Climate change and forests

How do woodlands and forests affect the climate?

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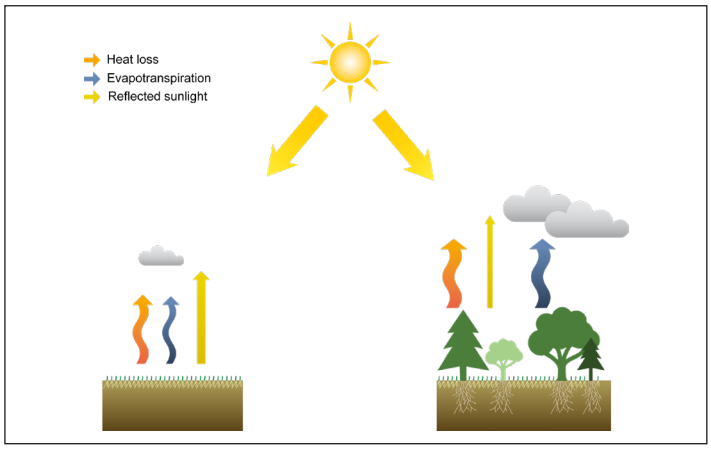
Trees, woodlands and forests are both influenced by the climate, and affect it, at local, regional and global scales.

Forests and the carbon cycle

- About 50% of the dry weight of trees is carbon accumulated from the CO_2 taken in during photosynthesis, so when trees grow they remove CO_2 from the atmosphere. Typically 45–55% of the carbon in forest trees is in the stem, 25–35% is in the roots, the rest in branches and leaves.
- Carbon also accumulates in forest soils as trees grow and dead leaves, roots and woody material decompose. In temperate zones, such as Britain, forest soils can contain as much carbon as the trees, and some soil types can contain considerably more.
- Globally, existing and new forests have taken up some of the CO_2 that has been emitted through the burning of fossil fuels since the start of the Industrial Revolution (1750). However, present land-use change, particularly loss of forests in the tropics, contributes 12% of the CO_2 released to the atmosphere by human activity each year. Restoration of damaged forests and planting new forests will help remove CO_2 from the atmosphere.
- Woody material produced by forests can substitute for fossil-fuel intensive materials and energy supplies, and if made into long-lived timber products results in carbon storage.

Forests and energy exchange

- Solar energy received at the surface is partly reflected, and the rest dissipated through heating the air and the ground and through evaporation.
- Forests reflect less solar radiation than crops and grassland, but the size of the effect (termed the 'albedo') depends on the differences in vegetation cover and the climate zone. In snowy climates the effect of forests in reducing reflection can be large.
- Forests have rougher and taller canopies than short vegetation, so forests allow more heat loss into the air and more evaporation, both of rainfall held on the canopy and transpiration through the leaves. The combined effect is known as evapotranspiration.
- Forests have deeper rooting so can take up more water from the soil and evaporate more than shorter vegetation, particularly in dry weather.



Difference in energy flow over grassland or forest; size of arrow shows relative magnitude.

- These physical effects on energy exchange mean that trees and forests cool the local climate, but the effect on the regional and global climate depends on the climatic zone and large-scale weather patterns.

Forests and other greenhouse gases

- Forests are key to the global carbon cycle and they affect the exchange of two other natural greenhouse gases: methane (CH_4) and nitrous oxide (N_2O). Although these gases have much lower concentrations in the atmosphere than CO_2, they are much more effective in preventing long-wave radiation loss from the atmosphere and thus they increase the 'greenhouse effect'.
- Most forest soils contribute slightly to the removal of CH_4 from the atmosphere, through the action of microbes oxidising the CH_4. However, if soils are very wet and are anaerobic CH_4 is produced by microbes. In wetland and peatland areas, including those with trees, these emissions contribute substantially to atmospheric CH_4 concentrations. However, the higher water use by trees can dry out soils reducing CH_4 production, as will any improvements to drainage made during planting to allow tree establishment and better growth.
- In addition to emissions from wetland soils, CH_4 release from the trees themselves has been observed, although measurements are very variable. Some of the CH_4 production is associated with microbes deep in decaying wood, and some may be transported up from wet soil as water is drawn up the tree trunk. The contribution this makes regionally or globally compared to wetland soils is not yet clear but is likely to be small.
- Forest soils can produce some N_2O but the rates of emission are usually very low compared to agricultural land as little or no nitrogen fertilisers are used.

Effect of afforestation on the climate

There are several interacting effects which can cause either warming or cooling effects on the overall climate.

Key effects are:

- Good tree growth results in more CO_2 removal from the atmosphere than other vegetation types such as crops and grasslands. This contributes a *cooling* effect.
- Planting trees may disturb the soil. This may cause enhanced decomposition of existing organic matter and release of CO_2. On the other hand, tree growth adds more organic matter from roots, dead leaves and woody material. The overall effect depends on soil type, planting methods and tree growth rate.
- Forests have a lower albedo and in British conditions reflect 5–15% less sunlight than shorter vegetation which contributes a *warming* effect.
- Forests increase evapotranspiration, which can increase cloud cover. Because clouds reflect more solar radiation than most land surfaces this can contribute to *cooling*.
- Some tree species emit more volatile organic compounds (VOCs) than grasses and crops, although this varies between species and with weather conditions. VOCs are important in the formation of aerosols and clouds, so are likely to contribute a small *cooling* effect.

Afforestation will generally reduce climate change, particularly in the longer term, but the net contribution will depend upon the local climate, how fast the trees grow, the previous vegetation cover and land use, the new forest type and how it is managed.

Trees, woodlands and forests can also help with reducing the impact of the changing climate through providing shade, shelter, flood and erosion protection, and are key to providing diverse habitats for wildlife.

More information:

Further details of our work on trees, forests and forestry is available at:
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