been the subject of intense dispute over the last three hundred years. Forests have been ontologically multiple: they have been variably performed as homeland, resource frontier, deer sanctuary, national resource, habitat, and increasingly, carbon store. As the Prelude to the thesis showed, over time multiple forests have been enacted through different practices, with the Highlands' contemporary degraded ecologies becoming their material legacy. By tracing this history, I reveal the ways financial and ideological concerns have shaped the Highlands' material forest ecologies, thus situating the rise of carbon within a wider historical lineage. The contingent status of forests in the Highlands also hints to opportunities for *disruptive performativity.* I pick up this theme in Chapter Eight, where I show how shifts in measurement can change the ways forests are conceived and shift the material ecologies which might correspondingly emerge.

Secondly, this review chapter maps the ways that forests have been both a 'frontier' for modern resource extraction and a romantic sanctuary from modernity's destructive practices. Throughout the 2000s, as Fraser & Robbins argue (2003), Scotland's trees have simultaneously functioned as a commercial resource (through timber production) and a space for enjoyment (through the creation of native woodlands). With the rise of the woodland carbon market, especially of 'boutique' carbon credits from native woodland creation, this proffered resource-enjoyment binary is no longer so explicit. Native woodlands are increasingly reservoirs of high value 'wild' carbon credits and the financial imperatives to plant extractable timber resources are not so clear-cut. This is a theme I return to in Chapter Five.

Thirdly, the chapter reveals how the Highlands has, since the Enlightenment, functioned as a 'natural laboratory' for experiments in resource extraction, environmental measurement, and nature's commodification. By reviewing this history, I reveal how the growing concern for maximising and measuring natural capital functions as part of a wider attempt to quantify and maximise returns from Scotland's environment. It also flags the new historical precedent set in attempts to measure the value of conservation and ecological restoration. The Romantic and the Modern have historically been separated, with the conservation of Nature sitting opposite

extraction, experimentation, and measurement. Increasingly, these worlds – with their separate discourses, frames, ontologies, epistemologies, and political commitments – intersect. This is a theme I return to throughout the thesis, especially in Chapter Seven.

4.1. Before Improvement

Forest historians H.M Steven and A. Carlisle, in their now classic text *The Native Pinewoods of Scotland* (1959), describe how the Highlands' arcing glens were left bare and exposed when the glaciers retreated. Relatively soon after, tree seeds blown northwards began populating the region. Scotland's woodlands were at their fullest extent, historian Chris Smout (2003) notes, around 6000 years ago, covering roughly 60 per cent of Scotland's land mass. Steven and Carlisle's account documents how the ecological composition of these woodlands has historically changed along with climatic conditions, with birchwood dominating between 5000BC – 500 BC, alongside alder and Scots pine. The distribution and composition of bogland, heathland, and woodland also shifted significantly before human influence was widespread. Tracing this history, as Warren (2002) notes, highlights the difficulty in ascribing a fixed 'natural' baseline towards which reforestation efforts should be directed.

Figure 26 One of the largest pockets of surviving Caledonian pinewood at Loch Arkaig.

Some areas of Caledonian pinewood, such as this, have a historical continuity tracing back to the end of the last Ice Age.

According to environmental historian Jan Oosthoek, “by the end of the first millennium most wildwood had gone, except from the remoter parts of the Highlands. Forest cover had shrunk to perhaps as low as 20 per cent of the Scottish land surface” (2013, p. 23). Although accounts of national Scottish forest cover are difficult to ascertain,[26] Steven & Carlisle note that “all the evidence leads to the conclusion, therefore, that by the sixteenth century the timber reserves outwith the Highland region were almost exhausted (1959, p.57). In contrast, until about 1600, there seems little evidence that the forests in the Highlands were exploited for timber for use

[26] The difficulty stems due to several interconnected reasons, which Steven & Carlisle (1959) describe. The pollen of different tree species is more-or-less legible over time. And the term 'forest' is vague, as I noted at the beginning of the thesis. Over history, its meaning has changed. It did not necessarily refer to land covered with trees but was a more open term to refer to ground inhabited by deer. For this reason, historical details difficult to glean from primary materials.

outside the region. The small numbers of Indigenous human inhabitants meant there was likely little significant human impact on the Highland woodlands. Highlanders kept smaller flocks of animals compared to lowland communities, thus limiting the impact of herbivore grazing on the natural regeneration of woodlands cleared for fuel and timber (T. C. Smout, 2006; Steven & Carlisle, 1959, p. 57).

Carlisle & Steven (1959, p.58) describe how, following the 'discovery' of the Highlands woodlands by non-Highlanders around 1600, native woodland exploitation grew during the seventeenth and eighteenth centuries, as influxes of external capital from Ireland, England and the Scottish Lowlands financed deforestation. Oakwoods were exploited for charcoal production, and Scots pines, especially on the West Coast were cut down and used as a construction timber, especially for shipbuilding. However, as I note further below, significant exploitation of the Highland pinewoods by forces external to the region did not occur until around 1790 (see also Smout, 2006).

In his seminal work *The Scottish Clearances* (2018),[27] the esteemed Scottish historian Thomas Devine describes how, from the fourteenth and fifteenth century onwards Highland society was constituted by clans, *A' Chlann,* translatable from Gaelic into English as 'the children'. Clans were communities of Indigenous Scots Gaelic people living together in agricultural townships across the Highlands, who largely believed in a shared common ancestor.[28] These townships were controlled by a clan chief, with land generally managed as a joint-tenancy farm. The Gaelic understanding of human-nature relations, widespread amongst clansfolk, is captured by the term 'Dúthchas' (as spelled by Devine) or Dùthchas (as spelled by Highland historian-activist Col Gordon). For Gordon (2023), Dùthchas is a multifaceted word, which refers to the understanding that the 'natural' place for Gaelic Highlanders is on the land. According to Devine, Dúthchas "articulated the expectations of the people that the ruling families had the responsibility to act as protectors to guarantee secure possession of some land in return for

[27] Devine uses the term 'The Scottish Clearances' to capture the widespread land clearance that took place across rural Scotland, in the Scottish Borders in the South of Scotland as well as in the Highlands.
[28] Although, as Devine notes, many clans strategically made ties with other kin-groups, assimilated smaller groups into larger ones, and infiltrated the existing landed hierarchy in other regions through marriage to solidify power. "This evidence of evolution and aggrandisement makes nonsense therefore of any claims that clans were united through ties of blood" (2018, p.30).

allegiance, military service, tribute and rental" (2018, p. 36). Land should be maintained in balance, and everyone had the right to it. This was a central idea in clan society, which led to tensions and disagreements between clansfolk and their future landlords.

Spurred on by a complex combination of political factors, religious orientations and difficult economic conditions, many clans supported the Jacobites, a revolutionary movement which began in 1688 and grew stronger in the first half of the eighteenth century.[29] The Jacobites did not acknowledge the dethroning of James II of England in 1688 as legitimate and thus supported the return of the House of Stuarts to the British throne. The movement was effectively crushed by the British military victory over the Jacobites at Culloden in 1746. Devine notes how Culloden "became the prelude to a massive military, judicial and political assault on clan society which the government assumed had spawned subversion" (Devine, 2018, p.56). 'Rebel' estates, previously managed by pro-Jacobite leaders, were forfeit to the crown. Even 'loyal' clans were not spared an avengement carried out by royal forces, which included depredations, burning townships, and stealing cows, which were the main form of capital for the rural Highland population. Protestantism and economic reforms were introduced, with the hope that ideological conformity and prosperity might foster loyalty to the British crown (Devine, 2018, p.58).

In the mid-eighteenth century, laws were passed which allowed new landlords from outside the Highlands to acquire land (MacKinnon & Mackillop, 2020). Meanwhile, Highland culture was (sometimes violently) pacified by the crown's military forces who remained in the Highlands. For example, bagpipe playing was banned in the region. Devine notes that this dissolution of Highland culture proved a "final factor encouraging many of the [landowning, clan leadership] elite entirely to throw off this historic responsibility [to 'Dúthchas', and the associated protection and guardianship of people living on their lands] in favour of the material advantages of proprietorship, so completing the transformation to landlordism" (2018, p.60). With these shifts, the Highlands became increasingly compartmentalised and privatised in patterns that are

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[29] According to Devine, less than a quarter of the men fighting against the Crown were Catholics, who "usually owed allegiance without equivocation to their co-religionaries, the Stuarts" (2018, p.51). Around 75% were Protestant Episcopalian who rejected the Protestant Presbyterianism of the crown. Despite offers to take the oath to Mary and William, they rejected and "were subjected to the penal laws in the same way as those of the Catholic faith" (2018, p.51).

recognisable today (Wightman, 2010; Hunter, 2017). Large estates were run by a single individual, with historic responsibility to people replaced by a commitment to creating revenue from land. Over this time, the Highland landscape was increasingly seen as a space for resource maximisation and extraction. Historical connections between people and land, previously respected and upheld by landowning elite within the clan system, were rejected by a number of incumbent and older landlords.

4.2. Improvement

Whilst the clan system was deteriorating in the rural Highlands, Scotland's cities were undergoing enormous shifts. Rapid industrialisation was driving urbanisation in the expanding industrial cities of Aberdeen, Glasgow and Dundee. From *c.*1760, Devine notes, the expanding urban population created a growing demand for agricultural produce and raw materials. Rural land was increasingly framed as an asset to support an improving *national* population; and for the landed classes, land became a novel source of profit. Many Highland estates, which prior to the 1750s largely provided subsistence for their local peasant populations, underwent an intensification of modern agricultural techniques.

Enlightenment ideas from thinkers working in Scottish universities, most notably Adam Smith, circulated from the lecture halls to the Highlands. Agriculture, industry, and society could be 'improved' by rational management (Jonsson, 2013). As Devine notes, "Nature was not preordained but could be changed for the better by rational and ordered human intervention." (2018, p.142). Informed by Enlightenment ideas, rents for land increased as estate owners looked to improve their social and economic position in British society whilst "the removal of families was judged the most 'rational' economic option" by landowners, estate factors and surveyors (Devine, 2018, p. 134). Single-occupier sheep farms and crofting townships were established, forcing Gaelic populations to relocate to other areas on the same estate or elsewhere in the Highlands, or emigrate to the industrialising Scottish cities or even abroad. This signalled a significant departure from the Gaelic understanding of Dúthchas and ushered in a cascade of material changes on Highland ecologies and forests, clearing not only local populations but an Indigenous environmental ontology, worldview, and set of practices.

Jonsson (2013) describes how, especially following the British loss of the American colonies in 1783, the Highlands became the 'Enlightenment's Frontier'. Previously framed as a 'sterile

wasteland' the Highland landscape offered a natural laboratory for research into how to maximise crop production in Northern soils, and how to measure, quantify, and maximise the material basis of the economy. With the loss of the Americas, naturalists turned their botanic and taxonomic attention to a "'New World' at the edge of the nation, brimming with natural abundance" (Jonsson, 2013, p.3). The intensification of scientific interest in measuring nature in the eighteenth century sets a precedence for contemporary interests in measuring natural capital. As I argue in Chapters Six and Seven, the Highlands' 'sterile wasteland' is again being transformed with high-tech measurement techniques, as research scientists and capitalists collaborate in establishing the objectively 'best' way to manage land and maximise returns.

Devine traces how traditional forms of working the land and communal land holding were thought by 'improvers' to inhibit the natural progression that 'Man' should make towards profit, progress, and reward. In the second half of the eighteenth century, transatlantic emigration offered an enticing alternative to dispossession and rent increases for rural peasant populations, who were given little choice. Land was seen as a site where rational human management, particularly in the emerging sciences of economics and agrarian production, could be practiced. Not only were landowners and managers determined to make more profit – but to do so was "an essential part of the ideological mission to modernize Scottish society" (Devine, 2018, p. 142). Summarising the period, Devine writes that, "[u]ncritical intellectual legitimacy and credibility were afforded instead to virtually everything that was novel and innovative" (2018, p. 141). The aristocracy solidified their ascendent power through generating profits; and legitimised their power by appealing to profit generation as a 'natural' moral virtue. This is a paradigmatic example of the society making performativity I outlined in the previous chapter. Displays of technical expertise and the apparent delivery of 'solutions' to pre-framed problems served to legitimise the concentration of land ownership and extractive modes of managing land. This pattern continues into the present day, as I argue in Chapter Six.

During this period, concepts of the natural order and economic interpretations of the environment were, Jonsson notes, hotly contested. For Adam Smith, David Hume, and others working in the liberal tradition, nature acted as a model self-regulating system, exemplifying the naturalness of equilibrium and balance, which the market would supposedly bring. This clashed with a 'conservative ecology of improvement', generated by "a loose constellation of natural historians, agricultural improvers, and conservative landowners [who] suggested instead that the natural order was too complex or fragile to be left unregulated, particularly on

the peripheries of the nation and empire" (Jonsson, 2013, p.3). Facing a slew of material phenomena such as subsistence crises and deforestation, conservative voices presented national or colonial autarky as preferable to free trade, with power entrusted to private landlords to guide land towards its 'best' state. Contemporary discourses legitimising large-scale land ownership continue to reproduce a narrative that successful land management can only be realised through concentrated control especially in regard to 'landscape-scale' nature restoration (Barnaud et al., 2021).

These ideological framings of nature had significant environment making effects. In the half-decade following 1790, Smout notes, "the lairds largely took over the exploitation of their own forests from outside speculators" (2006, p. 345). By the end of the eighteenth century, the extensive pinewoods in the Highlands became increasingly seen as a resource frontier for timber extraction. The Highland pinewoods would no doubt have disappeared quicker, Steven & Carlisle (1959) note, had it not been for the difficulty of transporting timber. (This is a major reason why small fragments of Caledonian pinewood still exist, which, as I specify in Chapter Eight, rewilders are directing restoration attention towards.) Land transport was nigh-on impossible, meaning most logs were floated downstream. Technological improvements, such the building of a railway to Ballater in the eastern Cairngorms in 1854, meant pinewoods in the Cairngorms and upper reaches of Deeside could be extracted into the late nineteenth century (Steven & Carlisle, 1959, p.93). According to Steven & Carlisle (1959, p.59), tree planting of Scots pine, almost certainly of native seed origin, began in the late seventeenth century and grew in scale in the early eighteenth; some of these plantations were felled during the war effort between 1914-1918.

Taken together, the history of the Improvement era signifies how the Highlands has historically functioned as a frontier for Enlightenment thinking. The region has long been at the heart of modernity's quest for metrological prowess, as developments in technoscientific knowledge production have intimately shaped how natural resources are extracted. These patterns are playing out again in the present, but with a novel focus; as I argue in Chapter Seven, nature restoration is increasingly subjected to modernity's attempts to measure nature.

4.3. Clearance

At the turn of the nineteenth century, local populations of Highlanders were cleared from their land and replaced by sheep farms, which were considered the most 'rational' (i.e. profitable) land use for the landowning elites. Devine notes that to many lairds, traditional Gaelic attitudes appeared archaic and wholly irrational, with landowners sometimes dismissing the 'primitive' or 'aborigine' local populations (2018, p.228). Experienced sheep farmers and shepherds from the Scottish Borders and northern England were brought in by lairds, with the hope of maximising income from these large estates.

Two partial but successive failures in potato and grain crop production, in 1836 and 1837, pushed much of the Highland population to near starvation (Devine, 2018, p.251). The precarity of Highland life showed that the dreams of the Enlightenment were increasingly unrealisable. Consequently, expert judgement and political opinion about rural population dynamics and land's 'carrying capacity' shifted. "At the end of the Enlightenment," Jonsson writes, "a darker vision was gaining ascendancy: the 'New World' of the north was not empty but 'full'" (2013, p.4). When improvement schemes failed to develop the Highland region, political economists increasingly referred to the Highlands as a compelling example of 'natural limits' to improvement. Informed by the hard-nosed liberal ideas of Thomas Malthus, the Highlands were thought by the ruling class to be overpopulated. Jonsson describes how the Highlands were framed as "a society on the edge of collapse, burdened with surplus population, exhausted resources, and permanent natural disadvantages" (2013, p.4). This framing anticipated a major trajectory of modern environmentalism, which continues to this day, as natural scientists and environmentalists warn of the natural limits to the biosphere (Lorimer, 2020).[30]

In the first half of the nineteenth century, many Highland estates were purchased by wealthy individuals. A large proportion were funded directly or indirectly from slavery. As historians Ian MacKinnon & Andrew Mackillop (2020) note, wealth amassed through slavery and other

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[30] The Half-Earth movement has roots in Malthusianism. By and large, these accounts place blame on the number of humans rather than the consumption patterns of some humans, effectively laying blame for ecological collapse on larger families, generally in the Global South. I sometimes came across these discourses during fieldwork. At one disconcerting moment, a Scottish estate ranger told me that all people over the age of 80 should be killed because they had had their productive time.

imperial sources was bolstered by the 'compensation' that slave owners received for their loss of so-called 'property' when slavery was abolished in the British empire in 1833. A particularly high number of land purchases happened in the decade following 1834, "precisely when the slavery compensation legislation was passed and when the capital paid out to former owners entered the British economy" (2020, p. 8).[31] Whilst not all landlords enriched by slave-related wealth cleared their land, the new 'slavery elite' were the landowners of estates where some of the most violent and inhumane examples of clearance occurred (Mackinnon & Mackillop, 2020).

4.4. Romanticism: The Victorian Highland Myth

As this new 'Highland elite', the "nouveau-riche of emergent landed proprietors" (Wightman, 2010a, p. 222) purchased estates across the Highlands in the nineteenth century, deer stalking became an increasingly fashionable activity, with large areas of land dedicated to hunting red deer for 'sport'. According to historian Andy Wightman (2010, p. 222),

> "Prior to 1811 there were only six or seven deer forests actively managed for hunting. By 1873, the number of estates had risen to 79 and, by the end of the nineteenth century, there were between 130 and 150 deer forests covering 2.5 million acres – a vast outdoor playground for the upper strata of British society."

Like the transition towards 'improvement' in the previous century, material and ideological conditions co-constituted this turn. In economic terms, resource extraction from the Highland landscape had become less profitable. The price of wool fell in the first half of the nineteenth century, ensuring that profits from sheep grazing diminished (Devine, 2018). Concurrently, as Oosthoek (2013) notes, vast areas of ancient pinewood had been cleared for timber and fuel and were no longer lucrative to extract; most of these woodlands were turned over to sheep running or used as part of a sporting estate, with local human populations cleared (see also Smout, 2006).

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[31] "33.5 per cent of the west Highlands and Islands – more than one-third of its total area – was sold into the hands of people directly or indirectly enriched by slavery. Moreover, as acreages have not been found for all of these estates, the true proportion will certainly be higher." (Mackinnon & Mackillop, 2020, p. 9).

Figure 27 An old growth stand of native pinewood by Loch Arkaig.

This is one of the few remnant forests that survived the histories of extraction from the region. Note the bald hills on the other side of the glen. Source: Kati Karki (reproduced with permission).

In the second half of the eighteenth and early nineteenth centuries, as Hayden Lorimer (2000) describes, the Highlands became increasingly framed by the landowning classes as a timeless and natural wilderness, bursting with magical natural beauty. The Highlands promised connection to Nature, offering spiritual renewal away from the intensities of modern life. This romantic celebration of Nature's purity emerged as a reaction to some of the perceived failures of the Enlightenment (Jonsson, 2013). Devine notes how this popular image of the Highlands was "[f]irst created during the Romantic era as a direct consequence in aesthetics and visual taste at that time, the iconography became shaped by new concepts of scenic beauty, the picturesque and the sublime, which transformed how humans saw and experienced their natural environment" (2018, p.17). Speaking in the idiom of performativity, the aestheticized *representations* of nature (paintings popular with the upper classes) had a significant environment making effect on the ecologies which emerged.

Anticipating a widespread trend in contemporary conservation, owning land and protecting 'wilderness' held cultural value for those with money accumulated through dirty practices. For landowners who purchased estates with imperial and slavery-related means, owning land was a means for disguising their original link with slavery (Mackinnon & Mackillop, 2020, p.12). Wightman (2010) describes how the new Highland elite could buy their way into the British class system, emulating a traditional land-owning aristocracy. These estates generally lost money, but secured other forms of social and cultural capital, especially as landownership was framed as a form of custodianship and conservation of Nature. As Wightman (2010) argues, this remains the case in the current day. For example, oil companies such as BP and Shell invest in nature restoration and reforestation schemes in the Highlands.

The royal purchase of Balmoral Estate in Deeside in 1852 loaded Highland estates with unparalleled levels of cultural prestige. Historian Fraser MacDonald describes Balmoral as the "paradigmatic expression" of the "Victorian Highland myth" (2023, p.10). Famous paintings from the Romantic movement, such as *A View of Balmoral* and *A View of Lochnagar,* and especially the work of Edwin Landseer (shown in the following two images), "show what the Highlands should look like, whom they should belong to, who should do the work, which species are thought to matter and for whose benefit the land should be managed" (MacDonald, 2023, p.2). Empty glens, cleared of people, became central to the imaginary of Scotland's past. Rather than Gaelic communities, the Highlands were imaginatively inhabited by the 'monarch of the glen', a lone stag against a blurry, unspecified Highland backdrop, immortalised in Landseer's famous painting of the same name (Tsing, 2017). The construction of this ecological aesthetic stands in contrast to the combination of aesthetics employed by rewilding organisations in the current day, which I describe in Chapter Seven; but tracing this history highlights the power that visual representations of Highland nature in constituting what land should look like and who it is for. I also return to this theme in Chapter Eight, where I consider how rewilding ecologists use visual techniques to legitimise new ways of conceptualising Highland forests.

Figure 28 'The Monarch of the Glen' by Edwin Landseer (1865). Reproduced under Creative Commons Licence.

Figure 29 'Death of the Royal Stag with the Queen Riding Up to Congratulate His Royal Highness' by Edwin Landseer, (1860). Reproduced under Creative Commons Licence.

As Hayden Lorimer notes, the Highlands were increasingly framed as a “passive leisure space” (2000, p. 416) for British colonial administrators and upper-class elites in the second half of the nineteenth century. Landowners "embraced new rhetorics of nationhood, ecological thought and landscape preservation" (2000, p.403) to legitimise deerstalking, presenting themselves as custodians of the Highland ‘wilderness’ that sat centrally in the construction of a specifically Scottish national identity. Red deer were “granted an antiquarian heritage and regal genealogy in the animal kingdom” (2000, p. 408) to match the social standing of their hunter, who could then assimilate the “conditioned nobility” of their prey into their own aristocratic distinction. The cultivation of custodianship and tradition were, and still are, means of retaining hegemonic control of land and its natures. This ‘Balmoralisaiton’ of the Highlands had significant, degrading environment making effects which continue into the present day. Species that predated on game such as eagles, hawks, ospreys, and pine marten were categorised as vermin and killed (Deary, 2009). Deer numbers proliferated, stifling the

conditions for trees to naturally regenerate. Wilderness areas were created, often because timber extraction ceased to be profitable.

In the twenty-first century, Scottish land continues to be concentrated in private hands. In his classic study of land ownership *The Poor Had No Lawyers* (2014), Wightman writes that half of Scotland's 19.5 million acres were owned by just 432 landowners, and 83% of rural land was privately owned. Land ownership remains the dominant political mechanism for determining who has the right to control estates, the large parcels of land that the Highlands are separated into. Within these conditions, the culture of nature privileging deerstalking has proven resilient (McMullen, 2019). Wightman, writing in 2010, notes that "there are around 340 such [deer forest] properties covering around 2.1 million hectares of land – over 50 per cent of all privately owned land in the [Highland] region." (2010, p. 217). The discourses which naturalise and legitimise the hunting estate are continually reshaped as landowners change their narratives to accommodate for shifting social and political conditions. "Economically and politically powerful sporting estates" use "framing power" to build a discourse "highlighting the multiple benefits of game management in terms of heritage, knowledge, local employment and biodiversity" (Barnaud et al., 2021, p. 69). This has important consequences for reforestation in the present-day Highlands: an extensive and carefully curated narrative about deer's rightful place ensures their high numbers are allowed to continue, despite the knock-on ecological effects they induce in suppressing natural regeneration.

The 'Victorian Highland myth' did not drastically upset the distribution of who owned and benefitted from land. But it did signify an ideological transition. The Enlightenment's future oriented vision of improvement gave way to the Romantic's nostalgic retreat into a carefully constructed past. Developing the Highland landscape through an integration of scientific insights from political economy and natural history was replaced by a focus on conservation, albeit of a landscape which emerged from centuries of deforestation and human clearance. An ecological composition that required extensive human and nonhuman labour to maintain it became framed as the eternal, timeless Scottish Nature. In reviewing this literature, it becomes evident that appeals to 'conservation' have long been a means of accumulating and exemplifying cultural and economic capital and legitimising large-scale landownership. The practices which animate Scottish conservation, however, are shifting. Instead of freezing the landscapes in their current (ecologically degraded) state, ecologies are being restored.

Figure 30 A stag in the West Highlands. Image taken from the roadside.

4.5. The Rise of Commercial Forestry

Although this Romantic culture of nature remained powerful and enduring throughout the twentieth century (H. Lorimer, 2000) and into the current day (McMullen, 2019), a commitment to maximise productivity in 'marginal' (i.e. commercially unproductive) land resurfaced in the early twentieth century. Oosthoek (2013) describes how, following the First World War, Britain required a repletion of its timber stock. A state forestry authority, the Forestry Commission,[32] was created in 1919 to manage and co-ordinate forestry in Britain. Echoing the agricultural improvers of the eighteenth century, it operated with "a desire to make better use of uncultivated and derelict land" (Oosthoek, 2013, p. 53), turning the peaty, boggy, heather-covered Highland moors into land ripe for timber production. The 'national interest'

[32] The Forestry Commission in Scotland is now known as Forestry and Land Scotland.

had shifted from agricultural production to timber production – but the Highlands once again served as a frontier for resource extraction and scientific experimentation.

Figure 31 A relatively young Sitka spruce plantation in the Central Highlands.

This shift was largely due to the state's increased concern for creating a 'standing timber reserve' in Britain, following World War 1. Prior to the war, Oosthoek (2013) notes, 92% of Britain's timber was imported. During the war effort, importing wood was difficult and Britain's timber reserves were nearly exhausted. Drawing on insights from 'scientific forestry'

developed in Britain's overseas colonies, the Forestry Commission experimented with different modes of producing timber in the Highlands, including increased mechanisation and fertilisation. Broadleaves such as oak proved impossible to grow in Highland soils, whereas Sitka spruce, a non-native conifer imported from Sitka, Alaska, flourished. By the mid-twentieth century, conifers[33] accounted for more than 90% of Scottish plantations (Oosthoek, 2013).

The establishment of the Forestry Commission, which purchased public lands and expanded timber production was also, Oosthoek (2013) notes, explicitly pursued to increase the number of people living in the Highlands and working the land. It was widely reported that forestry would create more rural jobs than sheep farming. By 1939, the Forestry Commission was the largest landowner in Britain, perhaps hinting to how strong state involvement to tackle perceived 'national' problems might set a precedent for a public response to the climate and ecological crisis.

[33] The only native conifers in Scotland are juniper, which cannot be grown as a commercial timber, and Scots pine, which can. Fears about disease and pests inhibit the widespread use of Scots pine as a commercial crop.

Figure 32 Felling trees in a Sitka spruce plantation.

As I describe further in Chapter Five, Sitka spruce plantations such as these can generate carbon credits, even if the trees will be cut down for timber.

Oosthoek (2013) documents that until the 1980s, Scottish forestry was largely run by the State, through the Forestry Commission. In 1979, the Thatcher government announced that forest expansion would continue but now would be mainly carried out by the private sector. In the 1980s, tax concessions and grants were used on a large scale by private investors; for high tax income earners, growing timber was a lucrative earner and landowners could effectively use forestry as a tax buffer. As I detailed in the Prelude, land in the Flow Country – an expansive blanket bog peatland in Northern Scotland – became a hub for private forestry. Afforestation in the Flow Country sparked a public concern with the conservation of Scotland's 'wild' places. Following a public campaign in 1985 from the Royal Society for the Protection of Birds (RSPB), showing the environmental destruction associated with afforestation on peatland, the tax breaks granted to Flow Country afforestation were removed in March 1988. Following the Flow Country controversy, which thrust conservation interests up the national social and environmental agenda, native woodland creation became central to State forestry policy. For

example, the percentage of trees planted that were native increased from just over 5% in 1988 to almost 50% in 1998 (Oosthoek, 2013, p. 166).

Writing in the early 2000s, political ecologists Paul Robbins & Alistair Fraser describe Scotland as gripped by a ‘schizophrenic forestry’, in which "two forms of forestry have emerged, each striving to produce differing forest types and each responding to the crisis of restructuring [Scottish forestry] in a different way" (2003, p. 104). Monocrop industrial timber plantations, consisting mainly of exotic conifers, grow alongside native woodland. For Robbins and Fraser, the production of native woodland is another "commodifiable artifice" (2003, 109) within capitalist forestry, harnessing the nationalistic and environmentalist discourse surrounding native trees such as Scots pine, to construct a forest wilderness “targeted at consumption through ecotourism” (2003, p. 95). Although this proffered commercial-wilderness binary is perhaps, as political ecologist Fiona MacKenzie (2013) suggests, overstated, it offers a helpful axis for conceptualising Scottish reforestation efforts. Commercial forestry and native woodland creation sit at each end, with different ecological, economic, and political motivations. But despite their differing visions for how reforestation should be pursued, they are brought together within Scottish forestry governance. As Chapter Five makes clear, commercial, non-native productive forestry and native woodland creation are subject to the same processes of carbon accreditation and measurement, and thus folded into the same carbon market. Highlighting the differential *value* and *quality* of these different forest types is central to the rewilding agenda, as I document in Chapters Seven and Eight.

4.6. Scottish Rewilding

Rewilding – as a discursive term and environmental imaginary – gained increased popularity in Scotland during the early twenty-first century. As Jamie Lorimer (2015) argues, rewilding is a form of nature conservation that departs from the ‘compositionist’ model of conservation, which has been historically enduring in the UK. The compositionist model is epistemically committed to the concept of ‘climax community’, treating contemporary landscape composition as the perceived desirable baseline to which conservation governance should be directed towards (even if the ecologies in these landscapes have been subject to intensive management regimes). As Lorimer shows in reference to Scottish corncrake conservation (2008), this conservation model can be economically expensive, neglect ecological and evolutionary processes, and ‘freeze’ landscapes in their current composition despite changing

climatic conditions. Ecological dynamism can be obscured or suppressed in favour of preserving static landscapes.

Geographer Holly Deary describes how Scottish rewilding developed out of the Romantic tradition, founded on an ideology centred on "authenticity, purity, and historical fidelity" which was "explicit in its alliance with naturalness and wilderness" (2015, p. 1). Conservation NGOs such as Trees for Life, alongside private landlords,[34] purchased estates and planted trees, fenced enclosures, and culled deer to expand native woodland cover. However, "given the ambiguity over 'natural conditions' in Scotland," (Deary, 2015, p. 1), as I reviewed above, there are tensions surrounding using historical fidelity and authenticity as guides for ecological restoration.

Figure 33 A native broadleaf forest covering a Highland Glen. The bald hills surrounding it hint to the historical suppression of natural regeneration. Source: Kati Karki (reproduced with permission).

[34] Landlords such as Anders Povlsen (who owns the fast fashion company ASOS) and Paul Lister (heir to the MFI fortune, the now bankrupt UK furniture business) are the major stakeholders in rewilding businesses (Wildland Limited and Alladale, respectively).

In Scotland, species reintroductions, which are a crucial element in rewilding's ecological principles, have been controversial. Speculative plans for predator reintroduction, most famously calls for bringing back the wolf at the Alladale Estate to create a 'game reserve', freighted rewilding with negative connotations for many local populations, who feared a new Clearances, as wealthy landowners determined how land should be managed (Deary & Warren, 2017, p. 215). Responding to these political controversies, rewilding discourse has largely transitioned away from predator reintroductions and towards the creation of native wildwood habitat (Martin et al., 2021).[35] Distancing from the 'wilderness' notion has been crucial for generating political support amongst local communities. As Deary argues, Scottish rewilding is increasingly concerned with 'wildness' rather than wilderness, through "restoring nature's autonomy and self-regulation" (2015, p.12) and allowing for ecological processes to operate independently of human management and control. Reintroducing species such as beavers, which shift watercourses and have cumulative effects on riparian ecology, have been a growing concern for the Scottish rewilding movement (J. Lorimer, 2020).

[35] Although interest in lynx reintroduction was present in interviews with rewilding executives and has a presence on the websites of rewilding NGOs such as Trees for Life and Scotland: The Big Picture.

Figure 34 Evidence of beaver activity in the Southern Highlands. Their reintroduction has proven controversial amongst some farming communities.

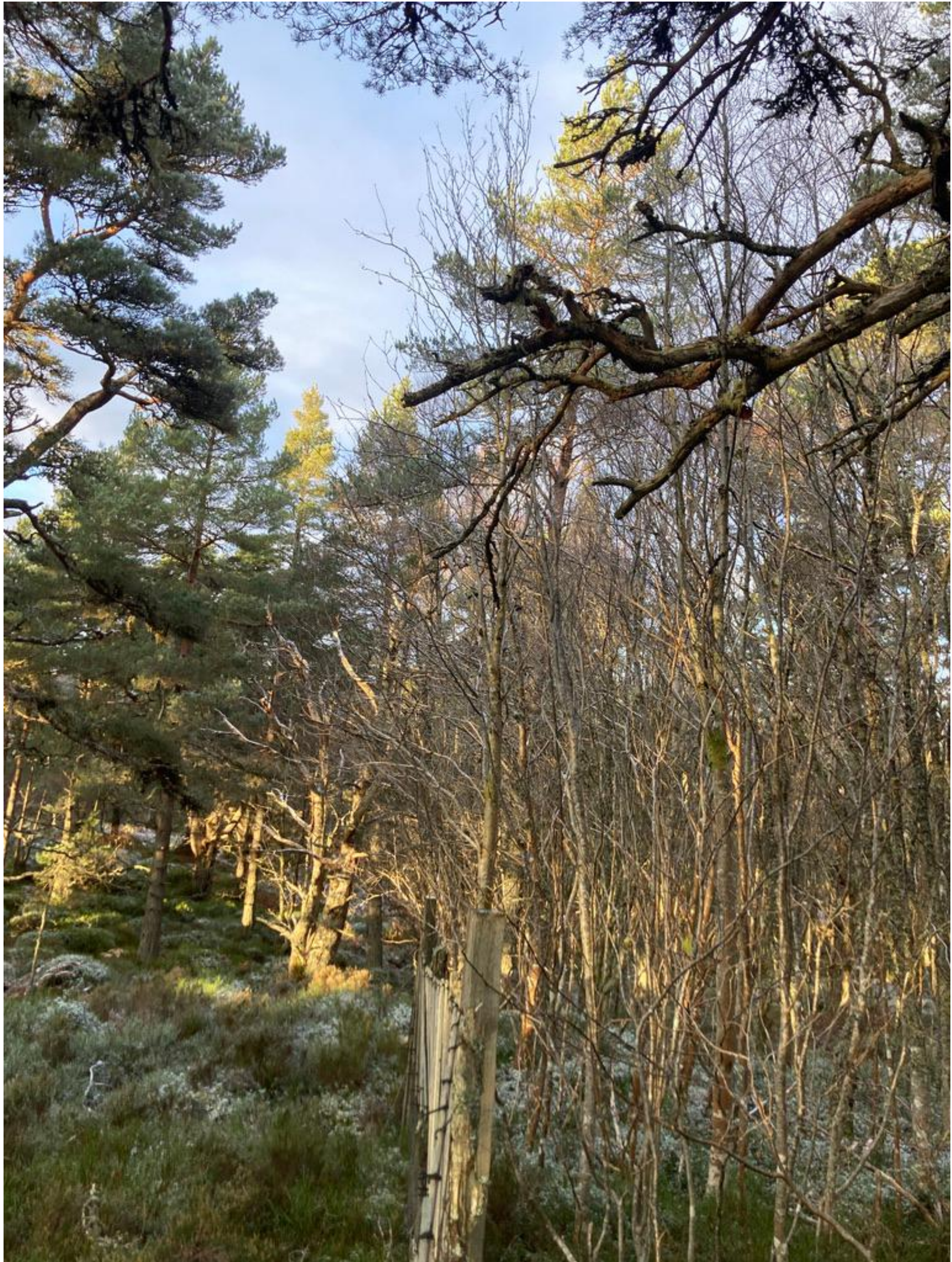

Figure 35 This is a classic 'fenceline shot', a type of image commonly circulated by Scottish rewilders.

A camera is placed along a deer fence, showing the woodland composition with/without deer pressure. On the right is the fenced-in woodland, with extensive woodland coverage. On the left is the forest heavily browsed by herbivores.

Using wildness rather than wilderness as a normative goal, rewilding organisations avoid accusations of reproducing a well-critiqued Nature-Society binary. Farming and commercial forestry, which sit central to the Highland economy, can be integrated with rewilding's vision. Landscapes are not understood in the modern's sense as inert sets of resources, nor are they wildernesses of 'pure' Nature. In the terms developed by Anna Tsing and her colleagues (2019), landscapes are better understood as 'patches' of more-than-human communities and dynamics. I return to this theme in Chapter Eight, where I show how rewilding ecologists are creating new forms of ecological surveying to capture this patchiness.

In this vision of rewilding, the overall landscape can be wilder, from gardens, to farms, to estates. The image below, produced and circulated by rewilding NGO *Scotland: The Big Picture*, presents a characteristic image of Scottish rewilding's imagined future. There are more native woodlands and more charismatic species, but it is not a wilderness. Rural populations continue to live in the houses in the centre of the image. Cows graze and commercial forests still exist but are part of a wider mosaic of species and land uses. The sky, of course, is blue.

Figure 36 The future of Scotland, imagined by rewilding NGO SCOTLAND: The Big Picture.

Note the difference in forest composition (Sitka spruce on the left, mostly native woodland on the right). Reproduced from the website of SCOTLAND: The Big Picture (2023).

The influx of wealthy private landlords, determining how the Highlands should look, has ensured that rewilding has been seen by a vocal minority of Highland residents as a contemporary manifestation of the Highland Clearances (Brown et al., 2011).[36] Correspondingly, rewilding organisations' discourse has increasingly come to include people (Martin et al., 2021).[37] Central to this 'repeopling' of the Highlands is the creation of a 'nature-based' economy. Rewilding is increasingly framed as an economic opportunity, as a chance to generate profit through natural capital markets (Martin et al., 2021; Wynne-Jones, 2020). As Kavita Sharma and their colleagues (2023) note, this might lead to an exacerbation of inequalities and an entrenchment of power dynamics, as wealthy individuals and businesses have greater purchasing and decision-making power than local community groups.

Figure 37 Touring the 'wilderness reserve' at Alladale Estate.

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[36] In interviews, some Highland residents told me how they see rewilding as a contemporary manifestation of the same colonial logics that have historically affected rural Scotland. For example, a community landownership activist, when discussing the rewilding estate at Alladale, told me how "it's so offensive to me that [Lister] calls it a wilderness reserve!" He noted that Alladale is "just down the road" from Croick Church, a famous site from the Highland clearances.

[37] For example, the Conservation Manager for a famous rewilding charity told me he saw no reason why rewilding cannot be integrated with a "nonbinary land use" that supports nature and people.

4.7. Conclusion: Technical Wildness

Reviewing the work of political ecologists and environmental historians, this chapter has shown how Highland natures have continually shifted, both ideologically and materially, under the weight of economic and political pressures. Land which was once a 'sterile wasteland' became the 'Enlightenment's fronter', where an intensification of scientific research and metrological sophistication could support the national interest. A century later, Scotland's moors became haunting manifestations of Nature's rugged sublime. The barren hillsides functioned as symbolic retreats from Victorian urbanism. When the nation required a new natural laboratory for scientific experimentation and commercial productivity in the twentieth century, the moorlands were planted with non-native conifers. And a growing public concern for environmental degradation and nature restoration drove the ascendency of rewilding. This historical review has presented a somewhat binary distinction between two schools of thought, two cultures of nature that have held largely competing visions of Scotland's environmental future.

During the widespread clearance of the Highlands' native pinewoods, the improvement of agricultural land, and the introduction of commercial timber production, modernity's commitments came at the expense of environmentalist ideals. They had, as I have traced throughout this chapter, various ecologically damaging consequences for the Highlands' multispecies communities. However, in the contemporary context of Scottish reforestation, the ecologically degraded landscapes ready to be 'improved' are *also* ready be made wild again, often by the same organisations. The two strands of the Janus-faced model of Scottish environmentalism – the Modern and the Romantic – arrive from different genealogical histories and might hold competing epistemologies and ontologies. But in the early 2020s, they share a common concern: to reforest Scotland.

As I show in the chapters that follow, the 2020s marks a new chapter in the history of Scottish environmental politics. With intensifying national and global demand for nature restoration and carbon sequestration, the Highlands' generally treeless moorlands are, once again, considered resource frontiers ripe for improvement (Sharma et al., 2023). Large tracts of cheap, plantable, unproductive land are framed as ready for science-led, enlightened, rational stewardship. Modernity's market-based governance and measurement techniques are increasingly presented as the best (indeed, only) available mechanisms for successfully

reforesting Scotland and delivering the nature-based solutions that society requires to avoid the worst forms of socio-environmental collapse. By leaning on the cutting-edge technologies of the present, the lost ecologies of the past might become materialise in the not-too-distant future.

As I articulate in the chapters that follow, the Scottish Highlands can be considered as an example, and perhaps even an epicentre, of a novel culture of nature growing in ascendency in contemporary nature restoration. I term this culture 'technical wildness', which can be understood as the novel set of ideologies, practices and discourses which increasingly frame high-tech, science-led land management (including carbon accounting and biodiversity measurement) as the best mechanism available for scaling up ecologically informed nature restoration. Technical wildness functions as a dialectical middle ground between the Modern and the Romantic, smoothing out the tensions between the apparently incommensurable cultures of nature.

Organisations who label themselves as 'nature restoration' or 'rewilding' specialists, including newly created private companies and start-ups looking to profit from the natural capital markets associated with nature restoration, are increasingly integrating a range of discourses from both traditions of Scottish environmentalism. Private companies, NGOs, and state departments employ a varied set of practices and discourses within their work portfolio. Through careful branding, marketing, and other communications-related work, these organisations perform their commitments to realising a flourishing Highland nature, often by drawing on classic tropes of the romantic tradition which depict a wild Scotland. Simultaneously, many of these same organisations make rhetorical appeal to the sophisticated technologies employed to measure the quantifiable biodiversity and carbon gains associated with their projects. Within this new world of technical wildness, affective and visually striking discourse is married to the cold, hard, rational allure of numbers and quantification. The spectacle of conservation and the spectacle of science are interlinked in a performative display to convince carbon credit purchasers, state departments and other relevant stakeholders of the saliency of how nature restoration is being pursued.

Throughout the following chapters, I show how the technical logics of quantification and metrology are central within the Scottish nature restoration movement. In Chapter Seven especially, I further develop the concept of technical wildness. Using the example of 'wild carbon'– carbon credits which are sold with increased financial value due to their apparent

ecological benefits – I show how rewilding organisations carefully and variably draw on a range of discourses to frame their ecological work. But prior to reaching Chapter Seven, we must understand the measurement practices shaping how carbon is accounted for. The following chapter helps us to understand the state-backed status quo mechanisms used for carbon accounting. But before we closely unpack the politics of Excel spreadsheets, let's take a moment to head into the forest. We might find something surprising lurking there.

Interlude: The Capercaillie

We crested a hill and saw a pock-marked heathland. Trees stretched out before us. The dark block of Sitka spruce on the left side of the glen appeared in higher definition than the native woodland smeared across the right. The view, seen in the image below, captured the diversity and duality of Scottish forests. Production and conservation, staring at each other across a river.

Figure 38 One glen, many forests. Note the different shades of green on each side of the glen, signifying the different forest ecologies.

Where we stood, heavy machinery had prepared a large area for tree planting. Half meter-deep ditches had been carved into the soil, into which tree saplings should have been planted. Despite someone evidently spending thousands of pounds lugging expensive diggers halfway up a mountain, it appeared that nobody had actually come to plant the trees. The ditches were clearly old; they had the dry texture that earth only takes on after sitting in the sun for too long. And they were empty.

Figure 39 The holes dug into the soil.

