LANDSCAPE DECISIONS

MAKING LANDSCAPE DECISIONS TO MEET NET ZERO CARBON:

PATHWAYS THAT CONSIDER ETHICS, SOCIO-ECOLOGICAL DIVERSITY, AND LANDSCAPE FUNCTIONS

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Making Landscape Decisions to Meet Net Zero Carbon: Pathways that consider ethics, socio-ecological diversity, and landscape functions

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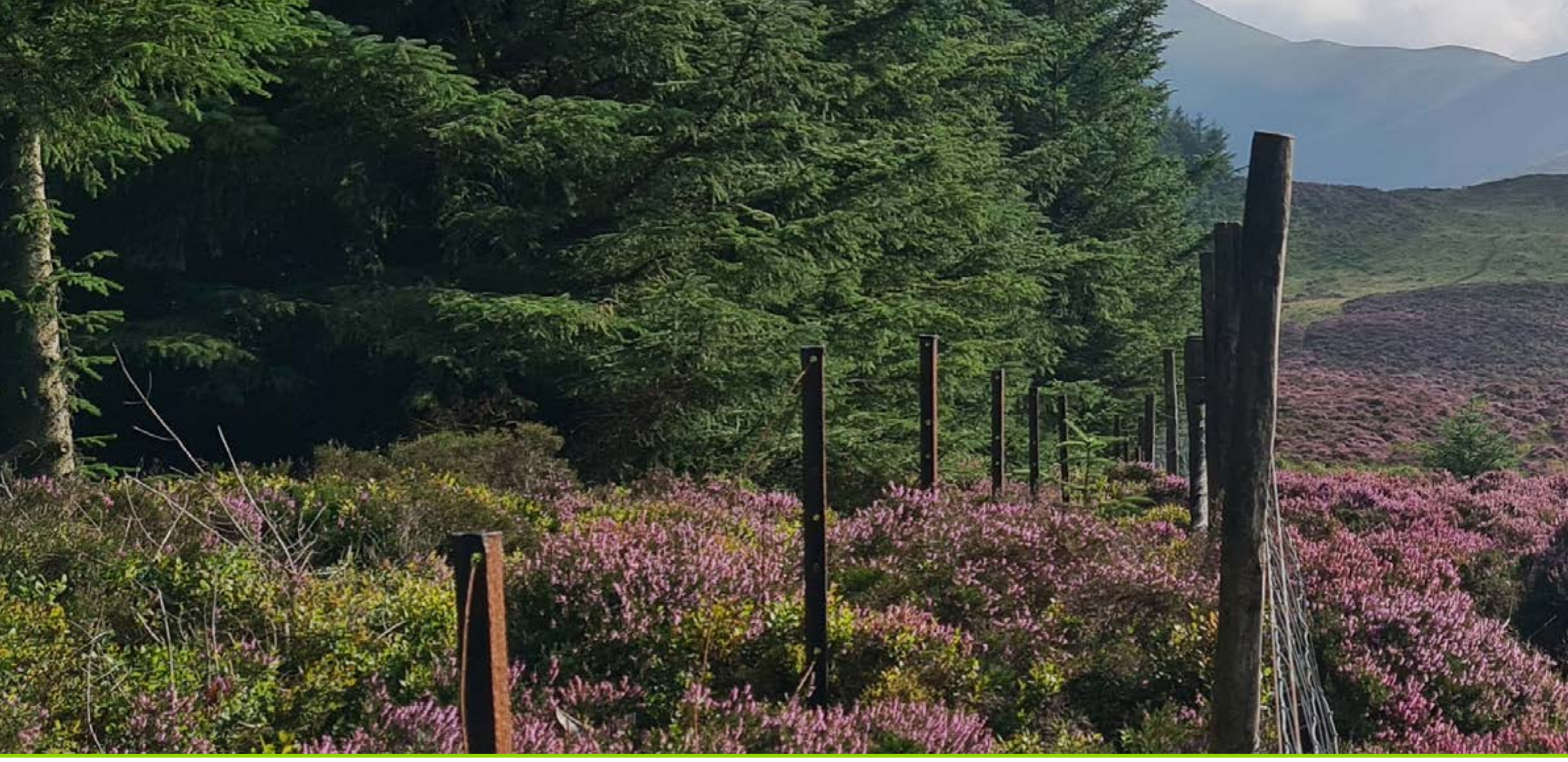

Executive summary

Landscapes are an integral part of the net-zero challenge; not only are they carbon stores but they constitute the environments upon which humans develop their livelihoods, interact and shape their cultures.

This report focuses on three key landscape types (agricultural, peatlands and forests), and the associated practices and impacts with particular relevance to the net zero carbon agenda.

We have brought together perspectives from natural and social science, humanities, and the arts to understand and evaluate how modern landscapes can absorb the impact of potential zero-carbon policies.

Key points

- There are multiple contradictions in the pathways towards achieving net zero carbon targets that include a loss in the benefits of biodiversity, human well being and cultural knowledge of the landscape.
- To mitigate these contradictions three key recommendations have been identified:

  (i) invest in transdisciplinary approaches for landscape management decisions,

  (ii) ensure the right ecosystem is promoted in the right place (no single land-use solution should be prioritised above others), and

  (iii) increase local and devolved decision making capabilities.
- Scientific approaches based on robust ‘evidence’ and aggregated data are still an essential ingredient in understanding landscape functions and that is key to the net-zero agenda.
- To achieve a transformative change it is not enough to just understand the importance of the landscape functions alone, but we need to place them in the social framing of landscape decisions.
- Swift action is essential, otherwise we head deeper towards an inability to reach net zero carbon targets, contribute to biodiversity collapse and, promote societal disengagement with landscapes.
- Setting the agenda for a net zero carbon target is an opportunity to review and renew existing policies and learn lessons from the consequences of past decisions.

The need for change

Incentivizing change in land-use choices is imperative and in terms of landscapes no decision is perhaps the poorest decision we can take, with disastrous consequences.

Unless we take action to reduce greenhouse gas emissions, global temperatures may rise to 4°C above pre-industrial levels by the end of the century. Summer maximum temperatures could rise by up to 10°C in parts of England by the 2080s. Sea level rise is predicted to be between 0.4 and 1 metre by 2100, and possibly by as much as 4 metres by 2300. Climate change will disrupt everyday life.

Challenging the current approach to change.

There needs to be an 'engagement with ethics' in the following ways:

1. Open conversations about decisions should not only be encouraged and facilitated, but are crucial to meeting ethical concerns.
2. Be very clear about who benefits from reducing carbon emissions in any given context, and why proposed decisions are important in relation to timeframes, aesthetics, environmental benefits and wellbeing.
3. It is crucial for there to be an understanding of what 'good' and 'bad' actually means in specific locations and for varying temporal scales, especially given that terms such as 'Net Zero Carbon' and 'Climate Change' are inherently long-term notions that may stretch beyond the lifetime of any one individual, and often ethically vague.
4. Discussion should be local, and should include stimuli to open up conversations about underlying ethical considerations that may not be immediately obvious; participatory and arts-based approaches are ideal to achieve this.
5. Elements that seem hard to capture - aesthetics, stories - are often the most important and intimate ways that people connect with and value landscapes.
6. Pre-decision assessments should include and acknowledge varying timeframes, including the overlap of past, present and future within a location.

What change?

Land use choices to achieve net zero carbon require broader considerations to reduce contradictions:

1. Avoidance of emissions should always be prioritised over mitigation. However it is acknowledged that net-zero carbon goals will likely require a combination of approaches.
2. Ensure that landscapes perceived to be 'high carbon' are not the only landscapes deserving protection. We must be mindful of which land uses are being replaced, and consider all functions
3. Including the biodiversity of existing ecosystems. Maintaining high biodiversity in the landscape requires a rich mosaic of appropriate habitats to be maintained and remain connected. We must avoid focusing the attention on a single land use on the basis of high carbon capture or storage potential. Shifting our focus to finding complementary carbon capture land uses will provide better synergies between priorities.
4. Any net zero carbon land use interventions should support (and better still, increase) biodiversity and bioabundance. We need to create and manage our carbon capture habitats with biodiversity in mind.
5. The location of renewable energy infrastructure needs to be carefully considered. Wind farm locations, heights of turbines etc. need to be selected to minimise adverse impacts on local ecosystems. It is preferential to site solar panels on buildings in places that are already highly human-modified. Where solar parks have been installed in fields, beneficial habitat management around panels should be incentivised.

Making the change

Key recommendations have been formulated to address some of the contradictions of the current net zero carbon strategy:

1: Invest in transdisciplinary and cross sectoral approaches for landscape management decisions and research

Gap 1.1: Decision-making for decarbonisation requires ethical, narrative and aesthetic inputs to complement cost benefit analysis

Gap 1.2: Improved education across all age ranges to form a better understanding of the landscape, including issues related to environmental and social justice

2: Promote the right ecosystem in the right place under the appropriate (right) management

Gap 2.1: Building resilience by enhancing diversity

Gap 2.2: Consider past, present and future human practices and ecological time scales.

Gap 2.3: Have a more robust critical assessment of technologies/practices in relation to future landscape impact

3: Increase local and devolved decision-making capabilities

Gap 3.1: Language, identity, and a sense of social justice should be explicitly linked to policy making.

Gap 3.2: Participatory and co-creative approaches can engage stakeholders in new and more effective ways

Gap 3.3: Landscape decision-makers should have access to different policy approaches

The outcome of change

Without swift action in response to these recommendations, we risk introducing land use changes that replace and inhibit functioning ecosystems and stand at odds with the aesthetic and cultural values of local communities. As such, these activities are likely to be reversed in future, with partial or even total loss of any carbon capture achieved. An alternative, more holistic approach is urgently needed.

We want to encourage policy and decision makers that the recommendations set out above are merely the starting point for broader conversations about the change needed to break with the status quo. Together, we must create new ways of doing, thinking and communicating that embed inclusive, place-specific, net-zero practices within landscapes that support both biodiversity and people.


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Introduction

Net Zero Carbon policies aim to achieve a positive impact on climate mitigation through the reduction of greenhouse gas sources and enhancement or creation of greenhouse gas sinks.

Large-scale land use change is necessary for the land use/ land use change and forestry (LULUCF) sector in the UK to contribute to Net Zero. A recent report by the Committee on Climate Change[1] lays out a pathway towards Net Zero that includes an increase in low-carbon farming practices for soils and livestock, planting between 90 and 120 million new trees per year, using 10% of existing farmland for agroforestry, restoring 55% of all peatlands, planting 23,000 ha of bioenergy crops each year, reducing meat and dairy consumption by 20% and reducing food waste by 20%.

Landscapes are thus an integral part of the net-zero challenge as they are carbon stores as well as constitute the environments upon which humans develop their livelihoods, interact and shape their cultures. This report focuses on three key landscape types (agricultural, peatlands and forests) and their associated practices and impacts which have particular relevance for net zero carbon agenda. The characteristics and functionalities of landscapes have been supported and sustained by management practices based on the needs, traditions, customs, and peculiarities that characterise any given society that acts upon them. In consequence, a constant process of change in practices and values are always at work. From this point of view, landscape forms are considered to be cultural products, subject to social and economic activity as well as products of the physical processes that maintain them. The combination of physical and biological elements, their functions, and the meanings embraced in the landscape inevitably vary in time and space, social, and cultural, contexts [2]. Perceived as a product of the imposing culture on a natural system and vice versa, landscapes automatically become contested concepts.

The complex dynamics characterising landscapes make the design of relevant policies and decision-making 'wicked' problems. Wicked problems have been described [3] as problems where there is no single formulation, have multiple solutions, are on-going with no point where they are 'solved', in the sense that a definitive and objective answer cannot be given. Achieving the goal of Net Zero Carbon is a specific problem with multiple solutions, coming from diverse directions (e.g. tree planting, biofuels, dietary change) and being relevant to different objectives (e.g. it can be a key focus for both climate change mitigation or adaptation agendas). For example, peatland restoration can help capture carbon as well as contribute to flood risk management; it requires changes to farming that can reduce carbon footprints and deliver changing diets, etc. In such complex situations, solutions can be difficult because of incomplete knowledge, contradictory, and/or changing requirements that are often difficult to recognise[4]. A large number of opinions are often involved and there are no right or wrong answers; answers may be better or worse from different points of view. Different views may be based on perceptions that specific solutions may serve better different interests. That can be because of incomplete knowledge on an issue or disconnection between cause and effect e.g. pollution problems are not seen as biodiversity loss or

[1] Greenhouse gases include CO2, but also non-carbon greenhouse gases such as methane (CH4) and nitrous oxides, which can be expressed as CO2-equivalents for the purpose of greenhouse gas accounting.

environmental degradation more generally. Almost always it is because of incredible interconnectedness with other complex issues. Without taking account of a range of social and cultural issues we won't be equipped to address the complexity of reducing our net greenhouse gas emissions and intertwined post-COVID19 economic issues. Landscape analysis, therefore, requires multi source and interdisciplinary approaches – the combination of widely varying methods often coming from different disciplines[5] to complement existing decision making frameworks. In this report, we have brought together perspectives from natural and social science, humanities, and the arts to understand and evaluate how modern landscapes can absorb the impact of potential zero-carbon policies.

