Natural Capital Committee

Advice on using nature based interventions to reach net zero greenhouse gas emissions by 2050

April 2020

Contents

Recommendations

The Natural Capital Committee's (NCC) recommendations for using nature based interventions to reach net zero greenhouse gas (GHG) emissions by 2050 – underpinned by a natural capital approach – are set out below.

Integrating net zero into broader environmental policy

1. The government's net zero GHG target **should be viewed in the broader context of the ten 25 Year Environment Plan (25 YEP) goals, noting that "*mitigating and adapting to climate change*" is goal seven.** A joined-up government response to climate change is needed: the current siloed approach, with several departments and other bodies involved but with no overall coordination, will fail to deliver the intended outcome and could even contribute to further degradation of the natural environment.

2. The importance of the Environment and Agriculture Bills in driving land / sea use change should not be underestimated. Following the successful passage of these Bills the government will set a number of environmental targets and implement Environmental Land Management schemes: taken together, this will be the main delivery framework for the 25 YEP. **An integrated, holistic natural capital system based approach which combines top down coordination with local delivery is critical in ensuring that targets and nature based interventions are designed in a way that maximises the full range of ecosystem services – including mental health and wellbeing benefits – minimises costs, and properly considers trade-offs.**

3. The government should urgently replace biodiversity net gain with environmental net gain, ensuring this applies to all nationally significant infrastructure and the marine environment. **Delivery of net zero will become incredibly difficult, if not impossible, without environmental net gain – it is the only approach that considers the impact on the terrestrial and marine ecosystems, including biocarbon stocks.**

4. Planning for infrastructure – including solar farms, wind turbines, buildings, railways and roads, all of which apply pressure on natural assets – should be fully joined up with any spatial planning for nature based interventions. This will ensure that natural capital is fully embedded in infrastructure decisions.

Using nature based interventions to deliver net zero

5. Nature based interventions can deliver carbon reductions at a fraction of the cost of engineered solutions and when delivered effectively can enhance the stocks of natural assets and the ecosystem services they provide. However, **the use of nature based interventions is not an alternative to a major systemic reduction of carbon emissions across all sectors. The government should develop a holistic strategy to reach net zero, which should include changes in energy, transport, housing, infrastructure, industry and land / sea use.**

6. The price of carbon should factor for the ten natural capital based 25 YEP goals and externalities. This is the only way to make sure that the price of carbon is not valued above other services / public goods that nature provides.

7. The maintenance of biocarbon stocks held within natural assets such as soils is as, if not more, important than creating new stocks of biocarbon. Government should consider the impacts on both.

8. Nature based interventions should be designed in a way that fully considers both the mitigation of GHG *and* adaptation / resilience to future climates.

9. Government should prioritise evaluating / undertaking spatial planning for the following five nature based interventions: i) maintaining and increasing tree cover, ii) maintaining and increasing soil carbon (including peatland restoration), iii) improving wildlife / biodiversity, iv) managing freshwaters and wetlands and v) sea use changes.

Addressing gaps in the evidence base

10. Significant evidence gaps related to understanding the impact of nature based interventions should be urgently filled**. Priority should be given to developing a comprehensive baseline of natural capital assets, as advised by the NCC. Without the baseline data it will be impossible to determine whether initiatives such as the government's new £640m 'Nature for Climate Fund' earmarked for tree planting and peat restoration will deliver the required environmental improvements.**

11. The government **should work with experts to significantly improve natural capital system modelling capability, including the full range of ecosystem services and assessing the carbon lifecycle of any approach. Designing interventions on the basis of least cost and without undertaking robust system wide scenario analysis is likely to result in perverse outcomes including increased GHG emissions.**

12. Monitoring programmes for soils and marine in particular are inadequate. **The government should urgently allocate funding to develop metrics given the important role of soil management in meeting net zero, and the need to understand the capacity of the marine environment in mitigating and adapting to climate change.**

13. The impact delivering net zero has on international carbon consumption should be evaluated. There is little point in achieving net zero in the UK if it pushes GHG emissions abroad and as a result damages the natural environment in other countries.

Background

In June 2019 the UK legislated to set a target of net zero greenhouse gas (GHG) emissions by 2050.[1] The major change required to meet this target will be a more rapid reduction of GHG emissions. The UK's Committee on Climate Change (CCC) has recommended that land use change should be a significant element of a holistic strategy to deliver this target.[2]

The Natural Capital Committee's (NCC) Terms of Reference requires it to advise on the "*… implementation of an integrated 25 year environment plan…"* [3] The NCC advises that the net zero target should be delivered within the framework of the ten 25 Year Environment Plan[4] (YEP) goals[5] recognising that "*mitigating and adapting to climate change*" is goal seven in the 25 YEP. The government needs to take an integrated approach to improving the environment. A carbon / GHG only siloed approach risks trading off functioning ecosystems and habitat for carbon capture. Failure to recognise these co-dependencies, benefits and costs in pursuit of a single objective irrespective of the wider consequences will simply repeat the failures of decades of land use policy and, in particular, agricultural policy.

In order to deliver the 25 YEP commitments the NCC has advised that the following framework is needed;

- The 25 YEP must be placed on a meaningful statutory basis with robust legally binding interim and long term targets across all ten 25 YEP goals, not just the four priority areas (air quality, water, biodiversity and resource efficiency and waste reduction) included in the Environment Bill.
- A comprehensive, England-wide environmental census of the stock of natural capital assets[6] is needed to establish a baseline against which progress towards the 25 YEP goals can be measured. Progress cannot be measured properly until a baseline is established.
- A natural capital approach should be embedded at the heart of all government decision making. This means natural capital must be integrated fully into local planning, infrastructure decisions and efforts to achieve net zero.

1 Department for Business, Energy and Industrial Strategy, *UK becomes first major economy to pass net zero emissions law* (2019): https://www.gov.uk/government/news/uk-becomes-first-major-economy-to-pass-net-zero-emissions-law

2 CCC, *Land use: Reducing emissions and preparing for climate change* (2018): https://www.theccc.org.uk/publication/land-use-reducing-emissions-and-preparing-for-climate-change/

3 NCC, *Natural Capital Committee Terms of Reference* (2016)*:* https://www.gov.uk/government/groups/natural-capital-committee

4 HM Government, *A Green Future: Our 25 Year Plan to Improve the Environment* (2018): https://www.gov.uk/government/publications/25-year-environment-plan

5 The ten goals are as follows: Clean air, clean and plentiful water, thriving plants and wildlife, reduced risk of harm from environmental hazards such as flooding and drought, using resources from nature more sustainably and efficiently, enhanced beauty, heritage and engagement with the natural environment, mitigating and adapting to climate change, minimising waste, managing exposure to chemicals, and enhancing biosecurity.

6 NCC, *Natural Capital Committee's advice on an environmental baseline census of natural capital stocks: an essential foundation for the government's 25 Year Environment Plan* (2019): https://www.gov.uk/government/publications/natural-capital-committee-advice-on-developing-an-environmental-baseline-census

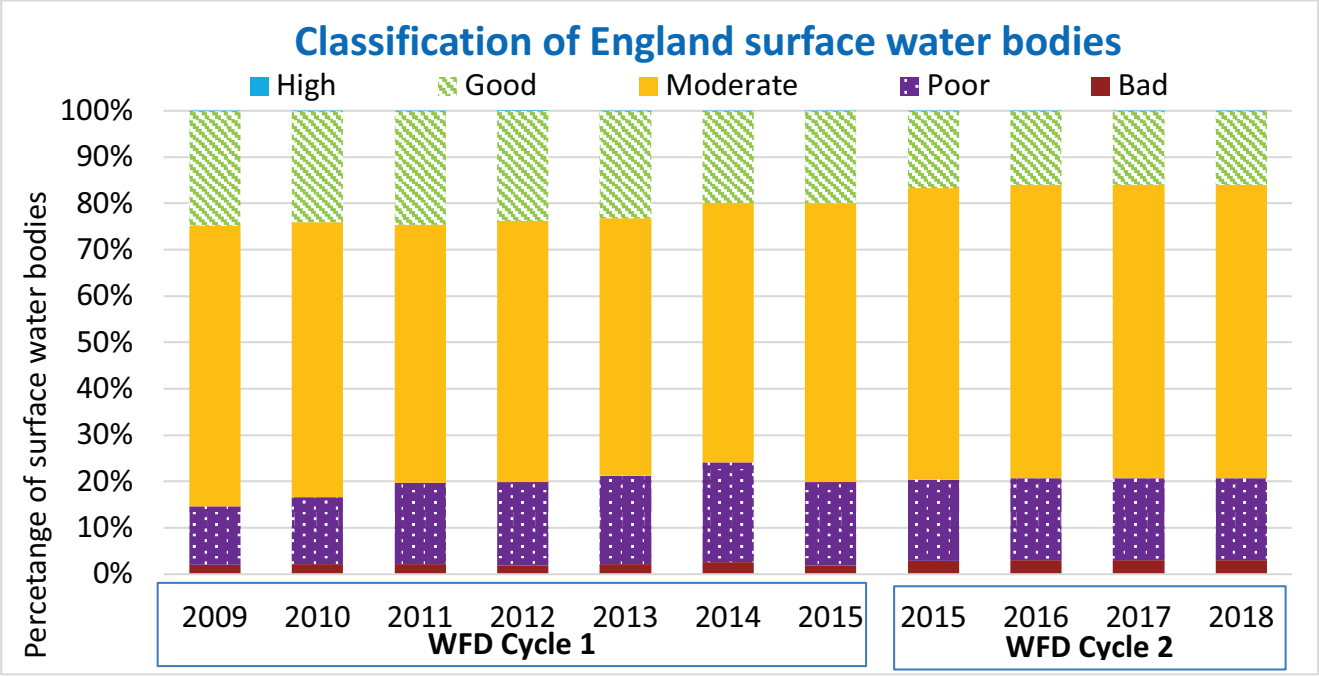
In its 2020 'State of Natural Capital Report', the NCC advised that "*no significant progress has been made towards most of the 25 YEP ten goals since 2011, with many areas in decline.*"[7] For example:

- There has only been a 2.2% increase in protected sites in favourable condition since 2013; the figure currently stands at 38.9%, against a 25 YEP target of 75%.[8]
- The 25 YEP commits to improving at least 75% of water bodies to be as close to their natural state as soon as practicable; currently only 16% of England's surface water bodies – as displayed in Figure 1 – are in a high or good condition status, and this percentage is declining.[9]
- The 2050 UK net zero target of 17% woodland cover will require tree planting at a rate of 30,000 ha per year: only 13,400 ha were planted in 2018/19.[10]

Nature based interventions, through changes in land / sea use and investment in natural assets, will be fundamental in reversing these declines and delivering net zero, as well as delivering a wide range of ecosystem service benefits. Technological solutions for storing carbon, in comparison, are costly.

This paper set out the NCC's advice on the use of nature based interventions. The NCC defines nature based interventions to be measures which restore or enhance natural assets and as a result, deliver multiple benefits, for example: carbon storage, flood alleviation, human wellbeing and biodiversity. The first section focuses on the necessary changes in land use and four key components: i) managing and increasing tree cover; ii) maintaining and increasing soil carbon, including peatland restoration; iii) improving wildlife / biodiversity; and iv) managing freshwaters and wetlands. The second section covers changes in sea use / marine.

Figure 1 Water surface bodies classification



Source Environmental Agency 2019

7 NCC, *State of Natural Capital Annual Report* (2020): https://www.gov.uk/government/publications/natural-capital-committees-seventh-annual-report

8 Defra, *Biodiversity 2020: A strategy for England's wildlife and ecosystem services: Indicators* (2019): https://www.gov.uk/government/statistics/england-biodiversity-indicators

9 Defra, *Biodiversity 2020: A strategy for England's wildlife and ecosystem services: Indicators* (2019): https://www.gov.uk/government/statistics/england-biodiversity-indicators

10 Forest research, *Woodland Statistics* (2019): https://www.forestresearch.gov.uk/tools-and-resources/statistics/statistics-by-topic/woodland-statistics/

Nature based interventions – land use changes

The NCC supports the recommendation by the UK CCC that land use change should be a significant element of a holistic strategy to deliver the net zero target[11] as set out in its recent report on "*Land use: Policies for a Net Zero UK*" (the main recommendations from this report are included in Annex 1).[12]

Land use policy impacts the type, distribution, and turnover of vegetation and therefore affects the extent and condition of natural capital assets including whether the land is a sink or source of carbon. The importance of the Environment Bill[13], Agriculture Bill[14] in laying the foundations for implementing the 25 YEP and driving land use change should not be underestimated. The 2020 Agriculture Bill confirms that actions to mitigate climate change will qualify for funding under the proposed Environmental Land Management (ELM) scheme. As the ELM scheme is also one of the main delivery frameworks for the 25 YEP, the question arises of how carbon offsetting will be prioritised alongside the other ecosystem services that ELMs will need to deliver.

Carbon stocks in nature

Well-designed land use policy will need to consider how carbon is stored in nature. In 2016, the Office for National Statistics (ONS) published preliminary estimates of carbon stock accounts for geocarbon (coal, oil, gas) and biocarbon. Biocarbon stock consists of the carbon stored in land based plants, soils, animals and ecosystems as a whole. These partial accounts estimate that there was 4,266 million tonnes (MtC) of recorded biocarbon in the UK in 2007, of which 94.2% (4,019 MtC) was contained in soil stocks and 5.8% (247 MtC) in vegetation stocks.[15] These accounts are partial due to the exclusion of certain UK habitats, including fen, marsh, swamp, open water and coastal margins as well as the carbon content of the animals living within the habitats – the NCC's proposal for a baseline census would improve these accounts considerably.

Land use change will not only affect GHG balance and directly related issues such as levels of soil and sediment, organic carbon and fertility – but will also impact multiple other related benefits and costs, as set out below:

- Agricultural production;
- Timber output;
- Seafood production;
- Habitats and wild species including those of conservation interest;
- The water environment including water quality, availability and flood risk;
- Recreational access and associated effects upon physical and mental health;
- Other (non-GHG) air pollution emissions such as ammonia emissions;
- Urban cooling;
- The provision of amenity views;
- Cultural and heritage features.

Socio-political considerations such as the impact of change on the livelihoods of farmers and other land-owners, or sea users fall outside the remit of the NCC although these can clearly impinge upon the design and implementation of policy.[16] Decisions about future land use should fully assess the options available, accounting for the challenges of scale and time to prioritise methods which deliver multiple benefits for wider environmental goals, climate change mitigation and adaptation. It will be difficult if not impossible to do this without robust baseline data and the appropriate spatial planning. The 2020 Budget[17] announced a £640m 'Nature for Climate Fund' for tree planting and peatland restoration. Without the baseline data it will be impossible to deliver optimal interventions or measure the improvements for the expenditure.

11 CCC, Land use: Reducing emissions and preparing for climate change (2019): https://www.theccc.org.uk/publication/land-use-reducing-emissions-and-preparing-for-climate-change/

12 CCC, Land use: Policies for a Net Zero UK (2020): https://www.theccc.org.uk/publication/land-use-policies-for-a-net-zero-uk/

13 Parliament, Environment Bill 2019-21 (2020): https://services.parliament.uk/bills/2019-21/environment.html

14 Parliament, Agriculture Bill 2019-21 (2020): https://services.parliament.uk/bills/2019-21/agriculture.html

15 ONS, UK Natural Capital: Experimental carbon stock accounts, preliminary estimates (2016) https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/uknaturalcapital/experimentalcarbonstockaccountsprelim-inaryestimates

16 Bateman and Balmford, Public funding for public goods: a post-brexit perspective on principles for agricultural policy (2018): http://www.exeter.ac.uk/media/universityofexeter/collegeofsocialsciencesandinternationalstudies/leep/documents/WP_03-2018_LEEP.pdf

17 BBC, Budget 2020: Mixed reaction on environmental issues (2020): https://www.bbc.co.uk/news/science-environment-51835950

For example, the recent funding of tree planting on a species rich grassland in Cumbria under the banner of environmental improvement illustrates the problems that can arise in the absence of good ecological data.[18]

Agriculture and GHG emissions

Agriculture comprises the majority of land use in the UK, covering over 72% of land area.[19] Comparatively, the CCC estimate one fifth is semi-natural land, including forestry, mountain, moor, heath and coastal margins.[20]

In 2018, agriculture accounted for just under 10% of all UK GHG emissions, with N_2O and methane from soils and livestock being the main sources.[21] Although in the UK overall GHG emissions have reduced by just under 23% since 2011, this has been limited to a few sectors (energy, waste management and business). In other areas, such as agriculture, there have been increases.[22] Currently agriculture is the fifth largest emitter of GHG emissions in the UK (as shown in Figure 2) when it only contributes 0.6% to the UK's GDP.[23, 24] The GHG emissions produced by agriculture should be considered in future agricultural subsidies and support mechanisms. For example, the current tax break available to the farming sector for red diesel undermines efforts to move to cleaner alternatives and does not support the 'polluter pays' principle which is embedded within the Environment Bill. It should also be noted UK government is not on track to meet the fourth carbon budget. [25]

Reducing GHG emissions from agriculture

The CCC advises that for deeper emissions reduction in agriculture of 35–80%, agricultural land would need to be released for other uses including afforestation and peatland restoration.[26] Land use change will play an important part in reaching the net zero target not just to prevent emissions from agriculture, but to increase the removal and storing of carbon through biological uptake across the landscape. Dietary changes could have significant effects on the GHG profile of the food system and recent research[27] has shown the very substantial scale of this potential. Indeed, the CCC's report targets just a 20% per capita reduction in beef, lamb and dairy consumption to deliver the emissions reduction scenario which they recommend.[28] Combined with reduced food waste this could help mitigate the risks of carbon leakage through imported food.

