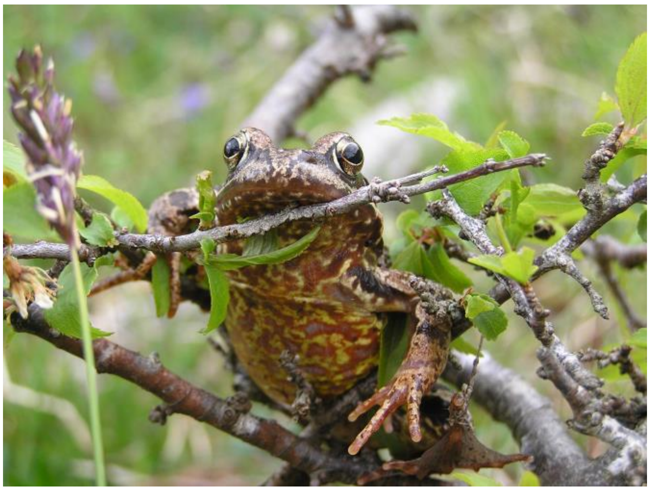

BIODIVERSITY CONSIDERATIONS FOR CARBON BUDGETS 2031-2040

ABSTRACT

This report summarises biodiversity considerations for the carbon budgets in Ireland 2031-2040. It includes a short narrative on potential biodiversity impacts from various scenarios included in the core modelling work of the Carbon Budgets Working Group (CBWG). It should be read in conjunction with CCAC Working Paper No. 33 – Assessment of Biodiversity Considerations in the Carbon Budget Process, which sets the broader context of climate change and biodiversity loss as interrelated challenges and provides more detailed discussion and background reference sources.

James Moran

Atlantic Technological University,
Member of CBWG

Contents

Executive summary

Biodiversity including the diverse range of ecosystems provide us with the range of goods and services on which we depend including food and fibre provision, water and climate regulation. Globally and within Ireland biodiversity is in decline. The main direct drivers of this decline include land/sea use change, over exploitation, climate change, pollution and invasive non-native species. It is increasingly recognised in policy circles that biodiversity decline and climate change are interconnected challenges, and climate action and protecting biodiversity are mutually supporting goals. However, they are rarely addressed in an integrated manner in practice. There are co-benefits of biodiversity action and for climate mitigation and adaptation while a narrow focus on either climate or biodiversity action can have negative impacts. Climate mitigation and adaptation together with action to reverse biodiversity decline requires transformative societal change. The interrelatedness of biodiversity loss and climate change issues is recognised in the EU Nature Restoration Law. Ireland's Climate Action and Low Carbon Development Act explicitly considers biodiversity as an integral part of national climate objectives. There is a clear need to ensure climate mitigation and adaptation plans together with national nature restoration plans under the Nature Restoration Law are mutually compatible.

CCAC Working Paper No. 33 – Assessment of Biodiversity Considerations in the Carbon Budget Process, highlights that policies to address climate change and biodiversity loss are not fully aligned and that the impacts of proposed climate actions on biodiversity are not adequately assessed. There is a clear need for improved policy alignment; need for land use change and systemic societal change to combat biodiversity and climate crises; the development of a national land use strategy underpinned by updated spatial data within a spatial planning framework to manage change is required; key uncertainties and knowledge gaps are recognised and increased knowledge generation and sharing is required; and there is a clear need to ensure that Ireland does not contribute to biodiversity loss and climate change internationally by off-shoring our impacts through our resource exports and imports.

This report attempts to assess the range of scenarios developed under core modelling work of the carbon budget working group from a biodiversity perspective. It must be noted that these models (The FAPRI-Ireland projections and the Teagasc MACC 2023; 2. TIMES-Ireland Energy Model (TIM); and 3. The General Overview of a Backcasting approach of Livestock Intensification (GOBLIN)) are not spatially explicit. The impacts of various climate mitigation measures on biodiversity under the various scenarios is landscape context dependent and it is only possible to flag potential impacts under the various model scenarios.