Mike, the ecologist I was working with, stood next to me. He was frustrated: how little consideration for local ecology was it possible to have? He pointed to the native woodland all around us, that could have regenerated into the area if careful deer management had been introduced. The ditches, Mike proposed, served as material reminders of forestry's destructive practices and logics. They hadn't even bothered planting the trees! As the rant died down, we sat in sorry silence.

Suddenly, a capercaillie flew out from the ditch next to us, flapping like a pheasant. Its shrill call and the flap of its beating wings contrasted to our speechlessness, which hung suspended into the air until Mike could blurt out "A caper!". Capercaillie are one of Scotland's most iconic and endangered birds. They went extinct in Scotland in 1785 and were reintroduced from Swedish stock in 1837. Now, they are on the brink of extinction again. Almost nobody I had met in Scotland had ever actually seen one. I was later told that no capercaillie had ever previously been recorded in the region Mike and I were surveying. The ground-nesting capercaillie was presumedly living here, in these strange potholes, because they offered a safe refuge. Almost all its natural habitat – Caledonian pinewood – has been destroyed.

Figure 40 A wild capercaillie in Glenfeshie.

Reproduced using Creating Commons Licence. Source: sighmanb, CC BY 2.0 <https://creativecommons.org/licenses/by/2.0>, via Wikimedia Commons

I have continually returned to the image of this panicked capercaillie when thinking through the paradoxes and intricacies of Scottish reforestation. The irony of finding Scotland's talismanic rare bird *here*, in the ruins, rather than in the pristine landscapes that so much energy has been given over to conserving, has not been lost on me. The bird, and that moment, seem drenched in metaphor. Were attempts to restore Scotland's forest ecologies analogous to a capercaillie, Scotland's mythical phoenix, rising above the Highlands' degraded landscape to overcome the destructive tendencies of modern forestry? Or were they more akin to a hopeless, terrified squawking, as even the ruins left in modernity's wake are uninhabitable?

5. The Woodland Carbon Code: Legitimacy, Credibility, Performativity.

5.1. Introduction

Although most forests store carbon, forests are not inherently carbon *credits,* value-bearing financial objects that circulate in the voluntary carbon market. The ontological, and sometimes literal, borders of a forest which determine what can be sold as carbon offsets, are not reducible to any *a priori* biophysical characteristics. Instead, forests are *made* carbon credits through *object making performances*, as their messy complexity is translated into a carbon number subsumable to the market (Sullivan, 2018). As Chapter Two highlighted, extensive work by STS scholars has traced how a large array of instruments, tools and technologies, including algorithms, spreadsheets, and metrics, are required for this translation to occur and be considered legitimate (see Robertson et al., 2023a).

In Scotland, only some forests are successfully translated into woodland carbon credits. This chapter seeks to understand why, how, and with what effects this selective translation occurs. Specifically, the chapter examines the practices and epistemic commitments comprising the Woodland Carbon Code (WCC), "the quality assurance standard for woodland creation projects in the UK, [which] generates independent verified carbon units" (Woodland Carbon Code, 2024). The WCC is a state-backed code of conduct, established in 2011 by the Forestry Commission, which sets the criteria that a woodland creation scheme must pass to generate carbon credits. It also calculates how many carbon credits a new project can generate over a 100-year period. It's an important governance mechanism in shaping Scottish forest creation; it effectively determines *which* trees, or more broadly, which forests and which natures, are financially valuable in the net zero economy.

In this chapter, I answer my first research question, ***how does the hegemonic form of forest measurement in Scotland perform reforestation?*** The chapter's central claim is that the WCC's legitimacy, and the legitimacy of the credits it generates, are stabilised through ongoing commitments to measurement conservativism and metric integrity. These constitute the object making performance necessary for generating high-integrity, trustworthy forest carbon credits. These object making performances in turn have environment making performative effects on the types of forest ecologies that become materialised in woodland carbon schemes. By developing this claim, this chapter brings nuance to discussions of environmental performativity. Through unpacking the creation and functioning of the WCC, opening up the 'black box' of its measurement procedure (Pinch, 1992) and situating it within its political economic setting, the WCC offers an insightful example for differentiating between two forms

of environmental performance. I show how the composition of Scottish forest ecologies is materially shaped by the WCC's need for legitimacy in a contested political atmosphere.

After outlining the history and functionality of the WCC in Section Two, in Section Three I show how the legitimacy of the WCC is constantly being (re)constituted through its laudable commitments to, and performances of, conservativism and integrity. In Section Four, I outline the environment making performative effects that emerge from the WCC's design, documenting how carbon brokers speculate it will encourage more broadleaf planting but might create streamlined forest ecologies. Closely analysing the performativity of the WCC reveals how the enactment of epistemic commitments through systems of measurement contributes to the creation of specific natures. The Conclusion highlights the difficulties of relying on carbon finance to realise ecologically diverse nature restoration.

5.2. The Woodland Carbon Code

The Woodland Carbon Code is the UK's government-backed standard for issuing woodland carbon credits which can be used in corporate claims of net zero emissions. John, the CEO of one of Scotland's largest forest carbon brokerage companies, explained how the WCC had first been created. The idea to sell UK-based forest carbon came to him in 2006. His small forestry business grew in 2007 when he started working with a car insurance broker who would "quote-unquote offset your carbon for 12,000 miles of motoring if you insure with us". Around that time, John realised that a code of conduct was needed to maintain the credibility of any carbon credits generated. If the market was flooded with bad practices and bad actors, the legitimacy of the whole market would fall apart. With the Director of ConFor, the trade association for the UK forestry industry, John consulted with the Forestry Commission, who understood the need for a code and "directed Forest Research [the research agency of the Forestry Commission] to go ahead and get on with it". After a long consultation between the code's designers, forestry experts, and economists, the WCC was piloted in 2010 and launched in 2011.

The WCC lays out a set of guidelines which forestry schemes must follow to generate carbon credits which can be sold to UK-based businesses looking to offset their emissions. Woodland creation projects must follow the UK Forestry Standard (UKFS), a set of laws, relevant codes of practice and industry guidelines that a forestry project must legally adhere to. One important rule, which I mentioned in the Prelude, is that trees cannot be planted on organic soil deeper

than 50cm. To generate carbon credits, forests must demonstrate additionality. Additionality means the new woodland captures carbon "over and above that which would have happened anyway" (The Woodland Carbon Code, 2019, n.p.). To be additional, a forestry project must pass two tests. To pass the Legal Test, there must not be a legal obligation for a forest to be planted. In Scotland, there is a legal requirement for an area of cleared forest to be covered in trees within 5 years of it being cut down (referred to in the industry as 'restocking'). This means that forestry projects replacing a recently cut down forest, mainly commercial forestry projects, are ineligible to generate carbon revenue.[38] It also means that forest 'conversions', such as the creation of native woodland on the site of a felled non-native dominated commercial forest, cannot receive carbon finance.[39]

Figure 41 A commercial plantation which is being clear-felled and replaced by a native woodland.

[38] This is a feature of the WCC heavily contested by some commercial forestry companies, who argue that all trees – irrespective of whether they are legally mandated to be planted – should receive carbon finance because the trees sequester carbon and the wood grown can replace other, more carbon-intensive building materials such as steel. This narrative can obscure that the forests would have been planted anyway, regardless of carbon finance, and hence are not additional.

[39] During my fieldwork, lobbying against this stipulation was growing, especially from landowners who wanted to generate carbon income from native woodland creation. For example, the Woodland Trust Scotland were converting a commercial plantation into a native pinewood in Loch Arkaig and were reliant on grant support. Carbon finance would have been a large economic boost for the project.

The project is ineligible for carbon credits because the timber being cleared must be legally 'restocked'. The creation a new native woodland fails to meet the Legal Additionality Test.

Projects must also pass an Investment Test, proving that they *require carbon finance* to be economically viable. This is commonly referred to as 'economic additionality'. Pat Snowden, the Head of Economics and Woodland Carbon Code at Scottish Forestry, describes this process in an online blog:

> "Where new woodlands have little or no revenue opportunities, it is much easier to show that payments for carbon credits are needed to make them viable. However, where a project has significant revenue opportunities, say from timber production, it is vital that due diligence is applied as to whether carbon payments are needed.
>
> "The purpose of carbon markets is to drive additional action towards climate change targets. Without additionality, they have no purpose." (Scottish Forestry, 2022, n.p.)

Effectively, if a project *would* go ahead without carbon finance, it clearly would not be additional. To prove that they require carbon finance, a project manager inputs data about the expected inputs and outputs of the project into the WCC Cashflow Spreadsheet. This spreadsheet determines whether the project would have been profitable without carbon finance.

In generating carbon credits, the WCC follows a two-step process: validation and verification. Only woodland creation projects that pass the UKFS and additionality checks will be *validated.* This involves an independent organisation that has been accredited by the UK Accreditation Service, such as the Organic Farmers and Growers Organisation or the Soil Association, checking through a Project Design Document to agree that it meets the criteria of the WCC. The body must also visit the woodland creation site "within three years of a project's registration and [validation] can only be completed once the trees are planted, or fencing / deer control is in place for natural colonisation / regeneration" (Woodland Carbon Code, 2022, p. 4). At validation, the WCC also predicts the amount of carbon a woodland project is expected to sequester, based on carbon prediction and monitoring tools developed by Forest Research.

Woodland creation projects must be independently *verified* five years after planting and then

every ten years (at years 15, 25, 35, etc.), to confirm that the trees are growing as planned and the carbon is being sequestered. Prior to the credits being verified, a Pending Issuance Unit (PIU) can be sold. PIUs are effectively a promise to deliver future carbon sequestration. PIUs cannot be used in offsetting claims because the carbon sequestration *has not yet occurred.* The number of PIUs that a project is allocated is calculated using the WCC Carbon Calculation Spreadsheet at the validation stage.

In practice, a project manager inputs data about the project (such as project duration, area planted, and species mix, as seen in Figures 42 and 43) into the WCC Carbon Calculation Spreadsheet to predict future carbon sequestration. It is freely accessible from the WCC's website and runs on Microsoft Excel. The calculation involves calculating the "long-term average carbon stock that is projected to accumulate on the site" and subtracting the "emissions resulting from the preparation of a site prior to planting" (Woodland Carbon Code, 2022, p.20), such as losses from the removal of vegetation and soil disturbance. The following four images are screenshots taken from the WCC Carbon Calculation Spreadsheet used for a commercial forestry project in East Ayrshire managed by one of the largest forestry companies in Scotland. They show the different types of data inputted about a project. (N.B. all project information is readily available on the UK Land Carbon Registry, a website-database that transparently stores public data about WCC and Peatland Carbon Code projects.)

Assumptions - Emissions from establishment - Table 1

Project Basics				
Project start date				23 April 2021
Project duration (years)				65
Total net planting area - excluding open space (ha)				88.66
Country				Scotland
If in England, Are you using the Woodland Carbon Guarantee?				*N/A*
If using the Woodland Carbon Guarantee, 10-yearly or 5-Yearly verifications?				*N/A*
Emissions from establishment	**spacing (m)**	**area (ha)**	**tCO_2e/ha**	**tCO_2e**
Seedlings	2.5	88.66	-0.24	-21.3
Ground Preparation (Fuel)		88.66	-0.06	-5.3
Tree Shelters		20.24	-0.82	-16.6
Fencing		127.88	-1.64	-209.7
Herbicide		88.66	-0.001	-0.1
Road Building		**km**	**tCO_2e/km**	**tCO_2e**
Roads		0.01	-43.13	-0.4
Emissions from removal of trees or other vegetation at the start of the project				
To be calculated separately if any trees or other vegetation is removed prior to planting. Show working on a separate sheet. (See Guidance 3.3 Project Carbon Sequestration)				0.0
Total Emissions from establishment				**-253.4**
Soil Carbon accumulation (currently only claimable for a site with mineral soil which was previously in arable use, managed with minimum intervention)				**area (ha)**
If previously arable site on mineral soil: Over what area are you claiming Soil C Sequestration (ha)				0.00
Baseline and Leakage				**Yes or No**
Baseline: Will your project area sequester a significant amount without planting trees? (See Guidance 3.1). If yes, ask the WCC team for further assistance				No
Leakage: Will your project cause significant emissions outside the project area? (See Guidance 3.2). If yes, ask the WCC team for further assistance				No

Figure 42 Initial data input for the WCC Carbon Calculator spreadsheet.

Assumptions - Species, Spacing, Yield Class - Table 2

Sectn No:	Actual Species	Actual Spacing (m)	Species/Model from Lookup Table	Spacing used in Lookup tables (m)	Error check only - If 'ERROR' then check spacing (column L)	Yield Class in ESC (if different to YC used)	Yield Class Used in Lookup Tables	Error check only - if 'ERROR' then check Yield Class (column P)	Management Regime from Lookup Tables	% of Area if mixture	Area (ha)	If Clearfelling: Age at clearfell (years)	Clearfell Cap (tCO2e/ha)
	Sitka Spruce	2.0	SS	2.0	NO	19.0	18	NO	Thinned	74.13%	65.72	35	148.5
	Norway Spruce	2.0	NS	1.5	NO	8.0	8	NO	Thinned	3.05%	2.70	45	76.0
	Downy Birch	2.5	SAB	2.5	NO	5.0	4	NO	No_thin	3.56%	3.16	0	0.0
	Alder	2.5	SAB	2.5	NO	6.0	6	NO	No_thin	1.78%	1.58	0	0.0
	Rowan	2.5	SAB	2.5	NO	4.0	4	NO	No_thin	0.67%	0.59	0	0.0
	Pedunculate/common oak	2.5	OK	2.5	NO	3.0	2	NO	No_thin	0.67%	0.59	0	0.0
	grey willow	2.5	SAB	2.5	NO	5.0	4	NO	No_thin	0.89%	0.79	0	0.0
	Hazel	2.5	SAB	2.5	NO	4.0	4	NO	No_thin	0.45%	0.40	0	0.0
	Aspen	2.5	SAB	2.5	NO	8.0	8	NO	No_thin	0.45%	0.40	0	0.0
	Bird cherry	2.5	SAB	2.5	NO	3.0	2	NO	No_thin	0.45%	0.40	0	0.0
	Scots Pine	2.0	SP	2.0	NO	9.0	8	NO	Thinned	4.82%	4.27	0	0.0
	Sycamore	2.0	SAB	2.5	NO	7.0	6	NO	Thinned	1.20%	1.07	0	0.0
	Downy birch	2.0	SAB	2.5	NO	5.0	4	NO	Thinned	1.20%	1.07	0	0.0
	Pedunculate/common oak	1.8	OK	2.5	NO	3.0	2	NO	Thinned	0.41%	0.36	0	0.0
	Beech	1.8	BE	2.5	NO	6.0	6	NO	Thinned	0.41%	0.36	0	0.0
	Downy Birch	3.0	SAB	3.0	NO	5.0	4	NO	No_thin	2.35%	2.08	0	0.0
	Alder	3.0	SAB	3.0	NO	6.0	6	NO	No_thin	1.17%	1.04	0	0.0
	Rowan	3.0	SAB	3.0	NO	4.0	4	NO	No_thin	0.44%	0.39	0	0.0
	Pedunculate/common oak	3.0	OK	3.0	NO	3.0	2	NO	No_thin	0.44%	0.39	0	0.0
	grey willow	3.0	SAB	3.0	NO	5.0	4	NO	No_thin	0.59%	0.52	0	0.0
	Hazel	3.0	SAB	3.0	NO		4	NO	No_thin	0.29%	0.26	0	0.0
	Aspen	3.0	SAB	3.0	NO	8.0	8	NO	No_thin	0.29%	0.26	0	0.0
	Bird cherry	3.0	SAB	3.0	NO	3.0	2	NO	No_thin	0.29%	0.26	0	0.0
	Select Species		Select Species First	Select Species First	NO		Select Species First	NO	No_thin	0.00%	0.00	0	0.0
	Select Species		Select Species First	Select Species First	NO		Select Species First	NO	No_thin	0.00%	0.00	0	0.0
	Woody Shrubs	Specify which woody shrub species here				Not accounted for in calculation - insert area of woody shrubs for completeness				0.00%	0.00	^^ only works with clearfell age multiples of 5 ^^	
Total Area										**100.0%**	**88.66**		

Figure 43 Data input regarding species, spacing between trees, and 'yield class' (the number of trees grown in an area).

Assumptions - Soil Carbon Emissions - Table 3. Input the previous landuse, soil type and site prep type . Use one line for each soil type/ soil prep type combination

Previous Landuse	Soil Type	Disturbance/ Site Preparation	Area (ha)	% Soil Carbon Lost	Soil C Emissions (tCO2e/ha)	Soil C Emissions (tCO2e/area)
Pasture	Organomineral	Medium Distrubance: Shallow/rotary (<30cm) plough, Disc/line scarification/continuous mounding	88.66	10	-58.7	-5201.4
Please select	Please select	Please select	0.00	0	0.0	0.0
Please select	Please select	Please select	0.00	0	0.0	0.0
Please select	Please select	Please select	0.00	0	0.0	0.0
Please select	Please select	Please select	0.00	0	0.0	0.0
Please select	Please select	Please select	0.00	0	0.0	0.0
		Total	**88.66**			**-5201.4**

**** Check total area here is at least the net area planted above**

Figure 44 Soil carbon release estimations. Based on type of ground preparation before planting.

One carbon unit sold is one tonne of CO2e. When generating PIUs, the WCC spreadsheet subtracts 20% from its initial carbon calculations, which will not be translated into PIUs. These will gradually be paid back as the project is subsequently verified. A further 20% is taken away, which is kept permanently in the Scottish Forestry buffer account to safeguard against overcounting, miscalculation or uncertainty within carbon science.

An employee of the WCC provided me with a helpful example:

1. A project is predicted to sequester 1000 tonnes of CO2e over 100 years.
2. 20% will be removed temporarily to be conservative, leaving 800 units.
3. 20% of these will be permanently removed and stored in the Scottish Forestry buffer. Therefore 640 PIUs are assigned up-front.
4. If the trees grow as expected, the 200 units originally set aside will be gradually given back to the project when it is verified. Although 20% of these will be added to the Scottish Forestry buffer.
5. If everything grows as planned, 800 units will be given to the project, even if 1000 units were sequestered.

Summary Carbon Sequestration over time

Cumulative to Year	A:	B = 80% of A	C: Negative	D:	E= B+C+D:	F:	G:	H=E+F-G	I=15- 20% of H	J=H-I	K=J/Net Area
	Cumulative Carbon Sequestrn from lookup tables (tCO_2e)	Cumulative Carbon Sequestrn Less 20% model precision (tCO_2e)	Removal of vegtn and/or Establishment Emissions (tCO_2e)	Cumulative Soil Carbon (loss in year 1 and cumulative accumuln if relevant) (tCO_2e)	Total Project Carbon Sequestration (tCO_2e)	Baseline (tCO_2e) - Normally Zero - No change over time	Leakage (tCO_2e) [Emissions are negative] - Normally Zero - No change over tine	Net Project Carbon Sequestration adjusted for Baseline and Leakage (tCO_2e)	20% Contribution to buffer (tCO_2e)	Claimable Carbon Sequestration (tCO_2e)	*Average total claimable sequestration per hectare by year x (tCO_2e/ha)*
5	554	443	-253	-5201	-5011	0	0	-5011	-1002	-4009	*-45*
10	2119	1695	-253	-5201	-3759	0	0	-3759	-752	-3007	*-34*
15	6734	5387	-253	-5201	-68	0	0	-68	-14	-54	*-1*
20	12160	9728	-253	-5201	4273	0	0	4273	855	3418	*39*
25	14055	11244	-253	-5201	5789	0	0	5789	1158	4631	*52*
30	15673	12538	-253	-5201	7084	0	0	7084	1417	5667	*64*
35	16718	13374	-253	-5201	7919	0	0	7919	1584	6335	*71*
40	17540	14032	-253	-5201	8577	0	0	8577	1715	6862	*77*
45	18264	14611	-253	-5201	9157	0	0	9157	1831	7326	*83*
50	18964	15171	-253	-5201	9717	0	0	9717	1943	7774	*88*
55	19409	15528	-253	-5201	10073	0	0	10073	2015	8058	*91*
60	19745	15796	-253	-5201	10341	0	0	10341	2068	8273	*93*
65	20033	16027	-253	-5201	10572	0	0	10572	2114	8458	*95*
70	20241	16192	-253	-5201	10738	0	0	10738	2148	8590	*97*
75	20437	16350	-253	-5201	10895	0	0	10895	2179	8716	*98*
80	20608	16487	-253	-5201	11032	0	0	11032	2206	8826	*100*
85	20762	16610	-253	-5201	11155	0	0	11155	2231	8924	*101*
90	20909	16727	-253	-5201	11273	0	0	11273	2255	9018	*102*
95	21159	16927	-253	-5201	11472	0	0	11472	2294	9178	*104*
100	21249	16999	-253	-5201	11545	0	0	11545	2309	9236	*104*

Figure 45 Table which estimates the amount of net carbon sequestration over time (in Column E).

Note the 20% buffer subtracted from carbon estimations in column I. The overall claimable carbon sequestration from a project is in Column J.

After a project has been verified, the WCC issues Woodland Carbon Units (WCUs). Validated PIUs are translated into WCUs and are displayed on the UK Land Carbon Registry. Because only UK companies can purchase WCUs, they are rendered legitimate ‘negative emissions’ in the UK government’s national carbon accountancy. If, at the verification stage (i.e. years 5, 15, 25, etc.), there are changes to growth rate or health of the trees, carbon sequestration will be re-assessed using the WCC spreadsheet. Currently coarse-grained measurement technologies, such as rangefinders to measure the height of a tree and tape measures to measure its diameter at breast height (DBH), are standardly used in verification. As I explore in more detail in

Chapter Six, private companies are developing novel technologies for measuring forest carbon with increased accuracy compared to the standard verification mechanisms.

Year	Type of Credit	Carbon Calculation	Check Type	Usable in Offset Claims?	Purchasable
0	Pending Issuance Unit (PIU)	Estimation using the WCC spreadsheet	Validation	No	Yes
5	Woodland Carbon Unit (WCU)	Calculation using WCC Spreadsheet (and potentially advanced measurement technologies)	Verification	Yes	Yes
15, 25, 35, etc.	Woodland Carbon Unit (WCU)	Calculation using WCC Spreadsheet (and potentially advanced measurement technologies)	Verification	Yes	Yes

Figure 46 Differences between WCUs and PIUs.

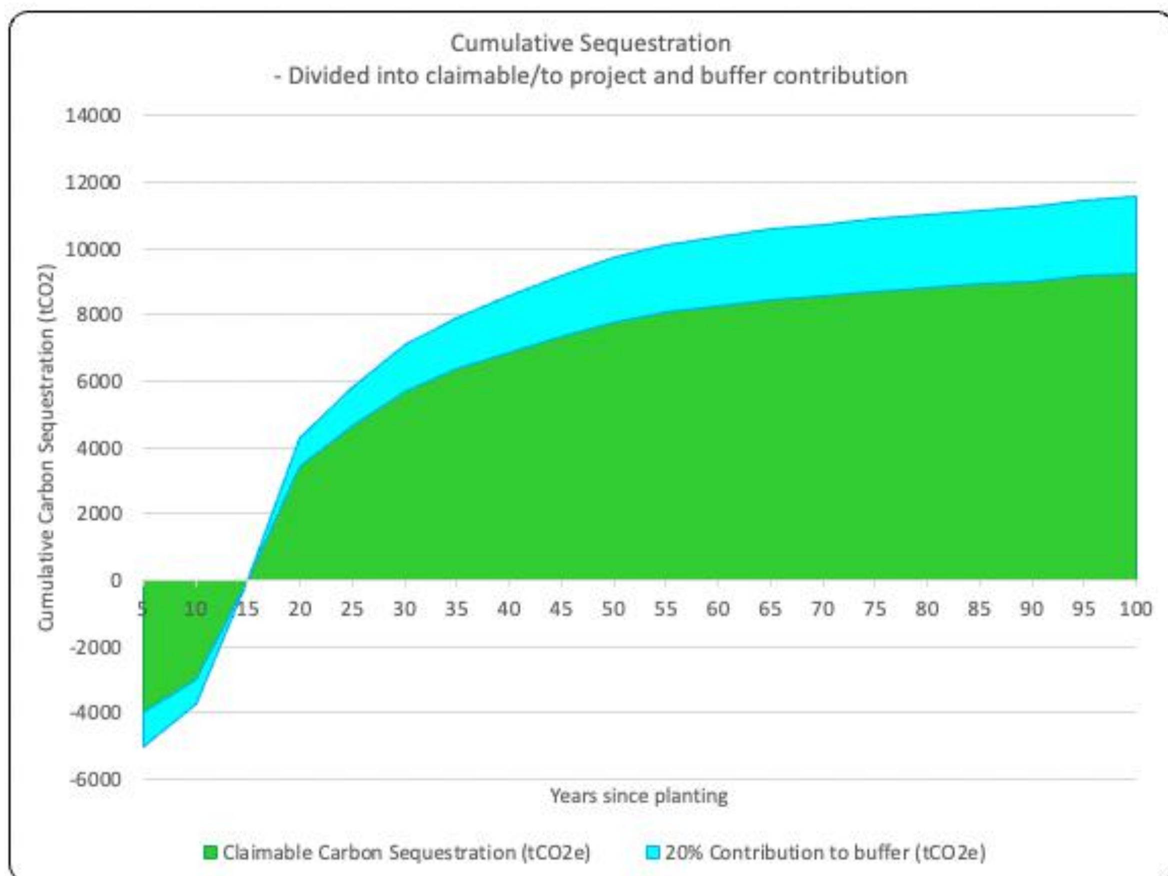


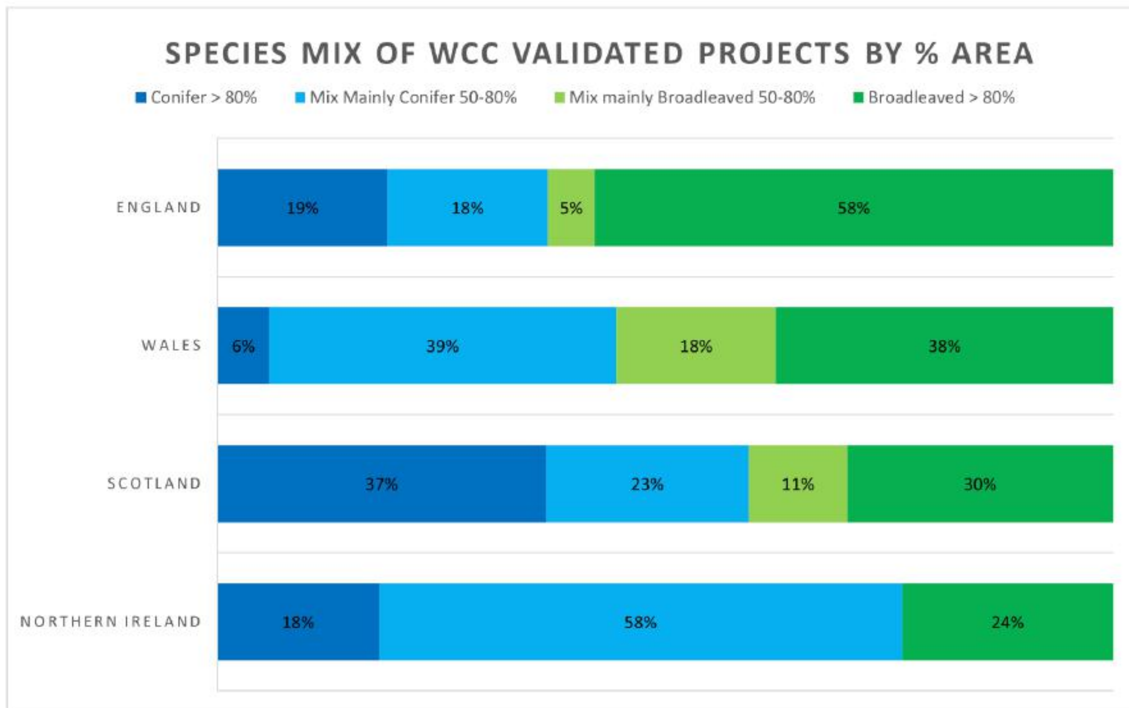
Figure 47 A visualisation of the cumulative carbon sequestered over time.

Net carbon sequestration is negative until year 15 due to carbon loss from soil, fencing, and other project preparation techniques. The rate of carbon sequestration evens out at roughly year 35 when the Sitka spruce will be clear-felled (cut down for timber).

As of 31 December 2023, there were 65,253 hectares[40] of Scottish woodland carbon projects registered on the UK Land Carbon Registry. According to the WCC's website(2023), these are expected to sequester 20,400,000 tonnes of CO2 equivalent (tCO2e) over the next 100 years, the large majority of which will eventually be available to purchase for companies looking to offset their emissions (20% will be kept in the buffer and will never be available to purchase) (Woodland Carbon Code, 2023). Of these, as Figure 49 shows, more than one-third of the forest area in Scotland accredited by the WCC is covered in more than 80% conifer species; these are almost certainly commercial forests that will be cut down and replaced. After the trees are cut down, to the surprise of many interviewees I spoke with, the carbon credits are still legitimate and can be sold. This is independent of the use case of the wood. Further restocks of the forest will not be able to receive credits.

[40] The majority of these (36,663 hectares) are designated as 'under development'. Slightly fewer (28,591 hectares) have been validated.

Species mix of validated and verified projects, by area and country



Note: In Scotland, conifers include native Scots Pine, frequently planted as part of native woodlands.

Figure 48 Species Mix of WCC Validated Projects by % area. Source: Woodland Carbon Code (2023, n.p.)

5.3. The WCC's Object Making Performativity

A relatively advanced technical understanding is required to talk about, let alone use, the WCC (McIntosh, 2023). The technical register in which the WCC is discussed meant that it was easy to assume, at least at the beginning of my fieldwork, that the WCC's mechanisms must have been the outcome of a coalition of scientific expertise. But as Mark Cooper (2015) notes in his articulation of the 'critical metrology' research project, measurement regimes for carbon sequestration are *always* the outcome of political contestation. As David Lansing (2012) highlights, there are just too many subjective decisions about where a forest starts and ends, and what counts as additionality (Gifford, 2020) to not have contestation about metric design or how to best measure forest carbon. Cooper stresses that acceptance of one metric for measuring carbon over another is always contingent on the social and material context into which it is embedded. As I highlighted in Chapter Two, the credibility of a metric is not solely dependent on an expert evaluation of its technical capacity to measure with more accuracy than any other metric available. Instead, a metric's credibility must be continually stabilised through what Cooper describes as the "establishment, fixity, and resilience of systems of measurement and commensuration" (2015, p.1787). It must maintain its legitimacy amidst challenges to its authority.

The UK carbon market, with its constituent rules, regulations, and the carbon units that are traded, is increasingly subject to scrutiny. Many interviews noted this point; as more forestry schemes are being verified than ever before, and carbon offsetting scams from other areas of the world are reported in the British media, the WCC's legitimacy is necessarily under the spotlight.[41] This section develops from the insights I outlined in Chapter Two, working from the assumption that the WCC's systems of forest carbon measurement and carbon accreditation are not solely or even necessarily undertaken in pursuit of the epistemic virtues of objectivity or absolute measurement accuracy. Instead, measurement is pursued in ways that uphold the identity of the WCC as a legitimate metric, and thus, in Lansing's (2012) terms, 'stabilise' the identity of the credits produced. This is achieved through two performances: measurement conservativism and metric integrity. Taken together, these perform the WCC's legitimacy.

Measurement Conservativism

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[41] For a more detailed review of carbon credit scams, see Valiergue & Ehrenstein (2022)

Aware of the reputational risk of selling WCUs for carbon that had not been materially sequestered, supporters and developers of the WCC have recognised that the WCC must calculate conservative estimates of carbon sequestration. Doing so guarantees against carbon over-estimations and mistakenly selling carbon credits which fail to materialise. If the WCC *does* produce excess carbon sequestration, beyond the number of credits sold, then all the better; highlighting the likelihood that more carbon is sequestered than sold provides extra legitimacy to the WCC.

As mentioned above, the WCC purposefully undercounts carbon. Several carbon brokers praised this approach. They were aware of the uncertainties inherent to calculating carbon and argued that the conservative measurements were a means of overcoming claims to perfect knowledge. For example, a carbon broker praised how the WCC mitigates against

> "that risk of slight uncertainty and the lack of measurability and any inaccuracies in the model and the models… [by deducting] I think it's 15% from its calculations for uncertainty. You then lose another 20% to a buffer, slightly to guard against the permanence of your carbon reduction."[42]

Another commercial forester, a former advisor to the WCC Board, was similarly honest about the impossibility of perfectly capturing the *real* amount of carbon stored within forest ecosystems. He argued that the WCC was trustworthy because it followed the logic of "we haven't got absolute knowledge, so we'll knock off 20% or 40%".

Rather than present the code as entirely accurate, a claim which would be subject to close scientific or technical critique, legitimacy is maintained through conservative undercounting. Carbon measurements are presented as scientifically informed, based on the state's finest available data (Forest Research's calculations). Flawed, but the best mechanism available. The WCC's measurement might be considered in Lansing's terms (2012) as a 'reflexive performance' as its users and developers negotiate the technical difficulties in ever fully and accurately measuring the carbon stored within a forest. It if cannot deliver perfect objective measurements, it should undercount.

[42] N.B. The WCC removes 20% not 15%, as described in Section Two.

Alongside undercounting, the WCC also employs a standardised approach to measuring carbon sequestration. When a project manager calculates the number of PIUs the project can generate, they must use fixed-data inputs (for inputs such as tree species, the spacing between the trees and the site's altitude) in the WCC's Carbon Calculator spreadsheet. This ensures that the same quantification and measurement processes apply universally to every project. This is an improvement on other forest carbon schemes, such as the US carbon forestry projects described by Gifford (2020), in which there is no standardised method of calculating forest carbon. Standardised measurement ensures that the WCC can avoid accusations of fraud, cronyism or data fudging, which, as Alice Valiergue & Véra Ehrenstein (2022) highlight, haunt carbon offsetting projects worldwide (for a full review, see also Carton et al., 2020).

Within this standardised measurement system, the WCC derives its calculations of carbon sequestration from well-established datasets about tree growth. These are largely based on research related to the standard practices of forestry, for which there is extensive data generated over decades. As Nick, a representative of the WCC put it, "the only data we have is, by definition, the standards of practice". If there is not extensive and relatively certain information available about a particular type of forestry, such as more novel or under-researched forms of forest creation such as natural regeneration or planting exotic species, the estimations of carbon sequestration are made extremely conservative to temper the likelihood of selling false credits. Carbon estimations have had to be overly cautious, as Nick explained,

> "Because we've had to have a standardised approach to it, we can't just say 'every single scheme we are going to go out individually and judge, based on how, with limited knowledge, what we think is going to happen.' We have to basically take the average and then make it very conservative. So we're almost erring under the lower side of things just to be cautious."

Nick explained that the WCC had needed to be "a bit more conservative in our figures" about carbon sequestration than other parties, such as commercial forestry companies, some of whom calculate the amount of carbon their projects sequester using their own methodologies. He explained that "We're just being very conservative in ours [the figures] because we're so aware that schemes do fail. Schemes aren't planted as thoroughly or beaten up as well as they should

have been."[43]

Standardised measurement and minimising measurement uncertainty are crucial epistemic commitments that maintain the WCC's legitimacy. They are attempts to guarantee that the WCC generates genuine and trustworthy credits.[44] This carefully curated metric design helps to, as Lansing describes, "constitute the forest as an object of economic exchange" (2012, p. 212). Conservativism brings together many elements of the object making performance I outlined in Chapter Two: the measurements are based on scientific expertise; the designers are aware of the inherent difficulties of accurately measuring carbon; epistemic trust is secured through a reflexive process of undercounting. Political impartiality and objective, data-driven insights are performed to stabilise the metric used to quantify carbon, the credits produced by the WCC, and the wider frame of exchange in which the credits are traded. Carbon measurement is shaped by the political atmosphere in which the WCC is embedded: conservativism allows the WCC to avoid political controversy.

Metric Integrity

The capacity to exclude some forestry projects from generating carbon credits is fundamental to maintaining the WCC's legitimacy. If all forests passed the additionality tests, clearly its exclusion criteria would be failing. Its performance of legitimacy would break down, and so would the credibility of the credits. As one forest carbon broker explained,

> "The credibility of the code [is] sacrosanct because without an absolutely robust unshakeable Woodland Carbon Code... our operation and the value of the carbon finance in supporting new woodland creation would be completely blown away."

Carbon brokers and representatives of the WCC stressed that maintaining the robustness of economic additionality was crucial for creating and maintaining the value of carbon credits. For example, Greg, a carbon broker, explained how,

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[43] "Beating up" is a forester's term to describe the process of replacing newly planted trees that have died, usually in the first year after planting.

[44] If a project is validated but fails its verification process – because the trees didn't grow as planned, or at all – the companies who have bought and sold the PIUs are left in a very awkward economic position. They might have taken money that may need to be returned.

> “The vast majority [of carbon buyers] have very keen interest in financial additionality being upheld and scrutinized and tested, despite the fact they acknowledge it's challenging. But they expect there are efforts made to try and ascertain whether a project is in need of that carbon funding to enable it to go ahead.”

As my fieldwork period progressed, the political climate within which the WCC was embedded shifted. Several carbon brokers explained that the market has changed rapidly in the last two years, since ‘planting fever’ had taken hold of the UK, especially in the run-up to COP26 in November 2021. The lucrative financial opportunities available from UK-based carbon forestry had become clearer. Acting in anticipation of a government-mandated net zero obligation for companies, or speculating on the growing carbon offset market, companies were looking to maximise the amount of carbon credits they could generate from their forestry projects. Increasingly, forestry companies were finding ways to accredit their commercial forestry projects, even if they were *clearly profitable* and should have therefore failed the economic additionality tests.

The financial profitability of a project needed to be performed through the WCC’s spreadsheet. If the spreadsheet could make a project appear financially unprofitable, it could generate carbon credits. As more companies used the WCC, its flaws were increasingly becoming evident. Chiefly, its Investment Test was not stringent enough. Large-scale commercial forestry organisations and investment firms, who increasingly have designated carbon departments who specialise in using the WCC, were exploiting loopholes in the WCC’s design. These companies were finding ways to pass dozens of large-scale commercial forestry projects through the WCC’s economic additionality calculator, even though these schemes clearly would be profitable without carbon finance. Several foresters and carbon brokers articulated how growing commercial timber was incredibly profitable in the early 2020s independently of carbon finance. As Snowden described in an online interview published in 2022, “the commercial timber market is performing strongly. Timber prices have risen substantially in recent years, and industry observers are pointing to a buoyant future” (Scottish Forestry, 2022, n.p.). These projects clearly *should be* failing the Investment Test – but due to the test’s design, were not.

Julie, a commercial forester, explained that many Sitka spruce-dominated commercial plantations[45] were passing the Investment Test, even though they "should struggle to get through the WCC because they aren't [economically] additional". She explained how a commercial forestry organisation could input massively variable prices into the WCC Cashflow Spreadsheet, making the cost of the project appear high. She gave me an example,

> "When I was working at [a large commercial forestry company], they were putting through a Sitka plantation into the WCC... and the landowner would just say, 'what do you want the [input] figures to say?' They'll come up with a budget for the 'alternative land use' that will just make it work. And it's only checked once! And the evidence you need to provide is minimal. So unless they check the evidence at that first point, you are validated and *you can make as much money as you want*!"

Julie stressed that calculating the financial costs of 'alternative land use' was beyond the knowledge of a commercial forester. Given the contingency and uncertainty of different land uses and market changes over the next 100 years, *nobody* could calculate this with any degree of accuracy. Julie explained how she was forced to input data about the potential income from sheep farming, an alternative land use, for a 50-year time horizon – something she knew nothing about. She had to "trust the figures" that a landowner would give her, even though she knew they might change the figures to "make farming look a lot worse than it actually is". The worse the 'alternative land use' appeared, the lower the 'baseline' against which additionality could be compared, and therefore the easier it was to prove that the new planting scheme *required* carbon finance to make it profitable.

Julie told me how landowners "will just make it work" or "fudge" their numbers to pass their project through the economic additionality calculator. Examples of data-fudging and gaming the system were commonplace during my fieldwork period (which, as I explained in Chapter Four, largely took place prior to October 2022). For example, another forester explained that when his project needed to prove it required carbon finance to be economically additional, he just added in the construction of a tarmac road to his pricing calculations which drastically increased the apparent up-front cost of the project. (I'm still not sure whether this was a

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[45] Which are notoriously profitable, especially given the generosity of financial support available for planting trees in Scotland.

provocative white lie. I took it at face value, assuming that it was at least half-true, and represented a wider dynamic in which the calculator was subject to manipulation.) Other foresters told me stories of inputting the price of a land purchase into the WCC cashflow, which ensured the project appeared unprofitable within the WCC's spreadsheet. In this way, owning land could be framed as a sunk cost rather than an asset increasing in value (a problematic narrative which, as historian Andy Wightman (2010) points out, has a long history in the Highlands).

The Excel spreadsheet served as a helpful prop that could generate legitimate and 'trustworthy' (Porter, 2021) numbers, which helped to perform financial additionality. These stabilised some commercial foresters' claims about requiring carbon finance for their new forestry schemes. Aware of the metric's stipulations, they used its design to their advantage. The metric, designed by experts and backed by the state, could bring seemingly objective impartiality to their claims.

Aware of the loopholes within the WCC, the mangers of the WCC tightened the economic additionality criteria in October 2022. Snowden describes the motivation behind this shift:

> "I don't think it has escaped anyone that woodland carbon credit schemes have significantly increased over the past few years. In Scotland we have seen over 500 new projects register for the WCC in the last two years, which is a fourfold increase.
>
> "During this time we've seen growing interest from a wider range of forestry projects. We welcome this interest and want to grasp the opportunities that such projects bring, including in commercial forestry, but have found that in some cases projects are testing the limits of how eligibility rules for the WCC currently operate. It was clear that we needed to review the rules of the Code so that it remains credible in the carbon market." (Scottish Forestry, 2022, n.p.)

Snowden describes the three changes that the WCC introduced in October 2022:

> "Firstly we've simplified the current system of tests to make it easier for projects and validators to use them. Secondly, we've standardised the tests so that they are applied more consistently.

> "Thirdly, and very importantly, we've made changes so that high up-front land values don't skew the calculations associated with the additionality test. We've replaced the purchase price of the land with published data on income foregone as a measure of the value of land. Our analysis shows that this results in more sensible and credible outcomes from applying the test." (Scottish Forestry, 2022, n.p.)

Nick, the representative of the WCC, explained that the WCC understood the "financial additionality test wasn't robust enough" so criteria were tightened "to increase the credibility of the carbon". He explained that,

> "Fundamentally the credibility of the code was at risk. And there are task forces out there that are looking at the integrity of these different codes internationally. And they're doing thorough reviews of every aspect of your permanence, your measurability, your verification process, your governance, your additionality. And so, if it can be proved that your additionality isn't up to scratch, then your code will become worthless. Your carbon units will become worthless. So we were forced into a very difficult position in a way by that. Not that we wouldn't want to be maintaining credibility, but that is the driving force behind it."

Nick stressed that the WCC was aware of land managers gaming the system, although that was not the main reason why the economic additionality criteria were tightened. "It's not about a lack of trust in people not putting in what we think is legitimate," he explained. "It's about a lack of predictability." Too many of the inputs of the WCC spreadsheet needed to be filled in by a project manager, several of which were impossible to predict. After all, as Nick put it, "How can someone say how much a road is going to cost in a hundred years' time? How much timber they're going to be making in 40 years' time?" The outcome of this input flexibility was that, "We [the WCC] found people with orders of magnitude different values for these different things, which made it impossibly hard for us to assess, and needless to say [for] the validators to assess". It was difficult to assess the extremely variable claims different organisations made about the costs of projects. Projects were not being measured in a standardised manner. The epistemic commitment to standardised measurement was being destabilised by the technical functionality of the WCC's own spreadsheet.

New fixed-input standardised costs and income columns were introduced. Instead of a forester inputting what they expected different elements of a project to cost, such as the cost of fencing, these became automatically inputted into the spreadsheet depending on the project's species mix, location, and size. As Greg, the carbon broker explained, after the economic additionality update, "in essence, there is far less opportunity to game your project and its budget and the incomes… there's going to be a pre-set cost and incomes hardwired into the additionality calculator". Inflated land prices, which forestry companies were happy to pay because the increased cost would be used in their economic additionality figures could no longer be inputted. The spreadsheet became more standardised and the types of forest which could be proven to need additional financial input from carbon credits diminished.