The CCC have reported that immediate opportunities to reduce emissions in the current agricultural system would still leave agriculture as one of the largest emitting sectors by 2050. Even the 'ambitious' steps set out in the CCC's 2020 land use report are anticipated to deliver a reduction in emissions from the agriculture, land use and peatlands sectors by just 64% to 21 $MtCO_2e$ by 2050.[29] These figures make it clear that – far from being an option for major offsetting of emissions from other sectors – the measures will not even mitigate the emissions of the agriculture, land use and peatlands sectors.

18 The Telegraph, *Nestlé farm to rip up saplings after eco drive planting wrecks wild flower meadow* (2020) https://www.telegraph.co.uk/news/2020/02/19/nestle-forced-apologise-rip-trees-planted-part-eco-drive-destroyed/

19 Defra, *Farming statistics - provisional crop areas, yields and livestock populations at 1 June 2019 – United Kingdom* (2019): https://www.gov.uk/government/statistics/farming-statistics-provisional-crop-areas-yields-and-livestock-populations-at-1-june-2019-united-kingdom

20 CCC, *Land use: reducing emissions and preparing for climate change* (2018) https://www.theccc.org.uk/wp-content/uploads/2018/11/Land-use-Reducing-emissions-and-preparing-for-climate-change-CCC-2018.pdf

21 BEIS, *Final UK greenhouse gas emissions national statistics: 1990-2018* (2020) https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2018

22 BEIS, *Final UK greenhouse gas emissions national statistics (1990-2018)* (2020): https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2018

23 BEIS, *2018 UK greenhouse gas emission: final figures – statistical summary* (2020): https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2018

24 World Bank, *Agriculture, forestry and fishing, value added (% of GDP)* (2020): https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS

25 CCC, *Carbon budgets: how we monitor emissions targets:* https://www.theccc.org.uk/tackling-climate-change/reducing-carbon-emissions/carbon-budgets-and-targets/

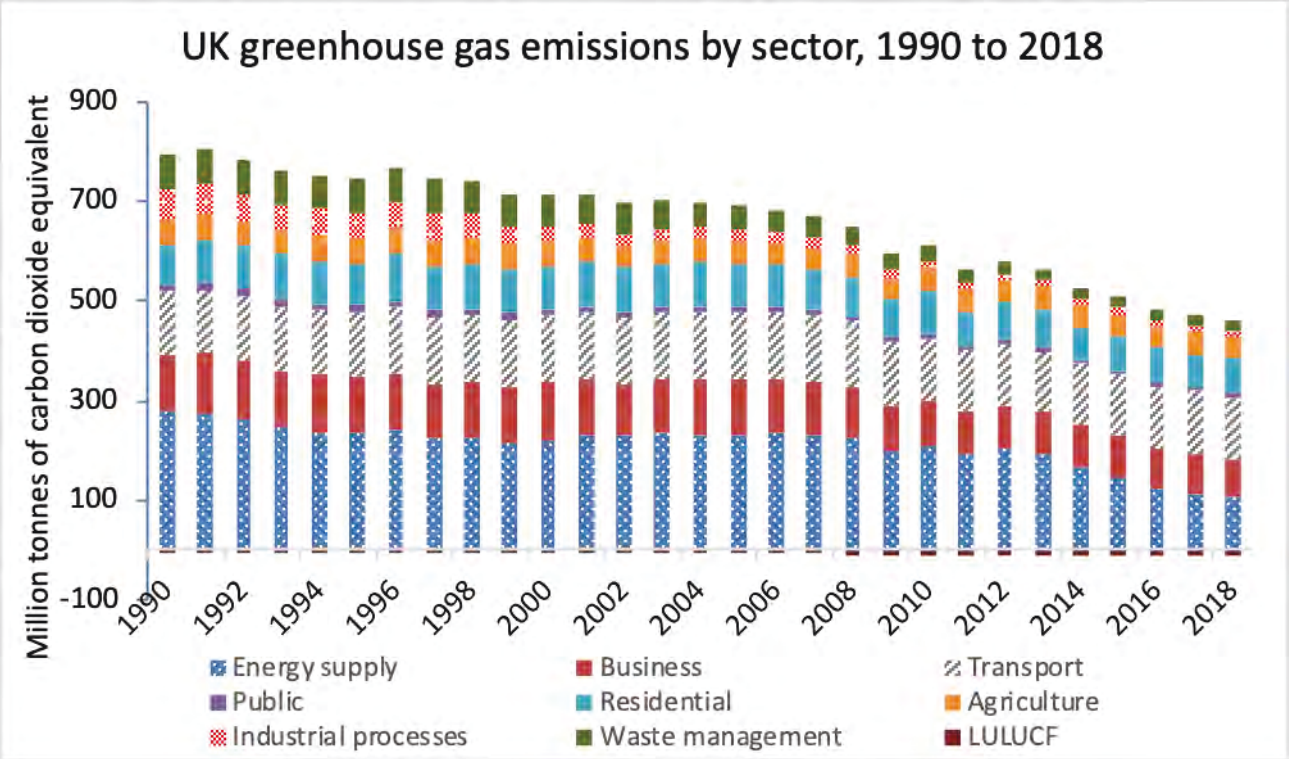
26 CCC, *Land use: reducing emissions and preparing for climate change* (2018): https://www.theccc.org.uk/wp-content/uploads/2018/11/Land-use-Reducing-emissions-and-preparing-for-climate-change-CCC-2018.pdf

27 E.g. Reducing food's environmental impacts through producers and consumers, J. Poore and T. Nemecek (2018) Science 01 Jun 2018: Vol. 360, Issue 6392, pp. 987-992 DOI: 10.1126/science.aaq0216 https://science.sciencemag.org/content/360/6392/987

28 CCC, *Land use: Policies for a Net Zero UK* (2020): https://www.theccc.org.uk/publication/land-use-policies-for-a-net-zero-uk/

29 CCC, *Land use: Policies for a Net Zero UK* (2020): https://www.theccc.org.uk/publication/land-use-policies-for-a-net-zero-uk/

Figure 2 UK Greenhouse gas emission since 1990



Source: BEIS

Any market driven interventions to delivering net zero will need to account for and fund the management of all our natural capital assets and the services they provide, delivering more than just carbon offsetting. The Climate Change Act[30] allows for the trading of carbon credits in order to reach net zero. Overseas offsetting is currently allowed under the act, but arguments have been advanced that this should not be allowed for net zero as it deflates the cost of carbon in the UK market. If this situation changes, and efforts to reach net zero allow carbon prices to be increased in the UK at the same time as polluters are able to pay farmers and land owners to offset their emissions, there is a risk that carbon sequestration will be delivered at the cost of other ecosystem services which cannot be as highly funded. Conversely, if low carbon prices mean that funding delivered through Environmental Land Management schemes is used to subsidise carbon sequestration, this might also detract from the delivery of other ecosystem services.

