POLICY BRIEF | FORESTRY SECTOR

INTEGRATED SOLUTIONS TO ADDRESS HIGH LEVELS OF CLIMATE CHANGE

We are not yet on track to meet the Paris goal to keep global mean temperatures below 2°C (and ideally 1.5°C) above pre-industrial levels. IMPRESSIONS modelled the impacts of higher levels of climate change (above +2°C) on the forestry sector across Europe, including interactions with agriculture, water and biodiversity.

Key messages

- There is a clear north-south gradient, with forest productivity predicted to increase in northern Europe, due to higher temperatures, and decrease in southern Europe due to hotter and drier summers. However the impacts vary depending on altitude, soil type and species.
- Elevated CO_2 concentrations could further boost productivity in northern Europe and may partly compensate for negative climate impacts in southern Europe, but this could be offset by an increase of forest turnover, e.g. by pests, diseases and wildfires.
- Forest managers can adapt to climate change by switching to better-adapted species and by planting a mix of diverse species in each stand to improve resilience. However, biodiversity and landscape impacts should be considered if native species are replaced with non-native species.
- Integrated land use planning should be used to optimise forest area, in view of the essential role that European forests and forest products play in achieving climate mitigation targets through storing and sequestering carbon, in addition to providing multiple additional benefits to society.

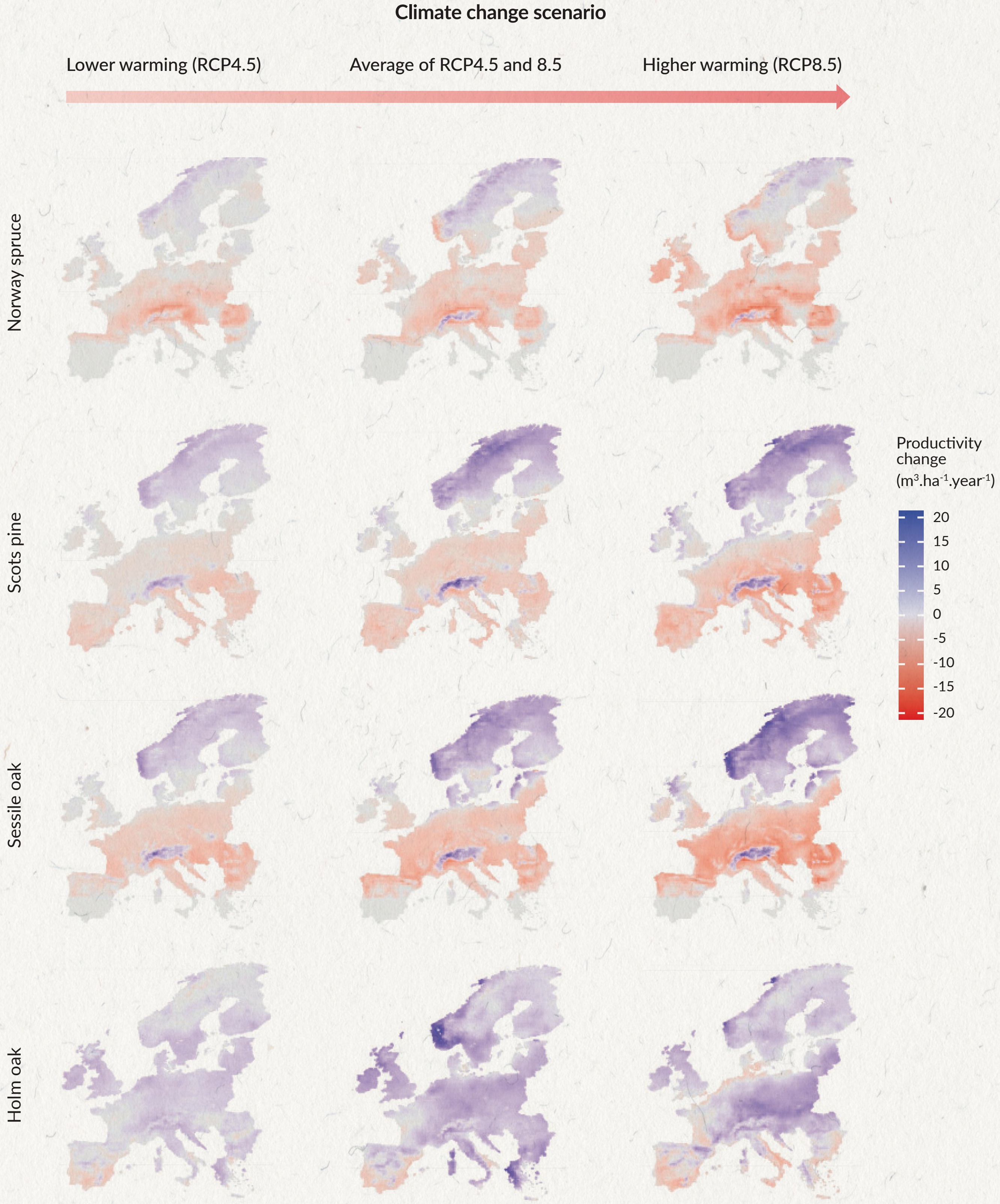
How will climate change affect forestry in Europe?