Nick was honest about the WCC's limitations, accepting that "with additionality internationally, there are always going to be false positives. There are always going to be false negatives". But the long and arduous task of updating the code, which involved consultations with industry representatives for over 18 months, stakeholder group meetings and two independent reports, was undertaken to mitigate and minimise the likelihood of false positives and false negatives. He was open about maintaining additionality being "fiendishly difficult [because] you're trying to prove a counter [factual]… we're trying to prove it's something that doesn't exist". The metric's screening of projects and measurement calculations could never be perfect, because of the continually changing political-economic climate and the sheer number of inputs necessary to calculate carbon sequestration and assess financial additionality.

With the fixed data inputs integrated into the WCC's spreadsheets, projects that clearly *should* have failed the Investment Test would now fail. Nick gave the example of a forest composed of "83% net planted Sitka spruce ... on good land and full grant support". This was clearly already a profit-turning project: it was growing commercial timber (Sitka spruce), on good land (the trees would grow well, and the harvesting would not be too strenuous) and already received grant support (the forest's establishment would be funded by Scottish Forestry, the state forestry department).[46] Tightening the economic additionality criteria was done to exclude projects such as this, and consequently, "to maintain the credibility for those that need it, to

[46] Scottish Forestry's Forestry Grant Scheme would likely cover the initial cost of planting trees, an annual maintenance payment for up to five years, and a capital grant for establishing deer fencing or tree protection.

maintain the money for those that need it". Clearly, projects like should not have passed the Investment Test. But the Excel spreadsheet, in its formulation prior to October 2022, could not *prove* that they were financially profitable using the WCC's apparently depoliticised technical apparatus. The variable input mechanisms on the spreadsheet created a performance of non-profitability, even though a project clearly *would* be profitable.

Nick explained that the changes to the additionality criteria meant that the WCC could "quite comfortably" reject "a decent proportion of projects because they aren't showing true additionality". Nick stressed that the WCC would need continual future updates, and to be tinkered with:

> "We knew it was going to be contentious… we've updated rules to reflect the current market and we're going to continue to have to do so. As the carbon environment continues to change, we have to make sure we're constantly up to date with that."

George Cusworth and his colleagues (2022) describe how the choice of metric used for quantifying carbon is subjected to incredible scrutiny within the farming sector. Different organisations lobby for different modes of measurement, aware that the choice of metric will affect whether their actions will be profitable. Closely analysing the WCC reveals how this 'reflexive performativity' operates at multiple scales. Prior to the economic additionality criteria being updated, commercial foresters were reflexive about the ways they inputted data, aware that the WCC's technological apparatus could help create a convincing performance that their actions were unprofitable. Metric designers, too, such as those working for the WCC, were reflexive about the limitations of their own metric design and could see its performative outcomes.

Performing Legitimacy

The contestation around the WCC's design highlights the complex ways that UK forests are translated into carbon credits. Opening up the black box of the WCC shows how the legitimacy – of its codes of conduct, systems of measurement, and the carbon credits it generates – are sites of political contestation. As Cooper (2015) reminds us, metrological legitimacy is not pre-given but is constantly being (re)performed in a dynamic political atmosphere. Focusing on metric design brings nuance to Lansing's argument, that performances are required to generate a legitimate carbon credit. In Lansing's example, the establishment of maps, brochures, fences,

and a range of other material and discursive infrastructures are required to convince carbon credit purchasers that carbon credits produced in a forestry project are legitimate: science-backed, expertly measured, and ultimately not a scam. They perform carbon's *materiality*, maintaining the identity of forests-as-carbon-sinks, creating carbon credits that offsetters would trust.

The object making performances creating UK-based woodland carbon credits are more complex. They are not so much concerned with proving the forest materially exists (the verification process does this, and we will hear more about this in the following chapter); they are more concerned with bringing expert legitimacy to claims of economic additionality, which is far harder to prove. Additionality is a word with multiple meanings in carbon forestry (Coffield et al., 2022). It often refers to the net increase of carbon sequestered in a landscape compared to a business-as-usual scenario. This 'additional' carbon storage - the gulf between a baseline and a future measurement - is translated into carbon units. Gifford describes additionality as "the crux of the offset" (2020, p.302) and shows how its calculation is shaped by significant power relations in forest carbon accreditation. Additionality claims become legitimate when they are made by experts, an identity that Gifford highlights is hard-fought rather than inherent. In the case of the WCC, when calculating carbon additionality, one maxim rings true: if in doubt, undercount. When the realist epistemology required for the carbon market is under threat – that it is possible to know how much carbon is stored in forests so we are certain the credits are 'real' – then be conservative.

Economic additionality is even harder to measure to carbon additionality. Future markets are impossible to predict or measure with absolute accuracy. STS scholars have highlighted how future calculations of markets or emissions are always a step into the unknown, necessarily based on speculations about uncertain future costs and market trends (Brice et al., 2020; Carton, 2019; Palmer & Carton, 2021). As this analysis makes clear, the choice of how to calculate economic additionality is highly contingent. If the material-technological elements that underpin the calculation start failing, they need updating. In the WCC's case, the Excel spreadsheet's capacity to exclude certain types of clearly already-profitable forestry projects from being attributed carbon credits needed to be reworked. The WCC's legitimacy as a sophisticated and depoliticised metric, trustworthy and credible, had started to break down.

Robertson and his colleagues Rebecca Lave and Martin Doyle highlight how the seemingly depoliticised technical artefacts used in environmental measurement, which "define natural processes as objects with value" (2023a, p. 1) are performative tools that are central to the object making performance which creates natural capital credits. A close examination of the WCC spreadsheets, and the seemingly technical (and apparently depoliticised) question of whether its columns should have variable or standardised data inputs, reveal how apparently small parts of a metrological apparatus stabilise the entire legitimacy of an industry (in this case, the forest carbon industry). Given their incredible power in assembling worlds, input columns became sites of political contestation. Many interviewees from within the forestry sector, including foresters and carbon brokers, told me they *knew* many commercial forestry projects generating carbon units were financially profitable without carbon finance. Updated technical artefacts, in this case updated spreadsheet columns, were necessary for presenting claims in the 'objective' sounding register required for them to be considered legitimate.

Unsurprisingly, following the updates to the spreadsheet, commercial foresters began lobbying against changes to how economic additionality should be calculated. As one carbon broker described,

> "[Commercial forestry organisations] were making a frightful fuss about how if carbon funding doesn't apply to these big, new Sitka plantations, no one will ever plant Sitka again and we will all run out of timber, which was hysterical nonsense… the economics are all pointing towards, you know, planting good Sitka plantations, where you can."

These foresters were (at face value) concerned that a shift in the WCC's mechanisms would affect which natures would be rendered financially valuable. They were, provocatively, arguing that the shift in measurement regime would curtail the financial viability of commercial timber production. Implicitly, this hints towards the ways that metrological design, fundamental in the object making performance, has a corresponding environment making performative effect. I trace these effects in the following section.

5.4. The WCC's Environment Making Performativity

Several interviewees from across the land sector identified themselves as pragmatists or realists. They were reflexive about the WCC's measurement system being epistemically flawed but argued that it was necessary for incentivising nature restoration. Effectively, its value lay in its environment making capacity to performatively generate more ecologically diverse forms of woodland, rather than in its accuracy. For example, Ben, a carbon broker with a "passion for native woodlands" was open about the limitations of the WCC's measurement regime, telling me that "if you look too closely under the bonnet [of the WCC], then the whole thing will fall apart". But he was,

> "…happy for it to work, even if it isn't the most 100% robust and rigorous and reliable thing, because we are in a climate emergency and we need to be channelling as much investment into nature-based solutions [and] ecosystem recovery that we can. And carbon is one of the ways we can do that".

His argument was based on a common discourse I heard in Scotland, that given the dire state of nature and the clear financial incentives to plant non-native conifer species in the current market, Scotland *requires* carbon finance to realise native woodland creation. Only through introducing a functioning woodland carbon market could a more diversified type of reforestation be introduced. But as I outlined in Chapter Two, the specificities of metric design can have powerful, and sometimes unexpected or perverse, effects on the types of natures which are rendered valuable. This begs the question, which natures and which woodlands were being performatively enacted by the WCC's metric design?

More native broadleaves

Carbon brokers speculated that the updated economic additionality criteria will affect which trees are planted for carbon credits. Echoing other interviewees, one carbon broker speculated that "the effect of [the updated economic additionality criteria] will be fairly radical in terms of shifting the focus towards more native broadleaf planting". Native broadleaves planted in native woodland creation schemes will not be sold as timber in the future, and thus, it's easy to show why they require carbon finance to be financially lucrative; they don't have another income stream. They can easily pass the Investment Test. Another broker speculated that,

> “Clearly attention is going to be more focused towards native broadleaf planting... Basically it means I think that pretty well all new native woods will pass the [economic] additionality rules, but quite a lot of the productive Spruce woods – depending on the previous land use – will not pass the additionality test.”

This speculation echoed the official line shared by the WCC. Snowden described the outcomes the WCC expected to see:

> “We estimate that schemes that are the most financially viable through conventional funding – for example from timber – may not pass the tests in the future if they intend to retain full grant support. This will of course depend on the site, given that financial returns to forestry vary in different locations.” (Scottish Forestry, 2022, n.p.)

To access the carbon market, some commercial foresters would have to decrease the amount of government grant support they would receive, making their productive forestry projects require carbon finance to be financially viable.

Many interviewees anticipated that the updated Investment Test would encourage more native woodlands to be created, especially as the price of carbon credits generated from native woodlands would be relatively higher than those generated from commercial plantations (a theme I return to at length in Chapter Seven). The forest we came across in the Prelude, managed by a wealthy landowner, is a characteristic example. Instead of choosing to generate profit through growing timber, landowners might choose to generate revenue through producing carbon credits in native woodlands. For many interviewees, this is the step-change long needed in the Scottish land sector. For too long, many argued, commercial productive forestry has held a unique financial position. Landowners have been offered a seemingly binary choice: grow commercial productive timber and generate profit or rely on grant support and hope it will cover the cost of creating native woodland.

The WCC, especially after its economic additionality criteria have been strengthened which deny Sitka dominated commercial projects from receiving carbon finance, offers a fundamentally new intervention into this binary. Does a landowner stick with commercial species and timber, or gamble on native species and carbon? The futures, here, are very uncertain. Native woodland warrants a ‘charismatic’ premium for the credits it generates. But

the premiums that they charge are hugely variable and are likely to change drastically over the coming forty years. There's no fixed price that carbon credits might receive in the future.

Instead of accepting this binary choice, some commercial foresters told me that they tinkered with the species mix of their commercial forest to pass the Investment Test, by increasing the percentage of native broadleaves. For example, the manager of one of the largest commercial forestry plantations planted in the UK in the last 30 years told me that he would be "taking a punt" by planting a large percentage of native broadleaf trees alongside Sitka spruce. This decision was also based on the assumption that carbon sequestered in native broadleaf trees will be worth more per unit than carbon sequestered in non-native conifer species, because of the 'nature restoration' story that can be sold alongside it. (We will return to this theme in more length in Chapter Seven.) Another forester told me he accessed carbon finance for a new commercial plantation by decreasing his Sitka spruce percentage from 70% to 60%. The other species he replaced with other commercial non-native species such as Douglas Fir and Norway spruce, and some native broadleaves.

Diversifying commercial forestry is widely encouraged by some people within the forestry sector, who argue that its narrow focus on growing non-native conifer, especially Sitka spruce, makes the industry susceptible to disease and contributes to biodiversity loss. Yet the ecological credentials of scaling up the percentage of native broadleaves planted was not necessarily lauded by ecologists and rewilders I spoke with. Several were particularly sceptical of native trees being planted on the fringes of Sitka-dominated commercial conifer plantations, which could make a commercial block look 'natural' from the outside (and economically unviable, in the technical judgement of the WCC). For several interviewees I spoke with, this diversification process was the most explicit form of greenwash by commercial foresters.[47] It allowed commercial foresters to receive carbon finance and charge a premium for growing carbon through planting native broadleaf trees. They could frame their slightly diversified commercial forestry practice as a form of nature restoration.

Streamlined ecologies

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[47] Moreover, as one commercial forester explained, although these native trees are framed as good for biodiversity and nature restoration, they are sometimes felled when the Sitka spruce is cut-down for timber. With it, the 'broadleaf habitat' that was framed as beneficial for biodiversity is destroyed.

For most rewilders I interviewed, carbon finance could be seen a double-edged sword. Although carbon finance might drastically increase the amount of finance pouring into nature restoration, the ecological structure of the native woodlands materialised, many interviewees suggested, would be powerfully shaped by the WCC's metric design. Many flagged how the WCC's commitment to measurement conservativism has powerful environment making effects.

In James Scott's (2022) seminal terms, the state requires its natures, and the flora within them, to be 'legible'. For crops such as grain, legibility demands they grow in easy to measure patterns above ground, making them assessable before harvest and subsequently organisable in accountancy books. The same is true for carbon, the resource extracted within carbon forestry schemes, even within projects labelled 'nature restoration'. The product, bought and sold on the market, must be legible, and the specificities of metric design determine what is and is not legible. As Robertson (2006) describes, natures growing in standardised ways can be more easily translated into natural capital credits, constituting a 'nature that capital can see'. For Mark, the CEO of a rewilding NGOs, the generation of woodland carbon was increasingly being shaped by the demand for carbon credits, and hence, the pursuit of natures legible to the WCC's measurement system. He argued that the WCC's dynamics ensured that even in native woodland creation schemes, "you end up with single species, single age, straight line tree planting" rather than other, diverse, and potentially underfunded and endangered forest types. Organisations labelling their projects 'nature restoration' or 'rewilding' were scaling up the creation of legible carbon, grown in uniform, measurable plantations, a practice which many rewilding ecologists I interviewed riled against. (In Chapter Eight, I describe an alternative form of forest creation which prioritises the restoration of remnant pockets of ancient woodland; for several ecologists I interviewed, focusing efforts on restoring these areas should be the central concern for nature restoration.)

Speculating on the future of 'natural carbon removal', political economist Nils Markusson anticipates that "it is much harder and more work is involved in assessing the removal effect of a heterogeneous, biologically diverse site that has been allowed to re-wild, than of a homogenous, engineered tree plantation" (Markusson, 2022, p. 3). Closely analysing the WCC brings empirical evidence to Markusson's hypothesis. Several carbon brokers explained that organised and uniform plantations are the easiest forest type to measure and provide relatively certain growth patterns, so they are prioritised by foresters creating native woodlands. They

offer investors a lower risk investment than other forms of forest creation such as natural regeneration, in which trees grow independently of human planting.

Greg, a carbon broker, explained that the WCC does favour “the uniformity of planting”. He explained that,

> “[the WCC] definitely does favour standardized 1100, 1600 to 2500 stems per hectare[48] planting over [natural] regen[eration] projects. There's clearly going to be different periods of uncertainty as to what density of stems are going to emerge on that site as a consequence of putting a fence around it or heavily reducing the deer.”

The amount of carbon expected to be sequestered is more easily calculated in forests grown in linear rows. Greg explained that the WCC’s measurement conservativism led towards “a uniformity of planting [because of] the relative ease that provides, [for] up front baselining and forecasting of future sequestration”. The standardised input columns, necessary for maintaining the code’s legitimacy, meant that standardised planting created the most lucrative forms of forest for the carbon market. This is a contemporary manifestation of a well-established trend in forestry. As I described in Chapter Two, historian James Scott (1998) has traced how industrial plantations have been produced in linear organisational forms that reflect the accountancy mechanisms which value and organise them. Similarly, in the Highlands, native woodlands reflect the organisational procedures of the WCC’s spreadsheets.

When forests naturally regenerate there is large unpredictability and variability in growth rate, spacing between trees and the expected carbon sequestered. And this is difficult to integrate with the WCC with any standardised measurement. It is very difficult to quantify the ‘additional’ carbon sequestered in messy ecosystems, especially when an Excel spreadsheet – and its columns – quantify carbon sequestration. The streamlined columns demand, and produce, streamlined natures.

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[48] “Stems per hectare” refers to the predefined number of trees (stems) planted in a given area (per hectare).

Figure 49 Natural regeneration in Glen Nevis.

Given its unpredictable growth patterns, reforestation projects such as this prove difficult to accredit with the WCC.

Given the difficulty of creating standardised input columns for the WCC's Carbon Calculation spreadsheet, Nick, the WCC representative, explained that the quantity of carbon credits estimated from natural regeneration must be extremely low, to reduce the risk of selling unsubstantiated carbon credits. He explained,

> "The WCC does allow for it [natural regeneration], but due to the high level of uncertainty as to what the future sequestration is going to look like, clearly, it evidently reduces the opportunity for those projects to maybe forward sell PIUs to generate income stream, because it presents a high degree, high degree of risk for those corporates who may be looking to invest in the project early on. Most naturally regenerating schemes that we [the WCC] deal with don't want any PIUs. They don't want upfront, 'risky' in their mind and our minds… they don't want to expose themselves to that risk."

The pursuit of conservativism, so necessary for maintaining the legitimacy of the carbon credits generated, has an environment making effect in determining which types of forest be accredited. Human-controlled tree planting that follows standard forestry practices (linear, planted at the same time), which facilitates more 'certain' growth patterns, is more easily rendered legible through the WCC. Although natural regeneration *can* be integrated into the WCC, the estimations have to be very conservative, given its difficulty to measure.

Ecologists and rewilders told me that they were forced to change their practices to receive carbon income. Mark, the CEO, argued that the obligation to follow the rigid constraints of the WCC has narrowed how he can generate income. He explained how,

> "The system doesn't allow for any wiggle room. It doesn't allow for any interpretation of the system. The system is rigid, and so arguably when you follow the Woodland Carbon Code, you lose out on the ability to optimise ecological gain, whether that's by allowing areas to naturally regenerate or put a value on wetland margins, all of these almost indefinable habitats. How do you put a figure on all of those? Where do you draw the lines?"

He suggested that,

> "[natural] regeneration is an excellent example. You know it's biologically, ecologically speaking, the most the most productive way of going about producing native woodland, but there's very, very little subsidy in the system to reward landowners for doing it… if you focus on carbon, inevitably there's a compromise in ecological gain."

Other ecologists widely told me that they were subtly forced to prioritise tree planting ahead of other forms of forest creation. This was despite "[natural] regeneration [being] the… holy grail, the preferred way of achieving those [ecological outcomes]" as Alex, the senior executive of a rewilding charity put it. For example, on a nature restoration project in the Western Highlands, the charity's ecologists recommended that attention should be directed towards conserving and regenerating the already existent ecological communities on the estate. By culling deer and erecting fencing, endemic communities could expand out. But, As Alex recalled, "[the landowner was] just not up for the risk that comes with regen, or he wants more guaranteed return… so he starts to give us the signals he wants to plant." So, the organisation

was “left with a choice between, well, do we want to be part of that, to facilitate that” or to move on. They had been pushed into facilitating native tree planting, to guarantee financial returns.

The legible carbon in Highland nature restoration schemes is produced through lower altitude, fast-growing mixed broadleaf woodlands, rather than habitats such as wetland margins, high-altitude scrub, swampland, or slow growing trees on peatbogs. Carbon-rich and fast-growing native species such as silver birch can receive a relatively high number of carbon credits per stem compared to other tree species or habitat types. Montane scrub species such as dwarf birch or woolly willow grow slowly and therefore their carbon benefits are negligible. Although these fringe ecosystems are important habitats on the brink of extinction, they fall from view within carbon-centric mode of framing woodland creation. Carbon, as political economist Donald Mackenzie (2009) highlights, is necessarily an abstraction which reduces complexity, making a system easier to govern. A focus on maximising carbon ensures a blindness to other ecological considerations.

In sum, across Scotland, ecological and economical concerns pull woodland creation in different directions. As Jamie Lorimer and Clemens Driessen (2014) highlight, the indeterminacy, uncertainty, and surprise of ecological dynamics is a celebrated facet in rewilding ecology – yet it sits contra to the WCC’s conservative rigidity and the need for standardised measurement techniques. As nature restoration is increasingly financed through the woodland carbon market, the practices of restoration are correspondingly altered to lower the exposures to risk that capital demands. Markets require streamlined temporalities; investors want predictable returns; and forests are enacted in ways that fit these demands. Stakeholders across the carbon and land sectors want highly robust, legitimate metrics; but many ecological dynamics are unpredictable, far exceeding the metrological streamlining necessary when relying on Excel spreadsheets to create value for nature. These natures fail to materialise.

5.5. Conclusion

The WCC is contentious. Its systems of measurement, its tests and regulations, and its performative effects on how nature restoration occurs are subject to dispute. Some foresters praise the WCC for its capacity to finance native woodland creation; others rile against the WCC’s knock-on effects on timber production. Some ecologists praise the new financial

opportunities available through the carbon market; others are frustrated that the narrow concern for carbon is obscuring consideration of other ecological processes and relations. The highly politicised engagement with the object making performances constituting a metric (conservativism and integrity) and the environment making performances emerging from a metric (more native trees; streamlined ecologies) provide a characteristic example of what Cusworth and colleagues identify as 'reflexive performativity' (2022). The seemingly arcane details of technical design, such the standardisation process for carbon quantification and the measurement of financial additionality, are highly contested sites. They are lobbied against by conservation and commercial interests, with actors well aware that the ways their worlds are measured will affect the worlds they operate within.

But despite the shared understanding that the WCC has powerful environment making effects on which forests are made valuable, and thus materialise, the WCC must maintain its identity as a politically neutral technical artefact. Appearing partisan, by seemingly taking sides between an implicit nature restoration / commercial forestry binary, would undermine the carefully curated performance of legitimacy, in which carbon finance is displayed as the rationalistic, science-led, politically independent form of governance necessary for scaling up reforestation efforts for climate and nature.

For example, Nick argued that even though he knew the WCC *would* inevitably have strong impacts on forest creation, the WCC management was ultimately "ambivalent" about the types of woodlands that were being planted: "you can plant what you like... it's completely up to you as long as you match and meet with the UK F[orestry] S[tandard]". He argued that "it's kind of outside our [the WCC's] remit" to determine which woodland should be planted. Rather, "it's important for us to base [the WCC] purely on the science. This is how much carbon is sequestered. We're basing on that. This is how much money you are making. We're basing it on that." Updating the economic additionality criteria was therefore, according to Nick, "not necessarily [about] pitting mixed broadleaves versus conifers" – it wasn't about excluding Sitka purposefully – but was about financing "any woodland that has some barrier to prevent it going ahead financially," which includes "big scale, mixed, broadleaf planting".

From closely analysing the internal mechanisms animating the WCC, we can learn more about how environmental performativity operates. There are many different performances necessary to convincingly showcase conservativism and integrity. Their constituent discourses require

appeals to scientific and extra-scientific narratives to stabilise claims of, for example, metric legitimacy in a contested political atmosphere. And as we see in the case of the WCC, these discourses have very real, although perhaps surprising, ecological and material consequences. Clearly, this example is revealing for understanding how object making and environment making performativity are interlinked. Object making performances that stabilise identities of metrics and the nature objects they help to generate (such as carbon credits) have environment making effects themselves. These material changes in the world can destabilise the very same identities from which the outcomes emerge. And new object making performances are correspondingly needed to maintain legitimacy. Different performances and performative outcomes feedback and shape one another in a dialectical process. This is fundamental to how 'environmental performativity' operates.

For example, when I asked Nick about the problematic material consequences of the WCC ("who would plant slow growing] scrubby willow when you could plant [faster growing] birch or oak?"), he told me that he "would never endorse people focusing purely on carbon" when creating a woodland. People should focus on the "other benefits," so that "people don't think, well, yeah, okay I'll plant broadleaves but I'll just plant birch because it's really fast growing. I'm not going to bother with the slower growing cause they don't give me the carbon returns I need." A landowner should "use carbon as the skeleton of that natural capital" but focus on other benefits too. He outlined an imagined future world, in which other forms of natural capital are also measured and translated into the price of the carbon credits:

> "Your carbon credits for that [slow growing] scrubby willow will be significantly more valuable than the birch, than the Sitka, because you've got far more environmental benefits in that location. So, we score them more highly on biodiversity or a local societal benefit, or flood mitigation score. Companies will pay more for that."

The underlying speculation: new metrics and new markets will have a beneficial effect in bringing about a well-balanced constellation of nature restoration, addressing the limitations of the WCC that emerge from its inherent reductionism. As I argue in more detail in Chapter Seven, a metric that can translate low-carbon ecosystems and habitat types into financially valuable natural capital credits appears epistemically impossible. Nevertheless, its performative value lies in its promise; natural capital markets, which necessarily reduce complexity to create natural capital commodities, need only be improved sufficiently to temper

the perverse effects of nature's financialisaton. The performance which legitimises this narrative follows a well-established script: *when we can internalise all the externalities, the market will prevail.* The problem is not the marketisation of nature and the apparent impasse of ever creating sophisticated enough metrics and markets that account for every valuable element of an ecosystem; rather, the failure lies in the technical capacity to design metrics and markets with enough complexity to bring about ecologically flourishing consequences. In a classic society making performance, the dominant natural capital ontology continues to be framed as the only available 'rational' mechanism for realising ecologically diverse nature restoration. The currently flawed metrics and markets need only be improved. Better markets, better metrics, better natures. It seems evident that this discourse obscures the fundamental contradiction lying at the heart natural capital markets: that ecological complexity cannot be easily measured nor financialised; and that ecological restoration will be streamlined in ways that reflect the ways it is measured. I return to this theme over the following three chapters, as I consider how different organisations, situated across a political and economic spectrum, attempt to use measurement to create alternative forest futures.

Ultimately, the WCC requires standardisation; the state requires legibility; the market requires certainty. But as this chapter has made clear, standardisation, legibility and certainty are antithetical to the complexity that is normatively pursued in ecologically diverse nature restoration. The insights developed in this chapter therefore offer an important critique to the market-based mechanisms framed as necessary for scaling up nature restoration in Scotland. Carbon money not only finances nature restoration, but fundamentally affects how it takes place and shapes which natures materialise. As I outlined in Chapters One and Two, reforestation and nature restoration are enacted in multiple ways by their constituent practices (Mol, 2002). The resulting ecologies are the contingent outcome of a web of epistemic commitments, political contestations, and technical artefacts. A shift in measurement practices can alter which natures become financially valuable. Apparently small technical shifts, such as the tinkering of an Excel spreadsheet, can have significant effects on determining which parts of nature can become value-bearing carbon credits. Highlighting the contingency of measurement systems – regarding how they were created, maintain legitimacy, and shape which natures materialise – also brings a sliver of political opportunity. An alternative metrological regime, and an alternative financialisaton process, might bring new opportunities. Developing this insight, that measurement can be *done otherwise,* the following chapter examines how private companies are using advanced measurement technologies to quantify

forest carbon in novel ways.

Interlude: Banking Carbon

I'm lost. Google Maps has sent me down the wrong entrance to the estate and now I'm off-roading on a dusty track. I pass a little crofting cottage and some faces smile at me, waving me onwards. Eventually, I park up in a farmyard. In a beyond-twee snapshot of rural life, a man is snoozing in an enormous tractor, lit up by the late afternoon sun. Wondering what to do and where to go, I head up the most grandiose-looking path I can find. I figure it'll lead me somewhere interesting, at the very least. After a couple of minutes I come to the manor house, whose turrets make it look like the Disney castle. There are griffins carved into the hedges and the flowerbeds are a sea of colour.

I ring on the doorbell and am greeted by Sarah, a friendly faced woman in her late-60s. She smiles and tells me, "You must be Theo!". I am. She throws on a pair of wellies and decides to show me around the estate. We set off for a tour of the grounds and instantly I feel Sarah's overwhelming excitement for rewilding. Although we maintain a conversation about nature and carbon, Sarah is often be distracted by something green or fluttering. Out in the field, we meet her husband Peter, who exudes warmth and joviality. He has a neat beard and a twinkle in his eye. Analogies, metaphors, and similes are his bread-and-butter, and soon we were lost deep in a metaphor in which Jesus (the shepherd) [here meant to be the state] was meant to look after the sole lost sheep [the traditional estate owner] rather than look after the 99 sheep who are doing well and following along [the rewilders]. The metaphor got lost and complicated, but it captured some of the rhetoric that Peter plays with.

Sarah and Peter took over the estate in the early 1980s but it has been owned by the family since the thirteenth century. Sarah tells me that the rewilding project started twenty-or-so years ago, when beavers were introduced. At the time, according to Peter, introducing beavers wasn't bureaucratically difficult – unlike today. Since then, the area given over to rewilding has grown, and there are plenty of beavers, butterflies, buttercups. But I'm also struck by how seemingly the majority of the estate is still farmland. It marks a drastic difference to what I had expected to see, having heard so much about the estate and surfed through the back corners of its website. Sarah explains it's a financial necessity, so that she and Peter can continue to make a living from the land. I wonder about carbon finance, envisioning the new financial futures it might unlock. Where there are sheep or cattle, might there soon be birch, oak, rowan, and alder?

We keep walking and bump into Camille, Peter and Sarah's daughter, who is set to inherit the estate. Sarah suggests that Camille and I might go for a stroll, and bids farewell. We wander up through a forest, foraging for wild sorrel amongst the birch trees. Camille tells me how she sees rewilding as a process of returning land that had been damaged by her ancestors to a better state, by letting nature take control. For Camille, rewilding isn't about addressing one scientifically determined issue, like maximising carbon sequestration or increasing measurable biodiversity. Doing so would mean constantly overhauling our current forms of management every time scientists found out something new, which would be absurd. The value of rewilding, to paraphrase Camille, lies in letting nature figure itself out and performing its own processes. Rewilding doesn't need to be measured and quantified all the time for its value to be apparent. I agreed, and we turned back towards the manor.

Figure 50 Open hillsides such as this are a common sight across the Highlands.

Every time I looked across them, I asked myself the same questions: might their ecological composition change with the money available from the carbon market? And which landowner had the power to decide?

*

It’s now early evening, and the midsummer sun makes life on the estate feel even more dreamlike. Peter, Sarah, and I are sitting in the reading room, with aristocratic portraits staring down on us. An empty fireplace takes pride of place, popular nature books are strewn across the table, and we are sharing a bottle of red wine. A grandfather clock ticks away in the background.

Recently, Peter explains, the estate received a grant to plant a 100-hectare native woodland. He paid £3000 to a contractor to get it carbon accredited by the WCC. I say that I’d love to see what a WCC contract looks like. The twinkle returning to his eyes, he stands up and goes over to his laptop to find the contract, then reads aloud through the points that are required of him to receive a woodland carbon credit. After a while, he trails off, telling me that he doesn’t take this too seriously. He signed the contract with misgivings, and ultimately, doesn’t really give a damn about the carbon credits, nor does he want to sell them. I ask if he is worried about signing a contract that stipulates how the forest should be managed over a hundred-year timeframe. Peter knowingly smiles and tells me that humanity is essentially forgetful; in short, he signed the contract, but nothing too significant will happen if he doesn’t adhere to the terms.

Camille interrupts our conversation, telling us that she doesn’t want the dirty money associated with carbon. She refuses to sell the carbon credits because they are immoral. Instead, she is going to hang onto them, in case she needs to sell the estate because of some unforeseen future catastrophe or because of unaffordable inheritance tax. The carbon credits are effectively *in the bank.* They’re a financial last resort to make sure the estate stays in their hands rather than in a property developer’s.

Later that evening, I look up the planting scheme on the Land Carbon Registry and found that the 79.2-hectare planting site is forecasted to capture 48,295 tCO2e over the next 100 years. With a “buffer” factored into the carbon calculation, the project is set to be attributed 38,636 PIUs. If these are sold for £20/tonne (which seemed the standard price for a PIU from a rewilding project in 2022) their value would be £773,720. The planting scheme is typical of many I came across in the Highlands – the creators of the woodland were sceptical or hesitant about producing carbon credits, and didn’t necessarily trust the science nor the governance framework that informed their creation. They thought offsetting was either immoral or a scam.

But they produced and banked the credits nonetheless, making the most of the financial opportunities available to estates restoring nature. The carbon credits, privately owned by the estate owners but generated with help from the state's grant support scheme, serve as a flexible asset saved for tougher times. With the incredible financial support available to landowners for forest creation, who can blame them?

6. 'Known Not Grown': Strategic Accuracy and Finding Carbon

6.1. Introduction

Eric and I are standing several hundred feet above sea-level, overlooking a picture postcard image of the Scottish Highlands. Lochs, mountains, and forests stretch before us. Eric is clutching the hand-held controller of a DJI M300 airframe drone, which the wind buffets from side to side. The drone steadies itself, then continues its pre-programmed flightpath. On the drone's controller screen, the estate looks mesmerising in the summer sunshine, everything green and blue. The controller emits a satisfying clicking sound every few seconds, announcing that the drone's 45-megapixel body-mounted camera has mapped another tree from the estate below us.

Figure 51 Eric's handheld remote for a drone-mounted camera, taking images of the forest canopy.

We spend a couple of hours on the hill, chatting about rewilding and carbon finance, waiting for the wind to subside. Eric tells me about his successful career in commercial forestry and his new entrepreneurial ventures. In the pockets of good weather, he sends the drone up. When

it takes off and lands, I feel slightly nauseous given its £40,000 price-tag flapping in the gusty conditions, but Eric gives off a cool demeanour. Leaning on a 4x4, I'm taken by how easy this high-tech form of ecological measurement appears to be. Last week I was on the same estate, wading knee-deep in bogs with measuring sticks to assess the estate's peat depth, and scratching my way through thick bracken trying to assess tree diameter with a tape measure. Today, I'm kicking back, with dry feet, watching a drone duck in and out of the buzzards' flightpaths.

Eric is the CEO of a natural capital measurement start-up. We are on an estate recently purchased by a green entrepreneur looking to generate revenue from nature restoration, principally through selling natural capital credits. Eric's company, Carbon Fix,[49] along with a range of other environmental measurement companies, has been hired to create a baseline of the carbon and biodiversity stocks on the estate. It is hoped that these technologies can subsequently prove the additional carbon and biodiversity uplift in the upcoming years with markedly more accuracy than current methodologies allow for.

[49] To reiterate, the interviewees and companies in this chapter are pseudonymised.

Figure 52 A DJI M300 airframe drone taking off and landing.

Specifically, Carbon Fix have been hired to create a 3-D forest carbon inventory of the estate, using a range of remote sensing technologies.[50] These technologies plausibly create an alternative – and more accurate – measurement process for calculating an estate's carbon stock, compared to the standard measurement tools used in forest carbon verification. They offer a marked increase to the prediction and verification methodologies that are standard for the Woodland Carbon Code.

After a few hours of drone mapping, Eric and I drive back to the estate's manor house. We head into the folly, a quaint tower overlooking the loch, and Eric pulls out his laptop. He wants to show me the presentation he usually gives to investors which explains how his measurement technologies work. Each slide takes me through a step in Carbon Fix's measurement process, documenting how forest stocks can be measured from different perspectives with different technologies. The PowerPoint sides are crisp and the transitions smooth. It's hard to not be

[50] By 'remote sensing', I use the broad definition developed by Anita Simic Milas and their colleagues (2018), that remote sensing involves flying objects, including manned aircrafts, satellites and drones, to scan the Earth and generate information about it.

impressed by the scientific references, high-profile collaborators and highly aestheticised images produced using drones and lasers. They come together in a very convincing performance of measurement expertise, showcasing the in-depth technological knowledge held by Eric and his company. Eric shows me an image similar to Figure 53 below, in which the component trees within a forest are mapped, differentiated and displayed with colour-coded precision. The image is produced by Terrestrial Laser Scanning (TLS) technology, which creates a 3-D representation of a forest's above-ground biomass. These beautiful images are a far-cry from the WCC's Carbon Calculator, the relatively unremarkable-looking Excel spreadsheet which I outlined in the previous chapter.

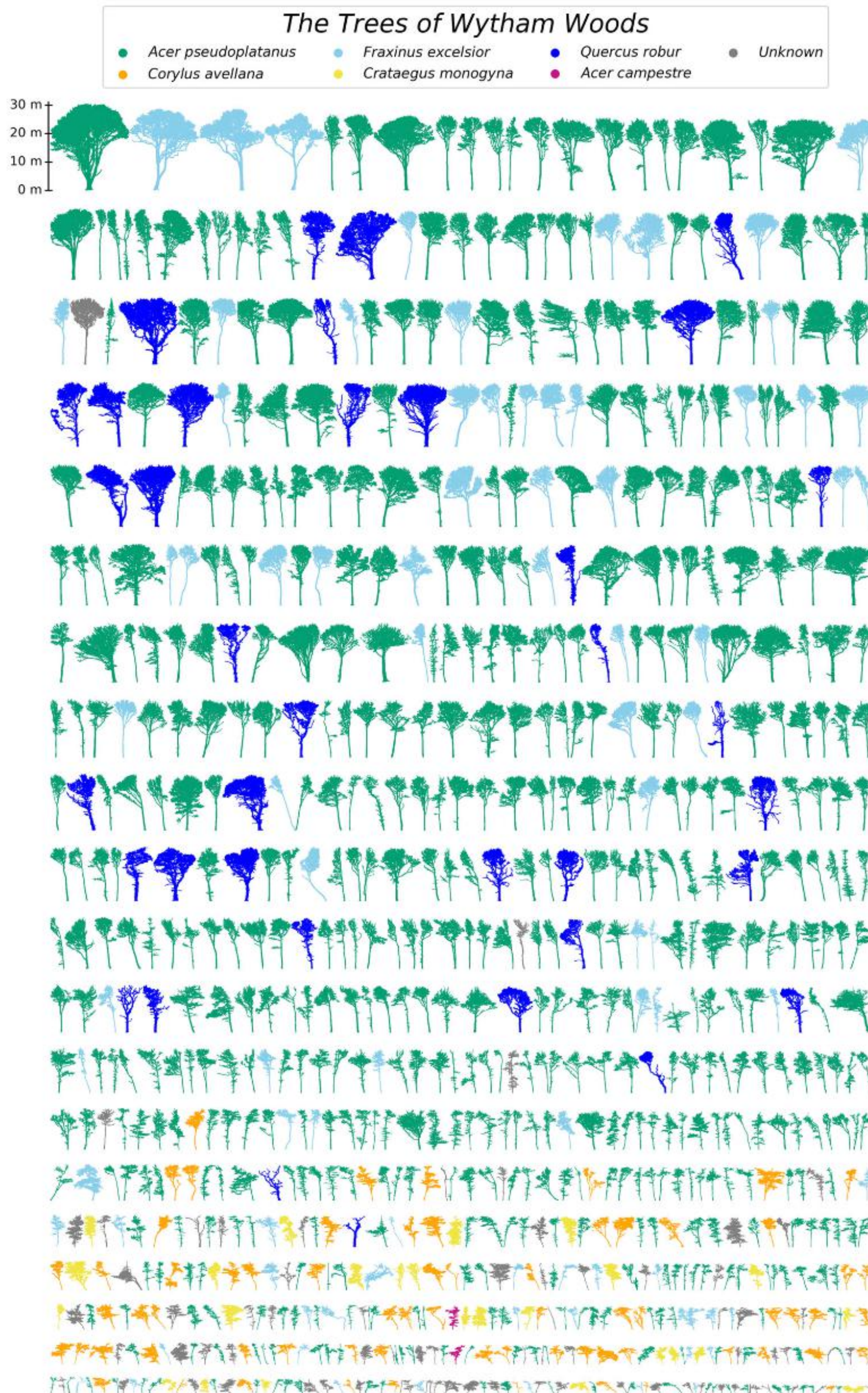

Figure 53 A 3-D model of Wytham Woods in Oxfordshire generated using Terrestrial Laser Scanning (TLS). Image reproduced from Calders et al. (2022).

Across the Highlands, a growing group of start-ups like Carbon Fix are bringing advanced measurement technologies (AMTs) to market, offering landowners the chance to verify forest carbon and other natural capital stocks, such as biodiversity and peatland carbon, with cutting-edge precision and accuracy. Many AMTs are largely developed in collaborations between university-employed research scientists and private companies. The technologies offer exciting methodological upgrades to the ways ecosystems can be measured. For example, AMTs can drastically increased the capacity for forest ecologists to understand the complex branching structure of trees. As remote sensing ecologist Kim Calders describes, "Recent advances in sensor and algorithm development have allowed us to assess in situ 3D forest structure explicitly and revolutionised the way we monitor and quantify ecosystem structure and function" (Calders et al., 2020, p. 1).

Private companies marketing AMTs promise landowners a fair return for ecological land management practices such as tree planting. AMTs can accurately measure the additional amount of natural capital growing on an estate. They replace coarse-grained, often dated measurement techniques that are ubiquitous in UK forestry mensuration (Calders et al., 2022). AMTs provide a stream of accurate ecosystem data that can inform rational environmental governance, whilst building trust in natural capital markets and the credits they generate. But as Jennifer Gabrys reminds us, critical scholars might equally understand the promise of measurement technologies, "as part of a neoliberal sales pitch, where digital technologies are packaged in a glossy veneer of democratic action that does little to shift the entrenched conditions of environmental pollution or social injustice" (2022a, p. 3). After all, as STS scholars have long highlighted, more accurate environmental measurement does not necessarily lead to 'better' environmental governance, however 'better' is defined (Bakker & Ritts, 2018).

As I outlined in Chapter Two, forest measurement is a highly contentious form of knowledge production, especially when measuring forest carbon. The technologies used to measure forests are always integrated within a wider set of infrastructures and social contexts, which shape what is measured, how it is measured, and why it is measured (Gabrys et al., 2022). The previous chapter showed how they function as part of the object making performance, determining which elements of forest ecologies become legible to the state and market. Crucially, the production of environmental data using ostensibly objective measurement technologies can have a depoliticising society making effect, obscuring the decision-making

processes that determine which environmental data should be generated and who benefits from it (Turnhout et al., 2014). This is especially pertinent for remote sensing technologies, whose "satellite gaze" presents a disembodied view from nowhere that appears impartial, even though technologies are designed and employed by people with their own political intentions (Bennett et al., 2022; see also Millner, 2020; Weizman, 2017).

In short, the ethical and political value of a new environmental measurement technology is not inherently good or bad. In the terms of political ecologist Naomi Millner, the use of new environmental measurement technologies is always "ambiguous" (2020). Different actors can use the same technologies to disrupt or entrench the modes of power and governance in which they are enrolled. Developing this insight, this chapter investigates the contingent political-economic networks in which AMTs are marketed in forest carbon verification, to address the research question, ***how are emerging high-tech measurement technologies changing the ways reforestation is performed?***

Although AMTs are being developed to measure a range of ecosystems, this chapter focuses on the novel AMTs used to measure forest carbon. I anticipate that the arguments developed here might inform scholars researching how natures are measured with sophisticated technologies in the creation of biodiversity offsets, peatland carbon offsets, stream credits, and other forms of natural capital. The central claim I develop in this chapter is that AMTs are designed to perform a series of epistemic processes – *identifying more carbon volume*, *bypassing conservative carbon estimates*, and *drawing upon a selective uptake of science* – which allow more carbon to be found in forests. After providing further context on the AMTs for forest carbon verification in Section Two, in Section Three I specify how more carbon can be found in forest ecosystems. In Section Four, I identify an emerging phenomenon in net zero governance, in which more carbon credits can be generated through a shift of measurement practices, rather than a shift in material carbon sequestration. I outline three key elements of carbon being 'known not grown': corporate actors employ a logic of 'strategic accuracy'; 'known not grown' leads to a regime of mitigation deterrence, in which radical decarbonisation is politically bypassed; and the pattern of beneficiaries likely follows the status quo distributions of wealth and power in the Highlands. The Conclusion specifies the society making effects that AMT usage performs and hints towards their disruptive political potential.

6.2. Advanced Measurement Technologies

In February 2024, as I was finalising this chapter, I received an email newsletter from the Woodland Carbon Code:

> "The Woodland Carbon Code team is exploring how remote sensing techniques could be used for Woodland Carbon Code projects. We're investigating how technology such as instruments on drones, planes and satellites could help with verification… We hope our research will help people who want to create Woodland Carbon Code projects. Using the latest science also helps us to continue to create high quality units for carbon buyers."

