Why wood producing forests can help us address the **climate and nature emergencies**

Dr Andrew Cameron of Aberdeen University reviews evidence that expanding productive forests create cost effective carbon sinks and reduce environmental damage to natural forests through timber extraction offsetting.

While productive forests are effective carbon sinks, produce timber on a sustainable basis, and provide a wide range of social and environmental benefits (eg Sejo and Botkin 1997, Pawson 2013, Barua et al. 2014, Confor 2020), there has been increased hostility towards production forestry in Scotland and elsewhere in Britain from environmental organisations (eg Crane 2020) and media commentators (eg Barkham 2020) with much of the criticism directed at the use of non-native species and forest expansion oriented towards commercial production.

Policy decisions associated with forest expansion are increasingly influenced by the paradigms of 're-wilding' (minimal/no human intervention unless at the early restoration stage leaving an area to nature as opposed to more active management) and 'nativeness' (use of species that arrived due to natural processes with no human intervention) with the general presumption that there will be limited if any timber production. However, greenhouse gas mitigation potential of forests depends on productivity and the capacity to lock up carbon in the harvested wood. When accounting for both forest growth and use of the wood, *productive forests support up to 269% more greenhouse gas mitigation potential than newly planted broadleaf conservation forests* (Forster et al. 2021). High productivity has the greatest influence on greenhouse gas mitigation (Doelman et al. 2020, Forster et al. 2021) and is consistent with other studies indicating that expansion of the forest area using fast-growing species is the most cost-effective way to sequester carbon (Stern 2007, Nijnik 2010). Productive species achieve maximum absorption of incoming solar radiation and therefore carbon capture potential at canopy closure, which for average yielding Sitka spruce (14 $m^3ha^{-1}year^{-1}$) is approximately between 12 and 16 years old from planting (Jarvis and Linder 2007). At harvesting, soil carbon stocks (and a considerable amount of nutrients) can be replenished if most of the residues (e.g. branches, offcuts, tree stumps) are retained on site (Jarvis and Linder 2007).

"PRODUCTIVE FORESTS SUPPORT UP TO 269% MORE GREENHOUSE GAS MITIGATION POTENTIAL THAN NEWLY PLANTED BROADLEAF CONSERVATION FORESTS."

Use of wood products in Britain has increased by almost 25% over the last decade and this has seen a subsequent rise in imports (Forestry Statistics 2020). Increasing demand is partly driven by environmental pressures to replace polluting or non-sustainable materials such as plastics with wood products. Sawn timber for construction uses less energy in its production than cement (5x), glass (14x), steel (24x), brick (35x), and aluminium (126x) (Koch 1992, Buchanan and Levine 1999). The thermal insulation properties of wood are better than concrete (5x), brick (10x), and steel (350x). A reduction in carbon emissions by substituting timber for masonry and concrete in building construction is around 20% and 60% respectively (Spear et al. 2019). Scotland is well ahead of the rest of the UK in timber frame construction with over 80% of new houses built using this method (STA 2018).

Scotland has roughly 1.5 million hectares of productive and non-productive forest representing 19% of its land area (EU average 38%) producing over six million m^3 of wood annually. Nevertheless, Scotland remains an importer of wood products and the UK is the world's second biggest importer of wood products importing 81% of its requirements costing £8.3 billion (data for 2019). A significant proportion of imported wood comes from Scandinavia and Central Europe; however, many European countries are revising down their production forecasts due to climate induced dam-

continued on p48

continued from p47

age (particularly drought stress and insect attack) raising concerns over where future imports will come from and whether production is sustainable. It is incumbent on developed nations as the biggest users of wood products to increase domestic wood production and to reduce the need for imports. This would indirectly facilitate the reduction in damage and loss of the world's natural forests (a significant contributor to greenhouse gas (GHG) emissions) through timber extraction offsetting (ie) increasing timber output from productive forests to replace/offset production from natural forests).