Climate models indicate lower rainfall and higher temperatures in southern Europe, leading to severe water scarcity. In the drought-prone Mediterranean basin and the dry continental interior, increased tree heat stress and transpiration are expected to lead to an average decrease in forest productivity of 1 to 4 m^3/ha/year (annual volume increment) by 2100, i.e. a decrease of 10% to 50% compared to the current climate. Climate change could even induce large-scale forest dieback. In Iberia, production of both cork and pine could cease completely by the 2080s under the RCP8.5 scenario (approximately 4 - 6°C warming across Europe)..

In contrast, forest productivity could increase in places where tree growth is currently limited by low temperatures, provided that precipitation remains adequate — typwically in northern Europe and at high elevations. Either extant tree species such as Scots Pine or Norway Spruce will become more productive, or it will become possible to use tree species that have higher economic value than those being used today (e.g. oak).

CO_2 fertilization may have a positive effect on forest productivity and could therefore increase the positive effects of climate change or partly compensate its negative effects. However, this is uncertain as vegetation may acclimate to higher CO_2 concentrations, or other factors such as nutrients or water may become limiting. Pests and diseases such as ash dieback (*Hymenoscyphus fraxineus*) and the pine processionary moth (*Thaumetopoea pityocampa*) could spread as a result of climate change, but more research is needed to better understand these risks.

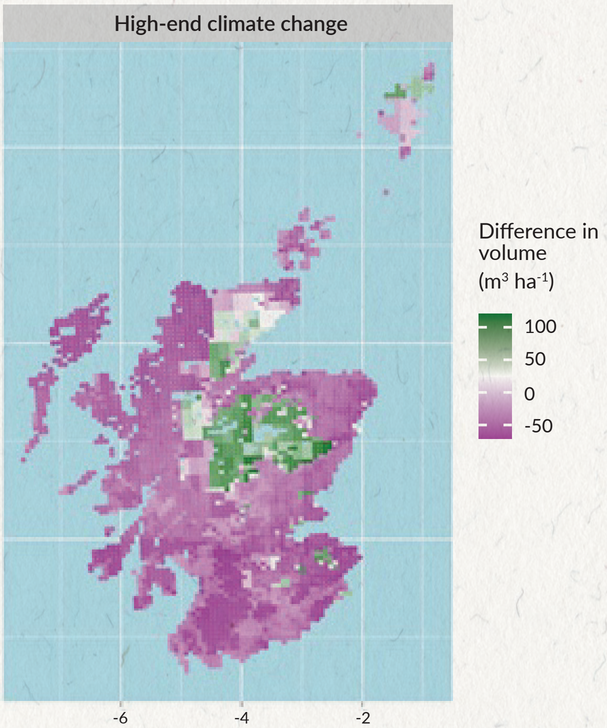
In addition, single extreme events (e.g. windthrow, heat waves) or series of events such as several drought years in a row could trigger widespread or species-specific tree mortality, including through increasing fire risk. Conversely, clusters of climatically favourable years could trigger forest expansion beyond current 'cold' treelines at high latitudes and high elevations. Invasive species such as the tree of heaven (*Ailanthus altissima*) or Japanese knotweed (*Fallopia japonica*) could also spread more rapidly. These impacts are not shown in the maps below, which are therefore conservative estimates of climate impacts. Many ecosystem services provided by forests will be affected strongly by these changes.



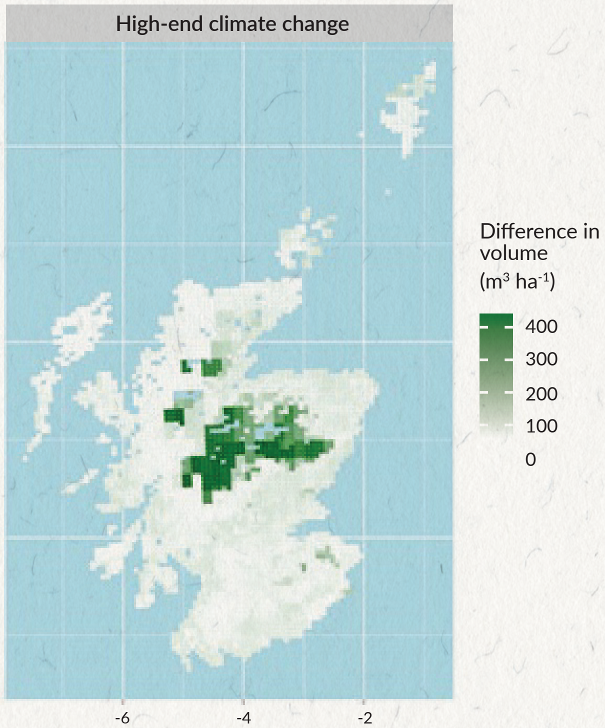
Change of productivity (annual volume increment) in 2070-2100 compared to baseline for two conifer (top) and two deciduous (bottom) species under increasing levels of climate change (left to right), based on the meta-ForClim model. The focus is on climate impacts only, so projections were made for homogeneous soil characteristics across Europe (water holding capacity set to 15cm to represent a mesic soil).