I was not surprised. During my fieldwork, the employment of remote sensing for forest carbon verification had always felt like an imminent future. The email hinted at its increasingly likely place in forest carbon verification. Remote sensing offers a potentially drastic improvement in forest carbon verification. As I outlined in the previous chapter, forest carbon credit verification is the process in which trees are proven to have grown, which confirms that woodland carbon credits used in offsetting schemes are linked to actual tree growth. Upon verification, a Pending Issuance Unit (PIU) can be translated into a Woodland Carbon Unit (WCU). Verification site checks are crucial for upholding the credibility of a WCU because they purportedly eliminate the production of 'ghost credits': carbon credits sold without material carbon sequestration having occurred. As Valiergue & Ehrenstein (2022) note, these ghost credits have haunted the carbon market in other geographical locations, undermining the performances of legitimacy needed to generate trustworthy credits.

Repeatedly in interviews, commercial foresters and carbon brokers predicted that remote sensing technologies will become the go-to verification method. As Nick, a representative of the WCC described in an interview in 2022,

> "Essentially, we [the WCC] do definitely encourage those [remote sensing] techniques, but at the moment, economies of scale wise, it's just not cost effective for a lot of people. And so they would love to do it, but they're kind of accepting that for the first five years from now, maybe the next five [or] ten years, it [remote sensing verification] may still be at least supplemented by mensuration on the ground, measuring of the trees. [The WCC is] already accepting projects that are going through verification through remote sensing and drones.

So, it's happening now. It's not necessarily a future-based thing…it's just a matter of months, if not a couple of years, until people start using that [remote sensing] as a standard approach."

Forestry companies are increasingly arguing that the standard mensuration approach, which uses tape measures and rangefinders, commonly used in forest carbon verification for credits accredited through the WCC, "…is not really an effective way of properly assessing how much carbon is there". Increasingly, Nick explained, forestry companies "are gonna be the ones that will think, you know, we'll pay an extra couple of grand for the mensuration and get some actual drone imagery".

Some start-ups are already offering landowners the opportunity to verify forest carbon credits with AMTs.[51] For example, on their website, Carbon Fix describe offering estates the chance to "independently verify" the carbon stored on their estates using a mixture of technologies. The drone's tree mapping imagery will be integrated and cross-referenced with tree measurements taken with an L1 LiDAR (Light Detection and Ranging) machine, and processed through photogrammetry, machine learning and software models. In the future, data produced through TLS will create a 3-D model of the branching structure of the estate's forests. TLS can be used to map and monitor individual tree change. The image below shows a visualisation of TLS forest measurement. Note the intricacy with which individual trunks and branches are visualised and reproduced in image form.

[51] Start-ups such as Carbon Fix cannot currently operate as private verifiers of forest carbon growth, which is still done by independent certification bodies. However, private verification is an emerging future trajectory in forest carbon measurement, with start-ups created to fill this apparent market niche. The exact business model seemed relatively unclear.

Figure 54 TLS image of an ash tree in London. Image reproduced from Calders et al. (2020, p.112102)

Carbon Fix has taken TLS forest scans at several test-sites to create in-depth data about above-ground biomass in different forest types (such as commercial Sitka spruce plantation or native broadleaf). When calculating a forest's carbon stock, Carbon Fix uses drones to quantify the number of trees (as described at the beginning of the chapter) and integrates these measurements with above-ground biomass data from the TLS test-sites. Taken together, these measurements estimate the forest's overall above-ground biomass which can inform forest carbon stock estimations.

AMTs are framed by their developers as crucial and necessary for scaling up science-driven, diverse nature restoration. In interviews, carbon brokers and tech entrepreneurs often suggested that only by harnessing the technical capacities of AMTs can forest carbon credits be verified at the speed and scale required, especially due to the growth of forest carbon projects validated by the WCC since 'planting fever' intensified in 2019. One experienced carbon broker suggested that remote sensing verification is "urgently needed because the first 15-year verifications will be happening very soon. And we need this technology. We need to be, we need to be testing it out now." Given the ways the woodland carbon market is growing, it seems highly unlikely that a small pool of independent organisations will be able to verify the continually increasing number of PIUs being translated into WCUs. This is especially the case using the standard methodologies for verification, which necessitates a verifier visiting the site in person to take field measurements.

The promise of remote sensing verification not only lies in their efficiency to assess forest growth with accuracy at scale. Start-ups present their technologies as having powerful potential for financing ecologically diverse forest creation. As we saw in the previous chapter, the WCC spreadsheet has powerful environment making performative effects; its standardised measurement process ensures that streamlined forests are granted the most carbon credits. The more elements of a forests' above-ground biomass which are legible, the more easily it can be translated into carbon credits. Previously difficult-to-measure ecological stocks and processes, such as the natural regeneration of native woodland, might be more easily measurable with AMTs. Their carbon (or other natural capital value) quantity might be measurable with enough certainty that they can be translated into trustworthy carbon credits. Capturing a relatively widespread narrative, one carbon broker suggested that "as remote sensing technology plays a greater role moving forwards, I think that will certainly open the door to growing interest and adoption of woodland regeneration… [and] a more diverse mix of woodland types". Even if trees are growing in complicated or unpredictable patterns, they might now be legible to the state or market. AMTs might diversify the 'nature that capital can see' (Robertson, 2006). Through their improved measurement accuracy, more elements of forest ecosystems could be measurable.

For other entrepreneurs I spoke with, AMTs also bring increased credibility to the woodland carbon market, encouraging more people to trust the offsetting mechanism. As I described in Chapter Two, performances of scientific legitimacy are crucial in the object making performance, granting legitimacy to the natural capital credits generated. The more sophisticated the measurement of nature, the more credible the credits. The above quote from the WCC's newsletter hints to this: "We hope our research will help people who want to create Woodland Carbon Code projects. Using the latest science also helps us to continue to create high quality units for carbon buyers." Appeals to the latest developments in science, such as this, as geographer Eric Nost (2022) notes, are a commonplace technique for bringing legitimacy to the state's governance interventions.

6.3. Finding Carbon

Clearly, there are a lot of laudable reasons why AMTs should be pursued for forest carbon verification: scaling up the speed and scale with which verification takes place; diversifying the types of ecologies which can be measured; increasing the credibility of the credits

generated. But it’s also important to consider the political-economic networks from which AMTs are developed. As Nost and political ecologist Jenny Goldstein remind us, environmental data do not just appear, but rather, are produced and reproduced through data infrastructures, in “place and time-specific networks of funding, standards, rules, technologies, and environments” (2022, p. 4). Within market environmentalist frameworks, the measurement of nature to create natural capital credits is not necessarily pursued solely out of a purely technical desire to measure with more detail and accuracy. Measurement technologies, as other STS scholars have long highlighted (Turnhout et al., 2014), create environmental data that supports profit-driven motivations. During my fieldwork, AMTs used for natural capital verification were being developed by and for the private sector.

AMTs employed in natural capital verification are at least partly designed *to increase financial returns from nature restoration*. Several AMT developers, in interviews and on company websites, present their technologies as capable of “unlocking”[52] the financial value of ecosystems, by making more elements of an ecosystem legible to natural capital markets. There is no fixed price for AMT forest carbon verification, although it is a large increase to the standard £1600-£2100 price range for WCC project’s to be verified. I spoke with several private landlords who were increasingly turning to AMTs to verify natural capital on their estates. For example, one entrepreneur-landowner told me that putting money towards AMT verification, rather than using the standard verification approach employed by the WCC, was fundamentally a business decision that would increase the returns available from forest carbon. How, though, can these returns be created? I suggest there are three distinct but related epistemic process which allow this to occur: i) identifying more volume; ii) bypassing conservative measurement, and; iii) drawing upon a partial uptake of science. These combine to find more carbon than the standard forms of forest measurement allow.

Identifying More Volume

Sam, a natural capital accountant, described the measurement choice landowners are presented with when verifying their natural capital. They can use the standard modes of carbon verification used by the WCC, or if they are looking for additional financial value for their natural capital, they can turn towards AMTs. Landowners can choose between “basic level

[52] “Unlocking” was a common word I heard during fieldwork from technology developers, across websites and business conferences.

[natural capital measurement, which] will cost five, ten or fifteen [thousand pounds] and the deeper level, which is fifty [thousand pounds]". Sam outlined the business model that AMT companies develop:

> "The 'Tier 3' [i.e. advanced measurement] stuff asks, do I want to spend extra to do this modelling, to prove that extra value? I.e., is it worth doing the [AMT] measurement, because I am going to get 40% more income from my carbon later down the line. That's fundamental to the business model to those companies: *can you measure stuff more accurately and therefore identify more volume and therefore identify more income?*" (emphasis added)

Sam and I were discussing an influential report produced by a private rewilding company, which compared measurements taken by AMTs with 'standard' measurement techniques for quantifying natural capital. I asked Sam whether he thought it was problematic that AMT companies always seemed to find "more of whatever [they] are looking for?" He replied, "No, I don't think so. Fundamentally if they didn't, the companies [doing the advanced measurement] wouldn't have a business model." Implicitly, the business model involves employing more accurate measurement technologies to identify more carbon volume (or other natural capital stocks, such as biodiversity) – and subsequently generate more natural capital credits. Increasing measurement accuracy, finding natural capital, and generating increased income are interlinked. This clearly sits outside the normative vision of depoliticised scientific research and measurement which Theodore Porter (2021) describes, in which measurement accuracy is *not* linked to finding more of what one is measuring, nor creating additional financial value. Accuracy is instead linked to the scientific virtues of impartiality and objectivity. Drawing on these epistemic virtues is important for framing the AMT measurement as a necessary, rational governance intervention designed independently of economic concerns.

For example, one CEO claimed his company's AMT measurement had recently measured three-times more carbon stored in a Scottish forest, compared to the measurement calculated by the WCC's Carbon Calculator spreadsheet. He described his frustration with the standard modes of carbon measurement employed within the UK forestry sector, claiming they only account for the carbon stored in tree trunks rather than the full branching structure of an entire forest. He argued this undercounting emerged from the UK forestry industry's historical concern with maximising timber (stored in trunks), instead of net overall biomass increase. The

measurement framework historically developed within Scotland's commercial forestry sector has been transcribed to carbon measurements. This was, he argued, having a knock-on effect on forest carbon measurements. Trunk biomass was not the sole store of carbon for a tree, but it was the only part legible to the WCC's spreadsheet. Therefore, trunk biomass was the only part of a forest that could be legitimately translated into carbon credits.

To back up his claim, Eric referred to a scientific paper published in *Ecological Solutions and Evidence* (see Calders et al., 2022), which showed how ecologists using TLS found 77% extra forest carbon biomass stored in a native broadleaf forest in Oxfordshire, when compared against the standard forest carbon measurement techniques employed by the UK Forestry Commission. The paper suggests that the UK's standard forest carbon accounting is based on outdated modelling, and woodland carbon storage is far greater than previously measured. TLS offers a methodological update to forest carbon measurement by accurately measuring the complex branching structure of a forest. TLS can individually measure each tree in a forest and does not rely on the reductive or standardised measurement practices that are common in the WCC. AMTs make more elements of a forest, including non-trunk biomass such as tree limbs, legible for carbon accounting.

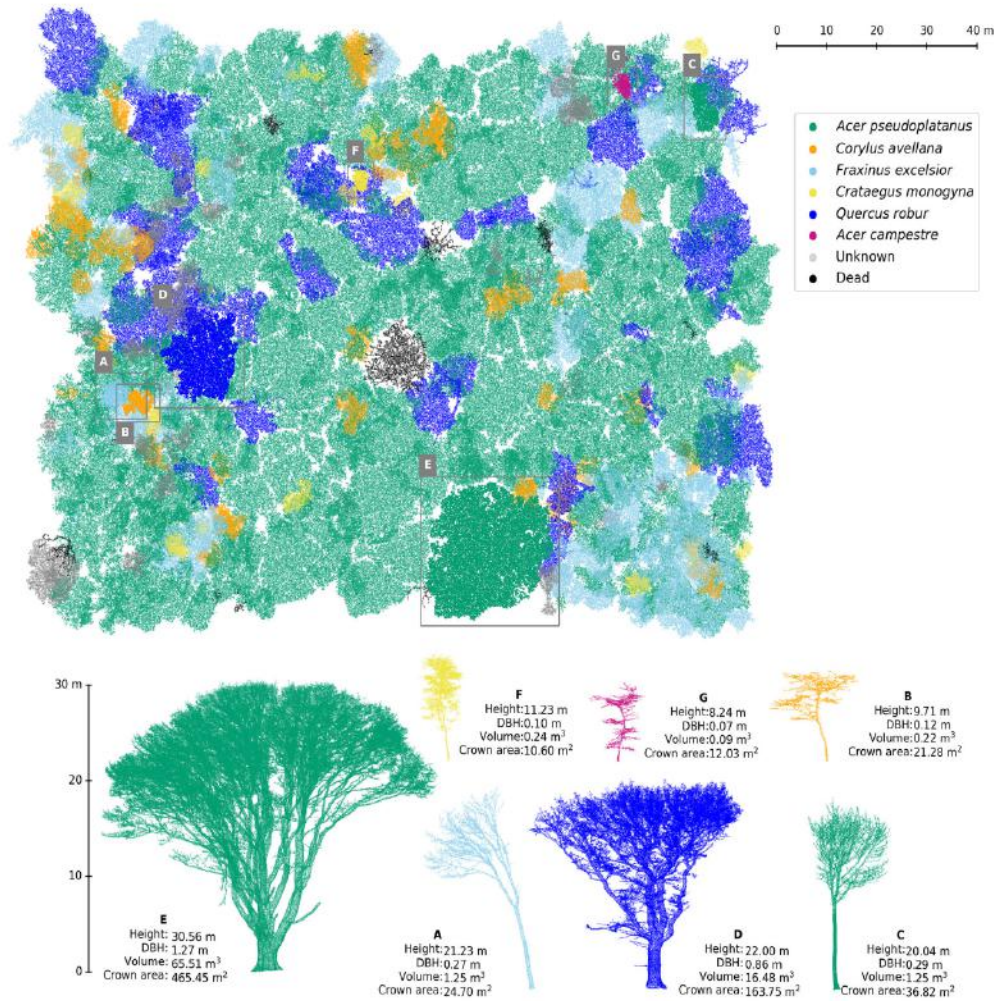

Figure 55. TLS at Wytham Woods in Oxfordshire. Image reproduced from Calders et al, 2022.

Political ecologists Morgan Robertson, Rebeca Lave, and Martin Doyle highlight that measurement tools that create financial value for ecosystems are not “inherently capitalist or developed for capitalist purposes” but become used to delineate and translate interacting ecological processes into “discrete ecosystem objects amenable to governance with markets” (2023a, p. 1). Like the metric developers in their study, AMT developers use scientifically robust, accurate forest carbon measurement techniques “scavenged” (2023a, p. 1) from science, which fix elements of ecosystems as value-bearing commodities. A shift towards more precise and scientifically legitimate processes of measurement can allow *more* elements of nature to be translated into value-bearing credits. In this example, when integrated into private natural capital accounting, increasing technical accuracy is directed to leverage an increased income for landowners.

AMTs do not always identify more above-ground biomass nor always find more carbon. For example, using LiDAR to measure its above-ground biomass stock, the estate owner of one company told me he found lower tree numbers in old growth plantations and woodlands than those projected by the WCC. AMT companies cannot *guarantee* finding more carbon; that would clearly rupture the performance of scientific legitimacy required to create trustworthy credits. Instead, AMTs can be enrolled as part of a wider object making performance in which more carbon can be found. As one soil ecologist put it, using TLS is "like increasing the carbon that they would have predicted at any given time".

Bypassing Conservative Measurement

The previous chapter traced how the WCC measures carbon conservatively, to maintain the stable identity of the credits generated. This performance is necessary to minimise the likelihood of generating false credits. When using AMTs, conservative measurement practices, including undercounting, are not as necessary to create the boundaries which perform the forest as a forest carbon credit. Several interviewees told me that the precision of these novel technologies allows for conservative carbon estimates to be bypassed. For example, as one experienced carbon broker told me, when using remote sensing for tree growth verification, "[you are doing] an active assessment of what's there … you could afford to be less conservative". Another carbon expert argued that remote sensing could find the "real" amount of carbon at verification, which the WCC Carbon Calculator spreadsheet could not.

Lauren Gifford shows how the process of generating bureaucratically legitimate calculations of carbon baselines and additionality are intimately linked to the creation of expert authority. Given the highly "flexible and subjective" (2020, p. 299) ways that forest carbon can be verified, being seen as a measurement expert is crucial for forest carbon calculations to be accepted. The initial AMT developers have established expertise by being the first mover in AMT marketisation, and subsequently presenting at conferences and collaborating with other high-profile institutions, such as esteemed university research groups and notable private rewilding companies.

Legitimacy also cultivated through a *display* of scientific expertise. As I noted in Chapter Two, measurement techniques that appear scientific and produce convincing numbers become loaded with epistemic virtue, and their measurements are correspondingly trusted (Lippert, 2015; Porter, 2021). When experts present their claim as objective, as Nost (2015) describes,

the partial knowledge practices which underlie them are obscured. This is especially the case when knowledge claims – in this case, about more carbon being stored in forests – are generated through high-tech measurement techniques that appear to cancel human biases. In Porter's terms, the trustworthy numbers produced through sophisticated measurement techniques seem to "lead ineluctably to valid conclusions" (2021, p.4). The legitimacy of AMT measurements is bolstered by the technologies' apparent scientific legitimacy. Lasers, drones and satellites emanate a scientific confidence which establishes trust in the measurements produced. A highly aestheticized presentation of environmental measurement, as shown in the images above, also confers a sense of expertise. These images exemplify the accuracy of forest measurements available using AMT measurement. During my fieldwork, as the Introduction to this chapter highlighted, I saw these same images circulating in private companies' reports and in presentations at conferences and business meetings. Technologies' perceived precision forms part of a object making performance, lending expert authority to claims being made about which elements of biophysical matter can be translated into a credit.

Lansing (2012) shows how the production of reports and brochures are required to convince investors of a forest's materiality for carbon forestry projects in Costa Rica. In Scotland's high integrity woodland carbon market, more than a decade after Lansing's study was published, a more sophisticated performance convinces offsetters not only of a forest's materiality (that it exists), but to show them the intricacies of its materiality. In other words, AMTs offer an upgrade to the object making performance. In the following chapter, I return to this theme, considering how these performances of technological expertise are crucial in creating not only the *quantity* of carbon credits generated, but also the *quality* of the credits.

Selective Science

Critique of AMT development is nuanced and difficult, largely because the technologies increase rather than decrease measurement accuracy, which is widely understood as a normative good in contemporary governance (Daston & Galison, 2007), especially in carbon accounting (Lippert, 2015). But as is common with neoliberal environmental governance, private companies pursue a situated form of measurement accuracy, which is complicit in reducing measurement complexity and supports the creation of financial value from ecosystems (Robertson, 2006). This, I suggest, is performed through a carefully selected choice of which science to include in natural capital measurement, which is commonplace in natural capital accounting. As Esther Turnhout and her colleagues (2014) suggest, sciences which

create data that fits more smoothly with the logics of the market, such as accounting for measurable stocks and flows, are prioritised.

Despite the growing scientific research into the complex flows of carbon in entire forest ecosystems, particularly highlighting the potential release of carbon through soil disturbance as trees become established (shown in papers by ecologists such as Friggens et al., 2020; Warner et al., 2022), the WCC calculates carbon sequestration largely through verifying whether or not trees have grown and above-ground biomass has accumulated. Soil carbon release is estimated in the WCC's validation checks, which Nick, the WCC representative, assured had been accounted for "conservatively" because of the uncertainty in soil science. However, several soil ecologists I interviewed were concerned that the WCC reproduced a reductive epistemology widespread in commercial forestry, in which a forest's carbon stock is assumed to be loosely equivalent to its above-ground biomass. The WCC's soil carbon estimations are based on soil carbon release when land is mounded or ploughed to prepare for tree planting. Soil scientists studying the relationship between tree growth and soil carbon have discovered complicated flows of soil carbon release when trees are established, which bring epistemic doubt as to whether tree growth leads to net carbon sequestration or emissions over decadal timeframes. Anna, a soil ecologist, expressed concern with the WCC's narrow epistemic focus and lack of close examination of soil carbon uncertainty. She was frustrated that "the WCC, as it is now, is very focused on the above ground". She described the WCC's verification method:

> "[It] is all about 'did the trees grow?' And then they do go back and measure the trees and actually verify credits properly. But it's like, if they're not looking at the soil carbon, they can't actually get the net carbon gain from their project."

Anna was concerned the reductive assumptions employed in the WCC "don't really align that well" for calculating forest carbon in "native natural forest restoration… they don't apply so well to the more naturalistic kind of environment". Within her field of soil ecology,

> "People are starting to understand that planting trees is not synonymous with carbon sequestration and that we need to look at whole ecosystem carbon sequestration, not just carbon being stored in trees."

Some natural capital measurement approaches, such as the drone-and-TLS package offered by Carbon Fix, reproduce the reductive epistemic assumption that measuring above-ground biomass is sufficiently equivalent to measuring forest carbon. The identity of the forest is bounded as above-ground biomass and performed through AMTs, rather than a more complicated assemblage of different sub-terranean and above-ground carbon stocks and flows. Yet despite this partial measurement of forest carbon, improving the accuracy of above-ground biomass measurement was often presented by carbon brokers as to some extent finding the actual amount of forest carbon.

Carbon Fix do not provide detailed real time calculation of soil carbon release from tree establishment and growth, nor do they attend to the uncertainty in soil science about forest-wide carbon sequestration. This would be an extensive (and no doubt expensive) endeavour that sits outside their business model and metrological expertise. One carbon broker explained he had been considering developing methodologies for soil carbon verification using remote sensing technologies, until he recognised that soil science was far too uncertain to integrate into his measurement process. Different professors and experts he had consulted with had recommended vastly different ways to calculate soil carbon. Afraid to negotiate this amount of complexity, he decided to not integrate this knowledge into his carbon measurements. This anecdote highlights how companies developing AMTs determine what to measure, choosing to include or exclude modes of scientific research that fit with their business model. As Robertson (2006) highlights, measurement uncertainty and methodological disagreement about how best to measure incredibly complex ecological phenomena are fundamental to the scientific method and characteristic of good scientific practice. But highlighting measurement uncertainty in forest-wide carbon measurement would undermine the creation of trustworthy carbon credits, which need a stable identity based on fixed epistemic foundations to be tradable.

When shaped by the need for profit, accurate and precise AMTs provide more epistemic credibility to claims about whether above-ground biomass has or has not grown, but do not necessarily integrate a range of uncertain scientific perspectives about forest carbon measurement. Highlighting uncertainty about forest carbon measurement would be outside the political-economic motivations of AMT developers. Here, echoing Lansing's (2012) study of carbon offsetting in Costa Rica, the boundaries of what should be measured as 'the forest' are demarcated by powerful experts with commercial interests. Knowledge claims that are

"unintelligible to the logics of offsetting" (2012, p.4), such as highlighting soil carbon uncertainty, sit outside the marketisation of carbon measurement science.

This is paradigmatic of the science-governance interface described by Turnhout and her colleagues (2014), in which a partial uptake of science that fits within economic motivations appears almost inevitable, especially when ecosystem measurement is privatised. Private companies creating apparent 'solutions' to climate change, such as technologies that measure and create value for nature restoration, are bounded by the need to create a measurement product which can produce additional financial value from measuring natures (Nost & Goldstein, 2022). Tech entrepreneurs are dependent on cutting-edge science to create exciting new products; but scientific uncertainty, which Robertson (2006) stresses is necessarily part of good scientific practice, does not integrate well into this model.

6.4. Known Not Grown

As I outlined in the previous chapter, a forest's financial value is intimately linked to additionality. In the Scottish woodland carbon market, the natural capital value of forests rests in the gulf between a measured baseline and a subsequent measurement. AMTs can extend this gulf. This extension is the phenomenon I term '*known not grown'*. It occurs when increased additionality is calculated, and subsequently an increased number of natural capital credits can be generated, *through a shift in measurement practices rather than a material change in ecologies*.

'Known not grown' sits contrary to the realist assumption at the heart of the carbon market's logics, that the generation of more numerous carbon credits is bounded to, or at least approximately equivalent to, increased quantities of carbon being sequestered within a forest. But as critical STS scholars working on carbon accounting have highlighted, there is an ontological distinction between the actual carbon stored in a forest and a carbon offset that represents it. Donald Mackenzie (2011) reminds us that it is *representations* of carbon, rather than material carbon itself, which circulate as carbon offsets in the net zero economy. Through creating an abstract digital rendering of the forest, AMTs can generate more scientifically-credible carbon offsets – fungible, tradable representations of carbon – without necessarily increasing the amount of carbon stored within forest ecosystems. This is potentially dangerous. More *negative emissions* can be calculated which could legitimise more *positive emissions*

being released elsewhere. There are three political consequences of carbon being 'known not grown': a strategic employment of accuracy is developed, a new frontier of mitigation deterrence might emerge, and an unequal distribution of beneficiaries could result.

Strategic Accuracy

Robertson, Lave and Doyle argue that recent critical work on neoliberal nature conservation has shown how "governance will readily adapt the tools of science but will tend to leave aside the practices which validate scientific data as accurate or precise" (2023a p.18). Although this claim might prove generally accurate, the phenomenon I term 'known not grown' presents a new trajectory in how carbon becomes 'known' in corporate carbon accounting. As I described in Chapter Two, anthropologist Ingmar Lippert (2015) traces how, when measuring a company's internal carbon emissions, carbon accountants can systematically *exclude* carbon emissions from their company's carbon portfolio. The 'reality' of their carbon emissions is performed through dint of creative and ad hoc measurement practices. And these performances allow a company to eschew responsibility and ultimately generate increased financial returns. Lippert describes how accuracy is put strategically to work in carbon accounting to *not* find carbon emissions and create convincing claims about emissions. Pleading ignorance, or actively undermining the credibility of carbon science, has been characteristic of many companies' relationship with carbon measurement, partly to hide the impacts and causes of climate change. This is a prime example of how a wilful *lack* of scientific knowledge – which Lindsey McGoey (2012) defines as a logic of 'strategic ignorance' – has served as a productive asset for consolidating power in political and corporate arenas. Institutions, especially companies and governments, thrive when wilfully ignorant, and power is maintained by institutions through "the deliberate effort to preclude, obfuscate or deflect knowledge from emerging" (Mcgoey, 2012, p. 570).

An inverse, though related, phenomenon occurs in situations of carbon being 'known not grown'. When the reality of *negative* emissions rather than *positive* emissions must be performed, companies develop a slightly more nuanced cultivation of situated measurement accuracy. Rather than reflexively exclude positive emissions through intentionally partial accountancy practices, companies developing AMTs reflexively use *situated*, strategic accuracy to include negative emissions. Accuracy is strategically directed as part of the object making performance, with technologies designed to find what needs to be found to generate increased income through natural capital markets. Through expert quantification practices,

convincing numbers can be generated to legitimise knowledge claims. These numbers, produced through sophisticated and highly accurate measurement techniques, bring a heightened sense of trust to truth claims; they also, as Nost (2015) points out, emerge from necessarily 'black boxed' systems of knowledge production.

The financial opportunities presented by the net zero economy potentially mark a step-change in the ways certain businesses embrace previously unknowable or unforeseeable processes. Undoubtedly, companies will continue to reperform the systematic *exclusion* of emitting corporate practices, as described in Lippert's study. Yet simultaneously, when producing or measuring *negative* emissions (through corporate tree planting, funding nature restoration, or a host of other carbon credit schemes), companies may increasingly seek science-related research that can make more certain claims about carbon sequestration. Here, technological-discursive practices make (certain elements of) material realities more, rather than less, legible. With terrestrial laser scanning and remote sensing imaging, carbon storage is literally made more visible through the creation of highly detailed 3-D maps of forests. These digital forests provide situated epistemic clarity, rather than epistemic doubt, which becomes an important mode of leveraging financial value from reforestation. Across the wider natural capital markets which are developing, situated forms of strategic certainty are increasingly likely to materialise alongside strategic ignorance.

Mitigation Deterrence

'Known not grown' also reveals how negative emissions measurement practices provide a novel frontier in *mitigation deterrence*, the process I described in Chapter Two, in which an overt focus on carbon removal, measurement or accountancy can deter or delay emissions reductions (Markusson et al., 2018, 2022; McLaren & Markusson, 2020). Mitigation deterrence scholars have highlighted how interventions that promise to capture carbon and generate negative emissions, such as Direct Air Capture (DAC), are often presented as 'technical fixes' to socio-ecological problems. By pointing to the looming dissemination of sophisticated carbon-capture technologies, powerful status quo actors can legitimise continued emissions and extraction. The discourses function as part of a society making performance, performing the reality that a better future is imminent (Markusson et al., 2017). High-tech AMTs are similarly presented in this depoliticised register, and the political-economic motivations behind their use obscured. Through displays of technological prowess, the frame of debate is foreclosed. Instead of asking *whether* forests should be reduced to their carbon value in

technocratic governance, scientific legitimacy is granted to the question of *how* forest carbon can be measured more accurately.

Duncan McLaren, whose work differentiates the many ways mitigation deterrence occurs, argues in favour of increasing carbon measurement accuracy for forest carbon, suggesting that "measures that enhance the monitoring and verification of negative emissions would also help limit some forms of mitigation deterrence" (2020, p. 2426). With more accurate measurement, opportunities for over-exaggerated carbon budgets might be diminished. In carbon offsetting schemes which produce unsubstantiated ghost credits, there is a large measurement gap between the material carbon stored in a forest and its representation in accountancy spreadsheets. Increasing measurement accuracy addresses this issue. Yet as this chapter makes clear, although AMTs do not generate ghost offsets (the credits have a legitimate link to a material reality), they employ a situated form of measurement accuracy to create higher additionality calculations. The example outlined here highlights how the pursuit of strategic accuracy is a process that can support a range of political-economic regimes. Rather than create negative emissions when carbon sequestration has *not* occurred, AMTs find carbon sequestration that *has* occurred. The motivations and consequences that emerge from finding more carbon are concealed behind a modernist ideal, that objectively finding the 'real' amount of carbon is inherently loaded with normative societal value.

'Known not grown' offers scholars a means for identifying a new frontier of mitigation deterrence that is likely to be increasingly common in net zero governance and emerging nature-based markets. Examples of 'known not grown' can already be identified in critical STS literature. For example, George Cusworth and his colleagues (Cusworth, Lorimer, et al., 2022) show how actors in the agricultural sector have lobbied for soil carbon storage to be treated as an 'offset' for livestock emissions. Lobbyists argue that carbon is stored in the ground through the grazing patterns of cows, which negates the emissions which emerge from their methane emissions. In this example, material atmospheric gas concentrations do not change, but due to a shift in carbon measurement practices, the amount of carbon *known* within soil drastically increases. Finding carbon and generating the corresponding 'negative emissions' allows continued livestock emissions to continue. In another paper, Cusworth and his colleagues highlight how agriculture emissions metrics are reflexively designed to extend the calculated the gap between a natural capital baseline and a future measurement, thus extending additionality measurements (Cusworth, Brice, et al., 2022). Increasing additionality is achieved

through altering the epistemic assumptions underlying a metric's functionality rather than through making a material intervention. Insights from these papers sit at the heart of Cooper's (2015) 'critical metrology' project: if measurements can be performed with *enough* legitimacy, they can be accepted.

Unequal Beneficiaries

The beneficiaries of 'known not grown' are skewed along the already existing lines of wealth and power that dominate the Highlands, which I outlined in Chapter Four. The capacity to access AMTs, find more carbon and consequently leverage higher returns from natural capital is reserved for people and organisations with the money to afford them. In an interview, Max, an entrepreneur-landowner, implicitly highlighted the uneven access to AMTs. He described the business opportunities available to landowners with degraded land to restore and the financial capital to access AMTs,

> "And of course, if you've got a landowner who can afford to say, you know, if I spend £50,000 a year and baseline [natural capital on my estate] this year… Measure it again in five years' time, and after a few management interventions take the credits to market, then the money I put up upfront, the return on that is going to be huge. Absolutely huge. It's not that difficult for a landowner if they get what's going on."

The standard price for measuring the baseline natural capital on an estate – £50,000 – is framed as a profitable investment. (N.B. In our conversation, £50,000 referred to the price of measuring a combination of natural capital assets including forest carbon, peatland carbon, and biodiversity.) This price tag would no doubt exclude cash-poor groups, such as smaller community forest organisations, from generating increased revenue from their estates by measuring with AMTs. Several times in interviews, workers in the community forestry organisations told me that their organisations were already excluded from accessing carbon finance because of their lack of expertise, finance and resources. As one activist noted, community woodland groups often don't have the "carbon credit architecture" to learn how to use the WCC, let alone employ high-tech AMTs to measure their estates. In the future, if AMTs such as remote sensing technologies become widespread for the WCC's carbon verification, it may be possible that verification becomes standardised for all projects; it is uncertain how much this will cost.

In contrast to small-scale community woodland organisations, some large-scale commercial forestry companies already have their own designated carbon teams. These companies would likely have the financial and staffing flexibility to adapt to changing verification options and use these to 'know' additional carbon in their forests. This also hints at the types of ecologies that become valuable with AMT verification. As I outlined in Section Two, much of the promise of AMTs lies in their capacity to measure previously difficult-to-measure forest types, and subsequently make them legible to natural capital markets. However, there is no limitation to the types of forest verifiable with AMTs. For example, one carbon broker suggested that remote sensing would be particularly helpful with verification of large-scale Sitka spruce plantations which have been successfully validated by the WCC. The broker gave the example of a "large Sitka spruce plantation at year 15 [i.e. 15 years after it was planted]" being so thick and dense that, "you can't get through the trees to do the counts and you can't navigate your way in and find exactly where your plot is, where you are meant to be or indeed marked your plot". Remote sensing would be able to, "take defined spots, draw a line round a plot designated, count the number of trees that are in that plot, assess the growth height of the trees in there which angled LIDAR can do". Increased numbers of commercial non-native forests might be verified using AMTs. It is unclear whether more carbon will be found; this requires further empirical investigation.

When the production of data is privately generated and privately analysed, the data produced about ecological restoration itself becomes a commodified resource. Data justice scholars have highlighted the dangers emergent when data is produced by companies and held in the private domain (Dencik & Sanchez-Monedero, 2022). In their formulation of 'environmental data justice', Lourdes Vera and colleagues (2019) argue that environmental data is often generated privately within an extractive logic, as data is taken from a situated place to facilitate the expansion of capital extraction. Largely, environmental data is produced and circulates in ways that suit corporate interests ahead of other, often marginalised multispecies communities. In the case of carbon being 'known not grown', access to environmental data is not evenly distributed but controlled by the private companies with the capacity to invest in using AMT.

6.5. Conclusion

Technologies that measure forests with in-depth, in situ specificity provide forest ecologists with potentially unprecedented access to understand forest ecosystem structure and function

(Calders et al., 2022; Demol et al., 2022; Malhi et al., 2018). But scientists, science funders and policymakers must maintain critical awareness of how these same measurement technologies are used to define natural stocks and processes as *nature objects* with financial value. Using scientific and technological developments to measure natural capital is not an *inherent* good; it can be a partial and highly politicised form of knowledge production (Robertson et al., 2023a). As Nost and Goldstein note, "approaches to govern nature with and through the digital are inherently entangled with the governance, politics, and materialization of the digital" (2022, p. 4). In their terms, asking questions such as "who funds this? Who has access to its tools? Who benefits from it?" (2022, p. 7) are crucial, as is simultaneously paying attention to the material networks through which data has been generated.

The AMTs I have described in this chapter contribute to an overall society making performance, in which natural capital framings of reforestation are legitimised by the apparent scientific sophistication with which forests are measured. Who benefits is not an accidental and unplanned outcome that emerges from increasing measurement accuracy, but to an extent, a consequence of deliberative choices. The choice of where to set the boundaries for a translation – from forest (nature) to forest carbon (nature object) – are not necessarily chosen in pursuit of scientific virtues, such as objectivity or impartiality, but can be shaped by profit. As start-ups offering private measurement for nature restoration proliferate, in Scotland and elsewhere, scholars must investigate how environmental measurement is enrolled by private measurement companies to create financial value from nature restoration. 'Known not grown' offers a framework to build a body of critique – but like other work revealing how mitigation deterrence occurs, it requires further empirical evidence. Other potential cases of natural capital being 'known not grown' in the Highlands warrant further investigation. In Scotland, a voluntary carbon market for peatland carbon credits already exists, and there is growing momentum for blue carbon markets (in which carbon captured in marine ecosystems is measured and sold as carbon credits). STS scholars might investigate how AMTs are being enrolled by companies to increase the amount of carbon found in these ecosystems. Moreover, other natural capital commodities, such as biodiversity credits, are likely being known not grown by AMTs. For example, during my fieldwork a biodiversity accountancy start-up was developing eDNA sampling techniques to find traces of biodiversity in nature restoration projects. This also warrants further qualitative and quantitative research.

The insights developed within this chapter are important for understanding the increasingly

high-tech and privatised trajectory of environmental measurement and data production within Scottish environmental governance. As I outlined in the conceptual framework, scholars have long highlighted how ecosystems are reduced, fixed and simplified to make them amenable to governance at a range of scales (Robertson et al., 2023a). The exciting affordances offered by novel measurement technologies might ensure that ecosystems need not be so streamlined to be quantified and subsequently generate natural capital credits. The novel affordances offered by new technologies can broaden which translations become acceptable. Yet simultaneously, the reductive framing of forests as carbon or other forms of natural capital, which ecologists frequently cited in interviews as a key problematic in the financialisaton of nature restoration, is central in the creation of sophisticated natural capital verification.

Instead, a reductionistic framing of forests as reservoirs of natural capital, principally carbon, is presented as the increasingly scientific and rational mode of valuing and financing forests, rather than a specific, value-laden, and politicised intervention. This is the reason why Gabrys and her colleagues (2022) argue that forests' digitalisation through measurement sits as at the heart of an ontological politics: the reduction of forests-to-carbon and nature-to-natural capital continues, creating a cache of environmental data that allows forests to be governed according to their carbon value. Meanwhile, the production of this scientifically-robust data presents reductive forms of carbon-centric governance as the objective means of accounting for – and governing – forests. Other ways forests might be valued – ecological relations, ecological flourishing, biodiversity, aesthetics, biodiversity functionality, rare species, cultural importance, cultural heritage – which rewilders and community forestry groups often celebrated in interviews, might be overlooked in favour of technocratic accounting practices. This is a paradigmatic occurrence of the *society making performativity* I outlined in Chapter Two: technological developments legitimise, rather than destabilise, the hegemonic modes of framing and governing forests. Natural capital verification science is being funded ahead of, for example, the measuring and monitoring the ecological health and resilience of old growth forests. As progressively more scientists measure the carbon stored in forests and peatlands, these necessarily partial knowledge practices become understood as *the* expert-led, ostensibly politically independent ways that scientists know and value forests. Questions about whether market mechanisms should be pursued, or whether they even have the best environment making effects, are side-lined, given the intuitive notion that more science will usher in better restoration.

This chapter has highlighted the increasingly spectacularised ways that environmental measurement is performed in Scottish nature restoration. As I have shown, there is a growing focus on aestheticising the technologically advanced ways that representations of nature (data visualisations, maps, and so on) are generated. Generating ever-more sophisticated displays is one means of securing trust for a system of measurement, as well as granting legitimacy to the measurements it generates and the nature objects correspondingly produced. Understood in the terms of 'environmental performativity', appeals to different scientific and expert knowledges, alongside displays of proficiency with technical artefacts, are leaned upon to create ever-more convincing object making performances. These performances have corresponding environment making performative outcomes. Much like Chapter Five, this chapter has highlighted how a specific material-discursive assemblage employed in the object making performance is linked to a specific environment making performative outcome. The choice to use drones and remote sensing technologies simultaneously creates a convincing display of measurement expertise and creates now socio-political conditions for environmental change. The performative effect promised is a measurable increase in native woodland cover; as this chapter has highlighted, the performative outcomes which ultimately materialise might be different from the ones sold in the marketing material. Other scholars must similarly probe the ruptures between the reality being discursively described in environmental governance schemes and the ecological reality actually materialising. Whilst documenting this rupture between reality and representation has long been a focus of political ecology and STS research, this chapter has shown how working with conceptual vocabulary from the 'environmental performativity' framework can help elucidate the nuances of this process.

But despite the problematic dynamics which might emerge from cases of carbon being 'known not grown', society should not abandon faith in scientific interventions and improvements. McLaren (2020) argues that research and political interest in climate technologies should not be stopped despite their often-problematic usage. Instead, governments must design and develop these technologies wary of mitigation deterrence and the ways profit motivations co-constitute the development of technologies. Holly Jean Buck (2019) makes a parallel argument, suggesting that greenhouse gas removal technology development and governance should not be abandoned by critical voices because of its overwhelming capitalist usage. Instead, as Malm & Carton (2021) argue, the Left must seize and socialise the means of carbon removal. These arguments can inform a more emancipatory politics of environmental measurement in

Scotland, and in carbon forestry more broadly, as different actors beyond private companies embrace the opportunities offered by AMTs.

Whilst this chapter has traced the political and economic context in which environmental data is produced and used, there is no *a priori* link between AMTs and a specific market environmentalist regime. AMTs might be, as I described in Chapter Two, reworked to diversify what is measured, creating a cache of environmental data that does not lock-in a reductive, carbon-centric mode of valuing landscapes and financing their restoration. Their ambiguous but exciting political potential can be enrolled as part of a *disruptive performance*, creating forms of data that support alternative forest worlds. For example, when employed outside the natural capital framing, drone imagery and remote sensing technologies might identify pockets of ancient woodland that require restoration attention. As I argue in Chapter Eight, this could usher in a step change in how reforestation is performed.

Rather than focusing solely on measuring carbon stocks or other discrete ecological stocks that can be translated into natural capital commodities, AMTs might monitor ecological processes affecting the capacity of woodlands to naturally regenerate. For example, Forestry and Land Scotland have begun using drones mounted with thermal imagery cameras to track deer numbers across 1000 hectares of conservation woodland around Loch Katrine in the Southern Highlands. Following reports that increased numbers of deer were inside an enclosed area, FLS developed drone imaging techniques "to identify and monitor exact numbers in a bid to prevent damage to the regenerating young woodland" (Forestry and Land Scotland, 2022, n.p.). Remote sensing can produce accurate, in-situ data that can inform deer culling, ensuring that areas fenced off to allow woodland habitat to grow without deer browsing pressure can regenerate. More accurate data might also provide more scientifically rigorous evidence that links deer browsing pressure to stifled forest growth.

Closely unpacking the ways that AMTs are discursively framed also documents one way that technologies are increasingly entering the quotidian discourse of organisations who frame themselves as 'rewilding' or 'nature restoration' practitioners. As I argue in the following chapter, a spectacular, high-tech representation of metrological science is a crucial performance within the emerging culture of nature which I term 'technical wildness'. AMTs function as material symbols of technical expertise and are central to increasing intersection of rewilding and green capitalism. Ultimately this chapter has specified how scientific developments, and

the cultivation of scientific legitimacy, offer opportunities for accumulating financial capital. Principally, technologies operate along modernist tendencies, literally measuring more of what they are looking for and, in this case, by ‘finding’ more carbon. In the following chapter, I attend more closely to the ways that the allure of measurement expertise is put to work to not just *quantify* but to *qualify* carbon credits. In doing so, the following chapter unpacks the complicated ways science and measurement create value for woodland carbon credits.

7. Wild Carbon: Nature, Numbers, and the Emergence of Technical Wildness

7.1. Introduction: The Launch Party

November 2021. Cop26. We're in Glasgow, here to discuss climate breakdown and how to stop it. I head down a set of stairs into a bar hidden from street level. Upon entering, I'm greeted by a throng of about a hundred people. Friendly faces from fieldwork smile at me: a peatland restoration activist; a carbon accountant; the editor of a magazine about Scotland's native woodlands. We had met in varying levels of dirt over the last six months, in bogs, forests and conference halls. Other powerful people are instantly recognisable: the manager of a landscape-scale rewilding project; the CEO of a natural capital tech start-up; professors from the University of Oxford. Their faces, much like others in the room, are synonymous with rewilding, populating the middle pages of The Guardian, The Times and The Independent. Someone approaches me, slurring his words. He tells me he's bored of being at COP and oversees a multi-billion-pound fund that invests in fossil fuel companies. He points out other investors, telling me about their links to Chevron, BP and Shell – and their net worth. The power in this room is palpable.

