The Sixth Carbon Budget and Welsh emissions targets

Call for Evidence

Evidence submitted by the Game & Wildlife Conservation Trust

The Game & Wildlife Conservation Trust ("GWCT") welcomes the opportunity to provide evidence to the Committee in relation to the Sixth Carbon Budget. Our areas of expertise (biodiversity, conservation, agri-environment and farming systems) require us to adopt a practical approach to net zero and to consider the questions posed in the context of the wider policy framework of agriculture and the environment. If we are to tackle climate change let's try to do so in a way that preserves peoples livelihoods, produces income and food, provides habitats for wildlife and improves soil health whilst reducing runoff and storing carbon. Not to do so is a missed opportunity.

We have answered Q1, Q5, Q6, Q7, Q8, Q9, Q13, Q16, Q17, Q27, Q33, Q34 (those not answered have been deleted).

Question and answer form

A. Climate science and international circumstances

Question 1: The climate science considered in the CCC's 2019 Net Zero report, based on the IPCC Special Report on Global Warming of 1.5°C, will form the basis of this advice. What additional evidence on climate science, aside from the most recent IPCC Special Reports on Land and the Oceans and Cryosphere, should the CCC consider in setting the level of the sixth carbon budget?

ANSWER:
Climate science is constantly evolving both in our understanding of the effect of the emissions and in possible adaptations to current practices. Adaptive policy delivery will be vital to ensure minimisation of unintended consequences and in this regard we emphasise the need to account for the work on:

- land-climate interactions and feedback loops (such as discussed in Chapter 2 of IPCC Climate Change and Land report[1]). Current evidence for land-induced climate change is

[1] Jia, G., E. Shevliakova, P. Artaxo, N. De Noblet-Ducoudré, R. Houghton, J. House, K. Kitajima, C. Lennard, A. Popp, A. Sirin, R. Sukumar, L. Verchot, 2019: Land–climate interactions. In: Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.-O. Pörtner, D.C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M, Belkacemi, J. Malley, (eds.)]. In press.

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limited but given that policy is promoting land use change as part of CDR the impacts of land cover on climate needs further study;

- the impacts of planting forestry in temperate zones on surface albedo and the biophysical effects on climate at different spatial scales [2,3];
- the limited potential for UK soils to sequester carbon, undertaken by the Rothamsted Research Institute [4];
- methane emissions from re-wetting peatland (particularly relevant given the increased weighting afforded to methane in GWP calculations) - see Heinemeyer *et al*[5] work for Defra (see also answer to Q34); and,
- carbon emissions from wildfire (as opposed to prescribed burning)[6] (Davies *et al* provides a useful review of the role of fire in UK peatland and moorland management[7]). See also answer to Q34.

B. The path to the 2050 target

Question 5: How big a role can consumer, individual or household behaviour play in delivering emissions reductions? How can this be credibly assessed and incentivised?

ANSWER:

Ambitions to reduce food waste need to be supported by a willingness on the part of consumers to pay a realistic price for domestic food production. The drive to reduce food prices has resulted in a focus on reducing the costs of production whilst increasing yields with consequent impacts on the environment through specialisation (monoculture) and inorganic fertiliser usage. Specialisation has seen traditional cropping rotations abandoned; these consisted of 'exploitative' (the cash crop) and 'restorative' phases (where crops were grown which replenished the soil's health and fertility). This has led to a decline in soil health and is starting to limit crop output. Maintaining crop yields

[2] E.g. Caldeira, K.; Bala, G.; Wickett, M. E.; Phillips, T. J.; Lobell, D. Carbon, Biophysics, and Climate: Where do Forests Warm? Where do Forests Cool? American Geophysical Union, Fall Meeting 2006, abstract id. GC51A-0431

[3] See reference 1 above.