The FAPRI Ireland projections result in three scenarios with different activity levels ranging from scenario 1 with continued expansion of dairy accompanied by contraction in suckler beef production to scenario 2 with lower activity levels resulting from a larger decrease in suckler cow number and more modest increases in dairy. Scenario 3 is a higher activity projection with larger increases in dairy cow numbers and modest decline in suckler cow numbers. These projections are combined with two MACC pathways with increasing levels of ambition in efficiency measures and land diversification including afforestation as you move from pathway 1 to 2. The impact of the efficiency and diversification measures depend on spatial targeting of measures, together with ongoing management practices adopted. The various scenarios imply targeted intensification of dairy in certain areas with conversion of land for various diversification options in other areas. Improved efficiency without spatial targeting of mitigations will do little to reduce biodiversity risks on both land and water. The scale of impact on biodiversity in some catchments will be substantial through both intensification of agricultural production and land use change. There is a clear need for integrated spatial planning recognising trade-offs at catchment scale to realise benefits for terrestrial and aquatic biodiversity.

In the energy sector the move away from fossil fuels is positive for biodiversity as fossil fuel use is associated with indirect biodiversity loss (driving climate change) and direct habitat loss and pollution. Results to date from modelling suggest substantial land use change will be required across forestry, agriculture, renewable energy (including bioenergy) generation. The TIM model, particular under high energy demand scenarios, requires significant carbon dioxide removals (CDR) which currently rely on land-based options such as afforestation. Improved management of existing forest resources and peatland restoration/improved management will be required. The impact of various scenarios is difficult to quantify as much is dependent on renewable energy generations options pursued and CDR strategies adopted. The regulatory framework for CDR, particularly emerging and novel CDR technologies, will need to take wider environment considerations (including biodiversity) into account.

The GOBLIN model also identifies the need for substantial land use change in terms of afforestation (up to 25,000ha per annum), water table management on organic soils and further intensification of agriculture to spare land for other land use. Terrestrial and freshwater biodiversity impacts will depend on spatial distribution of proposed land use change, ecosystem type/land cover type targeted and existing ecosystem condition.

In conclusion climate action and nature restoration measures need to be implemented in a manner that maximises synergises and minimises trade-offs. Measures to achieve C budgets will have significant impacts on biodiversity (positive /negative). Impacts will vary depending on the ecosystem/landscape context. Results to date from modelling suggest substantial land use change will be required across forestry, agriculture and renewable energy generation to meet national climate objectives. Biodiversity needs to be explicitly considered in a more holistic integrated land use framework. This will require a national land use strategy coupled with regional/local implementation mechanisms.

Introduction- Biodiversity and Climate Change

Biodiversity is the variety of life on earth and is defined under the convention on biological diversity as “the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems”. Biodiversity including the diverse range of ecosystems on earth provides humans with a diverse range of goods and services on which we depend for our survival (IPBES 2019). In Ireland for example, the diverse land base provides a range of provisioning, regulatory, supporting, cultural and aesthetic ecosystem services such as food and fibre provision, pollination, pest control, nutrient cycling, water and climate regulation. While also providing space for recreation, tourism and contributions to human health and well-being in general.

Globally biodiversity is in decline with 25% of species already threated with extinction and natural ecosystems have declined by approximately 47% relative to the earliest estimated distributions (IPBES 2019). The main direct drivers of this decline include land/sea use change, direct exploitation, climate change, pollution and invasive non-native species. These are compounded by conflicts and epidemics, and other indirect drivers related to human values and behaviour in the areas of economy, institutional organisation and governance (IPBES 2019). A similar pattern of biodiversity decline is recorded in Ireland where 85% of protected habitats are in unfavourable condition, over 50% of our native plant species are in decline and 30% of the semi-natural grasslands monitored have been lost in last 10-15 years (DCHG 2019; EPA 2024). The main drivers of biodiversity decline are similar to those recorded at global level including land use change, climate change, non-native invasive species, overexploitation and pollution; with indirect drivers associated with consumption and socio-economic factors (EPA 2024). The main pressures on biodiversity are associated with human activities in the areas of agriculture, commercial forestry, energy, industry fisheries, peat mining and tourism (EPA 2024). The seriousness of the situation is acknowledged at government level when the government declared a national climate and biodiversity emergency in May 2019.