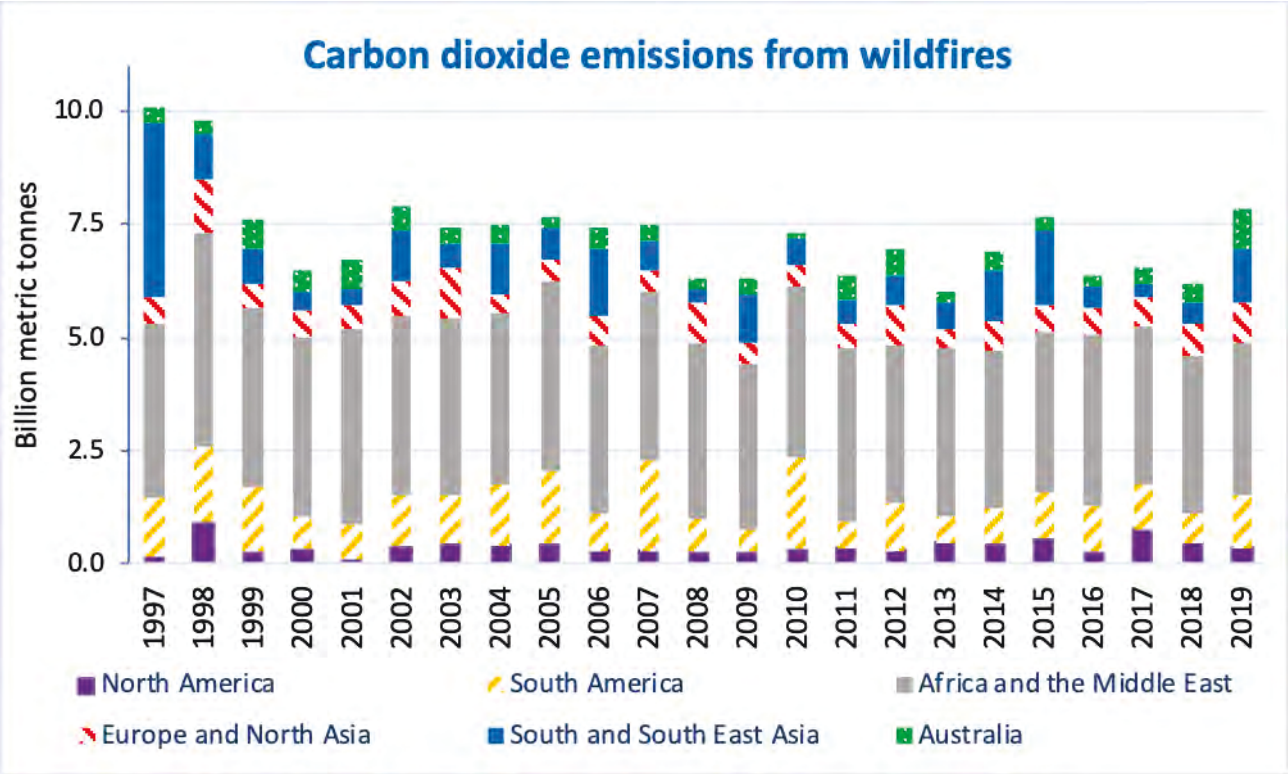
In trading terms, the UK is not an island. There is little point in advocating policies which move the domestic economy towards environmental protection and net zero at the cost of damaging other countries' environments or sucking in virtual GHG emissions via international trade. The NCC agrees with the recommendation from the CCC that delivering emissions reduction through domestic land use change should not be at the cost of increasing agricultural imports that risk 'carbon leakage'.

Actions to mitigate climate change must include the maintenance of current carbon stocks as well as a reduction in emissions and the need for actively removing GHG from the atmosphere. Without maintenance the carbon locked up in habitats is at risk of being released. For example, although forest fires are sometimes a natural process the most recent data from Global Fire Data (Figure 3) shows that in 2019 wild fires released around 7.8 billion metric tons of CO_2, with the spikes in 2015 and 2019 corresponding with major burning of peatlands in Indonesia and forest fires in the Brazilian Amazon respectively. When compared to the burning of fossil fuels, wild fires were responsible for 20% of the 36.8 billion metric tons of carbon released in 2019.[31] Considering how adapted and therefore resilient the carbon stock is to future climate change is essential to maintaining the stock.

30 Legislation.gov.uk., *Climate Change Act* 2008 (2008): http://www.legislation.gov.uk/ukpga/2008/27/contents

31 Blomberg Green, *Measuring the Carbon-Dioxide Cost of Last Year's Worldwide Wildfires* (2020): https://www.bloomberg.com/graphics/2020-fire-emissions/

Figure 3 Carbon dioxide emissions from wildfires since 1997 – in billion metric tonnes



Source: Global Fire Emissions Database

Decisions on what action to take need to consider the range of natural capital enhancements that nature based interventions offer. Nature offers the potential to store and sequester carbon at a much lower cost with a wider range of natural capital enhancements for the investment. For example, engineered solutions can cost between four and ten times more per tonne of CO_2 when compared to nature based interventions.[32] The following four options need to be evaluated, while recognising that each approach will be spatially explicit:

i) Managing and increasing tree cover;
ii) Maintaining and increasing soil carbon, including peatland restoration;
iii) Improving wildlife/biodiversity; and
iv) Managing freshwaters and wetlands.

32 The Royal Society, *Greenhouse gas removal* (2018): https://royalsociety.org/-/media/policy/projects/greenhouse-gas-removal/royal-society-greenhouse-gas-removal-report-2018.pdf

i) Managing and increasing tree cover

The amount of carbon stored in UK terrestrial vegetation comprises 247 MtC, or 5.8% of the total estimated biocarbon stock.[33] It is estimated forest degradation and deforestation contributes between 20% to global greenhouse gas (GHG) emissions.[34,35] Some studies claim that forests capture about half of the world's carbon emissions from the fossil fuels every year.[36] Besides carbon sequestration, forests can modulate the land-atmosphere exchange of energy and water vapour.[37]

The potential for forestry / increased tree cover to absorb carbon has led to a commitment to increase tree planting in England, including 1 million urban trees announced in the 25 YEP and 11 million trees initially announced in the Clean Growth Strategy.[38] The right tree in the right place for the right reason can bring a multitude of benefits including;

- Habitats for wildlife;
- Recreation and wellbeing;
- Flood storage and protection;
- Urban cooling;
- Air cleaning through particulate matter removal and the assimilation of some pollutant gases (SO_2, NO_2 and CH_2O) from air converting them to simple organic compounds and;
- Water filtration.

There is a risk that forestry / increasing tree cover is seen solely as a 'carbon sink', an offset for harmful activities that does not contribute to wider natural capital interests. The NCC advises that the following issues and trade-offs need careful consideration before embarking on a large scale planting programme under the banner of net zero.

33 ONS, *UK Natural Capital: Experimental carbon stock accounts, preliminary estimates* (2016): https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/uknaturalcapital/experimentalcarbonstockaccountspreliminaryestimates

34 Gibbs, H and Herold, M., *Tropical deforestation and greenhouse gas emissions (*2007): https://iopscience.iop.org/article/10.1088/1748-9326/2/4/045021

35 Solomon et al., *Climate Change 2007 The Physical Science Basis* (2007): https://wg1.ipcc.ch/publications/wg1-ar4/faq/docs/AR4WG1_FAQ-Brochure_LoRes.pdf

36 Pan et al., *A large persistent carbon sink in the world's forests* (2011): https://www.nrs.fs.fed.us/pubs/jrnl/2011/nrs_2011_pan_002.pdf

37 Hesslerová et al., *Daily dynamics of radiation surface temperature of different land cover types in a temperate cultural landscape: consequences for local climate* (2013)

38 BEIS, *Clean Growth Strategy* (2017): https://www.gov.uk/government/publications/clean-growth-strategy

39 NCC, *Natural Capital Committee's advice on an environmental baseline census of natural capital stocks: an essential foundation for the government's 25 Year Environment Plan* (2019) https://www.gov.uk/government/publications/natural-capital-committee-advice-on-developing-an-environmental-baseline-census

40 The Telegraph, *Nestlé farm to rip up saplings after eco drive planting wrecks wild flower meadow* (2020) https://www.telegraph.co.uk/news/2020/02/19/nestle-forced-apologise-rip-trees-planted-part-eco-drive-destroyed/

Data gaps

- The NCC have previously advised that the government undertakes a census of natural capital assets.[39] It is unlikely enough data exists currently to undertake spatially aware decision making which can consider all of the trade-offs and benefits of increasing tree cover. Without this data it is likely that mistakes will be made, such as the recent planting of a wildflower meadow under the banner of landscape improvement.[40] Or perverse outcomes will be overlooked, for example the planting of ancient woodlands with productive conifer species to the detriment of biodiversity.

Tree planting

- Increased tree planting without careful planning is likely to lead to the loss of other habitats and land uses, including species rich grasslands, heathlands and peatlands, particularly where these are in a degraded state. In addition, the wrong trees in the wrong places can have adverse impacts on soil (including soil carbon), water flows, water quality, recreation, biodiversity and air quality. Tree planting schemes will therefore need to employ rigorous monitoring, verification and spatially aware decision making to ensure that the right tree is planted in the right place at the right time for the right reason. This will be crucial to avoiding scenarios like the afforestation of peatlands in Scotland in the late 20th century, which was found in places to lead to a net increase in GHG emissions and the felling and replacement of ancient native woodlands with fast growing productive species.[41] Government should also consider natural regeneration rather than planting, trees outside of woodlands (including agroforesty) and hedgerows.