One third of global industrial timber comes from productive plantation forests, yet they comprise only 3% of the total global forest area (FAO 2020). While plantation forests continue to expand, this is not at a level sufficient to keep pace with global timber demand, which will have more than doubled by 2050. Productive plantation forests, based on current levels of expansion, are predicted to supply *less than one quarter of world demand by the middle of this century* with the shortfall increasingly sourced from natural and semi-natural forests (Indufor 2012). If developed countries do not expand production, this will almost certainly result in increased production elsewhere in the world to meet demand that in turn will push up prices increasing illegal logging particularly in tropical and semi-tropical regions that are unable to sustain increased production targets due to unsustainable timber extraction (Barua et al. 2014, Leskinen et al. 2018).

SAWN TIMBER FOR CONSTRUCTION USES LESS ENERGY IN ITS PRODUCTION THAN

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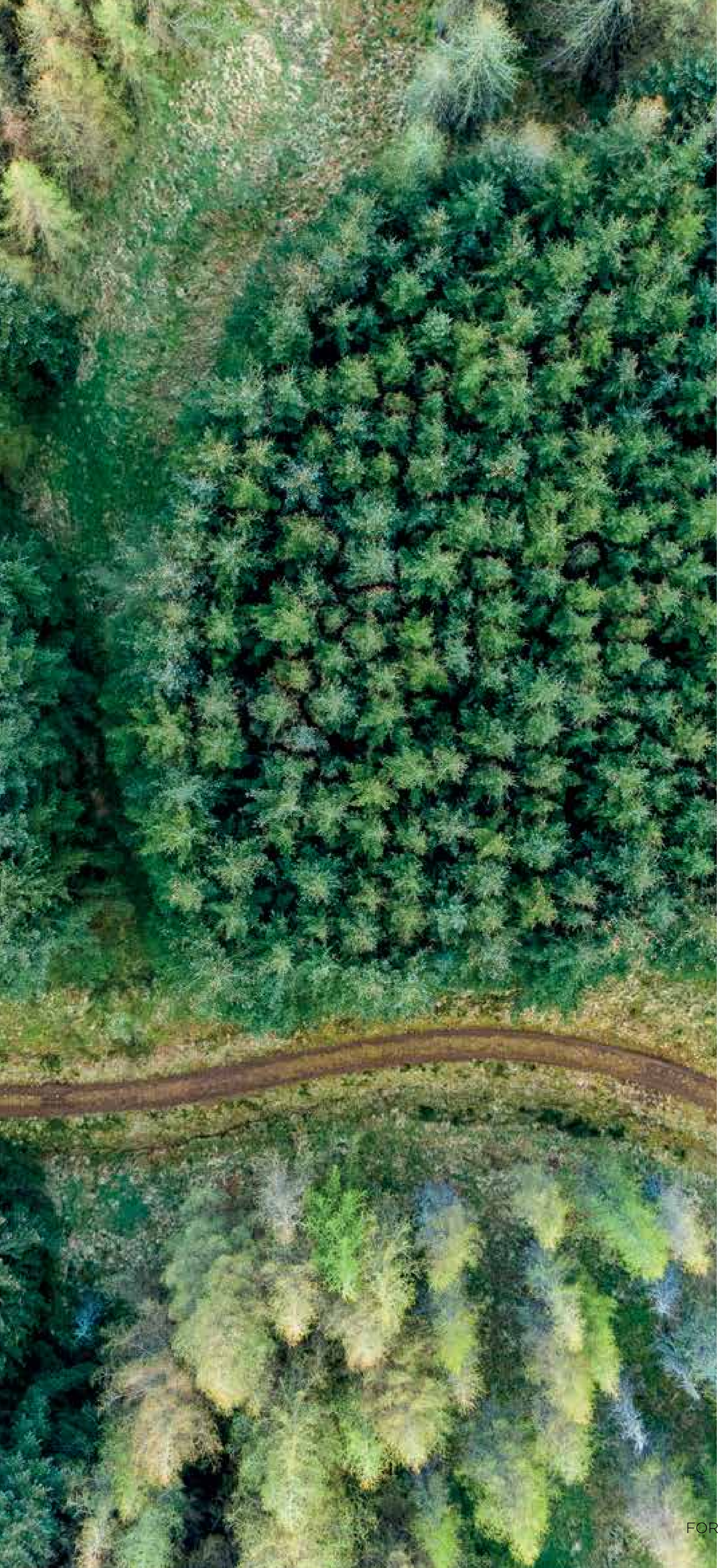
ALUMINIUM (126x)