Biodiversity decline and climate change are interrelated issues and there is increasing recognition in policy circles of their interconnectedness. However, it is evident that this is rarely addressed in an integrated manner in practice, as highlighted in the recent report from the IPBES_IPCC workshop on biodiversity and climate change (Pörtner *et al*. 2021). This report highlights that climate change increases the risks to biodiversity while natural and managed ecosystems play a key role in the fluxes and support climate change adaptation. The services provided by ecosystems, and underpinned by biodiversity, are being put at risk by increasing ecosystem degradation resulting from human activities and climate change. The report clearly states, “that limiting global warming to ensure a habitable climate and protecting biodiversity are mutually supporting goals”. Headline points from the report (Box 1) are listed below and mainly relate to limiting climate change and biodiversity loss as mutually supporting goals; co-benefits of biodiversity action and climate mitigation and adaptation; narrow focus on either climate or biodiversity action can have negative impacts; and the need for transformative societal change.

Box 1: Limiting climate change and biodiversity loss are mutually supporting goals (Headline recommendations from Pörtner et al. 2021. IPBES-IPCC co-sponsored workshop report on biodiversity and climate change.)

Limiting global warming to ensure a habitable climate and protecting biodiversity are mutually supporting goals, and their achievement is essential for sustainably and equitably providing benefits to people

Several land- and ocean-based actions to protect, sustainably manage and restore ecosystems have co-benefits for climate mitigation, climate adaptation and biodiversity objectives.

Measures narrowly focused on climate mitigation and adaptation can have direct and indirect negative impacts on nature and nature's contributions to people.

Measures narrowly focusing on protection and restoration of biodiversity have generally important knock-on benefits for climate change mitigation, but those benefits may be sub-optimal compared to measures that account for both biodiversity and climate.

Treating climate, biodiversity and human society as coupled systems is key to successful outcomes from policy interventions.

Transformative change in governance of socio-ecological systems can help create climate and biodiversity resilient development pathways.

The interrelatedness of biodiversity loss and climate change issues is recognised in the EU Nature Restoration Law (NRL), which came into force on the 18th of August 2024. Implementation of this regulation provides potential opportunities to design and implement measures to contribute to climate and biodiversity policy objectives. The NRL includes overarching objectives relate to long term sustained recovery of biodiverse and resilient ecosystems, while achieving the EU overarching objectives in relation to climate change mitigation and adaptation, accompanied by an objective to enhance food security. It includes restoration targets and obligations; an implementation framework comprised of national nature restoration plans, monitoring and reporting obligations; and financing requirements. It reflects the fact that restoration take time and requires commitments over long timeframes i.e. decades. There is a clear need to ensure climate mitigation and adaptation plans together with nature restoration plans are mutually compatible. Drafting of national nature restoration plans over next 2 years (2024-2026) provide an opportunity for enhanced alignment of policy and legislative targets in land and marine areas.

Ireland's Climate Action and Low Carbon Development Act explicitly considers biodiversity as an integral part of national climate objectives stating that "The State shall, so as to reduce the extent of further global warming, pursue and achieve, by no later than the end of the year 2050, the transition to a climate resilient, biodiversity rich, environmentally sustainable and climate neutral economy". This requires biodiversity considerations to be taken into account in climate change mitigation and adaptation plans.