[4] Poulton P, Johnston J, Macdonald A, White R, Powlson D. Major limitations to achieving "4 per 1000" increases in soil organic carbon stock in temperate regions: Evidence from long-term experiments at Rothamsted Research, United Kingdom. Glob Change Biol. 2018; 24:2563–2584. https://doi.org/10.1111/gcb.14066

[5] Defra research project - Restoration of blanket bog vegetation for biodiversity, carbon storage and water regulation - BD5104 (see also http://peatland-es-uk.york.ac.uk/)

[6] Allen KA, Harris MPK, Marrs RH. 2013 Matrix modelling of prescribed burning in Calluna vulgarisdominated moorland: short burning rotations minimize carbon loss at increased wildfire frequencies. J. Appl. Ecol. 50, 614–624. (doi:10. 1111/1365-2664.12075)

[7] Davies G M *et al*. 2016 The role of fire in UK peatland and moorland management: the need for informed, unbiased debate. Phil. Trans. R. Soc. B 371: 20150342. http://dx.doi.org/10.1098/rstb.2015.0342

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will be key to reducing emissions and will be necessary in order to re-purpose land for carbon sequestration.

De-valuing food has also led to significant increases in waste (see answer to Q33).

Question 6: What are the most important uncertainties that policy needs to take into account in thinking about achieving Net Zero? How can government develop a strategy that helps to retain robustness to those uncertainties, for example low-regrets options and approaches that maintain optionality?

ANSWER:

Net zero needs to be achieved whilst also protecting other ecosystem services. This in our opinion is the greatest uncertainty with regard to some of the policy measures proposed for the agricultural/land use sector. Others have stated a similar desire e.g. AHDB stated (23rd January 2020) "At AHDB, and in the wider agriculture sector, we are focused on ensuring the optimum outcome for the environment as a whole. This means we need to balance measures that reduce air and diffuse pollution, protect soils, enhance biodiversity, water quality and availability and reduce climate change impacts. Focusing on a single issue can result in perverse outcomes, and may reduce the UK's food security or result in the export of our food carbon emissions to other countries". This equates to the IPCC view (2018[8]) that "Measures like afforestation and bioenergy with and without CCS that directly compete with other land uses could have significant impacts on agricultural and food systems".

The benefits of afforestation are vulnerable to biotic and abiotic impacts which could turn a carbon sink into a carbon source e.g. forests in British Columbia, Canada, have turned from a carbon sink to a net carbon source following large-scale outbreaks of a native pine beetle[9]. Policy needs to address this risk and there needs to be a coordinated approach across Government. It also underlines the difference between temporary terrestrial sinks which are natural cycles of varying lengths but ultimately result in the release of C into the atmosphere (through decay, harvesting, oxidation, respiration, etc) and subterranean geological sinks which lock up C permanently until artificially extracted as fossil fuels. In designing climate change policy this important difference is

[8] Rogelj, J., D. Shindell, K. Jiang, S. Fifita, P. Forster, V. Ginzburg, C. Handa, H. Kheshgi, S. Kobayashi, E. Kriegler, L. Mundaca, R. Séférian, and M.V. Vilariño, 2018: Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press.

[9] Professor Michael Tausz (Director of Birmingham Institute of Forest Research) Posted on 20 Jul 2017 https://www.birmingham.ac.uk/news/thebirminghambrief/items/2017/07/using-forests-to-manage-carbon.aspx

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seemingly being overlooked.

The Net Zero report refers to "clear, stable and well-designed policies". Whilst this may be a desirable ambition given the evidence gaps that exist in the scientific evidence behind some of the policies being promoted we feel that there should be an emphasis on 'adaptive' policy. Davis *et al* 2014[10] highlight the lack of data at spatial and temporal scales and how this can impact on attributing emissions to products. Policy therefore should take into account these variations and not remove management tools until the evidence is unequivocal. For example policy should not ban heather burning on peat soils; it should respond to individual site conditions and to the emerging science that suggests that managing through prescribed 'cool' burns can aid carbon capture[11](as opposed to cutting) and reduce wildfire events[12] that lead to catastrophic emissions (and possible legacy emissions from erosion etc). Conditions for wildfire events to occur are likely to increase in response to climate change. Without precautionary action such events become natural disasters destroying sequestered carbon in both surface vegetation and the peat soil beneath. Rotational cool burns which are carried out and funded by those managing moorland for grouse shooting prevent the build-up of surface fuel load. The banning of cool burns will lead to the abandonment of grouse moor management and the accumulation of fuel load as occurred on Saddleworth Moor in spring 2018. Such intense events defy control by human intervention and require sustained pre-emptive action, with the associated costs, if they are to be avoided. See also answer to Q34.