- It is unlikely the nursery sector has enough capacity to supply the CCC's recommended yearly planting rate of 30,000 ha (depending on planting density that's 90–120 million trees per year).[42] Importing nursery stock is linked to outbreaks of tree pests and diseases. For example, recent outbreaks of *Phytophthora ramorum*, sweet chestnut blight and oak processionary moth can all be linked to the trade in plants.[43,44,45] This increases the risk that both the

41 Sloan, T. J. et al., *Peatland afforestation in the UK and the consequences for carbon storage* (2018) https://www.forestresearch.gov.uk/research/peatland-afforestation-in-the-uk-and-consequences-for-carbon-storage/

42 Whittet, R. et al., *Supplying trees in an era of environmental uncertainty: Identifying challenges faced by the forest nursery sector in Great Britain* (2016): https://www.sciencedirect.com/science/article/pii/S0264837716302794

43 Forest Research, *Ramorum disease (Phytophthora ramorum)*: https://www.forestresearch.gov.uk/tools-and-resources/pest-and-disease-resources/ramorum-disease-phytophthora-ramorum/

44 Forest Research, *Sweet chestnut blight (Cryphonectria parasitica*): https://www.forestresearch.gov.uk/tools-and-resources/pest-and-disease-resources/sweet-chestnut-blight-cryphonectria-parasitica/

45 Forest Research, *Oak processionary moth (Thaumetopoea processionea):* https://www.forestresearch.gov.uk/tools-and-resources/pest-and-disease-resources/oak-processionary-moth-thaumetopoea-processionea/

new trees and the existing stock will be impacted by disturbance from new pests and diseases. It should also be noted that availability of tree seed varies between years; species such as oak and beech have mast seeding years where in some years they produce a bumper crop and in others none at all.

- The amount of carbon sequestered will depend on many variables including the species and the end product, and will change over the life cycle of the tree. Carbon locked up in forestry has to be maintained through active management once it has been created.

Managing tree cover

- The Forestry Commission estimated that in 2019 only 59% of English woodland are actively managed.[46] Bringing the existing tree stock into active sustainable management should be as important as expanding woodland cover. The maintenance of the existing stock is essential to ensuring the resilience of trees and forests into the future. A major barrier to the future of UK woodlands is the populations of squirrel and deer which cause damage to trees and prevent trees regenerating. In addition, regeneration is critical to promoting genetic diversity and therefore adaptation to changing climates as well as future carbon storage.

- The carbon storage capacity of forests and trees is at risk from future deforestation or natural disturbances such as climate change and pest and disease outbreaks.[47,48] The 2012 outbreak of ash dieback[49] will severely impact the amount of carbon stored in the current tree stock. 12% of broadleaf woodland in Great Britain is ash, with an estimated 125 million ash trees in woodlands[50] and between 27–60 million ash trees outside of woodlands.[51] The outbreak of ash dieback is likely to lead to the death or removal of the majority of ash trees. The current tree planting targets will fail to replace what will be lost with no assistance available to replace the trees lost outside of woodlands. Carbon locked up in trees and forests has to be maintained once it is created and it is not guaranteed to remain stored through disturbance events.

The trade in wood

- The trade in wood should be assessed, in 2018 the UK gross consumption of wood was 56.4 million m^3 – 49 million m^3 of this imported.[52] A similar pattern of trade can be seen in wood pellets for heat and power generation, in 2018 eight million tonnes of wood pellets were imported, compared to 279 thousand tonnes being produced domestically.[53] There is little point managing, protecting and increasing England's forest area if the trade in wood and other products creates issues for other countries. The use of forest certification schemes such as Forest Stewardship Council (FSC) and the Sustainable Biomass Programme (SBP) should be required to prevent the unsustainable extraction of wood. For example, whilst some UK furniture and wood retailers (e.g. Marks and Spencer and B&Q) have policies on sourcing sustainable materials through certification schemes (FSC), many still have little or weak policies on the use of sustainably sourced wood leading to questions about the impact the trade is having on global deforestation. [54]

Better management of forests and trees should be viewed as ***a contributor*** to net zero – not the only answer. Government should consider these issues in its upcoming Tree Strategy.[55]

ii) Maintaining and increasing soil carbon, including peatland restoration

The ONS estimates indicate that in 2007 UK soils contained approximately 4,019 million tonnes of carbon (MtC), or 94.2% of the total biocarbon stock. Of this, the carbon stored in peat soils made up a majority accounting for 57.3%.[56] Peat soils are both a long term repository for stored carbon but when degraded, as the majority of UK peatlands are,[57] they are a highly significant source of GHG emissions. However, all soils have relevance here. The ONS estimates that in 2007 soil carbon contained in forest tree cover habitat made up 16.7% of the total UK carbon stocks. Estimates for the same period indicated that 9% of soil carbon was stored in improved grassland habitat, but this is primarily due to the large extent of this habitat rather than a high capacity to store carbon (carbon density).[58] Soils are

46 Forestry Commission, *Forestry Commission Key Performance Indicators: Headline Performance Update at 31 December 2019* (2020) https://www.gov.uk/government/statistics/forestry-commission-key-performance-indicators-headline-performance-update-at-31-december-2019

47 The Royal Society, *Greenhouse gas removal* (2018): https://royalsociety.org/-/media/policy/projects/greenhouse-gas-removal/royal-society-greenhouse-gas-removal-report-2018.pdf

48 Seidl, R. et al, *Invasive alien pests threaten the carbon stored in Europe's forests* (2018) https://www.nature.com/articles/s41467-018-04096-w

49 House of Commons, *Ash dieback disease: Chalara fraxinea* (2012) https://researchbriefings.files.parliament.uk/documents/SN06498/SN06498.pdf

50 Forest Research, *Forestry Statistics 2019* (2019) https://www.forestresearch.gov.uk/tools-and-resources/statistics/forestry-statistics/forestry-statistics-2019/

51 Defra, *Ash research strategy Annexes: Evidence Summary* (2019): https://www.gov.uk/government/publications/ash-tree-research-strategy-2019/annexes-evidence-summaries

52 Forest Research, *Forestry Statistics 2019* (2019) https://www.forestresearch.gov.uk/tools-and-resources/statistics/forestry-statistics/forestry-statistics-2019/

53 Forest Research, *Forestry Statistics 2019* (2019) https://www.forestresearch.gov.uk/tools-and-resources/statistics/forestry-statistics/forestry-statistics-2019/

54 WWF, *Timber scorecard* (2019) https://www.wwf.org.uk/timberscorecard

55 https://www.gov.uk/government/news/government-delivers-new-10m-fund-to-plant-over-130000-urban-trees

56 ONS, *UK Natural Capital: Experimental carbon stock accounts, preliminary estimates* https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/uknaturalcapital/experimentalcarbonstockaccountspreliminaryestimates

57 Natural England, *England's peatlands: carbon storage and greenhouse gases* (NE257) (2010) http://publications.naturalengland.org.uk/publication/30021

a non-renewable resource[59] of value not just for their storage of soil organic carbon (SOC) but also because of their fertility and role in food production. Improved soil management can bring a multitude of benefits including:

- Nutrient cycling;
- Water regulation;
- Carbon storage;
- Biodiversity;
- Enhanced climate resilience;
- Food and fibre production;
- Waste management;
- GHG emission control;
- Reduced erosion.

The sequestration of carbon in soils as a result of the net zero commitment will have a huge effect on agriculture, and is an opportunity to deliver improved soil health and restored ecosystems. It is vital that the right framework is available for delivering this, and the data to support decision making. The NCC advises that the following issues and trade-offs need careful consideration in making decisions on land use – all of which will impact on soils:

Data gaps

- The NCC has previously advised on developing a set of metrics for assessing healthy soils.[60] These should be developed as a priority and data gaps should be filled to deliver the information on soil type, condition and extent which will be needed to inform decision making regarding interventions for net zero at both national and local scales. This will require significant resources and the aim for a suite of actions to ensure soils are sustainably managed by 2030 is unlikely to be soon enough if interventions to sequester carbon in soils are to be implemented before this. Further data is needed on both soil carbon and other aspects of soil that deliver benefits, such as soil structure. For example, countryside Survey data used to assess soil carbon stocks includes top soil samples only up to a depth of 15cm.[61] Significant quantities of carbon are held below these depths, particularly in peatlands.[62] These data gaps need to be urgently addressed so that the appropriate interventions can be put in place. The most recent national surveys indicate our soils are currently losing soil carbon, and most arable soils have already lost 40–60% of their organic carbon.[63,64]

- The NCC advises that model outputs need to be better designed to incorporate available data before they are used to set emissions / storage targets. Policy should be based on the evidence, factoring in spatial analysis and risk, rather than the best possible scenarios indicated by some models. In the context of soils, evidence on how much carbon soil can sequester is lacking, with some experts reporting that the mitigation potential is only a fraction of what some modelling suggests.