Biodiversity Considerations in Carbon Budgets Process

The CCAC recently commissioned a report on biodiversity considerations in the carbon budget process (Molloy *et al.* 2024). This study builds on previous work on the impacts of climate change mitigation measures on biodiversity funded by the EPA (Gorman *et al.* 2023). Both studies emphasised the interconnected nature of the climate and biodiversity crises in Ireland, with climate change exacerbating biodiversity loss and highlighting that degradation of ecosystems is associated with weakened resilience to climate change. The authors highlighted that it is possible to implement carbon mitigation measures while protecting biodiversity. Key factors to mitigate against negative impacts include appropriate siting of measures and managing the resultant land use change to deliver synergistic gains for both climate and biodiversity. There is a clear need for climate mitigation to be undertaken in a "right action, right place" framework to maximise benefits of climate action for biodiversity (Gorman et al. 2023).

Molloy *et al.* 2024 focused more specifically on biodiversity considerations in the carbon budget process. The report highlights that policies to address climate change and biodiversity loss are not fully aligned and that the impacts of proposed climate actions on biodiversity are not adequately assessed. The scale of land and sea use change required to achieve the ambitious carbon budget targets will impact on the spatial distribution of biodiversity, how ecosystem function, their condition and ultimately the delivery of ecosystem services to society (i.e. food provision, water quality, carbon sequestration and storage etc.). The authors recommend that biodiversity needs to be incorporated into the carbon budget process with specific spatial dimensions considered. Key recommendations from Molloy et al. 2024 relate to the need for policy alignment; need for land use change and systemic societal change to combat biodiversity and climate crises; the development of a national land use strategy underpinned by updated spatial data within a spatial planning framework to manage change; key uncertainties and knowledge gaps are recognised that requires increased knowledge generation and sharing; and there is a clear need to ensure that Ireland does not contribute to biodiversity loss and climate change internationally by off-shoring our impacts through our resource exports and imports.

Biodiversity considerations and core modelling results (FAPRI, TIM and GOBLIN)

This section attempts to assess the range of scenarios developed under core modelling work of the carbon budget working group from a biodiversity perspective. It takes the form of a high-level narrative on some of the potential impacts. The lack of spatially explicit modelling limits the ability to assess biodiversity impacts.

Three core pieces of modelling in the area of agriculture, land use and energy inform the work of the carbon budget working group. These include: 1. The FAPRI-Ireland projections and the Teagasc MACC 2023, 2. TIMES-Ireland Energy Model (TIM) and 3. The General Overview of a Backcasting approach of Livestock Intensification (GOBLIN). These scenarios and associated modelling outputs have been assessed for their potential biodiversity impacts and a narrative summary is provided below. It must be noted that these models are not spatially explicit. The impacts of various climate mitigation measures on biodiversity under the various scenarios is landscape context dependent and it is only possible to flag potential impacts under the various model scenarios.

<u>FAPRI Ireland and MACC Pathways</u>

The FAPRI Ireland projections result in three scenarios with different activity levels ranging from scenario 1 with continued expansion of dairy accompanied by contraction in suckler beef production, to scenario 2 with lower activity levels resulting from a larger decrease in suckler cow number and more modest increases in dairy. Scenario 3 is a higher activity projection with larger increases in dairy cow numbers and modest decline in suckler cow numbers. These projections are combined with two MACC pathways with increasing levels of ambition in efficiency measures and land diversification including afforestation as you move from pathway 1 to 2.

Scenario 1 includes continued expansion of dairy cow numbers with reduction in suckler cow numbers. This implies conversion of grassland under suckler cow system with generally low stocking rate to more intensive dairy systems which have generally higher stocking rate per unit areas. They generally are associated with higher grass utilisation figures with a higher proportion of the biomass produced in the ecosystem consumed by the grazing animal. Dairy systems are associated with higher nutrient load per unit area which can lead to increased risks of nutrient losses to water and air depending on catchment characteristics and management practices adopted. This scenario assumes chemical fertiliser use at current rates and the current trajectory of impact on environment can be assumed without additional mitigation measures. It is difficult to assess impacts without spatial context but one of the major risks for biodiversity would result from the potential loss of biodiversity associated with extensive pastures. The conversion of semi-natural pastures to improved agricultural grasslands and associated biodiversity loss would be a continuation of the trend recorded in recent decades.