Policy to combat agricultural emissions rightly addresses 'low hanging fruit' in the form of low-carbon practices. However some of the more significant land use changes proposed need further exploration as to how they can be accommodated whilst supporting primary production. The Agriculture Bill now includes analysis of food security and so a multi-ecosystem service approach to land management will be important in considering the mitigations required and avoid unintended consequences such as those of significant ecological changes and exporting our emissions overseas (see Q33 and Q34 answers also).

Question 7: The fourth and fifth carbon budgets (covering the periods of 2023-27 and 2028-32 respectively) have been set on the basis of the previous long-term target (at least 80% reduction in GHGs by 2050, relative to 1990 levels). Should the CCC revisit the level of these budgets in light of the net-zero target?

ANSWER:

[10] Steven J Davis, Jennifer A Burney, Julia Pongratz & Ken Caldeira (2014) Methods for attributing landuse emissions to products, Carbon Management, 5:2, 233-245 http://dx.doi.org/10.1080/17583004.2014.913867
[11] Heinemeyer *et a*l 2018 https://rgs-ibg.onlinelibrary.wiley.com/doi/full/10.1002/geo2.63 (and https://rgs-ibg.onlinelibrary.wiley.com/doi/full/10.1002/geo2.78 for response to Evans *et al* comment on the paper).
[12] Marrs, R. H. *et al* (2019) Experimental evidence for sustained carbon sequestration in fire-managed, peat moorlands. Nature Geoscience.

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The GWCT would suggest that this is required as delayed mitigation responses increase the reliance on land based CDR which we are concerned would impact on broader ecosystem services and potentially result in unintended consequences such as feedback loops.

Question 8: What evidence do you have of the co-benefits of acting on climate change compatible with achieving Net Zero by 2050? What do these co-benefits mean for which emissions abatement should be prioritised and why?

ANSWER:
The sequestration of carbon in agricultural soils is not included in the current mitigation measures. We accept that this is probably correct given the opinion commissioned by and provided to Government by experts in this subject. However small increases in the soil carbon pool can deliver substantial benefits to soil structure, porosity, biological functioning, water infiltration (thereby reducing run-off and flooding) and agricultural productivity. The latter is of particular importance in ensuring domestic food production is maintained in the face of land use change if we are not to off-shore our carbon emissions.

We feel also that the disbenefits of each action should be addressed too. For example afforestation is a widely adopted 'natural climate solution' but the nature of the policy underpinning it is vital to avoid encouraging temporary sequestration (such as CCS based on woodland carbon cycles of 20-30 years as opposed to CO2 which remains in the atmosphere for 100 years) rather than increasing the area of mature, natural woodlands, and protect existing ones from threats[13]. This is also important from the perspective of delivering co-benefits such as biodiversity. As Professor Tausz states "Any policy incentives must aim at balanced outcomes for all forest goods and services. Incentives that commodify one service but not others, too often create unintended consequences. Where forests are concerned, such mistakes are expensive, because it takes a long time to reverse adverse effects on old trees and forests".

C. Delivering carbon budgets

Question 9: Carbon targets are only credible if they are accompanied by policy action. We set out a range of delivery challenges/priorities for the 2050 net-zero target in our Net Zero advice. What else is important for the period out to 2030/2035?

ANSWER:
Natural climate solutions are not the complete answer (with the risk that they become a substitute

[13] Professor Michael Tausz (Director of Birmingham Institute of Forest Research) Posted on 20 Jul 2017 https://www.birmingham.ac.uk/news/thebirminghambrief/items/2017/07/using-forests-to-manage-carbon.aspx

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for emission reductions) and there are significant risks to their adoption in terms of the impacts of land use change on food security, ecological cycles and possible counter-cyclical effects. As the CCC has already highlighted GGR technologies will be needed to supplement natural solutions and so it is important that the potential of these is urgently identified in order to avoid unnecessary land use changes such as planting energy crops and afforestation.