The cluster of scientists, entrepreneurs, investors, estate owners and land managers in this tiny bar are, in many ways, the Highlands' emerging green elite. Their suits juxtapose the green and khaki worn by the ecologists, who look ready to slink away to the Highlands only an hour north of Glasgow. It's confronting, though perhaps unsurprising, to see patterns of the past playing out in the present: a small band of wealthy and powerful people, a large proportion of whom aren't from the Highlands or do not live there, are gathered to discuss how the Highlands can and should be managed rationally, following an 'expert-led' business model informed by cutting-edge science and economic principles. There's no mention of Balmoral, although King Charles would not, I expect, feel too out-of-place here. No tartan, kilts or bagpipes. Whisky has changed to wine. We're even eating vegan burgers.

We've gathered for the launch of Rewilding Scotland's first annual Natural Capital Report. The report's lead author takes to the stage. He explains that throughout 2021, Rewilding Scotland has run its flagship estate in the central Highlands as an open laboratory for cutting-edge natural capital verification science. The report is based on a year of initial surveying work, in which scientists, including volunteers, contractors and Rewilding Scotland employees, and a range of partner organisations, such as private measurement companies, conservation NGOs and leading universities, have studied the biodiversity and carbon stocks at Rewilding Scotland's privately owned estates. At one particularly memorable moment during the

presentation, I see an image of myself, head-to-toe in Gore-Tex, clutching a clipboard with pages fluttering in the wind. I had been collecting peat-depth measurements; data that I now see visualised in the presentation's highly sophisticated aesthetic register. Quantities are given for the estate's carbon storage and biodiversity stocks. Some of these, I realise with a sense of surprise, were generated using data I helped collect.

Then CEOs from natural capital measurement start-ups appear on stage, followed by Rewilding Scotland's founder-CEO, alongside professors from high-profile universities. We hear how science and technology offer drastic improvements in ecosystem measurement, allowing rewilding to be pursued in more rational ways whilst creating high-integrity natural capital credits that investors can trust. We hear that Rewilding Scotland has become a world leading hub for natural capital verification science. The images of science in action, of measurement technologies and representations of data, were distinct from the images of rewilding that I'm used to seeing, all misty mountains and gnarled trees. Although pine marten, red squirrels and other charismatic species are part of the presentation's visual assemblage, they are joined by drones, lasers and satellite images of Highland landscapes.

Throughout the presentations, I kept asking myself a set of questions: why was a for-profit rewilding company wanting to become a research hub for natural capital verification science? Was rewilding even measurable? And given the plasticity of the term 'rewilding' (Gammon, 2018), which version of rewilding was being performed here? Perhaps Rewilding Scotland were simply cultivating scientific authority which, as other STS scholars have shown, attracts investment and accumulates prestige (Tsing, 2000; Kuchler & Bridge, 2023). But as the evening continued, it became clear that a far more complicated business model was also playing out, concerning measurement, expertise, and carbon. This Glaswegian bar was, on this November evening, the epicentre of what I term 'technical wildness', an emerging culture of nature growing in prominence in Scotland's land sector which I briefly outlined at the end of Chapter Three. Rewilding organisations, especially new private companies, are developing a combination of discourses to develop a narrative that the best way to realise a wild, authentic, and flourishing Highland ecology is to trust markets, metrics, and technical experts. High-value, high-integrity 'wild carbon' credits are one central commodity which emerge through emerging culture of technical wildness. In the terms of environmental performativity, wild carbon credits can be understood as nature objects produced through an object making performance. They are performed through sophisticated branding techniques and carefully

curated displays of technological expertise, convincing external stakeholders of the ecological gain which they represent. As I hinted at the end of Chapter Four, technical wildness smooths the tensions between romanticism's pursuit of the wild and modernity's pursuit of profit. In the chapter that follows, I unpack how rewilding organisations, including Rewilding Scotland, create wild carbon credits through a range of performative techniques, selling the dream of the technical wild.

7.2. The Voluntary UK Carbon Market

The two previous chapters have examined how carbon credits are *quantified*. They have revealed how a range of epistemic practices make carbon 'the same' (MacKenzie, 2009) across (and in spite of) different geographical, temporal and material states (Carton et al., 2021). But there is a tension at the heart of the UK carbon market: despite the need for equivalence and fungibility, carbon credits in Scotland are *not* the same. They sell for vastly different prices dependent on their *quality*. Telling the story of carbon quantification alone does not capture the political economy of the UK forest carbon market. As I reviewed in Chapter Two, carbon credits are differentiated from others on the market, in the process Michel Callon describes as '*qualification*', as sellers generate the financial value of a product through performing its qualities (Callon et al., 2002). Alongside the intrinsic elements of a good (in this case, the amount of carbon sequestered), a product's qualities "may also be brands, packaging, or special recipients, particular sales conditions such as location, seller's reputation or personal relations between the salesperson and customers" (Callon et al., 2002, p. 200).

There is no functioning biodiversity credit market in Scotland.[53] The market value for ecosystem restoration must therefore be nested within the price of a carbon credit. Characteristic of the voluntary carbon market, in which companies are not obliged to purchase carbon credits but do so voluntarily, selling 'charismatic carbon' (Wang & Corson, 2015) that has a unique story is vital for creating a higher value carbon credit (Valiergue & Ehrenstein, 2022). As I outlined in Chapter Two, scholars have highlighted that most charismatic carbon schemes are based in the Global South, with purchasers based in the Global North (Valiergue & Ehrenstein, 2022). In contrast, the producers and purchasers of carbon credits from Scottish

[53] Although there is a biodiversity offset market in England, and most interviewees were acting on the assumption that it will arrive in Scotland too. I describe this at further length in the Conclusion.

rewilding projects must be registered in the UK.[54] Instead of creating generic social or green benefits in the Global South, in the Scottish voluntary carbon market, there is also an ecological authenticity which is central to the creation of high-quality woodland carbon credits. Many interviewees explained that carbon credits which promise the creation of *wildness* can warrant a premium, often double or even triple the standard market rate for Pending Issuance Units (PIU).

This chapter offers an answer to my third research question, ***how do rewilding organisations create a premium carbon credit?*** I focus on how 'wild carbon' is generated. 'Wild carbon' is both a users' term (interviewees referred to wild carbon during fieldwork) and an analytical category. When I asked for clarification of the term, one experienced carbon broker gave me a helpful explanation:

> "[Wild carbon] is selling the idea that, that as well as carbon, you're purchasing ecological restoration or that ecological restoration is happening as part of the woodland creation they're engaging in. You're sort of seeing the value of that nesting in ecosystem service, translating through to a higher price for the carbon, which you might think of as the anchor ecosystem service."

My argument in this chapter builds from Callon's premise that it is not the essential qualities of a product – in this case, a carbon credit – that make it more or less valuable. Instead, these qualities and thus a credit's value are continually constituted through ongoing object making performances. This chapter shows how rewilding organisations differentiate themselves and the carbon credits they sell through variably performing three qualification processes, which they differentially weight. I term these *ecological aesthetics*, *trust in numbers*, and *spectacular science*. After showing how these are performed through two case studies, I identify the emergence of '*technical wildness*', a marginal culture of nature growing in prominence in the Scottish rewilding sector. Seemingly incommensurable environmental ontologies and their associated epistemic regimes are integrated in the creation of wild carbon. The conclusion

[54] UK carbon credits accredited by the Woodland Carbon Code can only be sold to offsetting organisations based in the UK. This policy allows the offsets to be included within UK national carbon accounting. It also narrows down the range of organisations purchasing carbon credits in the UK.

speculates about problems associated with technical wildness and spells out the wider implications of the rise of wild carbon in other geographical locations and markets.

7.3. Qualifying Carbon

Some rewilding organisations have successfully sold wild carbon for a significant premium. Andrew, the conservation manager for Caledonian Canopy, a rewilding charity, told me that the carbon credits sold from his organisation's woodland creation projects had warranted £25 per PIU, which is a marked increase from the average £10-£15 per PIU from other WCC-accredited projects. Andrew described these credits as "sexy carbon… accredited carbon with our rewilding biodiversity story around it". Offsetters trusted Caledonian Canopy's story because of their brand and their carefully curated "reputation as ecologically and socially minded – in actually delivering and doing something that's truly relevant to what public policy wants and what all this society talk is". Andrew explained that embedding the story of ecological regeneration into the credits was largely done through qualitative means. "Honestly, it's just kind of based on the principles of creating habitat and that's good for wildlife and good for connectivity," he explained. "There's no actual measurement of it." A project became understood as ecologically valuable through telling, and selling, "this idea, of 'this is genuine restoration' [and] that will get you what we think is a high price in the market". Purchasers of wild carbon credits do not *see* the multiple benefits associated with the woodland creation projects for themselves. Unlike the WCC's standardised and state-backed system for verifying the *quantity* of carbon credits, the *quality* of woodland carbon credits is generated through a more complicated, nuanced performance of storytelling, marketing, and branding. For Andrew, the reason why Caledonian Canopy had successfully sold charismatic credits was their "brand value… because we are who we are. That's part of what attracts buyers to us." But how to create a brand if you are a new rewilding organisation?

David Lansing (2012) describes how organisations must continually *perform* a carbon credit's materiality, through the production of brochures, spreadsheets, fences, and other material-discursive artefacts. Without these props, carbon forestry operators would struggle to convince the purchasers of carbon credits that their investments are legitimate and linked to actual carbon sequestration within forests. Similarly, Alice Valiergue & Véra Ehrenstein (2022) stress that carbon credit producers must continually convince the purchasers of 'high-quality' carbon credits of their more-than-carbon value. Based on interviews with carbon brokers and natural

capital organisations, I suggest there are three qualification processes that perform a woodland's 'wild carbon' value in Scotland. These categorisations are by no means exhaustive but were central qualification practices enacted by several of the organisations I spoke with in Scotland.

Ecological Aesthetics

The first qualification process involves employing spectacular visual storytelling to depict an ecologically flourishing Highland nature. Culturally significant symbols of Highland ecology are circulated to signify the ecological commitments of a rewilding organisation. This qualification process follows a well-established trend in conservation, which involves constructing a spectacular representation of wild nature to secure financial investment (Damiens et al., 2022; Sullivan, 2012). "Certain landscapes, species, and people" are, as political ecologist Charmaine Jones highlights, "most highly valued in the process of creating brands" (2012, p. 256). Likewise, geographer Amelia Moore (2019) notes how these carefully curated constructions of nature can function as a branding exercise, creating a link between a landscape imaginary and a rewilding organisation. Spectacular visual and written discourse, circulated in booklets, webpages, marketing material and social media, link an organisation's brand to the apparent wildness facilitated by an organisation's practices. They perform its commitments to ecological flourishing.

Click onto the homepage of the private rewilding company Rewilding Scotland, and the visual field is dominated by six images of its estates, which fade in and out every few seconds. The image slowly sweeps, emulating a bird's-eye-view of the landscapes, similar to Figure 56. First, we see a rocky outcrop of green farmland, jutting into the ocean with mountains rolling towards the horizon. Next, we see a river running through a forest of native broadleaves. Then two images of healthy-looking wetland, flanked with native trees. Finally, two images show a mosaic of forestry, farmland, and native woodland. Classic images of the Highlands – forests, lochs, blue skies, mountains – dominate the visual field.

On the homepage of rewilding NGO Caledonian Canopy, it's a similar visual story, with timelapse imagery and slowly moving drone footage displaying beautiful views of the Highland landscape. Hovering on the homepage, a new image appears every couple of seconds. Alongside the sweeping views of landscapes, we see plenty of mountains, individual gnarled pines, stands of native trees, and charismatic animal species such as beavers, eagles, red

squirrels. The visual language employed on the two websites is remarkably similar and reflects a common visual discourse used by a range of rewilding organisations.

Figure 56. A classic 'view from above' of the Highland landscape.

This image is similar to the visual milieu found on the homepages of Rewilding Scotland, Caledonian Canopy and other rewilding organisations.[55]

[55] To pseudonymise my research participants, this essay uses images taken by myself and the artist Kati Karki (used with permission). They are representative of the types of imagery common in rewilding marketing material. However, their washed-out, film-camera aesthetic slightly contrasts to the glossy, high-resolution imagery commonly found on rewilding organisations' websites.

Figure 57 Sunset at the Black Forest of Rannoch, one of the largest Caledonian pinewoods left in the Highlands.

This is a classic image drawing on the 'ecological aesthetic'. The trees are tall, the sky is blue, and there is little evidence of human intervention into the landscape.

Characteristic of the visual milieu employed by rewilding organisations, on Rewilding Scotland's and Caledonian Canopy's homepages, no humans are in sight.[56] Most of these images represent a wilderness, the "ultimate landscape of authenticity" (Cronon, 1996, p. 16), the natural antithesis of settled, humanized landscapes. These images share visual prompts with the romanticised landscape aesthetic that has dominated the cultural imaginary of the Highlands since the nineteenth century (H. Lorimer, 2000), which I outlined in Chapter Four. They resemble Scotland's romantic landscape paintings, such as '*A View of Lochnagar*' (Figure 10), which capture 'the sublime', the awe-inspiring and overwhelming grandiosity of Nature (Gandy, 2022, p.108). But despite sharing visual cues (landscape-scale; view from above;

[56] Although people do feature in other pages of the website.

Nature’s beauty), the ecological composition of the wilderness depicted stands in contrast to the wilderness central to what Fraser MacDonald calls the “Victorian Highland myth” (2023, p. 10). This is not the treeless heather moorland that has long been considered the “authentic” wilderness in Scotland (Deary, 2015), normalised through the landscape paintings of the nineteenth century and reproduced on whisky bottles and shortbread tins.

The novel imaginary depicts an *ecological wilderness*, largely concerned with representing the now-mythologised ancient Caledonian Forest, which, as anthropologist Matthew McMullen (2019) notes, has been central to the discursive framing of the Scottish rewilding movement. The place of trees is not solely the quaint grounds surrounding the castle, as in ‘*A View of Balmoral*’ (Fig 10); trees are the foregrounded protagonists in the landscape aesthetic. Images depict flourishing-appearing forest ecosystems, principally old-growth native woodland, as well as flooded peatland and the communities of nonhuman species that live within these ecosystems. The visual vocabulary for this ecological aesthetic is common across websites and brochures and largely follows a well-defined template. Images employ classic tropes: forests at the feet of the Highlands’ characteristic mountains; gnarled pines standing proud. The ecological imaginary draws on a similar visual discourse to the ‘spectacle’ (Igoe et al., 2010) of nature common in nature documentaries, in which affect-laden imagery devoid of humans creates emotive responses in viewers (Louson, 2018). These spectacular representations of nature, as Mike Goodman and his colleagues note, “work to frame affect as much as they do cognition: they are designed through visual means, to get our attention and pique our environmental imaginaries in ways that work to get us to feel, to connect and to ‘do’” (2016, p. 681).

Figure 58 Large stand of old-growth pines in Loch Arkaig.

Images such as this are common across the websites of rewilding organisations. Note the bald hills on the far side of the glen. Source: Kati Karki

As is common in conservation organisations' visual discourse (Barua, 2017; Sullivan, 2012), a spectacular visual representation of nonhuman life is fundamental to the representation of an ecological wilderness. Across the marketing and website material for rewilding organisations, images of Scots pine, Scotland's national tree, dominate. They function as a charismatic species, symbolising the ecologies within which they dwell, functioning as a digestible synecdoche of environmental protection (J. Lorimer, 2007). Images of capercaillie,[57] beavers, golden eagles, and red squirrels, as well as the locally extinct lynx, often feature too. These images function as part of a performance of ecological expertise, signalling to potential investors of the ecological commitments and knowledge held by the rewilding organisation, which they materialise through their forest creation projects. In Charmaine Jones' terms (2012) Scots pine are the most highly valued species in securing the brand of a rewilding organisation. They replace the charismatic stag as emblematic of the desired Highland wilderness, hinting towards the novel ecological imaginary associated with rewilding.

[57] The CEO of one of Scotland's largest rewilding organisations told me that capercaillie were central to their 'ecological narrative' in selling charismatic carbon.

Figure 59 Charismatic Scots pines. Source: Kati Karki.

Political ecologists Paul Robbins and Alistair Fraser argue that Scottish conservationists have historically drawn on "the moral value of trees – specifically indigenous trees" (2003, p. 110) in creating value for their work. In particular, Scots pine's role within the national identity is used in efforts that involve "appealing to the normative imagination of how the Highlands ought to appear" (2003, p. 112), leveraging support and state funding for woodland creation. Images of pines (such as the image on the front page of the thesis) – alone, weather-beaten, surviving – contribute to their sense of nonhuman wildness, triggering emotional and affective responses in humans. By leaning on a technique steeped in the romantic tradition of Scottish land aesthetics, rewilding organisations invert the register with which carbon credits are sold and marketed. They are not the manifestation of ecomodernist dreams; they are not the *same* as the carbon credits that have been extensively critiqued in the media for legitimising continuing greenhouse gas emissions. The visual frame contrasts to the accountancy spreadsheets commonly used by the Woodland Carbon Code (WCC), to create an implicit distinction between the forests created through rewilding and other forms of forestry.

Trust in Numbers

The second performance which qualifies wild carbon is the mobilisation of what Theodore Porter (2021) terms 'trust in numbers'. As I described in Chapter Two, numbers have a disproportionate social as well as epistemic value in governance regimes, capable of convincing publics of the expertise with which environmental management has been pursued (see also Daston & Galison, 2007). Eric Nost (2022) highlights how narratives which discursively privilege quantification can frame environmental governance interventions as the outcome of impersonal, science-led, decision-making. In Ingmer Lippert's (2015) terms, the seemingly depoliticised nature of numbers helps in performing the reality of carbon accounting. Numbers about carbon and biodiversity uplift, generated through sophisticated measurement techniques such as the AMTs we encountered in the previous chapter, grant a compelling sense of epistemic realness to truth claims about ecological gain. The normative value of these schemes is proven impersonally and *objectively,* which allows rewilding organisations to create a digestible story about ecological uplift within woodland creation projects. Cold, hard numbers function as signifiers of technocratic reason. In interviews, carbon brokers, rewilders, and foresters often stressed that generating convincing numbers allowed the benefits of woodland creation and rewilding to be communicated to investors or consumers with little ecological knowledge. Just as architectural theorist Rosetta Elkin (2022) forewarns in her study of afforestation politics in rural China, increasing the number of trees planted – a metric which

is easy to measure and communicate – was often described by Scottish foresters and carbon brokers as loosely equivalent to 'restoring nature' or 'improving biodiversity'. Forest growth, measured in terms of hectarage covered, the number of trees planted, or the amount of carbon sequestered (calculated by the WCC), operated as simple yet communicable metrics of ecological benefit, especially when it is native trees being planted.

Mark, a natural capital accountant, pithily explained there were two reasons why land managers might undertake natural capital measurement. "To create the evidence-base to create natural capital income and the other is to create the story, actually the stories you want to tell.... why are you creating that data? Income or story." Multiple interviewees stressed that numbers can be understood by businesspeople, even if, as one rewilding executive put it, they "didn't know their beech from their birch". Rewilding, in all its messy complexity, can be made understandable through quantification. For example, one landlord on whose estate natural capital verification technologies were being developed argued that numbers were important for helping "to engage people in ways that they understand and that they can relate to... like proving there's more biodiversity or carbon". Multiple interviewees made a similar point: that business-minded people funding rewilding through carbon credits like to have the certainty of returns from their investments, and producing numbers is the best way to satisfy this demand.

In another interview, the CEO of a native woodland conservation charity explained that generating numbers about trees planted and carbon sequestered resonated with employees at an oil company which was one of the NGO's main donors. Oil company engineers could understand what the company was contributing to and "could be proud" it was investing in nature restoration, even if they did not particularly care for the conservation of specific species or habitats. Ironically, perhaps, the CEO told me he did not believe the numbers his charity circulated were accurate (for many reasons, especially because of the uncertainty in soil science, as outlined in Chapter Five).[58] But despite his reflexivity and his informed scepticism, he used these numbers as a marketing technique because of their rhetorical appeal. Having been generated by the WCC, a state-mandated metric, they were legitimate *enough* to circulate as facts and had a clear performative value in securing trust and financial investment. Much like

[58] This included the claim that their native woodland creation projects were forecast to capture over 200,000 tonnes of carbon by 2080, which had been calculated using the WCC's Carbon Calculator spreadsheet.

other charismatic carbon schemes, representation and reality were likely highly different; but these convincing numbers could contribute to an ongoing performance of legitimacy, bringing assurance to purchasers of credits that they realise more-than-carbon benefits. The value of the nature objects created – in this case, the high integrity carbon credits – were performed with this quantitative narrative.

During my fieldwork period, the drive to measure the ecological benefits of woodland projects was noticeably intensifying. Several companies I spoke with were developing complicated, integrated ecological metrics that promised to objectively quantify the *overall* ecological value of a woodland creation project, including carbon, biodiversity, water retention and other ecological processes. These metrics, commonly referred to as 'eco carbon metrics' or 'wild carbon metrics', are designed to capture the complexity of ecological restoration, objectively synthesise the data, and communicate ecological gain in simple quantitative terms – often in one digestible number. In theory, at least, with the numbers generated from these wild carbon metrics it becomes epistemically possible for non-experts to weigh up ecological complexities with little to no previous ecological understanding. Multiple elements of the complexity of rewilding is internalised and can subsequently be integrated into the market price of a carbon credit, thus creating a legitimate verification tool for the ecological *quality* of a carbon credit, similar to the WCC's tools for verifying carbon quantity.

Emma, a forester who worked for a private rewilding company developing a wild carbon metric, expressed her frustration that setting the price for a charismatic carbon credit with an ecological story was largely "based on nothing, on a market price, on what people are willing to pay, rather than anything real". She was concerned that, her company "felt like we didn't have anything to say on why the carbon was that price". In her terms, it calculated a project's "real" ecological value – and subsequently, a "realistic price". She admitted creating this metric was "really complicated" but maintained that,

> "There are things we know that are happening that have ecological benefits from these woodlands, and if we can just find a way to measure that and explain it to people, we can tell the stories because we know these things. *It is basically about taking carbon and creating a story around it, and making it interesting*, because people don't want to buy something that's only about negativity." (Emphasis added)

The wild carbon metric's apparent objectivity is crucial for communicating tangible ecological benefits for highly numerate consumers, such as offsetting business. Emma speculated that her organisation's carbon credits would warrant a premium if the full range of ecological benefits associated with rewilding were successfully quantified. "People will be willing to pay that if they know why [a credit costs more]. We aren't just reflecting the market. It's a bit more scientific – semi-scientific rather than scientific… [the metric] just gives us a reason why we got to that figure." Sophisticated measurement and accurate numbers, here, are central part of the object making performance*,* functioning to create a believable and convincing story about ecological gain.

As I described in Chapter Two, employing quantitative and metrological techniques also signify an organisation's scientific, ecological, and financial understanding, part of what Kärg Kama describes as the "continuous investment" (2016, p. 845) of practices, efforts and discourses through which technical expertise is made and remade. Numbers' apparent precision, as Nost explains (2015), exemplifies the intricate ecological knowledge held by an organisation, whilst flagging the scientific and technical credentials that guide an organisation's rewilding efforts. Simultaneously, it reflects their understanding of natural capital markets, which demand precise measurement to make verifiable products (McElwee, 2017). Many carbon brokers told me that offsetting companies want to purchase credits from an organisation they can trust. The scientificity of this number-heavy technical discourse appeals to offsetting companies who want highly credible proof that their investment has realised ecological gain.

For this reason, several interviewees I spoke with saw wild carbon metrics – if they proved possible to develop – as potentially transformative for scaling up private finance into rewilding. The private sector could understand nature restoration in their own quantitative terms, and subsequently invest in it. As the CEO of one rewilding charity put it, "wild carbon metrics are the holy grail" for creating convincing, understandable, scientifically legitimate claims about the multiple benefits of nature restoration or forest creation. But he, like other metric designers or ecologists developing metrics, was hesitant about their feasibility:

> "It [measuring rewilding] becomes multifaceted beyond carbon, including biodiversity. We have spoken to 15 companies who all say it [a wild carbon metric] is possible through GIS or eDNA techniques, but nobody has done it yet. I'm still not convinced it is possible…

Rewilding is multifaceted, so many variables. How do you condense that down into a neat package? If someone does that, I'll take my hat off and we'll be all over it. I'm still not convinced it's possible."

The CEO hinted towards the ongoing tension within efforts to measure rewilding. For (most) rewilders, rewilding's value far exceeds any reductionistic measurement (Monbiot, 2014). As geographers Jamie Lorimer and Clemens Driessen (2014) note, for European scientists developing the ecological principles of rewilding, the value of rewilding projects arises from discovering which unplanned or accidental ecologies might emerge when more-than-human dynamics change. Rewilding can be celebrated as a 'wild experiment', a step into the unknown, where the expectations of what should be pursued are relatively uncertain and the value of projects is unclear. In rewilding, when so many facets of the material world are potentially valuable, especially as ecologies grow in surprising ways, a wild carbon metric that successfully captures this variability, and reduces it into a single, digestible number, seems an apparent epistemic impossibility. As I argued at the end of Chapter Five, a metric would seemingly require fixing a reductive framing of what 'counts' in assessments of ecological gain, which would perhaps curtail the chances for surprising ecological dynamics to be quantified (Cooper, 2015; Robertson et al., 2023a). But without a functioning wild carbon metric which can maintain legitimacy in a tense political atmosphere, developing the trust in numbers necessary for a convincing performance of technical expertise appears (potentially fatefully) difficult. I return to this tension at length in the following chapter.

Spectacular Science

It is not necessarily the cold, hard, impartial numbers generated through measurement techniques that signify an organisation's expertise and perform the value of a wild carbon credit. For wild carbon, a *spectacular* performance of scientific expertise and environmental measurement also functions as part of the qualification process. As other STS scholars have highlighted, sophisticated displays of technological prowess are a common means for securing investment and scientific authority (Kuchler & Bridge, 2023), especially within climate governance (Markusson et al., 2017). In Scotland, natural capital verification companies operate within what Anna Tsing describes as the 'economy of appearances' (2000), developing impressive technologies as part of a dramatic performance capable of leveraging notoriety and securing capital. These displays of technoscientific prowess, as Robertson, Lave and Doyle highlight (2023b, 2023a), combine with flauntings of objectivity and ethical neutrality, and the

production of reports and publications, to perform technical expertise. Rewilding organisations exemplify their nuanced scientific (ecological, economic, climatic) expert knowledges, which implicitly reveal the sophistication with which they manage land and create ecological benefits.

Private measurement companies, such as the Advanced Measurement Technology (AMT) developers described in the previous chapter, draw on spectacular representations of natural capital verification and measurement to develop their brand as cutting-edge experts in nature restoration. As political economists Heather Lovell & Donald Mackenzie (2011) highlight, being the initial developers of a technology or system of environmental accountancy can confer expertise to an organisation. Through bringing together several leading start-ups, and producing synthesised reports and presentations, Rewilding Scotland have been able to perform a highly convincing performance of technical capacity, signifying the scientific credentials on which their land management is based. Throughout my fieldwork, the natural capital measurement ongoing at Rewilding Scotland's estates was displayed in multiple ways: in presentations, newsletters, websites, reports, TV shows, and social media content. The vignette which this chapter began with is a compelling example of how their natural capital verification science was spectacularly mediated. The audience heard presentations from the CEOs of Rewilding Scotland's partner environmental measurement companies, including a company that measures environmental DNA (eDNA) – the nuclear or mitochondrial DNA released by organisms into the wider environment – to inform biodiversity accountancy. The audience also heard from developers working with remote sensing technologies for measuring forest carbon, whilst another CEO explained how satellite imaging can measure how peatbogs "breathe" and that his company can use this data to quantify seasonal carbon fluctuations in peatlands. Across these presentations, the audience saw beautiful images of landscapes from above, showcasing the beyond-human modes of vision that these companies have access to for measuring, monitoring, and understanding environmental dynamics.

Figure 60 Drone mapping at Rewilding Scotland's estate.

In an interview, Max, the CEO of Rewilding Scotland, described how the scientific measurement and employment of high-tech natural capital verification science ongoing at their estates functioned as a means of leveraging the company's brand value. The ongoing scientific work differentiates Rewilding Scotland from other private land management consultancies developing platforms for natural capital, which provide integrated land management services, offering landowners everything from forest and peatland management plans through to the brokerage of natural capital credits, as well as linking together several natural capital measurement companies. Max suggested that the scientific work was particularly important in Scotland as "everyone and their dog is trying to platform natural capital", alluding to the preponderance of new natural capital start-ups in the country.

Working in close collaboration with research scientists and private companies, Rewilding Scotland have developed an extensive scientific project for verifying natural capital. I asked Max about "how you're balancing producing science and knowledge [with] producing returns for investment". I asked if "there [is] a level of presenting the investment [into scientific research] as a philanthropic investment?". Max insisted to me that his investors would "spit the dummy" at any suggestion that investment into Rewilding Scotland's natural capital verification science was philanthropic. It was financially motivated. Developing improved natural capital verification and measurement was part of a future-facing business model, which

Max described:

> "I mean, obviously it's difficult to find where [science] fits on the balance sheet. If it's all down to P[rofit] and L[oss], then you'd be pruning all the science you do left, right and centre. You can't do that because you're trying to become an internationally acknowledged centre of excellence. Um, so, you know, we were trying to drag in as much grant income we can in the early years. We'll, yeah, we'll take risks with the science, but of course the flip side of that is the brand value and you could argue, we spent a hundred thousand pounds on science for that report and look at what it bought us in visibility, and brand value. It's an intangible asset on the balance sheet."

Earlier in the conversation, I had suggested that Caledonian Canopy had a "rewilding stamp" to differentiate their carbon credits from other organisations. I asked Max whether there had been a move towards creating a Rewilding Scotland "stamp". He replied that Rewilding Scotland had "developed brand value, as the business heads call it, simply because we seem to be where we want to be, which is right on the cutting edge of natural capital verification science". This, he hoped, would be reflected in the price of their natural capital credits, qualified and differentiated from other credits available on the market. The credits will be "Triple-A rated, gold-plated, verifiable credits" because of the high-tech measurement that verified them. In Max's terms,

> "[Buyers] will be hopefully queuing up to buy them both because they're rock solid verified. And they're [Rewilding Scotland] credits… That's what people under brand ['Rewilding Scotland'] will be working with."

As part of this spectacular representation of science and measurement, organisations can also integrate the brand value of the scientific institutions they are associated with into their own brand, pulling on what anthropologist Constantine Nakassis calls the "brand essence" of high-profile collaborators such as research scientists from prestigious universities. Excellence, reason, and justice – associated with scientists working at universities – can be assimilated into the rewilding organisation's reputation. This chimes with Goodman's (2010) research, which highlights how harnessing the brand value of celebrities has long been a performative intervention in qualifying 'high-quality' consumer goods, such as Fairtrade food products (see also Brockington, 2009). In Scottish nature restoration, drawing on the brand value of certain

individuals and organisations is similarly crucial in selling a high-quality product – but it is scientists and their affiliated organisations, rather than celebrities, who provide the much-needed epistemic legitimacy in the creation of wild carbon.

For example, the Rewilding Scotland website lists their high-profile collaborators. These include several prestigious universities (including the University of Oxford) as well as AMT companies, state departments, and an international conservation charity, which brings scientific legitimacy to Rewilding Scotland's work. The brands of these scientific institutions function, in part, as "performative citations" (Nakassis, 2012, p. 635) that link otherwise separate organisations. The performance convinces external parties that private natural capital companies, ecologists, and research scientists operate within the same political and epistemic framings of nature restoration, operating as part of a science-led project, independently of economic and political concerns.

In fact, the prestigious allure of the University of Oxford brand was almost inescapable during my fieldwork. As I explained in Chapter Four, I was headhunted by a new rewilding start-up who were developing natural capital verification technologies. The company's CEO told me that I was appealing to the company specifically because of my brand as an Oxford researcher. At another moment, members of my research group, including my own supervisor, were invited to work with one of the private companies I was researching. Other companies listed the University of Oxford on their website as a scientific collaborator. At multiple site visits, I was pointed to forests or peatlands that had been mapped and monitored by scientists from the University of Oxford. The performances of spectacular science in Scottish natural capital verification highlight an emerging trajectory in how charismatic carbon is qualified. It is not only ecological benefits which are widely circulated in marketing material. Measurement technologies, and representations of how they are used and who use them, are loaded with their own charismatic appeal in the creation wild carbon.

7.4. Differential Weightings

Rewilding Scotland offer a compelling example of a private rewilding company that employs the three qualification processes I have outlined. Romantic ecological aesthetics tell a convincing story of ecological uplift; this visual imagery sits alongside a performance of scientific authority, which emerges through a strategic use of symbols, discourses and visuals

that signify their expertise. They appeal to cold, hard numbers, and spectacularly represent the advanced scientific knowledge that underpins their land management and generation of natural capital. Together, these discourses perform Rewilding Scotland's proficiency in protecting and restoring nature, understanding its complexity with a range of scientific and measurement techniques, and analysing its potential financial, ecological, and natural capital value with sophisticated technologies and quantitative methods. As I detail further below, they reconcile elements of the Romantic and the Modern.

Anthropologists Frank Heuts and Anne-Marie Mol (2013) highlight that the value of any product – even the most everyday product, such as a tomato – is communicated in different registers for different consumers. The same, as Valiergue & Ehrenstein (2022) highlight, is also true for carbon credits. In the Scottish wild carbon market, the three qualification processes I outlined above are given differential amounts of emphasis by rewilding organisations, who create their own brand and market niche to appeal to different consumers. To highlight the variable ways these qualification processes can be emphasised, this section shows how another private rewilding company, Zulu Ecosystems,[59] variably weight the qualification processes.

Zulu Ecosystems, formally known as Zulu Forest Sciences, provide a different prioritisation of discursive aesthetics, epistemic practices, and storytelling techniques to qualify their carbon credits. They are a private woodland and peatland restoration project developer, whose website states that their "services span the entire value chain: land origination, project design, deal structuring, implementation, measurement, reporting and verification, as well as arrangement of offtake agreements and introduction of capital" (Zulu Ecosystems, 2024, n.p.). They design and deliver ecosystem restoration schemes[60] for landowners, measure and monitor the project in real-time, and generate high-integrity natural capital credits. Their online platform "combines rigorous science with high-resolution satellite imagery, remote sensing, and land analytics to baseline any area of interest and evaluate the suitability of a range of natural capital opportunities – in minutes" (Zulu Ecosystems, 2024, n.p.).

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[59] N.B. Zulu Ecosystems is not pseudonymised. Website images are available in the public domain and no direct interview quotations have been used in the analysis.
[60] They use the term regeneration and ecosystem restoration rather than rewilding on their website homepage.

Zulu Ecosystem’s website homepage is demonstrative of their mix of qualification processes and discourses. When you first land on the homepage, four images circulate. They replace each other every two seconds. The first image depicts a brown, treeless moorland, symbolic of an ecologically degraded Highland wilderness. It remarkably resembles the moorland depicted in ‘*A View of Lochnagar*’ by James Giles (Figure 10), which we saw at the start of Chapter Four, but without deer haloed in the light.

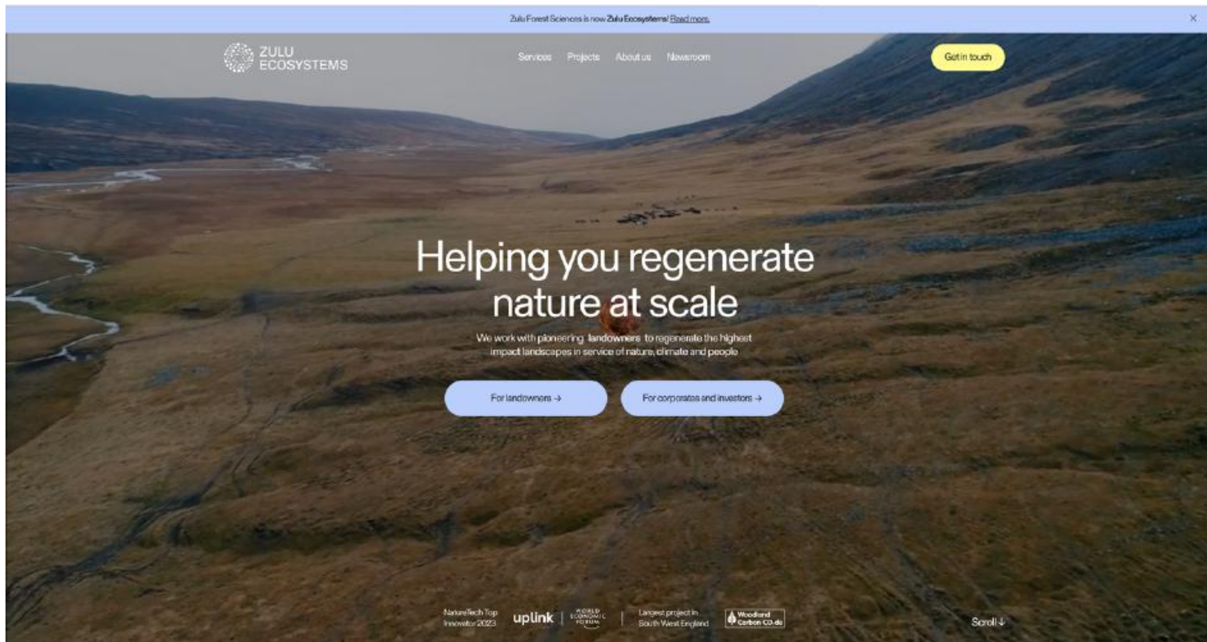

Figure 61 Zulu Ecosystems Homepage (2024). N.B. The following images all come from the same source.

Then an image characteristic of the *ecological aesthetic*, which depicts an expansive and diverse native woodland, swells and replaces the moor. The steady expansion of the new landscape figuratively conjures a sense of steady ecological regeneration and symbolises the shift in wilderness imaginaries that I identified above. The forest’s diversity is represented by the array of autumnal colours that wash across the landscape, a striking contrast to the homogenously brown moorland of the previous image. Both images are shot from a wide-angle by a slow-moving drone, helping to build a sense of the landscape-scale operations that the company undertakes.

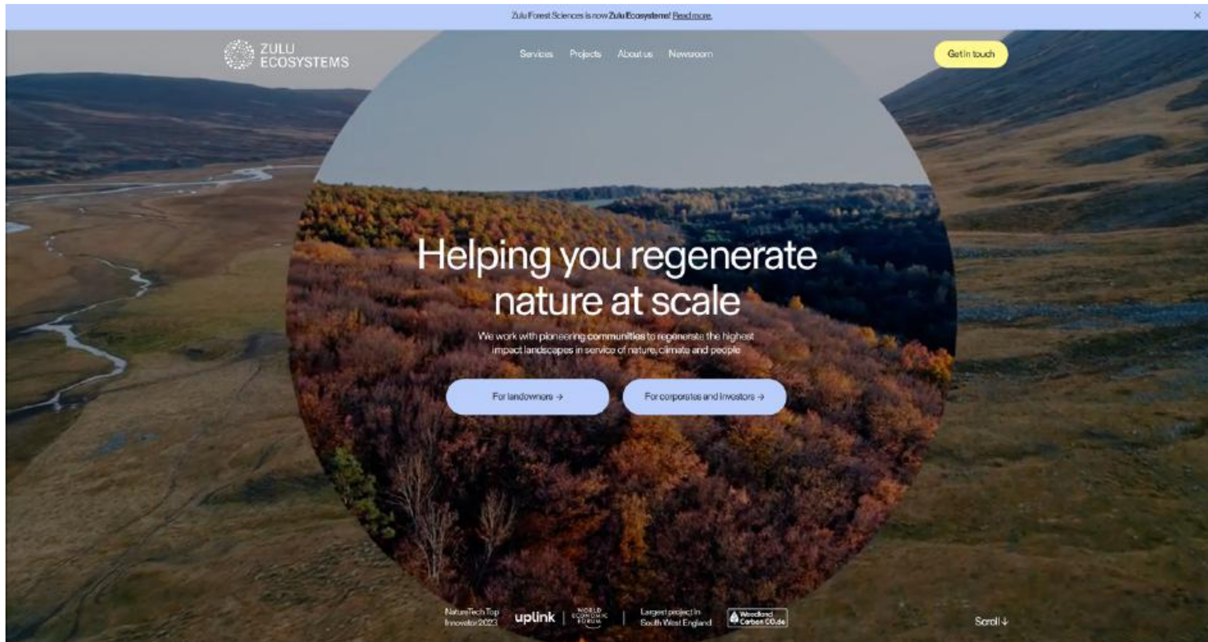

Figure 62 A steady shift from degraded peatland to diverse native woodland is captured by the image transition, which swells from the centre.

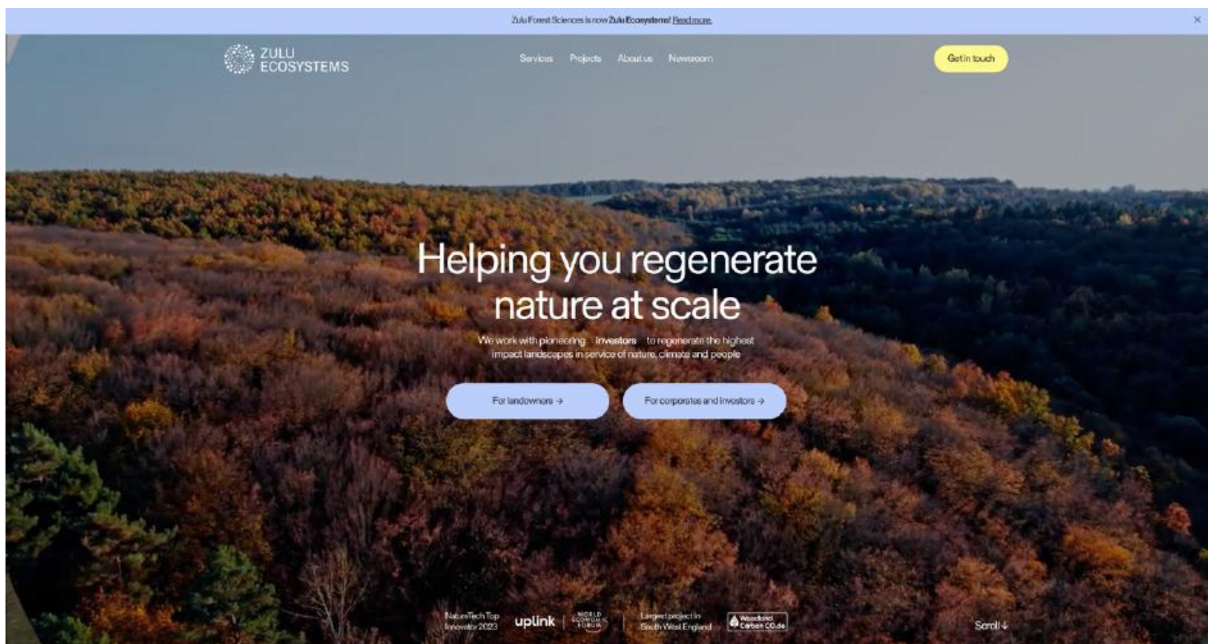

Figure 63 Images of a seemingly endless native woodland is characteristic of the ecological aesthetic.

A few seconds later, an image of a flooded, healthy peatland appears, with birds flying over the screen. It's a flourishing habitat, the normative ecology pursued in peatland restoration (which also generates carbon credits).