Scenario 2 is a modification of the above scenario with a slight increase in dairy cow number and an associated larger reduction in suckler cow numbers. Chemical fertiliser use would be reduced compared to scenario 1. There is potential for reduced impact on the environment with impacts likely to vary depending on landscape context. This scenario would be associated with lower potential risk to biodiversity with improved management practices and due to the possibility, that already improved agricultural grasslands could absorb increases in dairy cow numbers. However, greater risks of abandonment of extensive semi-natural pasture systems and impact of reduced biodiversity of semi-natural high nature value grasslands through abandonment could result without mitigation (e.g. incentives for targeted conservation grazing by livestock).

Scenario 3 is associated with the highest increase in dairy numbers, with lower decrease in suckler cow numbers than scenario 1. This scenario has the potential for increased impacts on environment. Chemical fertiliser rates would be higher than the other scenarios, with associated risks of loss to the environment. This poses the potential for substantial risks to freshwater and transitional/coastal waters biodiversity from nutrient loss. The risk of loss of conversion of semi-natural pastures to improved agricultural grasslands and associated biodiversity loss is greatest under this scenario. There is potential for increased nitrogen deposition in intensively farmed areas with resultant impact on sensitive ecosystem. For example, peatlands are known to be impacted by nitrogen deposition which impacts their biodiversity and reduces their ability to function in carbon capture and storage (Moore et al. 2019), in turn reducing their CDR potential.

The above scenarios are combined with two Maximum Abatement Cost Curve (MACC) pathways with increasing level of ambition in adoption of efficiency and land diversification measures as you move from pathway 1 to pathway 2.

MACC Pathway 1 includes livestock reductions due to diversification measures and associated reduction in fertiliser use, coupled with improved efficiency of production. Improved efficiency measures on their own without spatial targeting of mitigations and diversification options will do little to reduce biodiversity risks on both land and water from the scenarios above. Pathway 1 can reduce risks from various scenarios in areas where diversification opportunities are taken up in relation to freshwater biodiversity, assuming best forest management measures are adhered to and that grass for biomethane does not lead to local intensification and increases in fertiliser use. Risks for biodiversity remain in other areas. Drainage of 10 % of mineral soils under this pathway enhances risk of sediment and nutrient loss without mitigation. There is also potential for drainage to enhance contributions to flash flooding in certain catchments without mitigation (e.g. interception ponds, flood attenuation wetlands strategically planned in catchment). If undertaken in a more integrated manner with wider environment considerations taken into account, diversification measures under this pathway could be positive for biodiversity. Wider catchment considerations are currently rarely a factor in on farm drainage decisions. Updated national guidance on agricultural land drainage to include a more specific catchment-based approach would be required to enhance resilience of catchments to extreme weather events.

MACC Pathway 2 which is more ambitious has potential to further reduce biodiversity risks associated with the three scenarios. However, greater land use change involved under diversification measures in this pathway require site specific considerations to be taken into account to minimise trade-offs and enhance synergies between climate action and biodiversity. For example, higher afforestation rates pose greater risks to biodiversity from poorly sited forestry if new improved forestry guidelines published in June 2024 are not implemented to the highest possible standards. Increasing drainage targets to 25 % of mineral soils under this scenario further enhances risk of sediment and nutrient loss without mitigation, and the higher implementation targets increases the potential downstream flooding risks highlighted for pathway 1. The risk of loss of wet grasslands of biodiversity importance is substantial under a pathway where 25% of mineral soils are targeted for drainage. The potential for positive impacts on biodiversity from range of diversification initiatives depends on the implementation of these diversification measures and how biodiversity considerations are factored into design of new land use. Rapid deployment of diversification measures is needed, but the potential increased risk to semi-natural habitats from land use change under this pathway is substantial if land use change is poorly targeted and managed. The impact on biodiversity at local scale in some catchments will be substantial through both intensification of agricultural production and land use change. There is a clear need for integrated spatial planning recognising trade-offs at catchment scale to realise co-benefits for water and biodiversity from pathway 2.