Biochar has the potential to deliver multiple co-benefits. The IPCC in paragraph 4.9.5 of its Climate Change and Land report highlighted the potential for aiding long term carbon sequestration in soils as well as improving soil quality (and crop yields), reducing N losses, reducing GHG emissions from manure and stock residues and delivering greater benefits than biomass for bioenergy (a Core policy option); but these benefits vary, such as in response to soil properties. It is widely acknowledged that in order to achieve Net Zero by 2050 speculative options such as biochar will need to be a reality. The conclusions of the IPCC lead us to feel that the CCC's conclusion in its Net Zero report needs to be revisited and further investment in research to determine its applicability to the UK pursued as a priority. Biochar has the potential to be a sustainable GGR technology when combined with agricultural soils thereby limiting its impact on land use change and food security.

Heinemeyer *et al* (2018)[14] has shown the benefit of pyrogenic charcoal on carbon accumulation within peatlands managed for red grouse (e.g. by using prescribed or rotational burning). While more work is required to corroborate this finding, the finding itself is unsurprising, as pyrogenic charcoal is carbon-rich and resistant to decomposition[15]. Thus, as more charcoal is incorporated into the peat profile via burning, greater amounts of carbon will be locked away (assuming that the peat continues to accumulate)[16,17].

[14] Heinemeyer, A., *et al*. (2018) Peatland carbon stocks and burn history: blanket bog peat core evidence highlights charcoal impacts on peat physical properties and long-term carbon storage. GEO: Geography and Environment 5(2), e00063. https://doi.org/10.1002/geo2.63

[15] Leifeld, J., *et al*. (2018). Pyrogenic carbon contributes substantially to carbon storage in intact and degraded northern peatlands. Land degradation & development, 29(7), pp.2082-2091.

[16] Wei, X., *et al*. (2018). Global Pyrogenic Carbon Production During Recent Decades Has Created the Potential for a Large, Long-Term Sink of Atmospheric CO2. Journal of Geophysical Research: Biogeosciences, 123(12), pp.3682-3696.

[17] Jones, M.W., *et al*. (2019). Global fire emissions buffered by the production of pyrogenic carbon. Nature Geoscience, 12(9), pp.742-747

D. Scotland, Wales and Northern Ireland

Question 13: What specific circumstances need to be considered when recommending an emissions pathway or emissions reduction targets for Scotland, Wales and/or Northern Ireland, and how could these be reflected in our advice on the UK-wide sixth carbon budget?

ANSWER:
Ensure an appropriate balance to reduction targets across agriculture, transport, infrastructure, energy etc. which recognises that land management offers the opportunity to capture carbon. Ultimately, climate change stems from release of stored fossil carbon rather than via terrestrial carbon, so need to make sure that the burden carried by agriculture and other land management is not disproportionate to the changes asked of other sectors.

The relative proportions of livestock and arable farming in Scotland are significant. Livestock predominates on agricultural land in Scotland, of which 85% is Less Favoured Area, but also of High Nature Value. The need for change may therefore focus principally on sheep and cattle farming in Scotland, but there will be a balancing need to ensure that required adjustments, which may impact significantly on farm income, are offset by suitable payments or recovery for managing ecosystem services and public goods benefits.

Question 16: Do you have any evidence on the appropriate level of Scotland's interim emissions reduction targets in 2030 and 2040?

ANSWER:
No specific evidence other than that set out by Scottish Government, which is articulating a vision requiring a 75% reduction in emissions by 2030 compared to 1990 levels (Climate Change Bill 2019). This is strikingly ambitious, particularly given the administrative friction caused by the constitutional debate over a second referendum, but it may draw out the necessary focus on transformational change required.

Question 17: In what particular respects do devolved and UK decision making need to be coordinated? How can devolved and UK decision making be coordinated effectively to achieve the best outcomes for the UK as a whole?

ANSWER:
Cross-border issues (e.g. different standards, objectives). Mechanism for co-design where consistent standards or approaches are required. Need to re-build trust between Scottish and UK Governments to ensure policy co-ordination. Different legal systems to be taken into account.

E. Sector-specific questions

Question 27 (Buildings): Do we currently have the right skills in place to enable widespread retrofit and build of low-carbon buildings? If not, where are skills lacking and what are the gaps in the current training framework? To what extent are existing skill sets readily transferable to low-carbon skills requirements?

ANSWER:

It is not just the skills that are lacking; we need an entire re-think of the materials we use in construction moving away from fossil fuel intensive materials to those which utilise materials which capture carbon. The Trust has some experience in this area; in 2012 we won the Property and Construction Industries' (ProCon) "Sustainable Building of the Year Award" for our Visitor and Training Centre.