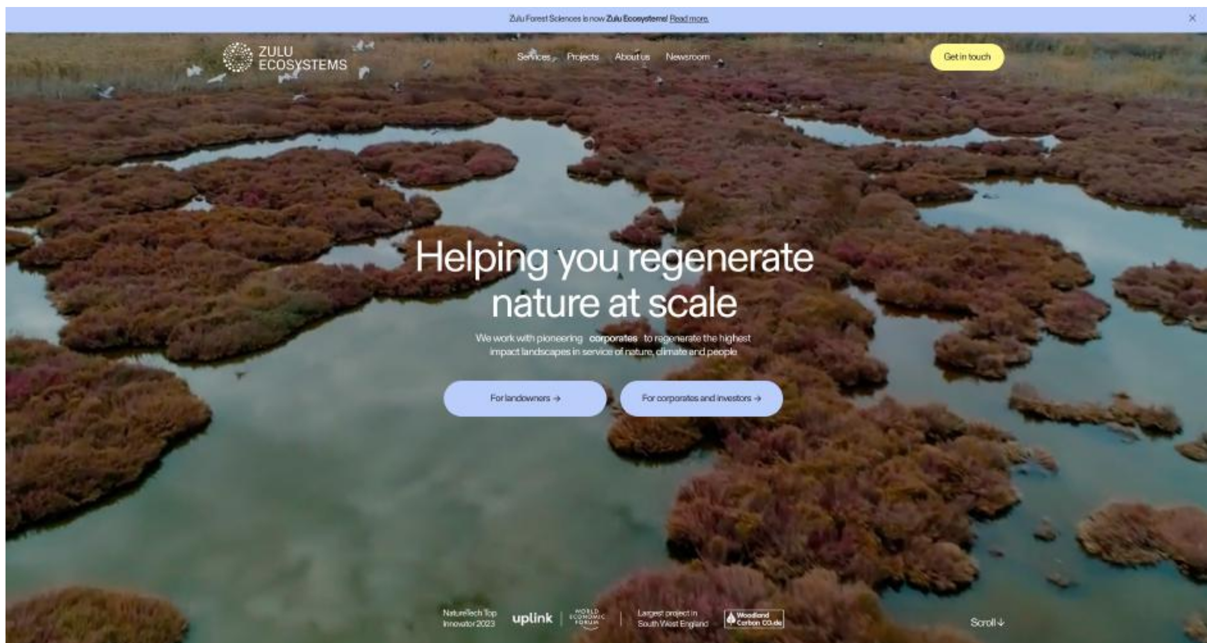

Figure 64 A flooded, healthy peatland.

The final image slowly swells. A satellite image of the landscape has been compartmentalised into discrete units and colour coded. These images signify the organisation's expertise at bounding, counting, and measuring the landscape, implicitly revealing their proficiency in understanding and organising ecological complexity.

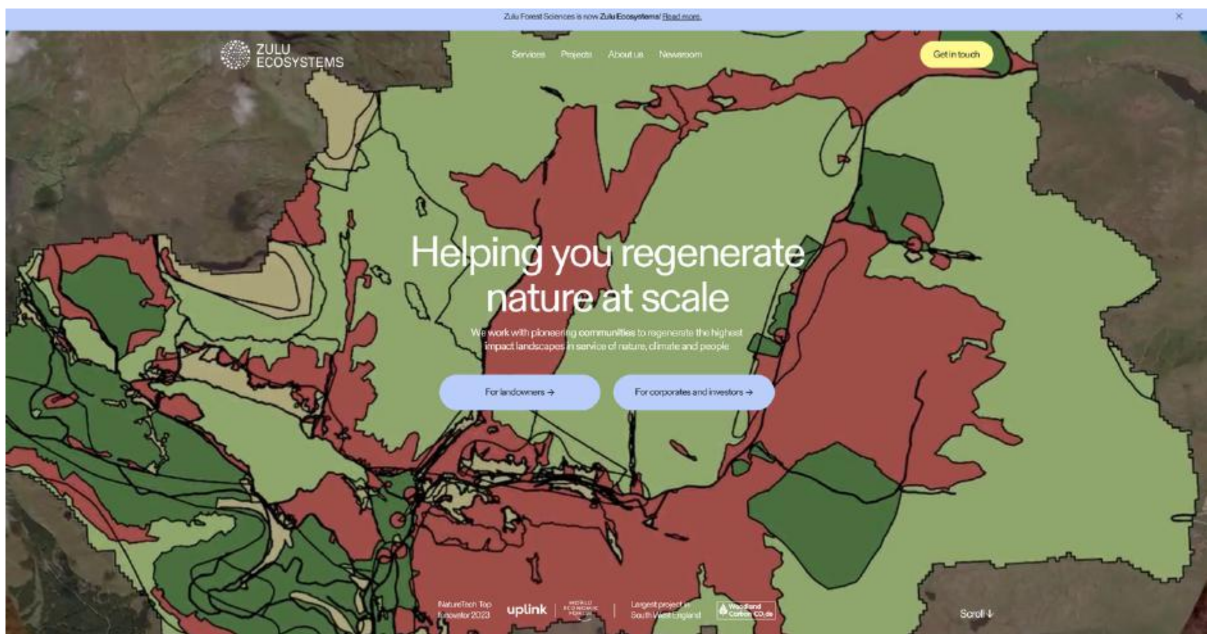

Figure 65 A cartographic, colour-coded image of the landscape from above.

This image captures the technical prowess with which the land is known, measured, and accounted for.

At the bottom of the page, the list of high-profile collaborators is displayed, each signifying a different element of the organisation's expertise: NatureTech Top Innovator 2023 (technological sophistication); the World Economic Forum and uplink, the World Economic Forum's open innovation platform (financial trust); "Largest project in South West England" (scale, realisability); Woodland Carbon Code (legitimised by the state; genuine carbon credits).

Upon scrolling down, we see a discursive *trust in numbers* framing immediately: "10 million hectares of land evaluated"; "10,000 hectares of planned restoration in 2023"; "1,000 hectares of active projects". Underneath, we see *spectacular science:* a sophisticated 3-D visualisation of Highland landscapes, colour-coded and annotated. The brand logos of high-profile scientific collaborators appear just below, including the science and technology specialist Cranfield University, Berkeley (University of California), the Scottish environmental agency NatureScot, and the UK Centre for Ecology and Hydrology, a not-for-profit scientific research institute.

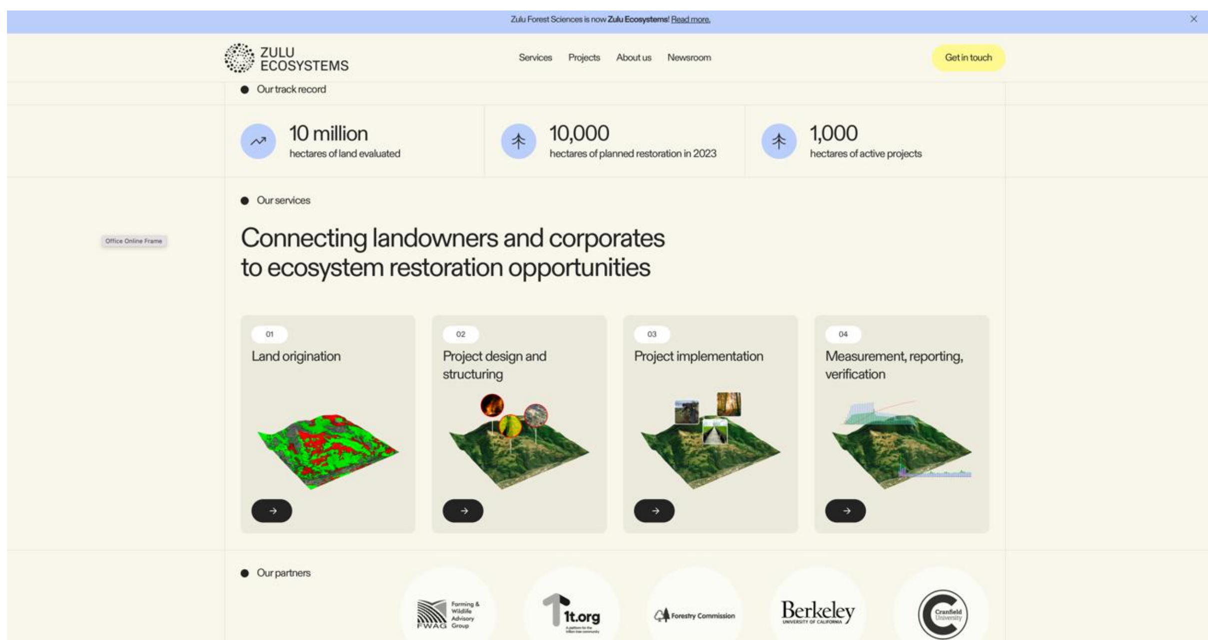

Figure 66 Different mapping layers each signify a different type of ecological and technical expertise.

On this homepage alone, we see the ecological aesthetic partnered with sophisticated visual representations of environmental measurement. Images of a flourishing forest and colour-coded satellite imagery offer different registers for communicating the value of rewilding, whilst the affiliated partners bring expert legitimacy to the company and its practices.

By bringing together multiple qualification processes in performing their rewilding organisation, successful branding operators such as Zulu Ecosystems (and Rewilding Scotland) have created a version of rewilding that can reconcile seemingly different epistemic qualities and values that might otherwise seem antagonistic. Displaying their proficiency and expertise in natural capital verification, organisations such as Zulu Ecosystems and Rewilding Scotland cultivate their own brand value and market niche as the leaders of a new wave of scientific, data-driven rewilding, which produces trustworthy wild carbon credits which realise ecological gain. This careful brand construction differentiates them from well-established rewilding charities like Caledonian Canopy, who have developed their reputation through decades of careful ecological activism and work, alongside their marketing campaigns. Through their blend of qualification processes, new rewilding organisations are representative of a culture of nature gaining prominence in Scotland, which I term ‘technical wildness’.

7.5. Technical Wildness

As I described in Chapter Four, technical wildness draws cues from the Modern and the Romantic, cultures of nature whose integration is, as cultural geographer Matthew Gandy notes, “often marked by attempts to reconcile the irreconcilable” (2022, p. 103). Literature from cultural and environmental geography, which I outlined at length in Chapters Two and Three, might suggest that these cultures of nature are discordant, potentially to the extent that they are impossible to integrate. As political ecologist Sian Sullivan notes, cultures of nature “denote what entities can exist, into what categories they can be sorted, and by what practices and methods they can be known” (2017, p. 222). If these cultures operate with seemingly different ontologies about nature and prioritise different epistemic practices, they surely enact reforestation and rewilding differently. Yet a growing subset of rewilding organisations, including Rewilding Scotland and Zulu Ecosystems, perform this ontological reconciliation through their careful storytelling and branding practices. In my experience of being immersed in the rewilding sector, organisations developing this culture of technical wildness were largely new natural capital companies that pulled on a narrative of rewilding in creating high-integrity wild carbon credits. Modern, science-led understandings of nature (instrumental, knowable, reducible, maximisable) are integrated with the Romantic’s privileging of a wilderness imaginary and an epistemology that favours sensuous experience (unknowable, immanent, irreducible) to create an alluring rewilding product (wild carbon).

During my fieldwork, I witnessed this culture of technical wildness grow in ascendency as new start-ups and consultancies entered the Highlands looking to create returns from nature restoration. In the cultural imaginary of technical wildness, it is possible to romantically pursue an enchanting encounter with spectacular and authentic landscapes, whilst maintaining that the best way to achieve this outcome is to trust the experts who have collected and analysed natural capital and economic data. Technical wildness draws on the implicit promise that precise quantification, calculation and financialisation are the most efficient means of making Scotland wild again, restoring ecological authenticity and complexity to Scotland's degraded ecosystems. Technical wildness appeals to businesspeople, investors, corporate offsetters, and urban dwellers, who partly understand the value of rewilding in the instrumental terms of carbon sequestration and the other nature-based solutions it delivers.

For many field ecologists and small-scale community foresters I spoke with, the emergence of technical wildness signalled a dangerous trajectory for rewilding, whose constituent practices and discourses were shifting under the weight of market pressures and the influx of interest in creating profit from rewilding. Technical experts, some of whom held relatively little situated knowledge about the Highlands and its ecologies, were weighing in on what should be considered valuable in Highland forests. Measuring and maximising the number of trees planted, carbon sequestered, or additional biodiversity uplift were increasingly becoming the foci for rewilding efforts. Other ecological considerations, such as the protection and restoration of ancient woodlands, which are worth relatively little in 'net' natural capital terms, were being side-lined as a result. (I describe this contestation with more detail in the following chapter). A new range of technical experts had disproportionate power in determining how forests should be measured, and how reforestation should be financed. In a paradigmatic example of society making performativity, the increased financial and political investment into natural capital verification (metrics, measurement technologies) was bringing scientific legitimacy to market mechanisms and expert-led forms of governance, shutting down political space for other approaches to enacting reforestation, even under the banner of 'rewilding'.

Technical wildness performs a similar form of storytelling to the "post-pastoral" epistemology common in other schemes labelled 'nature-based solutions'. Cusworth, Lorimer and their colleagues (2022), drawing on the work of Heather Paxson, highlight how regenerative farming practitioners blend romantic narratives – in their case, the cultural allure of pastoral livelihoods

– with the political and economic power of science and measurement, to brand regenerative agriculture as both a techno-optimist solution to interrelated crises, and the intervention that can restore the equilibrium of a past ecologically flourishing imaginary. Through creative storytelling, especially in marketing material, regenerative agriculture practitioners "are both modernising an ecologically sensitive agricultural epistemology, whilst ecologising modern agricultural technology" (Cusworth, Lorimer, et al., 2022, p. 8). Much like regenerative agriculture, rewilding is a heterogeneous and capacious label applied to organisations by themselves, rather than one imposed and certified from the outside. Its flexibility performs 'boundary work' (Star & Griesemer, 1989) reconciling otherwise unreconcilable epistemic communities and claims in the production of wild carbon.

The central tension at the heart of technical wildness lies in measuring and financialising wildness. Ecological complexity is, as Robertson (2006) highlights, impossible to measure in its entirety. There are inevitably uncertainties and immeasurable elements within an ecology, which eschew streamlined translations from nature into tradable nature objects. The value of measurement, Robertson and his colleagues (2023a) stress, rests in its capacity to capture *enough* complexity to function as a successful representation of the world, allowing value to be produced from natures. As this thesis has repeatedly argued, the natures that become valuable within natural capital regimes must be streamlined to fit the epistemic demands of markets and metrics. These natures might stand in contrast to those normatively pursued or materially produced by the rewilding movement writ-large, which has foregrounded the pursuit of ecological experimentation (J. Lorimer & Driessen, 2013, 2014), probiotic forms of environmental biopolitics (J. Lorimer, 2020), and the cultivation of nonhuman autonomy (Deary, 2015). As Gandy highlights, within an ontology of nature as active and dynamic, which is central to rewilding's ecological principles, ecologies become "both unfixable and to a significant degree *unknowable*" (Gandy, 2022, p. 86, emphasis added). In other words, echoing other scholars interested in the performativity of metrics, there is an epistemic impossibility of capturing the full ecological complexity of nature within numeric terms, regardless of the sophistication of the technologies employed (McElwee, 2017; Robertson, 2012). This ensures that quantifying 'wildness' – with metrics, technologies, or other quantitative devices – is necessarily an incomplete (bordering on quixotic) goal, and reductive stand-in metrics such as measured net biodiversity, or even carbon captured or trees planted, must function as a proxy.

Yet within technical wildness, this apparent tension which sits as a central paradox in the creation of wild carbon, is smoothed over. Through the qualification processes developed by rewilding organisations, including multiple branding and storytelling techniques, rewilding can promise many things to purchasers of wild carbon credits: that rewilding will create 'authentic' landscapes and bringing back dormant ecological processes; that this complexity will be measured with enough scientific certainty to generate trustworthy natural capital credits; that rewilding will be profitable and progress along the measurable trajectories required by the market. The ecological surprises which emerge from wild nature can be financed through the certainties of the market.

Technical wildness, which has emerged due to the increased interest in generating financial returns from nature restoration, marks a noticeable shift within the Scottish rewilding movement. In ideological and representative terms there is no longer a paradox nor trade-off for the pursuit of wildness to be an optimised socio-economic intervention, informed by late modernity's technologies such as markets and measurement techniques. Natural capital and offsetting, which I (Stanley, 2023) and other scholars (Robertson, 2006, 2012; zu Ermgassen et al., 2019) have shown to have perverse or streamlining environment making performative effects, are increasingly framed as the best (and perhaps, only) means of creating diverse, flourishing, and wild ecologies that people can have affective, personally enriching experiences in. Discursively, the necessary reductionism at the heart of the natural capital ontology (that nature can be successfully rendered into equivalent units and subsequently be exchanged) does not impinge on the production of wild landscapes, but ultimately facilitates it.

7.6. Conclusion

This chapter sought to understand how rewilding organisations generate wild carbon, a novel type of charismatic carbon credit emerging in Global North carbon markets. I have argued that a combination of discourses is creatively integrated by rewilding organisations seeking to create high-quality carbon credits, which are differentiated from others on the market. Closely examining the qualification of wild carbon reveals how a novel culture of nature – technical wildness – is emerging in the Highlands, which combines two seemingly incommensurable strands of Scottish environmentalism. The Romantic and the Modern, which have often promoted competing visions about what Scotland's nature is, how it should be valued, and how it should be governed, are assimilated into a coherent framework. As I reviewed in Chapter

Four, rewilding discourse in Scotland has shifted over time, from the celebration of wilderness to the facilitation of wildness and the inclusion of people (Deary, 2015; Deary & Warren, 2017; Dolton-Thornton, 2021). The emergence of technical wildness in the early 2020s marks a potentially new chapter in the ways rewilding is developing in Scotland. By tracing the emergence of the wild carbon market – a market only expected to grow – this chapter provides insight into the trajectories that future natural capital entrepreneurs might follow, in Scotland and elsewhere. As a market grows, it differentiates. We might well see a more intensified version of the different qualification processes I have identified, as organisations create their own market niche in an increasingly crowded market space. The promises to realise wildness, measure ecological diversity, and create trustworthy natural capital might be amplified further, with different measurement interventions and associated performances of technological and ecological expertise becoming more nuanced and convincing.

Through mapping the various elements involved in the object making performance underpinning the creation of wild carbon credits – ecological aesthetics, trust in numbers, spectacular science – this chapter has shown how multiple narratives can be simultaneously weaved together in rewilding discourse. This highlights an important point for the wider 'environmental performativity' framework: with careful enough curation, divergent narratives promising different environmental consequences or highlighting alternative political ecological commitments can be integrated, even if they appear *prima facie* disconnected. A pursuit of metrological sophistication can be recast as intimately linked to the pursuit of ecological authenticity, rather than antithetical to it. In terms related to performativity, the script can be ripped up and written anew. This highlights the important link between 'technical wildness' and 'environmental performativity' which has been implicit throughout this chapter: the realities of rewilding and nature restoration are continually being made and remade as they are enacted into being.

Companies developing wild carbon face similar critiques to those that have been lobbied against other charismatic carbon projects. Fundamentally, as Sian Sullivan describes (2017), in natural capital schemes there is ontological difference between what materially exists and what is represented (see also Cusworth, Lorimer, et al., 2022) – whether this representation comes in the form of aestheticised images of nature's spectacle or seemingly depoliticised numbers. In the 'economy of appearances' (Tsing, 2000), when necessarily partial mediations of the world convince offsetters of social and ecological realities, carbon projects accredited

by the WCC can become qualified as 'high-quality' or ‘wild’ independently of the ecological commitments and practices that have affected their design or materialisation. The representation of nature’s spectacle might convince a purchaser that ecological sensibilities are being followed. But, as Gandy stresses, there is “a lack of any necessary relation between the “scenic” (or other forms of aesthetic delight) and what is ecologically significant” (2022, p. 105). In simple terms, what looks good or ‘ecological’ in images, brochures, and websites might not be considered the best ecological intervention for a rewilding ecologist. For example, planting native trees is often framed as the definitive, ecologically informed rewilding intervention; but for some rewilding ecologists, as I outline in more detail in the following chapter, planting native trees is a distraction from other forms of forest creation.

As I mentioned in Chapter Four, forest types might undergo a process of ‘green rebranding’ (Cusworth, Lorimer, et al., 2022) as businesses or lobbyists frame certain forms of forestry as green or ecologically valuable within their storytelling or branding practices. This might involve creating partial forms of knowledge production to present a commercial timber plantation as ecologically beneficial – a practice which has a long history in commercial forestry, especially in Scotland (Oosthoek, 2013) – or displaying a new planting scheme in spectacular visual or written terms vastly different to its material production. For example, one commercial forester told me that he should rebrand his new forestry project, which consisted of 43% Sitka spruce and a mixture of other commercial conifer and native broadleaf trees, as “managed rewilding” to create a better PR campaign and sell charismatic wild carbon credits. When I suggested that the project clearly was *not* rewilding (with no reintroduction of missing ecological processes or species, the planting in linear rows of non-native conifer, and myriad other reasons), he shrugged “well, what even is rewilding?” This comment alludes to a point made by several rewilders: the discourses which qualify wild carbon can easily be commandeered by organisations without extensive ecological commitments or knowledge but have experience in creating high quality products or good branding techniques. When the quality of a rewilding project is generated through visual material which performs a project’s ecological value, the *actual, material ecologies produced* are not necessarily linked to anything ‘real’. In the creation of wild carbon, ‘rewilding’ can be a flexible term, put strategically to work by actors wanting to leveraging the value of their brand, land, and credits.

Through an exploration of wild carbon, this chapter has flagged two broader contributions to literature on the dynamics between measurement and neoliberal environmental governance.

Firstly, this chapter has shown that measurement technologies do not only quantify, turning the world into a set of abstracted numerical quantities; they also *qualify*, making carbon credits attractive products differentiated from others on the market. Measurement technologies employed for natural capital verification are enrolled within a performance of technical expertise that confers legitimacy, builds trust, and secures financial capital. This example provides empirical insight to Callon & Law's (2005) claim that quantification and qualification are not ontologically disentangled but operate within the same financialisaton process. Measurement companies develop their own brand value, linked to their epistemic legitimacy. I anticipate that in the future, *how* a natural capital credit is measured will have a significant influence on a credit's price. Increasingly, I suggest, the quality of natural capital credits will refer to the scientific legitimacy with which they were measured. This is reflective of the increased appetite for high-integrity natural capital markets emerging in the Global North, especially from nature restoration; and in response to the increasing media and scholarly attention highlighting the widespread creation of ghost credits from carbon forestry (West et al., 2020). In other nature-based carbon markets, such as regenerative agriculture and peatland restoration, similar dynamics appear likely. Further empirical attention is needed to examine the qualifying effects which different systems of measurement have on creating wild carbon.

Secondly, this chapter highlights the need for a closer examination of how natures are not only commodified as natural capital but qualified as high-value, branded *products*. Literature on neoliberal natures have largely focused on commodification and has thus largely been concerned with the processes of abstraction that translates a messy and complicated world into fungible natural capital commodities (Robertson, 2012). This process was the subject of Chapters Five and Six. Analyses of nature's commodification have been vital for showing the assemblage of material-semiotic devices necessary to make nature subsumable to market forces (e.g. Robertson et al., 2023). Only through making parts of a forest visible to the market, through technical processes of measurement, quantification, data manipulation, verification, and insurance, can they become commodities and create financial value for carbon forestry projects. Put simply, in Lauren Gifford's (2020, p.1) terms, "you can't value what you can't measure". The arguments in Chapters Five and Six have shown that this quip is, of course, partly correct – natures must be made measurable to become value bearing natural capital credits. However, a far more complicated relationship between environmental measurement and financial value creation is playing out in the Scottish voluntary carbon market. Measuring an ecosystem is not an equivalent process to creating a value-bearing natural capital credit. For

wild carbon credits, *you can value what you can't measure*. Scientific authority, brand, and even the processes of natural capital measurement itself, are all elements of carefully curated object making performances that have a powerful influence on a carbon credit's perceived quality. They are important performative signifiers which co-constitute a carbon credit's supposed ecological value and legitimacy, and ultimately its financial value. Measurement, in other words, not only quantifies. Measurement qualifies.

Interlude: The Lone Pine

My phone rings. I look at the screen and see Mike's name pop up. Mike is the Highland ecologist who I spent hundreds of hours with over summer. This is the first time he has called me for months. I'm intrigued, given that we haven't spoken much over winter – the occasional voice notes and WhatsApp messages have been enough to keep our friendship ticking over, but I've been down south, spending more time in libraries than forests. I'm having a coffee with an old friend, so I can't pick up. But then a minute later, my phone screen lights up again, with a voice note. Curiosity gets the better of me so I excuse myself, head outside and listen.

> *"Hello, I got very excited! We've got a soft confirmation that the fence project around that lone pine that we saw is gonna go ahead, so we'll be putting up a kilometre deer fence around it, giving it and the birch trees around it plenty of space, to let it spread out naturally, which is like, the best-case scenario."*

Mike pauses, and laughs, and I can hear his smile through the phone.

> *"Super exciting! It's so good cause if we wouldn't have went out and found that pine, this wouldn't be happening! I don't know, it feels very meaningful, and I thought I should share this with you!"*

A wave of nostalgia sweeps through me, and I remember the tree Mike is talking about. We had spent a long time searching for it.

One evening, I headed to Mike's for a beer and pizza. He smirked at my choice of BrewDog and the 'Lost Forest' marketing material scrawled across the can. He wasn't the only rewilder to do that. We were chatting about the historical dynamics of Scottish woodland cover and I was interested to hear more about how woodland composition had fluctuated over time. We started to look at some nineteenth-century maps of Highland glens. These were unlike the Ordnance Survey maps of Scotland I had grown accustomed to. Gaelic was scrawled all over them and there certainly seemed to be more trees. Each enclave of woodland seemed to have its own Gaelic name. Unlike the generic green sections of contemporary Ordnance Survey maps, even individual trees were recorded. It was clearly more detailed, perhaps hinting to the

more proximate human-forest relations between rural Highlanders and the trees they shared land with – until the Clearances.

Mike had discovered a software provided by the National Library of Scotland that lets you merge old maps with contemporary satellite images. Fading the old and new maps in and out, Mike showed me areas where previously extensive forests had now all but disappeared. We were poring over a recent satellite image of a glen in the West Highlands, generally a sea of brown and purple, when a tiny smatter of green caught Mike's eye. Mike layered the satellite image over a map from the 1870s, and then faded the images in and out. Exactly where the green spot was on the satellite image, a tree stood on the old map. We hatched a plan. We both had the next day off work, so we decided to drive over to the West Highlands, to try and find the tree.

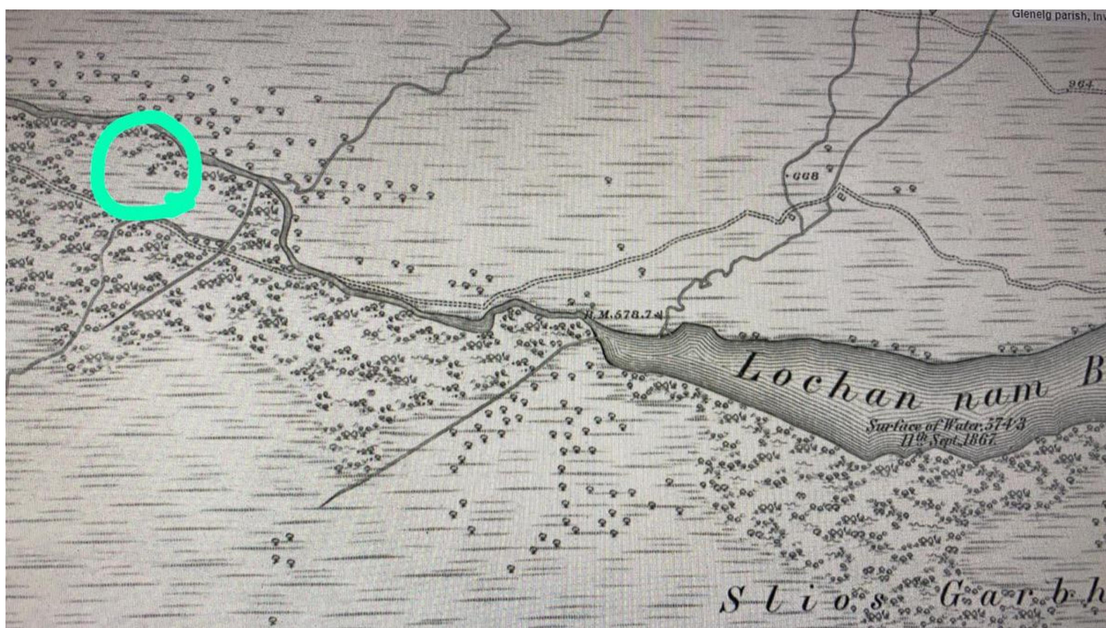

Figure 67 An 1870s map of the Highland glen showing the extent of forest cover.

The green circle is the site of the lone pine. The image shows Mike's screen and was taken with my iPhone.

The next morning, we set off and drove for about three hours. The roads were winding and the sun was blazing. We parked at the end of the road, literally miles from any house. Then we threw on our boots and headed up the hill, climbing about five hundred metres up. There wasn't really a path, so we had to bash through the heather and bog myrtle. Horseflies attacked us, and

we landed in a few peaty bog holes. Luckily, there was slightly too much of a breeze for the midges to come out. We crested the hill and followed a small stream down the other side into an expansive glen.

The glen was eerie; empty; seemingly devoid of life. Heather stretched across to the ridgeline opposite us, with a loch shimmering at the bottom in the summer sun. As we headed down, the stream grew wider, carving a smile into the face of the rock. About a hundred metres down, Mike started running through the heather, clearly excited. I rounded a tussock and saw it too – the lone Scots pine. It was the tree we had found on the satellite image. I felt like I was on a wildlife safari with an expert guide. But instead of finding charismatic animals, we had found a charismatic tree. To the naked eye, it was the only visible tree for hundreds of metres, maybe even miles. We swung on the pine's branches, dancing around to avoid the horseflies. We sipped from the stream that passed underneath it.

Figure 68 The lone pine.

The pine had an enormous crown and stood at least 15 metres tall, but it was hidden in a steep

ravine, which was probably the reason it had been spared the axe. It was still producing pinecones, myth busting the relatively common claim that old trees don't produce seeds. It hinted that natural regeneration could expand from it, if deer pressure was reduced. We found scattered birch and rowan as well as a single clump of bog blaeberry, a major ecological element of Scotland's intact pinewood understory. These were invisible on both maps. The stumps of old pine trees, now shaggy haired with moss and lichen, surrounded the surviving pine, hinting at the widespread forest that had once covered where we stood. The entire forest which had once carpeted a significant proportion of the glen had now been reduced to a single pine. In Mike's terms, the forest was "just one bad storm away from dying" … But it wasn't dead yet!

Figure 69 The wild pine hidden in the ravine. I’m standing next to it, to give a sense of scale.

Figure 70 Pine stumps around the pine hint to the ancient woodland that once covered this hillside.

Mike began another impassioned speech. Although I've heard his 'wild tree' speech many times, I was eager to hear it again. To summarise: Mike has been surveying native pinewoods almost every day for the last eighteen months. He has seen them in the rain, snow, ice, sun, in

the east, west, north and south, on the mainland and in the Hebrides. He has seen almost every remnant of ancient Caledonian pinewood in Scotland. And through this in-depth knowledge of Scotland's most endangered and revered forests, he has seen the errors involved in what he terms "heavy handed human management". For Mike, "tree planting is part of the problem". The focus on planting native trees is a mistake and will be looked back on in fifty years' time as a bizarre practice. "In the future, we'll look back and think, what the hell were we doing?" The little islands of native woodland, which are popping up across people's estates, are "ecologically short sighted". They are part of the "growth mentality" which has dominated commercial forestry, in which people assume that the only way to grow – economically, ecologically, and now climatically – is by growing trees that we, humans, have planted.

The unquestioned desire to *plant*, Mike argued, is a legacy of dated assumptions which take root in commercial forestry. For Mike, it's abnormal that we rush the regeneration of trees whereas we give time to other plants like herbs and shrubs. "Growing carbon" is based on the same instrumental view of forests that has dominated the forestry industry's concern for "growing biomass". And, as I showed in Chapter Five, forests with a larger above-ground biomass become more financially profitable (with more carbon to be measured). Mike therefore advocates for an alternative framework to tree planting, which he calls 'wild trees', "the antithesis to tree planting" which involves "colonising refuges of intact ecosystems", as interventions are introduced which allow old communities of trees to expand outwards symbiotically. We will hear more about this in the following chapter. Finding the lone pine showed me, first hand, the exciting opportunities that new technologies offer to rewilding organisations. Combining readily available remote sensing data and archival material from the National Library of Scotland meant we could find surviving ecological fragments. Using readily available technologies, Mike had located an ecological community which might now expand.

8. The Wild Trees Survey: Regeneration, Wildness, and Disruptive Performativity

8.1. Introduction

"The place matters, even if it's fucked." The statement's directness broke the silence hovering in the crisp air. Perched together on a ridgeline, Mike and I were looking out over a Highland glen. The view was spectacular, perhaps even sublime. But I knew that to Mike, it was a sorry sight. All summer, I had accompanied Mike as he surveyed the ecological condition of Highland estates, mapping the health and resilience of fragments of Caledonian pinewood. This had principally involved monitoring the impact of large herbivores on ecological dynamics. As I described in Chapter Four, Mike had taught me what Anna Tsing calls the 'art of noticing' (2015), teaching me to read the importance of previously unnoticeable ecological details. Material clues such as over browsed blaeberry bushes became bioindicators, signifying a high concentration of deer, which helped me visualise the widespread levels of ecological suppression frustrating any chance of self-regenerating woodlands. From our vantage point, we could see silver birch scattered on the far side of the glen. Otherwise, the landscape was treeless. Earlier that morning, we had driven for more than an hour on a winding road across barren moorland. We had seen several stags, the symbolic protagonists of the romantic Highland imaginary, and not a single native Scots pine. As the road had bent and swerved and we neared our destination on the West Coast, Mike had become increasingly impassioned about the flaws of tree planting, the principles of rewilding, and the possibilities for another ecology in this haunted landscape.

Figure 71 The view from the ridge, with silver birch visible in the foreground and on the other side of the glen.

On the ridge, we were taking a well-earned rest, which were unnervingly infrequent when Mike was leading a survey. His passion for ecology seemed to flood into his whole being, granting him unparalleled fitness to negotiate the Highlands' sheer terrain and shit weather. Today was an exciting day. It was the first time we were testing the Wild Trees Survey (WTS), a new measurement system Mike had designed to gather environmental data that could generate communicable stories about the ecological importance of restoring fragmented populations of 'wild trees'. As I explained in the previous Interlude, 'wild trees' is a term Mike has created to describe the subset of native trees that have ecological and historical continuity from endemic ecological communities that repopulated the Highlands following the retreat of the glaciers roughly 11,700 years ago (Steven & Carlisle, 1959).

For Mike, protecting and facilitating the expansion of wild tree communities should be the focus for Scottish rewilding efforts. Due to their historical continuity with past ecosystems, they support a wide range of specialist and refugial species, including ectomycorrhizal fungi, epiphytic lichens, deadwood invertebrates and ancient woodland wildflowers. Wild trees boast high levels of genetic diversity, making them more resilient and adaptable to disease and climate change than native plantations. But centuries of political inertia, shifting baseline

syndrome, and the financial opportunities afforded to planting trees for carbon finance (which I outlined in Chapter Five) have ensured that wild trees are often ignored in reforestation efforts, even on estates that are undertaking so-called rewilding projects. The growing concern for nature restoration has brought an interest in planting native trees into the public and corporate spotlight; but, Mike stressed, there has not been sufficient differentiation about the qualitative, ecological differences between native trees of the same species. An overt focus on native/non-native ignores the wider ecological contexts in which trees are situated.

As we looked over the gorge, Mike voiced his frustration that foresters looking to cash in on carbon finance, and even rewilding NGOs, were simply transcribing the same logics and techniques from commercial forestry to native woodland creation. Mike lamented how,

> "Rewilding has been using the same model of tree planting as commercial forestry but has changed the tree species. It hangs onto the same system and people think it goes from being something damaging to something that's brilliant!"

Mike was not against planting trees *per se,* but rejected a relatively uncritical prioritisation of planting native trees within rewilding efforts. Mike wanted to elevate the focus on regenerating pockets of wild trees, many of which were on the brink of extinction.

We walked down into the glen, checking Mike's smartphone. The night before he had mapped where the wild tree communities were likely to be, based on a combination of satellite imagery and old maps, using much the same methodology we used to find the lone pine in the previous Interlude. And as if on cue, hidden in steep ravines, native trees such as birches, rowans, aspens, pines, oaks and willows came into view. Most were under two-metres tall, but many were crumpled and contorted in ways that revealed their old age. The terrain they called home was so steep that these wild trees had avoided the axes of the past. Littered around them, young saplings were growing. At a micro-scale, on ravine sides steep enough to preclude deer's easy grazing, a forest was regenerating independently of human planting; no heavy machinery, no human labour, no ground preparation. We recorded the diversity of species present onto a spreadsheet I was holding, along with the amount of browsing we could see on the trees.

Figure 72 Wild tree communities found on an estate on the West Coast. They can often be found along steep-sided river courses such as these.

It was exciting to see these fragments of naturally regenerating wild woodland. But I was uncomfortably aware that my knowledge and emotional response to this scene were the consequence of several months of ethnographic immersion with one of Scotland's leading ecologists. Not everyone has this privileged access. It seemed clear that something was needed to accelerate a shift in how the Highland landscape was understood and valued by other people, in ways which might allow the natural regeneration of wild woodland to be prioritised. Perhaps an alternative form of measurement, which recorded relatively unmeasured ecological processes and relations, could be that intervention. In that moment, I returned to my fourth research question, asking myself ***how might environmental measurement disrupt the status quo ways forests are valued and governed?***

This chapter examines how the WTS has been carefully designed to disrupt the ways in which natures are measured and woodland creation takes place. After outlining the WTS in detail in the following section, I argue that Mike has developed what Matthew Gandy describes as a 'tactical epistemology' (2022), strategically employing the performative power of measurement to disrupt how land is conceptualised, valued, and governed. The WTS performs

three shifts in how Highland nature is understood: forests are shown as the emergent outcome of historical processes rather than timeless or temporally static; land is shown to be made of heterogeneous patches composed of multispecies assemblages rather than an empty, homogenous *tabula rasa*; and trees are shown to be vibrant and lively matter already in a state of suppressed resurgence rather than inert resources to be maximised. In tracing these shifts, I argue that the WTS can be understood as an empirical of example of *disruptive performativity*, as the hegemonic modes of valuing and governing natures are destabilised through the introduction of a new measurement regime. In the Conclusion I situate the WTS in its wider political context and caveat some of its political potentially.

8.2. The Wild Trees Survey

The WTS constitutes the first three steps of the Wild Trees Framework, the 10-stage process designed by Mike and his colleagues at a rewilding NGO (shown in Figure 73 below), which prioritises the protection and regeneration of wild trees and generate recommendations for ecosystem restoration projects based on principles from rewilding ecology. The information collected can help landowners, as Mike described, “to understand [ecological] refuges in a holistic way”, showing how existing ecological communities which include wild trees and refugial species relate to an estate’s overall ecological health and functionality. By collecting data which supports this holistic framing, the WTS offers an alternative to the standard types of ecological surveying which take place when planning a woodland creation scheme. Commonly, several separate ecological surveys are undertaken which measure different ecological elements, such as regeneration density (the number of young saplings growing independently of planting), herbivore impacts (the effects of deer on plant growth) and vegetation patterns. Foresters I interviewed explained that generally these data are recorded as required to meet the criteria of the state’s Forestry Grant Scheme but they are not necessarily combined to create an overall, integrated assessment of an estate.[61]

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[61] As a point of comparison to the WTS, I asked a native woodland creation advisor from a leading conservation charity to describe how she surveys a site before a forest creation scheme. It begins with a desktop study using publicly accessible web pages to look at a site’s characteristics such as the altitude, soil, flooding likelihood, exposure, and so on. She then looks for constraints, such as whether the site has any designations like Site of Special Scientific Interest or whether there are archaeological findings or scheduled monuments nearby. She consults ecological records to see if any bird, butterfly, moth, plant species have been recorded on site, because some species such as curlew can mean planting cannot go ahead

Instead of assessing whether or not tree planting can legally take place, the WTS aims to identify where biodiversity is already present on an estate and map its concentrations, including highlighting where there are biodiversity hotspots and refuges of wild trees. It measures their health, diversity, and resilience; undertakes an estate wide peat-depth survey; and shows which landscape interventions can help facilitate the recovery of these areas. As I detail further below, this is important for ensuring that ecological criteria are considered in the initial decision-making process about how land should be managed, *before* planting is considered rather than after. If there are areas of wild trees requiring protection, they should be prioritised; only after this has taken place can planting options be considered. In short, a shift in measurement (which is central to an object making performance) might correspondingly enact a shift in an environmental project's material outcome (its environment making performance).

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or require further justification. She then looks at the National Vegetation Classifications for the site, to see which native species do well in the area and looks at surrounding native woodlands to see which species grow well, then visits the site to look at herbivore browsing and soil type and depth, to chat with the landowner about their intentions, and to see if there are unrecorded rare species and habitats. She might still organise a consultation with an ornithologist, archaeologist, botanist or other specialist.

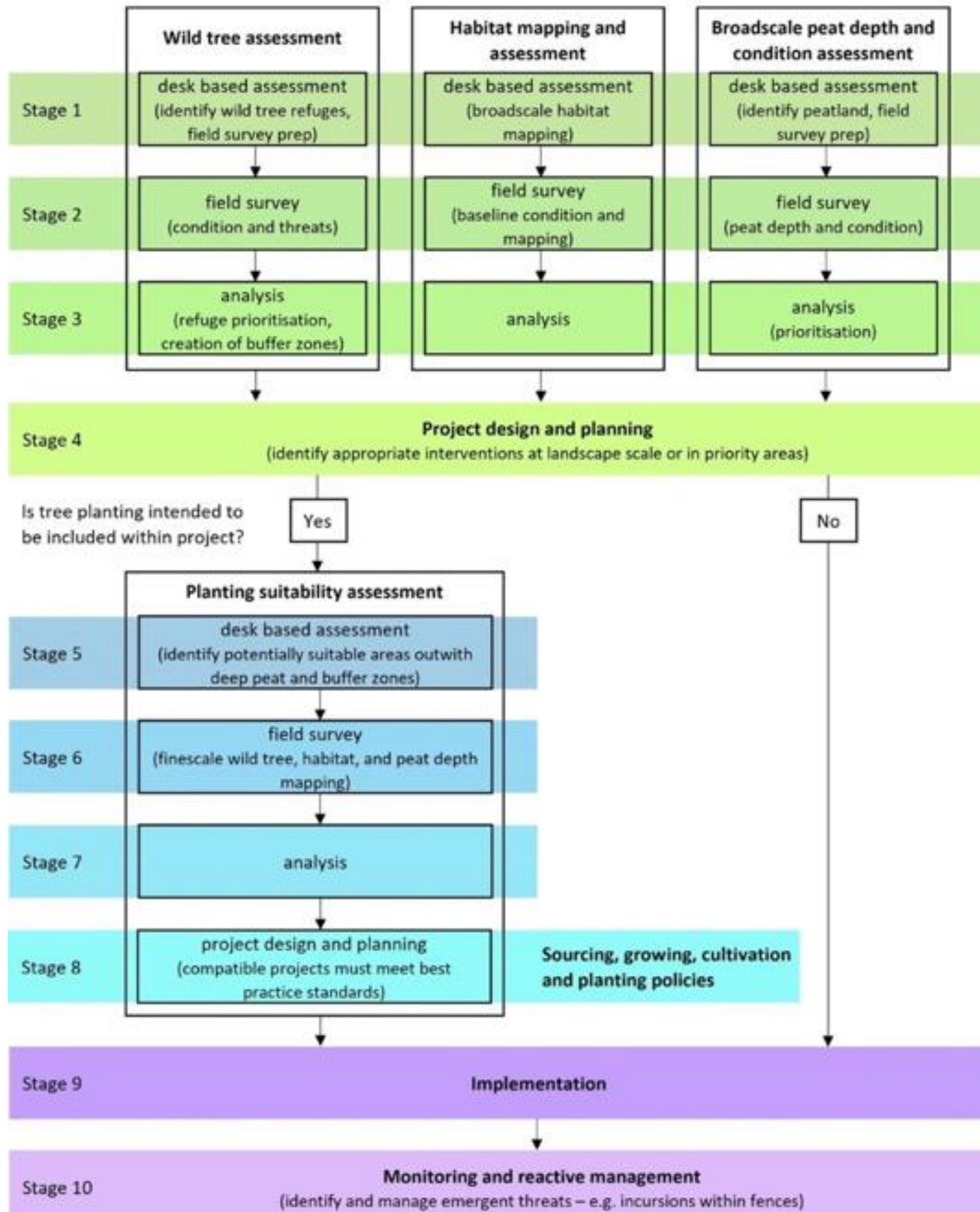

Figure 73 The Wild Trees Framework.

