HOW DO TREES INFLUENCE THE AIR WE BREATHE?

Forest Canopy FOUNDATION

Why is air important?

Poor air quality is described as one of our era's greatest afflictions (Manisalidis et al., 2020) due to its impact on both Earth's climate and human health. In this paper, we focus on the localised impacts of poor air quality and look at how diligent tree planting can effectively mitigate this issue.

The pollutants of most concern to human health are particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen dioxide (NO_2), ozone (O_3) and sulphur dioxide (SO_2), often from anthropogenic sources. Whilst the role of SO_2, in terms of generating health impacts, has dramatically declined in the past 60 years due to the success of emission control policies (Jones et al., 2017), many pollutants remain at dangerously high levels in the lower atmosphere in some areas of the UK.

In the UK, air pollution is a major cause of respiratory and cardiovascular morbidity (Holgate, 2017, Jones et al., 2017) with 40,000 deaths each year attributable to pollutant inhalation. Between 2017 and 2025, the total cost to the NHS and social care of air pollution ($PM_{2.5}$ and NO_2 only) is estimated to be £1.60 billion, with less robust estimates as high as £5.56 billion. In addition, poor air quality is also linked to significant reductions in crop yield (Fowler et al., 2008) and loss of biodiversity (Reid et al., 2005).

How do trees influence air quality?

Trees provide a localised air quality regulation service (UKNEA, 2011) through the filtration of airborne pollutants. This can happen either by internal absorption of pollutants via stomatal uptake or the deposition of pollutants on external surfaces including leaves and bark (Bignal et al., 2004). The dry deposition of pollutants by UK habitat types is shown in **Figure 1** (based on 2015 figures – Jones et al., 2017). Per hectare, woodland is the most effective broad habitat at filtering air pollutants from the lower levels of the atmosphere.

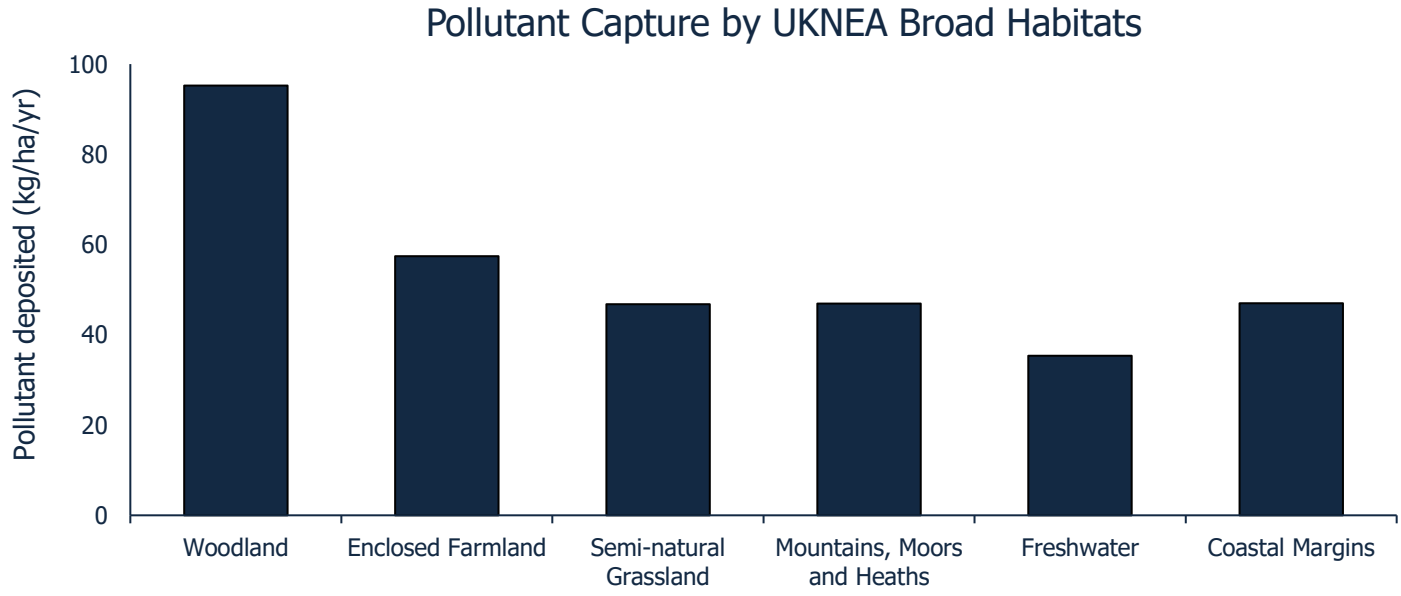

Figure 1: A graph showing the amount of pollution deposited in a range of common UKNEA broad habitats (based on data from Jones et al., 2017).