Impacts depend on the species and on local conditions. Mediterranean tree species are projected to be severely affected by extreme drought events in the most southern parts of Europe, but their growth is likely to remain constant or even increase elsewhere. For example, Holm oak is already expanding northwards along the Atlantic coast of France. Norway spruce, which is widely used in plantations outside its natural range (e.g. at low elevation in Central Europe), is expected to exhibit strong negative impacts in most of Europe, except at the highest elevations. The more drought tolerant Scots pine will mostly exhibit negative impacts in the driest European regions, although its response may vary depending on local topography and soil conditions. In Scotland, for example, more detailed modelling shows that yields of the native Scots pine are projected to decrease at low elevations and in areas where the soil has low water-holding capacity, but to increase in the Highlands. In contrast, yields of some non-native species (i.e., Douglas fir and Sitka spruce) could increase. This has implications for the selection of tree species in Scottish reforestation policy, which in turn could affect biodiversity and landscapes.

Scots pine (*Pinus sylvestris*)



Douglas fir (*Pseudotsuga menziesii*)



Difference in harvested volume under high climate change (average of RCP4.5 and RCP8.5 compared to baseline) using the ForClim model with local topography and soil conditions.

What adaptation and mitigation pathways are possible?

Forestry can be adapted to the changing climate by switching to climatically better adapted species, and moving towards forestry systems that include more than one species at the stand scale. This is especially relevant for species that have both a high ecological or economic importance and a high projected vulnerability to climate change, especially when they are already outside their natural range (e.g. Norway spruce).

The timing of switching to new species is important, due to the long production periods in forestry. Switching should not be so late that the productivity of current species falls, but also not too early because new species may not thrive under current climatic conditions, for example because of their sensitivity to frosts (e.g. Sessile oak and Holm oak at high latitudes and elevations) or a short growing season. Thus, the timing of species switches needs to be determined at the regional scale. Forest managers must take into account both the rates of anticipated future climate change and the ecological properties of extant, as well as new, tree species (so-called "trend-adaptive management"). This is challenging because the extent of climate change is rather uncertain at the local level.

If new non-native species replace native species, there could be trade-offs with biodiversity and landscape value. Many native species of birds, invertebrates and mammals depend on native tree species, and native forests are also important and highly valued cultural assets, which may contribute to a sense of place and also to tourism. Therefore switching to non-native species should not be undertaken if alternatives are available.

Using a mix of tree species will enhance the future viability and productivity of forests. Different tree species have widely different sensitivities to driving forces, such as frosts, heat or drought, or natural disturbances such as fire. Due to this and the unavoidable uncertainty in regional climate projections, it is likely to be highly beneficial to move from single-species to multi-species stands, as an insurance policy against catastrophic losses of timber and ecosystem services at the stand scale. There are multiple examples demonstrating not only the feasibility of mixed stands, but also their high utility in terms of both economic revenue and ecosystem service provision. Examples include Scots pine (*Pinus sylvestris*) – Silver birch (*Betula pendula*), European Beech (*Fagus sylvatica*) – Norway spruce (*Picea abies*) or Norway spruce – Silver fir (*Abies alba*) stands.

Adapting forests to climate change will also have major benefits for climate mitigation, and will be particularly important for achieving negative emissions in order to meet the 1.5°C target. EU forests and the forest sector currently mitigate about 13% of total EU emissions, as well as providing low carbon bioenergy. Carbon is also stored in forest products such as building materials and furniture. However, the future climate mitigation potential of European forests depends strongly not only on the carbon that is stored on a per area basis, but also on total forest area, which results from competition with other land uses such as agriculture and urban development.

Policy Recommendations

- Consider switching to more climatically suitable tree species to adapt to future climate change, especially for Norway spruce planted outside its native range, but plan the timing of the switch carefully, and consider the implications for native biodiversity and characteristic landscapes.
- Shift to more diverse stands to improve resilience to future change, including pests and diseases.
- Integrated land use planning should consider trade-offs between forests, agriculture and other land uses in the light of the essential role of forests in climate mitigation.

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