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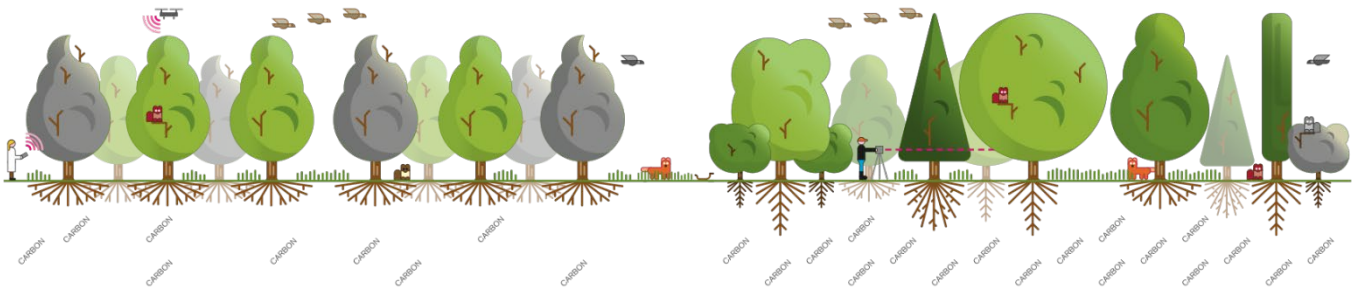
Forest Innovation to tackle the Climate and Biodiversity Emergencies



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Forest Innovation to tackle the Climate and Biodiversity Emergencies

A University of Birmingham/Birmingham Institute of Forest Research (BIFoR) White Paper arising from the Conference titled: “Trees for the Future - Diversity and complexity for resilience and carbon storage”, held at the University of Birmingham, UK on 03-04 November 2021

Overview

- Planting mixed woodland enhances tree growth and productivity. Mixed woodland plantations should, therefore, play a key role enabling the UK to meet its 2050 net zero greenhouse gas emissions targets.
- Elevated atmospheric CO_2 concentrations (eCO_2) increase photosynthesis, which is necessary (but not in itself sufficient) for increased carbon storage in forests. Remote sensing data have revealed an increased greening of the earth over the last 20 years that is largely due to greater leaf area in forests. Such findings demonstrate that UK forests are effective in carbon uptake in the future, as well as improving soil health.
- Undisturbed forests eventually reach carbon balance. They may continue to provide long-term carbon draw-down and storage by building ‘recalcitrant’ soil carbon. To secure and enhance long-term draw-down and storage in the forest canopy above ground, wood products must be taken from the forest and stored long term. Hence, woodland planning must incorporate harvesting for timber and other wood products in order to contribute to long-term carbon budgeting, biodiversity enhancement, and the delivery of societal benefits.
- Current afforestation and forest management regulations and guidelines are innovation-averse and highly vulnerable to globalised disease and climate risks. Neither the Nature for Climate Fund[1], nor the ongoing series of UK Carbon Budgets[2], provide the space for innovation to manage these risks.
- Private actors are pathfinding recolonisation and silvicultural portfolio approaches to increase resilience and manage social risks such as ‘carbon colonialism’.
- Choosing forest-facing post-16, apprenticeship, and degree training is a direct route to climate action for UK school leavers but this case is not being made to them.
- Forest-facing education is tarnished by outmoded and educationally indefensible caricatures of practice-based learning (*cf*. medicine or veterinary science), severely hindering One Health responses to the climate and nature emergencies and the pandemic.
- The benefits of woodland creation are inherently context-dependent, and sensitive to what tree species are used. For example, as sources of nitrogen pollution come under control in the UK, adding nitrogen fixing tree species will enhance woodland carbon sequestration rates under most circumstances.

Trees and the Climate Emergency

Nature-based solutions to climate mitigation are a key feature of the UK roadmap to net zero and they must remain a key feature of the UK’s longer-term climate planning.