Soil management

- Soil degradation through erosion, intensive farming and development incurs losses estimated at between £0.9 –1.4 billion per year for England and Wales alone.[65] Restoration, farm extensification and the enhancement of trees in the landscape through a policy of planting the right trees in the right place for the right reason will all be important for preventing further soil losses.

Soil carbon

- Potential for soil carbon sequestration should not be overlooked. The NCC has previously advised that managing soil organic carbon (C) is central to optimising soil function because organic matter influences numerous soil properties supplying ecosystem services, and that methods to deliver this could bring multiple co-benefits.[66] Care is required regarding just how much C soils can retain, but operational envelopes can be developed. Policy makers should take an evidence based approach to pursue low risk interventions, recognising the other ecosystem service benefits alongside GHG mitigation. For example, evidence shows that integrating leys into crop rotation and the use of cover crops have the potential to deliver carbon sequestration in agriculture. Policy makers should be aware that interventions to incorporate woody biomass into production systems offer greater mitigation potential, as does reducing the loss of carbon from degraded peatlands.

- Interventions to increase soil carbon should consider other soil benefits, as the potential for soil carbon sequestration is limited in comparison to other mitigation strategies. For some soil types, management to increase soil carbon may in fact deliver greater benefits in other areas. For example, evidence suggests that the quantity of additional organic carbon in soil under no till is relatively small but that the resultant increase in carbon near the surface can be beneficial for biodiversity and functionality.[67]

58 ONS, *UK Natural Capital: Experimental carbon stock accounts, preliminary estimates* https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/uknaturalcapital/experimentalcarbonstockaccountspreliminaryestimates

59 It takes an average of 100 years to generate 1cm of topsoil; thus soil should be considered as a non-renewable resource and managed accordingly.

60 See https://www.gov.uk/government/publications/natural-capital-committee-advice-on-developing-an-environmental-baseline-census and Natural Capital Committee advice on soil management: https://www.gov.uk/government/collections/natural-capital-committee-documents

61 Countryside Survey https://countrysidesurvey.org.uk/content/summary-data

62 Ostle et al, *UK land use and soil carbon sequestration* (2009) https://www.sciencedirect.com/science/article/pii/S0264837709000945

63 Graves, A. R. et al., *The Total Costs of Soil Degradation in England and Wales* (2015): https://www.sciencedirect.com/science/article/pii/S0921800915003171

64 Environment Agency, *The state of the environment: soil* (2019): https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/805926/State_of_the_environment_soil_report.pdf

65 Graves et al., *The total costs of soil degradation in England and Wales* (2015) https://www.sciencedirect.com/science/article/pii/S0921800915003171

66 https://www.gov.uk/government/publications/natural-capital-committee-advice-on-soil-management

67 Powlson et al, Limited potential of no-till agriculture for climate change mitigation (2014) https://ccafs.cgiar.org/publications/limited-potential-no-till-agriculture-climate-change-mitigation#.XlQGEpX7SUk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This indicates that this practice is beneficial for soil quality and adaptation to climate change, but that it has a limited role in mitigation. Interventions aimed only at improving soil carbon might lose these co-benefits.

- Studies indicate that many of the soils that hold the most carbon stocks are also potentially the most sensitive to climate change. In peatlands, rankers, peaty-podzols, stagnogleys and brown earths, many of which occur in the UK uplands, reductions in soil moisture linked with warming or drought could increase the release of soil carbon.[68] Studies on grassland and arable soils have also found that prolonged flooding can both reduce the levels of below ground carbon by shifting the way carbon passes from plants into the soil and also cause increases in GHG emissions from soils.[69, 70] Interventions should aim to increase the resilience of these soils in order to maintain their carbon stocks, and interventions aimed at sequestering carbon should account for pressures from both land use and climate change.

Soils and land use

- Interventions aimed at managing long term soil carbon equilibria need to consider the interaction between soil type and land use:

    - Peat soils should be taken out of anything but the lowest impact agriculture. 78% of UK peatland are in a degraded state[71] leading to peatlands becoming a large net source of emissions.[72] The Committee on Climate Change advised that restoring at least 50% of upland peat and 25% of lowland peat would reduce peatland emissions by 5 $MtCO_2e$ by 2050, while allowing food production to continue on the most productive land.[73] The NCC advises that in the absence of data on the depth of lowland peat, the current rates of erosion mean that farming in such habitats which leads to the loss of peatland soils is an unsustainable practice and should be halted to prevent the loss of this non-renewable asset.[74] Peat soils should not be used for tree planting – carbon losses resulting from land use changes, such as oxidation as a consequence of drying out, can occur rapidly and are extremely difficult to reverse in the short term.[75] The Peatland Strategy[76] should take into account the issues raised here.

    - Other soils generally exhibit increases in soil carbon when moved from high to low intensity agriculture (e.g. stopping tillage) – and again when moved to woodland. Caution should be taken in prioritising carbon sequestration ahead of other soils benefits, and in particular soil should not be depended upon to offset other emissions.

iii) Improving wildlife / biodiversity

Biodiversity is particularly important in a changing climate as it underpins the maintenance of ecosystem functions and services – their 'resilience' – and it is very hard to replace once depleted below certain (often unknown) thresholds. Almost all evidence shows huge declines in biodiversity, with little sign of this improving – for example, the UK government has missed almost all of the 2020 Aichi targets.[77] Due to data deficiency it is difficult to quantify the amount of carbon within biodiversity. Biodiversity does include trees and vegetation, for which estimates of stored carbon are mentioned above.

Biodiverse landscapes bring a multitude of other benefits, including:

- Carbon storage;
- Ecosystem function;
- Recreation and wellbeing;
- Food production;
- Adaptation to climate change;
- Nutrient cycling.

Efforts to achieve net zero should not solely focus on improving carbon and biodiversity. All natural capital assets should be considered. The NCC advise that the following issues should be addressed:

- Species and genetic rich ecosystems have a greater potential to adapt, so conserving biodiversity is crucial to maintaining ecosystem function and the services provided into the future.[78] For example, a recent study

68 Ostle, N. J. et al, UK land use and soil carbon sequestration (2018) https://www.sciencedirect.com/science/article/pii/S0264837709000945

69 Sánchez-Rodríguez, A. R., et al Extreme flood events at higher temperatures exacerbate the loss of soil functionality and trace gas emissions in grassland (2019): https://www.sciencedirect.com/science/article/pii/S0038071718304395#!

70 Barnes, C. J. et al, Extreme rainfall affects assembly of the root-associated fungal community (2018) https://nph.onlinelibrary.wiley.com/doi/full/10.1111/nph.14990

71 ONS, UK natural capital: peatlands (2019) https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/uknaturalcapitalforpeatlands/naturalcapitalaccounts

72 Evans et al, Lowland peatland systems in England and Wales – evaluating greenhouse gas fluxes and carbon balances (2016)

73 CCC, Land use: Policies for a Net Zero UK (2020): https://www.theccc.org.uk/publication/land-use-policies-for-a-net-zero-uk/

74 Land, D., Johnson, S., Productive lowland peatlands (2019) https://www.iucn-uk-peatlandprogramme.org/sites/default/files/2019-11/COlFens_

75 Ostle et al, UK land use and soil carbon sequestration (2009) https://www.sciencedirect.com/science/article/pii/S0264837709000945

76 Mentioned in; HM Government, A Green Future: Our 25 Year Plan to Improve the Environment (2018): https://www.gov.uk/government/publications/25-year-environment-plan

77 JNCC, United Kingdom's 6th National Report on the Convention on Biological Diversity (2019): https://jncc.gov.uk/our-work/united-kingdom-s-6th-national-report-to-the-convention-on-biological-diversity/

78 Convention on Biological Diversity, *Interlinkages between biological diversity and climate change…* (2003): https://unfccc.int/sites/default/files/execsum.pdf

in sub-tropical forests found that each additional tree species increased the total carbon stock by 6.4%.[79] The lack of data on species richness, abundance and the interactions between species make it difficult to fully assess the pressures on species and habitats.

- Climate change is likely to accelerate species declines through loss of habitat, rate of change and physical barriers to migration. Land / sea use change will need to consider future climate scenarios and factor for how species ranges could change. However, the impact climate change will have on individual species and the system as a whole is largely unknown. Filling data gaps should be urgently prioritised through the delivery of an environmental census of natural capital assets.

- Under future environmental change the maintenance of ecosystem functions and services are crucial, and decisions should not be based only on the delivery of ecosystem functions and services under current conditions.