Scientific approaches based on robust 'evidence' and aggregated data are essential in understanding landscape functions and that is key to the net-zero agenda. To achieve transformative change however, it is not an issue of understanding the importance of the landscape functions alone but to place those in the social framing of landscape decisions. Insights from arts and humanities elicit historical understandings and practices, intuitive and embodied knowledge, imagined futures, as well as singular perspectives and meanings contributing to the interpretation of values people hold for landscapes[6]. Creative practices can reframe issues[7] and enable ethical and aesthetic discourses [8] to inform understandings and foster transformative changes in the behaviours of individuals and societies [9]. Combining perspectives from natural and social science, the arts and humanities, therefore, allows for a broader understanding of the complex challenges imposed by Net Zero Carbon targets. Individual, community, and institutional responses to climate change are formed by landscape heritage values, familiarity with, and sense of, place, identity and social relations in space, and these can be revealed through arts, humanities and social science approaches. [5,10–12]

Achieving Net Zero Carbon results through landscape decisions will require greater consideration of how this aim fits into ethical perspectives and worldviews. One important reason for prioritising this is the very language of 'Net Zero Carbon' itself': if decisions are to include individuals as well as groups of decision-makers, then it has to be clear what the concept behind 'Net Zero Carbon' really signifies. The quantitative nature of the term itself suits data-driven approaches, where emissions and removals of greenhouse gases are counted and measured, but does not necessarily convey why this is desirable, or how action might be encouraged. Within the context of Defra's 25-year environment plan, focusing solely on Net Zero Carbon would risk unintended detrimental impacts on other goals such as halting biodiversity loss. Moreover, landscapes represent cultural understandings of space, which includes both symbolic and lived meanings, and any change that threatens those can potentially become the object of conflict and rejection by society. Hence the trade-offs and synergies between net zero and other goals need to be fully considered. In this report, we consider how a broader consideration of narratives can assist the impact and outcomes of specific scenarios and case-studies, and encourage the government to see net carbon emissions as merely the starting point for change, rather than the change itself.

The report, therefore, focuses on a unique multidisciplinary perspective on some of the pressing issues of landscape decision-making in relation to Net Zero Carbon.

Part A: Thinking about change

Engaging with decisions means engaging with ethics

As discussed above, making decisions about landscapes is never a straightforward, anodyne process. Landscape decisions are made by people, and people operate within ethical frameworks. These decisions, and their effect on the distribution of resources (material or immaterial), are always a process involving moral judgment and ethical decisions. In the context of affirming zero-carbon policies, these take the form of moral claims about the allocation of environmental goods and burdens, the needs of e.g. current and future generations, or humans and non-humans. Whilst certain landscape choices may have the potential for a significant impact on reducing emissions and creating and enhancing carbon sinks, a focus on land over people can mask some of the nuanced decisions taken in reality. We suggest that notions such as 'goals' and 'accountability' are fully considered in situ to ensure they are meaningful. As long as landscapes are also defined by mindsets (such as expectations in relation to appearance or wellbeing), then any decision-making needs space for contemplation of broader ethical frameworks, including potential biases.

A deliberative approach to decision making (see Part C - R1, R2) is particularly important when considering carbon emissions. In Part B we illustrate how such approaches cater for specific landscape contexts. The notion of a morally right choice behind emissions reductions is inherent, but this may not be the same as the actions that lead to reductions, and the connections may need articulating. In any one scenario, a landscape decision about emission reduction may conflict with e.g. expected aesthetics (how a landscape looks and feels), recreational use, or cultural value. To pull together the complex range of ethical factors at play in each specific scenario requires a recognition that qualitative factors can be as persuasive and compelling as quantitative and that a more sustained focus on narrative may in fact help to nurture strategies for long-term change, such as the idea of 'responsibilisation'[13] and the notion of 'unintended consequences', which foster ideas of shared responsibility.

A consideration of ethics is also crucial if we are to ensure that inequalities in relation to e.g. race and ethnicity, class, gender, age, access, and location do not become further embedded through offsetting goals. Landscape decisions in relation to carbon reduction are not ethically distinct from other socio-cultural decisions. In particular, the choice of where carbon reducing activity occurs has potential to integrate or isolate different communities, depending on whose voices are included.

In short: if we want to affect change, then closer consideration of the stories we are telling, the different time-scales over which these occur, and the differing cultural evaluations, interests and assumptions of individuals and groups, all need to be embedded in the decision-making process. Approaches such as co-production of services, co-design of systems and co-evaluation, and methods such as citizen science, citizen observatories and arts-based approaches[6] can deliver engagement at scales from the local to the national, and should not be seen as desirable elements, but as essential parts of policy making to meet Net Zero Carbon objectives[15].

[2] Key leverage points in a system are identified by Meadows in the classic essay 'Leverage Points: Places to Intervene in a System' (1999). The most effective point is identified as 'The mindset or paradigm out of which the system—its goals, power structure, rules, its culture—arises'.

Example 1: Future-facing moralities

Any landscape is a capsule of different times, containing the past, present and future. Many decisions are couched in relation to a notion of future benefit and progress or development; however, it is often left unclear who exactly the decisions are benefitting, and how far into the future their impacts might reach. When large concepts such as 'climate change' are folded into decisions, as with Net Zero Carbon, it can become unclear where in time the benefits are met. Relying on a general benevolence towards as yet unborn future generations should not be assumed as given and may be culturally reliant. For example, a general concern expressed by ancient Romans towards future peoples does not necessarily translate into decisions made explicitly for them that take priority over those already alive, or where the pay-off will not be primarily felt in the present.

The question of how responsible we should feel ourselves to be towards those not yet born is a known philosophical conundrum; an example often given is that policy changes made now will result in different future people being born, and so it becomes difficult to understand exactly to whom we have a moral obligation and why this should matter[16] It is incumbent on policy-makers to be clear and specific about the who (however general) and when of landscape-decision making, and, when any benefits are to be met beyond the lifetime of those affected now, to meet tensions with dialogue and discussion in advance. There are already useful examples of how decisions can be framed within an ethical narrative across the constituent parts of the UK; in Wales, for example, the 'Well-being of Future Generations Act'[17] explicitly engages with the idea that future generations have a moral standing. This is meant to ensure that decisions made by public bodies do not impact the ability of future generations to meet their own needs, and offers a model that is neat in its clarity and could be reproduced elsewhere. In England, the White Paper on sustainable fisheries for future generations outlines proposed approaches to fisheries management that build a sustainable fishing industry in line with the 25 Year Environment Plan.[18]

Moral decision-making in relation to the future does not always have to be distant, involving non-existent actors. Different, sometimes competing, valuations are attached to the idea of the past (history, archaeology, culture) and the present (use, lived experience, the existence of particular landscape appearances), and these often intersect in the close future. There is a strong sense that cultural artefacts - archaeological sites, for example - should be retained and preserved indefinitely. The tensions that thus arise between, say, past material, present access, and future health, cannot and should not be simplified for quick decision-making; rather, serious attention needs to be paid to place and detail, to ensure that 'the future' is not used as a space unrelated to the past and present, and which always looks different and progressive. Local detail is paramount in this context.

As with past histories, when imagining the future, and future people, it is crucial to consider which people are included, and active consideration given to ensure that present ethical frameworks that allow inequalities in landscape decision-making are not projected forward. Reducing emissions presents an opportunity for imagining a future that helps to shift ethical frameworks too.

Some projects in the Landscape Decisions Programme are considering how ethics can be future-leaning and generative, and not only something to be identified, such as Field\work and Field || guides[19] (both focussed on agricultural landscapes). These projects use ancient narratives as a means to help articulate ideas about what might be important for communities in the present and future. This approach may be fruitful as a means of negotiating different understandings of the future in relation to Net Zero Carbon, and especially in helping to substantiate how its uncertain temporalities can become meaningful for different communities.

[3] The project 'Design Innovation and Land Assets (DI&L)' from the Landscape Decisions Programme [14] directly demonstrates co-design approaches.

Example 2: Narratives and storytelling

Narratives are powerful and compelling things that shape memory, affect value, and have the capacity to alter behaviour. The legacy of landscape narratives affects what activities we expect to happen in particular places, as well as moral valuations of that activity. So, for example, the idea of the 'georgic' not only impacts on what we expect an agricultural landscape to look like, but also the type of labour we expect and how it is valued (hence the notion of the 'good' farmer). Similarly, 'pastoral' comes to signify both the aesthetic expectations of particular landscapes and the leisure that you can expect to find there; the stories have nurtured the concept of what a relaxing space should look like. Understanding these embedded cultural expectations that emerge through stories over hundreds of years is a crucial aspect of appreciating the value of different landscapes; it also offers a potential method for helping to foster changes to landscape decisions. In short, if we want to bring about effective landscape decisions that will aid Net Zero Carbon goals, we need more helpful stories.

In relation to Future Facing Moralities (above), the question of whose stories get to be heard is important;[20] stories can be generative and offer the means to allow for many voices, but this opportunity has to be encouraged. The stories of any landscape are part of an ongoing dialogue between humans and their surroundings. Storytelling can be directed towards the human and/or the non-human, to imagine the future as well as represent the past, so that a specific site might be described as a location for human activity, or where the non-human elements are foregrounded (landscape biographies that engage with geologic time, for example).

Narrative and storytelling are central to all the arts and to design. Different art forms evoke and express different aspects of experience and embodiment. There have been various books exploring subjective landscape experience in recent years, through e.g. 'new nature writing' and psychogeography, which prioritise experience as a crucial aspect of understanding and affect. Likewise, there has been an emergence of object-led understandings of 'place' in publications that bridge literature, philosophy and politics, as well as approaches based on 'deep mapping' that aim to understand the connections between the social, economic, cultural and environmental dimensions of places. Post-colonial literatures make critical contributions to ways of storytelling. Design, and Service Design specifically, offers particular capacities to focus on dynamic incentives, feedbacks, liabilities, accountabilities as well as to create deliberative and engaging processes, while respecting the sovereignty and agency of human & nonhuman actors.

This emphasis on the interconnectedness of landscapes informs the Scottish Government's 'Place Principle',[21] which recognises that place is where people, location and resources combine to create a sense of identity and purpose. This approach engages individuals in new ways, valuing in particular biodiversity and sense of place, and underpins urban planning and regional adaptation programmes. A number of projects within the Landscape Decisions programme are engaged with the power of narratives for landscape decision-making; for example the 'Changing Landscapes, Changing Lives' research network. Each of these offer potential models for dialogue.

[4] (a term emerging from Virgil's Georgics, a Roman agricultural teaching poem of significant influence in later agricultural science, philosophy, literature, art; the word usually means agricultural or rustic with associated values)

Example 3: Landscape aesthetics and appearance

Everyone has expectations as to how different landscapes should appear. These expectations often correlate to such ideas as beauty, wellbeing, and identity (e.g. national, local, vocational), and can be fostered by narratives (see example 2). Landscape aesthetics can contribute to quality of life in relation to e.g. harmony and inspiration.[22] The aspects of a landscape that we judge to be important or significant often corresponds to what is perceivable to us as humans, and what is reproduced and strengthened through cultural artefacts (paintings, literature), so that elements of a landscape outside our usual visual field - such as soil microbiology - may not have the same perceived value as topographical features. At the same time, recent work would indicate that landscape aesthetic quality may be judged as highest for areas that are not usually accessible or visible;[23] in other words, aesthetics and appearance could map very closely onto imagined landscapes. Landscape aesthetics has only recently been considered as an element that should be valued within the ecosystem services framework, yet represents one of the most 'intimate' ways that humans experience landscape.[22] Its significance within decision-making is, therefore, neither trivial nor superficial.

Given that many landscape choices in relation to Net Zero Carbon involve a level of perceivable change to the appearance of landscapes - e.g. planting trees or building wind turbines - the issue of how we ethically appraise different landscape appearances as good or bad[24,25] becomes significant. This is particularly the case with regards biodiversity, where what is 'good' for non-human species may not look 'good' to humans. Working together with communities is also important to help negotiate and compare these with other sorts of ethical dilemmas (e.g. future responsibilities). However, in the case of aesthetics, awareness of non-residential communities (such as tourists) needs to be included, given that some economies are directly linked to cultural understandings of beauty and escape. In terms of innovative participatory and arts-based approaches, 'A New Environmental Impact Assessment for Natural Scotland: Environment, Imagination and Aesthetics' project [26] offers a very useful model with potential for reproduction elsewhere.