[1] https://www.gov.uk/government/publications/nature-for-people-climate-and-wildlife/nature-for-people-climate-and-wildlife

[2] https://www.gov.uk/guidance/carbon-budgets

The pivotal importance of forests[3] in sequestering carbon has taken centre stage with ambitious projects across the UK designed to greatly increase tree planting and bring existing forests into management. There are gaps in current knowledge concerning the relative benefits of different tree species, in monocultures or mixed plantations, and their resilience and ability to be productive under climate change and the pressures of globalised disease. Nevertheless, there are reasons for optimism. For example, there is unequivocal evidence[4] that the Earth has become significantly greener over the past 30 years, with plants, particularly trees, producing greater leaf area a result of the global increases in carbon dioxide (CO_2).
The UK forest is an increasingly important component of the UK carbon budget but is subject to a highly uncertain spectrum of risks[5]. As with any asset, responsible risk management requires a *portfolio approach*, often colloquially known as 'spreading your bets'. The current types of UK forest assets are too narrow to allow this approach, as discussed below.

Better tree growth and sequestration of carbon in mixed woodland

Accumulating evidence demonstrates the importance of employing a diversity of tree species in current and future planting strategies[6]. This position paper summarises information concerning how mixed woodland can act as a carbon sink, increasing land carbon stock, i.e. total amount of carbon stored on the land in plants and soils, in the coming decades. The recent book-length case study[7] conducted on the Norbury Park estate in central England provides evidence that mixed planting has enormous benefits in terms of tree growth and resilience. This estate now captures over 5,000 tonnes of carbon dioxide per year, making it quite possibly the most carbon-negative land in the UK. Achieving such success requires careful management and ecological awareness. It is evident that there is a skills gap in forestry with too few practitioners being trained to care for and maintain the current development of plantations for the decades to come.

Current evidence demonstrates that genetically diverse, species-mixed, and uneven-aged forests are required to maximise carbon capture while increasing resilience to biotic and abiotic threats. Genetic diversity provides populations optimally selected for

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[3] We use the generic term forest to refer to any landscape in which trees play a major role in determining the ecological functioning of the landscape: planted high forests; natural, semi-natural, and planted woodlands; coppice; orchards; silo-pastoral and silvo-arable land; and the linear features (hedges etc) interspersed in the wider landscape.

[4] https://www.nasa.gov/feature/goddard/2016/carbon-dioxide-fertilization-greening-earth

[5] See https://secure.fera.defra.gov.uk/phiw/riskRegister/ for the current register of pests and diseases. Abiological risks centre around climate change-induced alteration of mean and extreme weather.

[6] See, for example, this 80-author paper in the journal *Science* from 2016, which analyses more than 770,000 forest plots in 44 countries: https://www.science.org/doi/10.1126/science.aaf8957

[7] Bradwell, J. (2021) Norbury Park: an estate tackling climate change, ISBN: 978-1-5272-9734-0. Available from office@harborneoffice.co.uk

current conditions, with gene-pool backup for the yet-to-be-experienced future. Each species in an intimately mixed forest environment has its own genetically programmed abilities for light harvesting, capture and light use efficiency, as well as accessing different nutrient sources, leading to higher yields overall. Mixed forests are also often more resilient to disease by diluting pest and pathogen populations. Uneven age, that is a near constant age pyramid, ensures that germinated seeds refresh forest genetics. Succession planting continuously provides harvestable timber and so steady jobs, in stark contrast to the cut-and-move-on dynamic of clear-felling, which causes periodic environmental and economic 'shocks' that are hard to deal with.

Carbon sequestration

Since 2017, the Birmingham Institute for Forest Research (BIFoR) Free-Air CO_2 Enrichment (FACE) facility has accumulated terabytes of measurements[8] describing the details of how a mature oak forest responds to elevated concentrations of CO_2. Several strands of evidence support the conclusion that mature oak-dominated temperate deciduous mixed forests grown under eCO_2 can effectively capture more carbon dioxide and grow faster than those grown under ambient conditions. The BIFoR FACE facility is the world's largest climate change experiment and the only forest FACE facility in the northern hemisphere. Over a season, the deciduous woodland patches exposed to elevated CO_2 at BIFoR FACE show about a 25 % increase in photosynthesis compared to the woodland in contemporary air[9]. What happens next remains to be determined categorically and peer-reviewed — being a crucial part of the evidence gap recognised by the recent report of the Science and Technology Select Committee of the House of Lords[10] — but the general pattern is clear. The enhanced carbon gain influences tree physiology, leading to greater fine root production and enhanced release of nutritious exudate into the surrounding soil. This in turn benefits the soil microbiome leading to increased microbial biomass and more carbon belowground overall.