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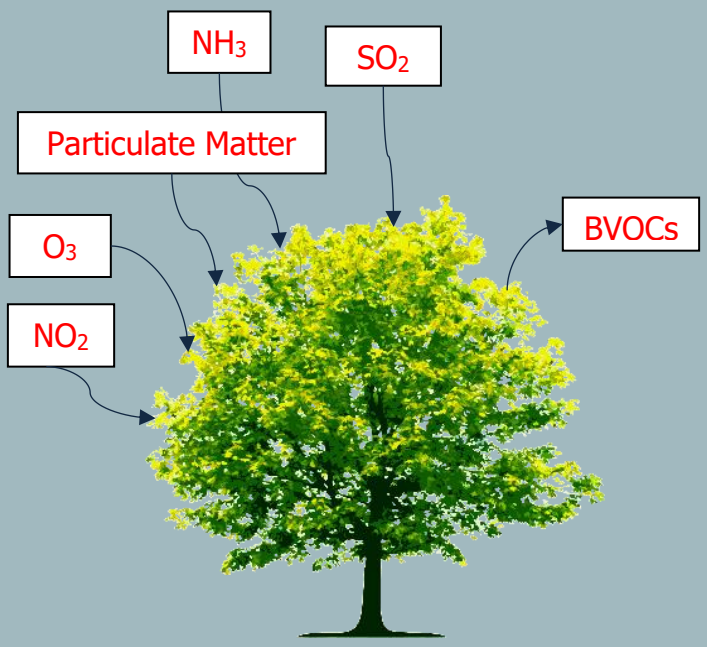
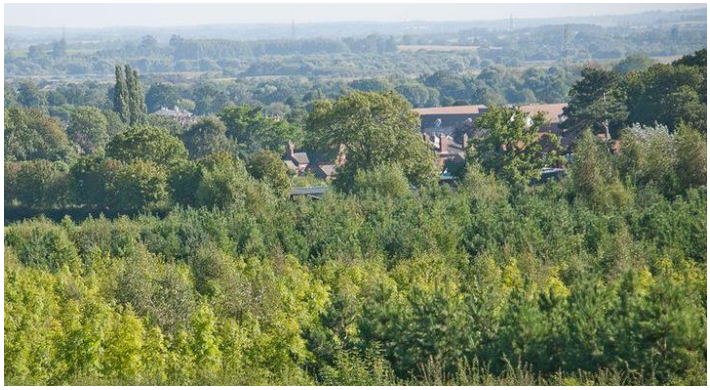
Although all tree species filter air of pollutants to an extent, certain species have been shown to have adverse effects on the atmosphere through the release of biogenic volatile organic compounds (BVOCS). These BVOCs are used by some species to attract pollinators and repel harmful insects. However, in combination with anthropogenically sourced nitrogen (NO_x), these BVOCS can contribute to the production of pollutants including ozone and particulate matter. Production rates of BVOCs peak in response to stress, typically rapid increases in daytime temperature (Office of Science, 2018) although the effect of BVOCs release is often considered negligible for woodlands less than ~1000ha.



To assess the net effects of trees on air quality (pollutant filtration vs BOVS emission), studies have attributed an urban tree air quality score (UTAQS) to common UK tree species (Donovan et al., 2005). Whilst species such as english oak, crack willow and poplar have been shown to have detrimental impacts on air quality, most species planted in the UK have a capacity to improve air quality with species such as larch, common alder, field maple and larch being the most effective.

How can woodlands be designed to best improve air quality?

Several factors play a role in the capacity of a woodland creation scheme to improve local air quality. As the effects of trees on air are highly localised, the location of planting is key to mitigate pollution from point sources. Planting in areas where levels of pollutants such as nitrogen dioxide (NO_2) and particulate matter ($PM_{2.5}$) are high, typically surrounding industrial centres and major transport links, will be the most effective.



Secondly, species choice is important. Planting a mix of species with a relatively high Leaf Area Index (LAI) will increase a woodland's ability to filter air as greater surface areas of biomass increase pollutant capture capacity. Large schemes should avoid overuse of species that may offset their benefits to air quality through the release of BVOCs (low UTAQS score).

Finally, the woodland's structural design is also important. Trees should be placed strategically in shelterbelts to screen emission sources and buffer sensitive habitats. To best reduce wind velocity (prevent uptake of particulate matter), shelters should allow about a third of wind through (DEFRA, 2021). If trees/woodlands are used as screens, deciduous species are advised as evergreens will become matted with solid matter. Wider belts enable more capture and should be planted downwind of emission sources. These passive barriers can also provide shade, noise reduction, improved aesthetics, and other ecosystem services.

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