Two projects in particular in the Landscapes Decisions Programme are considering the significance of landscape aesthetics and the potential there is for identifying and changing expectations. The AgLand project[27] focuses on identification of 'landscape archetypes' which describe the typical look-and-feel of landscapes in different regions of the UK. These are characterised by specific physical features, land cover types, landscape structures and land uses and feature specific aesthetics and cultural values. The Tipping Points project[28] is concerned with how our expectations in relation to landscape appearance may need to shift if we are to accept the kinds of landscape changes essential for reaching targets in relation to biodiversity and Net Zero Carbon.

[5] (e.g. Draft Glasgow City Region Adaptation Strategy 2020-2030 framed by the Scottish Government's 'Place Principle' p.12)

Example 4: Wellbeing

Wellbeing is a broad term, but one with associated value (economic and otherwise).[29] In general terms it describes positive impacts on people's mental and physical health, and is a crucial aspect of what it means to live a satisfactory and good life. A difficulty in the context of Net Zero Carbon and landscape decision making comes from the focus wellbeing often has on the individual (the word usually captures wellness relative to a particular person) and the implicit ethical rights someone might have to a good quality of life, and balancing this alongside the desires to meet the wellness of a larger group of people who may or may not yet be alive. In addition, the prompts for wellness can be highly subjective and 'shaped by life history and experiences',[30] which can add complexity to decision-making and the ways in which they are measured.

What is certain is that landscapes are crucially important in delivering wellbeing impacts on people's lives. For example, they provide opportunities for recreation by spending time in nature, for exercise outdoors (especially important during pandemics such as Covid-19) and for spiritual, religious and cultural experiences as well as education,[31] and in these activities overlap with many of the issues highlighted under Example 3: Landscape aesthetics and appearance, above. Whilst wellbeing is often implicitly understood as deriving from leisure, landscapes have the potential to offer other crucial aspects of individual wellbeing, such as food and housing security as sites for building and growing.

It becomes especially important again, then, for landscape decisions to be clear and articulate how the differing needs of individuals, and not only large groups, are being assessed and met during any consultation processes. Processes that seek to account for the wellbeing of varying socio-economic backgrounds, and which take e.g. age, gender, race, ethnicity, and accessibility into account are fundamental. In the Landscapes Decisions programme, a number of projects are engaged in the experiences of distinct user communities, such as the 'Women in the Hills'[32] network, which aims to consider barriers and catalysts to women's recreational activity.

Principles - Thinking about change

- Open conversations about decisions should not only be encouraged and facilitated, but are crucial to meeting ethical concerns.
- Be very clear about who benefits from reducing carbon emissions in any given context, and why proposed decisions are important in relation to timeframes, aesthetics, environmental benefits and wellbeing.
- It is crucial for there to be an understanding of what 'good' and 'bad' actually means in specific locations and for varying temporal scales, especially given that terms such as 'Net Zero Carbon' and 'Climate Change' are inherently long-term notions that may stretch beyond the lifetime of any one individual, and often ethically vague.
- Discussion should be local, and should include stimuli to open up conversations about underlying ethical considerations that may not be immediately obvious; participatory and arts-based approaches are ideal to achieve this.
- Elements that seem hard to capture - aesthetics, stories - are often the most important and intimate ways that people connect with and value landscapes.
- Pre-decision assessments should include and acknowledge varying timeframes, including the overlap of past, present and future within a location.


Public
Footpath

Part B: What should the change be?

Land-use choices and incentives for change

Unless we take action to reduce greenhouse gas emissions, global temperatures may rise to 4°C above pre-industrial levels by the end of the century. Summer maximum temperatures could rise by up to 10°C in parts of England by the 2080s. Sea level rise is predicted to be between 0.4 and 1 metre by 2100, and possibly by as much as 4 metres by 2300. Climate change will disrupt everyday life. Many people will experience climate change through its effects on water, and especially through floods and droughts. Heat related morbidity and mortality in the population are also expected to increase.[33] Thus, it is apparent that incentivizing change in land-use choices is imperative and in terms of landscapes no decision is perhaps the poorest decision we can take, with disastrous consequences.

Landscapes are emergent properties from complex, interdisciplinary interactions across a variety of scales. For example, an individual land-use decision might be partially dependent on the environmental characteristics of the land (e.g. soil type/quality, temperature, precipitation), and the geographic location (urban/rural, commuter belt/remote), but also on the socioeconomic status of the landowner and the land user (people or organisations), and the actions of their neighbours and wider social networks. Landscape decisions are also influenced by culture, history and social norms, as outlined in Part A. As such, achieving a common goal across landscapes e.g. net zero, requires alignment across multiple policies, sectors and scales. This section considers how a common goal across landscapes might be achieved, including some specific examples, focusing on rural landscapes.

B.1 Landscape choices that absorb and/or prevent the release of carbon

Human activities, through Land Use, Land-Use Change and Forestry (LULUCF) activities, affect changes in carbon stocks between landscapes and the atmosphere. Management and/or conversion of land uses (e.g. forests, croplands and grazing lands) affect sources and sinks of greenhouse gases. As such, the role of LULUCF activities in the mitigation of climate change has long been recognised and can be divided into preventing activities that release greenhouse gases and promoting activities that absorb greenhouse gases. It is widely considered (e.g. as part of the mitigation hierarchy; Figure 1) that avoidance of emissions should be prioritised over mitigation (i.e. via sequestration), although net-zero carbon goals will likely require a combination of both approaches. It is encouraging that the 'prevention principle' which backs this mitigation hierarchy is set out in the Government Environmental Principles Policy Statement[34].

A variety of options for mitigation of greenhouse gas emissions exist in land systems. General mitigation options for preventing the release of greenhouse gases could include forest-related activities such as reducing emissions from deforestation and degradation, and enhancing the sequestration rate in existing forests (Box 2). Other prominent examples are agriculture, where options include improving crop and grazing land management (e.g. improved agronomic practices, nutrient use, tillage and residue management; Box 1) and better management in peatlands, (e.g., prevention of burning activities that dry out peat; Box 3).

Activities to increase uptake of greenhouse gases include encouraging creation of new forest areas, restoration of organic soils and degraded peatlands, better farming techniques for the conservation of wetlands that are drained for crop production (adaptive management), and restoration of degraded lands. As peatlands disproportionately hold 1/3 of global soil carbon, covering ~4% of the global land mass, the restoration of carbon-rich peatlands present a significant mitigation choice at national scales. By international standards the UK has large areas of peatlands, ~10% of the UK land area. In the UK this choice to improve peatland condition cannot be overlooked given the potential to restore the 80% of carbon sequestering peatlands that are estimated to be damaged or degraded. These peats can occur on upland grazing areas, e.g. moorlands, and lowland agricultural areas, e.g.'fens', that require implementation of appropriate and contrasting techniques to complement or replace existing land uses that are currently detrimental to the retention of carbon. Box 3 illustrates the progress and prospects for net zero emissions in upland peats.

Actions at the top of the hierarchy should be prioritised

ENERGY Wolfe 2005	CARBON Horgan 2011	BIODIVERSITY IUCN, UNOC 2012
Energy Saving	Avoid wasted Energy	Avoidance
Energy Efficiency	Efficient Conversion	Minimisation
Renewables	Renewable Energy	Restoration
Low emission		
Conventional with Offset	Offset	Offset

Figure 1: Example mitigation hierarchies across a number of key challenges[35]

The main drawback of LULUCF activities is their potential reversibility and non-permanence of carbon stocks as a result of human activities, with the release of greenhouse gases into the atmosphere, disturbances (e.g. fires or disease), or environmental change, including climate change, threatening the resilience of carbon stocks. Furthermore, there are obvious opportunity costs with the prevention of development of land (i.e. preventing HS2 would maintain carbon and biodiversity stores, but would stop infrastructure improvement and have political consequences). However, the impacts of these trade-offs are often entirely dependent on how decisions are implemented (e.g. by being location specific). Key impacts on existing policy goals are outlined below.

The growth of the carbon offsetting industry has increased interest in developing techniques to capture atmospheric carbon, e.g. The Orca plant that started operating in Iceland, September 2021. Concern over the reversibility of biological storage mechanisms, the (often) long timescales required to capture carbon this way and the amount of land these nature-based approaches require for sufficient carbon capture (compared to the amount of land that societies are willing to dedicate) has led to growing interest in non-biological storage options. These include storing CO_2 in geological reservoirs (e.g. ex-mines) and chemically capturing atmospheric carbon via mineralisation.

However, underground storage is not without risk of reversibility (e.g. leakage due to ground tremors) and is equally limited by physical capacity, given that much of the carbon was originally removed from the ground in solid form (i.e. as coal) and returning it in gaseous form requires a much larger storage volume. Many of these techniques are still in the early stages of development and the wider environmental impacts of such actions have barely begun to be investigated. For instance, spreading crushed olivine rock along beaches has been proposed as one means to capture carbon via mineralisation [36]. Yet beaches represent complex ecosystems and the introduction of vast quantities of additional minerals to the environment (plus any contaminates accumulated through production processes) would almost certainly impact sand organism function, with knock-on impacts for other higher trophic levels that depend on them. Such concerns have led to calls for greater regulation and transparency in the emerging carbon offsetting sector [37].

Given the amount of atmospheric carbon that must be sequestered in order to prevent climate warming exceeding the 2 degree threshold, a mixture of biological and (potentially more immediate) non-biological storage approaches are almost certainly needed, alongside drastic reductions in emissions. However, it is essential that attempts to avert the environmental and ecological crises of climate change do not generate a second ecological crisis by employing non-biological techniques that cause further unintended environmental damage. Strict regulation will be needed to control and monitor the environmental and human impacts of chemical carbon storage techniques, along with legislation to prevent biological storage actions being reversed in future. This could include protecting such areas from later development and requiring that appropriate management regimes are implemented.

B.1.1 Impacts on biodiversity

Many carbon-rich landscapes are high in biodiversity, so landscape decisions for net zero aims can be beneficial to biodiversity. Increasing carbon stocks may be advantageous for modified and degraded landscapes, however, we need to be mindful that the trajectory to the new habitat is understood, so the carbon stock and biodiversity increase is appropriate for the maintenance and functioning of the new landscape.

Afforestation and reforestation can have very different impacts on biodiversity whilst sequestering substantial amounts of carbon. Firstly, some fast-growing, non-native coniferous species are capable of removing high levels of carbon from the atmosphere rapidly, but with minimal added benefit to biodiversity (and potentially a cost, depending on what the land use was before). Secondly, slower carbon capture could be preferred to have a positive impact on biodiversity (e.g. using native species found in ancient woodlands). It is now well understood that the choice of planting what trees and where, should be determined by the functions of the habitat to be replaced and the effects this land use change will have on the anticipated climate changetax relief concessions in Scottish peatlands replaced open moorland habitat with pine woodland. The price paid was detrimental forest edge effects on bird breeding[38] and low quality timber yields because of the inappropriate soil conditions[39]. Monies are now having to be channelled into felling and restoration led by Nature Scot, the RSPB and other NGOs (e.g. LIFE Peatlands Project). The lessons are that afforestation can only work for biodiversity, especially maximising the opportunity for enhancing landscape connectivity, in the right location, and with the right choice of species and time. Of course, it is well established that newly established woodlands are often initially less diverse until they reach a mature stage with high levels of biodiversity. However, there are some species, such as reptiles, that greatly benefit from younger stand ages (3-12 year plantations[40]) and cannot persist when the woodland reaches a mature closed canopy state, due to the increased shading. This means that the greatest species richness would be achieved through management that creates niches for these and other species that depend on clearings and/or early successional stage growth, alongside those that require mature woodland.

We must also be mindful of which land uses are being replaced by 'high carbon' ecosystems; landscapes perceived to be 'high carbon' are not the only ones deserving of protection if that comes at the expense of biodiversity in another habitat. For example, the range and function of biodiversity that many grassland or mosaic ecosystems in temperate climates will host is likely to be different from that of closed canopy woodlands. Erasing one habitat for the sake of another landscape function could be counter productive for biodiversity and the function it has in maintaining a habitat. Biodiversity in adjacent habitats can also be mutually supportive as some species may thrive in both habitats or in the transition between them. In addition in many cases grass meadows can achieve net zero carbon while some types of woodlands can't - see box 2. Maintaining high biodiversity within the landscape can only occur if a rich mosaic of appropriate and harmonious habitats are maintained and can remain connected. This must be kept in mind when aiming to simultaneously satisfy carbon capture and biodiversity agendas, and it means we must avoid focusing attention on a single land use on the basis of high carbon capture/storage potential.

Instead, shifting our focus to finding complementary carbon-capture land-uses may provide a better balance of results. For instance, combining a new woodland with an adjacent carbon capture meadow will maintain carbon capture on two different timescales. The woodland will slowly accumulate carbon over decadal timescales. In contrast, the meadow, which can be mown each year, will provide carbon capture benefits in its first year and will continue to capture carbon at a constant rate as long as the meadow is present, if it is annually mown and the cut vegetation is removed and used for non-emitting purposes (e.g. composted). In terms of biodiversity, this woodland/grassland habitat complex then provides for woodland-dependent species, open-habitat species, edge species and those that use multiple habitats in close proximity. It creates a habitat mosaic, connectivity and improves landscape permeability for multiple species with different habitat preferences.