"PRODUCING TIMBER AT THE CURRENT LEVEL OF DEMAND WOULD LIKELY EXCEED ALL THE WORLD'S REMAINING NATURAL FORESTS TO SUPPLY. PRODUCTIVE COMBINE HIGH PRODUCTIVITY AND FOCUSED ACTIVITY IN RELATIVELY SMALL AREAS LEAVING A SMALLER ENVIRONMENTAL FOOTPRINT."

Natural forests produce relatively low volumes of usable timber ranging from about $1\text{-}3m^3ha^{-1}year^{-1}$ (Sedjo and Botkin 1997) with the result that large areas of forest need to be logged to achieve an economic timber output resulting in serious environmental damage in extracting the timber (Barua et al. 2014). Productive forests on the other hand combine high productivity and focused activity in relatively small areas leaving a smaller 'environmental footprint'. With annual global use of industrial timber estimated at around six billion cubic metres, a volume that would require 2-6 billion hectares of natural forest to achieve (global area of natural forest roughly 3.75 billion hectares - FAO 2020b), *producing timber at the current level of demand would likely exceed all the world's remaining natural forests to supply*. By contrast, productive forests readily produce at least ten and up to $20m^3ha^{-1}year^{-1}$ (higher yields are not uncommon) (Sedjo and Botkin 1997), and this would require only *0.3 to 0.6 billion hectares of productive forest to meet the entire current global use of industrial timber, a fraction of what would be needed from natural forests.* This would also allow most of remaining natural forests to be devoted to wildlife protection and habitat conservation (Sedjo and Botkin 1997).

A key criticism of productive forestry is the use of non-native species even although numerous studies have demonstrated that forests of non-native trees can be as biodiverse as forests of native species (eg Humphrey et al. 2000, Sax et al. 2004, Smith et al. 2008, Quine and Humphrey 2010, Irwin et al. 2014). The immediacy of climate change has renewed the debate on appropriate tree species to use in productive forests, with potential susceptibility to more severe climatic events and novel pests and diseases. Given their long lifecycles, trees planted at the present time will still be alive in a future environment that is likely to be more challenging than at present and has highlighted the need for a greater range of more resilient species to be used and the establishment of species mixtures (eg Pretzsch 2009, Mason and Connolly 2013, Cameron 2015, Isbell et al. 2015, Pretzsch et al. 2017). While native species have an advantage of a long history of inherited adaptation to their environment, they can be more vulnerable to environmental damage than introduced species (Battipaglia et al. 2009). For example, in Britain ash dieback (*Hymenoscyphus fraxineus*), acute oak decline (several biotic factors), oak processionary moth (*Thaumetopoea processio-*



nea), Asian longhorn beetle (*Anoplophora glabripennis*), and *Xylella fastidiosa* are affecting native broadleaved species.

Maintaining current species composition of native woodlands may no longer be possible because some native species of flora and fauna may not survive due to the inability to adapt quickly enough to the rapidly changing environment.

This is not a reason to stop the restoration and expansion of endangered native woodlands in Scotland and elsewhere; however, it must be recognised that *dealing with the imminent environmental crisis associated with climate change will require new thinking regarding future afforestation*. Use of non-native species well adapted to the forest site is an important part of adaptive forest management given an uncertain future climate and concerns over future threats to forest trees from pests and diseases (eg Spathelf 1997; Johann 2006).

While the Scottish Government is committed to expand the forest area from 15,000 to 18,000 hectares of new tree planting each year by 2025 with the aim of increasing forest cover to 21% of the land area by 2032, the already alarming impact of a changing climate suggests that a more ambitious annual target of *productive forest* of at least 30,000 hectares is needed with the aim of afforesting at least one third of the land area closer to the European average. Opportunities for productive tree planting must be supported at every level with a simple robust application process. Planting grants should be scaled with carbon capture potential to encourage tree planting with the optimum mitigation value.

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