Overall, the impact of the efficiency and diversification measures on biodiversity depend on spatial targeting of measures, together with ongoing management practices adopted. The various scenarios imply targeted intensification of dairy in certain areas with conversion of land for various diversification options in other areas. Improved efficiency without spatial targeting of mitigations will do little to reduce biodiversity risks on both land and water. The scale of impact on biodiversity in some catchments will be substantial through both intensification of agricultural production and land use change. There is a clear need for integrated spatial planning recognising trade-offs at catchment scale to realise benefits for terrestrial and aquatic biodiversity.

<u>TIMES-Ireland Energy Model (TIM)</u>

In the energy sector the move away from fossil fuels is positive for biodiversity as fossil fuel use is associated with indirect biodiversity loss (driving climate change) and direct habitat loss and pollution. Electrification of transport and heat, while decarbonising electricity supply requires significant upscaling of renewable energy and electricity transmission and distribution infrastructure, including storage. The results from the TIMES-Ireland Energy Model (TIM) highlights that significant carbon dioxide removals (CDR) are required, particular under high energy demand scenarios. All scenarios require emissions removals e.g. BECCS or other CDR. CDR currently relies on land-based CDR through afforestation, improved management of existing forest resource and peatland restoration and improved management. The TIM model results suggests that substantial land use change will be required across forestry, agriculture and renewable energy (including bioenergy) generation. Energy transitions required under lower demand scenarios may be more feasible to achieve and result in less use of non-renewable and renewable resources than those required to service high energy demand scenarios. The impact of various scenarios is difficult to quantify as much is dependent on renewable energy generations options pursued and CDR strategies adopted.

The TIM model scenario results further emphasise the challenges around implementation of measures to meet carbon budgets, while also meeting biodiversity requirements under the EU Nature Restoration Law. We need to avoid potential negative impacts of renewable energy infrastructure and bioenergy production in Ireland, while realising the benefits for biodiversity from switch away from dependence on fossil fuels. How we meet current and future energy demands also poses risks of off shoring our biodiversity impacts which needs to be avoided e.g. importation of biofuels to meet biofuel targets poses risks to biodiversity internationally depending on their origin. Improved spatial targeting of renewable energy generation must endeavour to avoid further habitat loss/fragmentation, species loss, degradation of ecosystem quality and function. This is of particular relevance in terms of climate targets for ecosystem that are important for CDR. Under future climate change projections, the reversibility of restoration of carbon rich ecosystems is a real risk. Under changing climatic conditions including more frequent extreme weather events these ecosystems vulnerability to drought, wildfires, pest and disease increases. In planning our energy generation and transmission infrastructure the vulnerability of these ecosystems must not be exacerbated through poor spatial targeting of infrastructure. Improved spatial targeting of infrastructure and the planning regulatory framework needs to take wider environments considerations and trade-offs into account. The regulatory framework for CDR, particularly emerging and novel CDR technologies, will need to take wider environment considerations (including biodiversity) into account. There is current a lack of high-resolution spatial data to inform planning which enhances risks of poor targeting or may contribute to delays in roll out of required infrastructure.