The benefits to these species will be maximised if we choose to create and manage our carbon capture habitats with biodiversity in mind. For instance, making use of natural regeneration to create new woodlands, rather than planting whips, will ensure a local species mix and will create scrub habitat, benefiting species such as warblers that rely on these intermediate successional stage habitats that have now become scarce in our landscapes. Similarly, ensuring a carbon capture meadow is not mown before mid-July will ensure ground nesting birds are undisturbed.

In general, all net zero carbon land use interventions should aim to support, if not increase, biodiversity and bio-abundance to be compliant with the UK's commitment to the UN Convention on Biodiversity.

B.1.2 Impacts on human well-being and public perception

Trade-offs are often apparent between targets for net zero carbon and human well-being. Landscapes are experienced by humans in material terms that contribute to their well being through the fulfilment of basic needs (e.g. food, water, energy, shelter and security). Landscapes are also environments with which humans are engaging perceptually. How people perceive landscapes defines how they interact with them and both, processes of perception and interaction, are very important for their well-being. They may highly value agricultural landscapes thinking about food security but also value the diversity of vegetative formations of established ecosystems for their aesthetic qualities. As cultural landscapes, such areas sustain social and collective memories contributing to cultural ecosystem services (e.g. recreation, connection with nature, social or economic relations). There is further an association between the nativeness of the species and their aesthetic and cultural value. However, many non-native species have been naturalised and highly valued by people (e.g sycamore, sweet chestnut[41]). Likely, stable and diverse ecological assemblages rendering services such as carbon sequestration, flood and erosion control. However, fast-growing non-native woodland species may be better to achieve net zero carbon targets in a short period of time - so regulating services are more complex. Similarly, it is currently not known if native species provide better air cleaning services (with obvious health benefits) than non-native species. As previously discussed, the opportunity cost of not developing the land (or developing it for high carbon land uses) can also impact on human wellbeing (e.g. less food, less and more expensive housing).

B.1.3 Carbon capture potential and economic cost

LULUCF activities to achieve net zero carbon hold the potential to absorb and store very large amounts of carbon. Such activities are reasonably cheap to undertake - e.g. £2.5 billion worth of social, economic and environmental benefits will be generated from The Northern Forest project[42] that has been set up to plant at least 50 million new trees. Often the highest economic costs associated with LULUCF activities are the opportunity costs lost as a result of locking in long-term to high-carbon land use types. However, for the bogs and fens of England (containing 584 Mt C or ~5 years of total countrywide CO_2 emissions [43]), it has been calculated that in many restoration scenarios, even with low 'shadow prices' for carbon, the costs of restoration will often outweigh the opportunity costs lost, especially when the multiple benefits of such restoration projects are taken into account. The most difficult opportunity costs to overcome are the restoration of wasted peat converted for agriculture and grazing (Natural England 2010), this suggests investment into alternative farming practices in fens and lowlands that would maintain higher groundwater levels, conserve carbon storage and maintain livelihoods requires action.

Similarly, the impacts of poor landscape decisions in the LULUCF sector can result in huge carbon releases. For instance, the IPCC WG1 (2007) estimated CO_2 emissions associated with land use change, averaged over the 1990s, were 0.5 to 2.7 GtC yr–1, with a central estimate of 1.6 GtCyr-1.

B.2. Land use choices that provide alternative energy sources

In the energy sector, fossil fuels have been the main energy source due to their relatively low price. However, our energy demand is predicted to rise in the future, and we can no longer rely on finite and polluting energy sources. In the last decade, we have seen a positive shift towards expanding our alternative, renewable energy capacity, both on a local and global level. Such infrastructural changes have the potential to avoid a large quantity of future emissions that would occur under business as usual scenarios. The mitigation hierarchy (Figure 1) ranks avoidance measures such as this amongst the most important activities to minimise future impacts. However, altering landscapes for the provision of renewable energy is not without trade-offs with other conservation-oriented goals. For example, terrestrial and marine wind farms provide about one third of all the UK's electricity and are typically situated within open landscapes where there are greater winds. However, in these areas, the aesthetic impact of the farms is greater, and these locations are often on the fringe of the national grid. Here we discuss the synergies and trade-offs associated with wind, solar and biofuels production and other policy goals. We also highlight the lack of current research around the potential negative biodiversity impacts of heat pumps.

B.2.1 Impacts on biodiversity

Wind farms can have consequences for biodiversity: birds are known to collide with turbines both on- and off-shore, with many site- and species-specific factors known to influence collision risk.[44] Of particular concern is the frequency of breeding seabird collisions with in-shore wind turbines while commuting to and from their nests.[45] Seabird populations globally are under enormous pressure due to climate change impacts and habitat loss and many are in decline. They are slow-breeding and long-lived, making their populations highly sensitive to loss of mature breeding individuals. On land, bat fatalities have also been associated with wind turbines[46] and these not only arise due to collisions but also through barotrauma, where the rapid pressure changes around the moving blades cause internal injuries. These cases emphasise the need to carefully consider wind farm locations and turbine heights to minimise adverse impacts on local and transient species.

Distinctively, solar parks and wind farms can provide biodiversity benefits. Land in between panels, and turbines, can be managed to benefit biodiversity, with pollinator-friendly planting frequently proposed as a means to deliver complimentary biodiversity benefits alongside energy generation[47]. However, tensions exist between the desire for easy and cheap ground management (best satisfied by frequent mowing to turf level) and the need for more specialist equipment to cut, rake and maintain wildflower habitat whilst also carefully manoeuvring around expensive solar installations. As a compromise, such habitat management tends to be relegated to park margins and even widespread adoption of this is likely to require regulatory or financial incentives to park owners.

Giving land over to solar parks can also have wider consequences for the surrounding environment. Ultimately, this is driven by conservation of energy: the solar energy that would have heated the ground is instead being intercepted, converted to electricity and this energy is then removed from site (via the electric cables). This reduction in ground heating can alter the microclimate at the site (which can itself change plant-soil carbon dynamics[48]), may cause a reduction in night-time temperatures in the surroundings[49], influence local winds and even potentially affect rainfall[50]. All of these may have knock-on impacts for surrounding ecosystems and suggest that it is preferential to site solar cells/panels in places that are already highly human-modified (e.g. on buildings) rather than in more natural habitats.

Growing biomass crops (e.g. miscanthus) to provide an alternative to fossil fuels faces the same biodiversity challenges as any crop, namely giving landscapes over to large-scale crop monocultures reduces landscape complexity and reduces resources for species that do not benefit from the crop habitat. Supporting biodiversity alongside biomass crops therefore requires farmers to take additional measures such as reducing field sizes, reducing fertiliser inputs, maintaining diverse boundary features (e.g. hedgerows, grassy/flower-rich margins) and embedding patches of semi-natural habitat in among the crops in order to provide resources for other species and maintain landscape permeability.

Heat pumps are being increasingly promoted for supplying heat directly to homes and other buildings by extracting thermal energy from either the air around the building, from nearby water bodies, or from the ground at shallow depths of ~6m that have stored solar energy (extraction of deeper geothermal energy reserves liberated by the Earth's formation is not a renewable energy source). The use of heat pumps to extract energy from the external environment to heat interiors necessarily reduces the temperature of the surrounding environment. Research into the environmental impacts of heat pumps has to date focused on the negative impacts of coolant leakage and research is needed into the thermal consequences for surrounding ecosystems. It is essential to assess how widespread adoption of heat pumps may reduce surrounding air/ground/water temperatures and potentially affect the survival chances of other species that are exposed to lower temperatures as a result. This shouldn't only be considered within suburban/urban areas themselves (which have traditionally provided a thermal refuge for many species, especially during winter) but should also consider the consequences of cold air drainage extending such impacts out into the wider countryside.

B.2.2 Impacts on human well-being

Whilst society views solar and wind farms positively, many of the negative aspects are solely borne by those local to the parks, resulting in considerable NIMBYism (Not In My Back Yard) with regards to these developments. For example, wind farms are often associated with poor TV and radio reception[51], and/or increased psychological fear of enormous wind turbines close by[52] in adjacent communities. As such, planning applications can create or enhance divisions in communities, resulting in the applications being contested which can lead to considerable stress.[53] At a national-scale, these negative impacts are offset by the production of clean energy - a much needed resource.

Growing biomass crops shares many trade-offs and synergies with the activities covered in Section B1. Whilst, high carbon, high biodiversity areas are often important for cultural ecosystem services (e.g. recreation, aesthetics) and so improve an aspect of wellbeing for some people, higher yields would often be achieved with monocultures or using non-native crops. As previously discussed, the opportunity cost of not developing the land (or developing it for high carbon land uses) can also impact wellbeing (e.g. less food, less and more expensive housing).

B.2.3 Carbon capture potential and economic cost

The mitigation hierarchy (Figure 1) ranks the avoided emissions through use of renewable energy sources as one of the most preferable targets for achieving net-zero carbon aims. The energy supply sector is the single largest contributor to the UK's greenhouse gas emissions and, as such, there are considerable gains to be made by switching to renewable energy. This process has already begun. For example, the energy supply sector was the largest contributor to the decrease in carbon dioxide emissions between 2018 and 2019. Carbon dioxide emissions from this sector were provisionally estimated to be 90.1 Mt in 2019, a decrease of 8.4% (8.3 Mt) compared to 2018 [54].

Sites for renewable energy must be chosen with care in order to not detrimentally impact other aspects of the Sustainable Development Goals. For example, locating wind farms in peatlands (and other agricultural areas) often requires semi urbanisation with access roads damaging, destroying and compacting the local structure and hydrology of soils (critical in peat functioning, and sometimes leading to peat landslides).

Principles - What should the change be?

Recommendations of land use choices for incentivizing change are summarised

1) Avoidance of emissions should always be prioritised over mitigation. However it is acknowledged that net-zero carbon goals will likely require a combination of approaches.

2) Ensure that landscapes perceived to be 'high carbon' are not the only landscapes deserving protection. We must be mindful of which land uses are being replaced, and consider the biodiversity of existing ecosystems. Maintaining high biodiversity in the landscape requires a rich mosaic of appropriate habitats to be maintained and remain connected.

3) We must avoid focusing the attention on a single land use on the basis of high carbon capture or storage potential. Shifting our focus to finding complimentary carbon capture land uses will provide better synergies between priorities.

4) Any net zero carbon land use interventions should support (and better still, increase) biodiversity and bioabundance. We need to create and manage our carbon capture habitats with biodiversity in mind.

5) The location of renewable energy infrastructure needs to be carefully considered. Wind farm locations, heights of turbines need to be selected to minimise adverse impacts on local ecosystems. It is preferential to site solar panels on buildings in places that are already highly human-modified. Where solar parks have been installed in fields, beneficial habitat management around panels should be incentivised.

Box 1: Example: Aligning agriculture and diet change

Carbon context

10% of the UK's greenhouse gas emissions are due to agriculture (comprising 1% of total carbon dioxide emissions, 70% of total nitrous oxide emissions and 50% of total methane emissions[55]). Fuel use is reportedly the primary source of agricultural CO_2 emissions, with fertiliser use, animal manure and digestion being the primary contributors of other gases. However, these estimates do not include the carbon footprint of manufacturing fertilisers and pesticides, nor do they include the carbon cost of producing and importing animal feeds such as soybeans. The need for both has increased in recent years due to:

i. agricultural intensification and increasing reliance on chemical inputs.

ii. the need to specialise in either arable or livestock in order to maintain economic viability and spatially decoupling the two mutually beneficial processes of crop production and fertiliser-producing livestock.

iii. increasing demand for meat and promoting increasingly indoor livestock systems over grass feeding.

The carbon (and water) cost of meat production in particular has led to a recent drive to encourage consumers to switch to more plant-based diets. However, if the emissions reductions benefits of this are to be fully realised, then this requires going beyond simply feeding the imported soybean to the human rather than the cow. Sustainable human diet change can only be achieved through parallel, long-lasting and considered changes to the agricultural system supplying it, requiring well thought-out landscape decisions.

Landscape functions

72% of the UK is farmland and it is well recognised that this land must provide multiple other functions in addition to food production, including maintaining soil, water and air quality, reducing flood and fire risk, carbon capture/storage, supporting biodiversity, sustaining rural communities and livelihoods, and preserving cultural heritage. The demands on farmland and those who manage it are huge.

Net zero ideals and conflicts

Incentivising the alignment of agriculture with diet change is very likely to lead to a reduction in emitted greenhouse gases. Pathways to achieve this could include a return to mixed farming systems incorporating grass and legume leys to reduce carbon costly fertiliser inputs and carbon costly stock feed imports, and a shift towards growing more native beans, pulses and grains to support plant-based diets without exporting our carbon footprint abroad. This would have an added benefit for biodiversity through more diverse crop rotations and more mass-flowering crops for pollinators. Within biodiversity constraints, the growth of some bio-energy crops could be added. Promotion of soil health and carbon capture through the adoption of no- or low-till soil management regimes and cover crops to minimise soil disturbance is another option as well as the use of 'smart technology' to minimise machinery use (and its associated emissions). However, the full carbon cost of this technology should be accounted for and it should never be allowed to discourage managers from gaining direct on-the-ground experience and to lose connection with their land as a result.