- The multiple pressures on land and sea use and changes as a result of net zero, if interventions are implemented without using a natural capital approach, are likely to have negative impacts on biodiversity. For example, biodiversity could decline if there is widespread implementation of biomass energy with carbon capture and storage (BECCS), depending on the biofuel chosen.[80,81] Even where BECCS is implemented on land released from intensive agriculture, policy will need to address the impacts on the whole system, such as indirect land use change which could occur as a result.[82]

iv) Managing freshwater and wetlands

Freshwaters and wetlands support a diverse range of species including invertebrates, plants, amphibians, fish and mammals. In the UK more than 40,000 lakes[83] and half a million ponds have been recorded.[84] Freshwater habitats are particularly vulnerable in a changing climate; heat, drought, flooding, sea-level rises and land-use changes are likely to change and damage many freshwaters and wetlands.[85] It is widely reported that flooding events, as seen recently, will become more common as the climate changes. Other nature based interventions (afforestation, for example) can reduce the impact of flooding.

The creation and restoration of freshwater habitats brings a multitude of natural capital benefits, including:

- Alleviation of flooding;
- Wildlife benefits;
- Water regulation;
- Recreation and wellbeing;
- Nutrient cycling.

The NCC advise that the following issues should be addressed;

- The increase in flood events is likely to adversely impact the amount of carbon stored in soil, and increase the risk of soil erosion. The current land use of flood plains should be reviewed and the impact of increased flooding evaluated.[86]

- Although freshwaters cover a relatively small proportion of the Earth's surface area they have a role in the carbon cycle; recent evidence has demonstrated that of the carbon inland waters receive from the environment, some of this is buried in sediment and some is delivered to the oceans however a portion is returned to the atmosphere. The impact that changes in land use, climate and the quality of freshwaters has on this process should be assessed.

- Recent evidence suggests a changing climate could alter the microbial diversity of lakes which will lead to an increase in carbon emissions through the decomposition of organic matter (logs and leaves) which fall into water bodies.[87] An increase in the number of trees adjacent to freshwaters could increase the amount of organic matter entering the water and therefore further compound the issue.[88] A natural capital approach should be used when deciding where to expand tree cover.

79 Liu, X., et al. Tree species richness increases ecosystem carbon storage in subtropical forests (2018): https://royalsocietypublishing.org/doi/10.1098/rspb.2018.1240

80 The Royal Society, *Greenhouse gas removal* (2018): https://royalsociety.org/-/media/policy/projects/greenhouse-gas-removal/royal-society-greenhouse-gas-removal-report-2018.pdf

81 Harper, A. et al., *Land-use emissions play a critical role in land-based mitigation for Paris climate targets* (2018): https://www.nature.com/articles/s41467-018-05340-z

82 Albanito, F. et al., *Mitigation potential and environmental impact of centralized versus distributed BECCS with domestic biomass production in Great Britain* (2019): https://onlinelibrary.wiley.com/doi/full/10.1111/gcbb.12630

83 CEH, *Lakes portal*: https://www.ceh.ac.uk/news-and-media/news/uk-lakes-portal-40000-lakes-at-your-fingertips

84 Freshwater Habitats Trust, *Strategic Framework* (2013-2020): https://freshwaterhabitats.org.uk/wp-content/uploads/2013/09/FHT-Strategy-booklet_Sep13_web-version.pdf

85 Freshwater Habitats Trust, *Climate change:* https://freshwaterhabitats.org.uk/wp-content/uploads/2015/11/FHT_Our-line-on-Climate-Change_Nov15.pdf

86 Gebremichael, A. W. et al., *Flooding related increases in CO_2 and N_2O emissions from a temperate coastal grassland system* (2017): https://www.biogeosciences.net/14/2611/2017/bg-14-2611-2017.pdf

87 Tanentzap, A. J. et al., *Chemical and microbial diversity covary in fresh water to influence ecosystem functioning* (2019): https://www.pnas.org/content/116/49/24689

88 World Economic Forum, *Freshwater lakes emit a dangerous amount of carbon and it's only going to get worse* (2019): https://www.weforum.org/agenda/2019/11/freshwater-lakes-already-emit-a-quarter-of-global-carbon-and-climate-change-could-double-that/

Nature based interventions – sea use changes

Marine ecosystems are important for climate regulation, and are responsible for an estimated 55% of the world's biologically sequestered carbon.[89] The ocean has taken up between 20–30% of total anthropogenic CO_2 emissions since the 1980s, as well as more than 90% of the excess heat in the climate system since 1970, putting a strain on marine ecosystems and the services they provide.[90]

It is estimated that 48 tonnes of soil carbon are stored per hectare of coastal margin habitat, however estimates of the carbon contained within the vegetation of coastal margins has not been estimated due to data limitations.[91] Evidence is lacking regarding carbon stocks in UK marine habitats.

Benefits from better management of marine natural capital include:

- Biodiversity;
- Recreation and wellbeing;
- Carbon storage and sequestration;
- Food production;
- Waste management;
- Flood water storage and protection from extreme weather events.

The NCC has identified the following issues and trade-offs which need to be considered in managing the marine environment in consideration of the net zero target:

- Evidence regarding potential to further offset emissions in the marine environment is highly equivocal. There is uncertainty regarding proposed interventions aimed at mitigating carbon in the marine environment, with a lack of evidence and difficulties monitoring their effect, meaning that for some types of intervention such as ocean fertilisation there is a high risk of adverse consequences.[92, 93] However, indirect mitigation measures that involve biological and ecological adaptation, by preserving biodiversity and habitats and reducing nutrient and organic carbon pollution, provide significant co-benefits with limited adverse side effects.[94]

- As well as easing pressures on marine ecosystems, marine and coastal interventions should focus on protecting and restoring threatened habitats, with appropriate funding being delivered in recognition of the huge benefits that this could bring. For example, although seagrass data is spatially limited, sporadic datasets indicate that 25–49% of UK seagrass populations were lost in the 25 years preceding 2006.[95] Seagrass is an important habitat for commercially important fish species, and evidence suggests that increasing ocean acidification may increase the capacity of seagrass meadows to sequester carbon.[96]

- The importance of carbon cycling in the UK's temperate marine ecosystems, offshore and inshore pelagic ecosystems, estuaries, sedimentary seabed etc. is largely ignored in natural capital accounting. In the UK for example, coastal habitats alone (e.g. saltmarshes and sand dunes) if maintained in their current state could contribute around £1bn in CO_2 sequestration over the period 2000–2060 (3.5% discount rate), but that may fall to £0.25 billion if habitat loss continues.[97]

89 Nellemann, Christian et al., *Blue carbon A UNEP rapid response assessment* (2009) https://gridarendal-website-live.s3.amazonaws.com/production/documents/:s_document/83/original/BlueCarbon_screen.pdf?1483646492

90 IPCC, *The ocean and cryosphere in a changing climate* (2019): https://report.ipcc.ch/srocc/pdf/SROCC_FinalDraft_FullReport.pdf

91 ONS, *UK Natural Capital: Experimental carbon stock accounts, preliminary estimates* https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/uknaturalcapital/experimentalcarbonstockaccountspreliminaryestimates

92 Shelf seas: The engine of productivity https://www.uk-ssb.org/shelf_seas_report.html

93 The Royal Society, *Greenhouse gas removal* (2018): **https://royalsociety.org/-/media/policy/projects/greenhouse-gas-removal/royal-society-greenhouse-gas-removal-report-2018.pdf**

94 Billé et al., *Taking action against ocean acidification: a review of management and policy options* (2013): https://www.ncbi.nlm.nih.gov/pubmed/23897413

94 Billé et al., *Taking action against ocean acidification: a review of management and policy options* (2013): https://www.ncbi.nlm.nih.gov/pubmed/23897413

95 Jones B., Unsworth R., The perilous state of seagrass in the British Isles (2016): https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4736943/#RSOS150596C25

96 Garrard, L., Beaumont, N., The effect of ocean acidification on carbon storage and sequestration in seagrass beds; a global and UK context (2014) https://www.sciencedirect.com/science/article/pii/S0025326X14004755

97 Beaumont et al., The value of carbon sequestration and storage in coastal habitats. Estuarine, Coastal and Shelf Science (2014) http://nora.nerc.ac.uk/id/eprint/504365/

These ecosystems sequester carbon faster and more efficiently per unit area than terrestrial forests. It is likely that reduced seabed disturbance would lead to an increase in climate regulation/CO_2 sequestration (already valued at £7 billion GVA in the coastal shelf),[98] although evidence is required. Measures taken to protect and restore these habitats can prevent further emissions and enhance their capacity to adapt to climate change, as well as bringing wider benefits to biodiversity, recreation and wellbeing, flood water storage and protection from extreme weather events, waste management, and food production.[99]

- Climate change impacts such as sea level rise, erosion, increased flooding and storm surges, and invasive species range expansion are likely to impose increasing pressures on our coastal and intertidal environment. Land use change due to agriculture and engineered defences means that coastal habitat such as saltmarshes have decreased in extent due to erosion from sea-level rise and coastal 'squeeze' from hard, built structures preventing natural roll back.[100] Saltmarsh cannot adapt to moderately high rates of sea level rise and may be lost without major intervention.[101] It is clear that the coast will be in an accelerated state of change over the coming decades, and interventions developed in response to this should assess the full long term outcomes of land use decisions, factoring in that these assets will in many places need to be protected and restored in order to play a role in climate change mitigation, but also in allowing communities, habitats and species to adapt to climate change.