Across the UK, the benefits delivered by woodland are determined by location and can be scientifically modelled across landscapes using data from BIFoR FACE and other experimental manipulations to ground-truth model predictions[11].

Tree species choice

There is no definitive evidence of which species will reap the maximum benefits under changing UK conditions. Mixtures of native and non-native should be considered as a matter of simple risk management. While conifers are key components of mixed woodland because they grow and sequester carbon more rapidly than broadleaves they have a smaller total carbon stock as mature woodland, but more research on the carbon storage of various forested landscapes is urgently required[10]. The UK Forestry

[8] MacKenzie, et al. (2021) *Hydrological Processes*, 35, e14096. https://doi.org/10.1002/hyp.14096

[9] Gardner et al. (2021) *Tree Physiology*, https://doi.org/10.1093/treephys/tpab090

[10] https://committees.parliament.uk/publications/8646/documents/87644/default/

[11] Norby, et al. (2015) *New Phytologist*, 2015, DOI: 10.1111/nph.13593

Standard requires diverse planting, with a maximum of 75% of one species in woodland. Climate change will affect the suitability of tree species in the UK, both directly through changes in temperature and precipitation, and indirectly through altered frequency and severity of outbreaks of pests and diseases[5]. Native tree species are genetically diverse; this diversity should be protected better to allow native species to adapt to climate change but the current UK efforts in this area are modest[12]. Breeding programmes may need to be amended to maintain greater genetic diversity in commercial, non-native, stock[13]; 'escape' of non-native seedlings into regenerating forest areas, as has been observed for Sitka spruce in the UK, Ireland, and Scandinavia[14], will not much increase genetic diversity and resilience, given the current narrowness of the non-native gene pool.

Values, skills, expertise, careers, and climate activism

The perceived lack of skills, expertise, and machinery to establish and manage woodland may limit the success of current tree planting efforts and lead to the ultimate failure of new forested areas to achieve carbon sequestration goals. The dearth of skilled forestry contractors is a barrier to success and expansion plans of existing woodland owners. A younger generation — highly knowledgeable about climate and enthusiastic to act rather than speak about it — is not being made aware of the challenging and rewarding careers available in the UK forest-facing industries (public, private, and third sector). Many forestry jobs are important but require relatively simple skills; others require a balance of 'book knowledge' and a practised hand; still others are as technical and intellectual as any STEM[15] frontier and should be recognised as such. The UK skills deficit is recognised by the Lords' Science and Technology Select Committee as rendering plans for 'Nature-based solution' to climate change at "severe risk of failure"[10].

The emerging and vital One Health[16] agenda requires that, in order to achieve better public health outcomes, professional practice in human health, animal health, and environmental management must be valued equally.

The sector can sometimes struggle to speak with one voice. Government can incentivise forest-facing career choices by embedding this point in build-back-better and levelling-up agendas. Successful initiatives that could provide vehicles for this government response are the Forestry Skills Forum[17] and the Community Forests in England[18].

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[12] https://www.forestresearch.gov.uk/research/uk-forest-genetic-resources-strategy/

[13] Tumas, et al. (2021) *Forestry*, 94, 734-744, https://doi.org/10.1093/forestry/cpab013