Other pathways include encouraging a shift towards more extensive grazing regimes with lower stocking densities using hardier, native breeds to supply a smaller meat demand, whilst providing conservation grazing (where appropriate) for biodiversity benefits and enabling some maintenance of historical upland farming practices. Re-establish hay meadows for providing stock feed, which would also be hugely beneficial for our declining ground nesting birds. In some situations, consider whether ecosystem restoration to a natural and carbon neutral state could enable a sustainable harvest of wild produce (e.g. reeds, fish, game etc.) with lower emissions and comparable financial benefit to conventional farming methods on that land. Supporting small-scale local production, e.g. market gardens would reduce food miles. It is imperative that small landholders are not excluded from subsidy (ELM) schemes.

Inclusive landscape decisions

Suggested changes involve significant changes to farm businesses and economic viability of established ways of life. It is essential that land managers and the farming community are involved and engaged in this and that the local knowledge for identifying areas with most potential for making such changes is taken into account.

Meeting the challenge

Landscape decisions go beyond just decisions about what to do with a parcel of land, to make these systemic changes a broader consideration of influencing factors need consideration. Huge financial investment is needed to change focus or diversify a farm business. Financial uncertainty around subsidies and Brexit predisposes farmers not to take risks or alter practices and favours sticking to status quo in current climate. Clear incentives would be needed to shift this. ELMS options must not just repeat previous options with different names but go beyond to offer something more joined up that includes support for more innovative, alternative and historic livelihoods and management practices that are beneficial for not only the reduction in greenhouse gas emissions but also biodiversity (e.g. local small-scale production, ecosystem restoration in tandem with food production).

Networks are needed to exchange knowledge on transitioning to beneficial farming practices and cultivation of novel crops and the skills shortage must be addressed, actively recruiting people for land-based jobs, coordinating with agricultural colleges on syllabus content that promotes net-zero practices, addressing the need for dignified affordable rural housing for rural land workers, along with campaigns to improve access to and public perceptions of land-based jobs.

History as a lesson

Old Abbey Farm in Caron Uwch Clawdd parish in mid Wales has been farmed for over 800 years as part of the former medieval grange of Strata Florida Abbey which grazed sheep on the extensive Cambrian Mountain uplands56. By adopting organic, resilient farming practice driven by agri-environment subsidies, the mixed land use that has characterised this farm for over 800 years is also beginning to resemble the Zero Carbon Britain's vision for sustainable agriculture. The most important and prized part of the farmers holdings are his distant sheepwalk representing centuries of hill farming practice and countless iterations of transhumant practice, now performed daily by quad bike, not seasonally by younger members of the kin group.

The modern farm retains the same boundaries as the medieval one and continues to seasonally graze its own sheep on distant upland sheepwalks in a universally recognised ancient form of transhumant practice for eg. Late medieval rentals show mixed land use on the 200 acre farm that continued virtually unchanged into the eighteenth century: wetland meadow for hay, arable land for cereals and root crops, domestic settlement just above the floodplain, infield for animal husbandry and a distant upland seasonal sheep grazing pasture. The farmer has implemented Glastir subsidies and has reversed the 20th century practice of overstocking sheep, encouraged by dangerous headage payments. By growing his own organic stock fodder he has reverted back into the arable production which had been an ancient tradition on the fertile floodplain.

Box 2. Example: Reimagining forests for carbon capture

Carbon Context

Trees and woodlands are highly valued for their ability to capture and store carbon. At 3.2 million hectares, woodland accounts for only around 13% of UK land cover but stores around 18 million tonnes of carbon annually [57]. The expansion of woodlands to 17% is seen as a key measure in meeting net-zero carbon targets. This needs to be achieved on a backdrop of increasing timber harvesting in the UK over the last 20 years, which has risen from 2,232 to 2,888 thousand green tonnes between 2000-2019 (wood production, roundwood removals)[58].

These directions are mainly realised by the carbon sequestration by the production of tree biomass. However, critically important amounts of carbon storage happen in forest soils. On average woodland soil carbon density in the UK lies between those of seminatural and pasture land types while in general carbon storage in soils depends on climatic conditions, land use and vegetation cover.[59] Changes in land use and woodland cover alter the biophysical conditions of a site; an increase in wood cover can many times result in a no net increase in ecosystem carbon stock as a whole despite the increase in above-ground carbon associated with tree biomass.[60] The carbon balance is affected by a variety of factors including environmental conditions, the tree species as a result of differences in growth rates,[61] the type of plantation, as well as the soil properties, the previous land cover, and the intensity of past and present management. For instance, there is great uncertainty about the changes in soil carbon associated with afforestation of pasture land especially by fast-growing tree species.[62] In addition, more trees mean potentially more wood available to harvest. An increase in wood harvest can overall lead to a net increase in carbon emissions therefore trade regulations and policies may be required.

Landscape functions

Woodlands are multifunctional landscapes valued for a broad range of environmental, economic and cultural benefits. Their ecosystems support a great variety of biodiversity and provide home for a variety of woodland-dependent species but are often most valuable in terms of biodiversity when they form part of a mosaic of habitats (e.g. with grassland, lowland heathland or wetland), in which they can also support edge-species and non-woodland dependent species with crucial resources. From an economic perspective, woodlands provide goods and services with a market value, such as timber or recreational uses but also indirect value derived from positive externalities e.g. flood or water management, temperature and noise regulation, clean air, health benefits, or indirect economic impacts such as increases in property prices. Visual, aesthetic and heritage aspects are highly valued by the public in terms of intrinsic, option or bequest values of woods and are often set alongside targets such as biodiversity and wildlife conservation. Other functions related to land use options for bioenergy, housing development, agriculture.[63]

Net zero ideals and conflicts

Woodland preservation and restoration are seen as key tools in reducing carbon emissions. Policies on woodland expansion, related strategies and incentives may shape land-use over the coming decades. However, the value and functions of woodlands will depend on where and what type and amount of woodland are created. The complexity introduced by ecological and environmental drivers accompanied by a wide diversity of stakeholder interests which often compete between themselves. Any new tree planting will be strongly influenced by the interests of landowners, land managers, related industries, wider publics as well as policy makers. Such challenges can be particularly relevant to afforestation and woodland expansion as they can allow or prevent afforestation with implications for meeting net zero carbon targets. For instance hydrological functions of forest for preventing floods are emphasised alongside net zero carbon arguments. However, reforestation is not an attractive solution to flooding everywhere and not all tree species function in the same way. [64,65] In addition, flood meadows themselves are a sensitive priority habitat that should not be afforested and instead valued for their own intrinsic carbon storage and flood alleviating properties. Besides environmental factors, pests and diseases pose a fundamental threat to new and old woodlands[66]. From an economic point of view, creating new woodland, especially on existing farmland, can be unattractive because of low economic returns.[67–69] Policies for woodland expansion should therefore support agro-sylvo-pastoral systems enabling a variety of forest (coppice, charcoal, timber, fattening livestock such as pigs and chickens) and agricultural uses and creating multifunctional biodiverse landscapes. These would require detailed and localised research combined with participatory practices[70] to support stakeholder choices and decisions. In particular, the view that converting land to woodland amounts to abandonment and essentially writing off that land in terms of production needs to be addressed [71] through a combination of re-education and identifying ways to make management practices such as coppicing economically viable in smaller woodlands.

In many places, pressure from deer browsing can hinder the woodland establishment and in particular limit the viability of natural regeneration (which is preferential to active planting for reasons detailed below). Modernising the venison supply chain to enable deer shot for population control to enter the supermarket supply chain, in preference to imported venison and intensively grazed livestock, would promote carbon sequestration through natural regeneration and maintain diets whilst simultaneously reducing carbon costly imports and domestic livestock production.

History as a Lesson

Despite the fact that British Isles have the lowest levels of woodland cover in Europe, a large variety of woodland types is favoured due to variations in climatic and geological conditions. This variety has been supported by human interventions and the application of complex management practices.[72] The idea that pre-neolithic wildwood was a continuous tree cover has been questioned and is now accepted between scholars that there was most probably a mosaic of habitats, incorporating some larger patches of dense tree cover forest [73] with open grassland, wood-pastures, heath and bogs. These landscape patterns were maintained by large herbivores [74]. Historical stages and processes of change presented as a series of transitions involving the transformation of the natural wildwood to today's treescapes (coming in the forms of woodlands, wood-pastures, and non-woodland trees)[75] . The exploitation of the wildwood was dominated by the management practices of wood-pastures and coppicing, some of which survived in the 18th and 19th centuries [72]. Planting on open ground became a dominant process in the 20th century where native woods were replaced by plantations, initially mixed broadleaved and conifers, and eventually with only conifers, for timber production. The same time native woodland was also created on marginal agricultural land. Nature conservation principles were applied in their management. The introduction and eventually naturalization (and acceptance as natural parts of the British countryside) of non-native tree species (e.g. sycamore) is also an important process. Studying the stages and characteristics of existing woods and the process from which they derived is important as it can influence our perceptions of the different habitats we may seek to preserve or to create.

Within England, forests were historically land set aside for hunting and as such they were rarely blanket tree cover and instead consisted of a mosaic of both open and closed habitats. These landscape mosaics, as we have highlighted elsewhere, support higher levels of biodiversity than any monoculture (by trees or other agricultural plants) while all additional habitats provide their own carbon storage benefits (with meadows believed to provide higher levels of carbon sequestration than many woodlands). Landscape mosaics are often cultural landscapes highly valued by people for their diversity, the visual aesthetic experiences they provide but also economic opportunities these multifunctional environments can support. When setting out to create new national forests, recalibrating our idea of what a forest is, so that we are aiming for this more heterogeneous mosaic of open and closed habitats, would provide a much richer suite of benefits.

Inclusive landscape decisions

Existing decision support tools (DST) and models evaluating the effects of land-use change will need to be redesigned to inform decision making in policy and practice for both the agricultural and forestry sector. On top of this, new models and tools are needed that better capture the biodiversity consequences of land-use change, accounting for the movement needs of species and those that rely on mosaic habitats. As well as regulatory (policies and legislations) economic tools (payments for ecosystem services or the new agroenvironnemental schemes ELMS) need to be designed to accommodate landscape diversity and complexity in decision making. Minimum area requirements for subsidy payments can prevent land managers from accessing support to create such vital mosaic habitats.

Strategies for woodland expansion should avoid rigid applications of afforestation policies. Natural or assisted regeneration (e.g. by planting tree islands as centres for regeneration) should be advocated and incentivised in preference to active planting wherever possible. Natural regeneration is cheaper and avoids the carbon, water and plastic costs traditionally incurred from raising, transporting and protecting whips. It also preserves local character and regional genetic diversity and so is less risky from a tree pathogen perspective, since it does not require transportation of trees and such genetic variation can include some level of resistance to introduced pests and disease. Crucially, natural regeneration can yield higher and faster biodiversity benefits due to creation of intermediate successional habitats, which are severely lacking in modern landscapes and on which many red-listed species depend. New and existing woodland plots should form parts of mosaic landscapes, intersected by carbon-capture meadow pastures and agricultural land. In terms of woodland management a combination of management practices (e.g selective cutting and coppicing as well as felling) should be employed across large areas of woodlands in order to generate variety in stand structure/age and support the needs of woodland specialist species whose populations have suffered due to lack of woodland management. Clear felling large stands should be avoided in small-scale woodlands. Such methods can have negative effects on biodiversity, leaving the woodland-dependent species that lived there potentially marooned in unsuitable surrounding habitat and are unpopular with human users who may develop connections with the woodland.

Pragmatic and realistic decisions on a case-by-case basis would need to balance net zero carbon targets with other interests. Participatory practices and arts-led dialogue, whether through single events or longer processes can explore a subject or problem in original, challenging or provocative ways, which question the truth claims of any one discipline, at times with unexpected, emancipatory outcomes. Positioned between deliberative and interpretive approaches, arts-led dialogue foregrounds imagination and can use contradictions and inconsistencies as creative opportunities.

Box 3. Example: Peat management

Carbon context

Peatlands are extensive across the UK, occurring mainly on upland moors (blanket bogs) and lowland flats (e.g. fens or lows). They are vast stocks of carbon-based greenhouse gases such as carbon dioxide and methane. As 10% of the UK land area with a disproportionately high amount of soil organic carbon, peatlands are a significant contributor to achieving UK net zero carbon emissions. Maintaining peat in good condition, with an appropriate water table depth is now understood to regulate the aggregate carbon emissions (a net carbon sink if peat is in good condition). The water table determines the balance between dryer oxidising conditions, releasing carbon dioxide, and deeper wet reducing conditions holding methane. Water table depth is influenced by natural and human activities that take place across this landscape. As a continuous ecohydrological system, degradation to any part of the system may cause puncturing or blockage in the water table, resulting in erosion or slow drying in parts of the system, resulting in a net carbon emission. Regeneration of degraded peat, generally through re-wetting, has great potential for reversing carbon loss by sequestering and retaining greenhouse gases.