Rather than going for the lower cost option of demolishing a disused brick built former cattle shed we kept the shell, recognising the huge carbon footprint of baking clay to make bricks. We then retrofitted straw bale insulation to the walls which uses the carbon captured by photosynthesis from growing a crop of wheat. This gives twice the insulation capacity of the oil-derived hydro-carbon material normally used using eight times less energy in the manufacture whilst being less combustible. The straw both locks up carbon in the building structure and saves carbon through heat loss reduction. We insulated the roof with ThermaFleece made from 100% renewable sheep's wool. Sheep's wool is currently of negligible value to farmers because it has been out-priced by unsustainable fossil-fuel derived fibres. Re-setting values according to GHG impact would provide a new income stream for farmers preserving valuable carbon holding pastureland.

The building is heated with home grown woodland thinnings and material from hedges coppiced to increase wildlife and biodiversity. In future such material will also come from our agro-forestry field where trees and sheep thrive side-by-side; the carpark is made from recycled silage plastic wrap, locking up a waste product and carbon simultaneously, whilst allowing water infiltration and preventing flooding; rainwater is captured from the roof to flush the toilets; solar energy is captured to provide electricity, saving 23 tonnes of carbon emissions in the first 6 years of operation.

The roof trusses are 100% wood from sustainable managed forests, where trees are re-planted to recapture carbon. However, the roof is supported by steel RSJ members. This is a high fossil fuel energy product. Developments in timber laminates should replace such materials in future, providing strength and locking in carbon.

Question 33 (Agriculture and Land use): In Chapter 7 of the Net Zero Technical Report we presented our Further Ambition scenario for agriculture and land use (see page 199). The scenario requires measures to release land currently used for food production for other uses, whilst maintaining current per-capita food production. This is achieved through:

- A 20% reduction in consumption of red meat and dairy
- A 20% reduction in food waste by 2025
- Moving 10% of horticulture indoors
- An increase in agriculture productivity:
  - Crop yields rising from the current average of 8 tonnes/hectare for wheat (and equivalent rates for other crops) to 10 tonnes/hectare
  - Livestock stocking density increasing from just over 1 livestock unit (LU)/hectare to 1.5 LU/hectare

Can this increase in productivity be delivered in a sustainable manner?

Do you agree that these are the right measures and with the broad level of ambition indicated? Are there additional measures you would suggest?

ANSWER:

Sustainability, in our opinion, requires that the mitigation measure adopted to reduce agricultural emissions delivers multiple benefits. For example, the land used to produce 'waste food' could be used to deliver multiple environmental benefits including measures such as beetle banks, permanent field margins, hedgerow trees, pollen and nectar mixes to feed insects, wildlife seed mixes to feed birds in winter or put aside for soil restoring measures or woodland planting/agro-forestry. The GWCT is currently undertaking research on the value of beetle banks to farm carbon sequestration. Earlier studies have demonstrated clear benefits to reducing run-off and soil erosion.

Numerous research studies have evaluated the positive contribution hedges provide to the landscape and to biodiversity generally. Perhaps less well documented is the contribution made to animal health and welfare and carbon sequestration. Future management practices need to consider these aspects. Evidence suggests that carbon is sequestered not only in the above ground hedge structures but also in the roots and the adjacent field margins. Soil bulk density tends to be lower beneath hedges allowing run-off water to infiltrate potentially contributing to soil erosion and flood reduction. Increasing tree planting within the hedge-line increases the benefits further. Farmers need to be encouraged to allow hedges to take up more space by becoming taller and wider (the carbon value of a 2m x 2m hedge is less than a 3m x 3m hedge). The tidy mindset needs to change to accept that tidy is not best for carbon or nature.

Increasing stocking densities through ceasing rough grazing on hill fringe/upland pastures and intensifying lowland grassland could be counter-productive. Rough grazing contributes to habitat mosaics that upland fringe species rely on and intensive grassland production contributes to carbon emissions through N use and poor soil quality – as well as reducing biodiversity. The uptake of 'high-sugar grasses' (HSGs) as a tool for increasing the efficiency of the use of protein (nitrogen (N)) in the rumen while reducing N losses (in the form of urine) to the environment will exacerbate the current lack of species diversity on intensive livestock farms. Such systems require high nitrogen fertiliser inputs, exceeding 400kg/ha/year with associated GHG impacts. Research in

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Ireland has shown that the dry matter yield of multi-species grassland managed at relatively low N input levels has been underestimated and that where legumes are present the yield may actually outweigh that of PRG (Smartsward). Plant species richness increases carbon storage.