The General Overview of a Backcasting approach of Livestock Intensification (GOBLIN)

The GOBLIN model also identifies the need for substantial land use change in terms of afforestation (up to 25,000ha per annum) and water table management on organic soils. Including the assumption to maintain bovine protein output leads to a requirement for further intensification of agriculture to spare land for other land uses including CDR, renewable energy generation and meeting projected wood product demand. Terrestrial and freshwater biodiversity impacts will depend on spatial distribution of proposed land use change, ecosystem type/land cover type targeted and existing ecosystem condition. Reduction in number of livestock and improved efficiencies assumes lower nutrient inputs on farms and has the potential to lower risks to freshwater and transitional/coastal waters biodiversity. The amount of spared land available under various scenarios leaves varying opportunities for spatial targeting of forestry, renewable energy and biomethane under the different scenarios. Diversification opportunities and land use decisions on this land will determine resultant environment impacts. Improved spatial planning and integrated land use planning has the potential to minimise trade-offs and enhance synergies. Risks from poor siting and trade-offs with biodiversity and water objectives must be minimised.

The three GOBLIN forestry scenarios result in increasing level of ambition and land use change. Scenarios 1 (8,000 Ha p.a.) and 2 (25,000 Ha p.a.) propose the same species mix 50:50

conifer:broadleaf. The opportunities for positive versus negative impacts on biodiversity associated with this expansion is very much dependent on-site location, establishment, ongoing management and harvesting practices adopted. For example, the prevailing relatively, short rotation clear fell forestry model will have much higher impact on the environment than progress towards continuous cover forestry and longer rotation systems. Afforestation rates approaching Scenario 2 targets were only technically feasible in the 1990s when marginal land from production perspective was planted, reducing trade-offs with food production but with major impacts on environment including negative impacts on the emissions profile of the national forest resource. Higher rates of conifer plantation have potential higher risks to the environment (water and biodiversity) and substantial change in current forestry practices are required under scenario 3 in particular (25,000 Ha p.a.; 70:30 conifer:broadleaf mix), to mitigate impacts, while benefiting from production opportunities under this scenario. Forest scenarios 1 and 2 assume planting on organo-mineral soils (15%) which potentially overlap with semi-natural wet grassland areas of conservation concern and would need much improved spatial targeting to avoid negative biodiversity impacts. However, there is potential positives for biodiversity depending on spatial targeting of forestry measures and move to more sustainable silviculture, particularly on degraded wet grasslands through conversion to close to nature silviculture practices.

Long term CDR through enhanced afforestation and peatland restoration under GOBLIN scenarios are dependent on appropriate siting, ongoing management practices adopted for afforestation and restoration actions, plus harvested wood product use. Improvements in existing forest management is needed and could be delivered in an integrated manner to deliver co-benefits for climate, biodiversity and water, cognisant of potential near term production trade-offs. Long term impacts on production targets in the model on both biodiversity and CDR are more uncertain and much would be dependent on building improved resilience in forest areas. There is a need to mitigate where possible potential impacts of future disease risk, extreme weather and wildfire risks associated with climate change. Major reversibility risks are associated with climate change which leads to questions related to a potential overreliance on CDR.

Peatland restoration CDR has the potential for substantial co-benefits for biodiversity and water resource management in terms of water quality and quantity. Improved management of water tables on organic soil co-benefits for water and biodiversity depend on the extent of water table management, paludiculture and nature restoration measures adopted. It must be noted that the carbon flux dynamics associated with restoration are highly variable depending on individual site context and long-term restoration commitments are required. Similar reversibility risks can be associated with peatland restoration as forests CDR, such as those related to extreme weather and wildfire risks. There are potentially less disease risks associated with peatland restoration as more carbon is stored below ground than in above ground vegetation relative to forest ecosystems. Peatland ecosystems are associated with lower sequestration rates than forest ecosystems but there is potentially more long-term storage in peatlands than forests, depending on production level targeted for forest resource.

It must be noted that the diversity of existing grassland sward composition is not captured in the GOBLIN model and could lead to erroneous conclusions in relation to benefits of reseeding with multi-species swards. Reseeding of extensive semi-natural grassland has potentially negative consequences for carbon, water and biodiversity perspective depending on current ecosystem condition. The biodiversity impacts in general associated with dairy specialisation and sustainable intensification included in the various GOBLIN scenarios would be similar to those discussed above for the FAPRI Ireland and MACC pathways modelling work.