Landscape functions

Peatlands have diverse ecosystem functions, have provided a low grade natural resource, and provide public leisure space. This wetland habitat is a niche of conditions with its own biodiversity portfolio, supporting native and migratory birds, unique mosses and fauna which are required to work together and maintain this environment. From an economic perspective, lowland peat is chiefly utilised for cultivation of crops, whilst in the uplands, moorlands are mosaicked with activities such as grazing, game hunting, cutting and forestry. This landscape also provides the source and supply of water to populations as well as water regulation and flood mitigation services, and the opportunities for finding exposed locations are suitable for renewable energies such as wind power. The overlapping of these landscape functions means many stakeholders are engaged in securing ownership and imposing decisions for the utilisation of this landscape. Inevitably, there is a crossing of opinions and decision-making. To restore this landscape into a net carbon sink, there are therefore many challenges and conflicts to address.

Net zero ideals and conflicts

Chiefly, to become a net zero carbon emitter, peat needs to be in a good condition everywhere. Studies now show that after several years restored peatland, e.g. removing forest concessions planted on peatland that was deliberately drained, will create a net carbon sink. A better understanding of emissions in different management scenarios (e.g. Peatland-ES-UK)[76] will provide a sound evidence base to contest and change land use that is detrimental to net zero emissions, e.g. halting grazing to reduce compaction from trampling and allow regeneration of native vegetation, and stopping game activities that involve altering and burning vegetation that causes peat to dry out. In the fen lowlands, to facilitate large scale cultivation, pumping of water in sodden lands drops the groundwater table to support national and international food supplies. Rewetting the lowland landscape requires research into new hydrological management, appropriate machinery and cultivars and consideration of the impacts on the economics of existing agriculture.

Inclusive landscape decisions

Since all these activities bring economic benefits to some people, a landscape decision that applies a broad brush approach to peatland restoration will be contentious. A better strategy would be a considered compromise between restoring natural peat functioning and existing livelihoods considering the functional contexts of the peat. For example, across landscapes lucrative for gaming, identifying, prioritising and targeting damaged peatland that can be restored quickly and protected in priority to damaged peat that may take many years to return to full functionality will be beneficial on many sides. As restoration progresses over time activities that are regarded as detrimental to the net emissions model will become constrained to peatland margins or areas of peatland that are beyond repair or are very thin and negligible in net carbon estimates. Long-term funding models, for example the UK Peatland Code, should be further developed to provide better economic alternatives and incentives to activities that escalate further damage and carbon loss in peatlands. This would also include supporting a more joined up and country-wide strategic plan between the current peatland restoration groups, particularly in England.

Net carbon alternatives

There are alternatives to bring a net zero carbon footprint to peatlands, and renewable energies seem an obvious choice. Wind power reduces the footprint of fossil fuel combustion but itself may be contentious due to the damage caused by installation and necessary permanent service infrastructure. For example, in the Republic of Ireland there are alarming coincidences of large peat slides close to wind farm installations. This results in more damaged carbon emitting peat as well as physical transfer of carbon out the local drainage basin. Wind farms must also need to be continually supplying the national grid to justify the damage inflicted on peat. Forestry is a quick carbon fix, but the correct varieties of trees and location of planting must be carefully considered. The tax break concessions of the 1980s and miserable yields and biodiversity impacts of non-native pines planted in Scottish peatlands have fully demonstrated the consequences of ill thought landscape decisions.

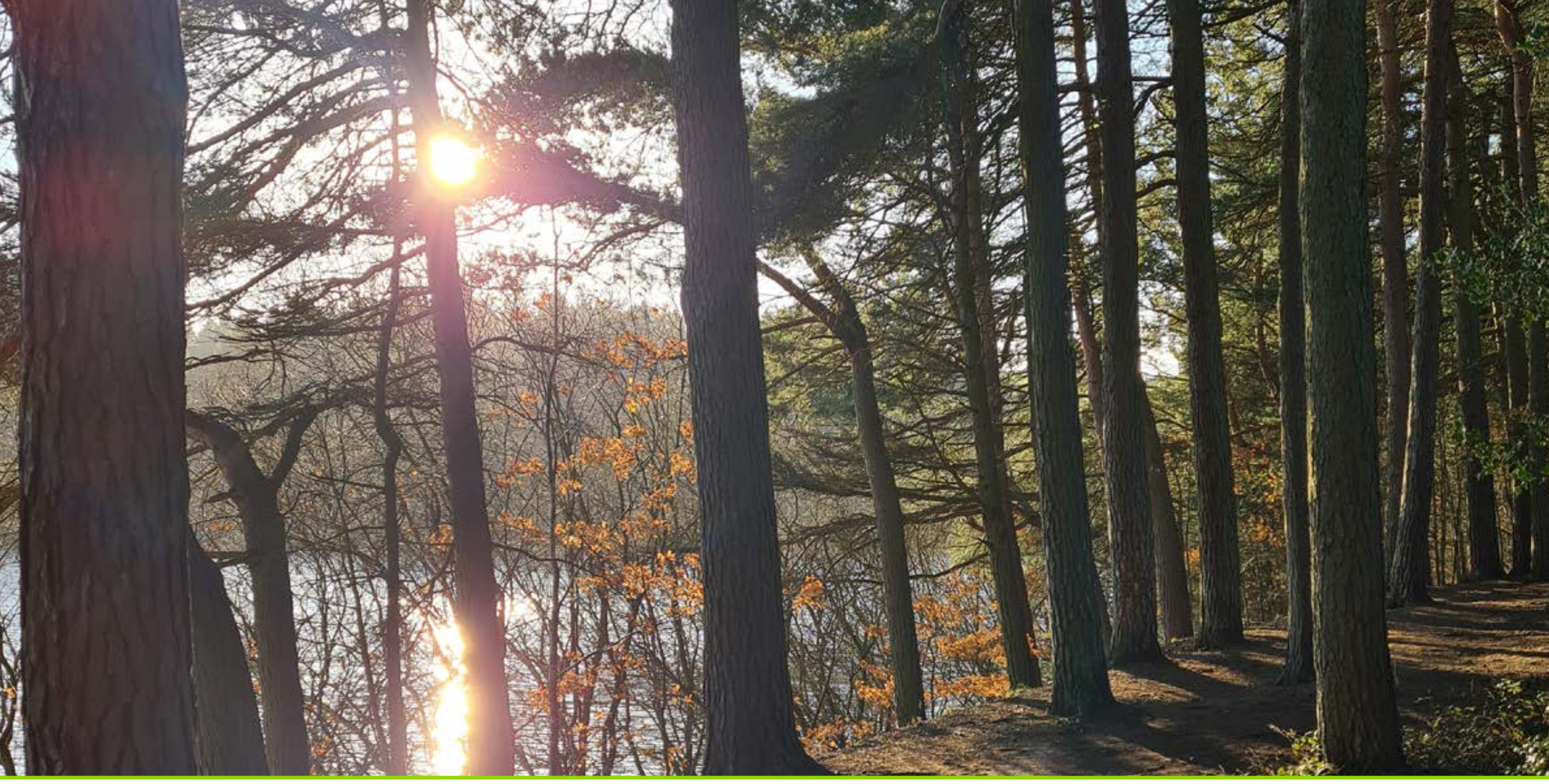
History as a lesson

The wet conditions and fragile organic nature of this landscape means that there are few modern historical activities that have been positive for peatlands. Removal of peat for horticulture and for burning physically removes and destroys the top of the peat soil profile, a key section in maintaining hydrological processes in peat. Planting trees, livestock farming in uplands and cultivating crops in lowlands have required drainage, compacting and drying out peat soil structure. Leisure activities such as game shooting (a relatively modern pastime c.1850+) result in modification of biodiversity to advantage game species by operating rotational burning. Burning also cumulatively dries out peat - a negative side effect to the ecohydrological properties required to keep peat in a near natural condition. Occupation of peatlands has historically involved drainage, thus few sustainable practices exist to draw from, for example foraging berries, mushrooms, and garlic are low impact and small scale.

Meeting the challenge

A key approach to reduce the impact of Net Zero Carbon landscape decisions on existing activities requires a detailed knowledge of peatland condition across the UK and a valued opinion on the needs and requirements of local communities. Science and arts are using tools and optimising methods that can facilitate such an approach. The sciences are developing satellite surveys using radar (e.g. Landscape Decisions Project STAMPs) and optical images, models of peat vegetation, moisture and condition, facilitated by field monitoring of vegetation, gas fluxes and water quality to provide better inventories to map peat functioning and emissions. The arts and humanities are demonstrating engagement with local communities and stakeholders using participatory methods to document the meaning, function and use of the landscape. Approaches to peatland restoration working with social and cultural as well as sciences are demonstrated in a number of Landscape Partnership projects (e.g. Galloway Glens[77], Pendle Hill Landscape Partnership[78], Flows to the Future[79]) bringing together heritage (archaeology, place-names, dialects and languages), arts (residencies, commissions, exhibitions and performances), education and skills (craft, tourism, and management) and community engagement (events and opportunities for involvement) alongside restoration work. Further support would accelerate the progress made by these social, cultural and scientific communities.

Such evidence can help to prioritise the most strategic areas for restoration, such as the least damaged peat that will have an immediate impact on carbon sequestration (short-term), and how the locality can support or be supported by this new landscape provision. With time, the next strategic areas for restoration can then be prioritised and invested in to continue the restoration cycle (medium to long-term). Long-term funding of these activities is therefore crucial to provide a holistic, inclusive, rapid and informed transformation of peatland towards a net zero landscape (medium to long-term). It will be possible to slowly transition out and even replace carbon-releasing landscape activities as prioritisation continues. To achieve a net zero carbon aim whilst supporting economic needs, the choices will be driven by better appreciated socio-economic contexts and the positive or negative impact they have on peatlands.



Part C: How do we make the change?

Become a better system

Section A and Section B clearly highlight that there is a need for an inclusive approach to decision making. The social framing of land use decisions to achieve the net zero agenda are equally as important as the scientific knowledge about synergies and trade-offs involved in land use changes. We set out three overarching recommendations and the major key gaps within them that require changes in the way that decarbonising decisions are made. We suggest the approaches that each recommendation needs to involve and mechanisms that would facilitate achievement of each one.

Recommendation 1: Invest in transdisciplinary and cross sectoral approaches for landscape management decisions and research

Approaches:

- Create spaces (physical and discursive), opportunities and programmes for learning where academics, arts researchers and practitioners, and different sectors (businesses,farmers, landowners, developers, investors, public bodies and communities), can come together, interact and make decisions;
- Acknowledge that different ways of working and different ways of knowing are equally important and integrated solutions require different academic sectors, businesses, investors, public bodies and communities to work together and respect their complementary contributions;
- Cost benefit analysis needs to be balanced with deliberative and equity focused processes;
- Build long-term collaborative capacity across academic, public, private and third sectors focused by the key challenges;
- Enable opportunities to reimagine, reflect, and involve plural narratives, inclusive of all forms of nature[80] with attention to different forms of involvement (implementation, innovation, resistance and activism).

Gap 1.1: Decision-making for decarbonisation requires ethical, narrative and aesthetic inputs to complement cost benefit analysis

Mechanisms

- Involve stakeholders in defining the problem, not just selecting from submitted proposals, and ensure that space remains for curiosity-driven researcher-led or arts-led work that may offer novel and unexpected insights;
- Ensure value is interrogated from different perspectives by investing in a range of forms of evidence (qualitative, quantitative, lived experience, creative);
- Include imaginative, ethical and aesthetic deliberation in assessment processes (e.g. in environmental impact assessment [26] and land availability assessment), alongside quantitative and economic approaches;
- Encourage and involve boundary spanning skills during landscape decision-making activities (including funders, professional bodies and artists);
- Use co-production and co-design [81], citizen observatories[82] and other participatory approaches which bring together communities with researchers to develop shared methods.
- Embed ethical, narrative and aesthetic elements to funding requirements;
- Ensure that key priorities (such as Net Zero Carbon and net biodiversity) are kept in focus; i.e. are not obscured by tick box exercises.

Gap 1.2: Improved education across all age ranges to form a better understanding of the landscape, including issues related to environmental and social justice

Mechanisms:

- Climate and Biodiversity literacy linked to local ecosystems (including environmental history) in the curriculum of primary, secondary and tertiary education;
- Education and Continued Professional Development for land managers, decision makers and statutory agencies on Carbon and Biodiversity;
- Engineers, Architects, developers, and Land Managers need to understand the carbon cycle and how to make low-carbon choices e.g. leading to increasing use of wood in the built environment. They need to recognise the implications of these choices using a holistic approach to decision making.
- Provide accessible to all opportunities for further education/training promoting nature awareness and enable those in disadvantaged positions to join them;
- Promote experiential learning by enabling equitable access to landscapes for recreational and health benefits.