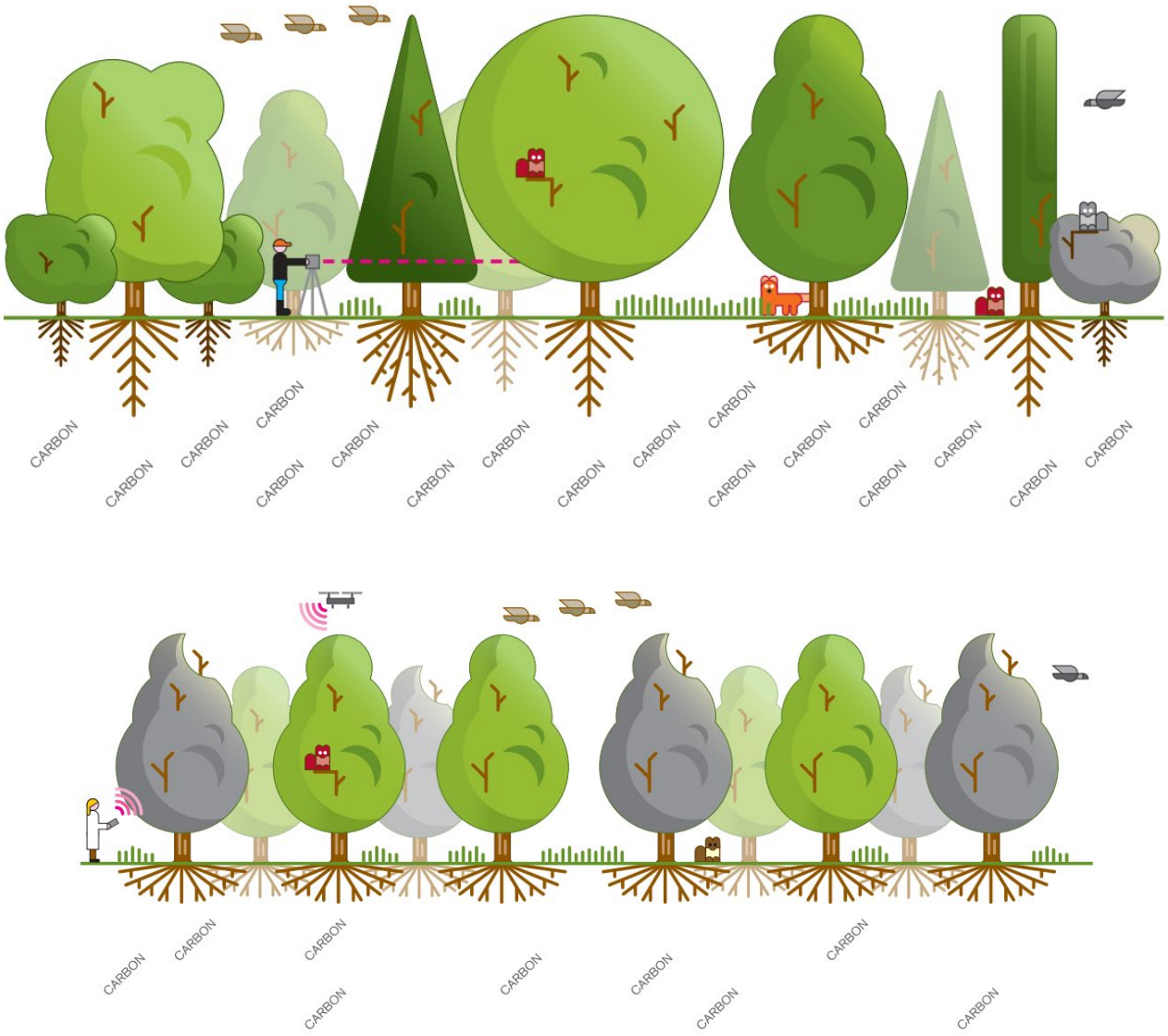
[14] https://conifersociety.org/conifers/picea-sitchensis/

[15] Benefits of science, technology, engineering and mathematics (STEM) education: https://www.gov.uk/research-for-development-outputs/benefits-of-stem-education

[16] https://www.cdc.gov/onehealth/index.html; https://www.euro.who.int/en/health-topics/health-policy/one-health

[17] https://www.lantra.co.uk/forestry-skills-forum

[18] https://englandscommunityforests.org.uk/



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Correspondence: bifor@contacts.bham.ac.uk