The UK grass-fed livestock system is arguably more sustainable than more intensive systems (particularly if the stock is grazed on species rich grassland)[18]. Improved grassland management could offset between 20-60% of emissions from grazing systems and it should not be forgotten that livestock farming provides an economic rationale for keeping carbon in the ground[19] often on land not suited to other economic uses.

In addition mixed farming has been eroded as policy and market pressures have encouraged farmers to specialise. Encouraging a return to mixed farming could provide a means of aiding both farming systems to improve carbon efficiency whilst also protecting food production and biodiversity (see also better soil management in Q34 below).

Finally we are concerned that ambitions to increase crop yields run contrary to the view that yields are likely to be affected by extreme weather events (the current 2019/20 Autumn/Winter is a case in point with the wet conditions significantly affecting the acreage of winter cereals drilled and any consequent impacts on soil quality of waterlogging are at this stage unknown) and non-climate factors such as nutrient availability and weed competition[20].

[18] A Greener World 2016: A Breath of Fresh Air - The truth about pasture-based livestock production and environmental sustainability.

[19] Garnett, T., Godde, C., Muller, A., Röös, E., Smith, P., de Boer, I.J.M., zu Ermgassen, E., Herrero, M., van Middelaar, C., Schader, C. and van Zanten, H. (2017). Grazed and Confused? Ruminating on cattle, grazing systems, methane, nitrous oxide, the soil carbon sequestration question – and what it all means for greenhouse gas emissions. FCRN, University of Oxford.

[20] Jia, G., E. Shevliakova, P. Artaxo, N. De Noblet-Ducoudré, R. Houghton, J. House, K. Kitajima, C. Lennard, A. Popp, A. Sirin, R. Sukumar, L. Verchot, 2019: Land–climate interactions. In: Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-

Question 34 (Agriculture and Land use): Land spared through the measures set out in question 33 is used in our Further Ambition scenario for: afforestation (30,000 hectares/year), bioenergy crops (23,000 hectares/year), agro-forestry and hedgerows (~10% of agricultural land) and peatland restoration (50% of upland peat, 25% lowland peat). We also assume the take-up of low-carbon farming practices for soils and livestock. Do you agree that these are the key measures and with the broad level of ambition of each? Are there additional measures you would suggest?

ANSWER:

- N use – the CCC has already identified improving N use efficiency but the 20-30% in efficiency on cropland is possible to exceed. A recently commissioned desk study by the GWCT, Harper Adams and Sheffield University estimated that N use efficiency could result in a 60-80% GWP reduction. This combined with better soil management could reduce the need for such extensive land use change.
- Better soil management – reducing soil compaction is important as compacted soils have the potential to emit more N_2O. GWCT research has shown that the combined gaseous emissions (CO_2 and N_2O) from soil varies little between min tillage/surface cultivations and conventional systems and energy use is actually greater in organic systems due to reliance on the plough both in gross terms and in energy used per tonne of crop. A better option would be to use the ELM scheme to re-introduce sustainable crop rotations that incorporate exploitative and restorative phases. In all-arable rotations, a common feature of intensification, soil heath can be rapidly restored by the inclusion of a restorative grass/legume rest period. This could be grazed by livestock to produce food or the green matter can simply be cut and composted within the field, feeding and restoring the soil with carbon and nutrients. This is important as livestock farming is implicated in contributing to GHG emissions and dietary choices are changing meaning that consumption, and therefore demand, are likely to fall. A ley period of between three and four years is optimal although in some circumstances two might be adequate. Including grain legume crops in arable rotations provides biologically derived nitrogen fertiliser and plant-based protein which can be used in human diets. The “de-intensification” of all-arable systems will have to be off-set by increases in efficiency to maximise effect.
- Tree planting– the GWCT is concerned that the ambition to plant 30000 ha/year with trees could result in large scale ecological disturbance and the inability to meet international conservation commitments. Inappropriate planting in open landscapes will impact upon the habitat of threatened wildlife species like skylark, corn bunting, grey partridge, lapwing and curlew which all depend on open treeless landscapes for their survival. We favour the incorporation of tree planting within the farmed landscape in small clusters, as hedgerow trees and as silvo-pastoral agroforestry. Regeneration of woodland in the uplands could also lead to the loss of protected heather and peatland habitat.
- Agro-forestry - in addition to contributing to GHG mitigation, research has shown that using native deciduous tree species such willow, alder and oak could provide a mineral