[6] Artist-led approaches include strategic proposals for Lough Boora in the Midlands of Ireland https://www.irishtimes.com/news/environment/for-peat-s-sake-rethinking-the-bog-1.4154970

Recommendation 2: Promote the right ecosystem in the right place under the appropriate (right) management

Approaches:

- 'Right' here is understood as what is ecologically, ethically, and practically appropriate, after assessing the characteristics of a given area (geology, hydrology, vegetation, human activity), and the potential of that area to sustain a particular ecosystem (e.g., peatland, woodland, heathland, grassland, parkland, scrubland) and sequester carbon.
- The end-goal of restoration for carbon sequestration (i.e. the 'right ecosystem') must be place-specific across all scales, from the scale of a designated landscape down to a field corner. This requires a far more nuanced regional and place-based approach.
- Avoid focusing on a single land cover at the expense of others. Aim for a diversity of carbon-storing ecosystems nationally, to provide greater and more resilient carbon storage and bigger biodiversity benefits.
- Recognise that climate change will affect ecosystems. Build in future resilience to climate change in management decisions.
- Recognise that connections to the past are key to biodiversity, communities and their interactions.
- Incorporate local on-the-ground knowledge to identify appropriate ecosystem and restoration activities from a multifunctional, multi-species and multi-temporal perspective.
- Invest in specialist skills and local knowledge to continually monitor the potential of the landscape and apply adaptive management practices to maintain the carbon sequestration capabilities, biodiversity and resilience of the ecosystems in the future.

Gap 2.1: Building resilience by enhancing diversity

Promote all facets of diversity within landscapes: diversity of landscape features, biodiversity, social diversity, diversity of land management and agricultural practices, diversity of approaches, diversity of technologies, economic diversity and gradients of human disturbance.

Mechanisms

- Invest in creating a network of carbon-storing ecosystems, e.g. a network of healthy rivers, woodlands, grasslands, scrublands, heathlands, etc.,
- Invest in the greening of built environments to meet carbon storage, ecosystem service and climate change mitigation and adaptation requirements, e.g. through soft engineering; increasing street trees and green walls in urban areas; limiting the use of hard surfaces in urban/suburban areas.
- Move away from large-scale crop monocultures towards more diverse mixed farming systems incorporating semi-natural habitat and agroforestry.
- Creation/renewal of transient, ecologically valuable, carbon-sequestering successional habitats (such as scrub formed during natural regeneration) should be given equal priority to climax habitats (such as woodland) in policy-making agendas.
- Development projects should adopt mitigation actions that promote biodiversity by incorporating and supporting locally important species/habitats.
- Promote economically diverse landscapes; identify and address barriers discouraging entry into rural land-based employment, including issues around land tenure.
- Improve the delivery of habitat management and ecosystem monitoring through a combination of increased funding to relevant statutory agencies and NGOs, incentives for landowners/managers, support for local volunteer/community action, upskilling/strengthening existing networks, and new initiatives to generate a tightly regulated 'green economy' offering increased professional opportunities in this sector.
- Diversify our transport system away from reliance on private cars with more investment in cycle lanes and small-scale electric transport with rewards, incentives and help for investors/developers and users.

Gap 2.2: Consider past, present and future human practices and ecological time scales.

Mechanisms

- Policy making must better account for ecological timescales and processes when setting goals, designing subsidies and assessing the appropriateness of mitigation actions.
- Support lasting landscape restoration and change strategies by long term monitoring of physical, ecological and social-economic progress.
- Plan a long term iterative approach that identifies the best locations for landscape recovery and protection, achieving rapid carbon gains and enhanced biodiversity protection, whilst phasing out detrimental land use activities.
- Use imagination based approaches (e.g. Futures, Scenarios, Deep Mapping)
- Bring together ecologists, environmental scientists, agronomists, foresters, economists and innovation specialists to find ways to make beneficial past land management practices economically viable again.
- Apply appropriate management informed by the past to ensure the wellbeing of future generations17
- Recognise the uniqueness of socio-ecosystems and the importance of long-term, undisturbed continuity (from the past and into the future) for functioning, biodiverse ecosystems and protect them from development and fragmentation.
- Update the biodiversity net gain approach accordingly to place a greater onus on people to respect and leave space for nature in situ wherever possible.
- Developers should be held to account financially if mitigation actions fail to reach and maintain agreed ecological and carbon targets within predefined timescales.

Gap 2.3: Have a more robust critical assessment of technologies/practices in relation to future landscape impact

Mechanisms

- Adopt deeper thinking impact assessments that consider (i) hidden knock-on effects of new activities, behaviours and technologies, (ii) long term environmental impacts or hazard risk to the environment, (iii) hidden power/ economic/social factors that may be obscuring or preventing more carbon-efficient alternatives.
- Any models used to predict future environmental, biodiversity and social impacts of landscape change must be fully validated against observational data and peer reviewed to ensure their predictions are reliable, realistic and comprehensive. Any factors identified that limit their real-world applicability should be made clear to practitioners. Confidence intervals should accompany outputs and the exact meaning of all modelled quantities should be clearly defined.
- Consider legislating against existing practices that are known to detrimentally impact the carbon storage potential of landscapes (e.g. banning the sale of disposable barbecues that are a major cause of wildfires.).
- Regulate to ensure the mitigation hierarchy (Figure 1) is applied in land management decisions which sets out an order of priorities to follow, (i) avoid, (ii) mitigate, (iii) restore and (iv) offset or, failing that, compensate.
- Invest in mapping, understanding and preparation to mitigate accidental carbon release scenarios such as disturbance of peatland stability, vegetation wildfires and leaks in carbon capture reservoirs.
- Earth Observation products should be developed to be usable by end users and must always be augmented with knowledge on the ground (e.g. citizen observatories) to capture context, landscape functioning and crucial habitat features.
- A review to determine the carbon costs of our changing working practices and our changing use of transport infrastructure, including increased use of doorstep delivery services.

Recommendation 3: Increase local and devolved decision-making capabilities

Approaches:

- People should have access to information, public participation in decision-making and access to justice in environmental matters, as outlined in the Aarhus Convention (1998);
- Address systemic relationships and value chains to ensure that no one 'sector' or interest group controls decision-making;
- Include diverse communities at a variety of scales (national, watershed/settlement and domestic);
- Ensure inclusivity and diversity in all decision making processes (eg public dialogues, consultations and local citizens assemblies) to address issues of fairness affecting lifestyle and behavioural shifts and benefit from a widespread sense of democratic renewal.
- Protection for positive local action taken by communities, e.g. by setting land aside for natural carbon sequestration processes, to prevent top-down decisions later reversing such actions (e.g. for larger-scale infrastructure projects) or displacing them (via offsetting) to alternative locations inaccessible to that community, in order to avoid rerelease of carbon and disillusionment;
- Promote co-ownership of assets to generate buy-in rather than nimbyism;
- Attention to economic and non-economic consequences across all actors;
- Include awareness of the significance and responsibilities of hidden decision-makers, such as tourists and non-local, non-residential actors, children, recreational and other users.

Gap 3.1: Language, identity, and a sense of social justice should be explicitly linked to policy making.

Mechanisms

- Scoping studies and interdisciplinary investigations to value different languages and dialects and the ways they can inform landscape decisions[83] (such as Gaelic Language for Ecosystem Services[84]) to balance scientific discourses.
- Consider multicultural values and heritage in landscape decision-making - landscapes are differently meaningful for people with different cultures, personal and social histories and memories.
- Engage with third and public sector organisations (cultural, environmental, equality, diversity and inclusion, local authority arts, museums and libraries)
- Increase ownership of subsidy schemes by co-designing objectives and responsibilities with the users.
- Greater accountability of politicians when making decisions around large-scale infrastructure projects that are intended to be 'for the public good', to make clear which public, at what time, and how 'good' is being qualified.
- Ensure meaningful consultations/deliberations with diverse publics on development projects regardless of scale to evaluate social and environmental consequences and to safeguard social justice.

Gap 3.2: Participatory and co-creative approaches can engage stakeholders in new and more effective ways

Mechanisms

- Enable participatory and co-creative approaches led by socially engaged artists and service designers involve stakeholders including businesses, investors, public and voluntary bodies as well as communities in developing solutions.
- Ensure co-design and co-production on the basis of an equal and reciprocal relationship between professionals, stakeholders, people using services, their families and their neighbours for results that meet their needs.[85]
- Promote citizens assemblies and deliberation to engage publics in wicked problems and find solutions to ambitious commitments to Net Zero Carbon agendas.
- Involve citizen science/citizen observatories in processes of monitoring in collaboration with research institutions, encouraging greater understanding of the dynamics of local ecosystems.[82]

Gap 3.3: Landscape decision-makers should have access to different policy approaches

Mechanisms

- Share best practice and learning between devolved administrations by testing and innovating across different areas and all nations.
- Make proposals transparent to demonstrate all parties concerned have been consulted and all interests have been considered for balanced landscape decisions;
- Proposals about landscape decisions should be audited with the aim to further review and consultation if necessary to identify gaps, oversights, avoidance or accidental omission of key factors and parties that should be consulted;
- Reform organizational structures and procedures capable of reconnecting the various parts of government to overcome policy 'silos'. Accept the integration principle in the draft environment principles, to embed environmental protection in other fields of policy.[34]
- Be guided by the Aarhus Convention (1998) providing access to information, public participation in decision-making and access to justice in environmental matters.
- Adopt the approaches such as those laid out in the Well-being of Future Generations (Wales) Act 2015[17], in Scotland's Place Principle[21], and the Environmental Principles currently being considered under the new UK Environment Bill[34].

Closing thoughts

Setting the agenda for a net zero carbon target is an opportunity to review and renew existing policies and learn lessons from the consequences of past decisions - both good and bad. In this report, we have reflected on these experiences, identified gaps and present a series of recommendations.

Without swift action in response to these recommendations, we head deeper towards an inability to reach net zero carbon targets, contribute to biodiversity collapse, promote societal disengagement with landscapes and, ultimately, disengage with the people who make landscape decisions. We risk turning over land to carbon storage activities that replace and inhibit functioning ecosystems and stand at odds with the aesthetic and cultural values of local communities. As such, these activities are likely to be reversed in future, with partial or even total loss of any carbon capture achieved. An alternative, more holistic approach is urgently needed.

There are numerous contradictions in the pathways towards achieving net zero carbon targets. As outlined in the recommendations, the key factors we believe need addressing immediately are (i) investing in transdisciplinary approaches for landscape management decisions, (ii) ensuring the right ecosystem is promoted in the right place (no single land-use solution should be prioritised above others), and (iii) local and devolved decision making capabilities need to be increased.

We want to encourage policy and decision makers that the recommendations set out above are merely the starting point for broader conversations about the change needed to break with the status quo. Together, we must create new ways of doing, thinking and communicating that embed inclusive, place-specific, net-zero practices within landscapes that support both biodiversity and people.

References

1. The Committee on Climate Change. Land use: Policies for a Net Zero UK. 123 https://www.theccc.org.uk/publication/land-use-policies-for-a-net-zero-uk/ (2020).

2. Selman, P. Sustainable Landscape Planning: The Reconnection Agenda. (Routledge, 2012).

3. Rittel, H. W. J. & Webber, M. M. Dilemmas in a general theory of planning. Policy Sciences 4, 155–169 (1973).

4. Levin, K., Cashore, B., Bernstein, S. & Auld, G. Overcoming the tragedy of super wicked problems: constraining our future selves to ameliorate global climate change. Policy Sciences 45, 123–152 (2012).

5. Leyshon, C., Geoghegan, H. & Harvey-Scholes, C. Landscape and climate change. in The Routledge Companion to Landscape Studies 453–463 (Routledge, 2018). doi:10.4324/9781315195063-36.

6. Saratsi, E. et al. Valuing Arts & Arts Research. (2019).

7. Mottram, J., Rust, C. & Till, J. AHRC research review: practice-led research in art, design and architecture. http://shura.shu.ac.uk/7596/ (2007).

8. Bakhshi, H., Schneider, P. & Walker, C. Arts and Humanities Research in the Innovation System: The UK Example. Cultural Science 2, (2009).

9. Galafassi, D. et al. 'Raising the temperature': the arts on a warming planet. Current Opinion in Environmental Sustainability 31, 71–79 (2018).

10. Adger, W. N. et al. Are there social limits to adaptation to climate change? Climatic Change 93, 335–354 (2009).

11. Ingold, T. Culture on the Ground: The World Perceived Through the Feet. Journal of Material Culture 9, 315–340 (2004).