The WTS constitutes the first three stages. Note that there are four stages which determine whether *tree planting should take place. Source: personal correspondence.*

Mike hoped that the WTS can become a widespread measurement system in the Highlands, potentially mandated to sit alongside the Woodland Carbon Code (WCC). He hoped that all new woodland creation projects must use the WTS when planning a native woodland creation scheme. The survey design has been shaped by Mike's extensive ecological knowledge, informed by both academic study and his situated understanding of Highland ecology. Having studied biology at university, he began working as a woodland ecologist in the Highlands. When I met him at the beginning of my fieldwork, he was approaching the end of four years of data collection and analysis for the most comprehensive study of the resilience and health of Caledonian pinewoods in 60 years (since the publication of Steven and Carlisle's *The Native Pinewoods of Scotland* in 1959). For the project, he visited 71 out of 84 mapped fragments of ancient pinewood recorded in the Caledonian Pinewood Inventory, the state-backed database largely based on Steven and Carlisle's research. The WTS involves three stages.

Stage One: Desk-based assessment.

A landscape-scale, desk-based assessment identifies potential refuge areas of wild tree populations. Old maps, such as original Ordnance Survey maps published in the nineteenth century, are reviewed alongside readily available GIS imagery, such as Google Maps satellite view. Areas where there was previously recorded forest and where there might be remaining fragments are recorded onto a smartphone map app, as are scattered trees or "semi-natural" appearing woodland (i.e. not commercial conifer plantations). Areas which often hold wild tree communities, such as steep ravines or north-facing slopes at over 500 metres altitude, are also recorded.

Stage Two: Field data collection.

10-metre-wide survey plots are placed every 200 metres within the potential refuge areas identified in stage one. The left-hand image below shows the mapped plots downloaded onto a smartphone. Transects are also plotted every 200 metres on watercourses within potential refuges, as seen in the image on the right. These transects extended 2.5 metres either side of a riverbank. Peatland depth is measured at each plot using a peat depth stick.

Figure 74 Plot placement on a smartphone.

The surveyor walks from point to point. At each plot or transect, several pieces of data are recorded, including: a list of the refugial species present including types of wildflowers, lichens, liverwort, fungi and mosses; the growth stage and condition of the trees in the area[62]; a record of the overall vegetation age and condition[63]; and the herbivore browsing rates on regenerating saplings and the lower shoots of the trees, by judging the extent of browsing pressure on their foliage.

[62] This involves counting the presence and number of trees of each species in the plot or transect, and recording whether they were 'regenerating' (i.e. young), maturing, mature, senescent (i.e. dying) or dead.
[63] These measurements involve the surveyor making a judgement of growth stage based on size, shape, and growing pattern of the tree.

Figure 75 (ABOVE) Setting out towards the wild trees. (BELOW) Surveying the glen floor.

Stage Three: analysing results.

The analysis phase involves data manipulation to calculate metrics for species diversity, ecological continuity, herbivore impacts, and non-native species. The estimated abundance of tree species is scaled from plots and transects to create estimates for the whole area of wild trees.[64] Taken together, an overall 'herbivore impact score' is generated and assigned to each plot. Ecological data regarding growth structure, regeneration density, browsing rates, herbivore impacts, refugial species composition and diversity, and presence and abundance of non-native species are then mapped, providing detailed cartographic representations of ecological dynamics, as seen in the images below. (Throughout the chapter, I refer to maps included in the first published report based on the WTS methodology, which documents the findings from Glen Mallie,[65] a West Highland glen.[66]) 'Recovery priority levels' are assigned based on interpretation of refuge-level data. These maps are presented to landowners alongside recommendations for land management, such as reducing deer densities or establishing new fence lines.

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[64] This data combines with calculated tree recruitment values (the extent that trees are regenerating) and vegetation browsing impacts.

[65] Glen Mallie has historical woodland cover dated back to at least the mid-1700s. Glen Mallie is mostly privately owned by one estate and is mainly used for deerstalking, apart from a block at the mouth of the glen owned by The Woodland Trust and Arkaig Community Forest, a community ownership group.

[66] Images are taken from the report and reproduced with permission. The report is in the public domain.

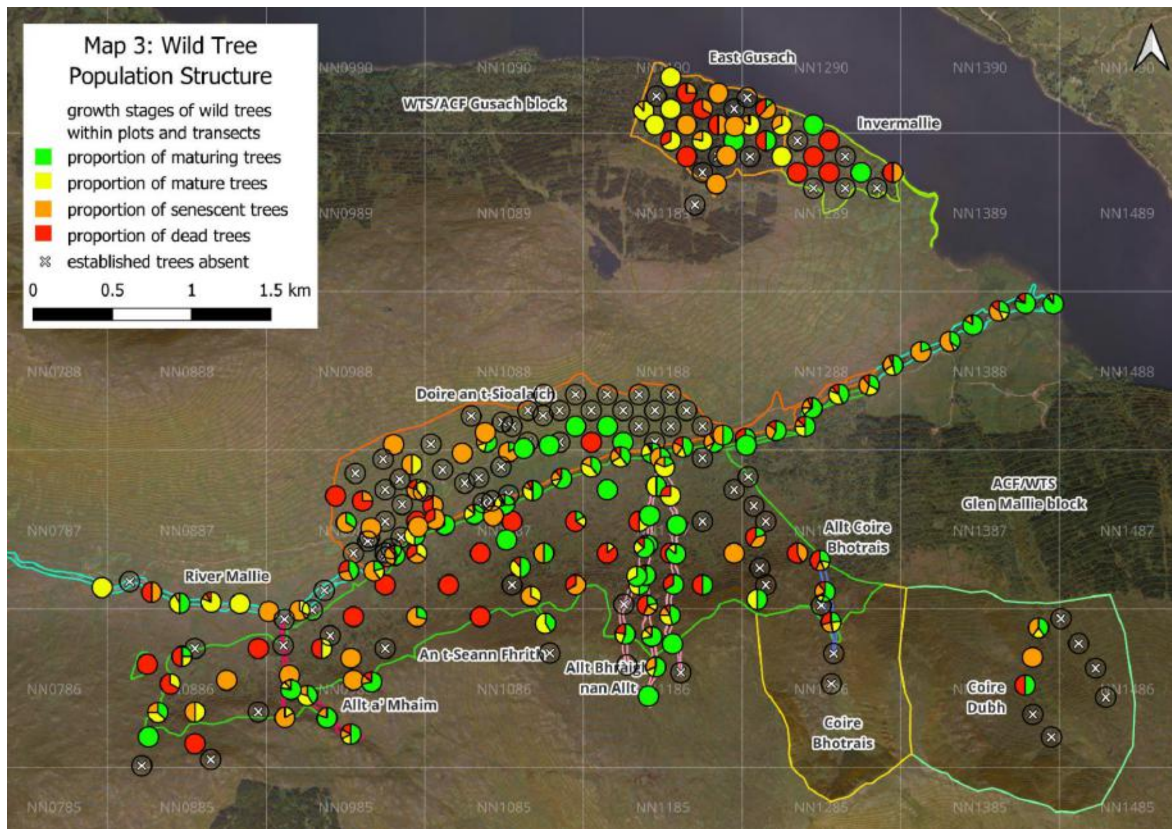

Figure 76 A map showing wild trees population structure.

The image represents the proportion of dead or dying trees in an area, highlighting a degraded and non-resilient woodland. The red circles signify that the woodland would not be able to regenerate if disturbed. Taken from the Glen Mallie Report (Rainey, 2023, p.16.)

8.3. Ecologically Informed Restoration

Over the course of my fieldwork, Mike and I spoke at length about the power of environmental measurement to shape political and ecological trajectories. During these conversations, the situated motivations behind the creation of the WTS became clearer. Mike argued that historically, the dominant concern for the Scottish forestry industry has been to maximise the growth of reliable, extractable, and measurable biomass, which is essential for producing economically profitable timber. Subsequently, extensive technoscientific research effort has been directed towards measuring forest growth from planting trees. And increasingly, Mike argued, the normative focus on speeding up and measuring biomass growth is being transcribed from commercial forestry to rewilding. As I alluded to in the previous Interlude, a "growth mentality", which has largely been concerned with growing biomass and growing profits, is now being applied to growing carbon. Planted trees grow quicker and sequester more

measurable carbon than trees grown through natural regeneration,[67] offering a steady natural 'solution' to the pre-defined 'problem' of climate change. And as I argued in Chapter Five, planting trees creates more steady returns from the woodland carbon market. Increasing the number of trees growing is largely understood as the 'best' form of woodland creation.

In this necessarily partial framing of what forests are (natural capital; carbon storage), how they should be valued (maximising measurable growth), and how they should be measured (measurable benefits; woodland carbon sequestered), the creation of wild woodland through restoring and regenerating wild trees appears relatively pointless. Mike argued that within the dominant framing of success in woodland creation, the natural regeneration of wild trees "looks like such a stupid idea" because tree growth rates and survival rates would likely decrease compared to planting trees. The extensive scientific research on Scottish forests highlights that it's very likely that a smaller area of land would be covered in native woodland, and less measurable carbon would be sequestered if natural regeneration was prioritised ahead of planting. The detractors of natural regeneration, Mike argued,

> "… can fall back on to all the kinds of science that's been done, because the questions that have been asked are all about how fast trees can grow and that's the measure of success. And all the science that has been done is proving that."

He stressed the importance of situating existing scientific research into forest measurement within its wider political context and considering measurement's environment making effects. As he put it,

> "It's great to measure ecosystem improvement. The problem is the net framing. If a company just wants to fund a scheme where biodiversity improves, then showing improvement is a good thing. The problem is when native woodland plantations are funded!"

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[67] The claim that planted trees grow quicker and sequester more carbon than natural regeneration is relatively well-accepted. As Mike's boss, put it pithily, "I don't think there's any dispute that our fastest route to carbon sequestration through woodland is to plant the lowlands on some of our most fertile, valuable land with trees".

His frustration alludes to an argument that I have stressed throughout the thesis: that all measurements are performed through human-designed technoscientific assemblages which are necessarily situated in specific political and economic contexts. As Mark Cooper (2015) notes, subjective and partial choices underlie any measurement design. Measurement systems which quantify ecologies according to their net stocks of natural capital (such as carbon sequestered), are often framed as the objective and non-political mode of valuing forests (Turnhout et al., 2014). But this dominant framing of forests as maximizable carbon reservoirs, as Mike's insight suggests, is the contingent outcome of the culture of nature which produced it. Modernity's dominant ontology of nature is performed through its hegemonic modes of measurement; in Sian Sullivan's terms, a modern understanding of forests is "conjured into being through particular practices of conceiving, framing, measuring, numbering and calculating the so-called natural world" (2018, p.2).

Clearly, Mike argued, the standard mode of measuring success in woodland creation was *not* the only way to measure it but the contingent outcome of a specific culture of nature. Although the measurements were objective, they were still based on a partial epistemic frame: "Yes, you're doing the science. You're collecting the evidence. You're taking the measurements, but that's as biased as anything else." Forest ecologies grow and function at a range of scales and speeds; there is, Mike argued, no *ecological* justification for using "growth rate as the only way to measure the success of ecosystem recovery". Growth rate is a metric designed and developed within commercial forestry. It is not a metric designed by ecologists with nuanced understandings of rewilding's ecological principles, which privilege the cultivation of nonhuman agency, interspecies relations, and emergent ecological properties such as resurgence and ecosystem resilience.

Mike was reflexive that he could not produce knowledge within the dominant epistemic framing of forests which would make the prioritisation, protection, and regeneration of wild trees appear a sensible or rational focus for reforestation efforts. Even *if* natural regeneration could be proven to be better than tree planting within a reductive framing of net stocks and flows (for example by proving the ecosystem services better delivered through natural regeneration than planting), other processes and properties which ecologists value, such as the protection of rare species, would almost inevitably continue to slip from view. Rewilding needed an alternative, yet similarly objective measurement system, that didn't attempt the

necessarily flawed translation of nature to natural capital stocks or overlook important properties of wild woodlands.

The WTS is Mike's attempt at creating this objective measurement system which facilitate a transition towards what Mike called "ecologically informed restoration". In the remainder of this section, I describe the three shifts it realises in how Highland natures are measured: through **tracing historical continuity,** forests become known as temporally extended; by **mapping existing diversity,** landscapes are understood as heterogeneous patches of multispecies history rather than as homogenous *tabula rasa;* and by **identifying regenerative potential,** trees become known as vibrant matter from which regeneration can proliferate rather than inert resources.

Figure 77 A lone pine in a dying wood.

Mike emphasised that restoring woodlands such as should be the focus for rewilding efforts, but doing so is valuless in the dominant ways 'success' is framed in native woodland creation schemes. Source: Kati Karki

Tracing Historical Continuity

The first shift which the WTS enacts is to chart the historical presence and continuity of wild trees on an estate. The WTS's use of old maps helps develop an important extended temporal understanding of Highland estates and highlights the multispecies histories which materially constitute them. For example, for the WTS undertaken at Glen Mallie, as seen in Figure 78 below, maps from 1772 and 1872 were consulted to track historical woodland cover. Referring to old maps before establishing a forest creation plan is not, as Mike explained, legally mandated. If historical woodlands are considered at all, standard practice for identifying their presence is to refer to governmental inventories such as the Ancient Woodland Inventory and the Caledonian Pinewood Inventory.

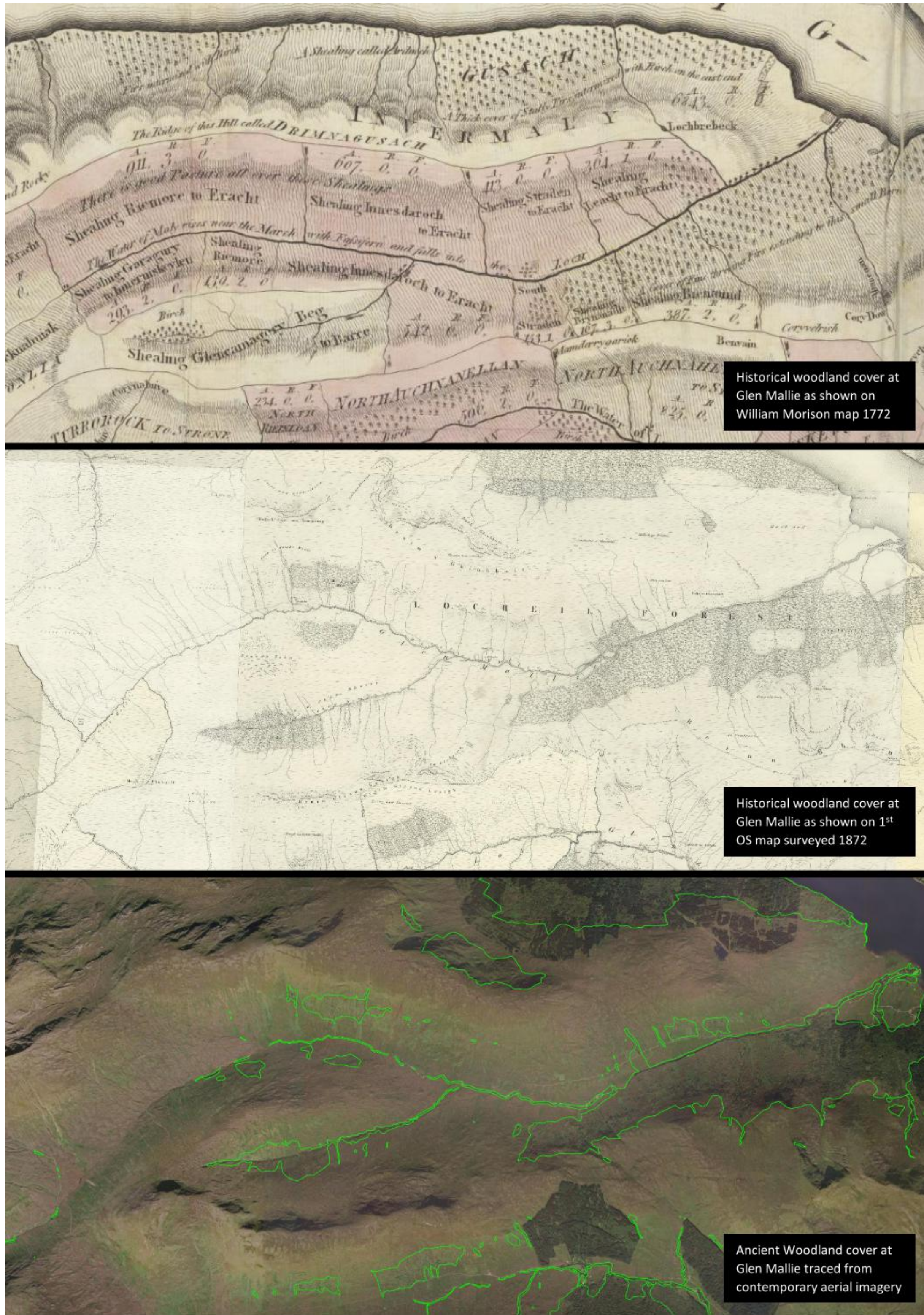

Figure 78 Mapping historical woodland communities.

This image is directly taken from the Glen Mallie report, showing the three maps (1772, 1872, 2023) employed in identifying wild tree populations. Source: Rainey, 2023, p.6.

These inventories of ancient woodlands are a classic example of Bowker's (2000) description of a database having performative power. As Bowker explains, some things receive more measurement attention than others, due to their economic importance, ease of measurement, taxonomic distinctions, or simply because they are more likeable. And as they are measured, and subsequently recorded within databases and inventories, these things become what is 'real' for data-driven, objective environmental governance. In the Highlands, the ancient woodlands that have been recorded within the exiting national inventories receive conservation attention from the state, and by extension, private landowners. The reality of these woodlands has been made real, and is continually reperformed, through the state-backed inventories. However, Mike explained that,

> "These inventories remain incomplete and can have arbitrary tree density criteria that result in important refuges being missed. Another sometimes used is the Native Woodland Survey Scotland, which also used restrictive tree density and size criteria that resulted in some of the most threatened (low density) and diversity (narrow ravines) refuges being missed."

The wild trees that have not been recorded in the Caledonian Pinewood Inventory, Ancient Woodland Inventory and Native Woodland Survey Scotland fall from governance focus. This slippage in measurement process has clearly had significant environment making consequences. Unrecorded wild tree populations are, in Scott's (1998) terms, 'illegible' to the state and do not receive statutory protection. Subsequently, as I witnessed on countless occasions during my fieldwork, many unrecorded wild tree populations are dying or on the brink of extinction. Wild trees might be in areas with no protection from herbivore browsing pressure, meaning their regenerating saplings cannot grow, such as the lone pine in the previous Interlude. Or they might be in found within commercial conifer plantations, which have been established near or even on top of them, which threatens the wild trees' access to sunlight and nutrients, as seen in Figure 79.

Figure 79 A commercial forestry plantation established on the site of an unrecorded Scots pine.

Mike explained that historically, in Scotland, for trees to be counted as a woodland and be included in the inventories, they needed to be classified as a 'habitat': a collection of 30 or more trees. This means that individual or small populations of wild trees, sometimes the last surviving remnants of a large expanse of ancient woodland, were not counted within a database and have been left unmanaged for decades. (The lone pine in the previous Interlude is a good example.) The WTS avoids the scientific debate about what constitutes a woodland by identifying wild tree *populations* (even one tree counts) rather than *habitats* (including 30 or more trees). Old maps are consulted to identify where these wild tree populations were in the past, based on the assumption that it is highly likely at least some of these trees will continue to live in the present. By consulting old maps rather than incomplete databases, the WTS can prove the existence of ancient woodlands that have been unrecorded, performing a new reality on which land management interventions can be based.

When old maps are consulted, an estate's wild trees and its biodiversity are situated within an extended historical timeline, which encourages landowners to notice the qualitative differences between *planting* native trees and *regenerating* wild native trees. This helps to perform an ontological distinction between the two types, upsetting the status quo ways that trees are governed. Generally, in Scottish native woodland creation, trees of the same species are treated relatively similarly.[68] This privileging of a species ontology is, like any taxonomic framing of nature, a necessarily partial boundary-making intervention, which shapes how forests are framed. As anthropologist Eben Kirksey (2015) highlights, the ontological boundaries of what constitutes a species are not inherent but are continually being (re)performed through scientific work. These performances include and exclude, creating equivalences between different organisms despite their differences. The dominant focus on tree species and whether or not it is native allows forests to be more easily governed using state apparatus (Scott, 1998). For example, treating trees of the same species as relatively interchangeable ensures they can be easily integrated into the WCC's spreadsheet. However, a tree's other properties, which are not considered in the species ontology, such as the multispecies histories and "more-than-human social structure" (Tsing et al., 2019, p.188) in which trees co-evolved and co-support, can be

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[68] Although there is close attention paid to the origin of seeds. Seeds are ecologically adapted to specific sites and their prevailing environmental conditions, including pests and diseases. For example, tree seeds planted in one region must be of that region's provenance. For a fuller explanation, see the Forestry Commission Scotland's (2006) report on '*Seed Sources for Planting Native Trees and Shrubs in Scotland*'.

overlooked. Sitting outside the dominant epistemic frame, these considerations can be labelled as 'qualitative' or non-scientific. Correspondingly, trees are abstracted from their ecological and historical worlds to become loosely exchangeable units of timber, biomass, or natural capital stocks such as carbon.

Contrastingly, the WTS creates environmental data which supports an ontological differentiation *within* tree species, which adds nuance to the ways they are framed. Through its appeals to historical continuity, the WTS empirically highlights that a silver birch plantation at the bottom of the glen and the natural regeneration of a wild silver birch higher on the hill are qualitatively distinct, both ecologically and culturally. One has a long historical and ecological lineage, the other does not. The value of individual trees is implicitly shown to far exceed their measurable carbon stores. In this way, the past can be appealed to, in order to legitimise rewilding interventions which prioritise regeneration. As geographers Caitlin DeSilvey and Nadia Bartolini exemplify, the past can be a discourse mobilised to justify the place of more-than-human communities in a particular region. In their study of a rewilding project in Portugal's Coa Valley, where prehistoric rock art imagery depicting wild horses has been found inside caves, "ancient images of animal others are enrolled in efforts to return 'wild' horses to the landscape" (2019, p.95). DeSilvey and Bartolini argue that mutual coexistence between humans and nonhumans is imaginatively proven by appealing to historical evidence. Turning to old maps of ancient woodlands has a similar effect in the Highlands. Although, as I argued in Chapter Four, there is no fixed 'natural' baseline in Scotland (Warren, 2002), appeals to old maps have a powerful performative role in showing the rightful place of wild trees on an estate. Maps highlight that fragments of the same forests which were important to human communities in the eighteenth and nineteenth centuries still exist. On old maps, woodlands and trees often have their own specific Gaelic names. As Mike explained,

> "If you use a wild trees framework, you identify these areas that are culturally important. Woodlands that have lost their Gaelic names and that once were valued by, you know, people in the past and now they're just ignored. There's a way of reconnecting communities to that thing that has almost been lost. Seeing the value in it again."

The map serves as external proof of intimate past human-forest relations. Highlighting the Gaelic names of individual stands of trees, and even individual trees, points to what has been

lost since the Highland Clearances: trees held cultural value that exceeded their measurable natural capital value such as their measurable carbon stock. And the Gaelic names also conjure the sense of Dùthchas, the Indigenous understanding growing in popularity once again in Scotland (Gordon, 2023), that there exists a sense of responsibility for people living on an estate to protect its ecological communities (Devine, 2018). With this appeal to the past, the urgent need to identify, protect, and restore wild trees breaks out of a purely *ecological* framing and operates in an emotional register. It is an example of the phenomenon which geographer Holly Deary (2015) identifies, that many land managers in Scotland embrace a celebration of the hybridity of cultural and natural heritage in the Highland landscape. Forcing surveyors to consult old maps and share this data with landowners has a powerful effect in creating visions of future multispecies landscapes. Large woodlands were here; they are now small, but they still exist; they can be large again.

The WTS's comparison of old and contemporary maps, in which ecological fragments are shown to have an *in situ* historical continuity, with contemporary remote sensing imagery, might be understood as a contemporary form of 'counter-mapping'. In Nancy Lee Peluso's (1995) famous study of counter-mapping in Kalimantan, she describes how local activists use "sketch maps to delineate and formalize claims to forest territories and resources their villages have traditionally managed" (1995, p.384). This strategy can "appropriate the state's *techniques* and *manner of representation*" (1995, p.384, emphasis in original). The WTS does not reterritorialize land claims but employs the hegemonic aesthetic representation of land – flattened cartographic space – as a means of *proving* ecological continuity. Like the start-ups described in the previous chapter, the maps lean into the 'spectacular science' aesthetic register. Consider the three maps in Figure 78. The top two images exemplify a nuanced understanding of the past; and the bottom signifies that land has been known with the precision afforded by contemporary remote sensing technologies. By bringing the aesthetic allure of the satellite image, which Eyal Weizman (2017) describes as the archetypal 'view from above', into visual conversation with old maps, ecologists undertaking the WTS can reveal their intertemporal understanding of ecological trajectories. The comparison brings a sense of epistemic realness to the land management recommendations they develop; signifying to a landowner the time-deepened and landscape-scale understandings upon which management recommendations, principally culling deer and erecting fencing, are based. This all functions as part of an object making performance, convincing land managers of the value of wild trees.

Mapping Existing Diversity

The second shift that the WTS introduces is to measure and map the wild trees and ecological diversity existing on an estate. This integrated data shows the heterogeneity of landscape composition to highlight the patchiness of ecological communities. This departs from the dominant natural capital model of framing land, in which the Highlands is understood as 'empty' and requiring tree planting to create additional stocks of native woodland.

This measurement choice has been carefully selected. Mike was frustrated that rewilders often referred to a "lack of seed source" (an existing grouping of trees that forests can naturally regenerate from) as a justification for establishing a planting scheme. This emerged because land managers would often decide where a new forest creation scheme would go based on the ease of access, visual impacts, lack of conflicts with other land managers (such as deerstalkers), and the perceived suitability of land for planting. Woodland creation projects would be established in areas where there was no seed source, so tree planting was indeed the only available option for native woodland creation. Mike argued that these were based on bizarre logics. For smaller estates, planting might well be the only option available for native woodland creation. But as Mike showed me repeatedly during my fieldwork, on most Highland estates there were wild trees refuges – if you knew where to look. "Why," as he rhetorically put it, "would you put your fence somewhere where there isn't a seed source?" In other words, why would you concentrate nature restoration efforts here when there are other, more ecologically important areas on the same estate?

By mapping existing diversity, the WTS encourages land managers to, in Anna Tsing's terms, 'notice' an estate's ecological composition when designing a management plan. Noticing existing multispecies communities, for Tsing, is crucial for understanding the types of ecological constellations that "allow landscapes of more-than-human liveability" (2017, p. 17). It is precisely the *lack* of noticing multispecies worlds and dynamics, a practice which has emerged from a narrow focus on one huntable species or extractable resource, that have created the dysfunctional ecological dynamics which characterise late-modernity in regions like the Highlands. Tsing describes the 'dream of the stag' (2017, p. 3) – a fetishisation with deer and their perceived nobility, which has created a blindness towards other species – that has led to ecological simplification in her Danish field site. This dream of the stag is ongoing in the

Highlands as well, as I outlined in Chapter Four. Simultaneously, there is also an emerging 'dream of the carbon', a focus on the carbon captured by woodlands and the financial opportunities woodland carbon delivers, which has ensured that other ecological considerations and multispecies dynamics are overlooked.

Elsewhere, Tsing, writing with fellow anthropologists Andrew Matthews, and Nils Burbandt (2019), argues that highlighting the 'patchiness' of landscape structure is important for generating a future-facing environmental politics which pays attention to the specific more-than-human histories shaping a landscape structure. This attention to specificity avoids an ontological flattening of land as a substrate for the human subject to design anthropocentric projects on. Noticing the patchy heterogeneity of existing woodland composition, which the WTS encourages through the specificities of its measurement design, supports a transition away from what Mike calls the "commercial forestry way of seeing the world" which involves "not looking at what's there" when creating a new woodland scheme. He described this partial vision as,

> "kind of like a colonial perspective on a landscape. You're wanting to blend your image in a way that's out of sync with what's actually there. Looking at what's there is really important to me, even if what's there is fucked and there's very little there."

As I argued in Chapters Two and Three, a specific culture of nature has shaped commercial forestry's framings of environmental problems, has long operated with an ontology of nature as both resource frontier and *tabula rasa* (Peluso, 2001; Braun, 2002). Forests are areas to extract from, maximise, streamline, or organise; and land can be improved through scientific interventions. Producing data which maps and measures existing diversity directs a landowner's attention to the estate's ecological communities, which disrupts a dominant understanding of the Highlands as 'empty'. As anthropologist Matthew McMullen (2019) notes, ever since the renowned Scottish ecologist Frank Fraser-Darling described the Highlands as a 'wet desert' devoid of biodiversity in 1959, the Highland landscape has been understood by many environmentalists as a space of loss. Appeals to this haunting ecological imaginary, as Deary (2015) argues, are often used as a justification for rewilding. This tale of degradation, which I described in Chapter Four, often portrays landowners as the privileged elite responsible for destruction (H. Lorimer, 2000; MacDonald, 2023). The WTS has been reflexively designed in a way to *persuade* rather than *blame* the select few landowners with power to shape the

Highlands' natures. Through mapping existing diversity, the WTS inverts the emotional tone for landowners from culpability to opportunity.

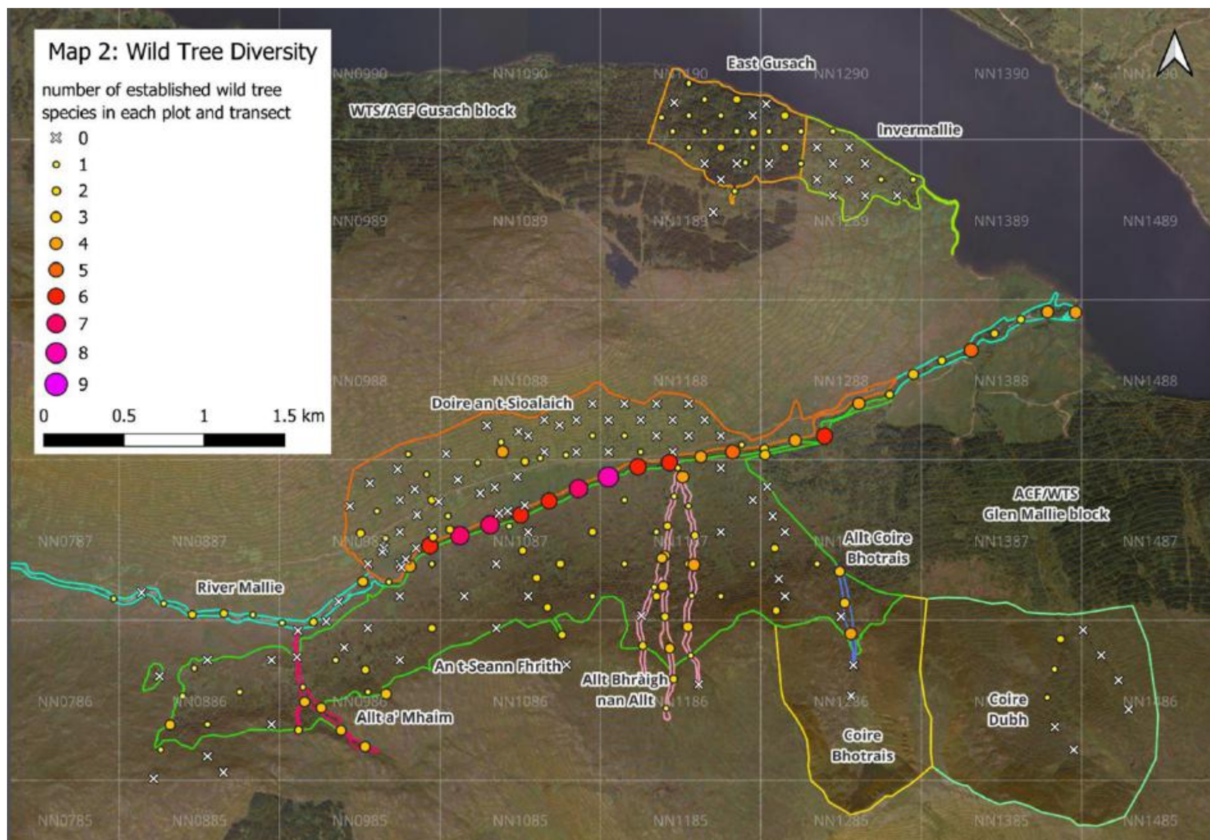

Figure 80 Wild Tree Diversity at Glen Mallie. The larger the circle, the more diverse the area already is. (Rainey, 2023, p. 10).

By measuring the remaining rare species diversity living in refugial areas, the WTS creates environmental data supporting a positive message about latent potential rather than a critical message about degradation. As geographer Lucas Brenet (2022) argues, numbers can do affective and emotional work in communicating stories about conservation. This is clearly the case for *restoration* as well. Mike explained that narratives about identifying 'priority areas for recovery' were effectively "positive[ly] rebranding" the phrase 'ecologically threatened area'. Instead of creating a negative emotional response in a landowner by quantifying ecological suppression caused by over-browsing, and thus implicitly laying blame on the traditional land management practices which create dysfunctional ecological dynamics, the WTS can create data which helps to generate hopeful messages. For example, with its focus on measuring existing diversity, the WTS undertaken at Glen Mallie found that the region had 23 different types of tree species, around half of Scotland's total. This allowed a positive story to be

communicated to the landowner, that the region has "very high level of diversity for one glen" (Rainey, 2023, p.11). This data could quantitatively back up the claim that "the potential for natural recovery at Glen Mallie is considered high" (ibid.). The report highlights that wild trees populations – although largely in a degraded state – held over 50 individuals, making them viable seed sources for natural regeneration.

Figure 81 Ecological fragments hidden in ravines.

Identifying Regenerative Potential

The third measurement focus involves quantifying the extent to which forests are already regenerating, to highlight that estates are in a constant but suppressed state of resurgence, rather than passive spaces which necessarily require human tree planting interventions to create new native woodland. This makes lively more-than-human dynamics legible in the terms expected within modernity. Using the WTS, an ecologist records herbivore browsing pressure[69] and counts the number of regenerating seedlings (i.e. young trees which have grown independently

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[69] This is done using the same methodology as the Herbivore Impact Assessments, which I had learned to undertake earlier in my fieldwork when collecting data for the Caledonian Pinewood Recovery Project. The ecologist holds up vegetation for close inspection and adjudicates the extent it has been eaten. Herbivore impact is ranked 1-5.

of planting) in a recorded area, to map where regeneration is already occurring and suppressed. Creating a map of herbivore pressure is important for highlighting a forest's resilience. When areas are largely old, dying, or dead, the capacity for them to recover from disturbance is threatened, whilst measuring a large quantity of regenerating trees highlights the exciting possibilities for woodlands to grow back if browsing pressure is reduced.

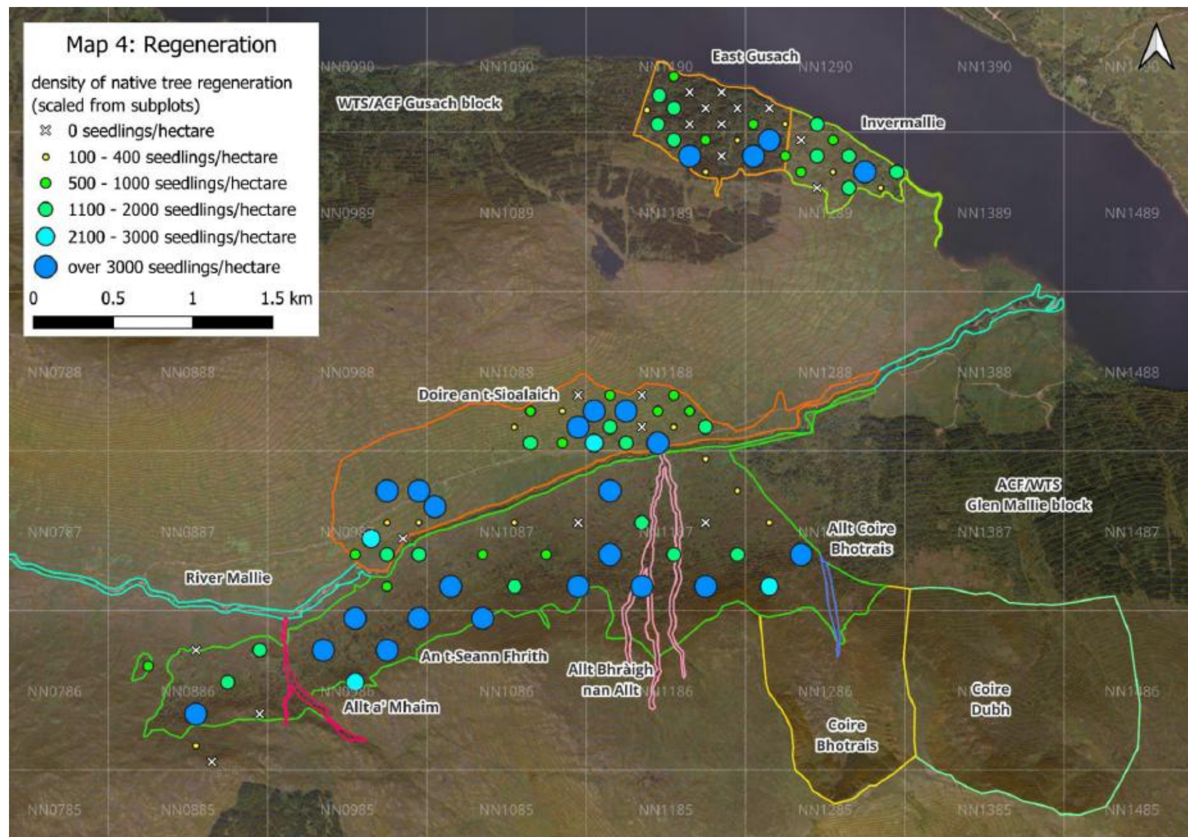

Figure 82 A map showing the number of regenerating trees in Glen Mallie.

The map shows a landowner where targeted deer culling and fencing interventions would best allow wild trees to naturally regenerate. Source, Rainey (2023, p. 16)

As I explained in Chapter Five, the uncertainty of natural regeneration is a major factor in tree planting becoming the widespread model for reforestation. The market, the state, and landowners require streamlined and predictable future forest growth, to create a 'nature that capital can see' (Robertson, 2006) which can be easily translated into legitimate carbon credits. In contrast, facilitating the natural regeneration of wild trees, widely praised by rewilders because it brings back non-human autonomy to multispecies worlds, is a step into the unknown. For many rewilders I interviewed, echoing arguments made by Jamie Lorimer (2017),

nonhuman autonomy *is wildness*, and is therefore the central facet of rewilding ecology (see also DeSilvey & Bartolini, 2019). But, as I have highlighted throughout this thesis, the uncertainty inherent to the ecological functioning of wild natures remains notoriously difficult to measure.

By measuring natural regeneration and its suppression, the WTS generates data ostensibly proving the ecological impacts that manifest from high deer concentrations, and importantly, brings an element of certainty to claims about forest creation through natural regeneration. As I argued in Chapter Two, appealing to this 'trust in numbers' is a central part in making specific translations of nature into data appear legitimate. For example, at Glen Mallie, around 450 hectares of ancient woodland was identified using the WTS. The published wild trees report notes that, "[an extra] 370 hectares [of ancient woodland] would develop if it [the protected area of woodland] expanded by 100 metres" (Rainey, 2023, p. 17) through establishing a deer fence. Although the quantitative benefit of facilitating natural regeneration (through deer fencing and culling) is not framed in reductive natural capital terms, it does draw on the apparent certainty that quantification affords.

*Figure 83 A close inspection of blaeberry (*Vaccinium myrtillus*) bushes.*

Recording browsing pressure involves measuring the extent to which foliage has been eaten. It takes some practice to interpret the different material clues.

Mapping vegetations patterns and using them as bioindicators of ecological health has the potential to foreground ecological processes which are otherwise difficult to measure. As Gandy (2022, p.160) highlights, closely measuring vegetation can reveal otherwise obscured

ecological dynamics which often slip from focus in environmental governance schemes. For this reason, sociologist Jennifer Gabrys suggests that learning to read bioindicators can create conditions for alternative forms of environmental politics. As Gabrys (2018, p.354) describes, "Bioindication signals the ways in which there are multiple modalities for 'taking measure' of environments, which could in turn generate alternative and speculative engagements [with nature]". The WTS, through measuring vegetation such as regenerating tree saplings and nibbled blaeberry bushes, generates data revealing ecological dynamics, relations, and configurations. These measurements work to highlight that regeneration is an already existing and suppressed process.

Unlike some of the natural capital measurement companies I described in previous chapters, the WTS has been designed for wildness to emerge as its performative environment making effect, without necessarily attempting to quantify it. Wildness, as Deary (2015) suggests, is an emergent and necessarily incomplete process that cannot be exhaustively quantified. The ecological survey techniques which the WTS employs, such as transect walks, as Gandy notes (2022, p.140) necessarily "belie the impossibility of knowing everything: there is only so much time, knowledge, and concentration that can be applied to any kind of ecological survey". The maps representing an estate's regeneration and its suppression demonstrate that Highland estates' landscape structures are not passive but "always coming into being" (Tsing et al., 2019, p.S188). Trees are shown to not only be inert resources, to be framed as timber reserves or natural capital stocks of carbon, but lively matter from which natural regeneration might emerge, and indeed, *is already doing so.*

8.4. Disruptive Performativity

Collectively, these three shifts in measurement are carefully and reflexively designed to reframe Highland natures away from the dominant natural capital ontology and towards an alternative, similarly science-led framing. A new means of valuing forests can be performed, conjured into being through a system of measurement which answers different questions and creates alternative forms of environmental data. In the terminology I developed in Chapter Two, the WTS is an example of *disruptive performativity.* The epistemic streamlining at the heart of natural capital framings is interrupted and different environment making effects might emerge as a performative consequence.

In his initial framing of 'critical metrology', Cooper (2015) stresses that the value of metrology lies in measurement systems' capacity to inscribe equivalence between different material forms. The process of rendering different elements of the material world 'the same' has environment making effects, shaping the material composition of forests worldwide (Edstedt & Carton, 2018). Cooper also stresses that measurement's political power rests in its coordination of *replicable* measurement procedures. In other words, measurement not only translates and distils the world's complexity into quantitative units of equivalence; it also makes people measure the world using a shared system of quantification. Herein lies what Mike describes as the "real" value of the WTS. Creating a standardised system makes people read and record the more-than-human world in a specific, situated way. Ecologies are not reduced to stocks, with measurement simply attempting to quantify their net increase or decrease. A diverse range of ecological processes and relations are recorded. As Mike hypothesised, "just following the wild trees framework, in and of itself, should lead to a better ecological gain… Following the wild trees framework makes sure nature restoration is doing the right thing ecologically. It would be a hell of a lot better than the current situation." In the terms of environmental performativity, a new object making performance, which generates data about wild trees, can realise an environment making effect.

In his study of the performativity of biodiversity databases, Bowker stresses that "taxonomies are invented, not discovered" (2000, p.648). 'Wild trees', much like the concept of biodiversity, is not an essential category but its reality is created and performed as it is measured. The WTS has been carefully designed to create data about wild trees, establishing it as an ontological category that demands governance attention, further scientific research, and prioritisation in land management.[70] Measuring wild trees and their situated place within multispecies ecologies brings scientific legitimacy to the new category of wild trees. In Sian Sullivan's terms, the WTS makes wild trees 'real', "literally in the ways [wild trees] are understood and encountered to be" (2017, p. 220). In the same way that measuring forest carbon stocks performs forests *as* carbon, measuring wild trees, in Lansing's (2012) terms, "bounds" these trees' ecological and political identities. The ecological differences *within* a native species – their multispecies context, their historical situatedness, the importance of endemism – which are valuable and

[70] This is already occurring. Dr. Emily Warner, an ecologist I work with at the Leverhulme Centre for Nature Recovery in Oxford, has begun research into wild tree populations in the Highlands.

important for rewilding ecologists, become legible (Scott, 1998) to the state and landowners as they are measured.

The WTS works with, rather than against, the disproportionate epistemic allure of technoscience that I outlined in the previous chapter to bring legitimacy to its systems of measurement. Like the developers of the Woodland Carbon Code and natural capital verification technologies, the legitimacy of the WTS is continually reperformed through its representative techniques, drawing on the epistemic realness of numbers and the combination of romantic and technological imagery. This is similar to the 'technical wildness' I described in the previous chapter, but performs a different frame of forests. Instead of intensifying a natural capital ontology which reduces natures into measurable stocks and flows, the WTS operates with a new materialist ontology in which natures are messy and nonhumans hold considerable, world-making force.