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Delmotte, H.-O. Pörtner, D.C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M, Belkacemi, J. Malley, (eds.)]. In press.

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supplement for ruminant livestock as well as shelter and shade[21,22]. Encouraging farmers to plant field corners and small copse on marginal land requires changes to the Woodland Grant Scheme which requires a minimum area and specifies tree densities (thereby excluding agro-forestry); schemes also need to allow controlled livestock to access wooded areas.

- Biomass - harvesting the biomass from hedgerows, agro-forestry and small farm woodlands for use on-farm (as demonstrated at the GWCT's Allerton project – www.gwct.org.uk/allerton) is a sustainable approach to mitigate individual farm emissions. As the IPCC states dedicated bioenergy crops could increase agricultural water demand and N use if inappropriately employed.
- Peatland management – whilst we acknowledge the need to restore our degraded peatlands, misguidedly the emphasis appears to be focussed on the uplands ignoring lowland peat-dominated soils because they support our most productive agriculture. The multi-functional nature of moorland must be understood when addressing policy objectives such as climate change and net zero. Existing land management systems that are proven to support multiple objectives, such as sustainable grouse moor management, can protect this vital ecosystem from other damaging economic activities such as commercial forestry, wildfire and contribute to improving biodiversity and economic resilience. The benefits of prescribed burning to the prevention of high/uncontrolled emissions from wildfire and to threatened upland wading bird populations are being overlooked. The dramatic wildfire on Saddleworth Moor in 2018 in which all surface vegetation was incinerated and 200 years of peat sequestered carbon burnt demonstrates the folly of management failure. Instead of banning prescribed burning, research should be undertaken on learning how to use the technique better. Cutting is not the simple alternative management option it seems. In many places it is not an option due to inaccessibility and unlike burning it does not mitigate wildfire risk as cutting does not remove the fuel load if the brash is left[23] and its decomposition releases GHG emissions, possibly 'locking away' less C than via charcoal from burning[24] .
- Reducing emissions from lowland arable soils presents a significant challenge. Much of the carbon losses occur through the oxidation of organic matter which accompanies the installation of subterranean drainage systems. Such systems are essential to make the

[21] Woodland Trust Research Briefing - Tree leaves as supplementary feed for ruminant livestock (N.R. Kendall, J.Smith, L.K. Whistance, S. Stergiadis, C. Stoate, H. Chesshire and A.R. Smith). November 2019

[22] https://www.agricology.co.uk/resources/agroforestry-livestock-systems

[23] Allen, K.A. *et al* (2013) Matrix modelling of prescribed burning in Calluna vulgaris-dominated moorland: short burning rotations minimize carbon loss at increased wildfire frequencies. JAppEcol.

[24] Heinemeyer, A. *et al* (2018) Peatland carbon stocks and burn history: blanket bog peat core evidence highlights charcoal impacts on peat physical properties and long-term carbon storage. GEO: Geography and Environment 5(2), e00063. https://doi.org/10.1002/geo2.63

Question 34 (Agriculture and Land use): Land spared through the measures set out in question 33 is used in our Further Ambition scenario for: afforestation (30,000 hectares/year), bioenergy crops (23,000 hectares/year), agro-forestry and hedgerows (~10% of agricultural land) and peatland restoration (50% of upland peat, 25% lowland peat). We also assume the take-up of low-carbon farming practices for soils and livestock. Do you agree that these are the key measures and with the broad level of ambition of each? Are there additional measures you would suggest?

soils agriculturally productive, along with the addition of lime which raises the soil pH. Re-wetting these soils would have a seriously negative impact on domestic food production and risks exporting the GHG emission elsewhere.

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