12. Lorimer, H. Herding Memories of Humans and Animals. Environ Plan D 24, 497–518 (2006).

13. Maye, D., Kirwan, J. & Brunori, G. Ethics and responsibilisation in agri-food governance: the single-use plastics debate and strategies to introduce reusable coffee cups in UK retail chains. Agriculture and Human Values 36, 301–312 (2019).

14. Design Innovation and Land-Assets (DI&L). Landscape Decisions Programme https://landscapedecisions.org/design-innovation-and-land-assets/ (2021).

15. Connected communities. Connected Communities | AHRC Connected Communities Programme. https://connected-communities.org/ (2016).

16. Meadows, D. H., Meadows, D. L., Randers, J. & Behrens III, W. W. The Limits to Growth. (Pans Books Ltd, 1972).

17. Government, W. Shared Purpose: Shared Future. Statutory guidance on the well-being of Future Generations (Wales) Act 2015. 37 https://gov.wales/sites/default/files/publications/2019-02/spsf-1-core-guidance.PDF (2016).

18. Defra. Sustainable fisheries for future generations. 60 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/722074/fisheries-wp-consult-document.pdf (2018).

19. Earnshaw, K. Field || guides. Landscape Decisions, a UKRI SPF https://landscapedecisions.org/field-guides/ (2021).

20. Haraway, D. J. Staying with the Trouble. Making Kin in the Chthulucene. (Duke University Press, 2016).

21. Scottish Government. Place Principle: introduction. https://www.gov.scot/publications/place-principle-introduction/ (2019).

22. Tribot, A.-S., Deter, J. & Mouquet, N. Integrating the aesthetic value of landscapes and biological diversity. Proceedings of the Royal Society B: Biological Sciences 285, 20180971 (2018).

23. Kalinauskas, M., Mikša, K., Inácio, M., Gomes, E. & Pereira, P. Mapping and assessment of landscape aesthetic quality in Lithuania. Journal of Environmental Management 286, 112239 (2021).

24. Brady, E. & Prior, J. Environmental aesthetics: A synthetic review. People and Nature 2, 254–266 (2020).

25. Brady, E., Brook, I. & Prior, J. Between Nature and Culture: The Aesthetics of Modified Environments. (Rowman & Littlefield Publishers, 2018).

26. Hodges, J. & Coleman, R. A New EIA for Natural Scotland. Coleman & Hodges https://colemanhodges.com/2018/10/10/a-new-environmental-impact-for-natural-scotland/ (2018).

27. Pywell, R. AgLAND New Science to Enable the Design of Agricultural Landscapes that Deliver Multiple Functions. Landscape Decisions, a UKRI SPF https://landscapedecisions.org/agland/ (2021).

28. Marland, P. Tipping Points: Cultural Responses to Wilding and Land Sharing in the North of England. Landscape Decisions, a UKRI SPF https://landscapedecisions.org/tipping-points-cultural-responses-to-wilding-and-land-sharing-in-the-north-of-england/ (2021).

29. Demystifying Health, Valuing Nature Paper 13. 24 http://valuing-nature.net/sites/default/files/documents/Reports/VNN-DemystifyingHealth-Web.pdf (2018).

30. Bates, V., Hickman, C., Manchester, H., Prior, J. & Singer, S. Beyond landscape's visible realm: Recorded sound, nature, and wellbeing. Health & Place 61, 102271 (2020).

31. Fish, R. & Saratsi, E. Naturally Speaking… A Public Dialogue on the UK National Ecosystem Assessment. Final Report. https://valuing-nature.net/sites/default/files/documents/NEA_Dialogue_Final_Report_final.pdf (2015).

32. Andrews, K. Women In The Hills (WITH). Landscape Decisions, a UKRI SPF https://landscapedecisions.org/women-in-the-hills-with/ (2021).

33. Environment Agency. Climate change impacts and adaptation. 19 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/758983/Climate_change_impacts_and_adaptation.pdf (2018).

34. Defra. Draft Environmental Principles Policy Statement. 20 https://consult.defra.gov.uk/environmental-principles/draft-policy-statement/supporting_documents/draftenvironmentalprinciplespolicystatement.pdf (2021).

35. Stevenson, M. & Weber, C. WWF Discussion Paper: Mitigation hierarchies. First Things First: Avoid, Reduce…. and only after that - compensate. https://wwfint.awsassets.panda.org/downloads/wwf_discussion_paper_mitigation_hierarchies_april_2020.pdf (2020).

36. Montserrat, F. et al. Olivine Dissolution in Seawater: Implications for CO2 Sequestration through Enhanced Weathering in Coastal Environments. Environ Sci Technol 51, 3960–3972 (2017).

37. Allen, M. et al. The Oxford Principles for Net Zero Aligned Carbon Offsetting 2020. 15 https://www.smithschool.ox.ac.uk/publications/reports/Oxford-Offsetting-Principles-2020.pdf (2020).

38. RSPB. Edge effects of forestry on Flow Country breeding wadersDetails. The RSPB https://www.rspb.org.uk/our-work/conservation/conservation-projects/details/362578-edge-effects-of-conifer-forestry-on-peatland-breeding-birds (2020).

39. The Peatlands Partnership. Restoring the Flows. The Flow Country https://www.theflowcountry.org.uk/flow-facts/flow-fact-4/ (2021).

40. Jofré, G. M., Warn, M. R. & Reading, C. J. The role of managed coniferous forest in the conservation of reptiles. Forest Ecology and Management 362, 69–78 (2016).

41. Peterken, G. Ecological effects of introduced tree species in Britain. Forest ecology and management 141, 31–42 (2001).

42. The Woodland Trust. The Northern Forest. Woodland Trust https://www.woodlandtrust.org.uk/about-us/what-we-do/we-plant-trees/the-northern-forest/ (2020).

43. Natural England. England's peatlands: carbon storage and greenhouse gases. 52 http://publications.naturalengland.org.uk/publication/30021 (2010).

44. Marques, A. T. et al. Understanding bird collisions at wind farms: An updated review on the causes and possible mitigation strategies. Biological Conservation 179, 40–52 (2014).

45. Lane, J. V. et al. Vulnerability of northern gannets to offshore wind farms; seasonal and sex-specific collision risk and demographic consequences. Marine Environmental Research 162, 105196 (2020).

46. Cryan, P. M. & Barclay, R. M. R. Causes of Bat Fatalities at Wind Turbines: Hypotheses and Predictions. Journal of Mammalogy 90, 1330–1340 (2009).

47. Semeraro, T., Pomes, A., Del Giudice, C., Negro, D. & Aretano, R. Planning ground based utility scale solar energy as green infrastructure to enhance ecosystem services. Energy Policy 117, 218–227 (2018).

48. Armstrong, A., Waldron, S., Whitaker, J. & Ostle, N. J. Wind farm and solar park effects on plant–soil carbon cycling: uncertain impacts of changes in ground-level microclimate. Global Change Biology 20, 1699–1706 (2014).

49. Barron-Gafford, G. A. et al. The Photovoltaic Heat Island Effect: Larger solar power plants increase local temperatures. Scientific Reports 6, 35070 (2016).

50. Li, Y. et al. Climate model shows large-scale wind and solar farms in the Sahara increase rain and vegetation. Science 361, 1019–1022 (2018).

51. Frolic, K. Where does wind turbine TV interference occur? Pager Power https://www.pagerpower.com/news/wind-turbine-tv-interference-occur/ (2016).

52. Chapman, S. & Crichton, F. Wind Turbine Syndrome: A Communicated Disease. (Sydney University Press, 2017).

53. Shrophire Star. Stress fear over Shropshire and Mid Wales windfarms plan. https://www.shropshirestar.com/news/2014/12/17/stress-fear-over-shropshire-and-mid-wales-windfarms-plan/ (2014).

54. BEIS. 2019 UK greenhouse gas emissions, provisional figures. 20 (2020).

55. Defra. Agricultural Statistics and Climate Change. 109 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/835762/agriclimate-9edition-02oct19.pdf (2019).

56. Bezant, J. Revising the Monastic 'Grange': Problems at the Edge of the Cistercian World. Journal of Medieval Monastic Studies 3, 51–70 (2014).

57. ONS. Woodland natural capital accounts, UK - Office for National Statistics. https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/woodlandnaturalcapitalaccountsuk/2020 (2020).

58. Forest Research. Forestry Statistics 2020. Chapter 2: Timber. (2020).

59. Bradley, R. I. et al. A soil carbon and land use database for the United Kingdom. Soil Use and Management 21, 363–369 (2005).

60. Friggens, N. L. et al. Tree planting in organic soils does not result in net carbon sequestration on decadal timescales. Global Change Biology 26, 5178–5188 (2020).

61. Rieger, I., Kowarik, I., Cherubini, P. & Cierjacks, A. A novel dendrochronological approach reveals drivers of carbon sequestration in tree species of riparian forests across spatiotemporal scales. Science of The Total Environment 574, 1261–1275 (2017).

62. Pérez-Cruzado, C., Mansilla-Salinero, P., Rodríguez-Soalleiro, R. & Merino, A. Influence of tree species on carbon sequestration in afforested pastures in a humid temperate region. Plant and Soil 353, 333–353 (2012).

63. Woodland Trust. The Economic Benefits of Woodland. A report for the woodland Trust prepared by Europe Economics. 15 https://www.woodlandtrust.org.uk/publications/2017/01/economic-benefits-of-woodland/ (2017).

64. Ecological effects of afforestation: studies in the history and ecology of afforestation in western Europe / edited by Charles Watkins. CAB International, (1993).

65. Bunce, R. G. H. et al. The landscape ecological impact of afforestation on the British uplands and some initiatives to restore native woodland cover. Journal of Landscape Ecology 7, 5–24 (2014).

66. Potter, C. Tree and Forest Pests and Diseases: Learning from the Past to Prepare for the Future. in Europe's Changing Woods and Forests: from wildwood to managed landscapes. (eds. Kirby, K. & Watkins, C.) 337–346 (CAB International, 2015).

67. Watkins, C., Williams, D. & Lloyd, T. Constraints on farm woodland planting in England: a study of Nottinghamshire farmers. Forestry 69, 167–176 (1996).

68. Wilson, G. A. & Hart, K. Financial Imperative or Conservation Concern? EU Farmers' Motivations for Participation in Voluntary Agri-Environmental Schemes. Environ Plan A 32, 2161–2185 (2000).

69. Morris, C. & Potter, C. Recruiting the new conservationists: Farmers' adoption of agri-environmental schemes in the U.K. Journal of Rural Studies 11, 51–63 (1995).

70. Wynne-Jones, S., Strouts, G. & Holmes, G. Abandoning or Reimagining a Cultural Heartland? Understanding and Responding to Rewilding Conflicts in Wales - the Case of the Cambrian Wildwood. environ values 27, 377–403 (2018).

71. Valatin, G., Moseley, D. & Dandy, N. Insights from behavioural economics for forest economics and environmental policy: Potential nudges to encourage woodland creation for climate change mitigation and adaptation? Forest Policy and Economics 72, 27–36 (2016).

72. Peterken, G. F. Woodland History in the British Isles - An Interaction of Environmental and Cultural Forces. in Europe's Changing Woods and Forests. From Wildwood to Managed Landscapes (eds. Kirby, K. & Watkins, C.) 265–278 (CAB Internantional, 2015).

73. Rackham, O. Savanna in Europe. in The ecological history of European forests. (CAB International, 1998).

74. Vera, F. W. M. Grazing ecology and forest history. (CABI Publishing, 2000). doi:10.1079/9780851994420.0000.

75. Rackham, O. Woodlands. (HarperCollins Publishers Ltd, 2006).

76. Peatland-ES-UK. Peatland Management and Ecosystem Services in the UK. https://peatland-es-uk.york.ac.uk/home (2020).

77. Galloway Glens. The Galloway Glens Landscape Partnership. The Galloway Glens Landscape Partnership https://gallowayglens.org/ (2021).

78. Pendle Hill Landscape Partnership. Pendle Hill Landscape Partnership. http://pendlehillproject.com/ (2021).

79. Flows to the Future Project. Flows to the Future Project. The Flow Country https://www.theflowcountry.org.uk/flows-to-the-future/ (2021).

80. Noorani, T. & Brigstocke, J. More-than-human participatory research. (2018).

81. Terrey, N. Codesign: Where do you start as a policy maker? Design Council https://www.designcouncil.org.uk/news-opinion/codesign-where-do-you-start-policy-maker (2014).

82. WeObserve. Citizen Observatories. WeObserve https://www.weobserve.eu/about/citizen-observatories/ (2018).

83. Inglis, D. & Pascual, U. On the links between nature's values and language. People and Nature, 00, 1-17 (2021).

84. NatureScot. Ecosystem Services and Gaelic: a Scoping Exercise. 90 https://www.nature.scot/naturescot-research-report-1230-ecosystem-services-and-gaelic-scoping-exercise (2021).

85. Zamenopoulos, T. & Alexiou, K. Co-design as collaborative research. (2018).

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