Mike stressed that he is well aware that the WTS is a performative intervention. The WTS is "just a tool," an ecologically engaged form of objective measurement, reflexively enrolled within a wider political context aimed towards changing the multispecies assemblage conditions through which wildness might emerge. He explained that the numbers the WTS produced, although objective and based on extensive and legitimate science, were effectively "just a performance" that created a digestible story about natural regeneration and prioritising wild trees that landowners and corporate actors could understand. Much like the WCC's spreadsheets and the drones employed by natural capital measurement companies, the measurements and reports published using the WTS survey can bring scientific and expert credentials to land management recommendations calling for the protection of wild tree areas, fencing, and deer culling. For example, in the WTS report on Glen Mallie, ecologists found that 97% of plots at Glen Mallie had a "high or greater" herbivore impact level. Using this data, Mike was able to communicate the commonly known (amongst most rewilders) impact of deer browsing in objective terms. He could show the landowner that chronic over-browsing was removing woodland resilience, as the woodland's capacity to recover following disturbance was suppressed. Using the numbers generated, Mike could point to areas that are very high priorities for nature recovery. For example, in one area, "75% of plots had no surviving trees, and where trees or their remains were found, all individuals were senescent or dead in 71% of cases". (Rainey, 2023, p.14). Numbers could legitimise the ecological recommendations for deer culling and fencing in a much-needed scientific, data-driven register.

The disruptive performativity outlined here can be understood as a nuanced version of the 'reflexive performativity' proposed by George Cusworth and his colleagues (2022). As I outlined in Chapter Two, they describe how non-technical experts weigh in on technical debates about metric design, aware of the metrics' effects in shaping the economic conditions in which they live. In the case of the WTS, instead of weighing in on technical debates about how to best measure forest carbon, Mike's intervention is to develop a metrological regime operating on an alternative epistemic register to the status quo framing of forests. Mike does not develop a narrative about the carbon benefits of natural regeneration (appealing to the fact it requires less machinery, no ground preparation, and no transported seedlings). Instead of lobbying for a form of environmental measurement developed by scientists that produces the 'best' numbers to support rewilding's goals, the WTS engages one step further upstream in the knowledge production process. In Weizman's terms, the WTS "take[s] over the means of evidence production" (2017, p.64) creating situated environmental knowledge about the latent potential of Scotland's wild trees to naturally regenerate. It creates a new frame of exchange, implicitly built upon a commonly held belief amongst rewilders: natural capital stocks such as carbon is not, and should not, be the sole focus for measuring and valuing forests.

Disruptive performativity integrates elements of *object making*, *environment making,* and *society making* performativity. Firstly, ecologies are translated into different forms of environmental data. New nature objects – in this case, wild trees – are minted through a convincing display of impartial measurement. Secondly, the specificities of an objective measurement system have been reflexively designed for their environment making effects. New material ecologies – which emerge from the natural regeneration of wild trees – might be created. And thirdly, the scientific rigour with which natures are measured brings legitimacy to a changed governance focus. New societal logics – concerned with identifying and protecting wild trees rather than maximising natural capital stocks – can be framed as an objective, scientifically-informed concern. Other scholars concerned with the disruptive and emancipatory power of measurement should similarly investigate how these three forms of performativity interrelate.

8.5. Conclusion

Whilst the previous three chapters have shown that 'measurementality' (Tunrhout et al., 2014) is an increasingly widespread phenomenon in the Highlands, as measurement techniques are put to work in the translation of nature into natural capital, the disruptive performativity of the WTS offers an uplifting alternative narrative about how measurement can highlight underprivileged ecological dynamics. Drawing on ethnographic material, this chapter has traced the political and ecological motivations that underlie the creation of the WTS, and has shown how this survey has been reflexively designed to realise new environment making effects. It provides an empirical extension of Gabrys and her colleagues' (2022) claim that collecting data about certain ecological functions and processes can direct governance to focus on different elements of an ecology, which can enact alternative ontologies of forests. Through a shift in measurement practices, different translations of nature into data can occur. New boundaries for the translation from nature to nature object can be set (Robertson, 2012), different parts of ecologies can become legible to governance regimes (Robertson, 2006), and what counts as "success" in reforestation projects can shift (Nost & Goldstein, 2022).

Here, we see the galvanising political potential at the heart of 'environmental performativity' close-up. The categories used to the govern the world are continually being made up, enacted into being through highly contingent networks of knowledges, technologies, policies, and a host of other things. The previous chapters have highlighted how appearing technically proficient, especially by using sophisticated measurement techniques, is increasingly central to the creation of trustworthy natural capital commodities. Simultaneously, as this chapter has highlighted, the aesthetic register of 'technical wildness' can be put to work by rewilding ecologists with a very different vision for what nature restoration and reforestation should look like, compared to the market environmentalist model. With a slew of environmental technologies available, rewilders such as Mike might convince people to pursue other forms of material interventions into how reforestation takes place.

But despite this appeal, the potential for Wild Trees to realise transformative landscape-scale forest creation must be heavily caveated. The WTS is complex and relatively difficult to use, requiring extensive understanding of the taxonomic classification system to record the diversity of tree species present. Characteristic of ecological surveying techniques, as Gandy (2022) describes, the WTS requires a sophisticated level of ecoliteracy, which other forms of measurement, such as the WCC, do not. As I learned in person, undertaking surveys is difficult,

tiring, and expensive. For example, at one relatively small estate, it took myself, Mike, and two other ecologists three days to complete a full WTS: twelve days of human labour. Admittedly, this was early in the WTS's development and, no doubt, the surveying methodology will be updated and streamlined. It will be interesting to see how technological developments will enhance the delivery and operation of the WTS. Drones might be helpful tools for surveying estates, used to identify where wild tree populations are situated, especially in difficult to access areas.

The WTS is still nascent in its development; at the point of writing in early 2024, only a few estates have been surveyed using the WTS. Whilst it's too early to explore empirically, it's highly likely that there will be contestation about its focus on prioritising areas of wild trees and forest creation through natural regeneration. Spurred on by 'planting fever', discourses centring the urgency of climate change have a powerful effect in directing state policy towards accelerating the scaling up woodland coverage (Sharma et al., 2023), and planting provides the steadiest returns. Tree planting follows what Lorimer describes as a modern temporality (Lorimer, 2020) in which there is a linear connection between trees planted and biomass accumulation. This temporality suits the logics of the market, which requires steady tree growth and correlated returns. The complexity with which the WTS measures rubs against the need for scale and speed, especially within a political economy focused on measurable carbon and profit.

Although the WTS diversifies how forests are measured and is designed to usher in alternative modes of woodland creation to the planting-centric status quo, it remains intimately bound with the carbon market. Native woodland creation is largely financed by the Woodland Carbon Code, a trajectory likely to intensify in future years. Rewilders I interviewed speculated that the WTS could be used as a qualification device: perhaps, if woodland creation projects have been measured with the WTS, and land managers have followed the ecologists' recommendations, the new woodland scheme will be branded as a wild trees project and warrant a charismatic wild carbon premium. But ultimately, as I argued in Chapter Seven, communicating the ecological value of rewilding projects is dependent on a complex range of discourses. Narratives about the obvious normative appeal of tree planting are well entrenched in the public zeitgeist and will likely prove resilient. Creating a widespread overhaul in how native woodlands are conceptualised, through overhauling a differentiation between wild and planted trees, will not happen overnight.

Despite these caveats, the WTS shows how measurement can support alternative, potentially more ecologically flourishing forest futures in the Highlands' complex political and economic context. Whilst creating a new metric might appear a bold and speculative intervention, it's important to consider it in reference to the history of the WCC, which I traced at the beginning of Chapter Five. Like all metrics, the WCC was established because some people saw the need for its existence. After commercial foresters began calling for its implementation, the WCC's design and stipulations emerged as the contingent outcome of a long and complex process between several different epistemic communities, including commercial foresters, ecologists, and research scientists. What appears now a scientifically rigorous, extensively researched, state-backed metric and accreditation system did not arrive, in Haraway's (1988) terms, 'from nowhere'. It arrived from somewhere, with the hope of making a high-quality and trusted woodland carbon market. Correspondingly, its emergence has co-produced a society making performative outcome, in which natural capital framings of forests, even in rewilding schemes, are ubiquitous. They are seen as the objective and rational way to measure forests rather than a partial and value-laden approach.

This chapter has traced how the WTS similarly arrives 'from somewhere', shaped by the political and ecological convictions that Scottish rewilding efforts should focus on regenerating the fragmented pockets of wildwood. The creation of the WTS reveals that despite the widespread proliferation of natural capital logics in the Highlands, knowledge practices and representative techniques are not necessarily linked to a specific mode of governing more-than-human life. Ecological surveying and cartography, both of which have a scientific genealogy steeped in modernity's pursuit of mastery and nature's organisation in Scotland (Jonsson, 2013) and further afield (Peluso, 2001), can be reflexively directed to realise complex ecological functioning rather than reductively translating it into exchangeable stocks of natural capital. The WTS provides a compelling example of how environmental measurement can be a radical political ecological intervention, speculatively designed to shift the ontological, epistemological, and biopolitical status quo common in forest creation schemes. Measurement holds power; even the apparently benign process of ecological surveying offers exciting opportunities for disrupting hegemonic forms of environmental politics.

9. Conclusion: A Call for Regeneration

I began this thesis by spelling out the multiple definitions of 'forest' in the Oxford English Dictionary. A forest can be understood as a tract of land covered in trees, an area under cultivation, a woodland set aside for the aristocracy to hunt in, or a wilderness. I hoped that alluding to this definitional multiplicity, before beginning my analysis, would implicitly encourage the reader to contemplate the variable ways that forests have been imagined in Britain by different groups of people in different periods of time. Turning to the dictionary was a pithy, and perhaps on the nose, allusion to Gabrys' concept of the 'forest multiple': forests do not have a shared essential essence or identity. They can be valued according to different sets of beliefs, known through different epistemic practices, and governed in different ways. As the previous chapters have highlighted, in the eyes of an ecologist, a forest might be understood as a historically continuous web of multispecies relations. For a commercial forester, a forest might be a growing stock of carbon or biomass. And for multispecies communities of forest dwellers, forests are homes, gardens, or food stores. Clearly, in efforts to reforest the Highlands, different forests can be restored.

In the bout of 'planting fever' which has shaped the dynamics of Scotland's contemporary environmental politics, different versions of reforestation are simultaneously performed through heterogeneous and overlapping assemblages of technologies, knowledges, and the practices of humans and nonhumans. Drawing on a range of case studies, my analysis has revealed the myriad ways that forests are translated into data, which subsequently shapes how they can be valued, governed, and materialised. Throughout my analysis, I have stressed that different actors in the Highlands, armed with a range of measurement tools and technologies, are continuously competing for metrological ascendency, aware of the significant power that measurement holds over their worlds, and reflexive that epistemic authority must be secured for their modes of valuing forests to be privileged in policy and politics. To summarise my overall argument: in the Scottish Highlands, measurement makes forests. And this is a process with social, political and ecological consequences which is highly contingent on power relations.

9.1. Argument Summary

This argument has developed through close attention to four related research questions, which tie to each of the four empirical chapters developed. To answer these questions, I offered '*environmental performativity*' in Chapter Two as a conceptual framework, which

differentiates three types of performance that animate environmental governance. There are *object making performances* such as natural capital verification and carbon quantification, which translate the world into exchangeable units. There are *environment making performances*, such as tree planting schemes, as new natures are created in ways that reflect the specificities of metric design. And there are *society making performances*, as the logics and framings underlying certain forms of governance are legitimised through their apparent success. In reviewing this scholarship, and by repeatedly stressing the partial and contingent nature of measurement, I also outlined how measurement can be understood as a transformative tool that might disrupt entrenched systems of governance. Environmental measurement can be reflexively directed to upset the status quo in moments of *disruptive performativity*.

The conceptual framework emphasised that measurement is always supported by, and supports, specific distributions of power in environmental schemes. This highlighted the need to contextualise environmental measurement within its wider social and political milieu. Therefore, Chapter Four developed an historical account of forests and natures in the Highlands, which traced how two dominant cultures of nature within contemporary environmentalism, the Modern and the Romantic, have held ascendency at different moments. Drawing on historical texts helped me to trace how these cultures of nature emerged and how they have been enacted through various practices, which have largely had a degrading impact on Highland ecology. I situated commercial forestry and rewilding within a wider historical context, and highlighted how the intersecting calls for nature restoration and natural capital appears to offer a new direction in the Highlands' ecological politics. With this conceptual framework and historical review established, Chapter Four described how I designed, delivered, and reflected upon my research. I explained the motivations for shifting from a narrow focus on the political ecology of forest carbon to a broader study on the epistemic politics of forest measurement. I outlined the different methods I employed, principally interviews, participant observation, and 'following translations'. These were generally insightful methods; but I outlined how and why they failed, and hinted at how I might have improved the research methodology.

The empirical analysis began with a close study of the Woodland Carbon Code (WCC) in Chapter Five, in which I developed an answer to my first research question: ***how does the hegemonic form of forest measurement in Scotland perform reforestation?*** I mobilised the concepts of object making performativity and environment making performativity to

distinguish the different performances animating the WCC's functioning. I showed how the code developers' laudable commitments to measurement conservativism and metric integrity are central to the code's legitimacy, and to the credits it generates. The WCC's legitimacy came under scrutiny during my fieldwork, and by describing how the code's additionality criteria were tightened, I provided an insightful case for tracing how metric design is constantly subject to renegotiation. I mapped how shifting carbon accreditation rules, in turn, had effects on which types of forests could be translated into carbon credits. This subsequently shaped which forests are materialised in reforestation schemes: more broadleaves are likely to be planted, but rewilders are subtly forced to prioritise tree planting ahead of other nature restoration practices. Through tracing the object making performances required to generate legitimate carbon credits and showing their environment making effects, the chapter showed how environmental performances interrelate. It also highlighted a problematic dynamic at the heart of Scottish nature restoration: the WCC is increasingly framed as a mechanism to finance nature restoration; but the WCC's design streamlines the natures that can be restored. This ecological streamlining is a phenomenon that many of the organisations we met in the following chapters were attempting to overcome.

Private companies are developing advanced measurement technologies (AMTs) for natural capital verification, which ostensibly offer an upgrade to the course-grained modes of verification standardly employed by the WCC. Chapter Six answered the second research question, ***how are advanced measurement technologies changing the ways reforestation is performed?*** I outlined the political and economic consequences associated with this development in measurement technology, with a particular focus on drones and terrestrial laser scanning. AMTs have been designed to *find more carbon* that the WCC's standard methodologies allow, through three processes: identifying more above-ground biomass, bypassing conservative estimates, and drawing upon a selective uptake of science. By empirically tracing these three processes, I proposed the concept of '*known not grown*' to define an incipient phenomenon in high-tech natural capital markets: more natural capital, such as forest carbon, can be found in ecosystems through a shift in measurement rather than due to a change in the material composition of ecologies. I described the unequal beneficiaries and dangerous consequences that emerge from 'known not grown', and concluded by showing how it provides a paradigmatic version of *society making performativity*: questions about forest carbon shift from *whether* forests should be reduced to their carbon content to *how* forest

carbon should be quantified. To finish, I hinted at the alternative ways that AMTs might be put to work to disrupt these patterns.

Taken together, Chapters Fix and Six highlighted the contingent ways that forest carbon is quantified. Whilst this analysis revealed the contested ways that forests are 'made the same' (MacKenzie, 2009), it only told part of the story about how forests are translated into value-bearing carbon credits. During my fieldwork, woodland carbon credits sold for variable prices, anywhere from £5-£30, and this upper price is expected to grow in the future (Hollingdale, 2022). In Chapter Seven, drawing upon Callon's concept of 'qualification', I defined three narratives – *ecological aesthetics, trust in numbers,* and *spectacular science* – that rewilding organisations perform to differentiate their 'wild carbon' credits from others on the market. By developing this analysis, I answered my third research question, ***how do rewilding organisations create a premium carbon credit?*** Drawing closely on two case studies, I showed how these performances are variably weighted by different organisations. Through tracing the mixture of discourses employed by rewilding organisations to create wild carbon, I offered '*technical wildness*' as a term to describe an emerging culture of nature gaining prominence in Scotland, which integrates seemingly disparate epistemic and ontological understandings of nature. Technical wildness promises that nature can be made wild again, and the best way to deliver this environmental future is to trust in modernity's metrics, markets, and measurement devices. The Modern and the Romantic, I argued, are increasingly assimilated under a shared narrative, which marks a new chapter in the history of the Scottish rewilding movement.

In defining technical wildness, I showed how rewilding organisations attempt to add *quality* to their *quantities* of carbon credits through appeals to their ecological commitments and scientific credentials. Chapter Eight described an alternative form of environmental measurement employed by a rewilding NGO, which helped me answer my fourth research question, ***how might environmental measurement disrupt the status quo ways forests are valued and governed?*** I described how Mike, a rewilding ecologist, designed the Wild Trees Survey to disrupt how forests are measured, conceptualised by landowners, and materialised in nature restoration schemes. Reflexively aware of the power that measurement holds to fix the ontological categories which governance is based upon, Mike carefully designed the Wild Trees Survey to realise three shifts in how forests are measured. The survey maps the historical continuity of ecological communities, highlights already existing species diversity, and maps regenerative potential. These shifts, I argued, have been introduced as part of a *disruptive*

performance. I detailed how the Wild Trees Survey facilitates resurgence rather than quantifies natural capital stocks, which might better allow wildness to emerge.

9.2. Key contributions

Although the project has researched developments in Scottish forestry in the early 2020s, my intention was not to provide insight solely into Scottish environmental politics. Heeding Noel Castree's warning, that it is impossible to extract much theoretical insight about broad concepts such as 'neoliberalism' from individual case studies, because their specificities are so context-specific (2005, p. 541), I am aware that Scotland does not reflect the world. Nonetheless, the integration of carbon and rewilding concerns which we see in Scotland, alongside the emergence of new natural capital verification technologies and the creation of wild carbon credits, may well set a precedent which is likely to be enrolled further afield in the UK, Europe, and beyond. After all, as other scholars have highlighted, 'planting fever' did not only grip Scotland (see Elkin, 2022; Carton et al., 2020). My hope is that this project has offered a partial answer to a broader theoretical investigation into the emerging and intensifying dynamics between measurement, carbon finance, and nature restoration. There are three central contributions this thesis has offered, which I hope will inform other studies.

Environmental performativity

This thesis has brought analytical nuance to the concept of performativity in critical environmental scholarship. Whilst a growing body of scholars have used the term to analyse the politics of environmental governance, relatively less attention has been directed to the different types of performance that animate these schemes, and the performative effects which materialise as a result. Differentiating object making, environment making, and society making performativity, and developing the concept of disruptive performativity, provides clarity. My hope is for other scholars to develop the environmental performativity lexicon to analyse different schemes in which environmental measurement is enrolled as a political tool, especially in net zero carbon and no net loss biodiversity schemes. The terms I have offered add depth to this growing body of scholarship and highlight different sites for further critical intervention.

In developing 'environmental performativity', I have extended the notion of 'reflexive performativity' first set out by George Cusworth and his colleagues (2022), which I detailed in

Chapter Two. In Scotland, as in other locations, stakeholders are aware that answers to seemingly technical questions about metric design will shape the worlds they can live in and weigh in on technical debates regarding the best way to measure natures. For example, as I argued in Chapters Five and Six, there is extensive disagreement about how best to measure forest carbon. Questions about which parts of a forest should 'count' as carbon and be measured are subject to contestation. The concept of 'known not grown', which I developed in Chapter Six, situates the disagreement about metric design within the broader political conditions in the net zero economy. As positive and negative emissions are rendered functionally equivalent, I anticipate that sophisticated measurement technologies will likely be developed to verify other forms of natural capital.

This thesis has also highlighted how measurement politics do not only occur in contestation about the best way to measure one pre-defined thing (such as forest carbon). There is also a more complicated ontological politics at play. Different actors are reflexive and strategic in the creation of new measurement regimes, aware that these make different natures legible to governance. The wild carbon metrics I described in Chapter Seven and the Wild Trees Survey outlined in Chapter Eight make clear that rewilders do not necessarily need to weigh in on debates regarding the 'best' way to measure forest carbon. Instead, with the intention of realising more ecologically regenerative futures, they can develop their own measurement systems, shifting the frames for how object making performances occur.

Technical wildness

Closely aligned to my discussions of environmental performativity is the concept of 'technical wildness', which I briefly outlined in Chapter Four and more explicitly developed in Chapter Seven. Organisations who describe themselves as 'nature restoration' or 'rewilding' practitioners, including NGOs and private companies, are increasingly drawing on science-driven narratives to highlight the metrological precision and technical expertise upon which their work is based. This is clearly a new type of environmental performance for rewilding organisations, who have largely sought to distance themselves from the modern urge for linearity, neatness and organisation. Wildness has largely been associated with celebrating immeasurability and the romantic wonder of a nature exceeding the confines of human measurement.

However, in the brave new world of technical wildness, quantifying natures to create stable and tradable natural capital commodities, and encouraging wildness to emerge from letting nature 'do its thing', are not incompatible opposites, but intimately linked. In conceptual terms, technical wildness sees the dawn of rewilding being performed differently, enacted by alterative sets of practices and discourses produced by novel more-than-human assemblages. New translations of nature into nature objects are occurring, and these will, as I have begun to specify in the chapters above, have very material environment making effects. Yet, *which* natures will materialise from the performances animating technical wildness are not clear-cut. If you believe the narratives circulated by many Scottish organisations, especially by the range of new nature-based green tech firms, the increased amount of metrological investigation will "unlock" the capital required for a new, wild, flourishing, resplendent Highland nature. However, based on the extensive first-hand research I have undertaken for this doctoral project, I remain sceptical.

The emergence of technical wildness potentially threatens some of the more established rewilding and conservation organisations based in Scotland. Their legitimacy has been hard-fought and, in many cases, hard-won through performances of ecological sensitivity and care for human communities. (It must be noted that referring to their work as 'performances' does not undermine their actions.) Convincing local stakeholders of the value of restoring ecologies has not been easy, and only now is the term 'rewilding' accepted in some areas in rural Scotland without derision. For many rural communities, as I documented in Chapter Four, the term still stirs up associations with the Highland Clearances and is understood by some as an indulgence for middle-class, urban elites. Although rewilding does not have a fixed definition, the influx of tech-led, for-profit rewilding companies operating within the umbrella culture of 'technical wildness', who often appear at first glance undifferentiable from rewilding NGOs, risks threatening to widen the gap between rural communities and the those seeking to restore nature. When restoring nature *must* turn a profit, the ecological commitments which many (self-defined) rewilders pride themselves on pursuing might well be subtly or blatantly side-lined. After all, despite performatively framing themselves as custodians of social or ecological benevolence, private companies existentially require profit to survive.

Forest quality over quantity

This thesis has also highlighted how measurement plays a central role in determining ecological *quality* as well as quantity. Extensive political ecology critique has focused on the ways that

different things are made geographically, temporally, and materially ‘equivalent’ so that the carbon market can function (Gifford, 2020; MacKenzie, 2009). Wim Carton and his colleagues argue that "‘undoing’ these equivalences would further a just response to the climate crisis" (2021, p.1); they might break the illusion that a tonne of carbon in one site is exchangeable for another, and bring context specificity to climate interventions. In the Scottish woodland carbon market, it seems that a large range of stakeholders, including carbon offset producers, brokers, and buyers, are doing just this, questioning the logic that a "a tonne of CO_2 should be treated as functionally equivalent irrespective of how, where, or when it is avoided, removed, or stored" (Carton et al., 2021, p.1.). In many ways, this differentiated pricing marks an improvement on other carbon forestry schemes, which have often treated landscapes and forests as maximizable machines to develop returns from, rather than sites where diverse, multifaceted ecologies should materialise (Moreno et al., 2015; Palmer, 2020; Palmer & Carton, 2021). In Scotland, as the previous chapters have highlighted, there is clearly an appetite for ecological restoration being folded into the carbon market and for ‘high-quality’ carbon.

However, this thesis has stressed that the ‘quality’ of a woodland carbon project is not an inherent property but is performed through a range of different narratives and techniques. Ultimately, quality is stabilised when two or more people agree it exists; this agreement is what determines the market price of a carbon credit (Valiergue & Ehrenstein, 2022). There is not one inherent reason why a credit generated at one native woodland creation project or rewilding scheme, which has followed careful ecological principles (such as protecting wild tree communities and providing habitats for niche or rare species) is more financially valuable than a credit generated at another native woodland plantation which has not followed these principles. Quality, in the eyes of the market, ultimately emerges from a project’s *representation* rather than its ecological reality, and rewilding organisations who can tell and sell the story of ecological restoration can warrant a premium. As carbon credits are increasingly sold to private companies looking to offset, *their* understandings of what ecological quality is are increasingly what determine which projects receive finance. The discursive frames which I outlined in Chapter Seven – *spectacular science*, *ecological aesthetics*, *trust in numbers* – convince purchasers of a project’s value. In Scotland, the quality of a credit is increasingly linked to the ways it was verified, rather than necessarily linked to the ecologies which materialise.

9.3. Future Directions

There were several directions the research did not take, and future trajectories in Scottish nature restoration which warrant further investigation. The metrics and governance mechanisms in Scotland are constantly shifting and further empirical work will bring nuance to understanding their impacts, especially regarding carbon credits and biodiversity credits.

Carbon Credits

Clearly more research must be done to follow the Woodland Carbon Code (WCC). The shifts in the WCC's additionality criteria, which I detailed in Chapter Five, were implemented in October 2022, after my fieldwork period had ended. Although I could interview stakeholders and discuss the anticipated effects the changed criteria might trigger, close attention should be directed towards the social and environmental consequences that have emerged from its new stipulations. Inevitably, the WCC will continue to be "gamed" in the future and new threats to its legitimacy will present themselves. Following how it continues to perform its legitimacy promises to be a fascinating empirical example in the decades to come. And a host of new problems will likely emerge, especially as new measurement technologies are introduced to improve its verification process. Using the *environmental performativity* conceptual framework could bring nuance to several other empirical cases in Scotland.

The analysis has focused on *forest* carbon, but forests are not the only landscape-type which can be successfully translated and sold as carbon credits. Peatland carbon credits are also readily available on the same Land Carbon Registry as woodland carbon credits. They are exchangeable with woodland carbon credits in claims of net zero and carbon neutrality. But several carbon brokers I spoke with told me that peatland carbon credits were generally worth far less per credit than woodland carbon credits, as their more-than-carbon 'story' was harder to sell. For example, one broker explained that lots of companies want to purchase woodland carbon credits because they can make claims such as "one tree planted for every x sold". There will surely be careful strategic work which elevates the story of peatland restoration to qualify the carbon credits generated, and further research might closely unpack how peatlands are represented and performed across marketing material.

Peatland carbon credits are also likely to be the site for a highly contested knowledge politics regarding measurement. Carbon brokers explained that calculations of carbon additionality are

harder to prove in peatlands than in forests. Additionality in peatland restoration is linked to emissions *avoided* rather than carbon *sequestered*. In other words, additionality calculations prove how many carbon emissions have *not* been released due to a land management intervention. It's difficult to prove this counterfactual. New technologies are being developed to better account for peatland health, distribution, and carbon storage. For example, NatureScot published a report about using Interferometric Satellite Radar (InSAR) to measure peatland surface motion. InSAR "provides a means of measuring peatland surface motion continuously and is not limited by scale or cloud cover" which allows for more accurate measurements of "the amount and distribution of peatland and associated carbon inventories" (Marshall et al., 2021, p.1). It will be interesting to see how the peatland carbon market matures; to see how peatland carbon is measured and credits verified; and to analyse the distribution of beneficiaries from peatland restoration projects. What will be the contestation regarding the 'best' way to measure peatland carbon? Will new measurement technologies allow more carbon to be 'known not grown' in peatlands?

Biodiversity Credits

Writing in early 2024, the ecological value of a woodland is "bundled"[71] into the price of the carbon credit. As I explained in Chapter Seven, the combination of values bundled together determines the variable prices of carbon credits. However, the introduction of a biodiversity offsetting market in Scotland seems likely, which might upset the dynamics of the carbon market. Biodiversity Net Gain (BNG), a policy intervention which "makes sure that habitats for wildlife are left in a measurably better state than they were before the development" (The UK Government, 2024, n.p.), became mandatory in England in February 2024. In England, construction developers must purchase biodiversity credits from other sites, such as nature restoration projects, to 'offset' the biodiversity damage caused by their development projects. As of early 2024, Scotland's environmental state body NatureScot are developing an adapted biodiversity metric, which would be suitable for creating biodiversity offsets for land development in Scotland (The Scottish Government, 2024). A biodiversity credit framework is also being developed by the WCC and its partners. On its website, the WCC describes their aim for the biodiversity credit framework:

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[71] This is a jargonistic term commonly used by carbon brokers and experts to describe multiple ecosystem services being integrated in the price of one credit. It contrasts to 'stacking', in which different ecosystem services are sold separately.

> “We hope that establishing a UK voluntary biodiversity crediting programme, managed by government-backed, high-integrity codes, will stimulate the biodiversity credit market. We also hope it will create new pathways for private finance to support ecosystem restoration.” (UK Woodland Carbon Code, 2024, n.p.)

Early studies of BNG schemes in other areas have shown that they often fail to deliver the ecological benefits promised (Simpson et al., 2021; zu Ermgassen et al., 2019). Close empirical research is needed to study which benefits are promised and whether they are realised. The likely introduction of BNG to Scotland opens space for future research into the mutable and changing relationship between biodiversity and carbon. Interesting theoretical and empirical questions abound: who has expertise in determining how biodiversity will be measured? If a biodiversity offset market is introduced, what will happen to the price of carbon credits? Could the new schemes provide an income stream for the natures that slip from view in a carbon-centric mode of financing forests? These are all open questions requiring close empirical investigation.

Moreover, biodiversity markets are not the only ‘market in the making’ (Callon, 2009). Interviewees name-checked the development of metrics for quantifying the carbon sequestered by sea algae, potentially opening space for a ‘blue carbon’ market. Others referenced soil carbon credits from regenerative agriculture, creating a soil carbon market. Even a ‘Woodland Water Code’ is being developed by a consortium led by Forest Research which develops credits “initially for water quality and then for flood alleviation and water cooling” (UK Woodland Carbon Code, 2024b, n.p.). A desk-based pilot for the Woodland Water Code is being run between May and September 2024. Plausibly, multiple credits for different ecosystem services will be sold from the same intervention (such as planting trees). It appears that with enough ingenuity, and the development of sophisticated enough metrics and technologies, there is no limit to which elements of the more-than-human world can be translated into a natural capital unit (carbon, biodiversity, water quality, and so on). Careful work will be required to unpack which metrological foundations allow these markets to emerge, to analyse the object making performances required for maintaining the legitimacy of these credits, and to track their environment making and society making effects.

These trajectories highlight that natural capital markets and metrics are central to the Scottish

government's vision for scaling up nature restoration. This thesis has identified the need for hesitancy. As I have repeatedly shown, metric design necessarily creates environment making effects by determining which natures become valuable. And natural capital framings are bound to measuring additional stocks, rather than rendering a range of ecological processes valuable. It seems clear, then, that the constituent practices of nature restoration and rewilding will be shaped by the economic worlds which finance them. Further empirical research is required to see how rewilding shifts over time. But in the spirit of 'reading for difference', I must stress that other models for ecologically informed restoration do exist. I end by sketching out an alternative vision.

9.4. Regeneration

Mike and I were sweaty and slightly sunburnt after a difficult day spent surveying a fragment of Caledonian pinewood. To cheer us up, Mike offered to show me his favourite woodland. We drove along the A-road and pulled into a relatively non-descript layby. I thought we were checking the map, but Mike unbuckled his belt and jumped out the car. I was surprised. I had expected to visit one of the more famous pinewoods in the area, such as those clustered around Glen Affric. Instead, we were looking upon a 50-metre-wide sliver of forest between the road and a river. The trees stretched for half a mile to our left and right. It wasn't a particularly alluring destination. The predictable assortment of crisp packets, coke bottles, and used wipes littered the parking bay. But Mike was ecstatic as we headed into the trees, pointing to the diversity and abundance of plant species under the canopy of Scots pine. At one point, he literally fell to his knees to look at a rare flower. I crouched down and joined him but did not recognise the species, not knowing its ecological importance or what it indicated about ecological health. To Mike, so fluent in the peculiar language of Highland ecology, it clearly signified far more than its relatively benign appearance let on.

As we walked further from the roadside, the real beauty of the woodland became more apparent to me, even with my relatively limited ecological knowledge. With a disconcerting sense of déjà vu, I realised that I had camped here before earlier in my fieldwork, when I had first arrived in the Highlands. It looked the same but it *felt* completely different now, after several months spent developing taxonomical knowledge and an understanding of interspecies dynamics. *I noticed that I noticed* small details which would have been unremarkable to most people, including myself four months before. The undergrowth, rich with chantarelle (*Cantharellus*

cibarius) and blaeberries (*Vaccinium myrtillus*), felt a foot higher than what I'd come think of as the natural or normal level. Other things were different, uncanny. When surveying other fragments of Caledonian pinewood, we were generally lucky to find four or five plant species in a plot. Here, there were easily ten tree species around us at any given moment, species I could now easily recognise. Birch, oak, rowan, alder, pine, juniper, willow. Mike quizzed me on why I thought the woodland was like this. I hazarded a guess: the A-road and the river functioned as relatively impermeable fences for deer, who could not browse the vegetation. With the lower browsing pressure, a more diverse range of woodland species could grow. Mike nodded his head and smiled proudly. The small woodland, I realised, was a reminder of the ecologies possible if deer numbers were successfully controlled.

Another afternoon, I visited Carrifran Wildwood, a native woodland creation project in Southern Scotland. An estate employee explained that literally *all* the wild trees had been cleared in the glen over successive centuries. A Forestry Grant Scheme payment had covered the cost of planting an initial 500,000 native trees just over twenty years ago, and now 750,000 trees had been planted. As the woodland had grown, and herbivore pressure had been reduced, surprising ecological happenings had occurred. Montane flora, which ecologists had previously assumed to only be able to live on upper ridgelines had "escaped" their high-altitude refuges, establishing themselves all the way down to the river which ran through the bottom of the glen. Ecologists studying the area realised that the so-called 'montane' flora had lived in high-altitude areas because these were the only areas they *could*. These were not necessarily the species' preferred ecological niches, but rather, the refuges that they had clustered into. Carrifran had become a site of accidental experimentation, where assumptions about which species belong where were being undone.

Figure 84 Carrifran Wildwood, an unexpected site of ecological experimentation.

Perhaps these two vignettes represent pasts that have been lost; perhaps they represent the forests futures that could exist once again; certainly, they are ecological presents. Presents to be shared and enjoyed. They are only single moments amongst many which helped me develop an understanding of Highland ecology and what I came to understand as the real value of rewilding. Rewilding does not demand heavy handed interventions like tree planting; it does not entail the return of a stable, historical, ecological baseline; and it might not even capture carbon. It is a mode of conservation that departs from the pre-conceived frames of success in environmental management. In the Highlands' specific ecological-historical context, I learned from ecologists that rewilding is best manifested by facilitating the natural regeneration of wild trees, and tipping ecologies towards a new equilibrium state. Some nonhumans' destructive capacities must be tempered to allow other multispecies communities to flourish. Allowing regeneration to occur is a step into the unknown as multispecies assemblages create unique ecologies which surpass the confines of existing human knowledge. Ecologies might exceed

framings of what nature should look like, which species should exist, and how they should relate.

I'm aware that this call for regeneration is an idealistic notion, a far cry from the hegemonic trajectories along which nature restoration is developing in the Highlands. Facilitating regeneration and accepting the unknowability and immeasurability of ecological dynamics rubs up against the logics of natural capital markets, which are increasingly framed as the necessary, and indeed *only*, mechanism for unlocking nature restoration at the speed and scale required to address interrelated ecological and climate breakdown. My celebration of regeneration, I am well aware, might be read as romantic hubris. As environmental philosopher Michael Marder (2023) suggests, (an unspecified) "we" have been lulled by the cadences of natural cycles, blindly accepting that the ashes of industrial destruction are fertilizers that nourish new growth. Trapped in what he labels 'The Phoenix Complex', humans do not believe that death really is death, or destruction really is destruction. Marder rejects societal faith that the metaphorical phoenix – forests, Society, or Nature – will rise again.

Perhaps Marder's diagnosis is fair. There is not an "infinitely self-regenerative capacity inherent to finite existence" (2023, p. 1). After all, a forest cannot grow back when all its trees are cut down. But Marder's argument against hope, in favour of "absolute hopelessness… [as] an antidote against the surfeit of self-deception" (2023, p.1), seems an armchair indulgence. Blowing on embers is a better metaphor than waiting for ashes to spontaneously metamorphise. Making fires, not relying on phoenixes. Going out and looking for ecological embers might be heart-breaking, as I learned first-hand during the countless hours of surveying I undertook. But in Scotland, as I am sure they do elsewhere, ecological fragments exist in the ruins of modernity. Measuring them is the first step towards an alternative mode of governance to the natural capital model; if these pockets were at least legible to the state, interventions which allow them to flourish might flow accordingly.

I write these concluding remarks with the conviction that, as J.D. Dewsbury (2000) argues, scholarship is performative. The words and theories that academics use to describe reality have the power to fundamentally shape it; in Latour's terms, they play a constitutive part in 'assembling' the world, setting the parameters of which social relations can be accepted. Theory shapes what counts as normal or acceptable. My conclusion, then, is written in the hope of disrupting the status quo ways that nature restoration takes place. Rather than only critique

the reductive frames shaping how forests are valued, my intention is to highlight the multiple other forests that might be performed in reforestation attempts. Flourishing, vibrant, wild, diverse, healthy, resilient, historically continuous forest communities can be valued in the terms required by modernity: for their ecosystem services, natural capital stocks, and utilitarian contribution to Scotland's market economy. But beyond these framings, I maintain that they matter because they matter. Forests should not require instrumental valuations to be protected and restored. Ecologies should not have to be reduced to a carbon quantity or a biodiversity score to be worthy of conservation or restoration. Trees should not need to be enrolled as nature-based 'solutions' to human-defined problems. The shared futures of the Highlands' suppressed multispecies communities should not need to rely on the whims of a market. The last fragments of ancient Caledonian pinewood still exist and can regenerate if political and ecological conditions change. More people must learn to notice.

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Appendix.[72]

Date	Role	Sector	Length	Type
01-Mar-21	CEO, Carbon Brokerage	Carbon finance	1 hour	Online Interview
06-Apr-21	Urban forestry project CEO	Rewilding - Charity	1 hour	Online Interview
20-May-21	Community Woodlands Manager for NGO	Community	1 hour	Online Interview
26-May	Biodiversity and Carbon accountant, Rewilding Estate	Private Rewilding	2 days	Ethnographic Visit
27-May	Estate Ranger, Rewilding Estate	Private Rewilding	3 hours	Ethnographic Visit
28-May-21	Senior Manager at Rewilding NGO	Rewilding - Charity	1 hour	In-person interview
28-May-21	Carbon Scientist	Science	1 hour	Online Interview
Jun-21	Biodiversity and Carbon accountant, Private Company	Private Rewilding	1 hour	Online Interview
02-Jun-21	Carbon Broker and Senior Manager, Forestry Company	Commercial Forestry	1 hour	Online Interview
03-Jun	Forest Carbon Broker, Private Company	Carbon finance	1 hour	Online Interview
08-Jun-21	Manager, Rewilding Network	Rewilding - Charity	1 hour	Online Interview
09-Jun-21	Peatland Restoration Activist	science	1 hour	Online Interview
09-Jun-21	Ecologist, Rewilding Charity	Rewilding - Charity	1 hour	Online Interview
10-Jun-21	Estate Manager, Rewilding Estate	Rewilding - Charity	1 hour	In-person interview
10-Jun-21	Estate Owner, Rewilding Estate	Rewilding - Charity	2 days	Ethnographic Visit
11-Jun-21	Estate Owner, Rewilding Estate	Rewilding - Charity	2 days	Ethnographic Visit
13-Jun-21	Forest Carbon Broker, Private Company	Carbon finance	1 hour	Ethnographic Visit
15-Jun-21	Commercial Forestry Consultant	Commercial Forestry	1 hour	Online Interview
18-Jun-21	Estate Manager, Rewilding Estate	Rewilding - Charity	0.5 hours	Online Interview
19-Jun-21	Tree Planter, Contractor	Commercial Forestry	2 hours	In-person interview
21-Jun-21	CEO, Tech Start-up/ Commercial Forestry Company	Tech Developer	2 days	Ethnographic Visit

[72] N.B. Interviews highlighted in yellow were multiday trips.

21-Jun-21	Woodland Manager, Forestry Organisation	Commercial Forestry	2 hours	Ethnographic Visit
24-Jun	Wild Carbon Specialist, Commercial Forester	Forestry	2 hours	Online Interview
28-Jun	Community Woodlands Activist	Community	1 hour	Online Interview
29-Jun	Ecologist, Rewilding Charity	Rewilding - Charity	2 days	Ethnographic Visit
05-Jul	Managers, Community Forestry Group	Community	1 hour	In-person interview
08-Jul	Wild Carbon Specialist, Commercial Forester	Private Rewilding	1 day	Ethnographic Visit
09-Jul	Ecologist, Rewilding Charity; Estate Manager, Rewilding Charity	Rewilding - Charity	1 day	Ethnographic Visit
21-Jul	Ecologist	Rewilding - Charity	0.5 hours	Online Interview
22-Jul	Manager, Tree Nursery	Private Rewilding	3 hours	In-person interview
02-Aug	Estate Manager, Rewilding Estate	Rewilding - Charity	1 hour	In-person interview
02-Aug	Forestry Contractor	Community	2 days	Ethnographic Visit
16-Aug	CEO, Native Woodland Charity	Rewilding - Charity	1 hour	Online Interview
30-Aug	Landowner	Private Rewilding	1 day	In-person interview
30-Aug	Manager, Tree Nursery	Private Rewilding	7 days	Ethnographic Visit
06-Sep-21	Forestry Contractor	Community	2 days	Ethnographic Visit
08-Sep-21	Estate Manager	Rewilding - Charity	1 day	Ethnographic Visit
10-Sep-21	Ecologist, Rewilding Charity	Rewilding - Charity	1 day	Ethnographic Visit
13-Sep-21	Forestry Organisation	Commercial Forestry	4 days	Ethnographic Visit
16-Sep-21	Manager, Tree Nursery	Rewilding - Charity	1 day	Ethnographic Visit
11-Nov-21	Private rewilding company launch event	Private Rewilding	1 day	Ethnographic Visit
29-Nov-21		Rewilding - Charity	1 hour	Online interview
24-Feb-22	Estate owner	Tech Developer	1 hour	Online interview
12-Mar-22	Carbon Scientist	Private Rewilding	1 hour	Online interview
17-Mar-22	Carbon Scientist	Science	1 hour	Online interview
23-Mar-22	Ecologist, Rewilding Charity	Rewilding - Charity	3 days	Ethnographic Visit

25-Mar-22	Ranger, Rewilding NGO	Rewilding - Charity	3 days	Ethnographic Visit
26-Mar-22	CEO, Rewilding Charity	Rewilding - Charity	3 hours	In-person interview
28-Mar-22	Rewilding Estate Manager	Private Rewilding	1 day	Ethnographic Visit
28-Mar-22	CEO, Rewilding Company	Private Rewilding	1 hour	In-person interview
05-Apr-22	Community Land Activist	Community	1 day	Ethnographic Visit
12-Apr-22	CEO, Rewilding Organisation	Rewilding - Charity	1 hour	Online Interview
13-Apr-22	Senior Manager at Rewilding NGO	Rewilding - Charity	1 hour	Online Interview
16-May-22	Forestry Organisation	Commercial Forestry	3 days	Ethnographic Visit
17-May-22	Commercial Forester	Commercial Forestry	0.5 hours	In-person interview
18-May-22	Carbon Broker	Carbon finance	0.5 hours	In-person interview
25-May-22	Carbon Broker	Carbon finance	1 hour	Online Interview
31-May-22	Carbon Broker	Carbon finance	1 hour	Online Interview
10-Jun-22	WCC manager	Carbon finance	1 hour	Online Interview
30-Nov-22	Senior Representative, Tech Start up	Tech Developer	1 hour	Online Interview
15-Dec-22	CEO, Tech Start-up/ Commercial Forestry Company	Tech Developer	1 hour	Online Interview