- The Marine and Coastal Access Act (2009) requires marine plans to account for the risks from climate change, but current plans don't provide details on what action will be taken to deal with the risks of rising temperatures and changing ocean chemistry.[102] Despite an increase in protected marine sites, data on condition is lacking and indicators are required which account for the impact on marine ecosystems in future GHG scenarios. Additionally, public money is still being used to fund land uses, particularly through agriculture, which have negative impacts on the coastal and marine environment. Monitoring and verification of GHG removal methods, as well as efforts to limit further emissions, should factor in these externalities and the role that the marine environment plays in regulating atmospheric GHGs.

98 Government Office for Science, Future of the sea (2018): https://www.gov.uk/government/publications/future-of-the-sea--2

99 Seddon, N. et al, Understanding the value and limits of nature-based 2 solutions to climate change and other global challenges (2019) file:///C:/Users/x947269/Downloads/preprints201911.0275.v1.pdf

100 MCCIP, .(2020): http://www.mccip.org.uk/media/1999/mccip-report-card-2020_webversion.pdf

101 Valiela I, et al., Transient coastal landscapes: Rising sea level threatens salt Marshes (2018) https://www.ncbi.nlm.nih.gov/pubmed/30021280

102 Marine and Coastal Access Act (2019): http://www.legislation.gov.uk/ukpga/2009/23/contents

Annex 1 – Main recommendations from the Committee on Climate Change's land use report

The Committee on Climate Change published its report on the reduction of land based emissions of greenhouse gases in November 2018,[103] and followed up in January 2020 with a report on policies to drive this change.[104] The reports made the following recommendations:

- **Low-carbon farming practices** such as controlled release fertilisers, improving livestock health and slurry acidification can reduce greenhouse gas (GHG) emissions from soils, livestock and manure management by 10 $MtCO_2e$ by 2050.

- **Afforestation and agro-forestry**. Increasing UK forestry cover from 13% to at least 17% by 2050 by planting around 30,000 hectares or more of broadleaf and conifer woodland each year. Together with improved woodland management this would deliver annual emissions sequestration by 2050 of 14 $MtCO_2e$ in forests with an additional 14 $MtCO_2e$ from harvested materials. Planting trees on agricultural land, while maintaining their primary use ("agroforestry"), could deliver a further 6 $MtCO_2e$ savings by 2050. Sustainably managed forests are important for reducing emissions across the economy. They provide a store of carbon in the landscape and harvested wood can be used sustainably for combustion and carbon sequestration in the energy sector (e.g. when used with Carbon Capture and Storage (CCS) technology) and as wood in construction, creating an additional stock of carbon in the built environment.
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- **Peatlands**. Restoring at least 50% of upland peat and 25% of lowland peat would reduce peatland emissions by 5 $MtCO_2e$ by 2050, while allowing food production to continue of the most productive land.

- **Bioenergy crops**. Expanding the growing of energy crops by around 23,000 hectares each year would deliver 2 $MtCO_2e$ emissions savings in the land sector and an extra 11 $MtCO_2e$ from the harvested biomass (e.g. when used with CCS). Bioenergy crops are faster growing than new woodlands and are needed as part of the overall mix of land-based measures. However, risks of negative impacts of bioenergy crops need to be managed.

- **Reducing consumption of the most carbon-intensive foods** (i.e. beef, lamb and dairy) by at least 20% per person and reducing food waste by 20% would save 7 $MtCO_2e$ of on-farm emissions by 2050. These measures imply a shift towards current healthy eating guidelines and can drive sufficient release of land to support the necessary changes in tree planting and bioenergy crops. Alongside expected population growth, they imply around a 10% reduction in cattle and sheep numbers by 2050 compared with 2017 levels. This compares with reduction of around 20% in the past two decades.

103 CCC, Land use: Reducing emissions and preparing for climate change (2018): https://www.theccc.org.uk/publication/land-use-reducing-emissions-and-preparing-for-climate-change/

104 CCC, Land use: Policies for a Net Zero UK (2020): https://www.theccc.org.uk/publication/land-use-policies-for-a-net-zero-uk/

Annex 2: Background to the Natural Capital Committee

The government's Environment White Paper: The Natural Choice was published in 2011. In this report, government committed to *'establishing an independent Natural Capital Committee (NCC) reporting to the Economic Affairs Cabinet Committee... The Committee's remit was to advise the government on the state of English natural capital'* and what needed to be done about it. The NCC was established in 2012 as an independent committee chaired by Professor Dieter Helm.

Since then, the NCC has published plethora of advice on the sustainable use of natural capital in England and most notably a recommendation to the government to create a 25 Year Environment Plan. The government accepted this recommendation, developed it and it was launched by the Prime Minister, Theresa May in January 2018.

The Committee entered its 2nd term in January 2016, with the key focus being advising the government on the implementation of the 25 YEP; including the development of suitable metrics to be used to track progress against the Plan's objectives. [105]

Chairman Professor Dieter Helm, CBE

Dieter is a Professor of Economic Policy at the University of Oxford and a Fellow of New College, Oxford. He is author of Natural Capital - how to value the planet (Yale University Press) and his latest book Green and Prosperous Land was published March 2019 (William Collins).

Members

Professor Colin Mayer, CBE

Colin is Professor of Management Studies, Saïd Business School at the University of Oxford. He is an expert on all aspects of corporate finance, governance and taxation, the regulation of financial institutions and the role of the corporation in contemporary society.

Professor Chris Collins

Chris is Chair of Environmental Chemistry at the University of Reading. He is the Natural Environment Research Council Soils Coordinator and chairs Defra's Hazardous Substances Advisory Committee providing expert advice to the UK government on how to protect the environment, and human health via the environment from chemicals. His research focuses on determining the factors controlling exposure of biota to environmental pollution and the role of soil organic carbon in modifying pollutant exposure and the parallels between pollutant and carbon cycling in soils.

Professor Melanie Austen

Melanie is a marine ecologist and interdisciplinary marine researcher who is Head of Science for the Sea and Society group at Plymouth Marine Laboratory. She is an independent member of the Joint Nature Conservation Committee (JNCC), completed a 3 year term as the Chief Scientific Advisor to the UK's Marine Management Organisation (MMO) and for the last twenty years she has been developing and leading UK and EU funded collaborative marine research projects. She has been an Honorary Professor at the University of Exeter medical school since 2014, a member of other Expert Advisory Groups, and has chaired an EU Marine Board expert group on marine ecosystem valuation.

Professor Ian Bateman, OBE

Ian is Professor of Environmental Economics and a Director of the Land, Environment, Economics and Policy Institute (LEEP) at the University of Exeter. His research interests focus on ensuring sustainable wellbeing through the integration of natural and social science knowledge within decision-making and policy. Particular interests lie in the fields of quantitative analysis, integrated modelling and the valuation of non-market benefits and costs.

Professor Paul Leinster, CBE

Paul is Professor of Environmental Assessment at Cranfield University and was formerly Chief Executive of the Environment Agency. He also worked at BP International and Schering Agrochemicals, led an environmental consultancy and was Director of Corporate Environmental Services at SmithKline Beecham. He holds a BSc in chemistry, a PhD in environmental engineering and an MBA from the Cranfield School of Management.

Professor Kathy Willis, CBE

Kathy is a Professor of Biodiversity and Head of the Long-term Ecology laboratory at the University of Oxford. She is also the Principal of St Edmund Hall, one of the Colleges that makeup the University of Oxford. Until recently she was the Director of Science at the Royal Botanic Gardens, Kew. She has over 30 years of research experience focusing on modelling and remotely determining important landscapes for biodiversity and ecosystem services across the world. Most recently she has been leading a research team to develop new and emerging models and technologies to assist land managers in decision-making to ensure the best outcomes for business and biodiversity.

The Committee is supported by a secretariat based in Defra (Department of Food, Environment and Rural Affairs) - Headed by Maniv Pathak, with Elias Scheuermann, Rebecca McIlhiney, Jake Harvey, Andrew Canning-Trigg and James Farr.

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