Conclusions and Recommendations

Climate change is a major driver of biodiversity loss related to changes in ecosystem extent, distribution, condition, functioning and resultant services to society (e.g. provisioning, regulatory and supporting services). Climate action and nature restoration measures need to be implemented in a manner that maximises synergises and minimises trade-offs. Results to date from modelling suggest substantial land use change will be required across forestry, agriculture and renewable energy generation to meet national climate objectives. Given the dependence on CDR in the modelling scenarios, the risks associated with reversibility of restoration of carbon rich ecosystems under climate change projections (i.e. vulnerability to drought, flooding, wildfires, pest and disease) must be considered and mitigated for where possible.

The measures to achieve C budgets explored under the various model scenarios by the carbon budgets working group will have significant impacts on biodiversity with potential for both positive and negative impacts. These impacts will vary across the country and are very much dependent on the ecosystem and landscape/catchment context in which the various measures are implemented. Off-shoring climate and biodiversity impacts also needs to be avoided.

Climate mitigation and adaptation measures need to be implemented with co-benefits for nature restoration to meet legislative targets and international commitments. Biodiversity needs to be explicitly considered in a more holistic integrated land use framework. This will require a national land use strategy coupled with regional/local implementation mechanisms.

References

DCHG (2019). Ireland's 6th National Report to the Convention on Biological Diversity. Department of Culture, Heritage and the Gaeltacht.

EPA (2024). Ireland's State of the Environment Report 2024. Environment Protection Agency

Gorman, C.E., Torsney, A., Gaughran, A., McKeon, C.M., Farrell, C.A., White, C., Donohue, I., Stout, J.C. and Buckley, Y.M., 2023. Reconciling climate action with the need for biodiversity protection, restoration and rehabilitation. *Science of the Total Environment*, *857*, p.159316.

IPBES (2019), Global assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Brondízio, E. S., Settele, J., Díaz, S., Ngo, H. T. (eds). IPBES secretariat, Bonn, Germany. 1144 pages. ISBN: 978-3-947851-20-1

Molloy, A., Jarmain, C., Byrne, K. A., Daly, H., Emmerson, M., McKeon, C., Moran, J., Moriarty, R., Styles, D., Buckley, Y. M., 2024. Assessment of biodiversity considerations in the carbon budgets process. Report for Carbon Budgets Working Group. pp.69

Moore, T.R., Knorr, K.H., Thompson, L., Roy, C. and Bubier, J.L., 2019. The effect of long-term fertilization on peat in an ombrotrophic bog. Geoderma, 343, pp.176-186.

Pörtner, H.O., Scholes, R.J., Agard, J., Archer, E., Arneth, A., Bai, X., Barnes, D., Burrows, M., Chan, L., Cheung, W.L., Diamond, S., Donatti, C., Duarte, C., Eisenhauer, N., Foden, W., Gasalla, M. A., Handa, C., Hickler, T., Hoegh-Guldberg, O., Ichii, K., Jacob, U., Insarov, G., Kiessling, W., Leadley, P., Leemans, R., Levin, L., Lim, M., Maharaj, S., Managi, S., Marquet, P. A., McElwee, P., Midgley, G., Oberdorff, T., Obura, D., Osman, E., Pandit, R., Pascual, U., Pires, A. P. F., Popp, A., Reyes-García, V., Sankaran, M., Settele, J., Shin, Y. J., Sintayehu, D. W., Smith, P., Steiner, N., Strassburg, B., Sukumar, R., Trisos, C., Val, A.L., Wu, J., Aldrian, E., Parmesan, C., Pichs-Madruga, R., Roberts, D.C., Rogers, A.D., Díaz, S., Fischer, M., Hashimoto, S., Lavorel, S., Wu, N., Ngo, H.T. 2021. IPBES-IPCC co-sponsored workshop report on biodiversity and climate change; IPBES and IPCC. DOI:10.5281/zenodo.4782538.